BAHRIA CLASSIFICATION SOCIETY

BCS-G

BCS Guidelines

July 2022

These guidelines are prepared by embedding related IACS Recommendations. In order to have consistency, the numbering of the guidelines are kept as the same with related IACS Recommendations.

Unless otherwise specified, these Guidelines apply to ships for which the date of contract for construction as defined in BCS- PR 29 is on or after 1st of July 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on BCS website for details.
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BAHRIA CLASSIFICATION SOCIETY

Head Office Third Floor, Bahria Complex II, M.T Khan Road, Karachi

Tel : +92 21 35610242-3 Ext 192

Email : info@bahriaclassificationsociety.org

Website : https://www.bahriaclassificationsociety.org/

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BCS-G 10 Chain Anchoring, Mooring and Towing Equipment

1. Anchoring equipment

1.1 Anchoring equipment for ships having Equipment Number EN below 205 to 50.

(a) The anchoring equipment given here under applies to ships which are not covered under BCS-R A1, i.e. for ships having 50 ≤ EN < 205.

(b) The design basis of the anchoring equipment, i.e. the Equipment Number EN, is that given in BCS-R A1.

(c) These recommendations are applicable to ships operating in unrestricted service. Reductions of equipment may be considered for ships operating in restricted service.

Note:

References to BCS-R A1 are preceded by 'A1' throughout this document.

1.1.1 Equipment number EN

The equipment of anchors and chain cables should be as given in Table 1 based on an Equipment Number EN calculated in compliance with A1.2.

Table 1 Anchoring equipment

	Stockless bower anchors		Stockless stream anchor	Stud link chain cable for bower anchors				Stream wire or chain
					Min. diameter			
EN	No.	Mass per anchor (kg)	Mass per anchor (kg)	Total length (m)	Mild steel Gr. 1 (mm)	Special quality Gr. 2 or 3 (mm)	Length (m)	Breaking strength (kN)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
50-70	2	180	60	220	14	12.5	80	64.7
70-90	2	240	80	220	16	14	85	73.5
90-110	2	300	100	247.5	17.5	16	85	80.0
110-130	2	360	120	247.5	19	17.5	90	89.2
130-150	2	420	140	275	20.5	17.5	90	98.1
150-175	2	480	165	275	22	19	90	107.9
175-205	2	570	190	302.5	24	20.5	90	117.7

1.1.2 Anchors

1.1.2.1 Types of anchors

1.1.2.1.1 Ordinary anchors

(a) The requirements under A1.4.1.1 should be complied with.

(b) The mass of stocked anchors, when used, and that of stream anchors, excluding the stock should be 80% and the mass of the stock should be 20% of the mass as given in Table 1 for stockless bower anchors.

1.1.2.1.2 High Holding Power (HHP) anchors

The requirements under A1.4.1.2 and A1.4.2 should be complied with.

1.1.2.1.3 Super High Holding Power (SHHP) anchors

The requirements under A1.4.1.3 and A1.4.2 should be complied with.

1.1.2.2 Installation of the anchors on board

The bower anchors should be connected to their chain cables and ready for use. The stream anchor should be ready to be connected with its cable.

1.1.2.3 Proof testing of anchors

The requirements under A1.4.4 should be complied with.

1.1.3 Chain cables and wire ropes for anchors

1.1.3.1 Chain cables

(a) The anchors should be associated with stud link chain cables of one of the grades under A1.5.2, Table 3. For equipment numbers EN up to 90, as an alternative to stud link chain cables, short link chain cables may be used.

(b) Wire ropes for anchors may be adopted in compliance with 1.1.3.3

1.1.3.2 Proof and breaking loads of stud link chain cables

(a) The breaking loads (BL) and proof loads (PL) should be in compliance with the requirements under A1.5.3.

(b) The test load values, rounded off from the loads defined in (a) above, which should be used for testing and acceptance of chain cables with diameter between 11 and 19 mm are given in Table 2.

Table 2 Test load values for stud link chain cables

Chain cable diameter	Grade 1		Grade 2		Grade 3	
	Proof load	Breaking load	Proof load	Breaking load	Proof load	Breaking load
(mm)	(kN)	(kN)	(kN)	(kN)	(kN)	(kN)
1	*2*	*3*	*4*	*5*	*6*	*7*
11	35.8	51	51	71.7	71.7	102
12.5	46	65.7	65.7	92	92	132
14	57.9	82	82	116	116	165
16	75.5	107	107	150	150	216
17.5	89	127	127	179	179	256
19	105	150	150	211	211	301

1.1.3.3 Wire ropes for anchors

In alternative to the stud link or short link chain cables under 1.1.3.1, wire ropes may be used for:

(a) bower anchors of ships below 40 m in length

(b) stream anchor as stipulated in Table 1.

The wire ropes under (a) above should have:

(i) length equal to 1.5 times the corresponding tabular length of chain cable (col. 5 of Table 1)

(ii) strength equal to that of tabular chain cable of Grade 1 (col. 2 and 3 of Table 2).

A short length of chain cable should be fitted between the wire rope and bower or stream anchor having a length of 12.5 m or the distance between anchor in stowed position and winch, whichever is less. All surfaces being in contact with the wire need to be rounded with a radius of not less than 10 times the wire rope diameter (including stem).

Table 3 Mass of stud link chain cables

Chain cable diameter (mm)	Minimum mass per length of 27.5 m With Dee shackle (Kg)	Minimum mass per length of 27.5 m With lugless shackle (Kg)	Chain cable diameter (mm)	Minimum mass per length of 27.5 m With Dee shackle (Kg)	Minimum mass per length of 27.5 m With lugless shackle (Kg)
26	410	405	78	3640	3535
28	480	475	81	3940	3820
30	550	545	84	4240	4105
32	620	615	87	4555	4405
34	700	690	90	4870	4705
36	785	775	92	5085	4905
38	875	860	95	5405	5210
40	965	950	97	5630	5425
42	1055	1040	100	5970	5745
44	1150	1130	102	6210	5970
46	1260	1240	105	6580	6320
48	1370	1345	107	6845	6575
50	1485	1455	111	7380	7080
52	1605	1575	114	7795	7475
54	1725	1690	117	8220	7870
56	1850	1810	120	8650	8270
58	1985	1945	122	8960	8550
60	2125	2075	124	9275	8835
62	2275	2220	127	9740	9270
64	2430	2370	130	10210	9710
66	2590	2525	132	10540	10005
68	2755	2685	137	11320	10750
70	2925	2850	142	12110	11500
73	3185	3100	147	12950	12300
76	3460	3360	152	13890	13200

1.2 Anchoring equipment for ships in deep and unsheltered water

1.2.1 Scope and application

The hereunder given recommendations address anchoring equipment for ships in deep and unsheltered water which is not covered by BCS-R A1 and 1.1. These recommendations may be used to design or assess the adequacy of the anchoring equipment for ships intended to anchor in water with depth up to 120 m, current with up to 1.54 m/s, wind with up to 14 m/s and waves with significant height of up to 3 m. The scope of chain cable, being the ratio

between the length of chain paid out and water depth, is assumed to be not less than 3 to 4. Furthermore, these recommendations are applicable to ships with an equipment length, as defined in A1.2, of not less than 135 m.

1.2.2 Equipment Number for deep and unsheltered water

Anchors and chain cables should be in accordance with Table 4 and based on the Equipment Number EN_1 obtained from the following equation:

$$EN_1 = 0.628\left[a\left(\frac{EN}{0.628}\right)^{1/2.3} + b(1-a)\right]^{2.3}$$

where

$a = 1.83 \cdot 10^{-9} \cdot L^3 + 2.09 \cdot 10^{-6} \cdot L^2 - 6.21 \cdot 10^{-4} \cdot L + 0.0866$

$b = 0.156 \cdot L + 8.372$

L = Equipment length of the ship in compliance with A1.2

EN = Equipment Number calculated in compliance with A1.2.

Table 4 Anchoring equipment for ships in unsheltered water with depth up to 120 m

Equipment Number EN_1		High holding power stockless bower anchors		Stud link chain cable for bower anchors		
					Min. diameter (d)	
Equal to or greater than	Less than	Number	Mass per anchor (m_A)	Length	Special quality (Grade 2)	Extra special quality (Grade 3)
			(kg)	(m)	(mm)	(mm)
	1790	2	14150	1017.5	105	84
1790	1930	2	14400	990	105	84
1930	2080	2	14800	990	105	84
2080	2230	2	15200	990	105	84
2230	2380	2	15600	990	105	84
2380	2530	2	16000	990	105	84
2530	2700	2	16300	990	105	84
2700	2870	2	16700	990	105	84
2870	3040	2	17000	990	105	84
3040	3210	2	17600	990	105	84
3210	3400	2	18000	990	105	84
3400	3600	2	18300	990	106	84
3600	3800	2	19000	990	107	85
3800	4000	2	19700	962.5	108	87
4000	4200	2	20300	962.5	111	90
4200	4400	2	21100	962.5	114	92
4400	4600	2	22000	962.5	117	95
4600	4800	2	22900	962.5	119	97
4800	5000	2	23500	962.5	122	99
5000	5200	2	24000	935	125	102
5200	5500	2	24500	907.5	130	105
5500	5800	2	25000	907.5	133	107
5800	6100	2	25500	880	137	111
6100	6500	2	25700	880	140	113
6500	6900	2	26000	852.5	143	115
6900	7400	2	26500	852.5	147	118
7400	7900	2	27000	825	152	121
7900	8400	2	27500	825	154	123
8400	8900	2	28000	797.5	158	127
8900	9400	2	28900	770	162	132
9400	10000	2	29400	770	-	135
10000	10700	2	29900	770	-	139
10700	11500	2	30600	770	-	143
11500	12400	2	31500	770	-	147
12400	13400	2	33200	770	-	152
13400	14600	2	35000	770	-	157
14600		2	38000	770	-	162

1.2.3 Anchors

The bower anchors should be connected to their chain cables and positioned on board ready for use.

Anchors should be of the stockless High Holding Power (HHP) type. The mass of the head of a stockless anchor, including pins and fittings, should not be less than 60% of the total mass of the anchor. For the conditions of HHP anchors reference is made to A1.4.1.2 (a) and for the approval and/or acceptance of HHP anchors reference is made to A1.4.1.2 (c).

The mass, per anchor, of bower anchors given in Table 4 is for anchors of equal mass. The mass of individual anchors may vary to 7% of the tabular mass, but the total mass of anchors should not be less than that recommended for anchors of equal mass.

Suitable arrangements should be provided for securing the anchors when stowed, see 1.3.3.

For manufacture of anchors reference is made to BCS-R W29. For proof testing of the anchors reference is made to A1.4.4.2.

1.2.4 Chain cables for bower anchors

Bower anchors should be associated with stud link chain cables of special (Grade 2) or extra special (Grade 3) quality. The total length of chain cable, as given in Table 4 should be reasonably divided between the two bower anchors. For the proof and breaking loads of stud link chain cables reference is made to A1.5.3, Table 4.

For manufacture of anchor chain cables reference is made to BCS-R W18.

For the installation of the chain cables on board, 1.3 should be observed.

1.2.5 Anchor windlass and chain stopper

The application of BCS-R A3 is recommended for the anchor windlass design and testing and the chain stopper design.

Notwithstanding the requirements according to BCS-R A3, the windlass unit prime mover should be able to supply for at least 30 minutes a continuous duty pull Zcont, in N, given by:

$Z_{cont} = 35\ d^2 + 13.4\ m_A$

where

d = chain diameter, in mm, as per Table 4
m_A = HHP anchor mass, in kg, as per Table 4

In addition to the requirements of BCS-R A3, as far as practicable, for testing purpose the speed of the chain cable during hoisting of the anchor and cable should be measured over 37.5 m of chain cable and initially with at least 120 m of chain and the anchor submerged and hanging free. The mean speed of the chain cable during hoisting of the anchor from the depth of 120 m to the depth of 82.5 m should be at least 4.5 m/min.

For the hull supporting structure of anchor windlass and chain stopper reference is made to A1.7.

1.3 Installation of chain cables and anchors on board

1.3.1 Capacity and arrangement of anchor chain locker

(a) The chain locker should be of capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes and a self-stowing of the cables. The chain locker should be provided with an internal division so that the port and starboard chain cables may be fully and separately stowed.

(b) The chain locker boundaries and their access openings should be watertight as necessary to prevent accidental flooding of the chain locker and damaging essential auxiliaries or equipment or affecting the proper operation of the ship.

(c) Adequate drainage facilities of the chain locker should be adopted.

1.3.2 Securing of the inboard ends of chain cables

(a) The inboard ends of the chain cables should be secured to the structures by a fastening able to withstand a force not less than 15% BL nor more than 30% BL (BL = breaking load of the chain cable).

(b) The fastening should be provided with a mean suitable to permit, in case of emergency, an easy slipping of the chain cables to sea, operable from an accessible position outside the chain locker.

1.3.3 Securing of stowed anchors

(a) To hold the anchor tight in against the hull or the anchor pocket, respectively, it is recommended to fit anchor lashings, e.g., a ‘devil’s claw’.

(b) Anchor lashings should be designed to resist a load at least corresponding to twice the anchor mass plus 10 m of cable without exceeding 40% of the yield strength of the material.

2. Mooring and towing equipment

2.1 Mooring lines

The mooring lines for ships with Equipment Number EN of less than or equal to 2000 are given in 2.1.1. For other ships the mooring lines are given in 2.1.2.

The Equipment Number EN should be calculated in compliance with A1.2. Deck cargoes at the ship nominal capacity condition should be included for the determination of side-projected area A. The nominal capacity condition is defined in BCS-R A2.0.

Sections 2.1.1 and 2.1.2 specify the minimum recommended number and minimum strength of mooring lines. As an alternative to 2.1.1 and 2.1.2, the minimum recommendation for mooring lines may be determined by direct mooring analysis in line with the procedure given in Appendix A.

The designer should consider verifying the adequacy of mooring lines based on assessments carried out for the individual mooring arrangement, expected shore-side mooring facilities and design environmental conditions for the berth.

The definition of line design break force (LDBF) is given in BCS-R A2.0.

2.1.1 Mooring lines for ships with EN ≤ 2000

The minimum recommended mooring lines for ships having an Equipment Number EN of less than or equal to 2000 are given in Table 5.

For ships having the ratio A/EN > 0.9 the following number of lines should be added to the number of mooring lines as given by Table 5:

One line where $0.9 < \frac{A}{EN} \leq 1.1$,

two lines where $1.1 < \frac{A}{EN} \leq 1.2$,

three lines where $1.2 < \frac{A}{EN}$.

Table 5 Mooring lines for ships with EN ≤ 2000

EQUIPMENT NUMBER		MOORING LINES		
Exceeding	Not exceeding	No. of mooring lines	Minimum length of each line * (m)	Ship design minimum breaking load (kN)
1	*2*	*3*	*4*	*5*
50	70	3	80	37
70	90	3	100	40
90	110	3	110	42
110	130	3	110	48
130	150	3	120	53
150	175	3	120	59
175	205	3	120	64
205	240	4	120	69
240	280	4	120	75
280	320	4	140	80
320	360	4	140	85
360	400	4	140	96
400	450	4	140	107
450	500	4	140	117
500	550	4	160	134
550	600	4	160	143
600	660	4	160	160
660	720	4	160	171
720	780	4	170	187
780	840	4	170	202
840	910	4	170	218
910	980	4	170	235
980	1060	4	180	250
1060	1140	4	180	272
1140	1220	4	180	293
1220	1300	4	180	309
1300	1390	4	180	336
1390	1480	4	180	352
1480	1570	5	190	352
1570	1670	5	190	362
1670	1790	5	190	384
1790	1930	5	190	411
1930	2000	5	190	437

* 2.1.3 should be observed

2.1.2 Mooring lines for ships with EN > 2000

The minimum recommended strength and number of mooring lines for ships with an Equipment Number EN > 2000 are given in 2.1.2.1 and 2.1.2.2, respectively. The length of mooring lines is given by 2.1.3.

The strength of mooring lines and the number of head, stern, and breast lines (see Note) for ships with an Equipment Number EN > 2000 are based on the side-projected area A_1. Side projected area A_1 should be calculated similar to the side-projected area A according to A1.2 but considering the following conditions:

- The ballast draft should be considered for the calculation of the side-projected area A_1. For ship types having small variation in the draft, like e.g. passenger and RO/RO vessels, the side projected area A_1 may be calculated using the summer load waterline.

- Wind shielding of the pier can be considered for the calculation of the side-projected area A_1 unless the ship is intended to be regularly moored to jetty type piers. A height of the pier surface of 3 m over waterline may be assumed, i.e. the lower part of the side-projected area with a height of 3 m above the waterline for the considered loading condition may be disregarded for the calculation of the side-projected area A_1.

- Deck cargoes at the ship nominal capacity condition should be included for the determination of side-projected area A1. For the condition with cargo on deck, the summer load waterline may be considered. Deck cargoes may not need to be considered if ballast draft condition generates a larger side-projected area A1 than the full load condition with cargoes on deck. The larger of both side-projected areas should be chosen as side-projected area A1. The nominal capacity condition is defined in UR A2.0.

The mooring lines as given here under are based on a maximum current speed of 1.0 m/s and the following maximum wind speed v_w, in m/s:

v_w =	$25.0 - 0.002 (A_1 – 2000)$	for passenger ships, ferries, and car carriers with $2000\ m^2 < A_1 \leq 4000\ m^2$
=	21.0	for passenger ships, ferries, and car carriers with $A_1 > 4000\ m^2$
=	25.0	for other ships

The wind speed is considered representative of a 30 second mean speed from any direction and at a height of 10 m above the ground. The current speed is considered representative of the maximum current speed acting on bow or stern (±10°) and at a depth of one-half of the mean draft. Furthermore, it is considered that ships are moored to solid piers that provide shielding against cross current.

Additional loads caused by, e.g., higher wind or current speeds, cross currents, additional wave loads, or reduced shielding from non-solid piers may need to be particularly considered. Furthermore, it should be observed that unbeneficial mooring layouts can considerably increase the loads on single mooring lines.

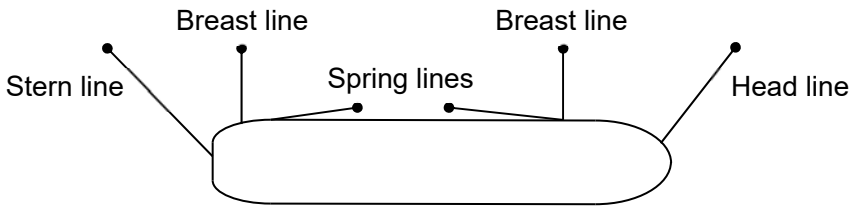
Note:

The following is defined with respect to the purpose of mooring lines, see also figure below:

Breast line: A mooring line that is deployed perpendicular to the ship, restraining the ship in the off-berth direction.

Spring line: A mooring line that is deployed almost parallel to the ship, restraining the ship in fore or aft direction.

Head/Stern line: A mooring line that is oriented between longitudinal and transverse direction, restraining the ship in the off-berth and in fore or aft direction. The amount of restraint in fore or aft and off-berth direction depends on the line angle relative to these directions.



2.1.2.1 Ship design minimum breaking load

The ship design minimum breaking load, in kN, of the mooring lines should be taken as:

$$MBL_{SD} = 0.1 \cdot A_1 + 350$$

The ship design minimum breaking load may be limited to 1275 kN (130 t). However, in this case the moorings are to be considered as not sufficient for environmental conditions given by 2.1.2. For these ships, the acceptable wind speed v_w*, in m/s, can be estimated as follows:

$$v_w^* = v_w \cdot \sqrt{\frac{MBL_{SD}^*}{MBL_{SD}}}$$

where v_w is the wind speed as per 2.1.2, MBL_{SD}* the ship design minimum breaking load of the mooring lines intended to be supplied and MBL_{SD} the ship design minimum breaking load as recommended according to the above formula. However, the ship design minimum breaking load should not be taken less than corresponding to an acceptable wind speed of 21 m/s:

$$MBL_{SD}^* \geq \left(\frac{21}{v_w}\right)^2 \cdot MBL_{SD}$$

If lines are intended to be supplied for an acceptable wind speed v_w* higher than v_w as per 2.1.2, the ship design minimum breaking load should be taken as:

$$MBL_{SD}^* = \left(\frac{v_w^*}{v_w}\right)^2 \cdot MBL_{SD}$$

2.1.2.2 Number of mooring lines

The total number of head, stern and breast lines (see Note in 2.1.2) should be taken as:

$$n = 8.3 \cdot 10^{-4} \cdot A_1 + 6$$

For oil tankers, chemical tankers, bulk carriers, and ore carriers the total number of head, stern and breast lines should be taken as:

$$n = 8.3 \cdot 10^{-4} \cdot A_1 + 4$$

The total number of head, stern and breast lines should be rounded to the nearest whole number.

The number of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the ship design minimum breaking load of the lines. The adjusted ship design minimum breaking load, MBL_{SD}**, should be taken as:

MBL_{SD}** = 1.2 · MBL_{SD} · n/n** ≤ MBL_{SD} for increased number of lines,

MBL_{SD}** = MBL_{SD} · n/n** for reduced number of lines.

where MBL_{SD} is MBL_{SD} or MBL_{SD}* specified in 2.1.2.1, as appropriate, n** is the increased or decreased total number of head, stern and breast lines and n the number of lines for the considered ship type as calculated by the above formulas without rounding.

Vice versa, the ship design minimum breaking load of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the number of lines.

The total number of spring lines (see Note in 2.1.2) should be taken not less than:

Two lines where EN < 5000,

Four lines where EN ≥ 5000.

The ship design minimum breaking load of spring lines should be the same as that of the head, stern and breast lines. If the number of head, stern and breast lines is increased in conjunction with an adjustment to the ship design minimum breaking load of the lines, the number of spring lines should be taken as follows, but rounded up to the nearest even number.

$$n_S^* = MBL_{SD}/MBL_{SD}^{**} \cdot n_S$$

where MBL_{SD} is MBL_{SD} or MBL_{SD}^* specified in 2.1.2.1, as appropriate, n_S is the number of spring lines as given above and n_S^* the increased number of spring lines.

2.1.3 Length of mooring lines

The length of mooring lines for ships with EN of less than or equal to 2000 may be taken from Table 5. For ships with EN > 2000 the length of mooring lines may be taken as 200 m.

The lengths of individual mooring lines may be reduced by up to 7% of the above given lengths, but the total length of mooring lines should not be less than would have resulted had all lines been of equal length.

2.2 Tow line

The tow lines are given in Table 6 and are intended as own tow line of a ship to be towed by a tug or other ship. For the selection of the tow line from Table 6, the Equipment Number EN should be taken according to 2.1.

The designer should consider verifying the adequacy of towing lines based on assessments carried out for the individual towing arrangement.

Table 6 Tow lines

EQUIPMENT NUMBER		TOW LINE	
Exceeding	Not exceeding	Minimum length (m)	Ship design minimum breaking load (kN)
1	*2*	*3*	*4*
50	70	180	98
70	90	180	98
90	110	180	98
110	130	180	98
130	150	180	98
150	175	180	98
175	205	180	112
205	240	180	129
240	280	180	150
280	320	180	174
320	360	180	207
360	400	180	224
400	450	180	250
450	500	180	277
500	550	190	306
550	600	190	338
600	660	190	370
660	720	190	406
720	780	190	441
780	840	190	479
840	910	190	518
910	980	190	559
980	1060	200	603
1060	1140	200	647
1140	1220	200	691
1220	1300	200	738
1300	1390	200	786
1390	1480	200	836
1480	1570	220	888
1570	1670	220	941
1670	1790	220	1024
1790	1930	220	1109
1930	2080	220	1168
2080	2230	240	1259
2230	2380	240	1356
2380	2530	240	1453
2530	2700	260	1471
2700	2870	260	1471
2870	3040	260	1471
3040	3210	280	1471
3210	3400	280	1471
3400	3600	280	1471
3600	-	300	1471

2.3 Mooring and tow line construction

Tow lines and mooring lines may be of wire, natural fibre or synthetic fibre construction or of a mixture of wire and fibre. For synthetic fibre ropes it is recommended to use lines with reduced risk of recoil (snap-back) to mitigate the risk of injuries or fatalities in the case of breaking mooring lines.

Notwithstanding the strength recommendations given in 2.1 and 2.2, no fibre rope should be less than 20 mm in diameter. For polyamide ropes the line design break force should be

increased by 20% and for other synthetic ropes by 10% to account for strength loss due to, among others, aging and wear.

2.4 Mooring winches

2.4.1 Each winch should be fitted with brakes the holding capacity of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80% of the ship design minimum breaking load of the rope as fitted on the first layer. The winch should be fitted with brakes that will allow for the reliable setting of the brake rendering load.

2.4.2 For powered winches the maximum hauling tension which can be applied to the mooring line (the reeled first layer) should not be less than 1/4.5 times, nor be more than 1/3 times the rope's ship design minimum breaking load. For automatic winches these figures apply when the winch is set to the maximum power with automatic control.

2.4.3 For powered winches on automatic control, the rendering tension which the winch can exert on the mooring line (the reeled first layer) should not exceed 1.5 times, nor be less than 1.05 times the hauling tension for that particular power setting of the winch. The winch should be marked with the range of rope strength for which it is designed.

2.5 Mooring and towing arrangement

2.5.1 Mooring arrangement

Mooring lines in the same service (e.g. breast lines, see Note in 2.1.2) should be of the same characteristic in terms of strength and elasticity.

As far as possible, sufficient number of mooring winches should be fitted to allow for all mooring lines to be belayed on winches. This allows for an efficient distribution of the load to all mooring lines in the same service and for the mooring lines to shed load before they break. If the mooring arrangement is designed such that mooring lines are partly to be belayed on bitts or bollards, it should be considered that these lines may not be as effective as the mooring lines belayed on winches.

Mooring lines should have as straight a lead as is practicable from the mooring drum to the fairlead.

At points of change in direction sufficiently large radii of the contact surface of a rope on a fitting should be provided to minimize the wear experienced by mooring lines and as recommended by the rope manufacturer for the rope type intended to be used.

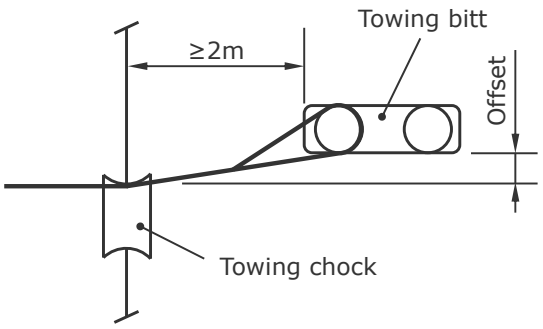
2.5.2 Towing arrangement

Towing lines should be led through a closed chock. The use of open fairleads with rollers or closed roller fairleads should be avoided.

For towing purpose it is recommended to provide at least one chock close to centreline of the ship forward and aft. It is also beneficial to provide additional chocks on port and starboard side at the transom and at the bow.

Towing lines should have a straight lead from the towing bitt or bollard to the chock.

For the purpose of towing, bitts or bollards serving a chock should be located slightly offset and in a distance of at least 2 m away from the chock, see figure below:



Warping drums should preferably be positioned not more than 20 m away from the chock, measured along the path of the line.

Attention should be given to the arrangement of the equipment for towing and mooring operations in order to prevent interference of mooring and towing lines as far as practicable. It is beneficial to provide dedicated towing arrangements separate from the mooring equipment.

For emergency towing arrangements for tankers reference should be made to SOLAS Chapter II-1, Regulation 3-4. For all ships other than tankers it is recommended to provide towing arrangements fore and aft of sufficient strength for ‘other towing’ service as defined in BCS-R A2.0.

3. Anchoring and mooring equipment for fishing vessels

3.1 Anchoring equipment

3.1.1 Application

The following provisions apply to fishing vessels operating in unrestricted service. Reduction of equipment may be considered for fishing vessels operating in restricted services.

3.1.2 General recommendations

(a) Each ship should be provided with anchoring equipment designed for quick and safe operation in all foreseeable service conditions. Anchor equipment should consist of anchors, anchor chain cables and a windlass or other arrangements for dropping and weighing the anchors and for holding the ship at anchor.

(b) The equipment of anchors and chain cables given in Table 7 is based on the Equipment Number EN which should be calculated as follows:

$$EN = \Delta^{2/3} + 2Bh + 0.1A$$

where

Δ = moulded displacement, in t, to the maximum design waterline,

B = greatest moulded breadth, in m,

h = effective height, in m, from the maximum design waterline to the top of the uppermost house.

= $a + \Sigma h_i$

a = distance, in m, from the maximum design waterline to the upper edge of the uppermost complete deck at the side amidships,

h_i = height, in m, on the centreline of each tier of houses having breadth greater than B/4.

For the lowest tier h is measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck.

When calculating h, sheer and trim can be ignored.

A = side-projected area, in m^2, of the hull, within the length of the ship between perpendiculars, and of superstructures and houses above the maximum design waterline having a width greater than B/4.

Screens and bulwarks more than 1.5 m in height should be regarded as parts of houses when determining h and A.

3.1.3 Particular recommendations

(a) For ships below 40 m in length the anchor chain may be replaced with wire ropes of equal strength of the tabular anchor cables of Grade 1. Wire ropes of trawl winches complying with this recommendation may be used as anchor chain cables.

(b) When wire ropes are substituted for anchor chain cables then:

(i) the length of the ropes should be equal to 1.5 times the corresponding tabular length of chain cable (col. 5 of Table 7),

(ii) a short length of chain cable should be fitted between the wire rope and anchor having a length of 12.5 m or the distance between anchor in stowed position and winch, whichever is less,

(iii) all surfaces being in contact with the wire should be rounded with a radius of not less than 10 times the wire rope diameter (including stem).

(c) High holding power anchors of approved design may be used as bower anchors. The mass of each such anchor may be 75% of the tabular mass for ordinary stockless bower anchors.

(d) The tabular anchor equipment may be increased for ships fishing in very rough waters.

Table 7 Equipment for fishing vessels

Equipment Number		Stockless bower anchors		Stud link chain cables for bower anchors		
					Min. diameter (mm)	
Exceeding	Not exceeding	Number	Mass per anchor (kg)	Total length (m)	Mild steel (Grade 1)**	Special quality steel (Grade 2)**
1	*2*	*3*	*4*	*5*	*6*	*7*
30	40	2	80	165	11	-
40	50	2	100	192.5	11	-
50	60	2	120	192.5	12.5	-
60	70	2	140	192.5	12.5	* -
70	80	2	160	220	14	12.5
80	90	2	180	220	14	12.5
90	100	2	210	220	16	14
100	110	2	240	220	16	14
110	120	2	270	247.5	17.5	16
120	130	2	300	247.5	17.5	16
130	140	2	340	275	19	17.5
140	150	2	390	275	19	17.5
150	175	2	480	275	22	19
175	205	2	570	302.5	24	20.5
205	240	2	660	302.5	26	22
240	280	2	780	330	28	24
280	320	2	900	357.5	30	26
320	360	2	1020	357.5	32	28
360	400	2	1140	385	34	30
400	450	2	1290	385	36	32
450	500	2	1440	412.5	38	34
500	550	2	1590	412.5	40	34
550	600	2	1740	440	42	36
600	660	2	1920	440	44	38
660	720	2	2100	440	46	40

NOTES

* Alternative to stud link chain cables, short link chain cables may be considered.

** The steel grades of the chain cables are covered by BCS-R A1, A1.5.2.

3.2 Mooring equipment

The mooring equipment is given by Table 8.

Table 8 Mooring lines for fishing vessels

Equipment Number		Mooring lines		
Exceeding	Not exceeding	Number	Minimum length of each line (m)	Ship design minimum breaking load (kN)
1	*2*	*3*	*4*	*5*
30	40	2	50	29
40	50	2	60	29
50	60	2	60	29
60	70	2	80	29
70	80	2	100	34
80	90	2	100	36.8
90	100	2	110	36.8
100	110	2	110	39
110	120	2	110	39
120	130	2	110	44
130	140	2	120	44
140	150	2	120	49
150	175	2	120	54
175	205	2	120	59
205	240	2	120	64
240	280	3	120	71
280	320	3	140	78
320	360	3	140	85.8
360	400	3	140	93
400	450	3	140	101
450	500	3	140	108
500	550	4	160	113
550	600	4	160	118
600	660	4	160	123
660	720	4	160	127

Appendix A
Direct mooring analyses

1. General

As an alternative to the prescriptive approach, direct mooring analysis may be performed to determine the necessary mooring restraint, i.e. number and strength of mooring lines. Direct analyses allow to optimize mooring equipment and arrangement for the individual ship and the port mooring facilities typical for the considered ship type and size.

2. Documentation

The calculations should be documented in a report. The report should include all assumptions made in calculations for the finally chosen mooring equipment, including lines, and its arrangement, reflected in the mooring arrangement plan as required by BCS- R A2.

3. Analysis methodology

Three dimensional quasi-static calculations should be performed to determine the acting mooring line forces. As a minimum, loads from wind and current should be accounted for in the analysis. Geometrical and material nonlinearities of mooring lines and fenders or breasting dolphins should be considered. An iterative calculation procedure should be applied to arrive at a converged solution with forces acting on mooring lines and on fenders or breasting dolphins being in equilibrium with forces and moments applied to the ship.

4. Environmental conditions

Mooring line forces should be calculated for environmental conditions given in 2.1.2 [of BCS-G 10]. Additional loads, e.g. wave loads or cross currents, or increased wind and current loads may be considered for certain ship types or for specific ports intended to be regularly called.

5. Steps to be taken in a direct mooring analysis

Direct assessment of mooring forces and determination of the necessary number and strength of mooring lines comprise the following steps:

a) Determine port mooring facilities representative for the considered ship type and size
b) Determine shipboard mooring equipment and arrangement
c) Determine mooring line type(s) to be used
d) Determine mooring layout(s) to be assessed
e) Determine ship loading condition(s) to be assessed
f) Select or determine wind and current drag coefficients
g) Determine wind and current forces and moments
h) Compute forces acting on all mooring line
i) Determine necessary strength of mooring lines
j) If strength of mooring lines should be altered, modify steps b), c) and/or d) with or without changing the number of mooring lines and repeat steps h) and i)

5.1. Port mooring facilities

Characteristics of port mooring facilities have strong influence on the resulting mooring line forces. Mooring analysis should be performed for port mooring facilities representative for the considered ship type and size, i.e. type of berth, type and arrangement of hooks/bollards, type and arrangement of fenders or breasting dolphins and height of pier above waterline.

Fenders or breasting dolphins in many cases may not affect the critical mooring line loads. Hence, initially, generic fender or dolphin arrangements and infinitely stiff load-deformation characteristics may be considered. If no fender or dolphin loads occur for load cases yielding the critical mooring line loads, more specific fender or dolphin arrangements and characteristics may be omitted.

If there are substantially different port mooring facilities typically encountered by the considered ship type, additional calculations should be performed to consider these variations.

5.2. Shipboard mooring equipment and arrangement

The mooring equipment and arrangement need to be chosen for the mooring analysis, i.e. location of mooring decks and location of mooring winches and fairleads. As a starting point, mooring equipment for the number of lines as determined by the prescriptive approach may be chosen, see 2.1.2.2 [of BCS-G 10].

5.3. Mooring lines

The mooring analysis should apply the mooring line type(s) intended to be supplied with the vessel. The geometrical and material nonlinearities of the mooring lines should be considered by the mooring analysis. Load-deflection characteristics of mooring lines can be taken from data sheets of rope manufacturers. If given, characteristics of the broken-in ropes should be applied.

To achieve a good distribution of mooring line forces, mooring line type and characteristics should be at least same for lines in the same service, e.g. for head and stern lines, breast lines and spring lines. For very stiff mooring lines, e.g. made of steel or high modulus synthetic fibers, the use of elastic tails should be considered to enhance the elasticity in the mooring system and taken into account for the mooring analysis.

5.4. Mooring layout

For the assessment of forces acting on mooring lines, a realistic mooring layout needs to be assumed, i.e. for each mooring line it needs to be determined from which bollard or winch, along which path, through which fairlead it is led and to which shoreside hook or bollard it is connected. Inboard parts of the mooring lines (between fairlead and shipboard fixation point) contribute to the elongation behavior of the line and should be included in the analysis.

The maximum number of lines connected to one shore mooring point needs to be limited to not load the shore side mooring points unrealistically high. For multi-purpose piers the number of lines per shore bollard should be limited to three. For other types of berths, the number mooring lines per shore mooring point is also

limited, e.g., by the available number of hooks. Reasonable assumptions should be made based on typical berth types encountered by the considered ship type.

Alternative mooring layouts should also be assessed, considering possible and reasonable options to moor the ship to the assumed port mooring facilities. Also, a different position of the ship relative to the shoreside mooring bollards/hooks should be assessed to find the critical mooring line loads for the normal operation of the ship. Exemptions may be given to e.g. tankers, LNG carriers or ferries if typically moored in the same position relative to the shoreside mooring facilities.

5.5. Loading conditions

Mooring line forces should be calculated for loading conditions given in 2.1.2 [of BCS -G 10].

5.6. Wind and current drag coefficients

To calculate the wind and current forces and moments acting on the ship, wind and current drag coefficients are needed for the considered ship type, size and loading condition. Drag coefficients should be as specific as possible for the considered ship and loading conditions.

There are different sources for drag coefficients. Some Industry Guidelines provide drag coefficients for tankers and LNG carriers which can be applied. Due to the similarity of hull forms and superstructures, these coefficients may also be used for bulk carriers and ore carriers. For other ship types drag coefficients may be taken from the literature, if available, or can be determined by CFD calculations or model tests. CFD calculations are to be justified with suitable validation and sensitivity studies.

There are some effects that can influence the drag coefficients, i.e. blockage (limited under keel clearance, solid quay walls), ship draft and wind shielding by solid quays and buildings or cargo stored on quays (e.g. container stacks). Effects from blockage and ship draft can only be accounted for by appropriate coefficients. Drag coefficient should be chosen or determined for realistic water depth to draft ratios and for the considered ship draft(s). Some Industry Guidelines provide current drag coefficients for ballast and loaded draft conditions and for different water depth to draft ratios. Wind shielding effects are typically not considered by the wind drag coefficients. The effect of wind shielding of solid quays may be considered by an equivalent reduction of the lateral wind area of the ship. Shielding by buildings or cargo stored on quays should not be considered as their presence is imponderable.

5.7. Calculation of wind and current forces and moments

Wind and current forces and moments can be calculated for the given environmental conditions with the geometrical particulars of the considered ship and the selected drag coefficients. Usually, the forces in longitudinal and transversal directions as well as the moment about the vertical ship axis (yaw) are calculated.

Wind forces and moments should be calculated for all directions in intervals of preferably 15°, but not more than 30°. Current forces and moments should be calculated for selected directions as per 2.1.2 [of BCS-G 10]. For ships regularly moored to non-solid piers or jetties, cross current may need to be considered in addition.

5.8. Calculation of mooring line forces

For all considered scenarios and all combinations of applied environmental conditions, the maximum mooring line force should be determined for groups of lines in the same service.

In case of all lines are intended to be attached to winches, brake rendering can be considered to better distribute line loads among all lines in a group of lines in the same service. Then, the average mooring line force of a group of lines may be determined and taken as mooring line force used to determine the necessary strength of the mooring lines according to section 5.9.

5.9. Strength of mooring lines

The necessary strength of mooring lines, i.e., the Ship Design Minimum Breaking Load (MBL_{SD}), results from the calculated maximum mooring line force ($F_{L, max}$) divided by the Work Load Limit (WLL) factor of mooring lines. The WLL factor and the resulting MBL_{SD} for different mooring line materials are shown in the below table.

Mooring line material	WLL factor	MBL_{SD}
Steel wire	0.55	$1.82 * F_{L, max}$
Synthetic fibers	0.5	$2.0 * F_{L, max}$

Preferably, all lines supplied to the ship should have the same characteristics and strength to avoid confusion of lines. However, for significantly different maximum calculated line loads, lines in different service may also have different strength and characteristics, e.g. for head and stern lines other than for spring lines.

BCS- G 11 Materials Selection Guideline for Mobile Offshore Drilling Units

Material selection for surface (ship or barge) type units is to be based on the material requirements contained in the Rules of BCS.
Structural elements for self-elevating and column stabilized units are to be considered in association with a defined minimum service temperature, influencing factors and application.

1. Minimum Service Temperature of Material

The minimum service temperature of the steel should be assumed equal to the lowest of the average daily atmospheric temperatures, based on meteorological data, for any anticipated area of operation. If data giving the lowest daily average temperature is not available and some other criterion is used (such as lowest monthly average temperature), BCS will use this Guideline with discretion.

2. Influencing Factors

A particular application in association with a defined minimum service temperature depends on toughness parameters, taking the following influencing factors into account:

(a) Stress Relieving: A lower service temperature than stipulated in the Tables for the relevant steel grade may be considered when a stress relieving heat treatment is employed.

(b) Cold Forming: When cold forming subjects the extreme fiber to greater than about 3% strain consideration should be given to applying a suitable heat treatment.

(c) Steel Manufacturing Process: When a steel manufacturing process, such as normalizing, controlled or TM rolling, or grain refinement, is utilized when not specifically required by BCS- R W11, a lower service temperature may be used subject to agreement of BCS

3. Application

Categories of Structural Members
For the purpose of this guide, structural members have been grouped into three application categories of increasing importance as follows:

Secondary: Structural elements of minor importance, failure of which is unlikely to affect the overall integrity of the unit.

Primary: Structural elements essential to the overall integrity of the unit.

Special: Those portions of primary structural elements which are in way of critical load transfer points, stress concentrations, etc.

Some specific examples of structural elements which would fall into the aforementioned categories are as follows:

Column Stabilized Units
Secondary Applications Structure

(a) internal structure including bulkheads and girders in vertical columns, decks, lower hulls, and diagonal and horizontal bracing, and framing members

(b) upper platform decks, or decks of upper hulls except areas where the structure is considered primary or special application

(c) certain large diameter vertical columns with low length to diameter ratios, except at intersections

Primary Application Structure

(a) external shell structure of vertical columns, lower and upper hulls, and diagonal and horizontal braces

(b) deck plating, heavy flanges, and bulkhead within the upper hull or platform which form "Box" or "I" type supporting structure which do not receive major concentrated loads

(c) bulkheads, flats or decks and framing which provide local re-inforcement or continuity of structure in way of intersections except areas where the structure is considered special application

Special Application Structure

(a) external shell structure in way of intersections of vertical columns, decks and lower hulls

(b) portions of deck plating, heavy flanges, and bulkheads within the upper hull or platform which form "Box" or "I" type supporting structure which receive major concentrated loads

(c) major intersections of bracing members

(d) external brackets, portions of bulkheads, flats, and frames which are designed to receive concentrated loads at intersections of major structural members

(e) "through" material used at connections or vertical columns, upper platform decks, and upper or lower hulls which are designed to provide proper alignments and adequate load transfer

Self Elevating Units

Secondary Application Structure

(a) internal framing, including bulkheads and girders, in cylindrical legs

(b) internal bulkheads and framing members of upper hull structure

(c) internal bulkheads of bottom mat supporting structure except where the structure is considered primary or special application

(d) deck, side and bottom plating of upper hull except where the structure is considered primary application

Primary Applications Structure

(a) external plating of cylindrical legs

(b) plating of all components of lattice type legs

(c) combination of bulkhead, deck, side and bottom plating within the upper hull which form "Box" or "I" type main supporting structure

(d) jack-house supporting structure and bottom footing structure which receives initial transfer of load from legs

(e) internal bulkheads, shell and deck of bottom mat supporting structure which are designed to distribute major loads, either uniform or concentrated, into the mat structure

▶

Special Application Structure

(a) vertical columns in way of intersection with the mat structure.
(b) intersections of lattics type leg structure which incorporate novel construction, including the use of steel castings.

NOTE: When an owner or designer specifies material grades which exceed that indicated by Table I (and when they have been approved), approval of materials of lesser quality will not be considered without the written consent of the owner or designer.

Table 1

Thickness limitations (mm) of hull structural steel according to BCS- R W11 and W16 for various application categories and design temperatures

Category	Grade	Minimum Design Temperature 0°C	–10°C	–20°C	–30°C	–40°C	–50°C
SECONDARY	A	30	20	10	X	X	X
	B	40	30	20	10	X	X
	D	50	50	45	35	25	15
	E	50	50	50	50	45	35
	AH	40	30	20	10	X	X
	DH	50	50	45	35	25	15
	EH	50	50	50	50	45	35
	FH	50	50	50	50	50	50
	AQ	40	25	10	X	X	X
	DQ	50	45	35	25	15	X
	EQ	50	50	50	45	35	25
	FQ	50	50	50	50	50	45
PRIMARY	A	20	10	X	X	X	X
	B	25	20	10	X	X	X
	D	45	40	30	20	10	X
	E	50	50	50	40	30	20
	AH	25	20	10	X	X	X
	DH	45	40	30	20	10	X
	EH	50	50	50	40	30	20
	FH	50	50	50	50	50	40
	AQ	20	X	X	X	X	X
	DQ	45	35	25	15	X	X
	EQ	50	50	45	35	25	15
	FQ	50	50	50	50	45	35
SPECIAL	A	X	X	X	X	X	X
	B	15	X	X	X	X	X
	D	30	20	10	X	X	X
	E	50	45	35	25	15	X
	AH	15	X	X	X	X	X
	DH	30	20	10	X	X	X
	EH	50	45	35	25	15	X
	FH	50	50	50	50	40	30
	AQ	X	X	X	X	X	X
	DQ	25	15	X	X	X	X
	EQ	50	40	30	20	10	X
	FQ	50	50	50	40	30	20

"X" indicates no application

NOTES:

1. Thicknesses greater than shown in the Table will be specially considered by BCS.

2. Substitution of materials considered to be equivalent to the Grades shown, or steels of different strength levels, will be specially considered by BCS.

3. Interpolation of thicknesses for intermediate temperatures may be considered.

◄◄

BCS-G13 Standards for Ship Equipment for Mooring at Single Point Moorings

Upon request from the Owner, BCS is prepared to certify that the vessel is specially fitted for compliance with Section 4.3 of "Mooring Equipment Guidelines (MEG 4)", published by the Oil Companies International Marine Forum, 2018, as amended.

Plans showing the arrangements should be submitted to the Classification Society for review.

The safety factor on yield load for bow chain stoppers and bow fairleads should be a minimum of 2 when the specified safe working load (SWL) is applied as given in Section 4.3 of the Guidelines. Their foundations and supporting structures should be adequate to withstand 2 x SWL of bow chain stoppers and bow fairleads.

Smit type towing bracket fittings should not be used as bow chain stoppers.

Calculations to demonstrate this capability should be submitted.

The chain bearing surface of the bow fairleads described in 4.3 should have a diameter at least seven times that of the associated chain.

The installation on board the ship should be confirmed by a Surveyor to the Classification Society.

Compliance with the foregoing should be suitably documented.

BCS- G14 Hatch cover securing and tightness

1. Application

1.1 The following recommendations apply to steel hatch covers that are fitted to hatch openings on weather decks.

1.2 These recommendations, when relevant, also apply to the non-weathertight hatch covers which are accepted on container ships in accordance with the BCS- I LL 64.

1.3 Where large relative movements between cover and ship structure or between cover elements are expected for ships having comparatively long/wide hatch ways, the application of these arrangements specified in this Recommendation for the gasket and securing arrangements are to be specially considered.

2. Design and Weathertightness

2.1 General

2.1.1 The weight of covers and any cargo stowed thereon, together with inertial forces generated by ship motions, are to be transmitted to the ship structure through suitable contact, such as continuous steel to steel contact of the cover skirt plate with the ship's structure or by means of defined bearing pads.

2.2 Weathertight Hatch Covers

2.2.1 The arrangement of weathertight hatch covers is to be such that weathertightness can be maintained in all sea conditions.

2.2.2 Weathertight sealings are to be obtained by a continuous gasket of relatively soft elastic material compressed to achieve the necessary weathertightness. Similar sealing is to be arranged between cross-joint elements. Where fitted, compression flat bars or angles are to be well rounded where in contact with the gasket and are to be made of a corrosion-resistant material.

2.2.3 The gasket material is to be of a quality suitable for all environmental conditions likely to be experienced by the ship, and is to be compatible with the cargoes carried. The material and form of gasket selected is to be considered in conjunction with the type of cover, the securing arrangement and the expected relative movement between cover and ship structure. The gasket is to be effectively secured to the cover.

3. Drainage Arrangement

3.1 General

3.1.1 Drain openings are to be arranged at the ends of drain channels and are to be provided with effective means for preventing ingress of water from outside, such as non-return valves or equivalent.

3.2 Weathertight Hatch Covers

3.2.1 Drainage is to be arranged inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming.

3.2.2 Cross-joints of multi-panel covers are to be arranged with drainage of water from the space above the gasket and a drainage channel below the gasket.

3.2.3 If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket is also to be provided.

4. Securing Devices

4.1 General

4.1.1 Devices used to secure hatch covers, i.e. bolts, wedges or similar, are to be suitably spaced along the coamings and between cover elements.

4.1.2 The minimum gross sectional area of each securing device is not to be less than:

$$A = \frac{1{,}4\,\overline{a}}{f} \quad (cm^2)$$

where

$\overline{a}$ = half the distance between the two adjacent securing devices, measured along hatch cover periphery, see Fig. 1 [m]

$f = (\sigma_F/235)^m$

σ_F = minimum upper yield stress of the material, not to be taken greater than 70% of the ultimate tensile strength [N/mm^2]

m = 0,75 for $\sigma_F > 235$ N/mm^2
= 1,00 for $\sigma_F \leq 235$ N/mm^2

Where the packing line pressure (see 4.2.2) exceeds 5 N/mm, the cross-sectional area of the securing devices is to be increased in direct proportion.

Rods or bolts are to have a minimum gross diameter not less than 19 mm for hatchways exceeding 5 m^2 in area.

4.1.3 Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

4.1.4 Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

4.1.5 Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

4.2 Weathertight Hatch Covers

4.2.1 Arrangement and spacing of securing devices are to be determined with due attention to the effectiveness for weathertightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

4.2.2 Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices. The packing line pressure is to be specified.

4.2.3 The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The gross moment of inertia of edge elements is not to be less than:

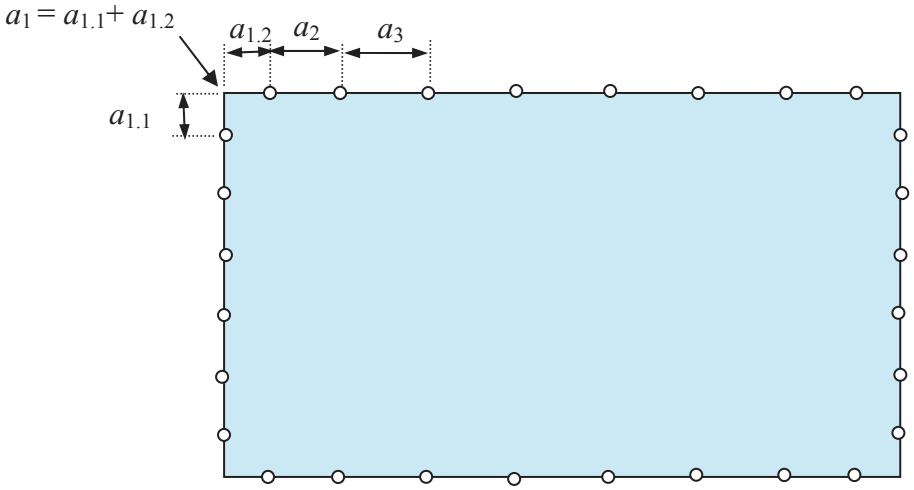
$I = 6\,pa^4$ [cm^4]

where
p = packing line pressure, with $p \geq 5$ [N/mm]

a = maximum of the distances, a_i, between two consecutive securing devices, measured along the hatch cover periphery (see Fig. 1), not to be taken as less than 2.5 a_c, [m]

a_c : max ($a_{1.1}$, $a_{1.2}$) [m]

▶



$$a = \max (a_i , a_{i+1})$$

$$\overline{a} = (a_i + a_{i+1})/2$$

Fig. 1 Distance between securing devices, measured along hatch cover periphery

When calculating the actual gross moment of inertia of the edge element, the effective breadth of the attached plating of the hatch cover, in m, is to be taken equal to the lesser of the following values:

- 0,165 a
- half the distance between the edge element and the adjacent primary member

4.2.4 The angle section or equivalent section bearing the rubber seal is to be of adequate size and well integrated with the cover edge element structure to ensure uniform sealing pressure all along the line of contact

5. Securing Arrangement for Hatch Covers carrying Deck Cargo

5.1 In addition to the recommendations given in 4, all hatch covers, especially those carrying deck cargo are to be effectively secured against horizontal shifting due to the horizontal forces arising from ship motions.

5.2 To prevent damage to hatch covers and ship structure, the location of stoppers is to be compatible with the relative movements between hatch covers and ship structure. The number should be as small as practically possible.

5.3 Considerations are to be given for assessment of cargo loads that towards the end of the ship vertical acceleration forces may exceed the gravity force. The resulting lifting forces must be considered when dimensioning the securing devices according to 4. Also lifting forces from cargo secured on the hatch cover during rolling are to be taken into account.

5.4 Hatch coamings and supporting structure are to be adequately stiffened to accommodate the loading from hatch covers.

5.5 At cross-joints of multi-panel covers vertical guides (male/female) are to be fitted to prevent excessive relative vertical deflections between loaded/unloaded panels.

5.6 In the absence of hatch cover lifting under loads arising from the ship's rolling motion, securing devices for non-weathertight hatch covers may be omitted. In such cases, it is to be proven by means of grillage and/or finite element analyses that an equilibrium condition is achieved using compression-only boundary elements for the vertical hatch cover supports. If securing devices are omitted, transverse cover guides are to be effective up to a height h_E above the hatch cover supports, where h_E must not be less than:

h_E = $1{,}75(2se + d^2)^{0.5} - 0{,}75d$ [mm]
$h_{E,min}$ = height of the cover edge plate +150 [mm]

where

e = largest distance from the inner edges of the transverse cover guides to the ends of the cover edge plate [mm]
s = total clearance within the transverse cover guide, with $10 \leq s \leq 40$ [mm]
d = distance between upper edge of transverse stopper and hatch cover supports [mm]

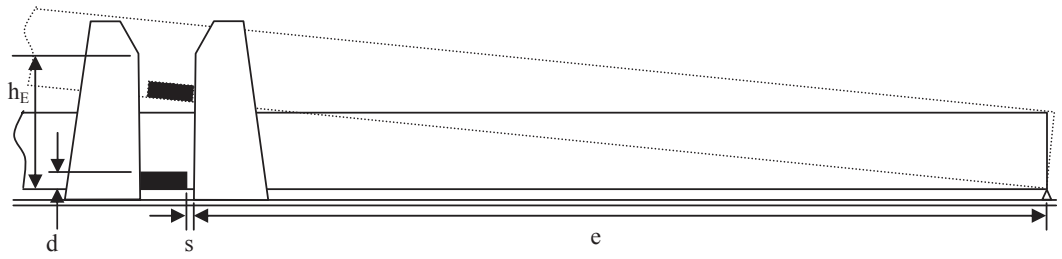


Fig. 2 Height of transverse cover guides

The transverse cover guides and their substructure are to be dimensioned in accordance with the transverse loads acting at a height h_E and an allowable stress defined by each Classification Society.

6. Tightness Testing of Weathertight Hatch Covers

6.1 Upon completion of installation of hatch covers, a chalk test is to be carried out.

6.2 This is to be followed by a hose test with a pressure of water not less than 200 kN/m^2.

The following may be assumed for guidance:

Nozzle diameter :	minimum 12 mm
Water pressure :	sufficient for a free height of water with the stream directed upwards of 10 meters maximum
Distance to structure :	maximum 1,5 meters

6.3 Alternative methods of tightness testing will be considered.

7. Operation Test

7.1 All hatch covers are to be operationally tested.

8. Operation and Maintenance

8.1 It is recommended that ships with steel hatch covers are supplied with an operation and maintenance manual including:

- Operating and closing instructions
- Maintenance requirements for packings, securing devices and operating items
- Cleaning instructions for the drainage system
- Corrosion prevention instructions
- List of spare parts.

BCS-G 16 Heading information for emergency steering position.

(SOLAS V, Amendments 2000, Regulation 19)

1. *All ships, irrespective of size, shall have a telephone, or other means to communicate heading information to the emergency steering position, if provided. (19, 2.1.9)*

1.1 If there is more than one emergency steering position, it shall be possible to receive heading information at each individual steering position.

1.2 Loud-speaker(s) of talk-back type, headphones or similar means shall be used to ensure hands-free reception of information at the emergency steering position.

2. *All ships of 500 gross tonnage and upwards shall have a gyro-compass heading repeater, or other means, to supply heading information visually at the emergency steering position, if provided. (19, 2.5.2)*

2.1 The gyro-compass repeater shall be positioned to be easily readable when reading the rudder angle on the rudder stock from emergency steering positions.

2.1.1 A gyro repeater with digital readout may be preferable for this purpose.

BCS-G 17 Guidelines for the Acceptance of Manufacturer's Quality Assurance Systems for Welding Consumables

1. General

1.1 Introduction

1.1.1 These guidelines supplement BCS-R W17 Approval of consumables for welding normal and higher strength hull structural steels and BCS-R W23 Approval of Welding Consumables for High Strength Steels for Welded Structures to facilitate a uniform procedure for the acceptance of manufacturer's quality assurance systems for welding consumables as an alternative to the annual procedures given in the above documents. Grades Y89 and Y96 are excluded from these guidelines.

Although the adoption of these guidelines is not mandatory, it is recommended that, in case BCS decides to implement them, all the clauses hereafter be fully complied with by the manufacturer, without exclusions.

1.1.2 By acceptance of the manufacturer's quality assurance system BCS delegates to the manufacturer the responsibility for checking that the necessary inspections and tests are carried out.

1.1.3 By acceptance of the manufacturer's quality assurance system BCS obliges the manufacturer to comply with the applicable requirements of BCS Rules.

1.1.4 BCS will check the effectiveness of the quality assurance system through verification of the Quality Management System (QMS).

1.2 Conditions

1.2.1 The conditions for the manufacturer to be granted the permission to carry out inspection and testing of welding consumables without the presence of a Surveyor are that:

- The manufacturer will implement a QMS according to a national or international standard certified by an accredited certification body or recognised by BCS.

- The QMS will be documented by the manufacturer, written hard copy or digitally. It should contain a statement that it has been approved and authorised for use by the company management. The latest version is be available to BCS upon request.

- The manufacturer will undertake to implement the QMS and provide personnel with the roles and responsibilities for implementing the QMS.

1.3 Scope

1.3.1 These guidelines and acceptance of any manufacturer's quality assurance system for welding consumables apply to maintenance of approvals already granted for welding consumables and auxiliary materials. Initial approval tests are to be carried out in accordance with BCS Rules and in the Surveyor's presence.

1.3.2 The acceptance of a manufacturer's quality assurance system applies only to the manufacturing works, for which it has been granted.

1.4 Definitions*

1.4.1 Quality: The degree to which a set of inherent characteristics of an object fulfils the requirement.

1.4.2 Quality Assurance (QA): Part of quality management focused on providing confidence that the quality requirements will be fulfilled.

1.4.3 Quality Management System (QMS): Part of the management system relating to quality.

1.4.4 Audit: Systematic independent and documented process for obtaining evidence and evaluating it objectively to determine the extent

1.4.5 External provider: A provider of products and/or services which is not part of an organisation (the manufacturer).

* These definitions are in substantial agreement with ISO 9000:2015.

1.5 Acceptance Procedure

1.5.1 Application for acceptance of a manufacturers' QA system for welding consumables is to be submitted to BCS in writing, attaching the documentation listed in Section 3. The works producing and packing the final product will be regarded as the manufacturer.

1.5.2 BCS will carry out an initial audit, checking the QA system for compliance with these guidelines and BCSRules.

1.5.3 The manufacturer will have to demonstrate that throughout the manufacturing process the QA system functions effectively and is capable of ensuring the quality required and of detecting nonconformity and initiating corrective and preventive actions.

1.5.4 The manufacturer will have to demonstrate that records will be kept on all QA measures, enabling BCS to check the efficiency of the QA system at any time and to verify whether the product meets its quality requirements.

1.5.5 Following successful audit of the works, BCS will issue a certificate of acceptance of the Quality Assurance System for Welding

Consumables. The manufacturer is obliged to advise BCS any essential modifications to either the manufacturing process or the QA system.

1.5.6 Approval by another organisation will not be accepted as sufficient evidence that arrangements for manufacture and quality comply with these requirements.

1.6 Period of Validity

1.6.1 The period of validity of an acceptance in accordance with the these guidelines is a maximum of 5 years, provided that during this period approved welding consumables and/or auxiliary materials are manufactured without any major interruptions, the quality of which is checked by manufacturing quality controls and the effectiveness of the QA system is controlled by periodic quality audits.

1.6.2 Prior to expiry of the period of validity, it is the manufacturer's responsibility to apply for renewal.

1.6.3 BCS may withdraw the acceptance, if the conditions under which it was granted no longer apply or if any major nonconformities are found in either the QA system
or the product concerned.

2. Requirements

2.1 Organisation and Personnel

2.1.1 Within the plant the quality assurance function is to be independent of the production departments. The person placed in charge of the department is be directly responsible to the company management and have the authority necessary to enable planning of all the requisite QA functions and to implement them effectively.

2.1.2 Personnel responsible for planning and implementing QA functions are to demonstrate competency for the function through suitable qualifications and experience. The professional qualifications and experience of personnel are to be documented and available upon request.

2.1.3 Manufacturers shall prepare an organisation chart which clearly describes and defines the areas of responsibility and activity of each individual. Any change in the personnel occupying responsible positions or changes in areas of responsibility and activity are to be brought to the attention of BCS.

2.2 Quality Planning

2.2.1 The requirements of subsequent sections are to be documented by the manufacturer to ensure the quality assurance of welding consumables.

2.2.2 The manufacturer’s quality assurance system for welding consumables is to specify the following quality assurance requirements:

a) Compliance with BCS Rules and any additional applicable standards or specifications;

b) Early identification of existing (and potential) nonconformity;

c) Customer requirements;

d) Effective corrective and preventative actions.

e) Maintenance and calibration of equipment which determines or influences quality.

2.3 Measuring and Testing Equipment

2.3.1 The manufacturer is to provide the measuring and testing appliances and equipment needed for the proper and competent performance of the controls and tests as required by the quality assurance system.

2.3.2 All measuring and testing equipment which determines or influences quality are to be regularly and competently maintained and are to be adjusted or calibrated in accordance with a recognised national standard. These operations shall be performed by competent persons appointed for that purpose.

2.3.3 The planning of maintenance and calibration activities, the persons responsible and the relevant records form part of the schedule under Section 2.2 and the associated documentation and shall be made available to BCS upon request
.

2.4 Corrective and Preventive Actions

2.4.1 Manufacturers are required to devise and regularly implement methods of detecting and correcting and preventing any factors in the production process and in quality assurance which are detrimental to quality. With this in view, nonconformities detected and the improvements needed as well as the quality audits specified in Section 5 are to be subjected to constant analysis and evaluation. The causes of the faults are to be ascertained and effective measures applied to improve quality.

2.5 Documentation

2.5.1 The manufacturer is to keep suitable records of all QA functions, inspections and test results. The records should give details of the nature and extent of the nonconformities, of improvements and retests, where applicable, and should indicate any corrective and preventive actions needed.

2.5.2 The records (test reports, inspection reports, customer feedback, etc) are to be made available to BCS on request, Additional records may be requested by BCS . All records including control of changes (e.g. version control) shall be kept by the works for at least five years.

3. Documents

3.1 The manufacturer is to compile the following documentation in the QMS:

a) Principles and scope of the system in accordance with Sections 1.1, and 1.3;

b) Description of the works production and testing facilities and methods;

c) Details of any computer facilities and the systems using those facilities for production and quality control;

d) Organisation of the works and the Quality Assurance Department in accordance with Section 2.1;

e) Description of quality assurance functions and procedures in accordance with Sections 2.2 to 2.5 and 4;

f) Details of systems and methods used to maintain a satisfactory standard of finished products which comply with the Rule requirements. This information is to be presented in the form of a flow chart indicating all stages where testing and inspection are carried out;

g) Work and inspection instructions in accordance with Sections 3.1 and 4;

h) Procedures for the handling of non-conforming products, see Section 4.6;

i) Corrective and preventive procedures in accordance with Section 2.4;

j) Procedures for authorisation and recording of concessions;

k) Instructions for the compilation and evaluation of the documentation described in Section 2.5;

l) Instructions for the performance and evaluation of quality audits in accordance with Section 5.1.

3.2 Work and Inspection Instructions

3.2.1 For the performance of quality assurance functions manufacturers shall compile and maintain documented work and inspection instructions which relate to the successive stages of manufacture and inspection.

3.2.2 The work instructions are to specify the sequence and interrelationship of the various QA functions and are to state who is responsible for carrying them out.

3.2.3 Instructions for the inspection of consumables should include the scope, method and equipment used and are to specify the acceptance criteria of in-process materials and final products.

3.2.4 Manufacturers shall ensure that the latest versions of work and inspection instructions are made available to all sections and individuals responsible for carrying out QA functions, and manufacturers shall verify that these are complied with.

3.3 Standards and Manufacturers' Specifications

3.3.1 The performance and assessment of QA measures may also be based on generally accepted rules of technology, such as standards, and on manufacturers' specifications (data sheets). These documents shall be listed in the QMS and/or instructions for testing or attached to these and incorporated into the acceptance procedure (Section 1.5).

4. Quality Controls

4.1 External Providers

4.1.1 Raw materials, rather than finished products, may be supplied by external providers.

4.1.2 Services such as maintenance, calibration, etc. may be supplied by external providers.

4.1.3 The manufacturer is to ensure that there are sufficient controls from external providers to ensure compliance with BCS Rule requirements and/or any additional applicable standard, specification or customer requirement.

4.1.4 The manufacturer will evaluate and monitor the performance of external providers to ensure compliance is maintained. It shall retain documented evidence of these activities.

4.2 Manufacturing Control

4.2.1 During manufacture, the manufacturer is to carry out appropriate checks ensuring the suitability of the process, quality of the intermediate product and timely initiation of any corrective and preventive measures required.

4.2.2 Production controls are to be carried out in accordance with a fixed plan and all (including negative) results obtained are to be recorded and made available for review by BCS upon request. Depending on the kind of product concerned, the controls are to include the checking of surfaces, drying, marking, and dimensions, as well as concentricity.

4.2.3 A relevant note printed on the packaging, such as a batch number, is to provide traceability of the materials used, the process of manufacture and the inspection and tests performed.

4.3 Identification and Marking

4.3.1 Manufacturers shall establish, apply and supervise a marking system enabling intermediate products to be identified at any stage of manufacture without any confusion.

4.3.2 The system is to be checked, i.e. the materials being manufactured are to be identified in accordance with a fixed plan. Relevant documents shall be prepared on the performance of these checks.

4.4 Final Inspection and Testing

4.4.1 The manufacturer should implement a system of inspecting and testing of the final products so that only welding consumables and auxiliary materials conforming to rule requirements or any additional applicable standard, specification or customer requirement are packed and delivered. The system should include regular weldability checks.

4.5 Weld Assemblies and Testing of the Mechanical Properties

4.5.1 At least once per year, from the date of approval, the manufacturer shall make welded assemblies and perform required tests of all approved welding consumables to ensure compliance with the annual test requirements of BCS-R W17 and BCS-R W23.

4.5.2 All test results, including unsatisfactory results, are to be reported to BCS before or during the audit as per section 5.2. Any corrective and preventive actions as a result of unsatisfactory tests are to be included.

4.6 Non-conforming Materials and Products

4.6.1 The manufacturer is to establish a procedure for the detection and subsequent rectification of non-conforming materials and products. This procedure is to include the prompt detection and withdrawal of non-conforming material and product, the corrective and preventive actions required, and the necessary retesting required.

4.6.2 The manufacturer is to ensure that the use of non-conforming materials and products is prevented.

4.6.3 Records are to be kept covering the nature and extent of non-conforming materials and products, the subsequent treatment and, where applicable, retests and any corrective and preventive measures which may be introduced. These records are to be compiled and evaluated in such a way as to enable conclusions to be drawn regarding the current quality level and hence the effectiveness of the QA system for welding consumables.

5. Quality Audits

5.1 Internal Quality Audits

5.1.1 During the period of validity of approval of a works QA system of welding consumables, systematic checks (quality audits) are to be carried out by the manufacturer at regular intervals on the whole, or parts of, the system. The audit scope and schedule are to be documented by the manufacturer and approved by BCS. The audits are to be performed by competent personnel and who are not employed in, or responsible for, the areas of activity concerned.

5.1.2 Quality audits are to include verification that:

a) Manufacture and quality assurance are being carried out in accordance with documented procedures;

b) Manufacture, inspection and monitoring equipment is in good working order and is properly calibrated;

c) Non-conformance in manufacture are detected without fail and the necessary steps are taken to overcome them and retest;

d) The necessary care is being taken to identify and eliminate the causes of non-conformances;

e) The documentation is complete and provides a reliable history of all QA functions and their effectiveness.

5.1.3 Records are to be kept of all quality audits. These records are to contain full details of the checks carried out on the whole, or parts of, the QA system including the results obtained and any corrective measures introduced. On request, these records together with the relevant documents are to be presented to the Surveyor.

5.2 Quality Audits by BCS

5.2.1 In addition to the internal audit required by paragraph 1.5.2 quality audits will be made by BCS as follows:

a) Upon expiry of the period of validity (see 1.5.1) a renewal audit is to be made;

b) Intermediate audits are to be made at intervals not exceeding 1 (one) year;

c) Spot checks are to be made, sufficient in frequency and character to satisfy the Surveyors that the originally established procedures are being maintained.

5.2.2 A renewal audit includes checks that throughout the manufacturing process the quality assurance system functions effectively and is capable of assuring the quality required and detecting non-conformity and initiating corrective and preventive actions.

5.2.3 An intermediate audit includes the items as 5.2.2 but it will cover less detail of the manufacturer’s quality assurance system.

5.2.4 A spot check is a random check throughout the approval period covering specific aspects of the quality assurance system. (For example, during other visits by a surveyor, as a follow up to checking non-conformity of the quality assurance system discovered during renewal/intermediate audits).

5.2.5 The results of all audits and spot checks are to be documented and retained for the approval period.

5.2.6 For this purpose the Surveyor of BCS shall be given access to the manufacturing plant and to the manufacturing documents and records. The works shall also provide the Surveyor with reasonable human and material assistance e (e.g. services, premises and instruments) to enable the duties to be carried out.

5.3 Management review of QA System

5.3.1 The manufacturer's management shall review the accepted quality assurance system at planned intervals to ensure its continued suitability and effectiveness. Records of the review are to be maintained.

5.3.2 Each review is to include an assessment of the internal quality audits (see 5.1).

BCS-G18 Fire Prevention in Machinery Spaces of Ships in Service – Guidance to Owners

1. Introduction

1.1 Based on past experience it is known that the combination of combustible materials and sources of ignition are the main cause of machinery space fires. The combustible material involved is in the majority of cases oil, i.e. fuel oil, lubricating oil, thermal oil or hydraulic oil. However, plastic materials in electrical installations may also be combustible material causing outbreak of fires.

1.2 There is a large variety of potential ignition sources and the most common are hot surfaces, e.g. exhaust pipes and steam pipes, over-heating of machinery or ignition from electrical installations due to short circuiting or sparks caused by operation of switchgear. Other frequent ignition sources are those associated with human activities, e.g. smoking, welding and grinding.

1.3 The experiences of classification societies confirm the importance of machinery space fire prevention and the reports of survey - class surveys as well as Passenger Ship Safety Surveys and Cargo Ship Safety Equipment Surveys - contain frequent references to lack of maintenance of fire safety of machinery spaces.

1.4 Where there is any doubt in applying this Guideline, clarification should be obtained from BCS. Attention is directed to the separate published Rules of each. This Guideline is not meant as a substitute for the society's Rules or the independent judgement and experience of Owners and Surveyors.

2. Contributing Factors to Machinery Space Fires

2.1 Failures resulting from the daily use of machinery space installations, such as e.g. oil leakages, breakage of flexible pipes.

2.2 Lack of adequate cleanliness adds to the fire hazard in two ways.

a) In the first place the probability of occurrence of fire, in particular due to ignition caused by human activities is increased because of the widespread presence of the combustible material in the form of oil spill/oily deposits.

b) Secondly, an unclean machinery space may cause a small fire to spread, e.g. a fire in an electrical switchboard or panel may develop into a full machinery space fire due to the presence of oil spills/oily deposits.

3. Measures to Reduce the Fire Risk

3.1 The classification requirements for the construction and inspection of machinery spaces cannot, alone, ensure the fire safety at all times; the effort of all parties concerned is necessary.

3.2 The Shipowners and their crews should apply a programme of maintenance and housekeeping.

3.3 Where leakage of flammable liquids occurs during normal service or routine maintenance work, special arrangement and early clean-up should be made by the crew to

prevent these fluids from reaching other parts of the machinery where danger of ignition may arise.

4. What is BCS Doing?

4.1 At the occasion of the class periodical surveys a machinery and electrical plant survey is carried out as prescribed in the Chapter I, regulations 7 and 10 of the International Convention for the Safety of Life at Sea, 1974, as amended.

4.2 The periodical surveys should mainly ensure that the standard to which the installation was originally built is maintained.

4.3 The Surveyor can only assess the actual condition of the machinery space fittings at the time of survey. In between two inspections the proper maintenance must remain the owner's responsibility.

4.4 Reference document: BCS-R F35, BCS-G 58 and MSC.1/Circ.1321.

5. Defects to Machinery Space Installations

5.1 This part deals with various types of defects found in machinery spaces, which for the most part are caused by a lack of proper maintenance or by improper operation.

5.2 Shielding of high pressure fuel oil pipes

Typical defects found may be of the following nature:

- Partially lacking or damaged shielding.
- Loose or defective end attachments of shielding.
- Flexible pipes used for shielding fitted in such a way that contact between high pressure fuel pipe and flexible pipe causes wear damage.
- Defective drainage arrangements.

5.3 Insulation of Exhaust Pipes, Thermal Oil Pipes and Steam Pipes. Commonly found defects are:

- Partially lacking insulation, typically in way of flanges or at locations where removal of insulation is necessary for maintenance.
- Oil soaked insulation due to damage or the lack of steel sheeting.

  The standard of insulation and protection against oil penetration into the insulation is an area where the general standard has improved over the years. In earlier days it was not uncommon for flanges to be left uninsulated and that metal sheeting of the insulation was incomplete. In cases where incomplete insulation or unsheeted insulation is found in locations where oil leakages may occur, the owner and operating personnel should make improvements regardless of the original standard.

5.4 Shielding of electrical equipment against oil and water leakages

Oil leakages into electrical equipment may be ignited due to sparks normally generated by operation of switchgear (fine oil spray is probably most susceptible to ignition). Water leakages may cause short circuiting and ignition of insulation or other material of plastic type. The owner and operating personnel should in particular look for signs of leaking flanges, deterioration of pipes and leakages from other machinery which may come into contact with subject electrical equipment.

6. Crew's and Owner's Duties with Respect to Machinery Space Installations

6.1 Attention should be directed at the condition of flexible pipes used in oil systems, e.g. in connection with hydraulic power arrangements, flexible pipes are used to prevent harmful vibrations and noise. High pressures in combination with pulsations may cause breakage of the flexible pipes, particularly in way of end attachments.

6.2 Also, flexible pipes for connecting fuel oil supply to oil burners are extensively used. Any signs of deteriorating conditions being revealed, should be replaced or at least temporarily repaired.

6.3 Broken or loose fastenings of oil pipes should be repaired because they may result in future damage.

6.4 It is Owner's responsibility to ensure that the machinery space is maintained in a clean condition.

A cleanliness level is not acceptable in cases where floor plates are slippery from extensive oil spills, or oil is seeping from machinery, or if painted surfaces have an oil layer, or when a fire hazard exists due, for instance, to accumulation of rags or other similar materials or presence of oil on bilge water surface.

BCS- G 34 Standard Wave Data

1. This recommendation is valid for ships carrying goods at sea, excluding vessels that operate at a fixed location (for example FPSO s), specifically aiming at ships as covered by BCS- R S11, and focusing on extreme wave loads.

2. Wave data as described by the scatter diagram given in TABLE 1, describe the wave data of the North Atlantic as defined in FIGURE 1, covering areas 8,9,15 and 16, as defined in Global Wave Statistics/1/ with changes according to /2/.

3. When calculating design wave bending moments, it is recommended to use a return period of at least 20 years, corresponding to about 10^{-8} probability of exceedance per cycle.

4. When calculating the pressure head from green seas on horizontal deck plates and hatch covers, the relative motion in the undisturbed wave at the centre line for the considered area, at a return period of 20 years, can be applied as a first approximation.

5. Combination of loads should be performed, preferably using simultaneous values, to ensure application of the design loads at a consistent probability level.

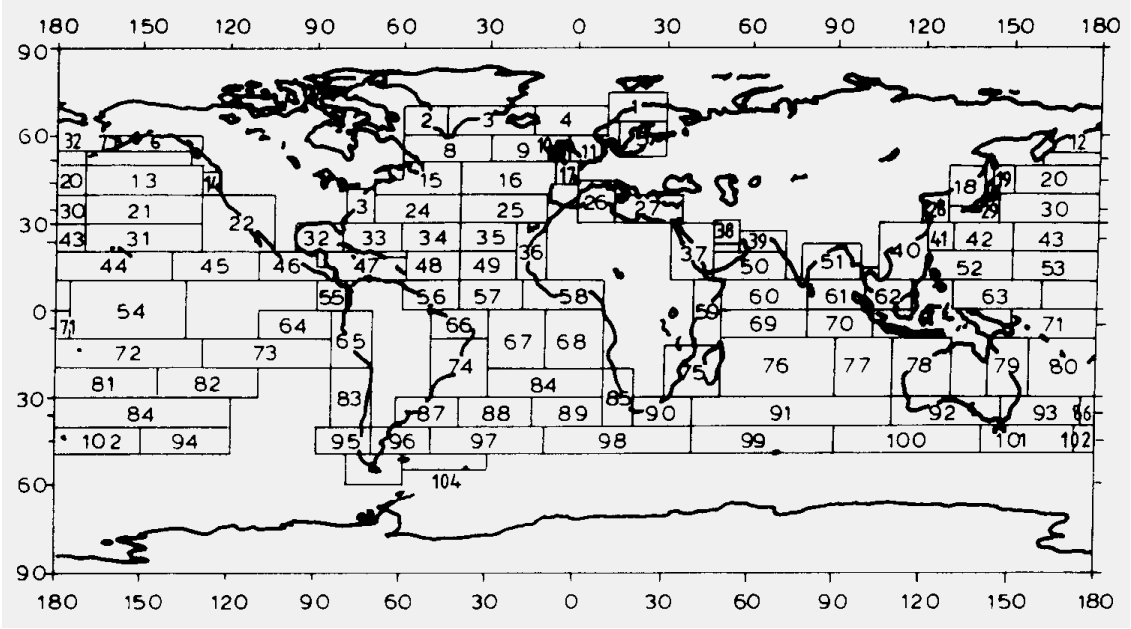


Figure 1 Definition of the extent of the North Atlantic

Table 1, Probability of sea-states in the North Atlantic described as occurrence per 100000 observations.
Derived from BMT's Global Wave Statistics

Hs/Tz	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	SUM
0.5	0.0	0.0	1.3	133.7	865.6	1186.0	634.2	186.3	36.9	5.6	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3050
1.5	0.0	0.0	0.0	29.3	986.0	4976.0	7738.0	5569.7	2375.7	703.5	160.7	30.5	5.1	0.8	0.1	0.0	0.0	0.0	22575
2.5	0.0	0.0	0.0	2.2	197.5	2158.8	6230.0	7449.5	4860.4	2066.0	644.5	160.2	33.7	6.3	1.1	0.2	0.0	0.0	23810
3.5	0.0	0.0	0.0	0.2	34.9	695.5	3226.5	5675.0	5099.1	2838.0	1114.1	337.7	84.3	18.2	3.5	0.6	0.1	0.0	19128
4.5	0.0	0.0	0.0	0.0	6.0	196.1	1354.3	3288.5	3857.5	2685.5	1275.2	455.1	130.9	31.9	6.9	1.3	0.2	0.0	13289
5.5	0.0	0.0	0.0	0.0	1.0	51.0	498.4	1602.9	2372.7	2008.3	1126.0	463.6	150.9	41.0	9.7	2.1	0.4	0.1	8328
6.5	0.0	0.0	0.0	0.0	0.2	12.6	167.0	690.3	1257.9	1268.6	825.9	386.8	140.8	42.2	10.9	2.5	0.5	0.1	4806
7.5	0.0	0.0	0.0	0.0	0.0	3.0	52.1	270.1	594.4	703.2	524.9	276.7	111.7	36.7	10.2	2.5	0.6	0.1	2586
8.5	0.0	0.0	0.0	0.0	0.0	0.7	15.4	97.9	255.9	350.6	296.9	174.6	77.6	27.7	8.4	2.2	0.5	0.1	1309
9.5	0.0	0.0	0.0	0.0	0.0	0.2	4.3	33.2	101.9	159.9	152.2	99.2	48.3	18.7	6.1	1.7	0.4	0.1	626
10.5	0.0	0.0	0.0	0.0	0.0	0.0	1.2	10.7	37.9	67.5	71.7	51.5	27.3	11.4	4.0	1.2	0.3	0.1	285
11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.3	13.3	26.6	31.4	24.7	14.2	6.4	2.4	0.7	0.2	0.1	124
12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	4.4	9.9	12.8	11.0	6.8	3.3	1.3	0.4	0.1	0.0	51
13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.4	3.5	5.0	4.6	3.1	1.6	0.7	0.2	0.1	0.0	21
14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.2	1.8	1.8	1.3	0.7	0.3	0.1	0.0	0.0	8
15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.7	0.5	0.3	0.1	0.1	0.0	0.0	3
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	1
SUM:	0	0	1	165	2091	9280	19922	24879	20870	12898	6245	2479	837	247	66	16	3	1	100000

The Hs and Tz values are class midpoints.

6. For evaluation of extreme global bending moments it is recommended to use zero speed, provided the vessel does not have a service restriction, in which case the limitation should be checked as well. The effect of forward speed (2/3 of design speed) is recommended to be checked, especially for local dynamic pressures.

7. The Bretschneider or two parameter Pierson-Moskowitz spectrum is recommended for the North Atlantic, described by the following expression:

$$S(\omega) = \frac{H_s^2}{4\pi}\left(\frac{2\pi}{\mathrm{T_z}}\right)^4 \omega^{-5} \exp\left(-\frac{1}{\pi}\left(\frac{2\pi}{\mathrm{T_z}}\right)^4 \omega^{-4}\right)$$

where:

H_s = The significant wave height (m)

ω = Angular wave frequency (rad/s)

$\mathrm{T_z}$ = The average zero up - crossing wave period (s)

$$\mathrm{T_z} = 2\pi\left(\frac{m_0}{m_2}\right)^{\frac{1}{2}}$$

The spectral moments of order n of the response process for a given heading may be described as

$$m_n = \int_{\omega} \sum_{\theta_0 - 90^\circ}^{\theta_0 + 90^\circ} f_s(\theta)\omega^n \cdot S\left(\omega / \mathrm{H_s}, T_z, \theta\right) d\omega$$

using a spreading function usually defined as $f_s(\theta) = k\cos^2(\theta)$

where k is selected such that:

$$\sum_{\theta_0 - 90^\circ}^{\theta_0 + 90^\circ} f_s(\theta) = 1,$$

where

θ_o = main wave heading

θ = relative spreading around the main wave heading

8. In long term calculations, all wave headings (0-360°) can be assumed to have an equal probability of occurrence and at most 30° spacing between headings should be applied.

9. When calculating vertical bending moments (Sag and Hog) proper corrections for non-linear effects are to be applied.

10. The dynamic sea pressure can be derived above the mean waterline (WL) based on linear calculation methods by a reduction of 1-one meter pressure head per meter distance from the mean WL using a dynamic sea pressure at a return period of 20 years, corresponding to about 10^{-8} probability per cycle. In case dynamic sea pressures at 10^{-4} probability per cycle are applied, a reduction of 1/2-half meter pressure head per meter distance above the mean WL should apply to ensure dynamic sea pressures at sufficient height above the mean WL.

11. When calculating design sea pressures at ship ends, due consideration should be taken to the occurrence of non-linearity s such as slamming on the bottom and non-vertical ship sides.

References

/1/ British Marine Tec hnology (Primary contributors Hogben N., Da Cunha, L.F. and Oliver, H.N.). “Global Wave Statistics”, Unwin Brothers Limited, London 1986.

/2/ Bitner-Gregersen, E.M., Cramer, E.H., Korbijin, F., “Environmental Description for Long-term Load Response of Ship Structures”, ISOPE June 1995, The Hague, The Netherlands.

BCS-G 35 Inspection and Maintenance of Electrical Equipment Installed in Hazardous Areas for Ships other than Tankers

1 Introduction

Electrical installations in hazardous areas possess features specially designed to render them suitable for operation in such atmospheres. It is essential for reasons of safety in those areas that, throughout the life of such installations, the integrity of those special features is preserved; they therefore require INITIAL inspection and either:

.1 regular **PERIODIC INSPECTIONS** thereafter or

.2 continuous supervision by skilled personnel and when necessary, maintenance.

It is recommended that the periodic inspection and maintenance of electrical equipment in hazardous areas be performed in accordance with the guidelines contained in the standard IEC 60079-17:2013 by means of **DETAILED INSPECTIONS**, **VISUAL INSPECTIONS** and **CLOSE INSPECTIONS**, whose periodicity is given below.

IEC 60079-17:2013*: Inspection and Maintenance of Electric Installations in Hazardous Areas (other than mines)*, should be regarded as a guide for owners (or their representatives), builders and Surveyors. It covers factors directly related to the inspection and maintenance of the electrical equipment comprising certified safe type electrical apparatuses, installed within hazardous areas. Application of this standard, either totally or in part, is the responsibility of builders regarding new installation and of owners (or their representatives) for equipment maintenance. This standard does not include conventional requirements for electrical nor for testing or certification purposes.

Note:

Correct functional operation of hazardous areas installations does not mean, and should not be interpreted as meaning that the integrity of the special features referred to above is preserved.

2. Periodicity of inspections

DETAILED INSPECTIONS, as defined in IEC 60079-17:2013, should at least be carried out on all the electrical apparatus and installations before they are brought into service, e.g. during new construction surveys or when modifications and/or repairs are made.

VISUAL INSPECTIONS, as defined in IEC 60079-17:2013, should at least be carried out during annual surveys.

CLOSE INSPECTIONS, as defined in IEC 60079-17:2013, should at least be carried out at special and intermediate surveys and should cover inspection of relevant electrical equipment installed in hazardous areas.

BCS-G36 Recommended procedure for the determination of contents of metals and other contaminants in stern tube lubricating oil

1. General

As provided by paragraph 1.2.14 of BCS-R Z21, a lubricating oil analysis should be carried out at the required intervals.

The documentation on lubricating oil analysis is to be available on board. Each analysis, to be performed by an appropriate method, should include the minimum parameters as listed:

- water contents, refer Section 4
- chloride contents, refer Section 4
- contents of bearing metal particles, refer Section 4 and 6
- oil ageing (resistance to oxidation), refer Section 5

2. Sampling procedure

Oil samples should be taken under service conditions, i.e. with a rotating shaft and the system at service temperature.

The samples are to be drawn from the same agreed position in the system which should be positively identified.

These samples, unless supervised by a Surveyor, are to be collected and identified by the Chief Engineer.

3. Contaminants determination

The contents of the following metals should be determined:

- in connection with contents of wear metals:

  Chromium
  Copper
  Iron
  Lead
  Nickel
  Silicon
  Tin

- in connection with contents of sea water:

  Magnesium
  Sodium

4. Metal and water content values

The metal and water content values should be considered taking into account the type of seals used and the chemical composition of the bearing material.

Suggested upper limits are given below for guidance only:

Water	1%	Nickel	10 ppm
Chromium	10 ppm	Silicon	40 ppm
Copper	50 ppm	Tin	10 ppm
Iron	30 ppm	Magnesium	30 ppm
Lead	10 ppm	Sodium	80 ppm
Chloride content in water	70 ppm (ingress of salt water)		

These limits should be considered versus the elapsed time.

It is important to have results of a number of sequential analyses in order to observe any trends taking place.

5. Oil ageing

Oxidation characteristics such as Total Acid Number (TAN), viscosity and oil appearance depend upon the type of oil used. Hence no recommended value is listed. Instead observation of any trends (such as viscosity and change in colour etc.) based on sequential analysis should be made. TAN is adversely influenced by oxidation for most typical oil lubricant types and also by hydrolysis in the case of unsaturated Environmentally Acceptable Lubricants (EALs). Observation of any trends on TAN should be made based on sequential analysis in conjunction with the limits defined by the oil maker for continued use in service.

6. Other analysis

Microscopic analysis of the particles may be recommended to identify the failure process and, where applicable, non-metallic bearing or seal material.

BCS- G39 Safe Use Of Rafts Or Boats For Survey

1. Access to Structures

1.1 For overall survey, means shall be provided to enable the attending surveyor(s) to examine the structure in a safe and practical way.

1.2 For close-up survey, one or more of the following means for access, acceptable to the attending surveyor(s), shall be provided:

a) permanent staging and passages through structures

b) temporary staging and passages through structures

c) lifts and moveable platforms

d) rafts or boats

e) other equivalent means.

1.3 Surveys of tanks or spaces by means of rafts or boats may only be undertaken with the agreement of the attending surveyor(s), who shall take into account the safety arrangements provided, including weather forecasting and ship response in reasonable sea conditions.

1.4 When rafts or boats will be used for close-up survey the following conditions shall be observed:

a) Only rough duty, inflatable rafts or boats, having satisfactory residual buoyancy and stability even if one chamber is ruptured, shall be used;

b) The boat or raft shall be tethered to the access ladder and an additional person shall be stationed down the access ladder with a clear view of the boat or raft;

c) Appropriate lifejackets shall be available for all participants;

d) The surface of water in the tank shall be calm (under all foreseeable conditions the expected rise of water within the tank shall not exceed 0.25 m) and the water level stationary. On no account shall the level of the water be rising while the boat or raft is in use;

e) The tank or space must contain clean ballast water only.

When a thin sheen of oil on the water is observed, further testing of the atmosphere is to be done to ensure that the tank or space is safe for entering;

Further reference is made to BCS- G 72 “Confined Space Safe Practice”.

f) At no time shall the upside of the boat or raft be allowed to be within 1 m of the deepest under deck web face flat so that the survey team is not isolated from a direct escape route to the tank hatch. Filling to levels above the deck transverses shall only be contemplated if a deck access manhole is fitted and open in the bay being examined, so that an escape route for the survey party is available at all times;

g) If the tanks (or spaces) are connected by a common venting system, or inert gas system, the tank in which the boat or raft is to be used shall be isolated to prevent a transfer of gas from other tanks (or spaces).

1.5 In addition to the above, rafts or boats alone may be allowed for close-up survey of the under deck areas for tanks or spaces if the depth of the webs are 1.5 m or less. If the depth of the webs is more than 1.5 m, rafts or boats alone may be allowed only.

a) When the coating of the under deck structure is in GOOD condition and there is no evidence of wastage; or

b) If a permanent means of access is provided in each bay to allow safe entry and exit. This means:

i. access direct from the deck via a vertical ladder and a small platform fitted approximately 2 m below the deck in each bay; or

ii. access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform shall, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water level is to be assumed not more than 3m from the deck plate measured at the midspan of deck transverses and in the middle length of the tank. (See Figure 1).

If neither of the above conditions are met, then staging or an “other equivalent means” is to be provided for the survey of the under deck areas.

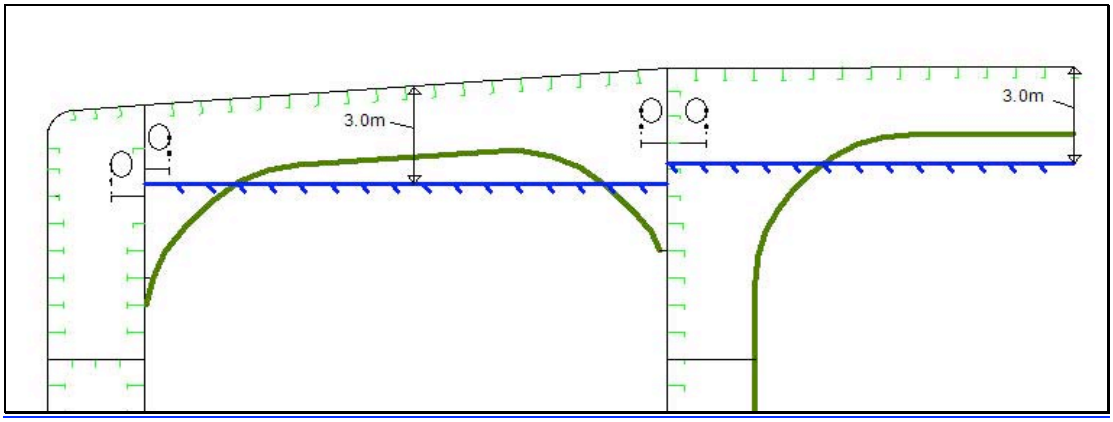


Figure 1

Note: Item 1.5 is a mandatory requirement (BCS-R Z10

s). **2.0 Safety Meetings**

2.1 The establishment of proper preparation and the close co-operation between the attending surveyor(s) and the company’s representatives onboard prior to and during the survey are an essential part in the safe and efficient conduct of the survey.

2.2 Applicable safety procedures and responsibilities shall be discussed and agreed to ensure that the survey is carried out under controlled conditions.

Safety Meetings shall be held prior to entering the tank or space and regularly during the survey on board.

Further reference is made to BCS- G 72 Confined Space Safe Practice.

3.0 Communication Arrangements and Equipment for Survey

3.1 The attending surveyor(s) shall always be accompanied by at least one responsible person assigned by the company experienced in tank and enclosed spaces inspection. In addition a backup team of at least two experienced persons shall be stationed at the hatch opening of the tank or space that is being surveyed. The back-up team shall continuously observe the work in the tank or space and shall keep lifesaving and evacuation equipment ready for use.

3.2 A communication system shall be arranged between the survey party in the tank or space being examined, the responsible officer on deck, the navigation bridge and the personnel in charge of handling the ballast pump(s) in the pump control room. These communication arrangements shall be maintained throughout the survey.

3.3 Adequate and safe lighting shall be provided for the safe and efficient conduct of the survey.

3.4 Adequate protective clothing shall be made available and used (e.g. safety helmet, gloves, safety shoes, etc) during the survey.

BCS-G 40 Survey Guidelines - Emergency Towing Arrangements

Initial Installation

Fixed gear such as strong points, fairleads, foundations and associated vessel supporting structure are to be demonstrated as adequate for the loads imposed by means of a submitted engineering analysis or calculations. If such analysis is deemed not appropriate depending on structural configuration, proof test may be required.

Articles of loose gear such as chains, towing pennants and associated end fittings, and shackles or other connecting links should be tested to the requirements of the Classification Society concerned.

Note: Where a manufacturer requests a certificate of type approval for a complete packaged towing arrangement, one assembled unit to undergo prototype test to 2 x SWL. Where certificate of type approval is not requested, the deployment test will serve as the prototype test.

General

1. Components and supporting structure were examined and found to be installed in accordance with approved drawings (1.1)

Forward Installation

* Existing tankers fitted with the emergency towing arrangements in accordance with Resolution A.535 (13) may retain existing towing arrangements at forward location. (1.3)
* Pick-up gear and towing pennant are optional at forward location. (2.2)
* Forward emergency towing arrangements which comply with the requirements for aft emergency towing may be acceptable. (3.1.5)

2. Strongpoint
   a) Strongpoint meets strength requirement. (2.3)
   b) Welds between strongpoint and supporting structure were examined by NDE. (2.3)

3. Fairlead
   a) Fairlead meets strength requirement. (2.3)
   b) Fairlead's location and opening is sufficient for passage as well as support of components. (2.7)

4. Chafing Gear
   a) Chafing gear meets strength requirement. (2.3)
   b) If chain, it is stud link and long enough to extend at least 3m beyond the fairlead. (2.8.1, 2.8.2)
   c) One end is suitable for connection to the strongpoint and the other end fitted with a standard pear-shaped open link and shackle. (2.8.3)
   d) Chafing gear is to secure to the strongpoint.

Note: Paragraph numbers of IMO Guidelines for Emergency Towing Arangements on Tankers (Resolution MSC.35 (63), adopted on 20 May 1994) are referred to in the parentheses.

5. Pedestal Roller

    a) A suitably positioned pedestal roller is fitted to facilitate connection of the towing pennant to the chafing gear. (3.1.4)

6. Deployment
    a) The forward emergency towing arrangement was tested after installation and proven capable of being deployed in harbour conditions in not more than 1 hour in the absence of main power on the ship. (2.1, 3.1.3)

Note: Deployment time should commence when crew takes the first action to deploy and should conclude when the towing connection is made fast on the towing vessel and the towing vessel is capable of taking a strain on the towing pennant.

Where an emergency towing arrangement has undergone deployment test, consideration may be given to waiving the deployment tests on similar vessels provided there are no design changes significantly deviating from the original tested arrangement.

Aft Installation

7. Strongpoint
    a) Strongpoint meets strength requirement. (2.3)
    b) Welds between strongpoint and supporting structure were examined by NDE. (2.3)

8. Fairlead
    a) Fairlead meets strength requirement. (2.3)
    b) Fairlead's location and opening is sufficient for passage as well as support of components. (2.7)

9. Chafing Gear
    * Requirement for chafing gear aft is dependent on design. (2.2)
    a) Chafing gear meets strength requirement. (2.3)
    b) If chain, it is stud link and long enough to extend at least 3m beyond the fairlead. (2.8.1, 2.8.2)
    c) One end is suitable for connection to the strongpoint and the other end fitted with a standard pear-shaped open link and shackle. (2.8.3)
    d) Chafing gear is secured to the strongpoint. (2.8.4, *3.1.1*)

10. Pedestal Roller
    * Requirement for pedestal roller aft is dependent on design. (2.2)
    a) A suitably positioned pedestal roller is fitted to facilitate connection of the towing pennant to the chafing gear. (3.1.4)

11. Towing Pennant
    a) The towing pennant meets strength requirement and has a certificate of test for 2 x SWL. (2.3)
    b) The length is at least twice the lightest seagoing ballast freeboard at the fairlead plus 50 meters, but not less than 100 meters. (2.4)
    c) The pennant has a hard-eye formed termination allowing connection to a standard bow shackle. (2.9)

12. Pick-up Gear
    a) A suitable pick-up gear and marker buoy is provided. (3.1.2)

13. Deployment
    a) The aft emergency towing arrangement was tested after installation and proven to be capable of being deployed in harbour conditions in not more than 15 minutes in the absence of main power on the ship. (2.1, 3.1.1) Note: Refer to Item 6 for Note on Deployment Test.

AT MANDATORY ANNUAL SURVEY OF SAFETY CONSTRUCTION CERTIFICATE:

Examination of the Emergency Towing Arrangements as far as practicable. Aft towing arrangement confirmed as pre-rigged and forward chafing gear confirmed as secured to strongpoint. Where light is provided on pick-up gear marker buoy, proper functioning confirmed.

AT RENEWAL/PERIODICAL SURVEY OF SAFETY CONSTRUCTION CERTIFICATE:

The emergency towing arrangements examined and confirmed as readily available with aft towing arrangement pre-rigged and forward chafing gear confirmed as secured to strongpoint. The pick-up gear, towing pennant, chaffing gear examined over full length for deterioration. Where pennant line is stored in a water tight condition and can be confirmed as maintained, consideration may be given to waiving the requirement to examine the pennant line over the full length. Strongpoint, fairlead and pedestal roller examined together with attachment to vessel.

BCS-G 41 Guidance for Auditors to the ISM Code

GUIDANCE FOR AUDITORS TO THE ISM CODE

IMO Resolution A.741(18) as amended by MSC.104(73), MSC.179(79), MSC.195(80), MSC.273(85) and MSC.353(92)

ANNEX

INTERNATIONAL MANAGEMENT CODE FOR THE SAFE OPERATION OF SHIPS AND FOR POLLUTION PREVENTION (INTERNATIONAL SAFETY MANAGEMENT (ISM) CODE)

PREAMBLE

1. The purpose of this Code is to provide an international standard for the safe management and operation of ships and for pollution prevention.

2. The Assembly adopted resolution A.443(XI) by which it invited all Governments to take the necessary steps to safeguard the shipmaster in the proper discharge of his responsibilities with regard to maritime safety and the protection of the marine environment.

3. The Assembly also adopted resolution A.680(17) by which it further recognized the need for appropriate organisation of management to enable it to respond to the need of those on board ships to achieve and maintain high standards of safety and environmental protection.

4. Recognizing that no two shipping Companies or ship owners are the same, and that ships operate under a wide range of different conditions, the Code is based on general principles and objectives.

5. The Code is expressed in broad terms so that it can have a wide application. Clearly, different levels of management, whether shore-based or at sea, will require varying levels of knowledge and awareness of the items outlined.

6. The cornerstone of good safety management is commitment from the top. In matters of safety and pollution prevention it is the commitment, competence, attitudes and motivation of individuals at all levels that determines the end result.

INTRODUCTION

1. Scope and application

This guidance is intended for use by ISM Code auditors when performing certification under the ISM Code, unless the relevant Administration has provided special instructions that indicate otherwise.

This document is also intended to promote audits' consistency and uniformity among ISM Code auditors by providing examples, which, however, are not to be interpreted as prescriptive solutions or checklists.

Reference is made to the following Resolutions adopted by the International Maritime Organisation (IMO):

(a) the "International Management Code for the Safe Operation of Ships and for Pollution Prevention" (ISM Code), adopted by Resolution A.741(18) as amended by MSC.104(73), MSC.179(79), MSC.195(80), MSC.273(85) and MSC.353(92) and made mandatory by Chapter IX "Management for the Safe Operation of Ships" of the SOLAS Convention;

(b) "Revised Guidelines on the Implementation of the International Safety Management (ISM) Code by Administrations", adopted by Resolution A.1118(30) and referred in this document as the "IMO Guidelines", which are applicable to Recognized Organizations (RO) when acting at the request of flag Administrations;

(c) the Code for Recognized Organizations (RO Code) which was adopted by resolutions MEPC.237(65) and MSC.349(92);

(d) the MSC.Circ.1059/MEPC.Circ.401 "Procedures concerning observed ISM Code Major Non Conformities".

2. Application of the ISM Code by Companies

By design, the ISM Code supports and encourages the development of a safety culture in shipping. The content of a Safety Management System (SMS) will therefore be affected by Company commitment, values and beliefs, which cannot be enforced through the regulatory process. In developing and implementing their systems, Companies may have used industry guidelines, such as the ICS/ISF "Guidelines on the Application of the IMO International Safety Management (ISM) Code".

Assessing compliance with the ISM Code from detailed prescriptive management system solutions is not practical and would be inconsistent with the intent of the ISM Code, which allows a Company to develop solutions which best suit the Company and their particular operation and ship type(s), whilst ensuring basic internationally agreed standards of safety management.

3. Certification process

The verification of compliance with mandatory rules and regulations, required as part of the ISM Code, neither duplicates nor replaces the surveys required by the other statutory certificates. The verification of compliance with the ISM Code does not relieve the Company, the Master or any other entity or person involved in the management or operation of the ship of their own responsibilities.

The verification process involves interviews of Company personnel and review of SMS documentation and records. Audit is a sampling process and is not exhaustive in nature. Issuance of certification is based upon verification that the sample is in compliance with the ISM Code. Where non-conformities have not been found and reported, it does not mean that none exist. Basic procedures for performing ISM Code verification are contained in “Procedural Requirements for ISM Code Certification”, BCS-PR 9, which reflect the IMO “Revised Guidelines on the Implementation of the International Safety Management (ISM) Code by Administrations”, Resolution A.1118(30), as applicable.

4. Editorial principles

For convenience, this document incorporates the actual text of the ISM Code, followed by the relevant recommended guidance for ISM Code auditors. The document will be updated as necessary consistent with BCS's experience in the audit process.

The term “should” used in the ISM Code shall be interpreted as “shall”.

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PART A – IMPLEMENTATION

1. GENERAL

ISM Code – paragraph 1.1

1.1 Definitions

The following definitions apply to parts A and B of this Code.

1.1.1 "*International Safety Management (ISM) Code*" *means the International Management Code for the Safe Operation of Ships and for Pollution Prevention as adopted by the Assembly, as may be amended by the Organization.*

1.1.2 "*Company*" *means the Owner of the ship or any other organization or person such as the Manager, or the Bareboat Charterer, who has assumed the responsibility for operation of the ship from the Shipowner and who on assuming such responsibility has agreed to take over all the duties and responsibility imposed by the Code.*

1.1.3 "*Administration*" *means the Government of the State whose flag the ship is entitled to fly.*

1.1.4 "*Safety Management System*" *means a structured and documented system enabling Company personnel to implement effectively the Company safety and environmental protection policy.*

1.1.5 "Document of Compliance" means a document issued to a Company which complies with the requirements of this Code.

1.1.6 "Safety Management Certificate" means a document issued to a ship which signifies that the Company and its shipboard management operate in accordance with the approved safety management system.

1.1.7 "Objective evidence" means quantitative or qualitative information, records or statements of fact pertaining to safety or to the existence and implementation of a safety management system element, which is based on observation, measurement or test and which can be verified.

1.1.8 "Observation" means a statement of fact made during a safety management audit and substantiated by objective evidence.

1.1.9 "*Non-conformity*" *means an observed situation where objective evidence indicates the non-fulfilment of a specified requirement.*

1.1.10 "*Major non-conformity*" *means an identifiable deviation which poses a serious threat to the safety of personnel or the ship or a serious risk to the environment that requires immediate corrective action or the lack of effective and systematic implementation of a requirement of this Code.*

1.1.11 "Anniversary date" means the day and month of each year that corresponds to the date of expiry of the relevant document or certificate.

1.1.12 "Convention" means the International Convention for the Safety of Life at Sea, 1974, as amended.

Definitions in SOLAS Chapter IX (1996)

“Bulk carrier” as defined in Regulations IX / 1.6 of the SOLAS Convention means a ship which is exemplified in paragraphs 2.2, 2.3 and 2.4 of BCS-R Z11
“Mandatory Ship Type and Enhanced Survey Programme (ESP) Notations”.

Definitions from BCS-PR 9

"Audit" means a process of systematic and independent verification, through the collection of sampled objective evidences, to determine whether the SMS complies with the requirements of the ISM Code and whether the Safety Management System (SMS) is implemented effectively to achieve the Code’s objectives.

“Auditor” means a person who is qualified and authorised to carry out ISM audits in accordance with the requirements of BCS-PR 10.

“Lead Auditor” means an auditor who is authorized to lead a team of two or more auditors.

“Branch Office” means a shore-based location identified and controlled by the Company responsible under the ISM Code which may perform safety management system related tasks and is operating under the same SMS of the Company.

“Safety Management Manual” is the documentation used to describe and implement the SMS.

“Technical deficiency” means a defect in, or failure in the operation of, a part of the ship’s structure or its machinery, equipment or fittings.

The following definition has some differences from the Code, as explained:

“Observation” – the definition from the Code was complemented, in the BCS-PR 9, stating that: it may also be a statement made by the auditor referring to a weakness or potential deficiency in the SMS which, if not corrected, may lead to non-conformity in the future.

Definitions from ISO 9000:2015

“Corrective action” – action to eliminate the cause of a nonconformity and to prevent recurrence.

Notes:

1. There can be more than one cause for a nonconformity.

2. Corrective action is taken to prevent recurrence whereas preventive action is taken to prevent occurrence.

“Preventive action” – action to eliminate the cause of potential nonconformity or other potential undesirable situation.

Notes:

1. There can be more than one cause for a potential nonconformity.

2. Preventive action is taken to prevent occurrence whereas corrective action is taken to prevent recurrence.

"Correction" – action to eliminate a detected nonconformity.

Notes:

1. A correction can be made in advance of, in conjunction with or after a corrective action.

2. A correction can be, for example, rework or regrade.

ISM Code - paragraph 1.2 (1.2.1 and 1.2.2)

1.2 Objectives

1.2.1 The objectives of the Code are to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular, to the marine environment, and to property.

1.2.2 Safety management objectives of the Company should, inter alia:

.1 provide for safe practices in ship operation and a safe working environment;

.2 assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards; and

.3 continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection.

In accordance with the IMO Guidelines (Res. A.1118(30)), the objectives of mandatory application of the ISM Code are to ensure:

1. compliance with mandatory rules and regulations related to the safe operation of ships and protection of the environment; and

2. the effective implementation and enforcement thereof by Administrations.

Effective enforcement by Administrations must include verification that the SMS complies with the requirements as stipulated in the ISM Code, as well as verification of compliance with mandatory rules and regulations.

The mandatory application of the ISM Code should ensure, support and encourage that applicable codes, guidelines and standards recommended by the IMO, Administrations, classification societies and maritime industry organisations are taken into account.

These objectives encompass the effective and on-going implementation of the SMS and, to a large extent, depend on reactive and proactive improvement of the SMS functions, as part of the ISM Code.

The ISM Code paragraph 1.2.2.2 introduces a mandatory requirement for a Company to assess all identified risks to their vessels, personnel and the environment and to establish appropriate safeguards, which implies that a risk assessment is to be carried out as part of the safety management activities.

Many risk assessment models are already available and Companies are free to choose any model which suits them. Depending on the nature and complexity of the operations, Companies may choose to adopt one or more models.

To help the Companies in establishing safeguards against all identified risks the following standards may be used:

- MCA – Code of Safe Working Practices for Merchant Seafarers, 2015 edition, Amendment 3, October 2018;
- ISO 31000:2018 – Risk management -- Principles and guidelines;
- IEC 31010:2009 – Risk management – Risk assessment techniques.
- BCS-G 127 - A Guide to Risk Assessment in Ship Operations

ISM Code - paragraph 1.2 (1.2.3.1)

1.2.3 The safety management system should ensure:

.1 compliance with mandatory rules and regulations; and

The effectiveness of the SMS in ensuring compliance with mandatory requirements should be one of the criteria used by the auditor when assessing whether the SMS established by the Company complies with the ISM Code.

Examples of objective evidence needed for verification are documented procedures and instructions, documentation of verification carried out by senior officers of day to day operations, and other records as exemplified below. If any non-conformity is identified, the NC should not be linked to this objective but rather to an appropriate more detailed requirement of the Code.

The Company is responsible for obtaining and maintaining within the prescribed validity dates all the certificates (including any condition of class that shall be complied with within their limit dates imposed by the classification society), and documents necessary to operate the ship, in accordance with relevant rules and regulations. Inadequate performance indicates that the SMS is either deficient or not functioning effectively.

All records having the potential to facilitate verification of compliance with the ISM Code should be open to scrutiny during an examination. For this purpose, the Company should provide the auditor with statutory and classification records relevant to the actions taken by the Company to ensure that compliance with mandatory rules and regulations is maintained. In this regard, the records may be examined to substantiate their authenticity and veracity. It shall be considered that the initial statutory records issued by the classification societies may not be in the same format and not related to all statutory certificates issued for the vessel.

Examples of objective evidence found at the office may include:

- verification of how the Company controls the class and statutory documentation, including validity, statutory conditions and conditions of class endorsed, surveys, audits, etc.;
- interview with the DPA(s) and some key personnel to verify familiarization with class and statutory requirements and rules;

- procedures and instructions defining the process which ensures compliance with mandatory international and national requirements.

Examples of objective evidence found onboard the vessel may include:

- verification of all class and statutory certificates, including validation, periodical survey endorsements, statutory conditions and conditions of class issued, etc.;

- verification of the copy of the DOC (copy not necessarily authenticated or certified), including, validity, flag, vessel type, etc.;

- interview with the officers to verify familiarization with class and statutory requirements and rules;

- procedures and instructions defining the process which ensures compliance with mandatory international and national requirements;

- results from port State inspections.

ISM Code - paragraph 1.2 (1.2.3.2)

1.2.3 The safety management system should ensure:

.2 that applicable codes, guidelines and standards recommended by the Organisation, Administrations, classification societies and maritime industry organizations are taken into account.

The ISM Code does not require mandatory compliance with these information sources. However, the auditor may encourage Companies to apply relevant codes, guidelines and standards to their particular operation, by the use of observations.

The interpretation of the term “taken into account” should be that, if not addressed in the Company’s SMS, reasonable justifications should be available.

In many cases, the flag Administrations may consider some codes, guidelines and/or standards as part of their regulations, which imply that those are to be considered as part of the item 1.2.3.1 above.

Where, in an effort to improve safety and pollution prevention, the Company has chosen to incorporate and make mandatory some of the applicable codes, guidelines and standards, this should be supported and encouraged by the auditor, who failing to find evidences of implementation should raise a non-conformity (or a major non-conformity depending on the real threat).

Examples of objective evidence found at the office may include:

- familiarization of the DPA(s) and key personnel with guides and guidelines and their systematic control;

- consideration of IMO, IACS, flag, Classification Societies guides and guidelines in system reviews.

Examples of objective evidence found onboard the vessel may include:

- familiarization of the master and officers are familiar with guides and guidelines.

ISM Code - paragraph 1.3

1.3 Application

The requirements of this Code may be applied to all ships.

This Code is mandatory for all ships to which the SOLAS regulations apply and to any other ship, if required by the flag Administration.

For vessels not required to comply with this Code and no requirement from the flag Administration exists, a “voluntary” document may be issued by the RO.

ISM Code - paragraph 1.4

1.4 Functional requirements for a Safety Management System

Every Company should develop, implement and maintain a safety management system which includes the following functional requirements:

.1 a safety and environmental-protection policy;

.2 instructions and procedures to ensure safe operation of ships and protection of the environment in compliance with relevant international and flag State legislation;

.3 defined levels of authority and lines of communication between, and amongst, shore and shipboard personnel;

.4 procedures for reporting accidents and non-conformities with the provisions of this Code;

.5 procedures to prepare for and respond to emergency situations; and

.6 procedures for internal audits and management reviews.

The functional requirements of the ISM Code are intended to ensure the implementation of safe practices in ship operations through written procedures and work instructions. These functional requirements summarise the detailed SMS requirements that are described in the remainder of the ISM Code.

2. SAFETY AND ENVIRONMENTAL PROTECTION POLICY

ISM Code - paragraph 2.1

2.1 The Company should establish a safety and environmental protection policy which describes how the objectives, given in paragraph 1.2, will be achieved.

It is the Company's responsibility to define and document its safety and pollution prevention policy, which must describe how the objectives in paragraph 1.2 will be achieved.

This document is fundamental to, and forms an integral part of, the Company's safety management system. The procedures and all lower-level objectives must act in support of the overall objectives established in the policy.

To evidence the top commitment, the Company's policy should be approved by a member of the top management.

Examples of objective evidence that may be found both in the office and on board include:

- a copy of the policy document;
- established safety and pollution prevention objectives.

ISM Code - paragraph 2.2

2.2 The Company should ensure that the policy is implemented and maintained at all levels of the organization both ship based as well as shore based.

The Company is responsible for ensuring that all relevant personnel at all levels of the Company, including shipboard personnel and sub-contractors with responsibilities relevant to the SMS, are aware of and understand the policy.

Comprehensive and effective internal audits, management reviews, corrective and preventative action, and other management processes are essential in ensuring that the policy is implemented and maintained.

Examples of objective evidence that may be found both in the office and on board are:

- interviews with relevant personnel to establish the level of awareness and understanding;
- records of internal and external audits;
- records of corrective and preventative actions and their evaluation;
- maintenance plan and records of maintenance of the ship and equipment.

3. COMPANY RESPONSIBILITIES AND AUTHORITY

ISM Code - paragraph 3.1

3.1 If the entity who is responsible for the operation of the ship is other than the owner, the owner must report the full name and details of such entity to the Administration.

The “Company”, as defined in 1.1.2 of ISM Code, other than the owner of the ship, is a synonym for the “entity” referred to in 3.1.

The flag Administration is to have full details of the entity(ies) other than the owner who have assumed the responsibility for operation of the ship and who on assuming such responsibility has agreed to take over all the duties and responsibility imposed by the ISM Code.

The reporting of the Company details of each ship to the flag Administration is an obligation of the owner of the ship.

Examples of objective evidence found at the office may include:

- a copy of letter from owner to flag Administration delegating the responsibility for operational and technical support to the ship manager/operator.

Examples of objective evidence found onboard the vessel may include:

- the details of the owner/operator are given in the SMS and agree with the details contained in valid DOCs and SMCs;

- the auditor is to verify that the Company details given in DOC and SMC are identical to the information given in the CSR (Continuous Synopsis Record).

ISM Code - paragraph 3.2

3.2 The Company should define and document the responsibility, authority and interrelation of all personnel who manage, perform and verify work relating to and affecting safety and pollution prevention.

The Company is to define and document the distribution and interrelation of authority within the SMS.

This should include the following:

- person(s) or position(s) with the highest authority in developing, implementing and maintaining the SMS;

- person(s) or position(s) with the overall operational responsibility, and authority relevant to safety and protection of the environment; and

- person(s) responsible for safety and protection of the environment on a routine basis.

The Company is to define responsibility in key job descriptions for shore-based and shipboard positions that have duties related to the SMS.

The job descriptions should contain details of the following:

- position (for instance, second engineer / superintendent / operations manager / Master, etc.);
- name and type of ship;
- communication lines for reporting including DPA;
- qualification required for the position;
- general responsibilities relating to safety and protection of the environment;
- specific duties;
- emergency duties;

and may include substitution of personnel in case of absence thereof. The Company is to define the level of knowledge required for the ship types that the Company is operating.

Examples of objective evidence found at the office may include:

- Company's organization chart with defined job descriptions defining the responsibility and authority of the personnel involved in the SMS;
- how the Company exercises effective control of the responsibilities of its subcontractors involved in the SMS;
- verification that the subcontractor fully meets the requirements set out in the SMS;

Examples of objective evidence found onboard the vessel may include:

- job descriptions of the personnel onboard involved in the SMS;
- shipboard personnel are aware of who bears full responsibility and has authority relating to SMS, and how they relate to the SMS.

ISM Code - paragraph 3.3

3.3 The Company is responsible for ensuring that adequate resources and shore-based support are provided to enable the designated person or persons to carry out their functions.

The designated person(s) may formally require the top management to provide resources, when deemed necessary to carry out their functions. The top management is responsible for evaluating the proposal and decide accordingly.

The Company top management is to state that appropriate resources and shore-based support will be provided at all times, and adopt this as its policy.

The Company is to develop procedures for determining the resources needed for maintaining the operational safety of the fleet.

The resources may be defined as personnel, training, drills, supplying vessels with sufficient spare parts and stores, etc.

The Company is to carry out evaluations to ensure that shore-based support is provided onboard.

Examples of objective evidence found at the office may include:

- records of internal audits, management review, master's review, ship's condition and performance reports, etc.;

- how the Company deals with the requests for resources.

Examples of objective evidence found onboard the vessel may include:

- the ship's condition shows that necessary resources were allotted and relevant shore-based support was provided;

- records of training and drills;

- records of spare parts and equipment supplied to the vessel;

- evidence that the Master's requests for shore-based support have been fulfilled.

4. DESIGNATED PERSON(S)

ISM Code - paragraph 4

To ensure the safe operation of each ship and to provide a link between the Company and those on board, every Company, as appropriate, should designate a person or persons ashore having direct access to the highest level of management. The responsibility and authority of the designated person or persons should include monitoring the safety and pollution prevention aspects of the operation of each ship and to ensure that adequate resources and shore based support are applied, as required.

Essential to the Designated Person's (DP's) ability to satisfy the requirements of this paragraph is the direct access he or she must have to the highest levels of the Company's management. The auditor must be satisfied not only that such access exists, but also that the DP is able to use it effectively in ensuring that adequate resources and shore-based support are applied.

The Code specifies neither the qualifications the DP should have nor the position he should occupy in the Company's organization. For that purpose the IMO Circular MSC-MEPC.7/Circ.6: "Guidelines on the qualifications, training and experience necessary for undertaking the role of the DP under the provisions of the ISM Code" was produced and, as a guideline, shall be taken into consideration (ISM Code 1.2.3.2). The Companies should be encouraged to comply with this Guideline.

Direct access to the Company's senior management may be formally established in organization charts, job descriptions or other documents in which authorities and responsibilities are defined. Evidence that the access is real and effective may be found in, for example, routine and ad hoc reports, assorted correspondence, minutes of management meetings in which the DP participates, and actions arising.

The monitoring itself and the provision of a link between the ship and the shore-based organization may include activities such as ship visits, the review and analysis of reports of accidents, hazardous occurrences and non-conformances, including near-misses, internal audit reports, inspection reports, the minutes of shipboard safety and management meetings, and reports of drills and exercises. All such information should be appropriately summarized and reported to those responsible for the areas concerned.

It is commonly believed that the DP must be made responsible for the entire administration of the management system documentation, for the planning and conduct of internal audits, and must act as the sole conduit for all contacts between the ships' staff and the organization ashore. This is not the case. It is better to think of the DP as the person responsible for ensuring that such processes are in place and operating as required, a role that is more likely to be effective when separated from the practical implementation.

Some flags duly recommend the nomination of an alternative DP(s) to reduce the potential for single point failure.

The DP's role is often combined with others such as Technical Superintendent or Operations Manager, and the auditor should be aware of the possibility of a heavy workload and other responsibilities having a detrimental effect on the position's effectiveness. Conflicts of interest may also arise. For example, a DP who should be arguing for expenditure on safety-related items may also be the manager who controls the corresponding budget.

Where the Company has chosen to employ outside contractors for the position of the DP, a number of additional factors need to be considered:

- the precise nature of the contractual relationship with the contractor, including any obligations imposed on the Company;

- the bases on which the choice of contractor was made;

- the suitability of the contractor to undertake the assigned roles;

- the timeliness, frequency, completeness and effectiveness of the communications between the contractor and the Company.

The Company may not be the only client of the contractor, and the provision of such services may not be the contractor's only activity. It is, therefore, important to verify that the contractor is fulfilling obligations as DPA, and that the Company is able to contact the contractor when necessary.

The DPA's role and effectiveness shall be addressed during Company audits.

In some cases, the ship will be the Company's only "site", and provision will need to be made for the remote back-up of computer systems and files, and the retention ashore of copies of important paper documents.

Examples of objective evidence found at the office may include:

- description of responsibilities, authorities and reporting lines;

- interviews to establish awareness of DP's role and identity;

- evidence of monitoring of the safety and pollution prevention aspects of the operation of the ship such as review of audit reports, accidents, hazardous occurrences and non-conformities, etc.

Examples of objective evidence found on board the ship may include:

- interviews to establish awareness of DP's role and identity;

- contact details;

- reporting requirements.

5. MASTER'S RESPONSIBILITY AND AUTHORITY

ISM Code - paragraph 5.1

5.1 The Company should clearly define and document the Master's responsibility with regard to:

The Company, taking into account its organisation, type of ships and service, should define and document the responsibilities and methods expected by the Master to carry out these functions.

The Master's responsibility in a broad sense may be found in any part of the documented system.

ISM Code - paragraph 5.1.1

5.1 The Company should clearly define and document the Master's responsibility with regard to:

.1 implementing the safety and environmental protection policy of the Company;

"Implementation of the safety and environmental protection policy" on board is under the responsibility of the Master. Effective implementation of this could be verified through satisfactory audit of various departments on board.

Examples of objective evidence found at office may include:

- accident, near miss and non-conformity reports for injury / pollution and follow up by Company;
- evidence that Safety Committee Meetings, Emergency Drills, training on safety related matters are carried out effectively as per schedule.

Examples of objective evidence found on board the ship may include:

- display of the policy at common places;
- understanding of the policy by officers and crew during interview;
- accident and near miss reports for injury / pollution;
- evidence of safe working environment and safe practices.

ISM Code - paragraph 5.1.2

5.1 The Company should clearly define and document the Master's responsibility with regard to:

.2 motivating the crew in the observation of that policy;

"Motivation of the crew" may be achieved by the Master explaining to them how they can personally benefit from the implementation of the policy as well as encouraging their perception of ownership.

This could be achieved through meetings between the Master or a delegated Senior Officer (e.g. at embarkation, during training or safety drills) and crew members who are requested to participate in the fulfilment of the Company objectives and continuous improvement of the safety management system.

Motivation of the crew may be ascertained through interviews.

Examples of objective evidence found at office and on board ship may include:

- evidence that Safety Committee Meetings, Emergency Drills, training on safety related matters, screening of safety films carried out effectively as per schedule;

- evidence that with an aim to promote motivation following are being carried out organising safety debates, lectures, competitions, presentation of safety awards etc.

ISM Code - paragraph 5.1.3

5.1 The Company should clearly define and document the Master's responsibility with regard to:

.3 issuing appropriate orders and instructions in a clear and simple manner;

Examples of objective evidence on board ship may include Master's standing orders and bridge night order book.

ISM Code - paragraph 5.1.4

5.1 The Company should clearly define and document the Master's responsibility with regard to:

.4 verifying that specified requirements are observed; and

The Master may delegate verification to Officers but retains responsibility to ensure that the methods defined and documented by the Company are used.

A checklist could be useful for the Master to verify that specific requirements are observed through actions/activities performed by crew members.

The auditor may verify how these activities are carried out on board through direct observation and/or by interviewing the crew.

Examples of objective evidence on board ship may include:

- a verification checklist used by the master;

- verifying during master's audit that various requirements of the Safety Management System are complied with such as deck log book, stability calculations, oil record book, voyage plan, drill records.

ISM Code - paragraph 5.1.5

5.1 The Company should clearly define and document the Master's responsibility with regard to:

.5 periodically reviewing the safety management system and reporting its deficiencies to the shore-based management.

The Master, as responsible person onboard, should inform the Company whenever there are deficiencies in the SMS relevant to the ship's operation.

Information on SMS deficiencies should include proposals for corrective action and recommendations for improving the SMS, as far as possible.

The auditor should expect that the Company has defined when and how the Master carries out the SMS reviews aboard ship. The word "periodically" clarifies that the "master's review" is not an isolated activity, it is an ongoing dynamic process aimed at continually improving the effectiveness of the safety management system.

Examples of objective evidence found at office may include:

- evidence that Master's Reviews of SMS have been received from ships at defined intervals (at least annually);
- evidence that that findings of the Master's Reviews received from ships have been studied, analyzed and necessary follow up action taken if necessary.
- that all agenda items of the Master's Review have been reported;
- that the Master's Review gives a clear picture of the status of implementation of SMS on board and that necessary suggestions/modifications to SMS have been reflected in the review.

Examples of objective evidence found on board the ship may include:

- evidence that Master's Review of SMS have been forwarded to Company office at defined interval;
- that all agenda items of the Master's Review have been reported;
- that the Master's Review gives a clear picture of the status of implementation of SMS on board and that necessary suggestions/modifications to SMS have been reflected In the review;
- timely follow up and response by the Company to issues raised in the Master's review.

ISM Code - paragraph 5.2

5.2 The Company should ensure that the safety management system operating on board the ship contains a clear statement emphasizing the Master's authority. The Company should establish in the safety management system that the Master has the overriding authority and the responsibility to make decisions with respect to safety and pollution prevention and to request the Company's assistance as may be necessary.

The SMS should state the Master's overriding authority and discretion to take whatever action is considered necessary in the best interest of crew, passengers, the ship and environment.

The overriding authority of the Master applies to all circumstances.

The auditor should verify that the Company has definitively documented that the Master has an over-riding responsibility and authority on shipboard operations as prescribed in Resolution A.443(XI) "Decision of the Shipmaster with regard to Maritime Safety and Marine Environment Protection".

Examples of objective evidence found at office may include:

- evidence that masters have exercised the "overriding authority" under SMS (if any).

Examples of objective evidence found on board the ship may include:

- evidence that master has exercised the "overriding authority" under SMS (if any);

- verify during audit of master that the master of the vessel understands the meaning of "overriding authority" as per SMS and that he has the authority to make decisions with respect to safety and pollution prevention and to request for Company assistance if necessary;

- interview with Master confirm practical understanding of his overriding authority in matters such as requesting tug assistance, use of Lloyd's open form for salvage assistance, deviation from procedures if the situation so dictate.

6. RESOURCES AND PERSONNEL

ISM Code - paragraph 6.1.1

6.1 The Company should ensure that the Master is:

.1 properly qualified for command;

The Master's qualification for command to be verified by the Company before assignment to a ship may be determined with reference to the following:

- certificate of competency, including validity and authenticity, complies with relevant flag State and STCW requirements;
- previous seagoing experience on the same type of ship;
- performance reports, including those from previous employers, if available;
- additional specific Company requirements.

Examples of objective evidence found at the office may include:

- Master's Certificate of Competence copy appropriately endorsed according to STCW requirements;
- Master's CV stating previous experience on the same type of ship;
- Company's written minimum requirements for the Master's qualification and experience.

Examples of objective evidence found on board the ship may include:

- Master's Certificate of Competence appropriately endorsed according to STCW requirements;
- standing orders and night orders.

ISM Code - paragraph 6.1.2

6.1 The Company should ensure that the Master is:

.2 fully conversant with the Company's safety management system; and

The Company should ensure that the Master is **"fully conversant"** with all requirements relating to the Company's safety and environmental protection policies.

The auditor should expect the Master to demonstrate familiarity with the SMS during onboard interviews. To assist this purpose, the auditor may find records of participation in regular meetings with the Company's management, attendance at seminars or training sessions on the SMS.

Examples of objective evidence found at the office may include:

- Master's appraisal records and evidence of their monitoring and evaluation by the Company;

- records of regular briefings on the SMS in the Company with the Masters;

- the Master's periodical SMS review for the Company.

Examples of objective evidence found on board the ship may include:

- knowledge, assessed by means of interviews, of the Company's SMS related procedures safety and safety management system meetings as applicable.

ISM Code - paragraph 6.1.3

6.1 The Company should ensure that the Master is:

.3 given the necessary support so that the Master's duties can be safely performed.

Through the interview process, auditor ensures the Master is given full support to fulfil his duties in maintaining the Company's safety and environmental policies. Evidence of this support would be how the Company responds to requests made by the Master.

Examples of objective evidence found at the office and on board the ship may include:

- written review and feedback from the Company of the safety meetings;

- Company timely feedback to the Master's requests for technical support, spare parts, elimination of deficiencies, additional training of personnel, response to emergencies, etc.;

- deficiencies identified in Master's handover forms have been taken care of by the Company.

ISM Code - paragraph 6.2

6.2 The Company should ensure that each ship is:

.1 manned with qualified, certificated and medically fit seafarers in accordance with national and international requirements; and

.2. appropriately manned in order to encompass all aspects of maintaining safe operations on board.*

** Refer to the Principles of minimum safe manning, adopted by the Organization by resolution A.1047(27)*

"Manning requirements" for vessels are defined by flag Administration. Administration requirements may be exceeded, if required, following the Company evaluation of minimum manning based on Principles of minimum safe manning defined in IMO resolution A.1047(27). The standards for certification and training of specific shipboard assignments for licensed and unlicensed personnel are described in the STCW Convention, as amended. The Company has to be familiar with such requirements consistent with ship type(s) and operation.

“Qualification of personnel” may be ensured by adopting a policy for recruitment (e.g. evaluation of personal CV, information from other Companies, interviews), selection of personnel (e.g. by an appraisal system) and, as far as possible, embarkation of personnel already known by the Company.
The Company should have a system in place for selecting personnel, especially if obtained through a manning agent. A procedure may then be expected to detail how the selection process is carried out to comply with the STCW Convention, as amended.
When recruitment or manning is obtained through a manning agent, the Company should adopt a procedure for checking that its policy is followed by the agent. A procedure may be expected providing details on how the recruitment and selection process is carried out.

“Medical fitness”, as required in the amended STCW Convention, should include that a reasonable policy exists and it has been implemented. Evidence of such a policy includes certificates or endorsements in seaman books and that crew members have undergone medical examination within the intervals established by the flag Administration.
Some Companies have their own medical department providing pre-employment and existing employees medical examinations. Such a policy, while beneficial, does not always detect medical problems which can exist when a crew member joins the ship.
Some Companies have established a formal drug and alcohol policy and process of screening crew. Such policy is a method by which a Company may help ensure that ship personnel remain medically fit for duty on a day to day basis. Should this exist, the auditor may include these activities in the audit.

Examples of objective evidence found at the office may include:

- Company evaluation of minimum manning requirements based on IMO resolution A.1047(27);

- written recruiting procedures and minimum requirements for the Officers’ qualification;

- the Officers’ CVs satisfying such minimum requirements;

- the Company’s established and documented procedures for monitoring expiring Certificates, when applicable.

Examples of objective evidence found on board the ship may include:

- the vessels are manned accordingly to the minimum safe manning required by the flag and any Company additional requirements;

- the watchkeeping Officers’ Certificates of Competence appropriately endorsed by the flag as applicable;

- valid certificates according to specific ship types as required by STCW convention;

- valid medical fitness certificates and medical examination reports as required.

"Appropriately manned" is further elaborated in IMO Resolution A.1047(27) “Principles of minimum safe manning”. Annex 3 describes responsibilities of Companies, which includes to “make an assessment of the tasks, duties and responsibilities of the ship's complement required for its safe operation, for its security, for protection of the marine environment, and for dealing with emergency situations”. In this respect, it seems appropriate to also refer to requirements of ISM Code 7 as well as ISM Code 8. It should also be noted that Companies’ responsibility includes to “ensure that the minimum safe manning is adequate at all times and

in all respects, including meeting peak workload situations, conditions and requirements, and is in accordance with the principles, recommendations and guidelines contained in this resolution;", which also includes to comply with rest hour regulations. The Company is also responsible for preparing and submitting to the Administration a new proposal for the minimum safe manning of a ship in the case of changes in trading area(s), construction, machinery, equipment, operation and maintenance or management of the ship, which may affect the safe manning".

Examples of objective evidence found at the office may include:

- the assessment of tasks, duties and responsibilities when deciding on the manning levels of the ship;

- that the Company has applied for new minimum safe manning document if there are any changes as described in the resolution.

Examples of objective evidence found at the on board the ship may include:

- records of rest in compliance with the requirements of the STCW and MLC conventions;

- that the vessel is manned in accordance with the minimum safe manning document;

- that the crew is able to conduct their duties as required within the SMS.

ISM Code - paragraph 6.3

6.3 The Company should establish procedures to ensure that new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarization with their duties. Instructions which are essential to be provided prior to sailing should be identified, documented and given.

The Company shall provide, in accordance with STCW, written instructions to the Master of each ship to which the Convention applies, setting forth the policies and procedures to be followed to ensure that all seafarers who are newly employed onboard are given a reasonable opportunity to become familiar with the shipboard equipment, operating procedures and other arrangements needed for the proper performance of their duties, before being assigned to those duties.

"New assignments" related to ship personnel may include another ship, a different job or promotion.

"Essential instructions" are those that clearly define the crew members role within the ship's organisation and ensure that they are prepared prior to taking up their duties on board. These instructions may include crew member's responsibility, authority and interrelationships with others involved in the SMS.

"Instructions prior to sailing" may include lifeboat station and responsibilities, fire station responsibilities and making available specific additional reference material associated with safety requirements from the SOLAS training manual.

"Familiarisation" is the process that allows a person embarking for the first time on a ship or transferred to new assignments to become familiar with that ship, its machinery, systems, equipment and operations. Familiarisation may be accomplished for instance by:

- embarking as supernumerary,

- receiving essential information in a language the seafarer understands,

- shore side seminars sponsored by industry or Company,

- observing onboard overlap while vessel in port,

- visual aids such as videos, manuals and operating instructions.

The choice and level of detail to assist familiarization will depend on individual experience and the job responsibilities. Should individuals require essential familiarization with an assignment prior to sailing, then the Company should identify such requirements and develop an appropriate plan. Examples may be familiarization with the equipment on the bridge or in the engine room.
A system of familiarization should also be applied to new or transferred shore staff where their responsibilities include safety and pollution prevention. This could include superintendents who are not familiar with a type of vessel being operated by the Company.

Examples of objective evidence found at the office may include:

- a documented training program for crew members;

- records of seminars and training courses;

- evidence of evaluation by the Company of appraisal.

Examples of objective evidence found on board the ship may include:

- evidence, obtained by means of interviews and observation of behaviour, when possible, that crewmembers have appropriate knowledge of SMS onboard procedures (ex working permits, bunkering checklists, etc.);

- correct performance of drills as required by SOLAS regulations, the SMS manual, the SOPEP, etc.;

- familiarization checklists duly signed by trainer and trainee.

ISM Code - paragraph 6.4

6.4 The Company should ensure that all personnel involved in the Company's safety management system have an adequate understanding of relevant rules, regulations, codes and guidelines.

The Company should have a plan on how to provide all personnel involved in safety and pollution prevention with information on mandatory requirements of the relevant Administration(s) and applicable codes and guidelines.

Such information may be communicated by:

- written instructions,

- description of job responsibilities,

- formal discussions with Company representatives.

Examples of objective evidence found at the office may include:

- Company library complete, controlled and updated;

- control and updating procedure for the Company library.

Examples of objective evidence found on board the ship may include:

- shipboard library complete, controlled and updated;

- control and updating procedure for the shipboard library;

- crewmember's knowledge, assessed by means of interviews, of rules, regulations, codes and guidelines.

ISM Code - paragraph 6.5

6.5 The Company should establish and maintain procedures for identifying any training which may be required in support of the safety management system and ensure that such training is provided for all personnel concerned.

The Company should identify the individual(s), ashore and onboard, having responsibility to define training needs appropriate for specific tasks, taking into account factors such as:

- previous training and experience,

- required proficiency in operation of equipment,

- familiarity with new equipment,

- familiarity with equipment when transferred to different type vessel,

- drills for emergencies,

- results of internal auditing.

Training may be supplemented by using visual aids, such as videos, manuals and operating instructions, or direct supervision by a superior.

Examples of objective evidence found at the office may include:

- Company and shipboard training plan;

- records of shore-side drills and training.

Examples of objective evidence found on board the ship may include:

- records of drills and training;

- internal audit reports.

ISM Code - paragraph 6.6

6.6 The Company should establish procedures by which the ship's personnel receive relevant information on the safety management system in a working language or languages understood by them.

The Company should establish the working language(s) onboard and the requested level of knowledge of foreign languages for the crew members.

The details and the amount of documentation should be determined by what is necessary to ensure all appropriate shipboard personnel can understand their respective roles.

In absence of documentation translated into the working language of the crew members, the auditor would expect to find objective evidence that proper familiarisation with the safety management system, as far as applicable, had taken place. Records of respective training sessions should be maintained.

Examples of objective evidence found at the office may include:

- internal audit reports, technical reports, circulars, etc.

Examples of objective evidence found on board the ship may include:

- standing orders, night orders, work orders, emergency stations, etc.
- an entry in the ship's log book about the working language is required (SOLAS Chapter 5, Reg. 14).

ISM Code - paragraph 6.7

6.7 The Company should ensure that the ship's personnel are able to communicate effectively in the execution of their duties related to the safety management system.

Sufficient instructions in a suitable language need to be verified, as well as ensuring an understanding of them by the crew. This could be verified by witnessing an exercise. Verification that the ship's personnel are able to communicate may be accomplished by verifying the execution of orders given by Officers as requested by the auditor.

The auditor should verify if procedures exist that ensure effective communication on board. Documented evidence must be available, e.g. from manning agencies at the recruitment stage and during crew appraisals. Those responsible for the care of passengers during shipboard emergencies should be able to communicate with them effectively.

Examples of objective evidence found at the office may include:

- what is the established working language of SMS;
- Company's minimum requirements in relation to language knowledge of crew members;
- sample of crew list.

Examples of objective evidence found on board the ship may include:

- capability, assessed by means of observation of behaviour, of crewmembers to understand each other during simulation of emergencies and during shipboard procedures;

- crewmembers' understanding, assessed by means of interviews, of emergency and operative signs onboard and safety guidelines.

7. SHIPBOARD OPERATIONS

ISM Code – paragraph 7

The Company should establish procedures, plans and instructions, including checklists as appropriate, for key shipboard operations concerning the safety of the personnel, ship and protection of the environment. The various tasks should be defined and assigned to qualified personnel.

"Shipboard operations" in the safety and environmental protection context mean:

- all those operations for which mandatory rules and regulations prescribe performance requirements or specific requirements for plans, procedures, instructions, records and checklists;

- those connected to the particular ship's type and which may affect safety and pollution prevention, to the extent established by the Company;

- those for which safe practices in ship operations and a safe working environment (ref. 1.2.1) have been recommended by the IMO, Administrations, classification societies and other industry bodies (ref. 1.2.3.2);

- those which the Company considers may create hazardous situations if not controlled by plans and instructions.

The ISM Code does not specify any particular approach to establish plans, instructions and checklists and it is for the Company to produce operating procedures and to choose methods appropriate to its organizational structure, its ships and its trades.

The methods may be more or less formal, but they must be systematic if assessment and response are to be complete and effective. Methods of Company identification of key shipboard operations may include the following:

- Company experience on those operations which may create hazardous situations if not controlled by plans and instructions;

- feedback provided from the SMS elements such as the Master's review of the SMS (ref. 5.1.5), internal audits, reports and analysis of non-conformities, accidents and hazardous occurrences;

- formalized systematic methods which the Company may decide to use as a tool for hazard identification.

Non-conformities should not be raised against the adequacy, but on the implementation of such methods decided by the Company to identify key shipboard operations.

"Procedures, plans and instructions" including checklists, are meant to govern or support shipboard activities related to the safety of the ship and the protection of environment. These should also deal with new ship types when relevant.

Examples are those routine activities which if not correctly handled could lead to hazardous situations, e.g. watch keeping, loading, discharging, gas freeing, tank cleaning, sailing (confined waters), passage planning, pollution prevention, etc.

Procedures, plans and instructions should have safety and protection of environment as a primary objective and should include, inter alia, measures to manage identified risks as referenced in 1.2.2.2 of the ISM Code.

The development of procedures should take into account relevant international and national mandatory rules and regulations and applicable codes, guidelines and standards for the type(s) of ship covered by the SMS. This information should be kept updated by the Company to take into account its operational experience.

The development process shall ensure that ship and trade specific issues are adequately dealt with.

If having the same shipboard procedures for multiple ship types, care must be taken to clearly identify the procedures that are relevant for each ship.

The Company should be involved to confirm that the list is consistent with the Company's particular operational experience and procedures.

Non-conformities may be raised against the adequacy of methods decided by the Company to identify key shipboard operations and when there is evidence that such plans, procedures and instructions are inadequate.

The approval of the performance of operations for which plans, procedures and instructions are required by mandatory rules and regulations, such as damage control plans, are dealt with separately and independently of ISM Code audits.

"Qualified personnel" means those who are qualified to identify key shipboard operations and carry out actions requested by plans, procedures and instructions.
When developing plans and instructions for key shipboard operations, the focus is on prevention, which requires the use of personnel who have adequate technical and/or operational knowledge relevant to the Company's operations.

The auditor should not prescribe particular requirements for qualified Company personnel to perform the review process.

Identification of tasks assigned to appropriately qualified personnel is an important consideration. Checklists may be used to facilitate the process. The auditor should expect the Company to have identified risks associated with a particular type of vessel and trade. Such identification should be documented in some form. Identified risks may simply be indicated in tables of contents.

Examples of objective evidence found at the Office may include:

- documented procedures for the preparation of plans and instructions for key shipboard operations concerning the safety of the ship and environmental protection;

- documented evidence of the decision making process and outcome thereof.

The effectiveness of the process should be evaluated based on the following evidence:

- evidence that a systematic review of mandatory rules and regulations applicable to each ship type included in the DOC is carried out by the Company (ref. 1.2.3.1 and 6.4) for the purpose of identification of the plans, procedures and instructions that are

required by mandatory rules and regulations for the type(s) of ships operated by the Company.
This evidence may include the existence of an appropriate library of applicable rules and regulations;

- evidence of a systematic review of recommendations given in form of codes, guidelines and standards by the IMO, Administrations, classification societies or other industry bodies, which the Company has decided that are applicable to their operation.

This evidence may include verification that:

- there is a list of these references,

- these recommendations are made available for those responsible for developing the plans and instructions for key operations;

- testing the completeness of the review by choosing a random sample of the operations for which there are requirements for plans, procedures or instructions in mandatory rules and regulations;

- verifying that the Company has established their own qualification requirements for those who are to be responsible for the development of plans, procedures and instructions for key operations; and

- that this has been used as a basis for a systematic identification of the plans, procedures and instructions that are required by mandatory rules and regulations for the type(s) of ships operated by the Company;

The shipboard audit should include:

- verification that key operations are under control by random sampling of those operations. This would involve the need to witness operations and confirm that the operation is conducted in accordance with procedures and instructions and will include discussion with crew members on their specific responsibilities associated with the key operation. The random sampling would depend on the type of ship, the ship operator, time available and availability of ship’s personnel.

- verification that an appropriate library of applicable rules and regulations, guidelines, codes and standards exists.

8. EMERGENCY PREPAREDNESS

ISM Code - paragraph 8.1

8.1 The Company should identify potential emergency shipboard situations, and establish procedures to respond to them.

Usually the following scenarios are addressed by emergency plans as applicable and/or required by the specific ship types:

- structural failure / heavy weather damage;
- failure of main propulsion;
- steering gear failure;
- electrical power failure;
- collision;
- grounding / stranding;
- shifting of cargo;
- cargo / oil spillage / jettison *;
- flooding;
- fire / explosion;
- abandoning ship;
- man over board;
- search and rescue operations;
- serious injury;
- piracy / terrorism *;
- rescue from enclosed spaces;
- helicopter rescue operations.

* Remark: references may be made to other separate emergency plans like SOPEP, SMPEP, SSP.

Depending on vessel's type and trade, some of emergency scenarios may be omitted (e.g. shifting of cargo on passenger vessels, piracy in certain trades). However, the list is not exhaustive and the Company shall identify all possible situations where shipboard contingency planning would be required relative to the ship's type, equipment and trade.

Examples of objective evidence found at the Office may include:

- records of drills;

- records of training ashore;

- emergency response plans.

Examples of objective evidence found onboard the ship may include:

- SOPEP manuals;

- records of drills;

- emergency response plans.

ISM Code - paragraph 8.2

8.2 The Company should establish programmes for drills and exercises to prepare for emergency actions.

For all emergency scenarios identified by the Company (see 8.1) a drill schedule should be prescribed by the Company; for this drill schedule no certain format is required, however, following information should be provided:

- frequency of the particular drills;

- extend of the particular drills (e.g. table top drill only, or practical drill followed by de-briefing and watching of a certain safety video);

- the Company might lay down who on board is responsible for the detailed planning of a drill scenario. Furthermore it appears to be prudent that a Company will instruct the vessels to perform practical drills under conditions with reduced personnel due to simulated casualties, i.e. back up / deputy staff should be involved in leadership and all tasks of a certain drill;

- in addition it may be beneficial for audit purposes to witness a shipboard safety drill or other practical demonstration (e.g. starting of life boat engine, donning of fire suit, first measures in case of detecting a cabin fire, etc).

Examples of objective evidence found at the Office may include:

- drill schedule for ships, shore-side and joint exercises;

- records of drills and training;

- analysis or evaluation of drills and exercises.

Examples of objective evidence found onboard the ship may include:

- drill schedule for ships, shore-side and joint exercises;

- records of drills and training;

- analysis or evaluation of drills and exercises.

ISM Code - paragraph 8.3

8.3 The safety management system should provide for measures ensuring that the Company's organization can respond at any time to hazards, accidents and emergency situations involving its ships.

It is important that Company shore and shipboard contingency planning is consistent and appropriately integrated.

Shore based emergency plans should include:

- procedures for the mobilisation of an appropriate Company emergency response team (incl. back up arrangements in the event of a prolonged emergency);
- the composition and duties of the persons acting within the contingency plan;
- procedures / checklists, etc. appropriate to the type of emergency which may assist in the systematic questioning of the ship during the response;
- the availability of vessel's contact numbers, ship particulars, plans, stability and cargo information, and safety and environmental protection equipment carried on board;
- details and contact numbers of all relevant parties including subcontractors, administrations, port states, Class emergency services, etc. who may need to be notified and consulted;
- procedures for notifying and liaising with the next of kin of shipboard personnel;
- procedures for issuing information bulletins to and answering queries from the media might also be included.

Examples of objective evidence found at the Office may include:

- emergency response plans;
- contact points for all relevant parties (ERT, owners, charterers, insurance, etc.);
- 24 hr contact number between the ship and the Company;
- back-up arrangement;
- specific drawings for ship types.

Examples of objective evidence found onboard the ship may include:

- emergency response plans;
- contact points for all relevant parties (ERT, owners, charterers, insurance, etc.);
- 24 hr contact number between the ship and the Company;

- specific drawings for ship type;
- status and location of emergency equipment and oil spill response gear.

9. REPORTS AND ANALYSIS OF NON-CONFORMITIES, ACCIDENTS AND HAZARDOUS OCCURRENCES

ISM Code - paragraph 9.1

9.1 The safety management system should include procedures ensuring that non-conformities, accidents and hazardous situations are reported to the Company, investigated and analysed with the objective of improving safety and pollution prevention.

Records of non-conformities, accidents, hazardous situations and relevant investigations produced by shipboard personnel and/or by the Company from operations or internal audits, should be provided to the auditor during audits to demonstrate effective functioning of the SMS.

Non-conformities may be identified as result of such activities as internal and external audits, class surveys, flag or port state inspections. The NCs may include non-fulfilment of technical as well as operational requirements.

Accidents are events that lead to unintended harm or damage such as deaths or injuries, pollution or property damage. Hazardous situations include near misses which are often defined as events that under slightly different circumstances may lead to an accident. Considering the importance of the near misses in the objective of improving safety and environment protection the IMO MSC-MEPC.7/Circ.7 provides a “Guidance on near-misses reporting”.

The auditor should be aware that terminology in reporting such events varies from Company to Company.

The auditor would also expect to see the effective implementation of a documented procedure dealing with the review and analysis of the events stated above. Analyses should aim to determine root causes, not only symptoms. This should include the objective for improvement. Corrective action should include both the “repair” to deal with the immediate situation as well as measures taken to prevent or reduce likelihood of recurrence.

ISM Code - paragraph 9.2

9.2 The Company should establish procedures for the implementation of corrective action, including measures intended to prevent recurrence.

This requirement mirrors the definition of corrective action in the ISO 9000 standard and clarifies that it is not only required to eliminate the detected non-conformity but also to eliminate the cause of the non-conformity to prevent recurrence of the problem. The action taken to avoid recurrence should address the root cause of the problem.

The Company should have procedures for carrying out the corrective actions suggested by analysis relevant to non-conformities, accidents and hazardous situations identified from internal audits and during operations.

Auditors should focus on the effectiveness of the procedure(s) for implementing corrective actions. Failure to comply with these issues in a timely manner should qualify for a non-conformity. Consistent, grave inability to comply in time should result in the issue of a major non-conformity.

Examples of objective evidence found at the Office and onboard the ship may include:

- personnel being aware of procedure(s) ensuring that non-conformities, accidents and hazardous situations are reported, investigated, analyzed and followed up;

- records of non-conformities, accidents and hazardous situations reported (check against documents such as class, flag and port state reports, medical logs and interviews);

- records of accident investigation and analysis;

- evidence of corrective action;

- evidence of effective and timely implementation of corrective action.

10. MAINTENANCE OF THE SHIP AND EQUIPMENT

ISM Code - paragraph 10.1

10.1 The Company should establish procedures to ensure that the ship is maintained in conformity with the provisions of the relevant rules and regulations and with any additional requirements which may be established by the Company.

The maintenance of the ship and equipment should be in accordance with the procedures established by the Company. These procedures should take into account international conventions, flag and Port State regulations, classification rules, requirements from manufacturers, feedback information from failures, damages, defects and malfunctions.

There are a number of acceptable systems associated with maintenance of equipment. The choice depends on ship design and Company philosophy. The auditor should expect to find maintenance process documentation and records indicating compliance with maintenance program requirements.

The ISM Code makes it clear that the Company is responsible for ensuring the safe operation of the ship and protection of the environment. In particular, the Company is required to ensure that the ship's hull, machinery and equipment are maintained and operated in accordance with the applicable rules and regulations and any additional requirements that may be established by the Company. Reference can be made to the BCS-G 74 "A Guide to Managing Maintenance with the Requirements of the ISM Code".

Objective evidence is necessary to confirm conformance with established maintenance requirements.

Examples of objective evidence found at the Office and onboard the ship may include:

- documented procedures and instructions for the onboard work routine;
- verification of their implementation in the day-to-day operation of the ship by the appropriate personnel.

ISM Code - paragraph 10.2.1

10.2 In meeting these requirements the Company should ensure that:

.1 inspections are held at appropriate intervals;

The Company should define the appropriate intervals and may be expected to justify their selection.

As part of shipboard responsibilities, there should be formal routine inspections of machinery, systems, equipment and structural integrity of the ship.

Examples of objective evidence found at the Office may include:

- shipboard inspection reports from ship staffs and/or Company superintendents at intervals as required by the maintenance plan;

- definition of inspection criteria such as manufacturer's recommendations; and
- monitoring of maintenance status.

Examples of objective evidence found onboard the ship may include:

- shipboard inspection reports;
- condition of ship; and
- results from other surveys and inspections.

ISM Code - paragraph 10.2.2

10.2 In meeting these requirements the Company should ensure that:

.2 any non-conformity is reported with its possible cause, if known;

This section of the Code refers to damage, defects, malfunctioning, deficiencies concerning ship and equipment, etc. Therefore, the term "non-conformity" in this context refers to a technical defect and/or technical deficiency which is caused by ineffectiveness/failure of the maintenance system.

Shipboard personnel, as part of the day-to-day operation of the ship, should have procedures which ensure that defects are reported promptly and rectified within a specified period of time.

A system should be in place to notify appropriate personnel both ashore and on board of defects and appropriate corrective actions.

Examples of objective evidence found at the Office may include:

- receipt of technical defect reports (damage, inspection reports, etc.) from the ship in accordance with the SMS procedures;
- analysis of defect and identification of causes;
- root cause analysis, if necessary.

Examples of objective evidence found onboard the ship may include:

- reporting of technical defects in accordance with SMS procedures;
- analysis of defect and identification of causes;
- root cause analysis, if necessary.

ISM Code - paragraph 10.2.3

10.2 In meeting these requirements the Company should ensure that:

.3 appropriate corrective action is taken; and

The Company should have documented procedures for corrective action of defects which cannot be promptly corrected by the shipboard personnel.

Defects which, for any reason, cannot be promptly dealt with by the ship personnel (e.g. due to lack of resources or material) or whose repair may be postponed (e.g. to the next dry dock or long stay) and which do not affect the ship's safety and environmental protection, should be included in a continuously updated list, to be available onboard and ashore.

The SMS should include instructions when ship's personnel are unable to correct a defect affecting the ship's safety or protection of the environment with available resources and material, in order to inform the appropriate person in the Company of the nature of the problem, whenever possible with proposals for corrective and preventive resolution.

Examples of objective evidence found at the Office may include:

- list of maintenance and repair carried out onboard;
- control, monitoring and supply of spare parts;
- evidence of preventive maintenance actions taken;
- evidence of timely follow-up and effectiveness of corrective action.

Examples of objective evidence found onboard the ship may include:

- list of maintenance and repair carried out onboard;
- control, monitoring and receipt of spare parts;
- evidence of preventive maintenance actions taken;
- evidence of timely follow-up and effectiveness of corrective action.

ISM Code - paragraph 10.2.4

10.2 In meeting these requirements the Company should ensure that:

.4 records of these activities are maintained.

Records of inspections, maintenance, damages, defects and relevant corrective actions should be kept as objective evidence of the effective functioning of the SMS. The records may be maintained in electronic format.

Examples of objective evidence found at the Office and onboard the ship may include:

- evidence of all records addressed above.

ISM Code - paragraph 10.3

10.3 The Company should identify equipment and technical systems the sudden operational failure of which may result in hazardous situations. The safety management system should provide for specific measures aimed at promoting the reliability of such

equipment or systems. These measures should include the regular testing of stand-by arrangements and equipment or technical systems that are not in continuous use.

The main intention of this paragraph is to increase reliability of equipment and technical systems of which a sudden operational failure can cause a dangerous situation. Hence, a risk assessment should be carried out to identify such equipment and systems. Once identified, measures should be taken to increase the reliability of the equipment or system, to ensure that it is in full operational condition whenever it is needed.

There are different methods for carrying out risk assessment of such equipment and systems, hence the first step should be to establish a suitable methodology for the assessment. One example is FMECA (Failure Mode, Effect and Criticality Analysis), but there are also other risk assessment techniques which may be successfully applied. In this respect, it is important to identify equipment and systems which are used in the operation of the vessel, and where a sudden failure can cause damage or injury to the vessel, the environment or to people.

The measures developed should aim to control the risk. An example introducing redundancy for stand-by equipment may be a solution to enhance the reliability of a technical system. Other means may be function tests and maintenance routines. In this respect it is also important to consider appropriate instructions for operation and maintenance of the equipment, as well as training and familiarization.

Equipment and systems that are not in continuous use, should be tested regularly and prior to conducting any operation to ensure that there will be no loss of function which may lead to an accident.

The testing and maintenance of stand-by equipment and infrequently used systems should be part of the Company maintenance procedures. Once identified, appropriate tests and other procedures should be developed to ensure reliability.

Examples of such equipment and systems may include but are not limited to:

- test of standby start of aux engines including emergency generator,
- test of windlass,
- test of lub oil pump for main reduction gear(s),
- test of Emergency bilge system,
- test of the arrangement for starting up from «dead-ship» condition,
- communication equipment (internal and external),
- test of isolation valve for engine room(s) on the fire line,
- alarms and emergency shutdowns,
- pre-arrival and pre-departure tests (of emergency steering gear, generators, emergency fire pumps, etc.).

Examples of objective evidence found at the Office may include:

- evidence that a methodology is established for identification of equipment and systems where failure can have negative consequences for safety or environment;

- evidence of identification of such equipment;

- evidence that the results from the assessment has been considered and that appropriate measures are identified and implemented;

- evidence that the Company is familiar with rules and regulations regarding relevant equipment, in particular emergency equipment;

- procedures for operation and maintenance;

- records of inspection and testing.

The focus of the ship audit should be to verify that the measures are implemented. However, it may also be relevant to consider whether all relevant equipment and systems have been identified.

Examples of objective evidence found onboard the ship may include:

- records of inspection and testing;

- relevant personnel are familiar with the operation and maintenance/test procedures for such equipment and systems;

- condition of relevant equipment;

- spare parts are available when relevant.

ISM Code - paragraph 10.4

10.4 The inspections mentioned in 10.2, as well as the measures referred to in 10.3 should be integrated into the ship's operational maintenance routine.

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11. DOCUMENTATION

ISM Code – paragraphs 11.1 to 11.3

11.1 The Company should establish and maintain procedures to control all documents and data which are relevant to the safety management system.

11.2 The Company should ensure that:

.1 valid documents are available at all relevant locations;

.2 changes to documents are reviewed and approved by authorised personnel; and

.3 obsolete documents are promptly removed.

11.3 The documents used to describe and implement the safety management system may be referred to as the "Safety Management Manual". Documentation should be kept in a form that the Company considers most effective. Each ship should carry on board all documentation relevant to that ship.

Well-designed and well-managed documentation is vital to the health and integrity of the system. It is essential in clarifying and communicating the Company's requirements, establishing and maintaining lines of communication, defining and clarifying responsibilities and authorities, and in developing a safety culture.

It is important to remember that the issue of a certificate means that the system complies with the requirements of the ISM Code. It is not a guarantee that it does so in the most efficient way possible. Some very inefficient systems have received ISM certificates! The management system should not create a large and unacceptable bureaucratic burden, but if it does, then the documentation has been badly designed and should be reviewed.

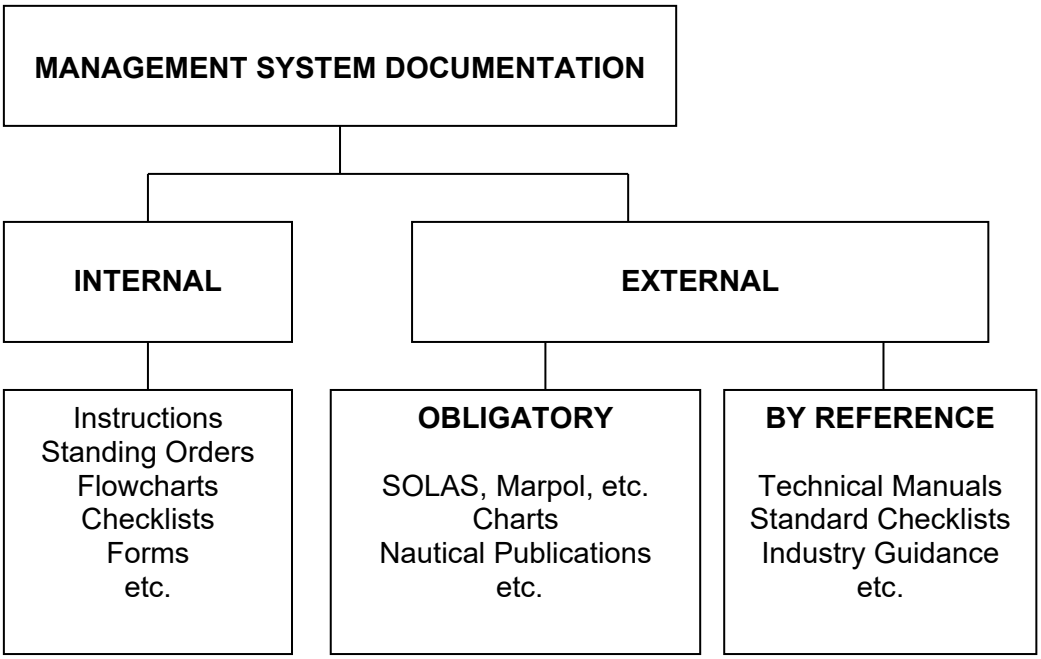
Although the Code does not specifically require the auditor to address the efficiency of the system, serious inefficiencies can reduce its effectiveness, and should not be ignored. The auditor can do much to contribute to the system's improvement by identifying duplication, repetition, ambiguity and redundancy.

The more concise a document, the more likely people are to read it, and the easier it will be to understand. Flow charts and well-designed forms and checklists can do much to reduce the number and size of the procedures, and keeping cross-references to a minimum makes amendment much easier.

A straightforward review and approval process is essential. To concentrate document authorization in one very senior position, for example, is likely to result in delay. It may be better to approve documents at lower levels more directly associated with the activities concerned, and with the flexibility of one or two alternative signatories. This has the added advantage of increasing the sense of ownership of those responsible for implementing the procedures.
Both internally and externally generated documents must be controlled where necessary. Where the Company has chosen to incorporate external documents into its management system documentation by reference, then those documents must be available where needed, and must be of the appropriate revision.

It may be helpful to visualize the general structure of management system documentation as portrayed in the diagram below, bearing in mind that detailed arrangements will vary considerably from one Company to another. Controls may be applied at the level of individual

procedures (which may be re-issued as changes arise) or whole manuals (for which minor amendments are accumulated to be included in regular revisions).



There is a balance to be struck between insisting on the control of every piece of paper in every area and excessive reliance on uncontrolled documents. The auditor should adopt a reasonable and practical approach, taking into account the nature of the document, the frequency with which it is likely to change, and the impact of the activity on safety and pollution prevention.

The same control principles apply to electronic documentation: only the means of application are different. There are also some additional considerations such as security of access, backup, virus protection and the reliability of power supplies.

Examples of objective evidence found at the Office and onboard the vessel may include:

- availability of documents & amendments where needed;
- removal & destruction or storage of obsolete documents;
- proper review & approval of documents & amendments;
- accurate identification of documents & revision status;
- the establishment of rules governing the availability and use of uncontrolled documents.

12. COMPANY VERIFICATION, REVIEW AND EVALUATION

ISM Code - paragraph 12.1

12.1 The Company should carry out internal safety audits on board and ashore at intervals not exceeding twelve months to verify whether safety and pollution prevention activities comply with the safety management system. In exceptional circumstances, this interval may be exceeded by not more than three months.

Internal audits are important to demonstrate the effective functioning and continuous implementation of the SMS, both ashore and onboard.

The Company is required to conduct these internal audits of their shore-side offices and each of their vessels to all elements of the ISM Code and of their own respective procedures at least once every 12 months.

The interval should normally not be exceeded and the Company should be able to explain the "exceptional circumstances" under which the audit could not be carried out.

It is also to be noted that when an internal audit interval exceeds the twelve months period (exceptional circumstances) the next scheduled internal audit (twelve months) should not be considered from the date of the last internal audit but from the former internal audit.

The Company should specify competence requirements for their internal auditors. Refer to ISM Code, Section 6.5.

Although Company audits are also based on sampling of procedures, records, corrective action implemented and verified and interviews of personnel ashore and onboard, it would be reasonable to expect the internal audit to be more comprehensive than the audit performed during external ISM Code certification.

Objective evidence is necessary to confirm conformance with the Company’s internal audit procedures, to demonstrate the efficiency of the SMS implementation, continuous improvement of the management system and management’s commitment to the SMS.

Examples of objective evidence found at the office and onboard the vessel may include:

- documented procedures for internal audits and reviews, including specification of competence for internal auditors;
- verification that internal auditor meets competence requirements;
- copies of internal audit reports and master’s and management reviews;
- schedule of planned internal audits, ashore and onboard vessels;
- sampling of corrective action taken and verification of effectiveness.

ISM Code - paragraph 12.2

12.2 The Company should periodically verify whether all those undertaking delegated ISM-related tasks are acting in conformity with the Company's responsibilities under the Code.

The Company which has taken over all the duties and responsibilities foreseen by the Code should provide adequate resources (e.g. technical, financial and human) to ensure that the safety management objectives will be achieved. Delegated ISM-related tasks being carried out by the Company's branch offices or by external entities should be outlined in the SMS.

The Company should verify that all the above involved parties undertaking delegated ISM-related tasks carry out these activities in accordance with established procedures.

The period and methods of verification should be addressed in the SMS manual and procedures.

The ISM Code requires the Company to ensure that:

- all personnel involved in the Company's SMS have an adequate understanding of relevant rules, regulations, codes, guidelines; and

- all personnel have the qualifications, training and experience that may be required in support of the SMS.

Examples of objective evidence may include:

- established procedures for periodical verification for adequate qualification/competence of all personnel delegated ISM-related activities;

- copies of records of delegated ISM-related activities undertaken by all personnel, including external entities;

- copies of records of the periodical verification including evaluation of delegated ISM-related activities.

ISM Code - paragraph 12.3

12.3 The Company should periodically evaluate the effectiveness of the safety management system in accordance with procedures established by the Company.

Internal audits and reviews should be able to demonstrate the Company’s dedication to ensuring that procedures they have established are implemented, effective and resulting in meeting the Company’s established goals and objectives.

At minimum these internal audits and reviews should occur in the office/s and onboard each vessel once every 12 months. This period could be less if internal audits or reviews indicate necessary.

Examples of objective evidence found at the office may include:

- established procedures for internal audits, management review of the SMS and Master’s review of the SMS;

- copies of management review meeting, Master’s review and internal audit reports.

Examples of objective evidence found onboard the vessel may include:

- internal audit performed onboard the vessel;

- Master’s review of the SMS;

- sampling of corrective action of deficiencies identified and verification of effectiveness of the corrective action taken.

ISM Code - paragraph 12.4

12.4 The audits and possible corrective actions should be carried out in accordance with documented procedures.

The Company shall ensure that established procedures are documented and maintained to effectively demonstrate their ability to conduct thorough internal audits and to identify deficiencies during these audits.

These procedures demonstrate the Company's commitment to their SMS and goals and objective established. Internal audits and handling of corrective action also illustrate the Company's commitment for continuous improvement of the SMS implemented onboard and ashore.

Examples of objective evidence found at the office may include:

- documented and maintained procedures for conducting internal audits and handling of corrective action;

- sampling of audit reports and corrective action to ensure Company procedures are being adhered to;

- internal audit reports reflect the real situation and is confirmed by external audits/inspection such as class, port state, vetting.

Example of objective evidence found onboard the vessel may include:

- maintenance of the established procedures regarding internal audits and corrective action;

- sampling of corrective action or deficiencies identified and disposition thereof;

- internal audit reports reflect the real situation as observed by the external auditor and various external audits/inspection such as class, port state, vetting.

ISM Code - paragraph 12.5

12.5 Personnel carrying out audits should be independent of the areas being audited unless this is impracticable due to the size and nature of the Company.

As a general rule "independent" means not auditing areas or activities for which you are responsible. This is also seen to be a conflict of interest.

For example, the Designated Person should not be allowed to audit himself or his department.

Likewise, on board a vessel the ship's crew should not be allowed to audit themselves on board. It is felt that this type of audit would not be effective as they are responsible for the vessel and it's operation and could be protective of their position.

For example, the Master or the Chief Engineer should not be auditing the Engine Department nor the Master or the Chief Officer auditing the deck Department.

Examples of objective evidence found in the office and onboard may include:

- procedures detailing audit process and the assignment of independent auditors.

ISM Code - paragraph 12.6

12.6 The results of the audits and reviews should be brought to the attention of all personnel having responsibility in the area involved.

Internal and external audit results should be the topic of a management meeting. This meeting should include the top management personnel. By reviewing the results from the audits management should be able to determine the effectiveness of the SMS and is it meeting the objectives and goals management have established.

Also, results from audits should be discussed within the department and onboard the vessel audited. This allows the department and vessel realize where continual improvement is required and where specific activities are meeting their objectives.

Examples of objective evidence found in the office may include:

- documented procedure on the management review meeting;
- copies of the internal and external audit reports;
- disposition of non-conformances identified;
- action taken to management review.

Examples of objective evidence found onboard the vessel may include:

- copies of the internal and external audit report conducted;
- status of non-conformances identified;
- copies of the Master's review of the SMS;
- relevant information from management review (it is not required to copy the management review to the vessel).

ISM Code - paragraph 12.7

12.7 The management personnel responsible for the area involved should take timely corrective action on deficiencies found.

Corrective action should be initiated as soon as possible for any deficiencies identified during either Master's review, Management Reviews, internal and external audits.

Timely corrective action allows personnel time to evaluate the action applied to a deficiency and to determine its effectiveness. Not taking timely corrective action allows a deficiency to exist longer than necessary and could lead to a breakdown of the SMS, it's effectiveness and possibly unsafe conditions.

Corrective action should be completed within time frames established. Verification of the corrective action to an identified deficiency is to ensure that the corrective action taken was and is indeed effective.

Examples of objective evidence found in the office may include:

- documented procedure for how the Company is to deal with deficiencies identified;

- assignment of corrective action and status of the corrective action applied;

- follow up to corrective action to ensure effectiveness.

Examples of objective evidence found onboard the vessel may include:

- status and disposition of non-conformances identified from previous internal, external audits and Master's review;

- method for verification of corrective action on board and its effectiveness.

PART B – CERTIFICATION AND VERIFICATION

For certification and verification, further reference should be made to the Part B of ISM Code, Revised Guidelines on the Implementation of the International Safety Management (ISM) Code by Administrations (IMO Resolution A. 1118(30)) and “Procedural Requirements for ISM Code Certification” (BCS-PR 9).

Annex 1

Guidance on Duration of Audits

The table determines the durations of ISM Code verification, which take into account that there could be variations depending on each Company or ship. One manday is 8 hours. The verification does not include document review. Sufficient time should be allowed for document review as necessary.

		MINIMUM AUDIT DURATION	
COMPANY			
small (up to 20 employees *)		1	
medium (between 21 and 50 employees)		2	
large (more than 50 employees)		2	
* number of relevant employees who carry out or have responsibility to the Safety Management System of the Company ashore			
	INITIAL VERIFICATION	**PERIODICAL VERIFICATION**	**RENEWAL VERIFICATION**
SHIP			
Category I			
passenger ships carrying 1500 passengers and above	2	2	2
Category II			
passenger ships and high speed craft carrying 300 passengers and above	2	1	2
Category III			
oil tankers, gas carriers, bulk carriers and other cargo ships of 500 grt and above and	1	1	1
Category IV			
mobile offshore drilling units (MODU) of 500 grt and above	1.5	1.5	1.5

Annex 2

Guidance - Companies and Vessels Operated by Owners-Masters

1. General

Purpose

There are a number of features peculiar to single ship, owner-master Companies that require special consideration when verifying compliance with the ISM Code. The purpose of this guidance is to establish a BCS approach to the assessment of the safety management system of these Companies.

The preamble of the code states that no two Companies are the same and the code is based on general principles and objectives, the code is expressed in broad terms so that it can have a wide-spread application, and that the cornerstone of good safety and pollution prevention is the commitment competence and motivation of individuals at all levels.

Background

The owner-master ship may not have any shore based organisation and this could give rise to problems of interpretation of the Code. The following sections of the code state or imply that the Company has a shore based organisation:

2.2 – The policy is implemented and maintained at all levels of the organisation both, ship based and *shore-based*.

3.3 – adequate resources and *shore-based* support are provided

4 – Designated person … to provide a link between the Company and those onboard…. And that adequate resources and *shore-based* support are applied…

5 – Master's responsibility and authority

5.1.5 – reviewing the SMS and reporting it deficiencies to the *shore-based* management.

5.2 – ….request the Company's *assistance* as may be necessary.

8.3 – ….the *Company's organisation* can respond at any time to hazards, accidents and emergency situations *involving it ships.*

9.1 – …non-conformities, accidents and hazardous situations are *reported to the Company*,…..

12 – Internal audits and system reviews

13 – Company DOC and shipboard SMC

The wording of the above requirements is based on the assumption that there will be a separation of roles and responsibilities that is impracticable in single-ship, owner-master operations.

Meeting the Code requirements

There are three approaches that the single ship operator or owner-master can adopt to ensure compliance with the Code's requirements:

1. to assign two or more roles to the same person,

2. to employ outside contractors to fulfil the role of designated person, internal auditor or shore based system administrator, for example, or

3. a combination of 1 & 2 above.

Whatever solution the Company may choose it should ensure effective operational and administrative control. It is the effectiveness of the solution rather than the location (ship or shore-based) of the involved personnel that is important. For example, effective reviews of the safety management system (SMS) may be carried out, and deficiencies identified, analysed and corrected, even though the entire process may be administered by the master, with no shore-based involvement.

Designated Person

The critical function of the Designated Person is to ensure that the safety and pollution prevention aspects of the operation of the ship are being effectively monitored, not the fact that the code refers to this as a shore-based position. Consequently, the owner-master may act as the designated person. The owner is the highest level of management and therefore responsible for the application of adequate resources, and may ensure adequate shore based support by, for example, establishing communications and contingency arrangements with agents or other third parties.

Emergency response

A dedicated shore based organisation is not necessarily required to ensure that Company can respond at any time to emergency situations onboard the ship. Again the effectiveness of the solution is the key issue. The emergency response plans should cover all identified potential emergency situations. The plans should include how outside assistance can be obtain i.e. Port State emergency response centres, salvage tug contractors, spill clean-up contractors etc.

The emergency plans should ensure that the shore based emergency organisations can readily obtain current crew details. The agents at the ships sailing and departure ports could be involved in this process.

Internal Audits

The Code aims for independent personnel in this function "unless this is impracticable due to the size and the nature of the Company." Experience shows that the risk for an ineffective audit will increase with the lack of independence and it is encouraged that Company should employ an external contractor for this purpose. However, most important is to verify that the chosen solution is effective, i.e. the internal audit is effective in ensuring that the SMS is implemented.

Documentation

Provision should be made for the remote back-up of computer systems and files, and the retention ashore of copies of important documents. Examples include current crew list with next of kin details, copies of charter parties, H & M Insurance, P & I cover etc.

Handling of outside contractors

Formalised procedures for selection of contractors are not required, but when a Company uses outside contractors the following factors should be considered:

1. the precise nature of the contractual relationship with the contractor, including any obligations imposed on the Company;

2. the basis on which the choice of contractor was made;

3. the suitability of the contractor to undertake the assigned roles;

4. the timeliness, frequency, completeness and effectiveness of the communications between the contractor and the Company.

The Company may not be the only client of the contractor, and the provision of such services may not be the contractor's only activity. It is therefore, important to ensure that the contractor is dedicating sufficient time and resources to filling the specified commitments to the Company, and that the Company is able to contact the contractor when necessary. It is encouraged that contractor is audited or otherwise controlled by the Company to ensure contractor is meeting obligations set forth by the Company.

2. Auditor's Guidance

ISM Code Elements 1 & 2:

Usually the objectives and the policy are orientated on long-term perspectives in order to keep the family business running; i.e. owners-masters are people-orientated and have an own interest in maintaining the vessel in excellent condition (exemptions possible!).

Instructions and procedures might be kept relatively short, but must be comprehensive enough that also a relief master and/or new crewmembers receive adequate information about the SMS.

ISM Code Element 3:

All ISM relevant functions of the master (e.g.: managing director, superintendent, crewing manager, designated person, Company security officer) must be clearly described. Although an official shore-based organization is not required, if all relevant tasks can be taken over by the master and relevant contacts can be made from the vessel (contact lists to be available), shore-based support is usually available through agents, charterers, brokers, consultant, P&I Club and family members. The contractual relationship and the role of this support have to be defined in the ISM-manual.

The owner-master may act as the DPA and MD in one person, provided that he can demonstrate that the safety and pollution prevention aspects of the operation of his ship are being monitored effectively. As the owner, representing the highest level of management, he is responsible for the application of adequate resources, and may ensure adequate shore-based support by, for example, establishing communications and contingency arrangements with agents or other third parties.

ISM Code Element 4:

It is fully acceptable if the role of the designated person is covered by the owner-master.

The owner-master may act as the DP provided that he can demonstrate that the safety and pollution prevention aspects of the operation of his ship are being monitored effectively. As the owner, he is the highest level of management, he is responsible for the application of adequate resources, and may ensure adequate shore-based support by, for example, establishing communications and contingency arrangements with agents or other third parties.

Where the Company has chosen to employ outside contractors, a number of additional factors need to be considered:
i) the precise nature of the contractual relationship with the contractor, including any obligations imposed on the Company;

ii) the bases on which the choice of contractor was made;

iii) the suitability of the contractor to undertake the assigned roles;

iv) the timeliness, frequency, completeness and effectiveness of the communications between the contractor and the Company.

The Company may not be the only client of the contractor, and the provision of such services may not be the contractor's only activity. It is, therefore, important to verify that the contractor is dedicating sufficient time and resources to fulfilling his commitments to the Company, and that the Company is able to contact the contractor when necessary.

In some cases, the ship will be the Company's only "site", and provision will need to be made for the remote back-up of computer systems and files, and the retention ashore of copies of important paper documents.

ISM Code Element 5:

A master's review of the SMS in addition to the management review, is not required.
A statement regarding the overriding authority of the master makes no sense for a owner-master himself, but of course such a statement must be available for a potential relief master.

ISM Code Element 6:

Quite often long standing crew members (having fulfilled many contracts for the same owner-master) are engaged; in such a case appraisal / crew ability reports are not necessarily required – as the work performance is known.
Familiarization protocols should only be used for new crew members.

On many ships operated by owner-master only 2 licensed bridge watch keepers are on board (respectively 2 persons for the supervision of cargo works); thus the auditor might pay special attention for compliance with minimum rest hours (STCW'78, A-VIII / 1).
On the other hand, the respective vessels quite often have considerable long port stays with no cargo works at night time and/or weekends.

ISM Code Element 7:

Operational plans, instructions, procedures and checklists could be kept to a minimum, but must be sufficient as guidance for the relief master and new personnel.

ISM Code Element 8:

If a shore-based contact is available, at least one emergency drill per year should include involvement of the shore-based support.

ISM Code Element 9:

Although it might appear in-practicable if the owner-master is reporting to himself, failures, accidents, etc. should be stated in writing and are to be analyzed.
However, if the system is running well, the reports might be kept to a minimum number.

ISM Code Element 10:

Reports from shore based superintendents are off course not required. However onboard inspections and maintenance activities are to be recorded.

ISM Code Element 11:

Provision should be made for the remote back-up of computer systems and files, and the retention ashore of copies of important paper documents.

ISM Code Element 12:

Internal audits could for example be carried out by the relief master.
However, in order to achieve full independency, it is advisable that the internal audits are carried out by a third party contractor.
The evaluation and review of the system could be combined with the internal audit (if a respective review statement is performed and signed by the owner).

3. The Audit Process

As the ship is the Company's only site, the auditor would have to conduct the Office Audits on the Ship. Whilst the office audit might overlap with the Intermediate Shipboard Audit, the auditor is however required to prepare separate audit documentation for office and ship.

For the office part of the audit, emphasis should be given to the specific requirements of the Code applicable mainly to the shore organization such as:

- S+E Policy;
- Responsibility and Authorities applicable to the key functions incl. Master and DPA;
- procedures covering element 12 of the Code.

Where found necessary by the auditor and/or requested by the Company, third party locations/outside contractors may be included in the audit.

Document of Compliance / Safety Management Certificate

Where the ship is be the Company's only "site," the ship cannot be given as the address on the DOC. In these cases, the address may be the Master's home address as communicated to the flag State, or that of an agent or other representative such as a bank, lawyer or a contracted Designated Person.

Annex 3

The Relationship between ISM Code & STCW

Training

The largest portion of the STCW addresses the requirements for training, verification, and certification of seafarers. Responsibility for seafarer certification rests with the flag Administrations, and is not the responsibility of the Companies. This clearly eliminates the Company's responsibility for many of the requirements of the STCW.

The Company, however, carries responsibilities relevant to seafarer training. The Company's responsibilities in this area fall into two categories:

1. those related to the certification of seafarers; and

2. training pertinent to the responsibilities imposed by the ISM Code.

Category 1:

Verification requirements fall under the responsibility of flag Administrations. Flag Administrations are responsible for requiring and verifying that seafarer training relevant to certified qualifications is performed within a quality system. In so far as some Companies may provide training relevant to seafarer qualification and certification, they fall under this regime. These verification activities may be delegated to recognized organisations, but do not fall under the context of ISM Code verification activities.

Category 2:

Responsibilities fall under the verification regime associated with the ISM Code. They are documented in Regulation 1/14, and Section A 1/14 of the STCW Code. Appropriate guidance is provided in Section B 1/14 of the STCW Code but is not mandatory. BCS may consider Section B 1/14 to provide "auditor guidance" relevant to what they might encounter in an audit.

Watchkeeping

The Company is responsible for proper watchkeeping practices. They are documented in Regulation VIII, and Section A-VIII of the STCW Code regarding watchkeeping. Appropriate guidance is provided in Section B VIII of the STCW Code but is not mandatory. BCS may consider Section B VIII to provide "auditor guidance" relevant to what they might encounter in an audit.

Additional consideration

BCS is to have an understanding of the process and documentation of recognition of certificates contained in Reg. I/2.5.

BCS is to verify that seafarers have appropriate certification relevant to required emergency, occupational safety, medical care and survival functions. The requirements for this certification are detailed in Chapter VI of the amended annex to the convention and corresponding section of the STCW Code.

Annex 4

Treatment of FPSO's, FSU's etc. with respect to ISM Code Certification

Operations should be evaluated against the following four situations when deciding whether the ISM Code applies:

1. The vessel disconnects from the mooring system at regular intervals to proceed under its own power to a discharge port. In this case, SOLAS and the ISM Code apply.

2. The vessel has the ability to disconnect from the mooring system, and will do so for meteorological or security reasons. SOLAS may apply in these circumstances. If so, it may be possible for the operator to obtain an exemption from the flag Administration.

3. The vessel disconnects from the mooring system and proceeds under its own power to a dry-dock or repair berth, for survey or repair, at very infrequent intervals, perhaps every five or ten years. In this case, it is likely that the administration and the operator will have reached agreement on the particular arrangements to be made when this occurs.

4. The vessel can be disconnected from the mooring system, but has no independent means of propulsion. Disconnection occurs only when repairs are needed that require that the unit be towed to a repair yard. SOLAS and ISM Code will not apply in this case.

In some parts of the world, a safety case regime may be in operation that requires the operating company to have developed a risk-based safety management system covering the operation of the oil field as a whole, including the vessel. The Company may have addressed the requirements of the ISM Code by combining the existing risk-based safety management system in conjunction with a bridging document which addresses requirements of the ISM Code that are additional to those specified by the risk-based system.

Any regulatory requirements imposed by the relevant coastal State authorities must also be taken into account by the operator.

However, despite this general guidance, the final responsibility for deciding whether the ISM Code applies, lies with the flag and coastal States. Where there is any doubt, the vessel's operator should contact both states in order to obtain a decision.

Annex 5

Guidelines for SMC, ISSC and MLC expiration dates alignment

1. Preamble

These Guidelines contain the recommendations applicable when a Company requests alignment of the expiry dates of the Safety Management Certificate, the International Ship Security Certificate and the Maritime Labour Certificate.

2. Definitions

2.1 “Alignment” means aligning the expiry dates of certificates, SMC, ISSC and MLC.

2.2 “Aligned audits/inspection” means ISM and ISPS audits as well as MLC inspection conducted in conjunction with each other when a Company requests alignment.

2.3 “Adjusted Certificate” is the certificate or certificates, either SMC and/or ISSC and/or MLC, which will have its expiration date adjusted so as to achieve alignment.

3. Conducting aligned audits/inspection

3.1 When the Company selects a single Society to provide aligned audits/inspection:

.1 the lead auditor must be qualified as Marine Management Systems Auditor, in accordance with the requirements of BCS-PR 10 and as Inspector, in accordance with the requirements of BCS-PR 10B;

.2 the Society must be authorized to conduct the ISM Code audit, ISPS Code audit and MLC, 2006 inspection by the flag Administration;

.3 TCMS apply as appropriate and in accordance with BCS-PR 18 and BCS-PR 36;

.4 all elements of the ISM Code and/or ISPS Code and/or of MLC, 2006 shall be covered in the aligned audits/inspection relative to the adjusted certificate(s);

.5 results of the aligned audits/inspection shall be documented and reported separately and in accordance with BCS-PR 9, BCS-PR 24 and BCS-PR 40.

3.2 Any change in the expiration date of the adjusted certificate requires a full renewal verification to be carried out, unless the expiration date of the adjusted certificate(s) is(are) moved backwards and provided that the adjustment does not circumvent any audit/inspection due or coming due at the time that the adjustment is completed.

4. Aligned SMC, ISSC and MLC through aligned audits/inspection

4.1 Upon successful completion of the alignment, the new adjusted certificate(s) is (are) to be issued.

Annex 6

Guidance on Interim Audits

Introduction

Clause 14.4 of the ISM Code states:

An Interim Safety Management Certificate may be issued following verification that:

.1 the Document of Compliance, or the Interim Document of Compliance, is relevant to the ship concerned;

.2 the safety management system provided by the Company for the ship concerned includes key elements of this Code and has been assessed during the audit for issuance of the Document of Compliance or demonstrated for issuance of the Interim Document of Compliance;

.3 the Company has planned the internal audit of the ship within three months;

.4 the master and officers are familiar with the safety management system and the planned arrangements for its implementation;

.5 instructions, which have been identified as being essential, are provided prior to sailing; and

.6 relevant information on the safety management system has been given in a working language or languages understood by the ship's personnel.

The period of interim certification is to allow for the special transitional arrangements when a ship is newly delivered, new to a Company, or is changing flag and to permit the ship to be operated under the new, or revised, Safety Management System (SMS) for a period of time so that sufficient objective evidence (e.g., records) is available for an auditor to evaluate the effective functioning, over time, of the SMS. It is not the purpose of the period of interim certification to give the Company time to introduce its SMS or time for shore-side and shipboard personnel to become familiar with, and develop competence, in its implementation.

The scope of an interim verification audit is defined by the Code and will vary to some degree depending upon whether the vessel is being newly delivered, is new to a Company, or is changing flag. Also, for practical reasons, an interim verification cannot be as extensive as an initial audit. Nevertheless, there is much that an auditor can do within the specified scope to test the readiness and, to some degree, the early implementation of the SMS.

A Company's SMS is to be fully and effectively implemented when the ship enters into service under one of the special transitional arrangements cited above. Interim certification was introduced because it takes time to generate evidence of implementation, not because it takes time to put the system into operation. It was not intended to serve as a licence to operate a ship that is not in full compliance with national and international requirements during the period leading up to the initial audit. Port state control authorities and flag States make no distinction between the level of implementation expected during the interim period and that expected under full certification. The consequences of any deficiencies for the Company and the RO are the same.

Guidance on the Conduct of Shipboard Interim Verifications

The following guidance is intended to assist auditors in carrying out shipboard interim verification audits:

1. Depending on the circumstances under which a ship is presented for an interim verification, it may already be engaged in some operations for which evidence of compliance with requirements will be available through direct observation, interview or the examination of the corresponding records. For example, activities such as loading, discharging, ballasting, bunkering and fuel oil transfer may be taking place and may be audited. The current loading condition and stability calculations can be audited. If crew members have been on board for some time receiving the ship or preparing to sail, records of hours of work and rest should be available. Chart corrections might have been made and the forthcoming voyage might have been planned.

   The less time that has elapsed since delivery, the less evidence will be available of past or current operations and activities. Even so, the objective is to verify the Company's commitment to safety and environmental protection and the effective implementation of its SMS.

2. Internal and external documents should already be fully controlled. All documented procedures, instructions, checklists and forms must be readily available at the locations in which they are to be used. The auditor should verify that they are appropriate for the ship type and are applicable to that ship in particular. Charts, nautical publications, technical manuals and drawings must have been provided. Flag State publications must be on board.

3. Testing of the familiarisation of the master and the officers with the SMS should not be restricted to their ability to identify the system documentation and to locate elements within it. They should be able to demonstrate knowledge and understanding of the activities and procedures for which they are responsible, especially those that are already in progress and emergency situations that could occur at any time in the current circumstances.

   For example, and as appropriate to their roles and responsibilities: Can they operate the emergency generator and the emergency fire pump? Can they operate the oil-water separator? Do they know, or can they locate quickly, the emergency contact details for the Company and for the emergency services?

4. Other crew-members should be interviewed to check that they have been thoroughly familiarised with their duties and the use of tools and equipment they may be expected to operate. Because less time is spent on sampling operational activities and records, more time should be spent on interviews. Particular attention should be paid to the ability of the ship's personnel to communicate with each other and their understanding of written procedures and spoken instructions.

5. Plans should exist for ship and ship/shore exercises and drills. Crew members must be thoroughly familiar with their roles in all of the potential emergency situations identified within the system. They must be able to quickly locate, and use effectively, the corresponding life-saving, fire-fighting and other emergency equipment. If time permits, the auditor may witness a drill or exercise.

6. Accessible parts of the ship relevant to its operation should be visited. Where time and circumstances have allowed, there should be evidence to show that identified technical deficiencies, structural defects or problems associated with house-keeping and hygiene

have been reported and that action is being taken to rectify them. Where appropriate, the class society or the flag Administration should have been notified.

7. A maintenance system should have been established and should be audited to verify that the corresponding databases have been prepared for use with maintainable items, including life-saving and fire-fighting appliances. Inspection routines, defect reporting procedures and mechanisms for the control and ordering of spare parts should be in place and audited together with any records already produced. If the ship is changing from one management Company to another, the crew may be carrying out remedial or outstanding maintenance tasks. Examples and evidence gathered during visits to other parts of the ship should be used to test the effectiveness of the system. This element of an interim verification is especially important given the frequency with which inadequate maintenance is given as a reason for detention.

8. Checks should be made of class and statutory certificates and records, the continuous synopsis record and the qualifications and medical fitness certifications of the crew.

9. Audit planning on board should take account of the time needed to carry out a thorough interim verification.

In summary, a ship's SMS is to be effectively implemented in order for an Interim Safety Management Certificate to be issued. The extent to which the auditor is able to verify compliance with the provisions of the ISM Code and the Company's SMS requirements will depend on the circumstances in each case. Nevertheless, when auditing for the issuance of an Interim SMC, the auditor should verify, in so far as is practicable, on a sampling basis, that the ship's SMS is effectively implemented.

BCS-G42 Guidelines for Use of Remote Inspection Techniques for surveys

1. General

1.1 Definitions

Remote inspection techniques may include the use of:

- Divers
- Unmanned robot arm
- Remote Operated Vehicles (ROV)
- Climbers
- Drones
- Other means acceptable to BCS.

1.2 When permitted remote inspection technique may be used to facilitate the required external and internal examinations, including close-up surveys and gauging.
The methods applied for remote inspection technique are to provide the survey results normally obtained for/by the Surveyor.
The results of the surveys by remote inspection techniques when being used towards the crediting of surveys are to be acceptable to the attending Surveyor. Inspections should be carried out in the presence of the Surveyor.

1.3 Confirmatory surveys/close-up surveys may be carried out by the Surveyor at selected locations to verify the results of the remote inspection technique.
Confirmatory thickness measurements may be requested by the attending Surveyor appropriately.

An inspection plan for the use of remote inspection technique(s), including any confirmatory survey/close-up survey/thickness measurements, is to be submitted for review and acceptance in advance of the survey.

2. Conditions

2.1 Use of remote inspection technique may be restricted or limited where there is a record or indication of abnormal deterioration or damage to structure or to items to be inspected.
The remote inspection technique may not be applicable if there are recommendations for repairs.
It may also be inapplicable if conditions, affecting the class of the vessel, are found during the course of the inspection.
If the remote inspection technique reveals damage or deterioration that requires attention, the Surveyor may require close-up survey/thickness measurements without the use of remote inspection technique to be undertaken.

3. Procedures

3.1 The inspection is to be carried out by a qualified technician with adequate knowledge of the items to be inspected.
Prior to the commencement of surveys, a pre-meeting should be held between the technician(s), the owner's representative(s) and the attending Surveyor(s) for the purpose to ascertain that all the arrangements detailed in the inspection plan are in place, so as to ensure the safe and efficient conduct of the inspection work to be carried out.

3.2 Means of thickness gauging and non-destructive testing may be required in conjunction with the use of remote inspection technique.

3.3 Items to be examined using remote inspection technique are to be sufficiently clean to permit meaningful examination.

3.4 Visibility is to be sufficient to allow for a meaningful examination.

BCS-G46 Guidance and Information on Bulk Cargo Loading and Discharging to Reduce the Likelihood of Overstressing the Hull Structure

1 Introduction
1.1 Factors Contributing to Hull Structural Failure
1.2 Actions Taken by IACS
1.3 Aims of This Publication

2 Loads and Hull Structure
2.1 Typical Bulk Carrier Structural Configuration
2.2 Design Limitations
2.2.1 General
2.2.2 Hull Girder Shear Forces and Bending Moments
2.2.3 Local Strength of Transverse Bulkhead, Double Bottom and Cross Deck Structure
2.3 Cargo Distributions Along Ship's Length
2.3.1 General
2.3.2 Homogeneous Hold Loading Conditions (Fully loaded)
2.3.3 Alternate Hold Loading Conditions (Fully loaded)
2.3.4 Block Hold Loading and Part Loaded Conditions
2.3.5 The change of weight distribution arising from fuel and ballast water

3 Onboard Loading Guidance Information
3.1 Loading Manual
3.2 Loading Instrument

4 Planning and Control of Cargo Loading and Unloading Operations
4.1 Preparation for Cargo operations
4.1.1 Cargo and Port Information
4.1.2 Devising a Cargo Stowage Plan and Loading/Unloading Plan
4.1.3 Ship/Shore Communication Prior to the Commencement of Cargo Operations
4.1.4 Before Commencing Cargo Operations
4.2 Monitoring and Controlling Cargo Operations
4.2.1 Monitoring of Stevedoring Operation
4.2.2 Monitoring the Ship's Loaded Condition
4.2.3 Hull Damage Caused by Cargo Operations

5 Potential Problems
5.1 Deviation from the Limitations Given in the Approved Loading Manual
5.2 Loading Cargo in a Shallow Draught Condition
5.3 High Loading Rates
5.4 Asymmetric Cargo and Ballast Distribution
5.5 Lack of Effective Ship/Shore Communication
5.6 Exceeding the Assigned Load Line Marks
5.7 Partially Filled Ballast Holds or Tanks
5.8 Inadequate Cargo Weight Measurement During Loading
5.9 Structural Damage During Loading/Unloading

6 Ballast Exchange at Sea

1. Introduction

1.1 Factors Contributing to Hull Structural Failure

As a result of concern regarding the high casualty rate of single side skin dry bulk carriers and the associated loss of life and cargo in the early 90s, where structural failure may have been a contributory factor, the International Association of Classification Societies (IACS) carried out comprehensive investigations in order to identify the likely causes of these ship casualties and introduced measures to minimise their recurrence.

The evidence available indicates that a majority of the ships lost were over 15 years of age and were predominantly carrying iron ore at the time of loss. The investigations identified that the principal factors contributing to the loss of these ships were corrosion and cracking of the structure within the cargo spaces. Other factors which could have contributed to the hull structural failure were over-stressing of the hull structure due to incorrect loading of the cargo holds and physical damage to the side structure during cargo discharging operations.

1.2 Actions Taken By IACS

To minimise the possibility of further casualties occurring on dry bulk carriers, a number of actions have already been implemented by the IACS Member Societies and ongoing work is being carried out which will bring further enhancements to the safety of these ships. The following list of actions have been implemented by IACS Member Societies. The results of the ongoing work will be made available to all interested parties in due course.

1991

The introduction of corrosion protection coating requirements for all salt water ballast spaces for new ships.

1992

Publication of the IACS brochure, 'Bulk Carriers: Guidance and Information to Shipowners and Operators', with the intention of advising the shipping community with regard to the potential problems of this ship type.

1993

The introduction of minimum thickness requirements for the webs of side shell frames in cargo areas for new ships.

The introduction of corrosion protection coating requirements for side shell structure and transverse bulkheads in all cargo hold spaces for new ships.

The introduction of more rigorous survey requirements. The implementation of the Enhanced Survey Programme (ESP) for bulk carriers by all IACS Member Societies at the first annual, intermediate or special survey from July 1993.

1994

Publication of the IACS Manual, 'Bulk Carriers: Guidelines for Surveys, Assessment and Repair of Hull Structures', providing guidance to surveyors of IACS Member Societies and other interested parties involved in the survey, assessment and repair of hull structures for bulk carriers.

1995

An implementation date of not later than 1st July 1997 has been agreed upon for the requirement that all existing bulk carriers of 150 metres in length and greater are to be fitted with an approved loading instrument.

1996

The introduction, as of January 1997, of an accelerated Enhanced Survey Program of the cargo holds of existing single skin bulk carriers which are 10 years of age or older, of 150 metres length or greater, and which have not commenced an enhanced special survey.

Improvements in the Enhanced Survey Program for all existing bulk carriers of 10 years of age or older which will further enhance close-up surveys and thickness measurements at annual, intermediate and special surveys.

The review of the requirements for loading instruments.

2005

The Common Structural Rules for Bulk Carriers (CSR-BC) were unanimously adopted by the IACS Council for implementation on 1 April 2006. The Rules were based on sound technical grounds, and achieved the goals of more robust and safer ships.

2015

IACS decided to harmonise the Common Structural Rules for Oil Tankers (CSR-OT) and the Common Structural Rules for Bulk Carriers (CSR-BC) in a single set of Rules "Common Structural Rules for Bulk Carriers and Oil Tankers" (CSR BC & OT) comprising of two parts; Part One gives requirements common to both Bulk Carriers and Double Hull Oil Tankers and Part Two provides additional specialised requirements specific to either Bulk Carriers or Double Hull Oil Tankers.

1.3 Aims of This Publication

IACS Member Societies and other parties involved in bulk cargo shipping are concerned with the possible damage and loss of bulk carriers carrying heavy cargoes. Of particular concern are the potential problems which may result during operations such as the introduction of very high capacity loading systems, lack of communication between ship and terminal and inadequate planning of cargo operations. It is also of concern to IACS Members that some seafarers, and ship and cargo operators do not have a clear understanding of the limitations imposed by the ship's classification society regarding the strength capability of the hull structure.

IACS considers that a positive step must now be taken to provide adequate guidance and information to all parties involved in the loading and unloading of dry bulk carriers so that there is an awareness and better understanding of the possible problems that may be encountered. To serve this purpose, it is the intention of IACS to make this publication available to all shipowners, ship masters, ship and cargo terminal operators and other interested parties worldwide.

2. Loads and Hull Structure

2.1 Typical Bulk Carrier Structural Configuration

The most widely recognised structural arrangement identified with bulk carriers is a single deck ship with a double bottom, hopper tanks, single skin transverse framed side shell, topside tanks and deck hatchways. For guidance on the structural terminology adopted in this publication, a typical structural arrangement of a bulk carrier cargo hold space is illustrated in Figure 1. In addition, a typical transverse section in way of a cargo hold and a longitudinal section of a typical corrugated transverse watertight bulkhead are illustrated in Figures 2 and 3 respectively.

Bulk carrier design does not alter significantly with size; fundamentally, a bulk carrier of 30,000 tonnes deadweight usually has the same structural configuration as that of a ship of 80,000 tonnes deadweight.

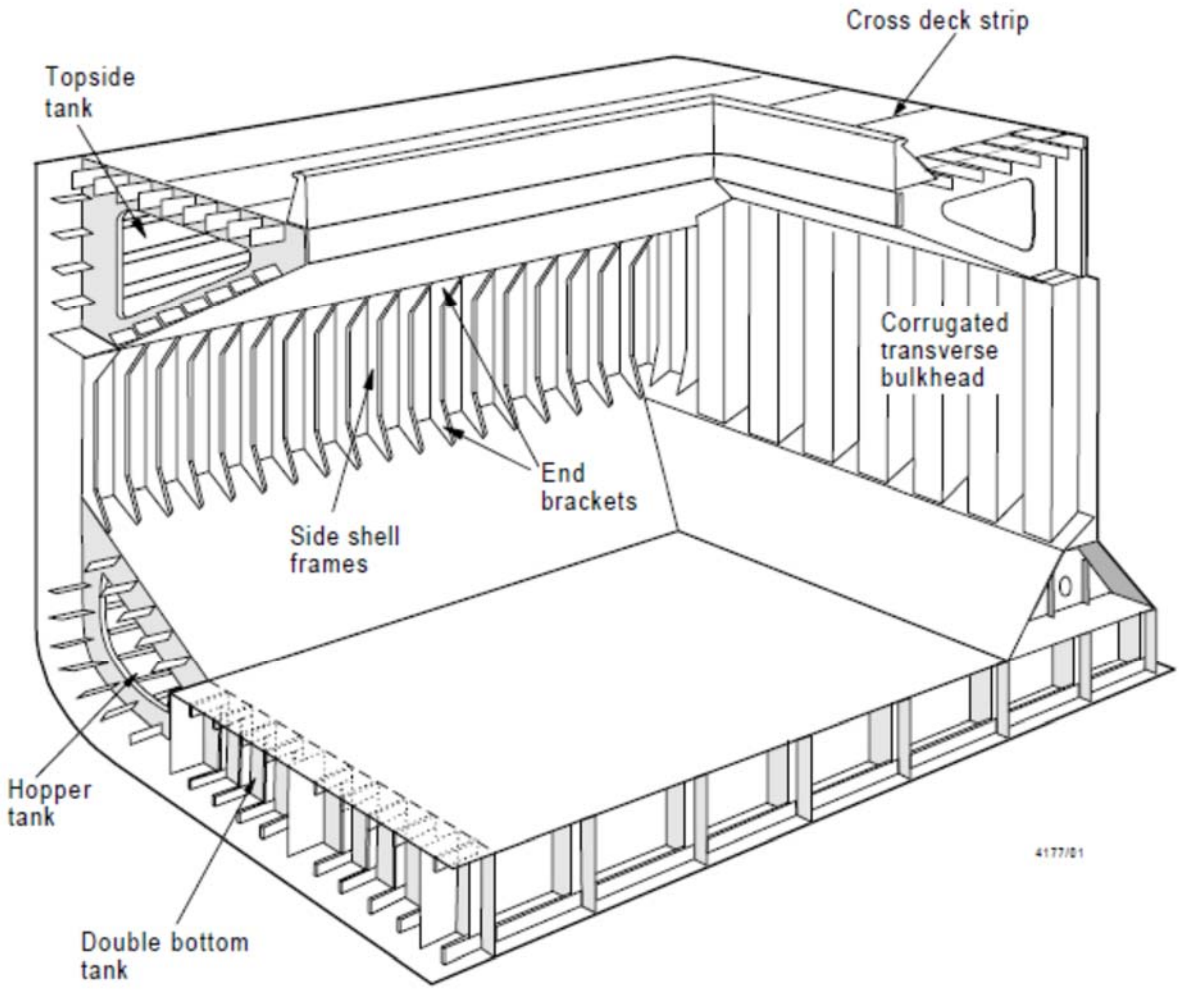


Figure 1: Typical Cargo Hold Structural Configuration for a Single Side Skin Bulk Carrier

In general, the plating comprising structural items such as the side shell, bottom shell, strength deck, transverse bulkheads, inner bottom and topside and hopper tank sloping plating provides local boundaries of the structure and carries static and dynamic pressure loads exerted by, for example, the cargo, bunkers, ballast and the sea. This plating is supported by secondary stiffening members such as frames or longitudinals. These secondary members transfer the loads to primary structural members such as the double bottom floors and girders or the transverse web frames in topside and hopper tanks, etc. see figure 2.

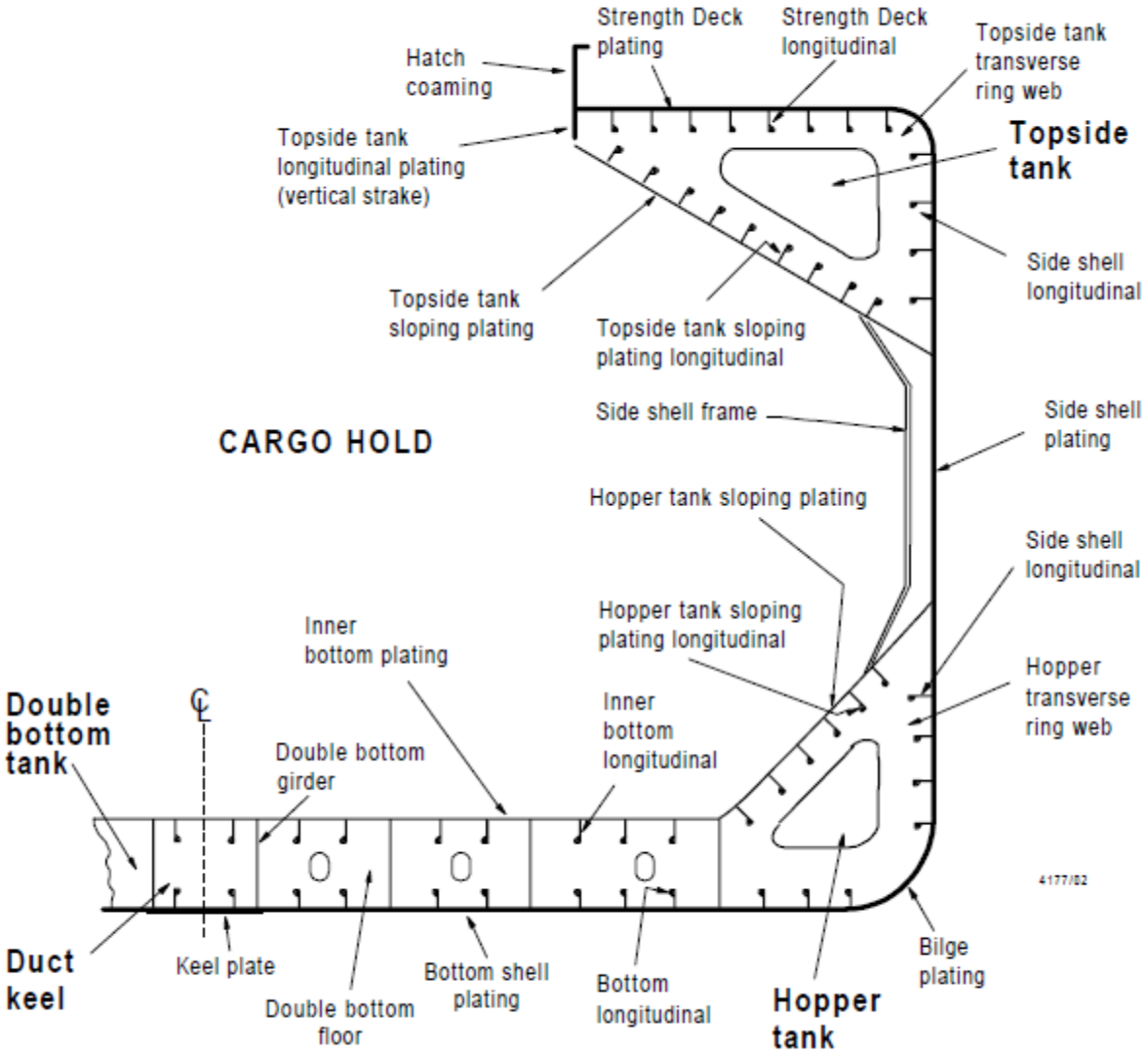


Figure 2: Nomenclature for Typical Transverse Section in way of a Cargo Hold

The transverse bulkhead structures, including its upper and lower stools, see figure 3, together with the cross deck and the double bottom structures are the main structural members which provide the transverse strength of the ship to prevent the hull section from distorting. In addition, if ingress of water into any one hold has occurred, the transverse watertight bulkheads prevent progressive flooding of other holds.

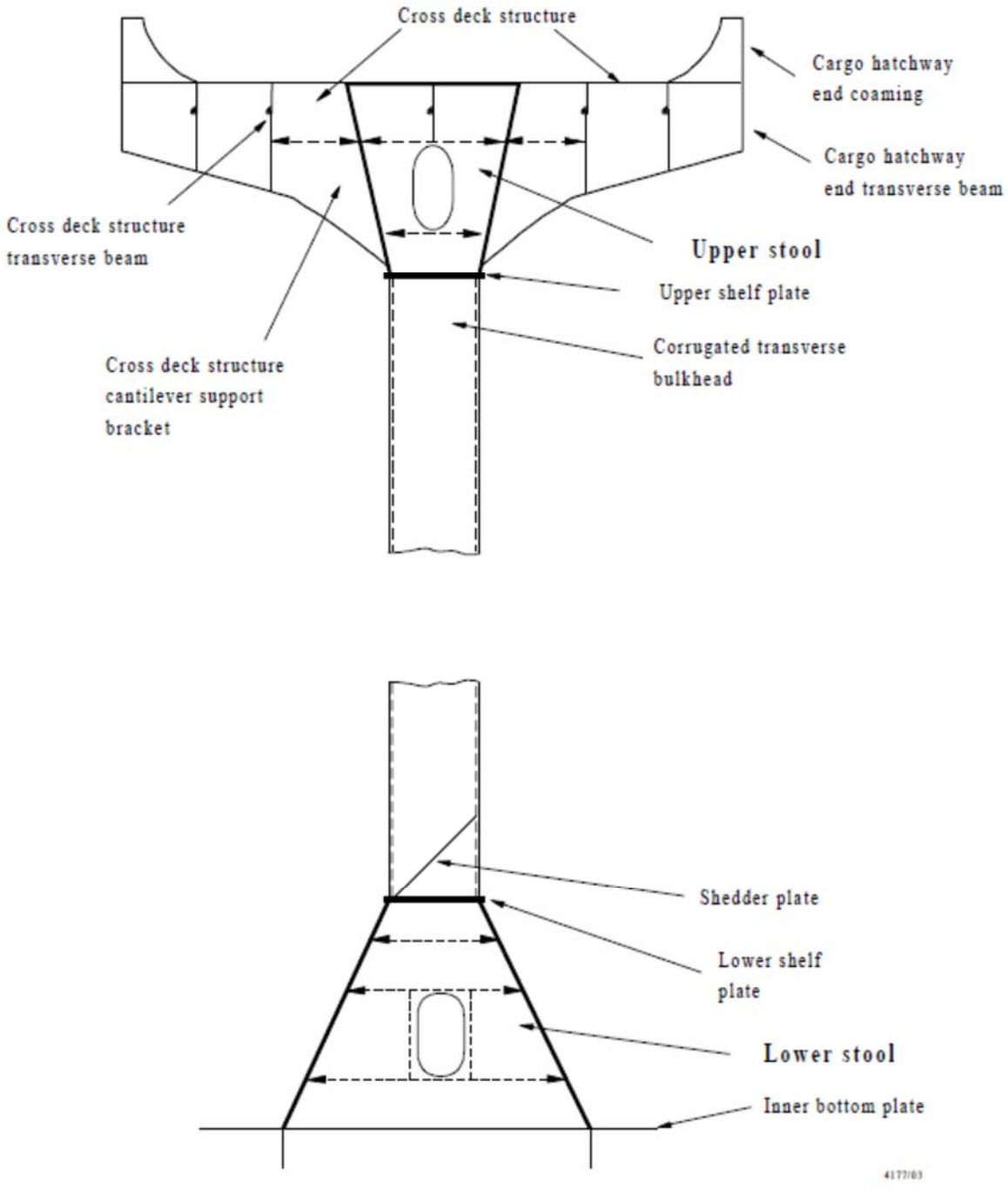


Figure 3: Nomenclature for Typical Corrugated Transverse Watertight Bulkhead

2.2 Design Limitations

2.2.1 General

All ships are designed with limitations imposed upon their operability to ensure that the structural integrity is maintained. Therefore, exceeding these limitations may result in over-stressing of the ship's structure which may lead to catastrophic failure. The ship's approved loading manual provides a description of the operational loading conditions upon which the design of the hull structure has been based. The loading instrument provides a means to readily calculate the still water shear forces and bending moments, in any load or ballast condition, and assess these values against the design limits.

A ship's structure is designed to withstand the static and dynamic loads likely to be experienced by the ship throughout its service life.

The loads acting on the hull structure when a ship is floating in still water are static loads. These loads are imposed by the:

- Actual weight of the ship's structure, outfitting, equipment and machinery.
- Cargo load (weight).
- Bunker and other consumable loads (weight).
- Ballast load (weight).
- Hydrostatic pressure (sea water pressure acting on the hull).

Dynamic loads are those additional loads exerted on the ship's hull structure through the action of the waves and the effects of the resultant ship motions (i.e. acceleration forces, slamming and sloshing loads). Sloshing loads may be induced on the ship's internal structure through the movement of the fluids in tanks/holds whilst slamming of the bottom shell structure forward may occur due to emergence of the fore end of the ship from the sea in heavy weather.

Cargo over-loading in individual hold spaces will increase the static stress levels in the ship's structure and reduce the strength capability of the structure to sustain the dynamic loads exerted in adverse sea conditions.

Carriage of intended cargoes which may liquefy at moisture content in excess of the transportable moisture limit or by any other causes will be specially considered in the strength of the cargo hold boundaries.

2.2.2 Hull Girder Shear Forces and Bending Moments

All bulk carriers classed with BCS are assigned permissible still water shear forces (SWSF) and still water bending moment (SWBM) limits. There are normally two sets of permissible SWSF and SWBM limits assigned to each ship, namely:

- Seagoing SWSF and SWBM limits (at sea).
- Harbour SWSF and SWBM limits (in port).

In addition, the permissible SWSF and SWBM limits in the hold flooded conditions are assigned to BC-A and BC-B ships defined in 2.3.1

The seagoing SWSF and SWBM limits in the normal or flooded conditions, whichever is applicable and/or more stringent, are not to be exceeded when the ship leaves the harbour or during any part of a seagoing voyage. In harbour, where the ship is in sheltered water and is subjected to reduced dynamic loads, the hull girder is permitted to carry a higher level of

stress imposed by the static loads. The harbour SWSF and SWBM limits are not to be exceeded during any stage of harbour cargo operations.

When a ship is floating in still water, the ship's lightweight (the weight of the ship's structure and its machinery) and deadweight (all other weights, such as the weight of the bunkers, ballast, provisions and cargo) are supported by the global buoyancy up thrust acting on the exterior of the hull. Along the ship's length there will be local differences in the vertical forces of buoyancy and the ship's weight. These unbalanced net vertical forces acting along the length of the ship will cause the hull girder to shear and to bend, see figures 4, 5 and 6, inducing a vertical still water shear force (SWSF) and still water bending moment (SWBM) at each section of the hull.

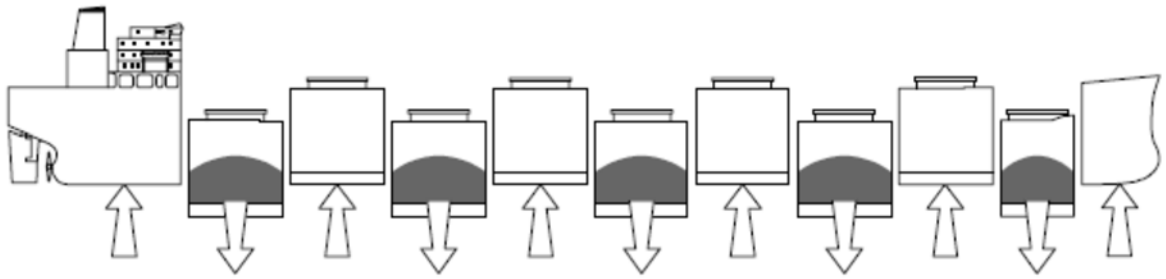


Figure 4: Shearing Action of the Hull Girder in Still Water

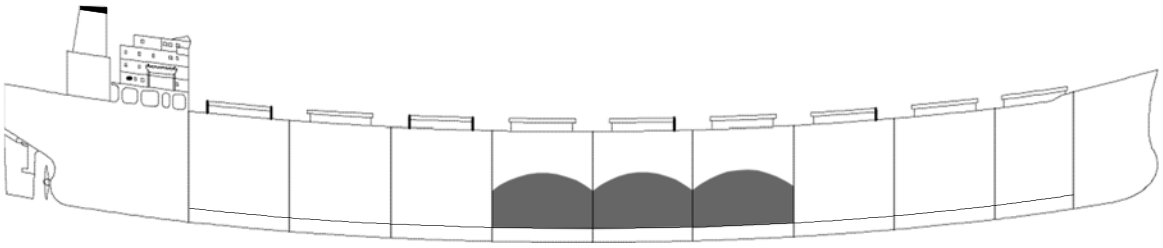


Figure 5: Bending Action of the Hull Girder "Sagging" in Still Water (Exaggerated Condition - Illustration Purposes Only)

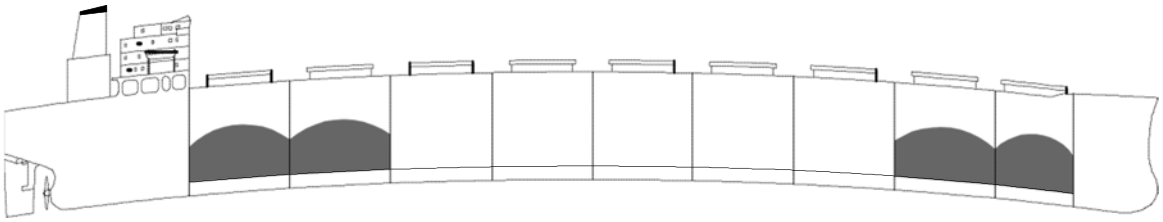


Figure 6: Bending Action of the Hull Girder "Hogging" in Still Water (Exaggerated Condition - Illustration Purposes Only)

At sea, the ship is subjected to cyclical shearing and bending actions induced by continuously changing wave pressures acting on the hull. These cyclical shearing and bending actions give rise to an additional component of dynamic, wave induced, shear force and bending moment in the hull girder. At any one time, the hull girder is subjected to a combination of still water and wave induced shear forces and bending moments.

The stresses in the hull section caused by these shearing forces and bending moments are carried by continuous longitudinal structural members. These structural members are the

strength deck, side shell, bottom shell and inner bottom plating and longitudinals, double bottom girders and topside and hopper tank sloping plating and longitudinals, which are generally defined as the ship hull girder.

Examples of permissible and calculated SWSF and SWBM are shown in figures 7 and 8 respectively.

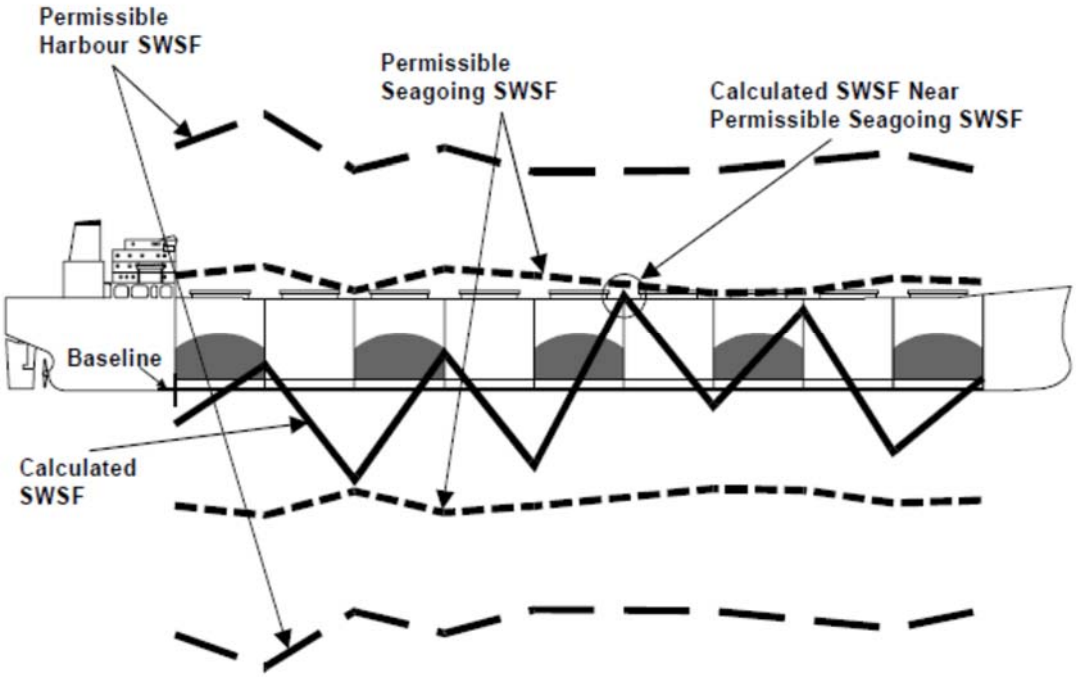


Figure 7: Relationship of the Permissible SWSF and the Calculated SWSF

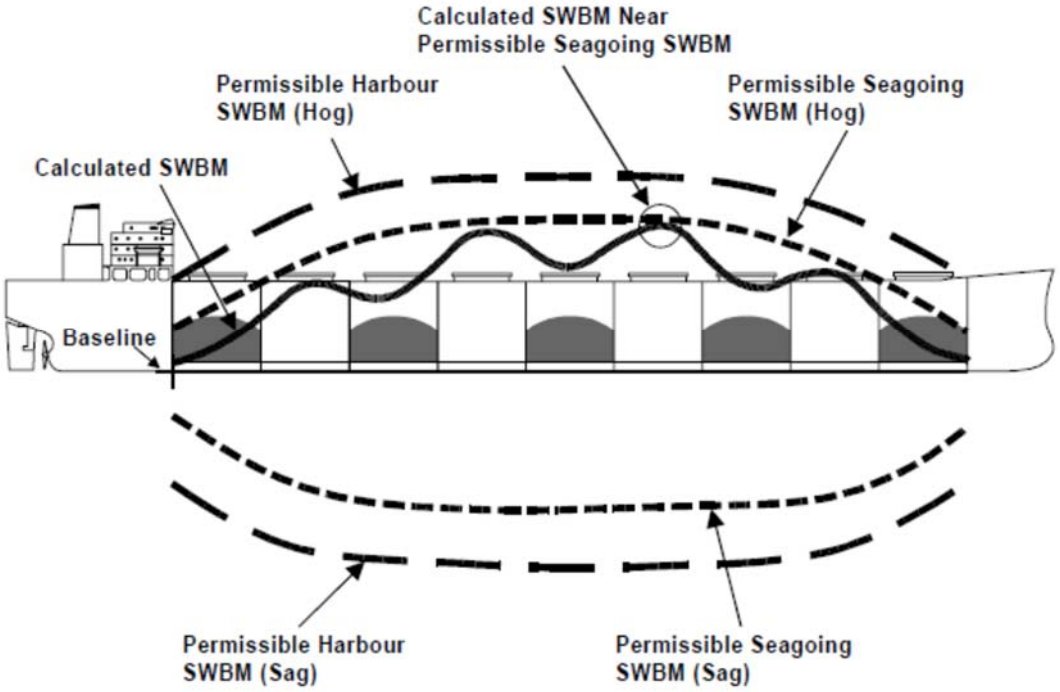


Figure 8: Relationship of the Permissible SWBM and the Calculated SWBM

2.2.3 Local Strength of Transverse Bulkhead, Double Bottom and Cross Deck Structure

To enhance safety and flexibility, all bulk carriers of 150 m in length and above are provided with local loading criteria which define the maximum allowable cargo weight in each cargo hold, and each pair of adjacent cargo holds (i.e. block hold loading condition), for various ship draught conditions. The local loading criteria is normally provided in tabular and diagrammatic form (hold mass curves).

Over-loading will induce greater stresses in the double bottom, transverse bulkheads, hatch coamings, hatch corners, main frames and associated brackets of individual cargo holds, see figure 9.

The double bottom, cross deck and transverse bulkhead structures are designed for specific cargo loads and sailing draught conditions. These structural configurations are sensitive to the net vertical load acting on the ship's double bottom. The net vertical load is the difference between the vertical downward weight of the cargo and water ballast in the double bottom and the hopper ballast tanks in way of the cargo hold and the upward buoyancy force which is dependent on the ship's draught.

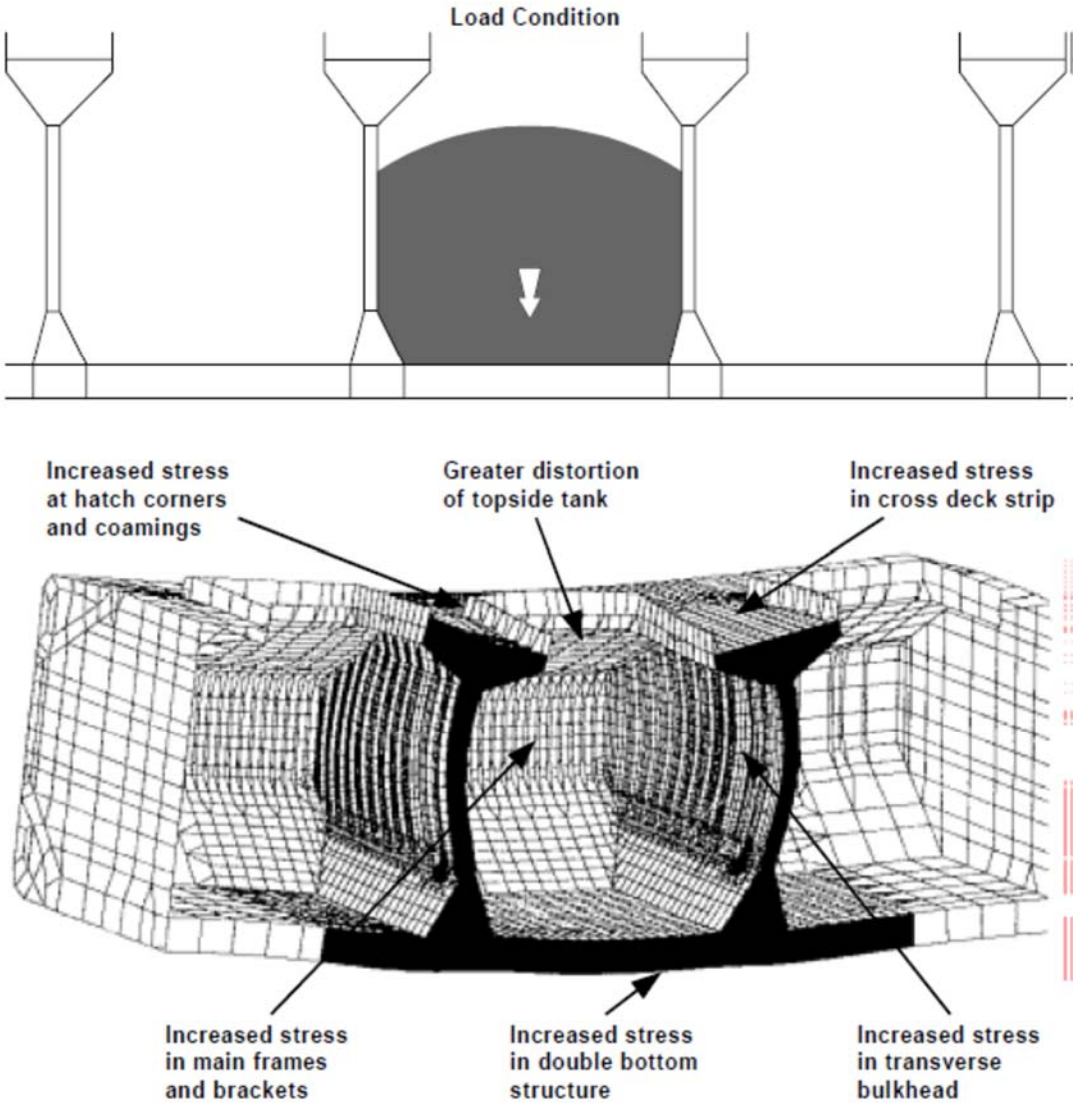


Figure 9: Exaggerated Deformation of the Localised Structure due to Overloading of the Cargo Hold

Overloading of the cargo hold in association with insufficient draught will result in an excessive net vertical load on the double bottom which may distort the overall structural configuration in way of the hold, see figures 10 and 11.

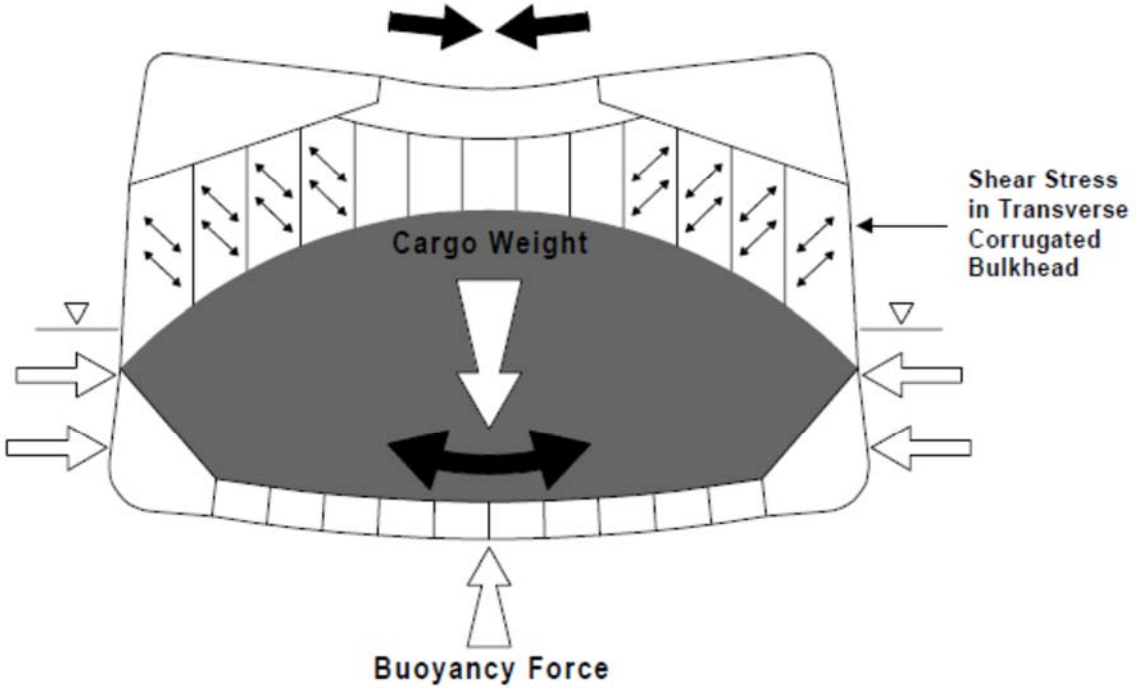


Figure 10: Shearing of the Transverse Corrugated Bulkhead and Compression of the Cross Deck

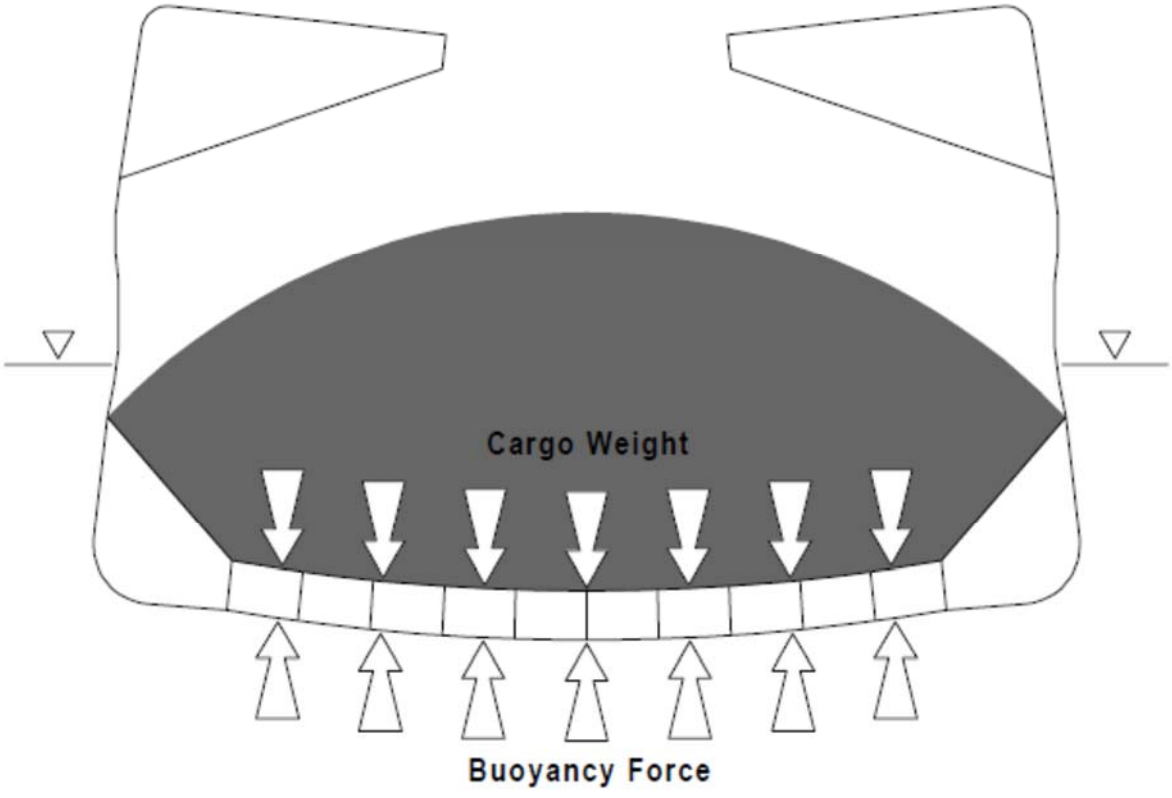


Figure 11: Excessive Flexural Deformation of the Double Bottom Structure

A typical Local Loading Diagram for a cargo hold (strengthened hold) combined with the adjacent hold limits, of a bulk carrier, is shown in figure 12.

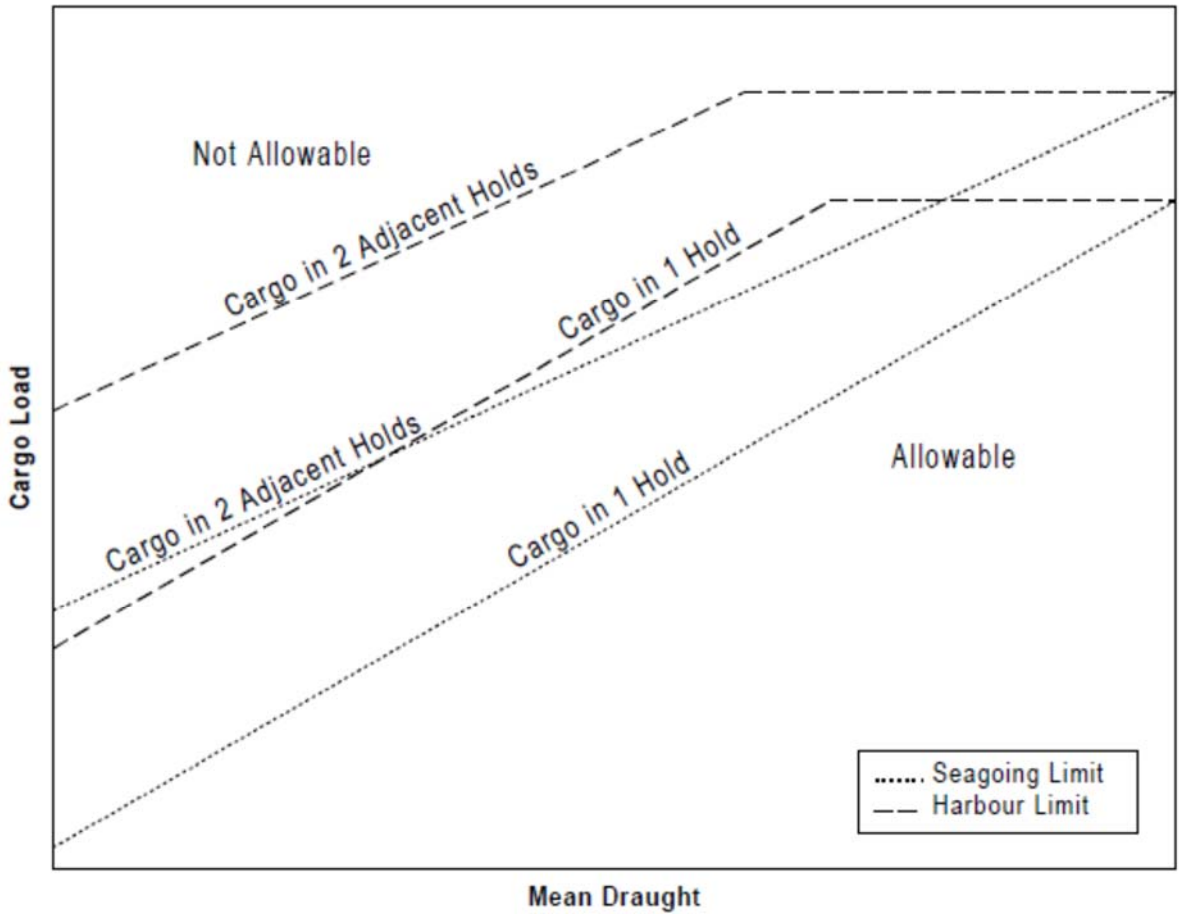


Figure 12: An Example of a Local Loading Diagram for a Bulk Carrier

The important trend to note from the local loading diagram is that there is a reduction in the cargo carrying capacity of a hold with a reduction in the mean draught. To exceed these limits will impose high stresses in the ship's structure in way of the over-loaded cargo hold. There are two sets of local loading criteria depending upon the cargo load distribution namely, individual hold loading or two adjacent hold loading.

The allowable cargo loads for each hold or combined cargo loads in two adjacent holds are usually provided in association with empty double bottom and hopper wing ballast tanks directly in way of the cargo hold. When water ballast is carried in the double bottom and hopper wing tanks, the maximum allowable cargo weight should be obtained by deducting the weight of water ballast being carried in the tanks in way of the cargo hold.

The maximum cargo loads given in the Local Loading Criteria should be considered in association with the mean draught in way of the cargo hold(s). In the case of a single cargo hold, the ship draught at the mid-length of the hold should be used. For two adjacent cargo holds, the average of the draught in the mid-length of each cargo hold should be used.

2.3 Cargo Distributions Along Ship's Length

2.3.1 General

Bulk carriers are designed and approved to carry a variety of cargoes. The distribution of cargo along the ship's length has a direct influence on both the global bending and shearing of the hull girder and on the stress in the localised hull structures.

The more commonly adopted cargo distributions are:

- Homogeneous hold loading condition.
- Alternate hold loading condition.
- Block hold loading condition.
- Part hold loading condition.

It is noted that there are additional service features for assigned BC-A, BC-B and BC-C notations with following requirements for bulk carrier having the ship rule length L of 150 m or above:

a) BC-A: For bulk carriers designed to carry dry bulk cargoes of cargo density 1.0 t/m^3 and above with specified holds empty at maximum draught in addition to BC-B conditions.

b) BC-B: For bulk carriers designed to carry dry bulk cargoes of cargo density of 1.0 t/ m^3 and above with all cargo holds loaded in addition to BC-C conditions.

c) BC-C: For bulk carriers designed to carry dry bulk cargoes of cargo density less than 1.0 t/m^3.

As per the CSR BC&OT, Pt 1, Ch 4, Sec 8, [4.1] and [4.2], the following additional service features are to be provided giving further detailed description of limitations to be observed during operation as a consequence of the design loading condition applied during the design in the following cases:

- {Maximum cargo density in t/m^3} for additional service features BC-A and BC-B if the maximum cargo density is less than 3.0 t/m^3

- {No MP} for all additional service features when the ship has not been designed for loading and unloading in multiple ports

- {Holds a, b, … may be empty} for additional service feature BC-A

- {Block loading} for additional service feature BC-A, when the ship is intended to operate in alternate block load condition

For CSR bulk carriers contracted for construction before 1 July 2015, the requirements in CSR BC, Ch 4, Sec 8, [2] (when applicable) and Ch 4, Sec 8, [4] should be complied with, so has to satisfy with the hull girder longitudinal strength requirements.

2.3.2 Homogeneous Hold Loading Conditions (Fully Loaded)

A homogeneous hold loading condition refers to the carriage of cargo, evenly distributed in all cargo holds, see figure 13. This loaded distribution, in general, is permitted for all bulk carriers and is usually adopted for the carriage of light (low density) cargoes, such as coal and grain. However, heavy (high density) cargoes such as iron ore may be carried homogeneously for BC-A and BC-B ships. For large ships (e.g. VLOC) the fully loaded condition is currently the most commonly utilized loading condition and should be preferably adopted in order to reduce the shear force occurrence between cargo holds.

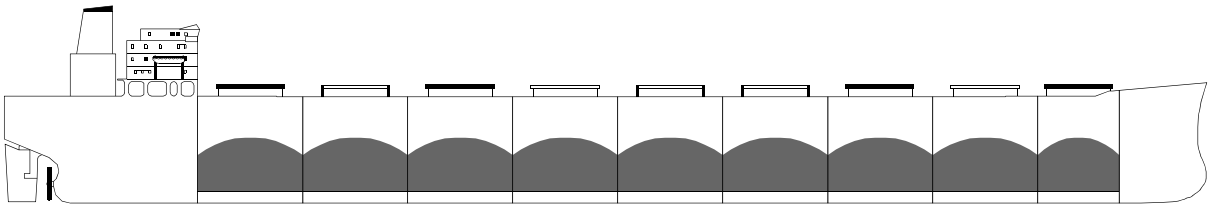


Figure 13: Homogeneous Hold Loading Condition (Fully Loaded)

2.3.3 Alternate Hold Loading Conditions (Fully Loaded)

Heavy cargo, such as iron ore, is often carried in alternate cargo holds on bulk carriers, see figure 14. It is common for large bulk carriers to stow high density cargo in odd numbered holds with the remaining holds empty. This type of cargo distribution will raise the ship's centre of gravity, which eases the ship's rolling motion. When high density cargo is stowed in alternate holds, the weight of cargo carried in each hold is approximately double that carried in a homogeneous load distribution. To support the loading of the heavy cargo in the holds, the local structure needs to be specially designed and reinforced. It is important to note that the holds which remain empty, with this type of cargo distribution, have not been reinforced for the carriage of heavy cargoes with a non-homogeneous distribution.

Ships not approved for the carriage of heavy cargoes in alternate holds by their classification society must not adopt this cargo load distribution.

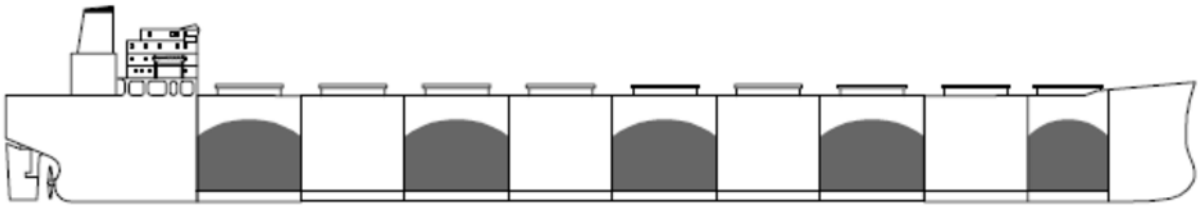


Figure 14: Alternate Hold Loading Condition (Fully Loaded)

2.3.4 Block Hold Loading and Part Loaded Conditions

A block hold loading condition refers to the stowage of cargo in a block of two or more adjoining cargo holds with the cargo holds adjacent to the block of loaded cargo holds empty, see figure 15. In many cases, block hold loading is adopted when the ship is partly loaded. Part loaded and block hold loading conditions are not usually described in the ship's loading manual unless they are specially requested to be considered in the design of the ship. When adopting a part loaded condition, to avoid over-stressing of the hull structure, careful consideration needs to be given to the amount of cargo carried in each cargo hold and the anticipated sailing draught.

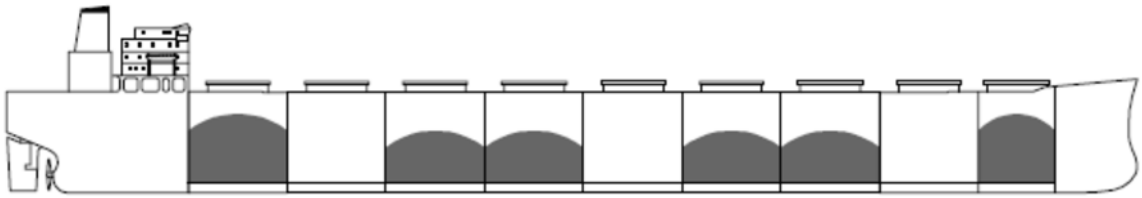


Figure 15: Block Hold Loading Condition

When a ship is partly loaded, the cargo transported is less than the full cargo carrying capacity of the ship. Hence, the sailing draught of the ship is likely to be less than its maximum design draught.

The weight of cargo in each hold must be adequately supported by the buoyancy up thrust acting on the bottom shell. A reduction in the ship's draught causes a reduction in the buoyancy up thrust on the bottom shell to counteract the downward force exerted by the cargo in the hold. Therefore, when a ship is partly loaded with a reduced draught, it may be necessary to reduce the amount of cargo carried in any hold.

To enable cargoes to be carried in blocks, the cross deck and double bottom structure needs to be specially designed and reinforced. Block loading results in higher stresses in the localised structures in way of the cross deck and double bottom structures and higher shear stress in the transverse bulkheads between the block loaded holds. The weight of cargo that can be carried in the block of cargo holds needs to be specially considered against the ship's sailing draught and the capability of the structure. In general, the cargo load that can be carried in blocks is much less than the sum of the full cargo capacity of the individual holds at the maximum draught condition.

Part loaded and block hold loading conditions should only be adopted in either of the following situations:

- The loading distributions are described in the ship's loading manual. In this case, the ship's structure has been approved for the carriage of cargo in the specified loading condition and the loading conditions described in the ship's loading manual should be adhered to, or,

- The ship is provided with a set of approved local loading criteria which define the maximum cargo weight limit as a function of ship's mean draught for each cargo hold and block of cargo hold(s). In this case, it is necessary to ensure that the amount of cargo carried in each hold satisfies the cargo weight and draught limits specified by the local loading criteria and the hull girder SWSF and SWBM values are within their permissible limits.

It is noted that for both alternative and block/part hold loadings, even the loading conditions have been approved and listed in the loading manual and meet the requirements of the loading instrument, the ship owners/operators are generally still unwilling to adopt these loading conditions in practice. This is because the alternative and block/part hold loadings have the significant impact on the localized structures due to the higher shear stress as mentioned above.

2.3.5 The change of weight distribution arising from fuel and ballast water

The loads induced by fuel and ballast water can have an effect on the weight distribution along the ship length. Therefore, considerations should be also given to the weight of fuel and/or ballast water, and its change. In particular, the longitudinal stress increased during the process of the ballast water exchange requires a special attention by a master or a ship's officer in charge.

3. Onboard Loading Guidance Information

3.1 Loading Manual

It is a statutory requirement of the International Load Line Convention that, noting exemptions, "the Master of every new vessel be supplied with sufficient information, in an approved form, to enable him to arrange for the loading and ballasting of his ship in such a way as to avoid the creation of any unacceptable stresses in the ship's structure."

Where the Master feels that he has insufficient information regarding the structural limitations or requires advice on the interpretation of the classification society's structural limitations imposed on his ship, advice should be sought from the ship's classification society.

The ship's approved loading manual is an essential onboard documentation for the planning of cargo stowage, loading and discharging operations. This manual, for bulk carriers, describes:

- The loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear force.
- The results of calculations of still water bending moments (SWBM), shear forces (SWSF) and where applicable, limitations due to torsional and lateral loads. SWSF and SWBM for each included loading condition.
- Envelope results and permissible limits of still water bending moments and shear forces in the hold flooded as applicable.
- The cargo hold(s) or combination of cargo holds that might be empty at full draught. If no cargo hold is allowed to be empty at full draught, this is to be clearly stated in the loading manual.
- Maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position.
- Maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions.
- Maximum allowable tank top loading together with specification of the nature of the cargo for cargoes other than bulk cargoes.
- Maximum allowable load on deck and hatch covers, where applicable.
- The maximum rate of ballast change together with the advice that a load plan is to be agreed with the terminal on the basis of the achievable rates of change of ballast.
- The relevant operational limitations.

The ship's loading manual is a ship specific document, the data contained therein is only applicable to the ship for which it has been approved.

3.2 Loading Instrument

The loading instrument is an invaluable shipboard calculation tool which assists the ship's cargo officer in:

- Planning and controlling cargo and ballasting operations.
- Rapidly calculating SWSF and SWBM for any load condition.
- Identifying the imposed structural limits which are not to be exceeded.

It is important to note that the loading instrument is not a substitute for the ship's loading manual. Therefore, the officer in charge should also refer to the loading manual when planning or controlling cargo operations.

A loading instrument or loading computer is an instrument, which can be either an analogue or digital, by means of which it can be easily and quickly ascertained that, at specified read-out points, the still water bending moments, shear forces, and the still water torsional moments and lateral loads, where applicable, in any load or ballast condition will not exceed the specified permissible values. Modern loading instruments consist of approved computational software operating on a shipboard digital computer.

In addition to these requirements, it shall ascertain as applicable that:

- the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position.
- the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds.
- the still water bending moment and shear forces in the hold flooded conditions, are within permissible values.

The ship's loading instrument is a ship specific onboard equipment and the results of the calculations are only applicable to the ship for which it has been approved. Single point loading instruments are not acceptable.

An operational manual is always to be provided for the loading instrument

The ship's deck officers should familiarise themselves with the operation of the onboard loading instrument.

The loading instrument is to be checked for accuracy at regular intervals by the ship's Master by applying test loading conditions.

At each Special Survey this checking is to be done in the presence of the Surveyor.

4. Planning and Control of Cargo Loading and Unloading Operations

4.1 Preparation for Cargo Operations

4.1.1 Cargo and Port Information

To make it possible to plan the cargo stowage, loading and unloading sequences, the cargo terminal should provide the ship with the following information well in advance:

- Cargo characteristics; stowage factor, angle of repose, amounts and special properties.
- Cargo availability and any special requirements for the sequencing of cargo operations.
- Characteristics of the loading or unloading equipment including number of loaders and unloaders to be used, their ranges of movement, and the terminal's nominal and maximum loading and unloading rates, where applicable.
- Minimum depth of water alongside the berth and in the fairway channels.
- Water density at the berth.
- Air draught restrictions at the berth.
- Maximum sailing draught and minimum draught for safe manoeuvring permitted by the port authority.
- The amount of cargo remaining on the conveyor belt which will be loaded onboard the ship after a cargo stoppage signal has been given by the ship.
- Terminal requirements/procedures for shifting ship.
- Local port restrictions, for example, bunkering and deballasting requirements etc.

Cargo trimming is a mandatory requirement for some cargoes, especially where there is a risk of the cargo shifting. BCS recommends that the cargo in all holds be trimmed in an attempt to minimise the risk of cargo shift.

Transportation of mineral concentrates, such as copper, iron, lead nickel or bauxite could be hazardous. The attention is drawn to the applicable requirements of the International Maritime Solid Bulk Cargoes (IMSBC) code. Depending on the cargo categories (A, B or C) of the code, test of Transportable Moisture Limit (TML) is to be performed to mitigate the risks of cargo liquefaction creating large free surface effect in cargo hold.

The ship's Master should be aware of the harmful effects of corrosive and high temperature cargoes and any special cargo transportation requirements. Ship Masters, deck officers, charterers and stevedores should be familiar with the relevant IMO Codes (for example, the IMO Code of Safe Practice for Solid Bulk Cargoes, the IMO Code of Practice for the Safe Loading and Unloading of Dry Bulk Carriers (BLU Code) and the SOLAS Convention).

4.1.2 Devising a Cargo Stowage Plan and Loading/Unloading Plan

The amount and type of cargo to be transported and the intended voyage will dictate the proposed departure cargo and/or ballast stowage plan. The officer in charge should always refer to the loading manual to ascertain an appropriate cargo load distribution, satisfying the imposed limits on structural loading.

There are two stages in the development of a safe plan for cargo loading or unloading:

- Stage 1: Given the intended voyage, the amount of cargo and/or water ballast to be carried and imposed structural and operational limits, devise a safe departure condition, known as the stowage plan.

- Stage 2: Given the arrival condition of the ship and knowing the departure condition (stowage plan) to be attained, devise a safe loading or unloading plan that satisfies the imposed structural and operational limits.

In the event that the cargo needs to be distributed differently from that described in the ship's loading manual, stress and displacement calculations are always to be carried out to ascertain, for any part of the intended voyage, that:

- The still water shear forces and bending moments along the ship's length are within the permissible Seagoing limits.

- If applicable, the weight of cargo in each hold, and, when block loading is adopted, the weights of cargo in two successive holds are within the allowable Seagoing limits for the draught of the ship. These weights include the amount of water ballast carried in the hopper and double bottom tanks in way of the hold(s).

- The load limit on the tanktop and other relevant limits, if applicable, on local loading are not exceeded.

The consumption of ship's bunkers during the voyage should be taken into account when carrying out these stress and displacement calculations.

Whilst deriving a plan for cargo operations, the officer in charge must consider the ballasting operation to ensure:

- Correct synchronisation with the cargo operation.

- That the deballasting/ballasting rate is specially considered against the loading rate and the imposed structural and operational limits.

- That ballasting and deballasting of each pair of symmetrical port and starboard tanks is carried out simultaneously.

During the planning stage of cargo operations, stress and displacement calculations should be carried out at incremental steps commensurate with the number of pours and loading sequence of the proposed operation to ensure that:

- The SWSF and SWBM along the ship's length are within the permissible Harbour limits.

- If applicable, the weight of cargo in each hold, and, when block loading is adopted, the weights of cargo in two adjacent holds are within the allowable Harbour limits for the

draught of the ship. These weights include the amount of water ballast carried in the hopper and double bottom tanks in way of the hold(s).

- The load limit on the tanktop and other relevant limits, if applicable, on local loading are not exceeded.

- At the final departure condition, the SWSF and SWBM along the ship's length are within the permissible Seagoing stress limits.

During the derivation of the cargo stowage, and the loading or unloading plan, it is recommended that the hull stress levels be kept below the permissible limits by the greatest possible margin.

A cargo loading/unloading plan should be laid out in such a way that for each step of the cargo operation there is a clear indication of:

- The quantity of cargo and the corresponding hold number(s) to be loaded/unloaded.

- The amount of water ballast and the corresponding tank/hold number(s) to be discharged/loaded.

- The ship's draughts and trim at the completion of each step in the cargo operation.

- The calculated value of the still water shear forces and bending moments at the completion of each step in the cargo operation.

- Estimated time for completion of each step in the cargo operation.

- Assumed rate(s) of loading and unloading equipment.

- Assumed ballasting rate(s)

The loading/unloading plan should indicate any allowances for cargo stoppage (which may be necessary to allow the ship to deballast when the loading rate is high), shifting ship, bunkering, draught checks and cargo trimming.

4.1.3 Ship/Shore Communication Prior to the Commencement of Cargo Operations

Effective means of communication are to be established between the ship's deck officers and the cargo terminal which shall remain effective throughout the cargo operation. This communication link should establish:

- An agreed procedure to STOP cargo operations.

- Personnel responsible for terminal cargo operations.

- The ship's officer responsible for the cargo loading/unloading plan and the officer in charge responsible for the on deck cargo operation.

- Confirmation of information received in advance.

- An agreed procedure for the terminal to provide the officer in charge with the loaded cargo weight, at frequent intervals and at the end of each pour.

- An agreed procedure for draught checking.

- The reporting of any damage to the ship from the cargo operations.

The ship's officer responsible for the cargo operation plan should submit the proposed loading/unloading plan to the cargo terminal representative at the earliest opportunity to allow sufficient time for any subsequent modifications and to enable the terminal to prepare accordingly. The ship's officers should be familiar with the IMO Ship/Shore Safety Checklist.

The SOLAS Convention required that:

- the plan, and any subsequent amendments thereto, shall be lodged with the appropriate authority of the port state,

- the ship's Master and the terminal representative shall ensure that the cargo operations are conducted in accordance with the agreed plan.

4.1.4 Before Commencing Cargo Operations

The cargo terminal should not commence any cargo operations until the loading/unloading plan and all relevant procedures have been agreed and the ship's Master has, where necessary, received a Certificate of Readiness issued by the respective maritime authorities.

Prior to the commencement of cargo loading operations, it should be determined that:

- No structural damage exists. Any such damage is to be reported to the respective classification society and cargo operations are not to be undertaken.

- The bilge and ballast systems are in satisfactory working condition.

- Moisture content of the intended cargoes which may liquefy is less than the transportable moisture limit (TML). The cargo shall comply with the requirement of IMSBC.

4.2 Monitoring and Controlling Cargo Operations

4.2.1 Monitoring of Stevedoring Operation

The officer in charge has responsibility for the monitoring of the stevedoring operation and should ensure that:

- The agreed loading/unloading sequence is being followed by the terminal.
- Any damage to the ship is reported.
- The cargo is loaded, where possible, symmetrically in each hold and, where necessary, trimmed.
- Effective communication with the terminal is maintained.
- The terminal staff advise of pour completions and movement of shoreside equipment in accordance with the agreed plan.
- The loading rate does not increase beyond the agreed rate for the loading plan.

If there is likely to be a change by the terminal to either the loading/unloading sequences or the cargo loading/unloading rate, the officer in charge is to be informed with sufficient notice. Changes to the agreed loading/unloading plan are to be implemented with the mutual agreement of both the ship and the terminal.

If a deviation from the loading/unloading plan is observed, the officer in charge should advise the cargo terminal immediately so that necessary corrective actions are implemented without delay. If considered necessary, cargo and ballasting operations must stop.

4.2.2 Monitoring the Ship’s Loaded Condition

The officer in charge should closely monitor the ship's condition during cargo operations to ensure that if a significant deviation from the agreed loading/unloading plan is detected all cargo and ballast operations must STOP.

The officer in charge should ensure that,

- the cargo operation and intended ballast procedure are synchronised.
- draught surveys are conducted at appropriate steps of the loading plan to verify the ship's loading condition. The draught readings, usually taken at amidships and the fore and aft perpendiculars, should be in good agreement with values calculated in the loading plan.
- ballast tanks are sounded to verify their contents and rate of ballasting/deballasting.
- the cargo load is in agreement with the figures provided by the terminal.
- the cargo is loaded/unloaded in compliance with the ship’s approved Local Loading Diagram (Hold Mass Curve) for each cargo hold, where applicable.

- the SWSF, SWBM and, where appropriate, hold cargo weight versus draught calculations are performed at intermediate stages of the cargo operation. These results should be logged, for recording purposes, against the appropriate position in the loading plan.

Following a deviation from the loading plan, the officer in charge should take all necessary corrective actions to:

- Restore the ship to the original loading/unloading plan, if possible, or

- Replan the rest of the loading/unloading operation, ensuring that the stress and operational limits of the ship are not exceeded at any intermediate stages.

The modified loading/unloading plan should be agreed by both the officer responsible for the loading plan and the cargo terminal representative. Cargo operations should not resume until the officer in charge gives a clear indication to the terminal of his readiness to proceed with the cargo operation.

4.2.3 Hull Damage Caused by Cargo Operations

All damages should be reported to the ship's Master. Where hull damage is identified, which may affect the integrity of the hull structure and the seaworthiness of the ship, the ship's owner and classification society must be informed.

A general inspection of the cargo spaces, hatch covers and deck is recommended to identify any physical damage of the hull structure. Any structural damage found is to be reported to the classification society and for major damage, cargo operations are not to be undertaken.

5. Potential Problems

5.1 Deviation from the Limitations Given in the Approved Loading Manual

Exceeding the permissible limits specified in the ship's approved loading manual will lead to over-stressing of the ship's structure and may result in catastrophic failure of the hull structure. When deviating from the cargo load conditions contained in the ship's approved loading manual, it is necessary to ensure that both the global and local structural limits are not exceeded. It is important to be aware that over-stressing of local structural members can occur even when the hull girder still water shear forces (SWSF) and bending moments (SWBM) are within their permissible limits.

Exceeding the maximum permissible cargo load in any hold will lead to over-stressing of local structure. Over-stressing of the local structure will occur when:

- The weight of cargo loaded into a hold exceeds the maximum permissible value specified at full draught.

- The weight of cargo loaded into adjacent holds exceeds the maximum combined value at full or reduced draught.

Over-stressing of the local structure may also occur when the weight of cargo loaded into an individual hold has insufficient support of upward buoyancy force; this circumstance can occur when cargo is transported by the ship in a shallow draught condition (for example, partial load condition with some holds full and remaining holds empty).

5.2 Loading Cargo in a Shallow Draught Condition

To minimise the risks of over-stressing the local structure, the largest possible number of non-successive pours should be used for each cargo hold.

Loading cargo in a shallow draught condition can impose high stresses in the double bottom, cross deck and transverse bulkhead structures if the cargo in the hold is not adequately supported by the buoyancy up thrust. If applicable, the cargo weight limits for each cargo hold, and two adjacent cargo holds, as a function of draught, (the local loading criteria) are not to be exceeded.

5.3 High Loading Rates

High loading rates may cause significant overloading within a very short space of time. The officer in charge should be prepared to STOP cargo operations if the loading operation deviates from the agreed loading plan.

There are three main problems associated with high loading rates which may result in over-stressing the ship's structure, namely:

- The sensitivity of the global hull girder SWSF and SWBM (An example is presented in Table 1 for illustration purpose only and may not reflect a realistic loading condition).

- Overloading the local structure.

- Synchronisation of the ballasting operations.

From the example given in Table 1, the inadvertent loading of 900 tonnes into each of the holds numbered 1 and 7 took 5.4 minutes if two loaders were in operation. The re-distribution of cargo causes the SWSF and SWBM to exceed the allowable limits by 17 and 33 percent respectively.

Table 1: An Example of the Sensitivity of the Hull Girder to Cargo Distribution of a Bulk Carrier with 7 Holds.

Loading Condition	Hold 1 (tonnes) *see note 1*	Hold 3 (tonnes)	Hold 5 (tonnes)	Hold 7 (tonnes) *see note 1*	Maximum SWSF (tonnes) *see note 2*	Maximum SWBM (tonnes-m) *see note 2*
Approved ore load condition	16,000	18,000	18,000	16,000	4,900 (97%)	144,700 (99%)
10% cargo of No.5 hold evenly loaded to holds 1&7	16,900 (5.4 mins)	18,000	16,200	16,900 (5.4 mins)	5,900 (117%)	193,500 (133%)

Notes:

1. The time taken to load the additional cargo is presented in the parenthesis under the respective hold cargo weight, assuming a loading rate of 10,000 tonnes per hour.
2. Figures in parenthesis in the SWSF and SWBM columns are the respective percentages of permissible.

High cargo loading rates may create problems with the ballasting operation as the pumping capacity of the ship may be relatively low compared to the cargo loading rate. In such cases the cargo operation must be stopped to ensure synchronisation with the ballasting operation is maintained. When necessary, the loading rate must be adjusted to synchronise with the ship's pumping capacity.

5.4 Asymmetric Cargo and Ballast Distribution

It is recommended that high density cargo be stowed uniformly over the cargo space and trimming be applied to level the cargo, as far as practicable, to minimise the risk of damage to the hull structure and cargo shift in heavy weather.

The distribution of cargo in a hold, and water ballast distribution, have an important influence on the resultant stress in the hull structure. The double bottom and the cross deck structure are designed based upon a trimmed cargo distributed symmetrically in a hold space.
Still water shear forces and bending moments given in the ship's loading manual and the corresponding calculations from onboard loading instruments are based on an even distribution of cargo in a hold space, unless otherwise indicated.

Still water shear force and bending moments calculated with an onboard loading instrument do not consider the torsional loads acting on the hull girder resulting from asymmetrical cargo or ballast loading

When heavy cargo is poured into a cargo space at one end of the cargo hold, the lateral cargo pressure acting on the transverse bulkhead, as a result of the cargo piling up at one end of the cargo space (see figure 16), will increase the loads carried by the transverse bulkhead structure and the magnitude of transverse compressive stresses in the cross deck.

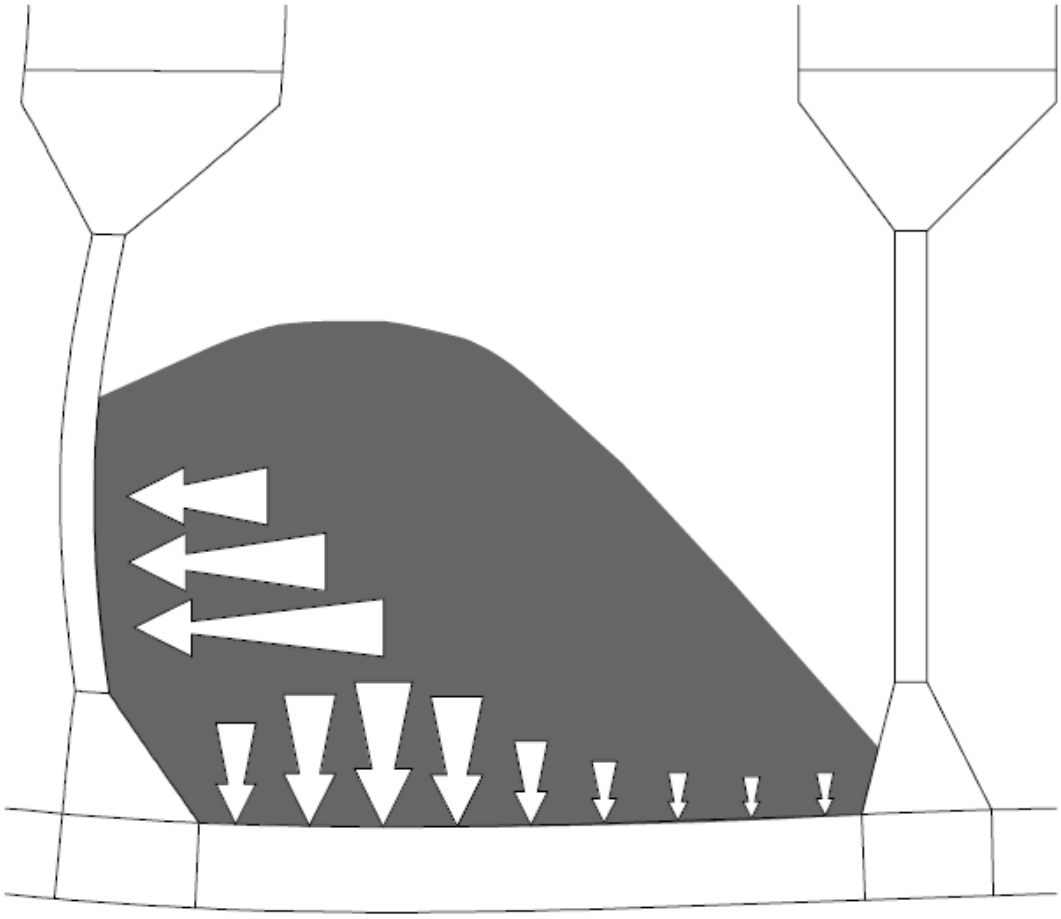


Figure 16: Asymmetric Longitudinal Cargo Distribution Within a Hold

When the same loading pattern is also adopted for the adjacent cargo hold (Figure 17), the lateral cargo pressure acting on the transverse bulkhead will be largely cancelled out. However, in this situation, a large proportion of the vertical forces on the double bottom is transferred to the bulkhead between the two loaded holds which could lead to shear buckling of the transverse bulkhead structure, compression buckling of the cross deck and increased SWBM in way of the transverse bulkhead. Cargo should always be stowed symmetrically in the longitudinal direction, and trimmed, as far as practical.

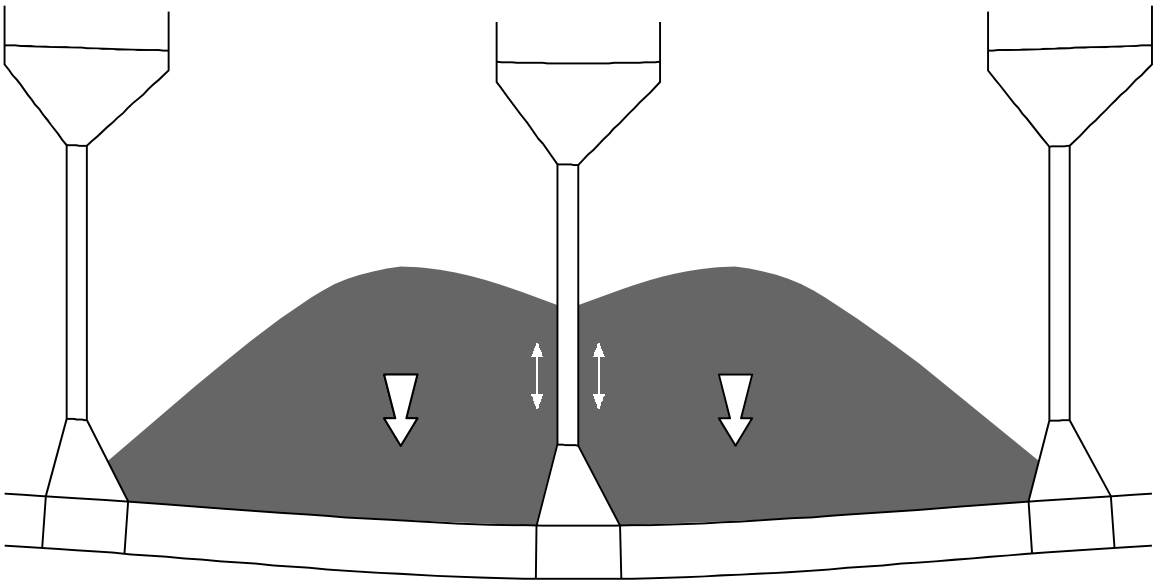


Figure 17: Asymmetric Longitudinal Cargo Distribution Within Adjacent Holds

Stowing cargo asymmetrically about the ship's centre line in a cargo space (see figure 18) induces torsional loads into the structure which causes twisting of the hull girder. When the hull girder is subjected to torsion, warping of the hull section occurs which gives rise to shearing and bending of the cross deck structure.

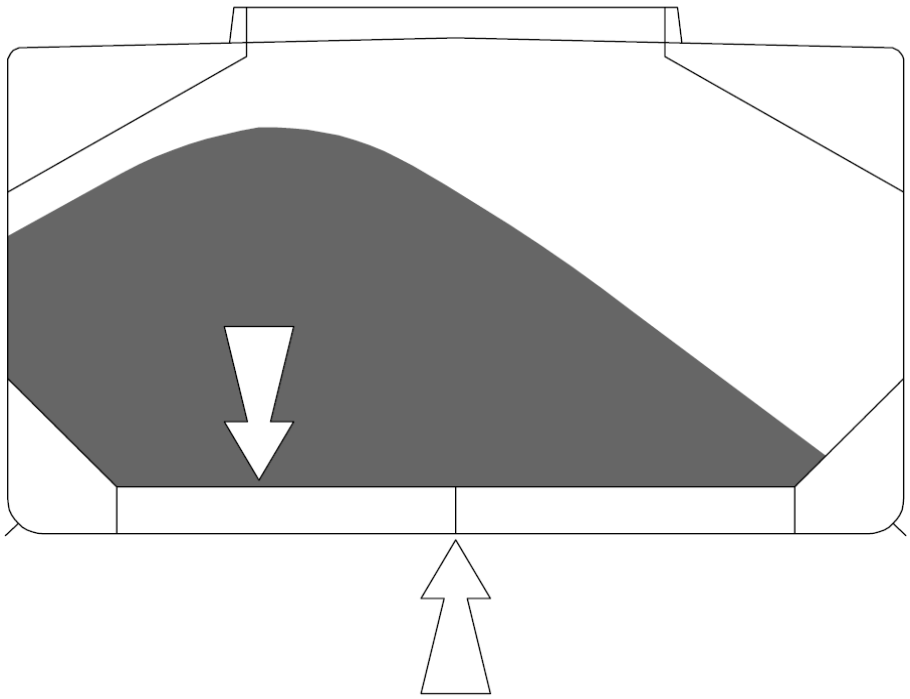


Figure 18: Asymmetric Transverse Cargo Distribution Within a Hold

Water ballast should always be carried symmetrically in port and starboard tanks with equal levels of filling. The final fill level of all water ballast tanks and holds must satisfy the requirements specified in the ship's approved loading manual to avoid damage to the internal structure due to sloshing effects.

The ballasting and deballasting of port and starboard ballast tanks should be carried out simultaneously so that the amount of water ballast in each corresponding pair of port and starboard ballast tanks remains the same throughout ballasting or deballasting operations, see figures 19 and 20. Asymmetrical distribution of water ballast induces torsional loads, causing twisting of the hull girder.

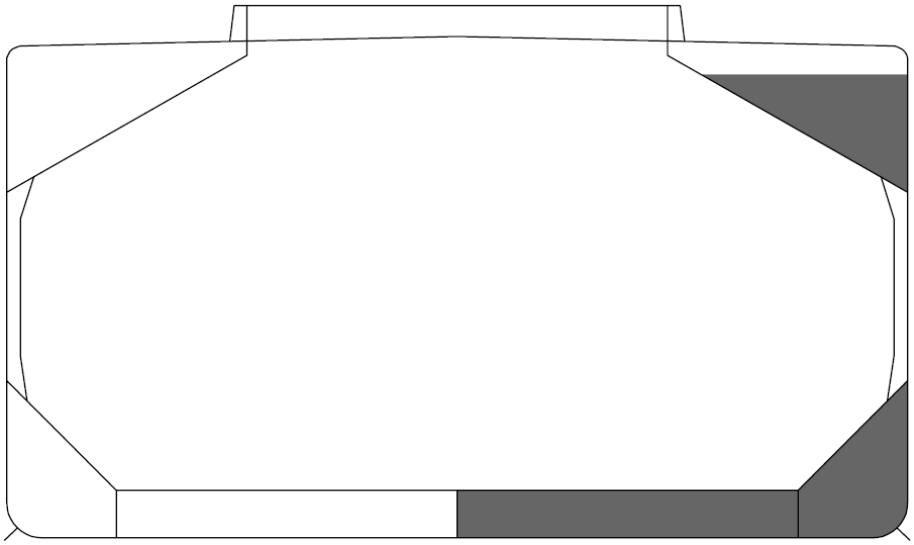


Figure 19: Asymmetric Transverse Distribution of Water Ballast

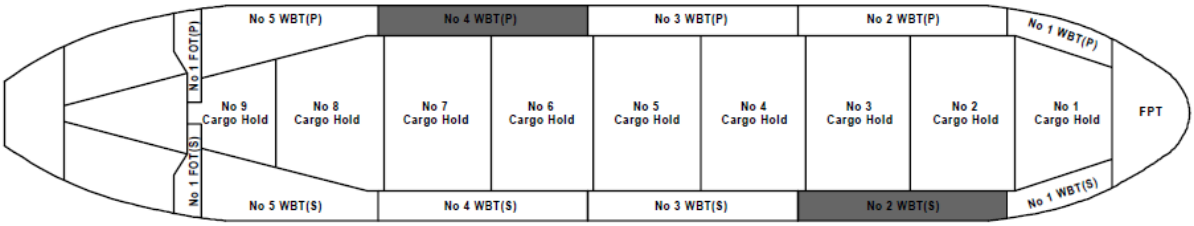


Figure 20: Asymmetric Longitudinal Distribution of Water Ballast

Torsional loading of the hull girder is considered to be an important contributory factor to recurring cracking at the hatch corners and to problems associated with hatch cover alignment and fittings. In extreme cases, this can lead to extensive buckling of the cross deck structure between the hatch openings.

5.5 Lack of Effective Ship/Shore Communication

The lack of effective ship/shore communication may increase the risk of inadvertent overloading of the ship's structure. It is important that there is an agreed procedure between the ship's officers and the terminal operators to STOP cargo operations. The communication link established between the ship and the terminal should be maintained throughout the cargo operation.

5.6 Exceeding the Assigned Load Line Marks

All ships engaged on international voyages are assigned with load line marks in accordance with the provisions of the International Load Line Convention 1966. The appropriate lines marked on the ship's side shall not be loaded to submerge the appropriate load line marks at any time during the seagoing voyage. To allow for the difference between the dock water density and the sea water density, the ship may be loaded beyond the appropriate mark by the dock water allowance. The dock water allowance is only applicable in a port environment. It is a statutory requirement that the ship is not to be loaded beyond the limits specified in the Load Line Certificate.

The practice of inducing a hogging deflection of the hull girder by end hold(s) trimming to maximise the cargo carrying capacity of the ship to the appropriate marks is to be avoided as this may result in the over-loading of the end holds beyond the allowable limit and an increase in both the local and global stresses.

5.7 Partially Filled Ballast Holds or Tanks

Sailing with partially filled ballast holds is prohibited unless the approved loading manual approves of such a practice. Cargo holds designed for partially filled in harbour for the purpose of reducing the ship's air draught are not to contain any water ballast while at sea.

Where ballast holds, and in some instances ballast tanks, are partially filled, there is the likelihood of sloshing. Sloshing is the violent movement of the fluid's surface in partially filled tanks or holds resulting from the motion of the ship in a seaway. Sloshing will result in the magnification of dynamic internal pressures acting on the hold/tank boundaries. For any tank design, dimensions, internal stiffening and filling level, a natural period (frequency) of the fluid exists, which, if excited by the ship's motions, can result in very high pressure magnification (resonance) which can result in damage to the tank/hold's internal structure.

To minimise the effects of sloshing, the liquid's motion needs to be controlled by ensuring that tanks are either pressed up or empty (sloshing can occur at low filling levels).

Where a ship has been specially designed for partially filled ballast tanks and/or hold(s) whilst at sea, the filling levels specified in the ship's loading manual are to be followed.

5.8 Inadequate Cargo Weight Measurement During Loading

During cargo loading operations it is important to ascertain the cargo weight loaded into each individual cargo hold and the associated loading rate. Overloading the cargo hold will increase the stress levels in the ship's structure. At high loading rate ports, where there is no suitably positioned cargo weighing equipment, the ship's cargo officer should request that the terminal stops loading to allow draught surveys and displacement calculations to be performed to ensure compliance with the agreed loading plan.

An appropriately positioned cargo weighing device, which can provide continuously, or at least at each step, an accurate indication of the weight of cargo that has been loaded into each individual hold, is an important piece of equipment which can be used to avoid overloading of individual cargo holds. Therefore, BCS recommends that suitably positioned weighing equipment is installed at all terminals, especially those terminals with high loading rates.

The weight of cargo loaded onboard a ship is normally determined from the ship's draughts and, where fitted, shoreside weighing equipment.

Overloading of the ship’s structure, can result from:

- Inaccurate terminal weighing equipment providing incorrect data.
- The limited time available to check the draught and determine the load onboard especially at high loading rate terminals.
- Loading cargo in a hold, in excessive of the allowable limit, to compensate for partial bunkers.

At some terminals the cargo weighing equipment is positioned at a location, remote from the loading operating position. In such cases it is difficult for the officer in charge to determine how much cargo has been loaded into a specific hold and this equipment may not provide the necessary accurate information.

5.9 Structural Damage During Cargo Loading/Unloading

Terminal operators should be aware of the damage that their cargo handling equipment can inflict on the ship's structure. It is important that the protective coatings in cargo holds and water ballast tanks are maintained. The cargo holds and deck areas should be inspected by the ship's deck officers upon completion of cargo discharge to identify any signs of physical damage, corrosion or coating damage to the ship's structure. Where hull damage is identified, which may affect the integrity of the hull structure and the seaworthiness of the ship, it should be reported accordingly to the classification society.

The internal hold structure and protective coatings in the cargo hold and the adjacent double bottom are vulnerable to damage when the cargo is discharged using grabs. For ships having one of the additional service features BC-A or BC-B the additional class notation GRAB [X] is mandatory, where X is an empty grab weight in tons. The bulk carriers shall be designed for the most extreme grab weight that can be expected during ship life, and it is assumed that larger vessels are more likely to encounter the largest grabs as they will more frequently carry coal and iron ore than handy size ships. For CSR ships contracted for construction on or after 1st July 2015, the minimum mass of the grab is taken as 35 t for vessels with length exceeding 250 m, 30 t for ships between 200 m and 250 m and 20t for smaller vessels. For CSR ships contracted for construction before 1st July 2015, the Grab requirement is applicable to BC-A and BC-B ships and the mass of the grab is taken as 20 t.

Other types of equipment employed to free and clear cargo, including hydraulic hammers fitted to extending arms of tractors and bulldozers can inflict further damage to the ship's structure, especially in way of the side shell and the associated frames and end brackets. Chipping (sharp indentations) and the local buckling or detachment of side frames at their lower connection could lead to cracking of the side shell plating which would allow the ingress of water in to the cargo space.

The protective coatings that may be required to be applied in the cargo hold are also subject to deterioration caused by the corrosive nature of the cargo, high temperature cargoes, cargo settlement during the voyage and the abrasive action of the cargo. Where no protective coatings have been applied or the applied protective coatings have broken down, the rate of corrosion in that area will greatly increase, especially when carrying corrosive cargoes, such as coal. Corrosion will weaken the ship's structure and may, eventually, seriously affect the ship's structural integrity. The severity of the corrosion attained by a structural member may not be easily detected without close- up inspection or until the corrosion causes serious structural problems such as the collapse or detachment of hold frames resulting in cracks propagating in the side shell.

Impact damage to the inner bottom plating or the hopper sloping plating will result in the breakdown of coatings in the adjacent water ballast tanks, thereby intensifying the rate of structural deterioration.

6 Ballast Exchange at Sea

The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, entered into force globally on 8 September 2017. From the date of entry into force, ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan.

Ships have to carry:

- A ballast water management plan - specific to each ship, the ballast water management plan includes a detailed description of the actions to be taken to implement the ballast water management requirements and supplemental ballast water management practices;

- A ballast water record book - to record when ballast water is taken on board; circulated or treated for ballast water management purposes; and discharged into the sea. It should also record when ballast water is discharged to a reception facility and accidental or other exceptional discharges of ballast water; and

- An International Ballast Water Management Certificate (ships of 400 gt and above) – this is issued by or on behalf of the Administration (flag State) and certifies that the ship carries out ballast water management in accordance with the BWM Convention and specifies which standard the ship is complying with, as well as the date of expiry of the Certificate.

There are two ballast water management standards (D-1 and D-2).

The D-1 standard requires ships to exchange their ballast water in open seas, away from coastal areas. Ideally, this means at least 200 nautical miles from land and in water at least 200 metres deep. By doing this, fewer organisms will survive and so ships will be less likely to introduce potentially harmful species when they release the ballast water. The D-2 standard specifies the maximum amount of viable organisms allowed to be discharged, including specified indicator microbes harmful to human health.

From the date of entry into force of the BWM Convention, all ships must conform to at least the D-1 standard; and all new ships, to the D-2 standard. Eventually, all ships will have to conform to the D-2 standard. For most ships, this involves installing special equipment to treat the ballast water. A ship undergoing a renewal survey linked to the ship's International Oil Pollution Prevention Certificate after 8 September 2019 will need to meet the D-2 standard by the date of this renewal survey.

A major hazard when carrying out ballast exchange at sea is the sloshing of seawater in ballast tanks and holds, see section 5.7. The variability of the sea and swell conditions in a short period of time is an important factor in deciding whether to exchange ballast water at sea. Responsibility for deciding on whether to exchange ballast at sea must rest with the ship's Master, taking into account the permissible limits in respect of structural strength and stability and the sea and weather conditions prevailing at the time.

BCS recommends, where the exchange of ballast water at sea is to be carried out, that the following guidelines be followed:

- The ship's Master must ensure that the necessary calculations are carried out at each intermediate step so that:
  - Adequate intact transverse stability is maintained.
  - The permissible seagoing SWSF and SWBM are not exceeded.
  - For each cargo hold and block of cargo hold(s), the combined weight of the cargo in the hold(s) and the water ballast in the double bottom and hopper wing ballast tanks directly in way of that hold(s) does not exceed the allowable Seagoing limits for all intermediate draught conditions.
  - The present and forecast sea and swell conditions must be favourable to ensure that significant sloshing loads, which could cause structural damage to holds or tanks, cannot be generated.

- If the ship has been provided with a ballast exchange sequence and procedure approved by BCS, it should always be used and followed.

- To minimise the risk of structural damage, the exchange of water ballast at sea should always be carried out in calm weather conditions. All available weather forecasting should be utilised to determine that the weather condition is likely to stay calm within the 'weather window' of the ballast water exchange operation. This 'weather window' should be determined based upon the ballast water exchange sequence and the achievable ballasting/deballasting rates. A sufficient time margin should always be included to allow for any unexpected circumstances such as the breakdown of ballast pumps.

- Ballasting and deballasting of each pair of symmetrical port and starboard wing and double bottom ballast tanks should always be carried out simultaneously, such that the amount of water ballast carried in each tank is always the same, to avoid the introduction of twisting and torsional loads into the hull girder, see section 5.4.

- The progress of the ballast/deballast operation and the weather and sea condition should be closely monitored throughout the ballast exchange operation.

- The practice of continuously pumping in new ballast water from the sea and allowing the old ballast water in the tank to overflow through the tank's ventilation pipes may be considered. However, caution should be exercised as over pressurisation of the ballast tank could result if one or more of the vent lines are obstructed and lead to structural damage.

- If there is any difficulty in establishing a safe ballast exchange sequence, or if there is any doubt in the interpretation of an approved procedure or the stress limits imposed on the ship, no attempt should be made to exchange water ballast at sea.

BCS-G 47 Shipbuilding and Repair Quality Standard

Part A Shipbuilding and Remedial Quality Standard for New Construction

Part B Repair Quality Standard for Existing Ships

PART A
SHIPBUILDING AND REMEDIAL QUALITY STANDARDS FOR NEW CONSTRUCTION

1. Scope

2. General requirements for new construction

3. Qualification of personnel and procedures
- 3.1 Qualification of welders
- 3.2 Qualification of welding procedures
- 3.3 Qualification of NDT operators

4. Materials
- 4.1 Materials for structural members
- 4.2 Surface conditions

5. Gas Cutting

6. Fabrication and fairness
- 6.1 Flanged longitudinals and flanged brackets
- 6.2 Built-up sections
- 6.3 Corrugated bulkheads
- 6.4 Pillars, brackets and stiffeners
- 6.5 Maximum heating temperature on surface for line heating
- 6.6 Block assembly
- 6.7 Special sub-assembly
- 6.8 Shape
- 6.9 Fairness of plating between frames
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- 6.11 Preheating for welding hull steels at low temperature

7. Alignment

8. Welding Joint Details
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- 8.2 Typical fillet weld plate edge preparation (manual welding and semi-automatic welding)
- 8.3 Butt and fillet weld profile (manual welding and semi-automatic welding)
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- 9.1 Typical misalignment remedial
- 9.2 Typical butt weld plate edge preparation remedial (manual welding and semi-automatic welding)
- 9.3 Typical fillet weld plate edge preparation remedial (manual welding and semi-automatic welding)
- 9.4 Typical fillet and butt weld profile remedial (manual welding and semi-automatic welding)
- 9.5 Distance between welds remedial
- 9.6 Erroneous hole remedial
- 9.7 Remedial by insert plate
- 9.8 Weld surface remedial
- 9.9 Weld remedial (short bead)

REFERENCES

A1. BCS-G 76 “Bulk Carriers - Guidelines for Surveys, Assessment and Repair of Hull Structure”
A2. TSCF “Guidelines for the inspection and maintenance of double hull tanker structures”
A3. TSCF “Guidance manual for the inspection and condition assessment of tanker structures”
A4. BCS-R W7 “Hull and machinery steel forgings”
A5. BCS-R W8 “Hull and machinery steel castings”
A6. BCS-R W11 “Normal and higher strength hull structural steels”
A7. BCS-R W13 “Thickness tolerances of steel plates and wide flats”
A8. BCS-R W14 “Steel plates and wide flats with specified minimum through thickness properties (“Z” quality)”
A9. BCS-R W17 “Approval of consumables for welding normal and higher strength hull structural steels”
A10. BCS-R W28 “Welding procedure qualification tests of steels for hull construction and marine structures”
A11. Annex I to BCS-R Z10.1 “Hull surveys of oil tankers”, Z10.2 “Hull surveys of bulk carriers”, Z10.3 “Hull Surveys of Chemical Tankers”, Z10.4 “Hull Surveys of Double Hull Oil Tankers” and Z10.5 “Hull Surveys of Double-Skin Bulk Carriers”
A12. BCS-R Z23 “Hull survey for new construction”
A13. BCS-R W33 “Non-destructive testing of ship hull steel welds”
A14. BCS-G 96 “Double Hull Oil Tankers- Guidelines for Surveys, Assessment and Repair of Hull Structures”
A15. BCS-G 55 “General Dry Cargo Ships- Guidelines for Surveys, Assessment and Repair of Hull Structures”
A16. BCS-G 84 “Container Ships- Guidelines for Surveys, Assessment and Repair of Hull Structures”
A17. BCS-R W31 “YP 47 Steels and Brittle Crack Arrest Steels”
A18. BCS-R W32 “Qualification scheme for welders of hull structural steels”
A19. BCS-R W34 “Advanced non-destructive testing of materials and welds”
A20. BCS-R W35 “Requirements for NDT Suppliers”
A21. BCS-R S33 “Requirements for Use of Extremely Thick Steel Plates in Container Ships”

STANDARDS

EN 10163-1:2004 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections – Part 1: General requirements

1. Scope

It is intended that these standards provide guidance where established and recognized shipbuilding or national standards accepted by BCS do not exist.

1.1 This standard provides guidance on shipbuilding quality standards for the hull structure during new construction and the remedial standard where the quality standard is not met.

Whereas the standard generally applies to

- conventional merchant ship types,
- parts of hull covered by the rules of BCS,
- hull structures constructed from normal and higher strength hull structural steel,

the applicability of the standard is in each case to be agreed upon by BCS.

The standard does generally not apply to the new construction of

- special types of ships as e.g. gas tankers
- structures fabricated from stainless steel or other, special types or grades of steel

1.2 In this standard, both a "Standard" range and a "Limit" range are listed. The "Standard" range represents the target range expected to be met in regular work under normal circumstances. The "Limit" range represents the maximum allowable deviation from the "Standard" range. Work beyond the "Standard" range but within the "Limit" range is acceptable. In cases where no ‘limit’ value is specified, the value beyond the ‘standard’ range may be accepted subject to the consideration of BCS.

1.3 The standard covers typical construction methods and gives guidance on quality standards for the most important aspects of such construction. Unless explicitly stated elsewhere in the standard, the level of workmanship reflected herein will in principle be acceptable for primary and secondary structure of conventional designs. A more stringent standard may however be required for critical and highly stressed areas of the hull, and this is to be agreed with BCS in each case. In assessing the criticality of hull structure and structural components, reference is made to ref. A1, A2, A3, A11, A13, A14, A15, A16, A19 and A21.

1.4 Details relevant to structures or fabrication procedures not covered by this standard are to be approved by BCS on the basis of procedure qualifications and/or recognized national standards.

1.5 For use of this standard, fabrication fit-ups, deflections and similar quality attributes are intended to be uniformly distributed about the nominal values. The shipyard is to take corrective action to improve work processes that produce measurements where a skew distribution is evident. Relying upon remedial steps that truncate a skewed distribution of the quality attribute is unacceptable.

2. General requirements for new construction

2.1 In general, the work is to be carried out in accordance with BCS rules and under the supervision of the Surveyor to BCS.

2.2 Welding operations are to be carried out in accordance with work instructions accepted by BCS.

2.3 Welding of hull structures is to be carried out by qualified welders, according to approved and qualified welding procedures and with welding consumables approved by BCS , see Section 3. Welding operations are to be carried out under proper supervision by the shipbuilder. The working conditions for welding are to be monitored by BCSin accordance with BCS-R Z23 (ref. A12).

3. Qualification of personnel and procedures

3.1 Qualification of welders

3.1.1 Welders are to be qualified in accordance with BCS-R W32 (ref.A18) or other recognized standard accepted by BCS.
Recognition of other standards is subject to submission to BCS for evaluation. Subcontractors are to keep records of welders qualification and, when required, furnish valid approval test certificates.

3.1.2 Welding operators using fully mechanized or fully automatic processes need generally not pass approval testing provided that the production welds made by the operators are of the required quality. However, operators are to receive adequate training in setting or programming and operating the equipment. Records of training and operation experience shall be maintained on individual operator’s files and records, and be made available to BCS for inspection when requested.

3.2 Qualification of welding procedures

Welding procedures are to be qualified in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.

3.3 Qualification of NDT operators

Personnel performing non-destructive testing for the purpose of assessing quality of welds in connection with new construction covered by this standard, are to be qualified in accordance with BCS rules or to a recognized international or national qualification scheme. Records of operators and their current certificates are to be kept and made available to the Surveyor for inspection.

In case, of non-destructive examination carried out by an independent firm from the shipbuilder, such firm has to comply with BCS-R W35 (Ref.A20).

4. Materials

4.1 Materials for Structural Members

All materials, including weld consumables, to be used for the structural members are to be approved by BCS as per the approved construction drawings and meet the respective BCS Requirements (see ref. A4, A5, A6, A7, A8, A9 and A17). Additional recommendations are contained in the following paragraphs.

All materials used should be manufactured at a works approved by BCSfor the type and grade supplied.

4.2 Surface Conditions

4.2.1 Definitions

Minor Imperfections:	Pitting, rolled-in scale, indentations, roll marks, scratches and grooves
Defects:	Cracks, shells, sand patches, sharp edged seams and minor imperfections exceeding the limits of table 1
Depth of Imperfections or defects:	The depth is to be measured from the surface of the product

4.2.2 Acceptance without remedies

Minor imperfections, in accordance with the nominal thickness (t) of the product and the limits described in Table 1, are permissible and may be left as they are.

Imperfection surface area Ratio(%)	15～20%	5～15%	0～5%
t < 20 mm	0.2 mm	0.4 mm	0.5 mm
20 mm ≤ t < 50 mm	0.2 mm	0.6 mm	0.7 mm
50 mm ≤ t	0.2 mm	0.7 mm	0.9 mm

Table 1 Limits for depth of minor imperfection, for acceptance without remedies

Imperfection surface area Ratio (%) is obtained as influenced area / area under consideration (i.e. plate surface area) x 100%.

For isolated surface discontinuities, influenced area is obtained by drawing a continuous line which follows the circumference of the discontinuity at a distance of 20 mm. (Figure 1)

For surface discontinuities appearing in a cluster, influenced area is obtained by drawing a continuous line which follows the circumference of the cluster at a distance of 20 mm. (Figure 2)

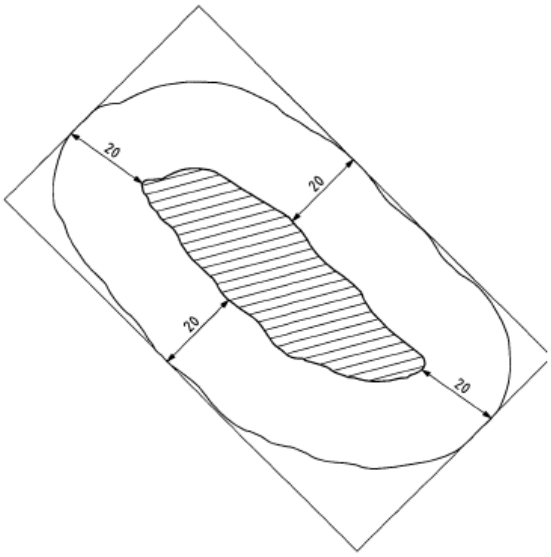


Figure 1 - Determination of the area influenced by an isolated discontinuity
(EN 10163-1:2004)

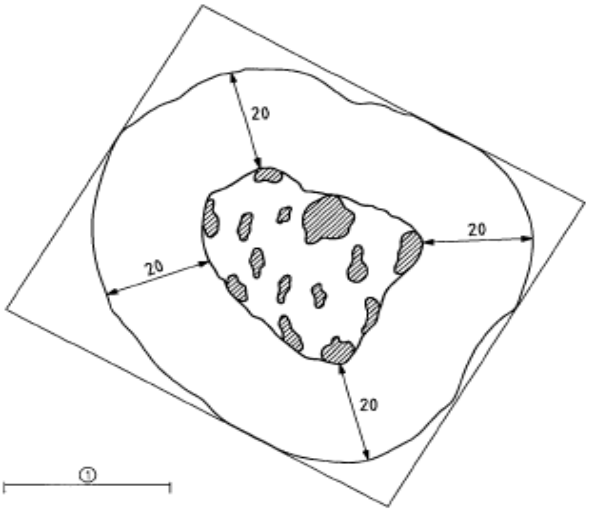


Figure 2 - Determination of the area influenced by clustered discontinuities
(EN 10163-1:2004)

4.2.3 Remedial of Defects

Defects are to be remedied by grinding and/or welding in accordance with BCS-R W11 (ref. A6).

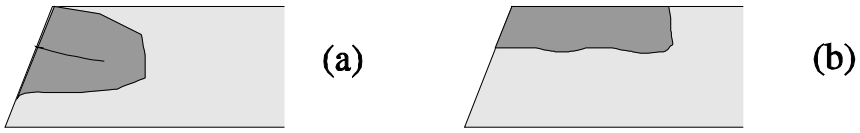
4.2.4 Further Defects

4.2.4.1 Lamination

Investigation to be carried out at the steelmill into the cause and extent of the detected laminations. Severe lamination is to be remedied by local insert plates. The minimum breadth or length of the plate to be replaced is to be:

- 1600 mm for shell and strength deck plating in way of cruciform or T-joints,
- 800 mm for shell, strength deck plating and other primary members,
- 300 mm for other structural members.

Local limited lamination may be remedied by chipping and/or grinding followed by welding in accordance with sketch (a). In case where the local limited lamination is near the plate surface, the remedial may be carried out as shown in sketch (b). For limitations see paragraph 4.2.2.



4.2.4.2 Weld Spatters

Loose weld spatters are to be removed by grinding or other measures to clean metal surface (see Table 9.13), as required by the paint system, on:

- shell plating
- deck plating on exposed decks
- in tanks for chemical cargoes
- in tanks for fresh water and for drinking water
- in tanks for lubricating oil, hydraulic oil, including service tanks

5. Gas Cutting

The roughness of the cut edges is to meet the following requirements:

Free Edges:

	Standard	**Limit**
Strength Members	150 µm	300 µm
Others	500 µm	1000 µm

Welding Edges:

	Standard	**Limit**
Strength Members	400 µm	800 µm
Others	800 µm	1500 µm

6. Fabrication and fairness

6.1 Flanged longitudinals and flanged brackets (see Table 6.1)
6.2 Built-up sections (see Table 6.2)
6.3 Corrugated bulkheads (see Table 6.3)
6.4 Pillars, brackets and stiffeners (see Table 6.4)
6.5 Maximum heating temperature on surface for line heating (see Table 6.5)
6.6 Block assembly (see Table 6.6)
6.7 Special sub-assembly (see Table 6.7)
6.8 Shape (see Table 6.8 and 6.9)
6.9 Fairness of plating between frames (see Table 6.10)
6.10 Fairness of plating with frames (see Table 6.11)
6.11 Preheating for welding hull steels at low temperature (See Table 6.12)

7. Alignment

The quality standards for alignment of hull structural components during new construction are shown in Tables 7.1, 7.2 and 7.3. BCS may require a closer construction tolerance in areas requiring special attention, as follows:

- Regions exposed to high stress concentrations
- Fatigue prone areas
- Detail design block erection joints
- High tensile steel regions

8. Welding Joint Details

Edge preparation is to be qualified in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.

Some typical edge preparations are shown in Table 8.1, 8.2, 8.3, 8.4 and 8.6 for reference.

8.1 Typical butt weld plate edge preparation (manual and semi-automatic welding) for reference - see Table 8.1 and 8.2
8.2 Typical fillet weld plate edge preparation (manual and semi-automatic welding) for reference - see Table 8.3 and 8.4
8.3 Butt and fillet weld profile (manual and semi-automatic welding) - see Table 8.5
8.4 Typical butt weld plate edge preparation (Automatic welding) for reference - see Table 8.6
8.5 Distance between welds - see Table 8.7

9. Remedial

All the major remedial work is subject to reporting by shipbuilder to BCS for approval in accordance with their work instruction for new building.

Some typical remedial works are shown in Tables 9.1 to 9.13.

9.1 Typical misalignment remedial - see Tables 9.1 to 9.3
9.2 Typical butt weld plate edge preparation remedial (manual and semi-automatic welding) - see Table 9.4 and 9.5
9.3 Typical fillet weld plate edge preparation remedial (manual and semi-automatic welding) - see Tables 9.6 to 9.8
9.4 Typical fillet and butt weld profile remedial (manual and semi-automatic welding) - see Table 9.9

9.5 Distance between welds remedial - see Table 9.10
9.6 Erroneous hole remedial - see Table 9.11
9.7 Remedial by insert plate - see Table 9.12
9.8 Weld surface remedial - see Table 9.13
9.9 Weld remedial (short bead) - see Table 9.14

Table 6.1 – Flanged Longitudinals and Flanged Brackets

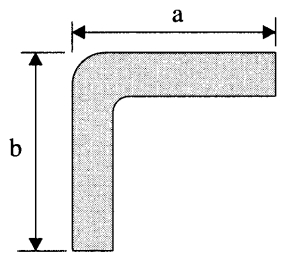
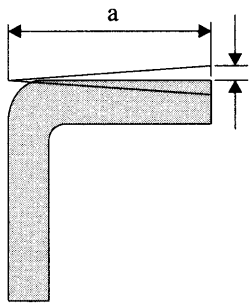
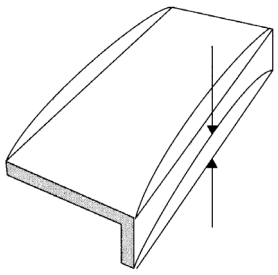
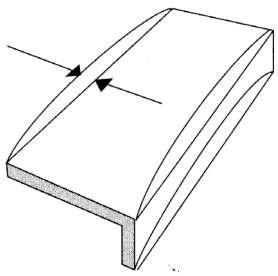
Detail	Standard	Limit	Remarks
Breadth of flange  compared to correct size	± 3 mm	± 5 mm	
Angle between flange and web  compared to template	± 3 mm	± 5 mm	per 100 mm of a
Straightness in plane of flange and web  	± 10 mm	± 25 mm	per 10 m

Table 6.2 – Built Up Sections

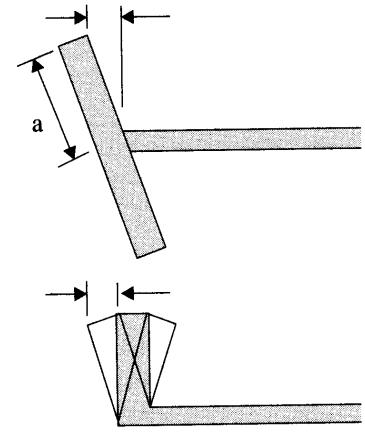
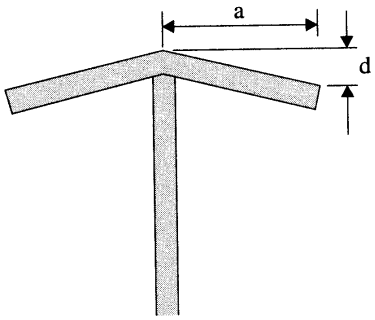
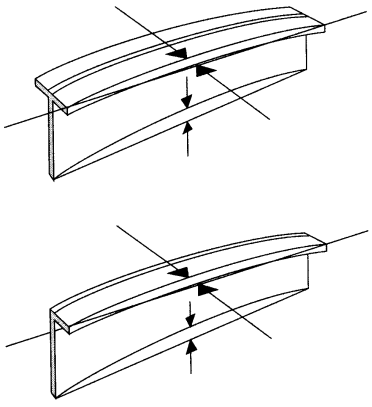
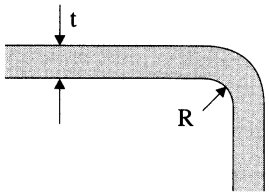
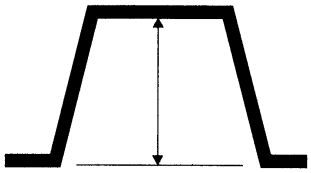
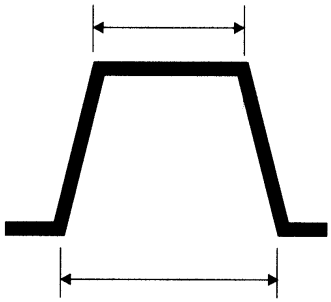
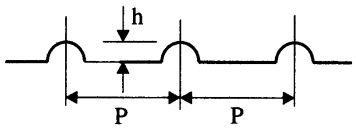
Detail	Standard	Limit	Remarks
Frames and longitudinal 	± 1.5 mm	± 3 mm	per 100 mm of a
Distortion of face plate 	$d \leq 3 + a/100$ mm	$d \leq 5 + a/100$ mm	
Distortion in plane of web and flange of built up longitudinal frame, transverse frame, girder and transverse web. 	± 10 mm	± 25 mm	per 10 m in length

TABLE 6.3 – Corrugated Bulkheads

Detail	Standard	Limit	Remarks
Mechanical bending 	R ≥ 3t mm R ≥ 4.5t mm for CSR ships [Note 1]	2t mm [Note 2]	Material to be suitable for cold flanging (forming) and welding in way of radius
Depth of corrugation 	± 3 mm	± 6 mm	
Breadth of corrugation 	± 3 mm	± 6 mm	
Pitch and depth of swedged corrugated bulkhead compared with correct value 	h : ± 2.5 mm Where it is not aligned with other bulkheads P : ± 6 mm Where it is aligned with other bulkheads P : ± 2 mm	h : ± 5 mm Where it is not aligned with other bulkheads P : ± 9 mm Where it is aligned with other bulkheads P : ± 3 mm	

Notes:

1. For CSR Bulk Carriers built under the “Common Structural Rules for Bulk Carriers” with the effective dates of 1 July 2010 and 1 July 2012, the standard is R≥2t mm.

2. For CSR ships, the allowable inside bending radius of cold formed plating may be reduced provided the following requirements are complied with.

   When the inside bending radius is reduced below 4.5 times the as-built plate thickness, supporting data is to be provided. The bending radius is in no case to be less than 2 times the as-built plate thickness. As a minimum, the following additional requirements are to be complied with:

   a) For all bent plates:
   - 100% visual inspection of the bent area is to be carried out.
   - Random checks by magnetic particle testing are to be carried out.

   b) In addition to a), for corrugated bulkheads subject to lateral liquid pressure:
   - The steel is to be of Grade D/DH or higher.

The material is impact tested in the strain-aged condition and satisfies the requirements stated herein. The deformation is to be equal to the maximum deformation to be applied during production, calculated by the formula $t_{as\text{-}built}/(2r_{bdg} + t_{as\text{-}built})$, where $t_{as\text{-}built}$ is the as-built thickness of the plate material and r_{bdg} is the bending radius. One sample is to be plastically strained at the calculated deformation or 5%, whichever is greater and then artificially aged at 250°C for one hour then subject to Charpy V-notch testing. The average impact energy after strain ageing is to meet the impact requirements specified for the grade of steel used.

Table 6.4 – Pillars, Brackets and Stiffeners

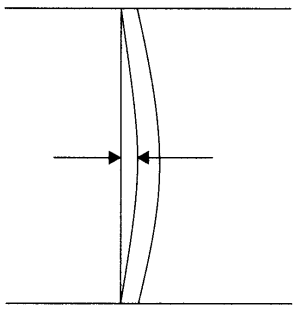
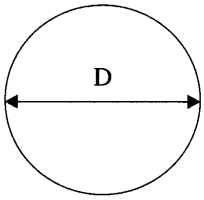
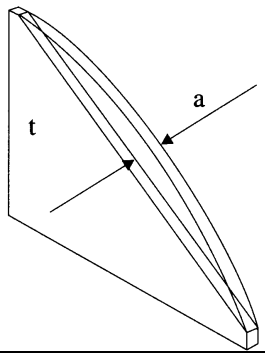
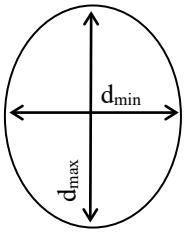
Detail	Standard	Limit	Remarks
Pillar (between decks) 	4 mm	6 mm	
Cylindrical structure diameter (pillars, masts, posts, etc.) 	± D/200 mm max. + 5 mm	± D/150 mm max. 7.5 mm	
Tripping bracket and small stiffener, distortion at the part of free edge 	$a \leq t/2$ mm	t	
Ovality of cylindrical structure 		$d_{max} - d_{min} \leq 0.02 \times d_{max}$	

Table 6.5 – Maximum Heating Temperature on Surface for Line Heating

Item		Standard	Limit	Remarks
Conventional Process AH32-EH32 & AH36-EH36	Water cooling just after heating	Under 650°C		
TMCP type AH36-EH36 (Ceq.>0.38%)	Air cooling after heating	Under 900°C		
	Air cooling and subsequent water cooling after heating	Under 900°C (starting temperature of water cooling to be under 500°C)		
TMCP type AH32-DH32 & AH36-DH36 (Ceq. ≤ 0.38%)	Water cooling just after heating or air cooling	Under 1000°C		
TMCP type EH32 & EH36 (Ceq. ≤ 0.38%)	Water cooling just after heating or air cooling	Under 900°C		

NOTE:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}(\%)$$

Table 6.6 – Block Assembly

Item	Standard	Limit	Remarks
Flat Plate Assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	±20mm	
Squareness	± 5 mm	±10mm	
Deviation of interior members from plate	5 mm	10mm	
Curved plate assembly			
Length and Breadth	± 4 mm	± 8 mm	measured along the girth
Distortion	± 10 mm	± 20 mm	
Squareness	± 10 mm	± 15 mm	
Deviation of interior members from plate	5 mm	10 mm	
Flat cubic assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	± 20 mm	
Squareness	± 5 mm	± 10 mm	
Deviation of interior members from plate	5 mm	10 mm	
Twist	± 10 mm	± 20 mm	
Deviation between upper and lower plate	± 5 mm	± 10 mm	
Curved cubic assembly			
Length and Breadth	± 4 mm	± 8 mm	measured along with girth
Distortion	± 10 mm	± 20 mm	
		± 15 mm	

Squareness Deviation of interior members from plate Twist Deviation between upper and lower plate	± 10 mm ± 5 mm ± 15 mm ± 7 mm	± 10 mm ± 25 mm ± 15 mm	

Table 6.7 – Special Sub-Assembly

Item	Standard	Limit	Remarks
Distance between upper/lower gudgeon	± 5 mm	± 10 mm	
Distance between aft edge of boss and aft peak bulkhead	± 5 mm	± 10 mm	
Twist of sub-assembly of stern frame	5 mm	10 mm	
Deviation of rudder from shaft center line	4 mm	8 mm	
Twist of rudder plate	6 mm	10 mm	
Flatness of top plate of main engine bed	5 mm	10 mm	
Breadth and length of top plate of main engine bed	± 4 mm	± 6 mm	
NOTE: Dimensions and tolerances have to fulfill engine and equipment manufacturers' requirements, if any.			

Table 6.8 – Shape

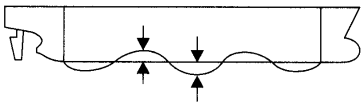
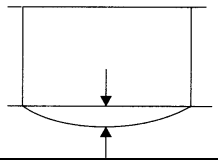
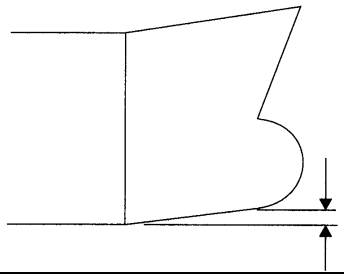
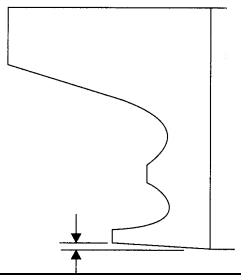
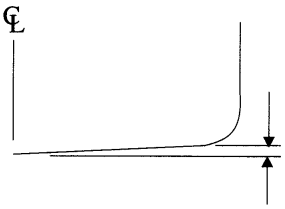
Detail	Standard	Limit	Remarks
Deformation for the whole length 	± 50 mm		per 100 m against the line of keel sighting
Deformation for the distance between two adjacent bulkheads 	± 15 mm		
Cocking-up of fore body 	± 30 mm		The deviation is to be measured from the design line.
Cocking-up of aft-body 	± 20 mm		
Rise of floor amidships 	± 15 mm		The deviation is to be measured from the design line.

Table 6.9 – Shape

Item	Standard	Limit	Remarks
Length between perpendiculars	±L/1000 mm where L is in mm		Applied to ships of 100 metre length and above. For the convenience of the measurement the point where the keel is connected to the curve of the stem may be substituted for the fore perpendicular in the measurement of the length.
Moulded breadth at midship	±B/1000 mm where B is in mm		Applied to ships of 15 metre breadth and above, measured on the upper deck.
Moulded depth at midship	±D/1000 mm where D is in mm		Applied to ships of 10 metre depth and above, measured up to the upper deck.

Table 6.10 – Fairness of Plating Between Frames

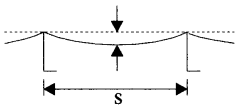
Item		Standard	Limit	Remarks
Shell plate	Parallel part (side & bottom shell)	4 mm	8 mm	
	Fore and aft part	5 mm		
Tank top plate		4 mm		
Bulkhead	Longl. Bulkhead Trans. Bulkhead Swash Bulkhead	6 mm		
Strength deck	Parallel part	4 mm	8 mm	
	Fore and aft part	6 mm	9 mm	
	Covered part	7 mm	9 mm	
Second deck	Bare part	6 mm	8 mm	
	Covered part	7 mm	9 mm	
Forecastle deck poop deck	Bare part	4 mm	8 mm	
	Covered part	6 mm	9 mm	
Super structure deck	Bare part	4 mm	6 mm	
	Covered part	7 mm	9 mm	
House wall	Outside wall	4 mm	6 mm	
	Inside wall	6 mm	8 mm	
	Covered part	7 mm	9 mm	
Interior member (web of girder, etc)		5 mm	7 mm	
Floor and girder in double bottom		5 mm	8 mm	

Table 6.11 – Fairness of Plating with Frames

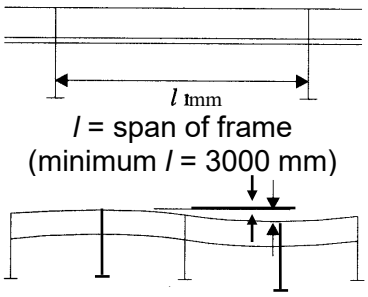
Item		Standard	Limit	Remarks
Shell plate	Parallel part	±2 *l* /1000 mm	±3 *l* /1000 mm	*l* = span of frame (mm) To be measured between on trans. space (min. *l* = 3000 mm)
	Fore and aft part	±3 *l* /1000 mm	±4 *l* /1000 mm	
Strength deck (excluding cross deck) and top plate of double bottom	-	±3 *l* /1000 mm	±4 *l* /1000 mm	
Bulkhead	-		±5 *l* /1000 mm	
Accommodation above the strength deck and others	-	±5 *l* /1000 mm	±6 *l* /1000 mm	
 *l* = span of frame (minimum *l* = 3000 mm) To be measured between one trans. space.				

Table 6.12 – Preheating for welding hull steels at low temperature

<table>
<tr><td colspan="2" rowspan="2">Item</td><td colspan="2">Standard</td><td>Limit</td><td>Remarks</td></tr>
<tr><td>Base metal temperature needed preheating</td><td>Minimum preheating temperature</td><td></td><td></td></tr>
<tr><td>Normal strength steels</td><td>A, B, D, E</td><td>Below -5 ºC</td><td rowspan="4">20 ºC [1)]</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Higher strength steels (TMCP type)</td><td rowspan="2">AH32 – EH32
AH36 – EH36</td><td>Below 0 ºC</td></tr>
<tr><td>Higher strength steels (Conventional type)</td><td>Below 0 ºC</td></tr>
<tr><td colspan="6">(Note)
1)This level of preheat is to be applied unless the approved welding procedure specifies a higher level.</td></tr>
</table>

Table 7.1 – Alignment

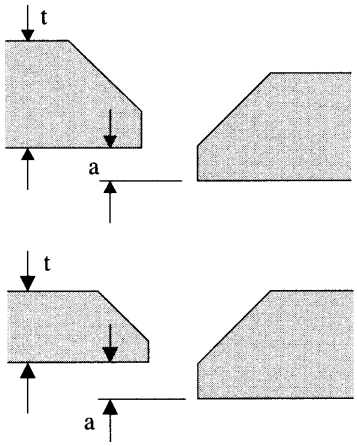
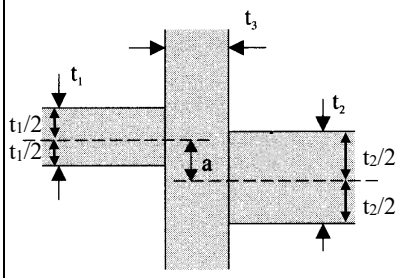
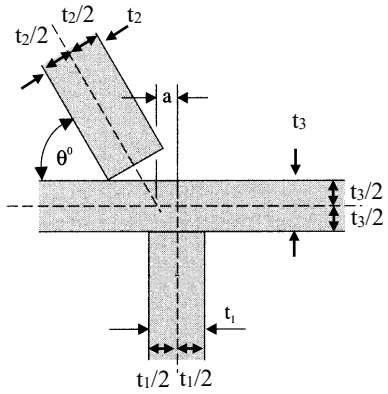
Detail	Standard	Limit	Remarks
Alignment of butt welds 		a ≤ 0.15t strength member a ≤ 0.2t other but maximum 4.0 mm	t is the lesser plate thickness
Alignment of fillet welds  $t_1 < t_2$		Strength member and higher stress member: $a \leq t_1/3$ Other: $a \leq t_1/2$	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1, then t_3 should be substituted for t_1 in the standard.
Alignment of fillet welds 		Strength member and higher stress member: $a \leq t_1/3$ Other: $a \leq t_1/2$	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1, then t_3 should be substitute for t_1 in the standard.

Table 7.2 – Alignment

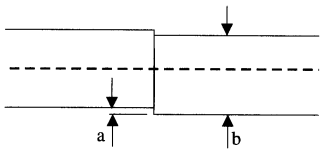
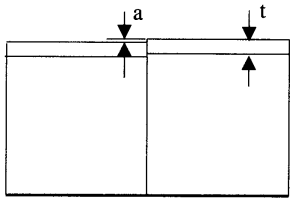
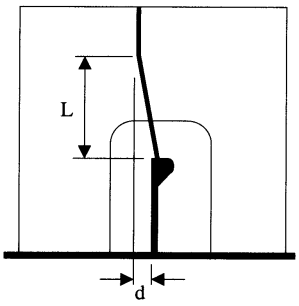
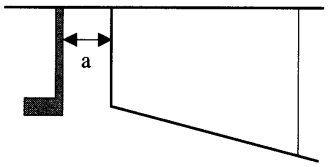
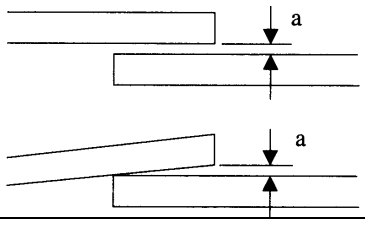
Detail	Standard	Limit	Remarks
Alignment of flange of T-longitudinal  b (mm)	Strength member $a \leq 0.04b$ (mm)	a = 8.0 mm	
Alignment of height of T-bar, L-angle bar or bulb  	Strength member $a \leq 0.15t$ Other $a \leq 0.20t$	a = 3.0 mm	
Alignment of panel stiffener  	$d \leq L/50$		
Gap between bracket/intercostal and stiffener  	$a \leq 2.0$ mm	a = 3.0 mm	
Alignment of lap welds  	$a \leq 2.0$ mm	a = 3.0 mm	

Table 7.3 – Alignment

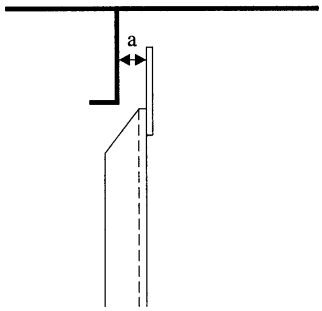
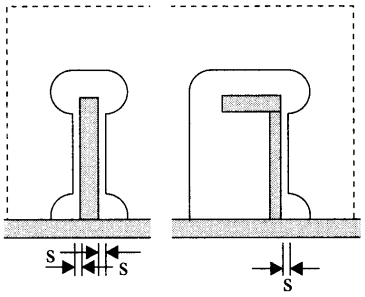
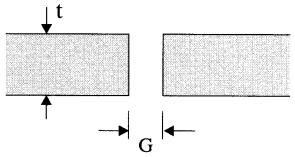
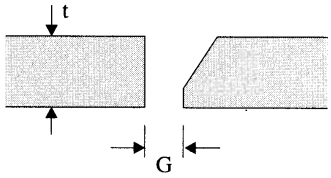
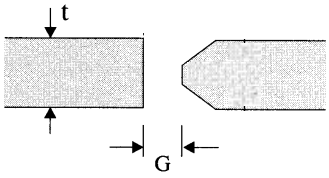
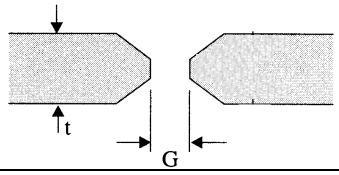
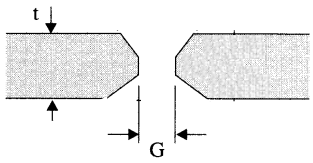
Detail	Standard	Limit	Remarks
Gap between beam and frame 	a ≤ 2.0 mm	a = 5.0 mm	
Gap around stiffener cut-out 	s ≤ 2.0 mm	s = 3.0 mm	

Table 8.1 – Typical Butt Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

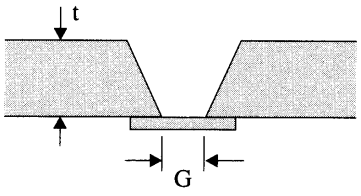
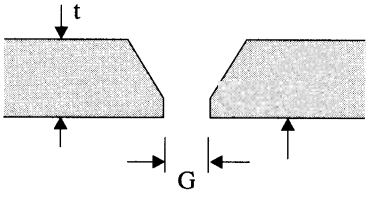
Detail	Standard	Limit	Remarks
Square butt $t \leq 5$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Single bevel butt $t > 5$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Double bevel butt $t > 19$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Double vee butt, uniform bevels 	G ≤ 3 mm	G = 5 mm	see Note 1
Double vee butt, non-uniform bevel 	G ≤ 3 mm	G = 5 mm	see Note 1

NOTE 1

Different plate edge preparation may be accepted or approved by BCS in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.

For welding procedures other than manual welding, see paragraph 3.2 Qualification of weld procedures.

Table 8.2 – Typical Butt Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

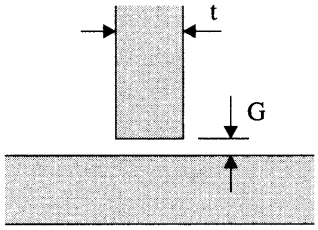
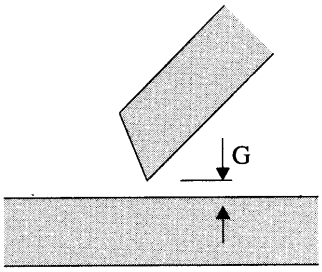
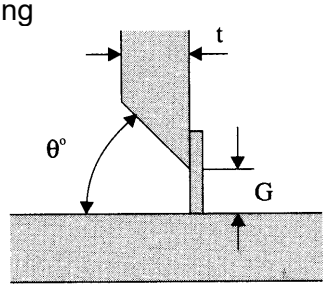
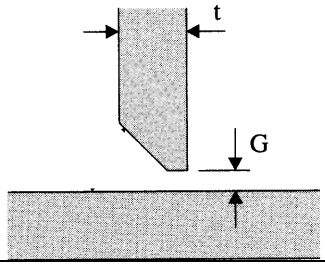
Detail	Standard	Limit	Remarks
Single Vee butt, one side welding with backing strip (temporary or permanent) 	G = 3 to 9 mm	G = 16 mm	see Note 1
Single vee butt 	G ≤ 3 mm	G = 5 mm	see Note 1

NOTE 1

Different plate edge preparation may be accepted or approved by BCS in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.

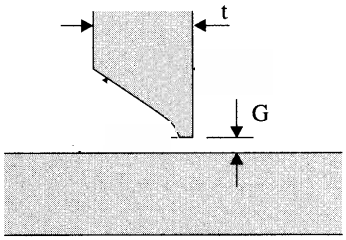
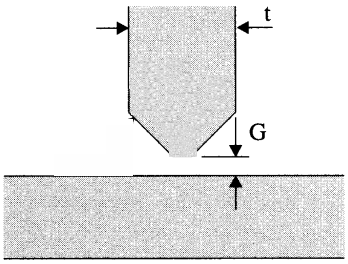
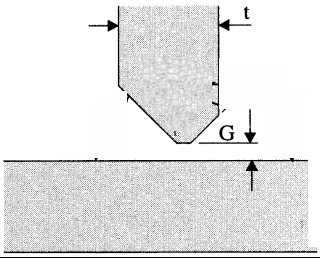
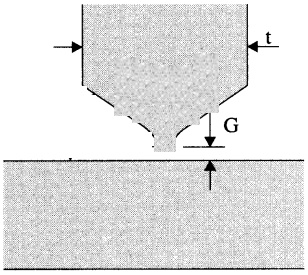
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.3 – Typical Fillet Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Tee Fillet 	G ≤ 2 mm	G = 3 mm	see Note 1
Inclined fillet 	G ≤ 2 mm	G = 3 mm	see Note 1
Single bevel tee with permanent backing 	G ≤ 4 to 6 mm θ° = 30° to 45°	G = 16 mm	Not normally for Strength member also see Note 1
Single bevel tee 	G ≤ 3 mm		see Note 1

NOTE 1
Different plate edge preparation may be accepted or approved by BCS in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.4 – Typical Fillet Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Single 'J' bevel tee 	G = 2.5 to 4 mm		see Note 1
Double bevel tee symmetrical t > 19 mm 	G ≤ 3 mm		see Note 1
Double bevel tee asymmetrical t > 19 mm 	G ≤ 3 mm		see Note 1
Double 'J' bevel tee symmetrical 	G = 2.5 to 4 mm		see Note 1

NOTE 1
Different plate edge preparation may be accepted or approved by BCS in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.5 – Butt And Fillet Weld Profile (Manual Welding and Semi-Automatic Welding)

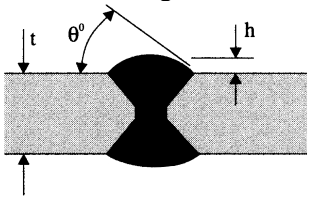
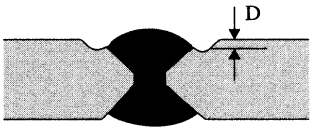
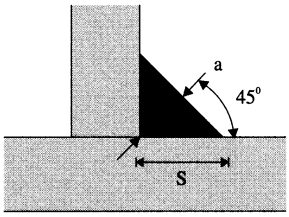
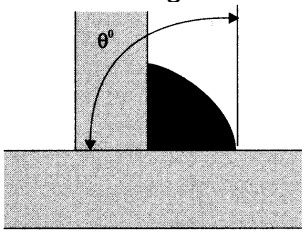
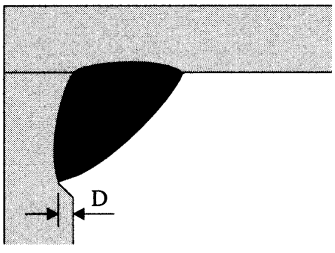
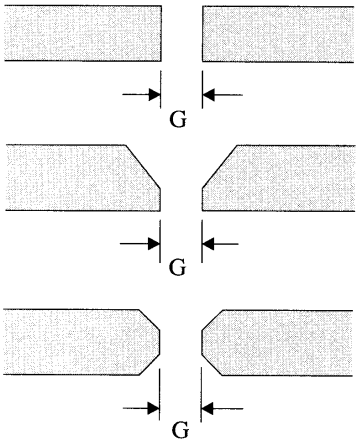
Detail	Standard	Limit	Remarks
Butt weld toe angle 	$\theta \leq 60°$ $h \leq 6$ mm	$\theta \leq 90°$	
Butt weld undercut 		$D \leq 0.5$ mm for strength member $D \leq 0.8$ mm for other	
Fillet weld leg length  s = leg length; a = throat thickness		$s \geq 0.9s_d$ $a \geq 0.9a_d$ over short weld lengths	s_d = design s a_d = design a
Fillet weld toe angle 		$\theta \leq 90°$	In areas of stress concentration and fatigue, BCS may require a lesser angle.
Fillet weld undercut 		$D \leq 0.8$ mm	

Table 8.6 – Typical Butt Weld Plate Edge Preparation (Automatic welding) for Reference

Detail	Standard	Limit	Remarks
Submerged Arc Welding (SAW) 	$0 \leq G \leq 0.8$ mm	G = 2 mm	See Note 1.

NOTE 1

Different plate edge preparation may be accepted or approved by BCS in accordance with BCS-R W28 (ref. A10) or other recognized standard accepted by BCS.

For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.7 – Distance Between Welds

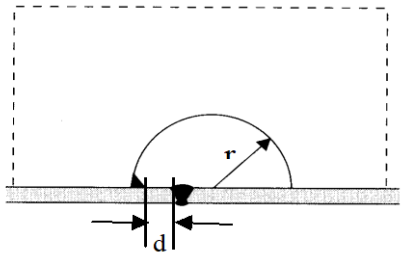
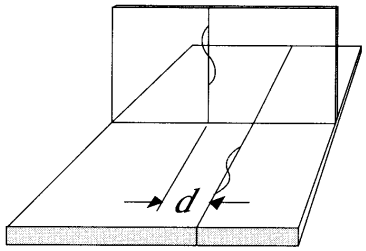
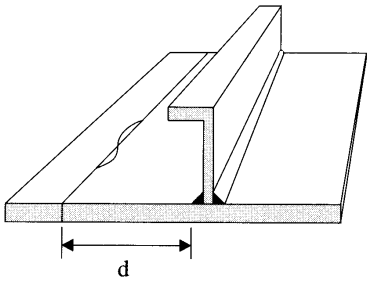
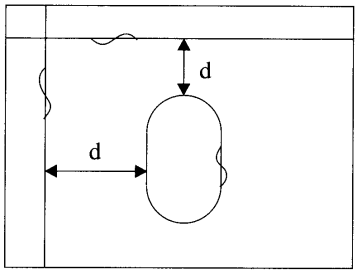
Detail	Standard	Limit	Remarks
Scallops over weld seams 		for strength member d ≥ 5mm for other d ≥ 0mm	The “d” is to be measured from the toe of the fillet weld to the toe of the butt weld.
Distance between two butt welds 		d ≥ 0 mm	
Distance between butt weld and fillet weld 		for strength member d ≥ 10 mm for other d ≥ 0 mm	The “d” is to be measured from the toe of the fillet weld to the toe of the butt weld.
Distance between butt welds 	for cut-outs d ≥ 30 mm		
	for margin plates d ≥ 300 mm	150 mm	

Table 9.1 – Typical Misalignment Remedial

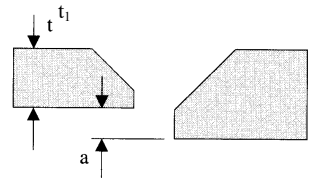
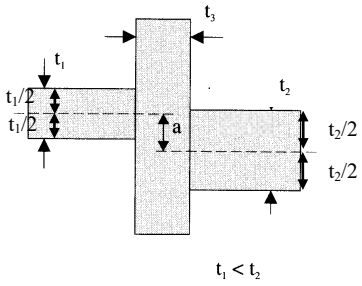
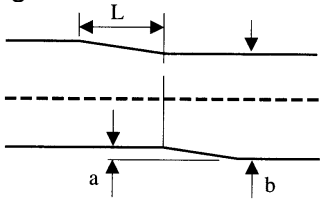
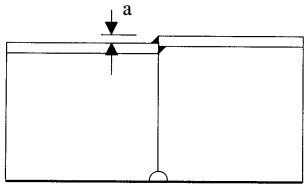
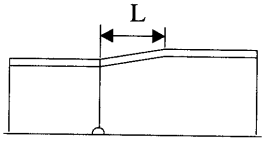
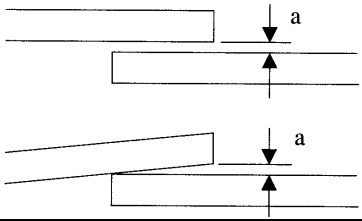
Detail	Remedial Standard	Remarks
Alignment of butt joints 	Strength member $a > 0.15t_1$ or $a > 4$ mm release and adjust Other $a > 0.2t_1$ or $a > 4$ mm release and adjust	t_1 is lesser plate thickness
Alignment of fillet welds 	Strength member and higher stress member $t_1/3 < a \leq t_1/2$ - generally increase weld throat by 10% $a > t_1/2$ - release and adjust over a minimum of 50a Other $a > t_1/2$ - release and adjust over a minimum of 30a	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1 then t_3 should be substituted for t_1 in standard
Alignment of flange of T-longitudinal 	When $0.04b < a \leq 0.08b$, max 8 mm: grind corners to smooth taper over a minimum distance L = 3a When $a > 0.08b$ or 8 mm: release and adjust over a minimum distance L = 50a	
Alignment of height of T-bar, L-angle bar or bulb 	When 3 mm < a ≤ 6 mm: build up by welding When a > 6 mm: release and adjust over minimum L = 50a for strength member and L = 30a for other 	
Alignment of lap welds 	3 mm < a ≤ 5 mm: weld leg length to be increased by the same amount as increase in gap in excess of 3 mm a > 5 mm: members to be re-aligned	

Table 9.2 – Typical Misalignment Remedial

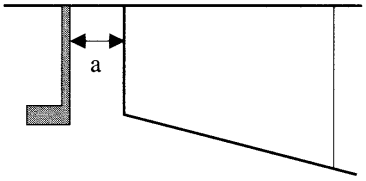
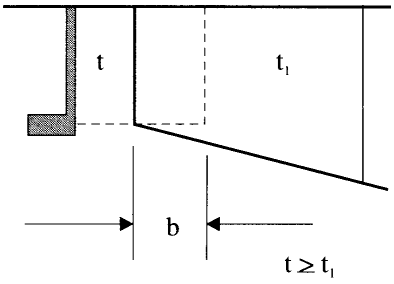
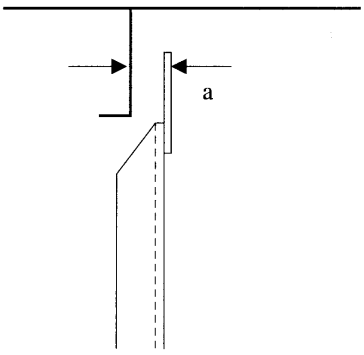
Detail	Remedial Standard	Remarks
Gap between bracket/intercostal and stiffener 	When 3 mm < a ≤ 5 mm: weld leg length to be increased by increase in gap in excess of 3 mm	
	When 5mm < a ≤ 10 mm: chamfer 30° to 40° and build up by welding with backing	
	When a > 10 mm: increase gap to about 50 mm and fit collar plate  b = (2t + 25) mm, min. 50 mm	
Gap between beam and frame 	3 mm < a ≤ 5 mm: weld leg length to be increased by the same amount as increase in gap in excess of 3 mm a > 5 mm release and adjust	

Table 9.3 – Misalignment Remedial

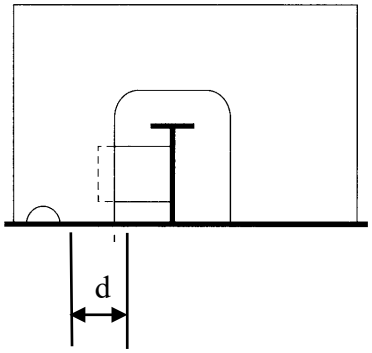
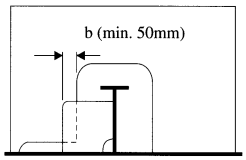
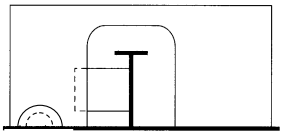
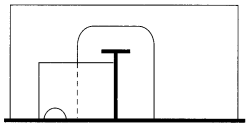
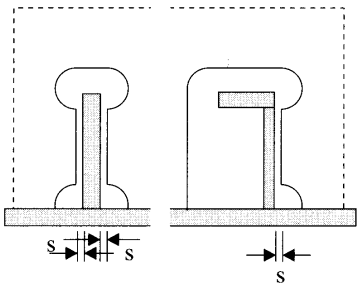
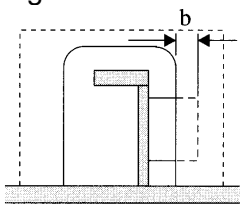
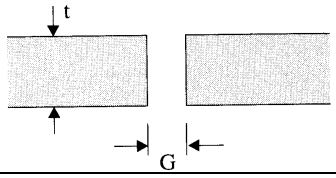
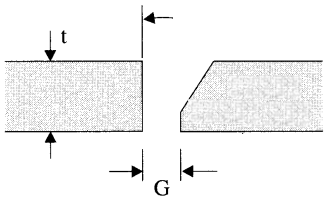
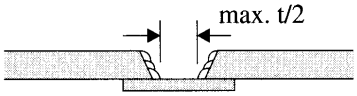
Detail	Remedial standard	Remarks
Position of scallop 	When d < 75 mm web plate to be cut between scallop and slot, and collar plate to be fitted  Or fit small collar over scallop  Or fit collar plate over scallop 	
Gap around stiffener cut-out 	When 3 mm < s ≤ 5 mm weld leg length to be increased by the same amount as increase in gap in excess of 2 mm	
	When 5 mm < s ≤ 10 mm nib to be chamfered and built up by welding	
	When s > 10 mm cut off nib and fit collar plate of same height as nib  20 mm ≤ b ≤ 50 mm	

Table 9.4 – Typical Butt Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

<table>
<tr><th>Detail</th><th>Remedial standard</th><th>Remarks</th></tr>
<tr><td>Square butt
 
</td><td>When G ≤ 10 mm
chamfer to 45° and build up by welding

When G > 10mm build up with backing strip; remove,
back gouge and seal weld;
or, insert plate, min. width 300 mm</td><td></td></tr>
<tr><td>Single bevel butt
 
</td><td rowspan="4">When 5 mm < G ≤ 1.5t (maximum 25 mm)
build up gap with welding on one or both edges to maximum of 0.5t,
using backing strip, if necessary.

Where a backing strip is used, the backing strip is
to be removed, the weld back gouged, and a
sealing weld made.
 

Different welding arrangement by using backing material approved by BCS may be accepted on the basis of an appropriate welding procedure specification.

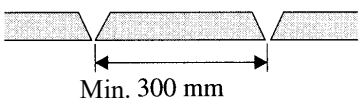
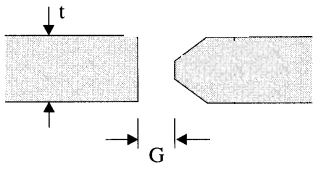
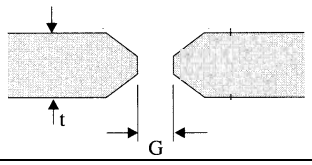
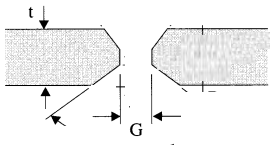
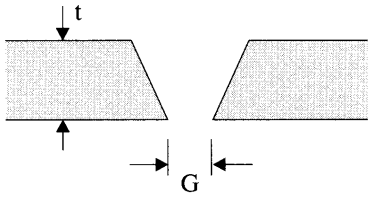
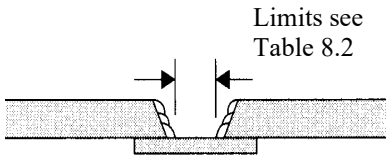
When G > 25 mm or 1.5t, whichever is smaller,
use insert plate, of minimum width 300 mm
 
</td><td rowspan="4"></td></tr>
<tr><td>Double bevel butt
 
</td></tr>
<tr><td>Double vee butt, uniform bevels
 
</td></tr>
<tr><td>Double vee butt, non-uniform bevel
 
</td></tr>
</table>

Table 9.5 – Typical Butt Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

<table>
<tr><th>Detail</th><th>Remedial Standard</th><th>Remarks</th></tr>
<tr><td>Single vee butt, one side welding
 
</td><td rowspan="2">When 5 mm < G ≤ 1.5t mm (maximum 25 mm), build up gap with welding on
one or both edges, to “Limit” gap size preferably to “Standard” gap size as described in Table 8.2.

Where a backing strip is used, the backing
strip is to be removed, the weld back
gouged, and a sealing weld made.

Different welding arrangement by using backing material approved byTL may be accepted on the basis of an appropriate welding procedure specification.
 

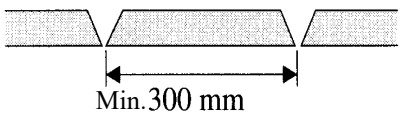
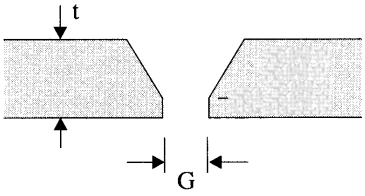
When G > 25 mm or 1.5t, whichever is smaller, use insert plate of minimum width 300 mm.
 
</td><td rowspan="2"></td></tr>
<tr><td>Single vee butt
 
</td></tr>
</table>

Table 9.6 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

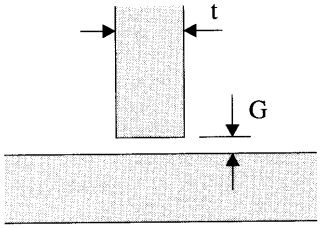
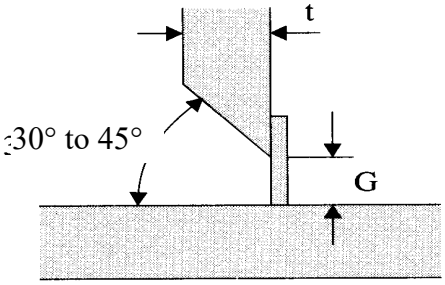
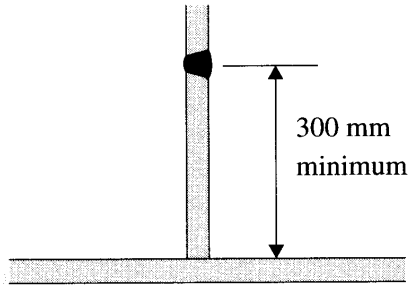
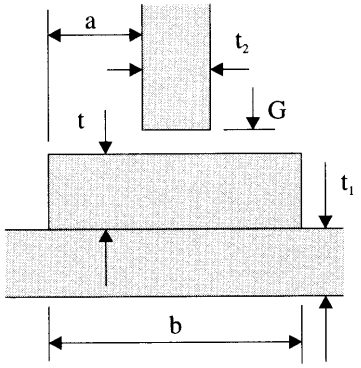
<table>
<tr><th>Detail</th><th>Remedial standard</th><th>Remarks</th></tr>
<tr><td rowspan="3">Tee Fillet
 
</td><td>3 mm < G ≤ 5 mm – leg length increased
to Rule leg + (G-2)</td><td rowspan="3"></td></tr>
<tr><td>5 mm < G ≤ 16 mm or G ≤ 1.5t - chamfer by 30° to 45°,
build up with welding, on one side, with backing strip if necessary, grind and weld.
 
</td></tr>
<tr><td>G > 16 mm or G > 1.5t use insert plate of minimum width 300 mm
 
</td></tr>
<tr><td>Liner treatment
 
</td><td>$t_2 \le t \le t_1$
G ≤ 2 mm
a = 5 mm + fillet leg length</td><td>Not to be used in cargo area or areas of tensile stress through the thickness of the liner</td></tr>
</table>

Table 9.7 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

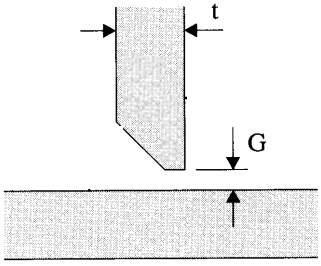
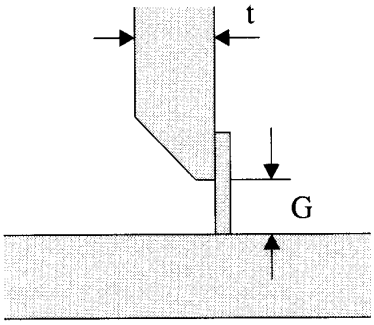
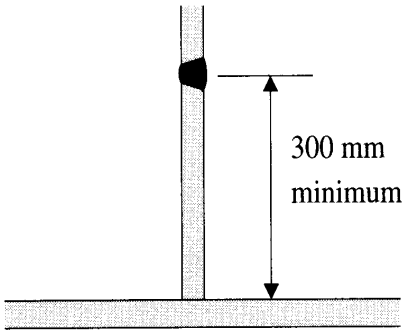
<table>
<tr><th>Detail</th><th>Remedial standard</th><th>Remarks</th></tr>
<tr><td rowspan="3">Single bevel tee
 
</td><td>3 mm < G ≤ 5 mm
build up weld</td><td rowspan="3"></td></tr>
<tr><td>5 mm < G ≤ 16 mm - build up with welding, with backing strip if necessary, remove backing strip if used, back
gouge and back weld.
 
</td></tr>
<tr><td>G > 16 mm new plate to be inserted of
minimum width 300 mm
 
</td></tr>
</table>

Table 9.8 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

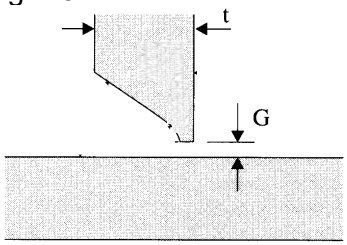
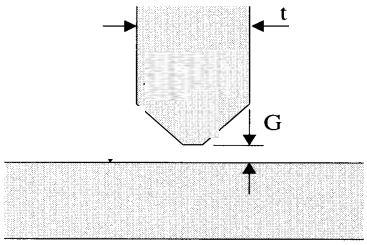
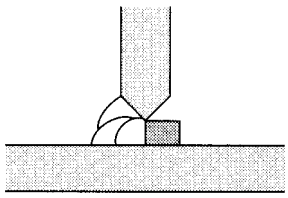
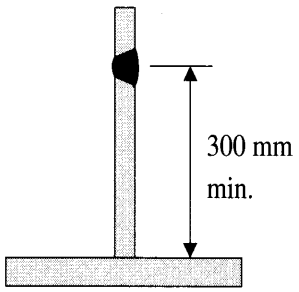
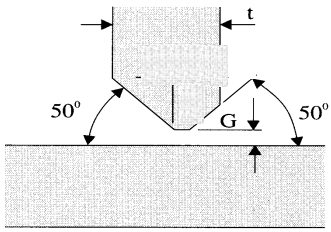
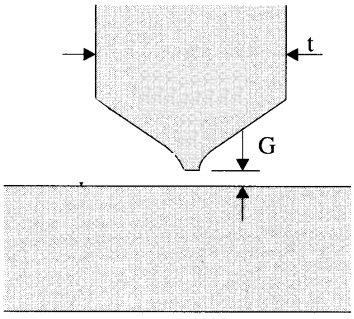
<table>
<tr><th>Detail</th><th>Remedial standard</th><th>Remarks</th></tr>
<tr><td>Single ‘J’ bevel tee
 
</td><td>as single bevel tee</td><td></td></tr>
<tr><td>Double bevel tee symmetrical
 
</td><td rowspan="3">When 5 mm < G ≤ 16 mm build up with
welding using ceramic or other approved
backing bar, remove, back gouge and back
weld.
 
When G > 16 mm-insert plate of minimum
height 300 mm to be fitted.
 
</td><td rowspan="3"></td></tr>
<tr><td>Double bevel tee asymmetrical
 
</td></tr>
<tr><td>Double ‘J’ bevel symmetrical
 
</td></tr>
</table>

Table 9.9 – Typical Fillet and Butt Weld Profile Remedial (Manual Welding and Semi-Automatic Welding)

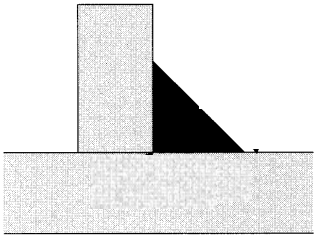
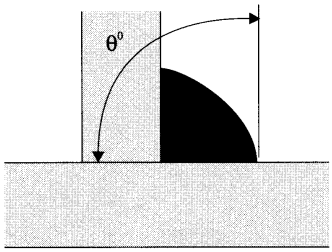
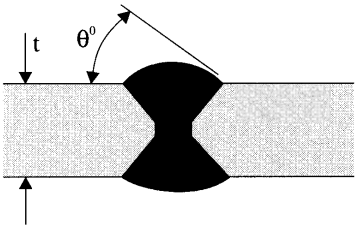
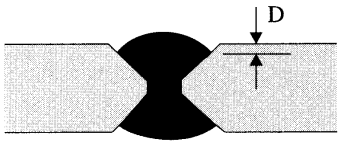
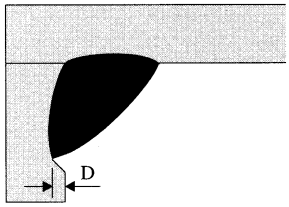
Detail	Remedial standard	Remarks
Fillet weld leg length 	Increase leg or throat by welding over	Minimum short bead to be referred Table 9.14
Fillet weld toe angle 	$\theta > 90°$ grinding, and welding, where necessary, to make $\theta \leq 90°$	
Butt weld toe angle 	$\theta > 90°$ grinding, and welding, where necessary, to make $\theta \leq 90°$	
Butt weld undercut 	For strength member, where $0.5 < D \leq 1$ mm, and for other, where $0.8 < D \leq 1$ mm, undercut to be ground smooth (localized only) or to be filled by welding Where $D > 1$ mm undercut to be filled by welding	
Fillet weld undercut 	Where $0.8 < D \leq 1$ mm undercut to be ground smooth (localized only) or to be filled by welding Where $D > 1$ mm undercut to be filled by welding	

Table 9.10 – Distance Between Welds Remedial

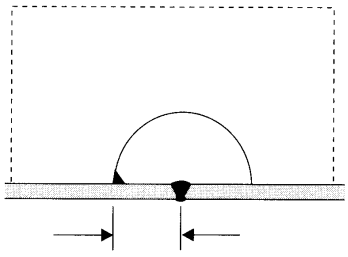
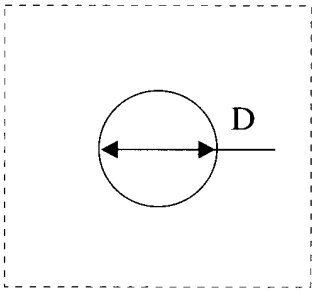
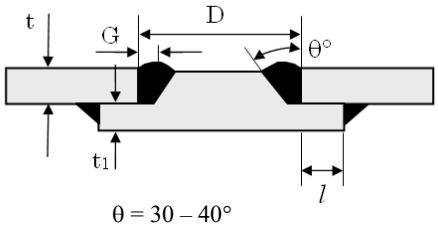
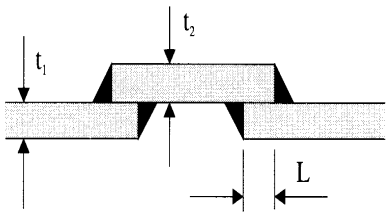
Detail	Remedial standard	Remarks
Scallops over weld seams 	Hole to be cut and ground smooth to obtain distance	

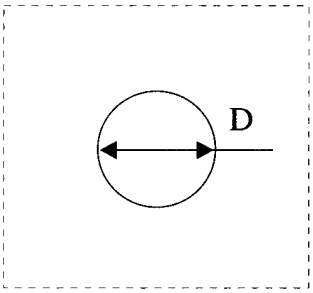
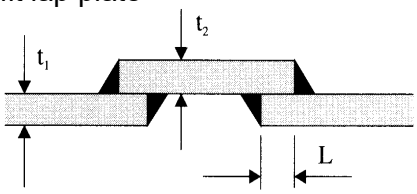
Table 9.11 – Erroneous Hole Remedial

<table>
<tr><th>Detail</th><th>Remedial standard</th><th>Remarks</th></tr>
<tr><td rowspan="2">Holes made erroneously D < 200 mm
 
</td><td>Strength member
open hole to minimum 75 mm dia., fit and weld spigot piece
 

θ = 30 – 40°
G = 4 – 6 mm
1/2t ≤ t1 ≤ t
l = 50 mm
Or
open hole to over 300 mm and fit insert plate</td><td rowspan="2">Fillet weld to be made after butt weld

The fitting of spigot pieces in areas of high stress concentration or fatigue is to be approved by BCS.</td></tr>
<tr><td>Other
open hole to over 300 mm and fit insert plate

Or fit lap plate
 

t1 = t2 L = 50 mm, min</td></tr>
<tr><td rowspan="2">Holes made erroneously D ≥200 mm
 
</td><td>Strength member
open hole and fit insert plate</td><td rowspan="2"></td></tr>
<tr><td>Other
open hole to over 300 mm and fit insert plate
Or fit lap plate
 

t1 = t2 L = 50 mm, min</td></tr>
</table>

Table 9.12 – Remedial by Insert Plate

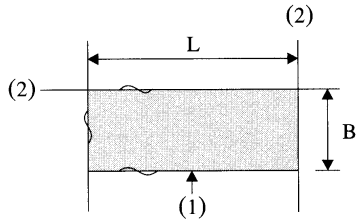
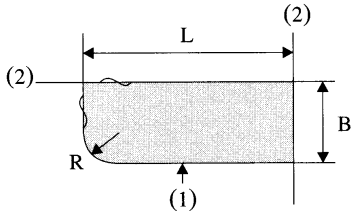
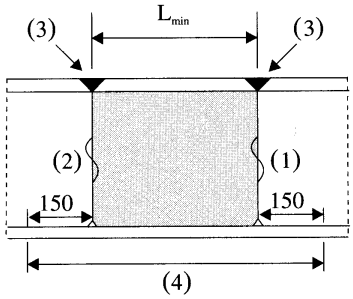
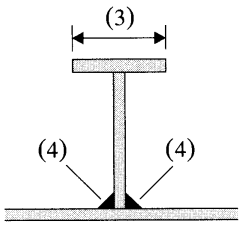
Detail	Remedial standard	Remarks
Remedial by insert plate   	L = 300 mm minimum B = 300 mm minimum R = 5t mm 100mm minimum (1) seam with insert piece is to be welded first (2) original seam is to be released and welded over for a minimum of 100 mm.	
Remedial of built section by insert plate   	$L_{min} \geq 300$ mm Welding sequence (1) →(2) →(3) →(4) Web butt weld scallop to be filled during final pass (4)	

Table 9.13 – Weld Surface Remedial

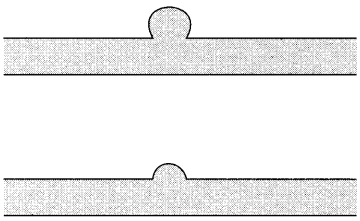
Detail	Remedial standard	Remarks
Weld spatter 	1. Remove spatter observed before blasting with scraper or chipping hammer, etc. 2. For spatter observed after blasting: a) Remove with a chipping hammer, scraper, etc. b) For spatter not easily removed with a chipping hammer, scraper, etc., grind the sharp angle of spatter to make it obtuse.	In principle, no grinding is applied to weld surface.
Arc strike (HT steel, Cast steel, Grade E of mild steel, TMCP type HT steel, Low temp steel)	Remove the hardened zone by grinding or other measures such as overlapped weld bead etc.	Minimum short bead to be referred Table 9.14

Table 9.14 – Welding Remedial by Short Bead

Detail	Remedial standard	Remarks
Short bead for remedying scar (scratch)	a) HT steel, Cast steel, TMCP type HT steel (Ceq > 0.36%) and Low temp steel (Ceq > 0.36%) Length of short bead ≥ 50 mm b) Grade E of mild steel Length of short bead ≥ 30 mm c) TMCP type HT steel (Ceq ≤ 0.36%) and Low temp steel (Ceq ≤ 0.36%) Length of short bead ≥ 10 mm	Preheating is necessary at 100 ± 25°C
Remedying weld bead	a) HT steel, Cast steel, TMCP type HT steel (Ceq > 0.36%) and Low temp steel (Ceq > 0.36%) Length of short bead ≥ 50 mm b) Grade E of mild steel Length of short bead ≥ 30 mm c) TMCP type HT steel (Ceq ≤ 0.36%) and Low temp steel (Ceq ≤ 0.36%) Length of short bead ≥ 30 mm	

NOTE:

1. When short bead is made erroneously, remove the bead by grinding.
2. $Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$

Part B

Repair Quality Standard for Existing Ships

Part B - Shipbuilding and Repair Quality Standard for Existing Ships

CONTENTS:

1. Scope

2. General requirements to repairs and repairers

3. Qualification of personnel

3.1 Qualification of welders
3.2 Qualification of welding procedures
3.3 Qualification of NDT operators

4. Materials

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4.2 Equivalency of material grades

5. General requirements to welding

5.1 Correlation of welding consumables to hull structural steels
5.2 General requirements to preheating and drying out
5.3 Dry welding on hull plating below the waterline of vessels afloat

6. Repair quality standard

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6.6 Application of Doubling Straps
6.7 Welding of pitting corrosion
6.8 Welding repairs of cracks

No. 47 (cont)

REFERENCES

B1. BCS-G 76 “Bulk Carriers - Guidelines for Surveys, Assessment and Repair of Hull Structure”
B2. TSCF “Guidelines for the inspection and maintenance of double hull tanker structures”
B3. TSCF “Guidance manual for the inspection and condition assessment of tanker structures”
B4. BCS- R W11 “Normal and higher strength hull structural steels”
B5. BCS-R W17 “Approval of consumables for welding normal and higher strength hull structural steels”
B6. Annex I to BCS-R Z10.1 “Hull surveys of oil tankers”, Z10.2 “Hull surveys of bulk carriers”, Z10.3 “Hull Surveys of Chemical Tankers”, Z10.4 “Hull Surveys of Double Hull Oil Tankers” and “Z10.5 Hull Surveys of Double-Skin Bulk Carriers”
B7. BCS-R Z13 “Voyage repairs and maintenance”
B8. BCS-R W33 “Non-destructive testing of ship hull steel welds”
B9. BCS-G 96 “Double Hull Oil Tankers - Guidelines for Surveys, Assessment and Repair of Hull Structures”
B10. BCS- G 55 “General Dry Cargo Ships - Guidelines for Surveys, Assessment and Repair of Hull Structures”
B11. BCS-G 84 “Container Ships - Guidelines for Surveys, Assessment and Repair of Hull Structures”
B12. BCS-R W28 “Welding procedure qualification tests of steels for hull construction and marine structures”
B13. BCS-R W32 “Qualification scheme for welders of hull structural steels”

STANDARDS

ANSI/AWS D1.1:2020 Structural Welding Code – Steel
ASME BPVC, Section IX:2019 Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications
ASTM A 131:2019 Standard Specification for Structural Steel for Ships
EN 10025-2:2019 Hot Rolled Products of Structural Steels - Part 2: Technical Delivery Conditions For Non-alloy Structural Steels
EN 10025-3:2019 Hot Rolled Products of Structural Steels - Part 3: Technical Delivery Conditions For Normalized/normalized Rolled Weldable Fine Grain Structural Steels
EN 10025-4:2019 Hot Rolled Products of Structural Steels - Part 4: Technical Delivery Conditions for Thermomechanical Rolled Weldable Fine Grain Structural Steels
EN ISO 15607:2019 Specification and Qualification of Welding Procedures For Metallic Materials - General Rules
GB 712:2011 Ship and ocean engineering structural steel
ISO 4950-2:1995/Amd 1:2003High yield strength flat steel products — Part 2: Products supplied in the normalized or controlled rolled condition — Amendment 1
ISO 9606 -1:2012/COR2:2013Qualification testing of welders — Fusion welding — Part 1: Steels — Technical Corrigendum 2
ISO 15614-1:2017Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys
JIS G 3106:2015 /Amd 1:2017 Rolled steels for welded structure (Amendment 1)

1. Scope

1.1 This standard provides guidance on quality of repair of hull structures. The standard covers permanent repairs of existing ships.

Whereas the standard generally applies to

- conventional ship types,
- parts of hull covered by the rules of BCS,
- hull structures constructed from normal and higher strength hull structural steel, the applicability of the standard is in each case to be agreed upon by BCS.

The standard does generally not apply to repair of

- special types of ships as e.g. gas tankers
- structures fabricated from stainless steel or other, special types or grades of steel

1.2 The standard covers typical repair methods and gives guidance on quality standard on the most important aspects of such repairs. Unless explicitly stated elsewhere in the standard, the level of workmanship reflected herein will in principle be acceptable for primary and secondary structure of conventional design. A more stringent standard may however be required for critical and highly stressed areas of the hull, and is to be agreed with BCS in each case. In assessing the criticality of hull structure and structural components, reference is made to ref. B1, B2, B3, B6, B8, B9, B10 and B11.

1.3 Restoration of structure to the original standard may not constitute durable repairs of damages originating from insufficient strength or inadequate detail design. In such cases strengthening or improvements beyond the original design may be required. Such improvements are not covered by this standard, however it is referred to ref. B1, B2, B3, B6, B8, B9, B10 and B11.

1.4 BCS-R W33 (Ref.B8) scope is for new construction only, however, for the purpose of NDT applicability within this Recommendation, BCS-R W33 may be used as reference for NDT methods and acceptance standards.

2. General requirements for repairs and repairers

2.1 In general, when hull structure covered by classification is to be subjected to repairs, the work is to be carried out under the supervision of the Surveyor to BCS. Such repairs are to be agreed prior to commencement of the work.

2.2 Repairs are to be carried out by workshops, repair yards or personnel who have demonstrated their capability to carry out hull repairs of adequate quality in accordance with BCS's requirements and this standard.

2.3 Repairs are to be carried out under working conditions that facilitate sound repairs. Provisions are to be made for proper accessibility, staging, lighting and ventilation. Welding operations are to be carried out under shelter from rain, snow and wind.

2.4 Welding of hull structures is to be carried out by qualified welders, according to approved and qualified welding procedures and with welding consumables approved by BCS, see Section 3. Welding operations are to be carried out under proper supervision of the repair yard.

2.5 Where repairs to hull which affect or may affect classification are intended to be carried out during a voyage, complete repair procedure including the extent and sequence of repair is to be submitted to and agreed upon by the Surveyor to BCS reasonably in advance of the repairs. See Ref. B7.

3. Qualification of personnel

3.1 Qualification of welders

3.1.1 Welders are to be qualified in accordance with BCS-R W32 (ref.B13) or to a recognised national or international standard, e.g. ISO 9606 -1:2012/COR2:2013, ASME BPVC, Section IX:2019, ANSI/AWS D1.1:2020. Recognition of other standards is subject to submission to BCS for evaluation. Repair yards and workshops are to keep records of welders qualification and, when required, furnish valid approval test certificates.

3.1.2 Welding operators using fully mechanised of fully automatic processes need generally not pass approval testing, provided that production welds made by the operators are of the required quality. However, operators are to receive adequate training in setting or programming and operating the equipment. Records of training and production test results shall be maintained on individual operator's files and records, and be made available to BCS for inspection when requested.

3.2 Qualification of welding procedures

Welding procedures are to be qualified in accordance with BCS-R W28 (ref.B12) or a recognised national or international standard, e.g. EN ISO 15607:2019, ISO 15614-1:2017, ASME BPVC, Section IX:2019, ANSI/AWS D1.1:2020. Recognition of other standards is subject to submission to BCS for evaluation. The welding procedure should be supported by a welding procedure qualification record. The specification is to include the welding process, types of electrodes, weld shape, edge preparation, welding techniques and positions.

3.3 Qualification of NDT operators

3.3.1 Personnel performing non destructive testing for the purpose of assessing quality of welds in connection with repairs covered by this standard, are to be qualified in accordance with BCS rules or to a recognised international or national qualification scheme. Records of operators and their current certificates are to be kept and made available to the Surveyor for inspection.

4. Materials

4.1 General requirements for materials

4.1.1 The requirements for materials used in repairs are in general the same as the requirements for materials specified in BCS's rules for new constructions, (ref. B4).

4.1.2 Replacement material is in general to be of the same grade as the original approved material. Alternatively, material grades complying with recognised national or international standards may be accepted by BCS provided such standards give equivalence to the requirements of the original grade or are agreed by BCS. For assessment of equivalency between steel grades, the general requirements and guidelines in Section 4.2 apply.

4.1.3 Higher tensile steel is not to be replaced by steel of a lesser strength unless specially approved by BCS.

4.1.4 Normal and higher strength hull structural steels are to be manufactured at works approved by BCS for the type and grade being supplied.

4.1.5 Materials used in repairs are to be certified by BCS applying the procedures and requirements in the rules for new constructions. In special cases, and normally limited to small quantities, materials may be accepted on the basis of alternative procedures for verification of the material's properties. Such procedures are subject to agreement by BCS in each separate case.

4.2 Equivalency of material grades

4.2.1 Assessment of equivalency between material grades should at least include the following aspects;

- heat treatment/delivery condition
- chemical composition
- mechanical properties
- tolerances

4.2.2 When assessing the equivalence between grades of normal or higher strength hull structural steels up to and including grade E40 in thickness limited to 50 mm, the general requirements in Table 4.1 apply.

4.2.3 Guidance on selection of steel grades to certain recognised standards equivalent to hull structural steel grades specified in TLs' rules is given in Table 4.2

Items to be considered	Requirements	Comments
Chemical composition	- C; equal or lower - P and S; equal or lower - Mn; approximately the same but not exceeding 1.6% - Fine grain elements; in same amount - Detoxidation practice	The sum of the elements, e.g. Cu, Ni, Cr and Mo should not exceed 0.8%
Mechanical properties	- Tensile strength; equal or higher Yield strength; equal or higher - Elongation; equal or higher - Impact energy; equal or higher at same or lower temperature, where applicable	Actual yield strength should not exceed BCS Rule minimum requirements by more than 80 N/ mm^2
Condition of supply	Same or better	Heat treatment in increasing order; - as rolled (AR) - controlled rolled (CR) - normalised (N) - thermo-mechanically rolled (TM)[1)] - quenched and tempered (QT)[1)] [1)] TM- and QT-steels are not suitable for hot forming
Tolerances	- Same or stricter	Permissable under thickness tolerances; - plates: 0.3 mm - sections: according to recognised standards

Table 4.1 Minimum extent and requirements to assessment of equivalency between normal or higher strength hull structual steel grades

Steel grades according to Classification Societies' rules (ref.B4)						Comparable steel grades(1)			
Grade	**Yield stress R_{eH} min. (N/mm^2)**	**Tensile strength R_m (N/mm^2)**	**Elongation A_5min. (%)**	**Average impact energy for t≤50mm Test temp. (^oC)**	**(J, min.) L** **T**	**EN 10025:1990 (2) ISO 4950-2:1995**	**EN 10025 series:2004**	**ASTM A 131 GB 712-2011**	**JIS G 3106**
A	235	400-520	22	+20	- -	Fe 360B	S235JR	A	SM400B
B				0	27 20	Fe 360C	S235J0	B	SM400B,SM400C
D				-20	27 20	Fe 360D	S235J2	D	-
E				-40	27 20	-	S275NL,S275ML	E	-
A 27	265	400-530	22	0		Fe 430C	S275J0	-	-
D 27				-20	27 20	Fe 430D	S275J2,S275N,S275M	-	-
E 27				-40		-	S275NL,S275ML	-	-
A 32	315	440-570	22	0		-	-	AH32	SM490B,SM490C
D 32				-20	31 22	-	-	DH32	-
E 32				-40		-	-	EH32	-
A 36	355	490-630	21	0		Fe 510C	S355J0	AH36	SM520B,SM520C
D 36				-20	34 24	Fe 510D,E355DD	S355J2,S355N,S355M	DH36	-
E 36				-40		E355E	S355NL,S355ML	EH36	-
A 40	390	510-660	20	0		E390CC	S420N,S420M	AH40	SM570
D 40				-20	39 26	E390DD	S420N,S420M	DH40	-
E 40				-40		E390E	S420NL,S420ML	EH40	-

Note: (1) In selecting comparable steels from this table, attention should be given to the requirements of Table 4.1 and the dimension requirements of the product with respect to BCSrules. Some steel grades as per national or international standard are defined with specified yield and tensile strength properties which depend on thickness. For thicknesses with tensile properties specified lower than those of BCS's Rules, case-by-case consideration shall be given with regards to design requirements.
(2) EN 10025:1990 is superseded by EN10025 series: 2019 (e.g. EN 10025-2:2019, EN 10025-3:2019, EN 10025-4:2019).

Table 4.2 Guidance on steel grades comparable to the normal and high strength hull structural steel grades given in BCS rules

5. General requirements to welding

5.1 Correlation of welding consumables with hull structural steels

5.1.1 For the different hull structural steel grades welding consumables are to be selected in accordance with BCS-R W17 (see Ref. B5).

5.2 General requirements to preheating and drying out

5.2.1 The need for preheating is to be determined based on the chemical composition of the materials, welding process and procedure and degree of joint restraint.

5.2.2 A minimum preheat of 50° C is to be applied when ambient temperature is below 0° C. Dryness of the welding zone is in all cases to be ensured.

5.2.3 Guidance on recommended minimum preheating temperature for higher strength steel is given in Table 5.1. For automatic welding processes utilising higher heat input e.g. submerged arc welding, the temperatures may be reduced by 50° C. For re-welding or repair of welds, the stipulated values are to be increased by 25° C.

Carbon equivalent [1)]	**Recommended minimum preheat temperature (° C)**		
	t_{comb} ≤ 50 mm [2)]	**50 mm < t_{comb} ≤ 70 mm** [2)]	**t_{comb} > 70 mm** [2)]
Ceq ≤ 0.39	-	-	50
Ceq ≤ 0.41	-	-	75
Ceq ≤ 0.43	-	50	100
Ceq ≤ 0.45	50	100	125
Ceq ≤ 0.47	100	125	150
Ceq ≤ 0.50	125	150	175

Table 5.1 Preheating temperature

5.3 Dry welding on hull plating below the waterline of vessels afloat

5.3.1 Welding on hull plating below the waterline of vessels afloat is acceptable only on normal and higher strength steels with specified yield strength not exceeding 355 MPa and only for local repairs. Welding involving other high strength steels or more extensive repairs against water backing is subject to special consideration and approval by BCS of the welding procedure.

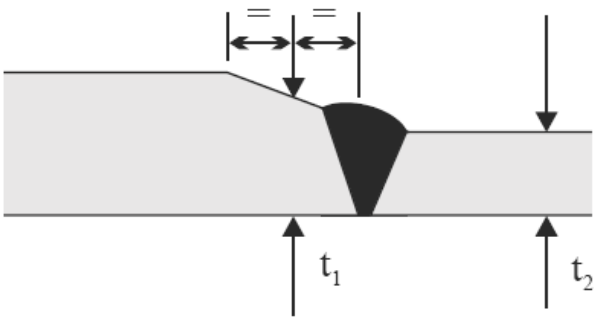
5.3.2 Low-hydrogen electrodes or welding processes are to be used when welding on hull plating against water backing. Coated low-hydrogen electrodes used for manual metal arc welding should be properly conditioned to ensure a minimum of moisture content.

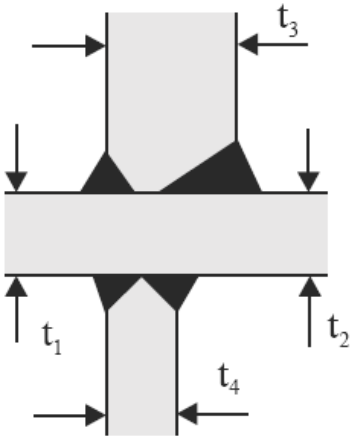
5.3.3 In order to ensure dryness and to reduce the cooling rate, the structure is to be preheated by a torch or similar prior to welding, to a temperature of minimum 5° C or as specified in the welding procedure.

Notes:

1) $$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}(\%)$$

2) Combined thickness $t_{comb} = t_1+t_2+t_3+t_4$, see figure





6. Repair quality standard

6.1 Welding, general

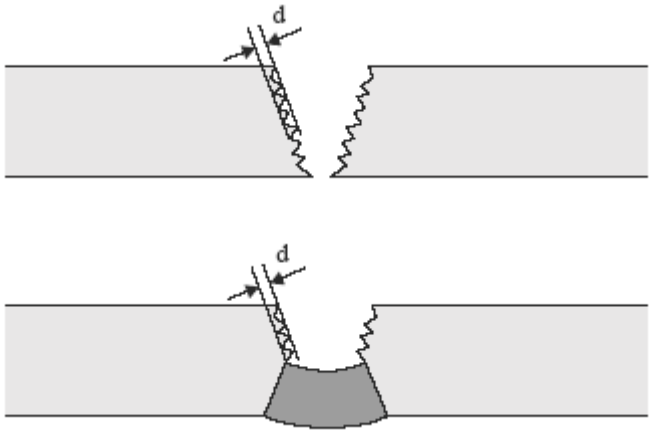


Fig 6.1 Groove roughness

Item	Standard	Limit	Remarks
Material Grade	Same as original or higher		See Section 4
Welding Consumables	TL-R W17 (ref. B5)	Approval according to equivalent international standard	
Groove / Roughness	See note and Fig 6.1	d < 1.5 mm	Grind smooth
Pre-Heating	See Table 5.1	Steel temperature not lower than 5°C	
Welding with water on the outside	See Section 5.3	Acceptable for normal and high strength steels	- Moisture to be removed by a heating torch
Alignment	As for new construction		
Weld Finish	BCS-R W33 (ref. B8)		
NDT	BCS-R W33 (ref. B8)	At random with extent to be agreed with attending surveyors	

Note:

Slag, grease, loose mill scale, rust and paint, other than primer, to be removed.

6.2 Renewal of plates

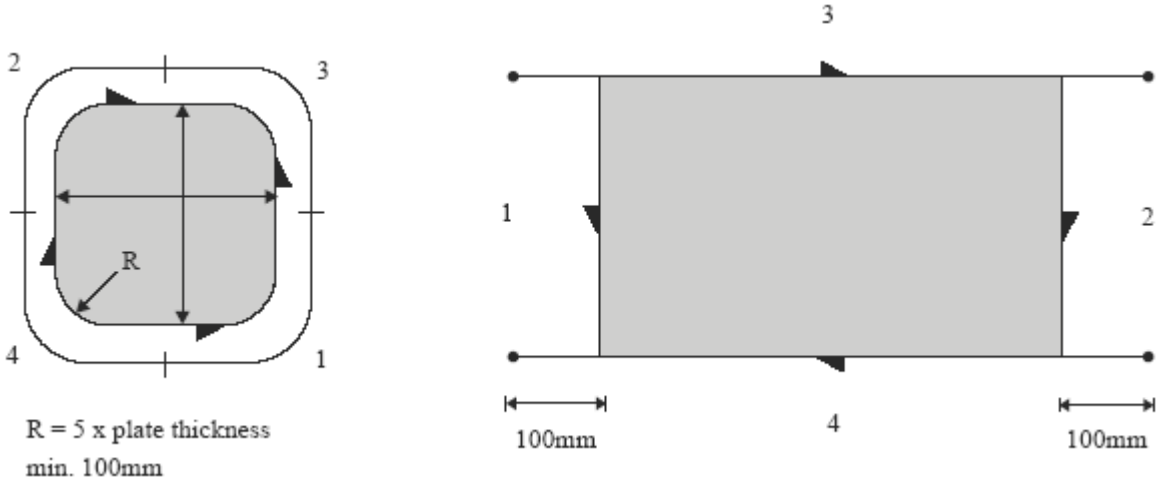


Fig 6.2 Welding sequence for inserts

Item	Standard	Limit	Remarks
Size Insert	Min. 300 x 300 mm R = 5 x thickness Circular inserts: D_{min} = 200 mm	Min. 200 x 200 mm Min R = 100 mm	
Marterial Grade	Same as original or higher		See Section 4.
Edge Preparation	As for new construction		In case of non compliance increase the amount of NDT
Welding Sequence	See Fig 6.2 Weld sequence is 1→ 2 → 3→4		For primary members sequence 1 and 2 transverse to the main stress direction
Alignment	As for new construction		
Weld Finish	BCS -R W33 (ref. B8)		
NDT	BCS- R W33 (ref. B8)		

6.3 Doublers on plating

Local doublers are normally only allowed as temporary repairs, except as original compensation for openings, within the main hull structure.

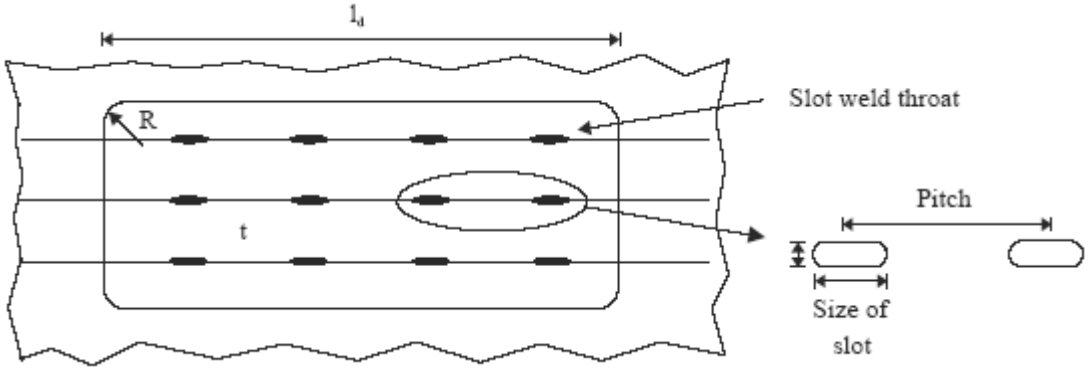


Fig 6.3 Doublers on plates

Item	Standard	Limit	Remarks
Existing Plating		General: t ≥ 5 mm	For areas where existing plating is less than 5 mm plating a permanent repair by insert is to be carried out.
Extent / Size	Rounded off corners.	min 300 x 300 mm R ≥ 50 mm	
Thickness of Doubler (td)	td ≤ tp (tp = original thickness of existing plating)	td > tp/3	
Material Grade	Same as original plate		See Section 4
Edge Preparation	As for [newbuidling] new construction		Doublers welded on primary strength members: (Le: leg length) when t > Le + 5 mm, the edge to be tapered (1:4)
Welding	As for [newbuidling] new construction		Welding sequence similar to insert plates.
Weld Size (throat thicknesss)	Circumferencial and in slots: 0.6 x td		
Slot Welding	Normal size of slot: (80-100) x 2 td Distance from doubler edge and between slots: d ≤ 15 td	Max pitch between slots 200 mm dmax = 500 mm	For doubler extended over several supporting elements, see Figure 6.3
NDT	BCS-R W33 (ref. B8)		

6.4 Renewal of internals/stiffeners

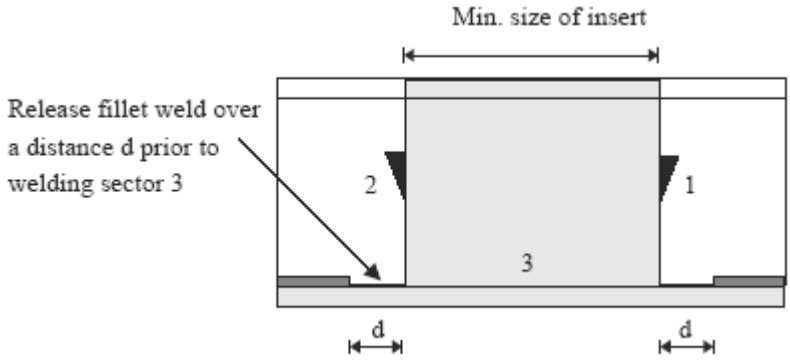


Fig 6.4 Welding sequence for inserts of stiffeners

Item	Standard	Limit	Remarks
Size Insert	Min. 300 mm	Min. 200 mm	
Marterial Grade	Same as original or higher		See Section 4.
Edge Preparation	As for new construction. Fillet weld stiffener web / plate to be released over min. d = 150 mm		
Welding Sequence	See Fig 6.4 Welding sequence is 1→ 2 →3		
Alignment	As for new construction		
Weld Finish	BCS-R W33 (ref. B8)		
NDT	BCS-R W33 (ref. B8)		

6.5 Renewal of internals/stiffeners – transitions inverted angle/bulb profile

The application of the transition is allowed for secondary structural elements.

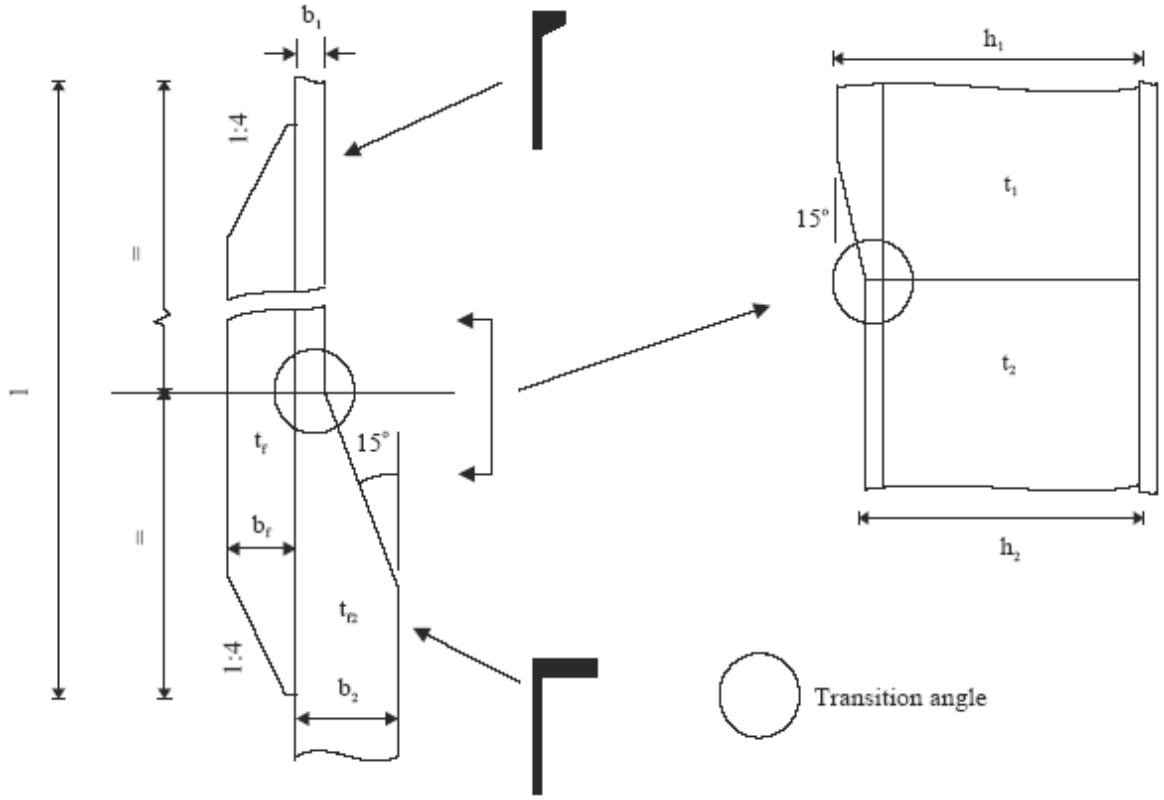


Fig 6.5 Transition between inverted angle and bulb profile

Item	Standard	Limit	Remarks
(h_1- h_2)	≤ 025 x b1		
$\lvert t_1 - t_2 \rvert$	2 mm		Without tapering transition.
Transition Angle	15 degrees		At any arbitrary section
Flanges	tf = tf_2 bf = bf_2		
Length of Flatbar	4 x h_1		
Material			See Section 4.

6.6 Application of Doubling Straps

In certain instances, doubling straps are used as a means to strengthen and reinforce primary structure. Where this has been agreed and approved, particular attention should be paid to:

- the end termination points of the straps, so that toe support is such that no isolated hard point occurs.
- in the case of application of symmetrical or asymmetrical-ended straps, the corners at the end of the tapering should be properly rounded.
- any butts between lengths of doubling straps, so that there is adequate separation of the butt weld from the primary structure below during welding, and so that a high quality root run under controlled circumstances is completed prior to completing the remainder of the weld. Ultrasonic testing should be carried out on completion to verify full penetration.

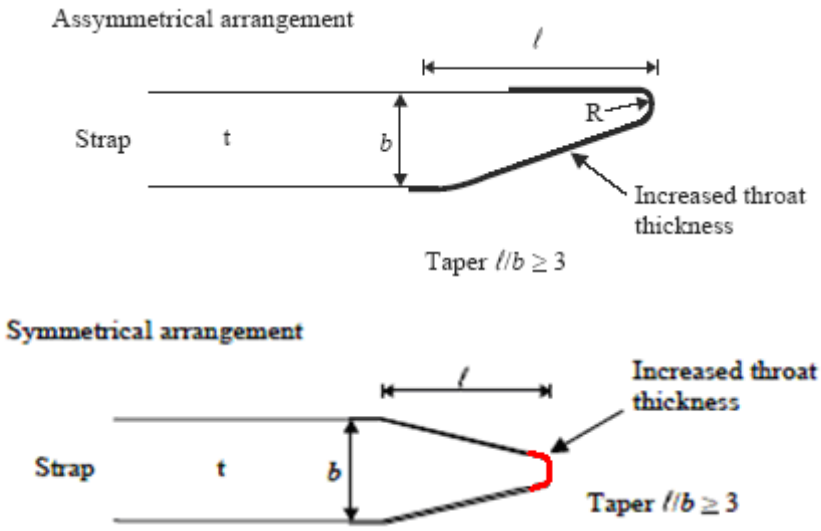


Fig 6.6 Application of Doubling Straps

Item	Standard	Limit	Remarks
Tapering	*l/b>3*		Special consideration to be drawn to design of strap terminations in fatigue sensitive areas.
Radius	0.1 x *b*	min 30 mm	
Material			See paragraph 2.0 General requirement to materials.
Weld Size			Depending on number and function of straps. Throat thickness to be increased 15 % toward ends.
Welding	Welding sequence from middle towards the free ends		See sketch. For welding of lengths > 1000 mm step welding to be applied.

6.7 Welding of pitting corrosion

Notes:

Shallow pits may be filled by applying coating or pit filler. Pits can be defined as shallow when their depth is less that 1/3 of the original plate thickness.

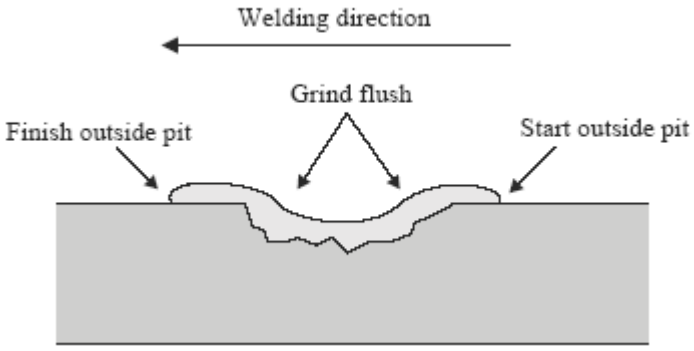


Fig 6.7 Welding of pits

Item	Standard	Limit	Remarks
Extent / Depth	Pits / grooves are to be welded flush with the original surface.	If deep pits or grooves are clustered together or remaining thickness is less than 6 mm, the plates should be renewed.	See also BCS -R W11 (ref. B 4)
Cleaning	Heavy rust to be removed		
Pre-Heating	See Table 5.1	Required when ambient temperature < 5°C	Always use propane torch or similar to remove any moisture
Welding Sequence	Reverse direction for each layer		See also BCS -R W11 (ref. B
Weld Finish	BCS-R W33 (ref. B8)		4)
NDT	BCS-R W33 (ref. B8)	Min. 10% extent	Preferably MPI

Reference is made to TSCF Guidelines, Ref. B2 & B3.

6.8 Welding repairs for cracks

In the event that a crack is considered weldable, either as a temporary or permanent repair, the following techniques should be adopted as far as practicable. Run-on and run-off plates should be adopted at all free edges.

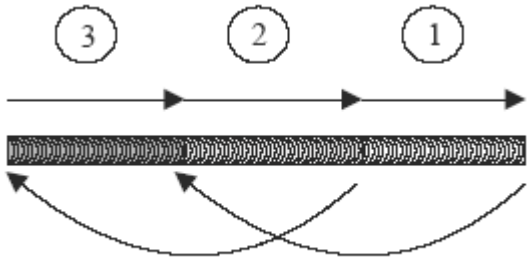


Fig 6.8.a Step back technique

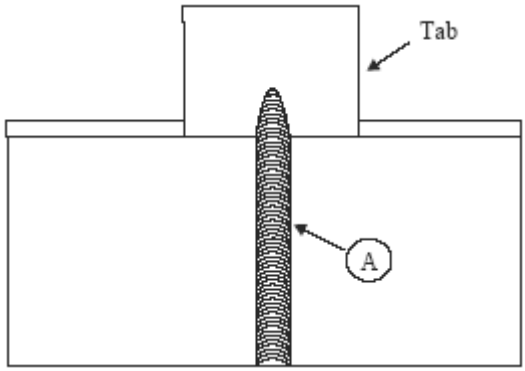


Fig 6.8.b End crack termination

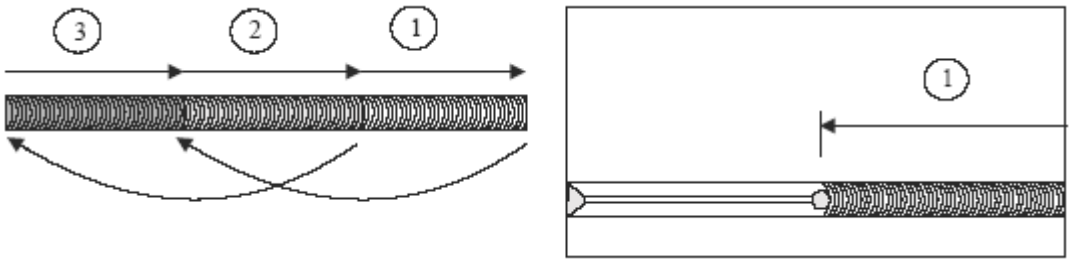


Fig 6.8.c Welding sequence for cracks with length less than 300 mm

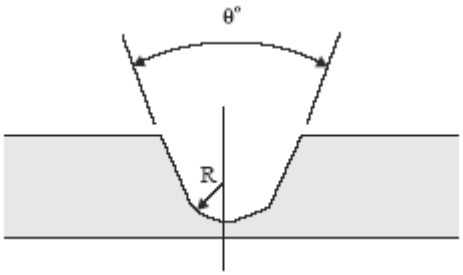


Fig 6.8.d Groove preparation (U-groove left and V-groove right)

Item	Standard	Limit	Remarks
Groove Preparation	θ = 45-60° r = 5 mm		For through plate cracks as for newbuilding. Also see Fig 6.8.d
Termination	Termination to have slope 1:3		For cracks ending on edges weld to be terminated on a tab see Fig 6.8.b
Extent	On plate max. 400 mm length. Vee out 50 mm past end of crack	On plate max 500 mm. Linear crack, not branched	
Welding Sequence	See Fig 6.8.c for sequence and direction	For cracks longer than 300 mm step-back technique should be used Fig 6.8.a	Always use low hydrogen welding consumables
Weld Finish	BCS-R W33 (ref. B8)		
NDT	BCS-R W33 (ref. B8)	100 % MP or PE of groove	100 % surface crack detection + UE or RE for butt joints

BCS-G 48 Recommendations on Loading Instruments

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1. INTRODUCTION

1.1 These Guidelines may be used by BCS in conjunction with their requirements and procedures when approving loading instruments for ships not yet fitted with an approved loading instrument.

1.2 These guidelines are applicable to a loading instrument which is a computer based system consisting of a calculation program and the computer hardware on which it runs. Guidelines pertaining to the calculation program's system and functional specifications are contained in sections 3.1 and 4, respectively. Guidelines pertaining to the computer hardware specification for type approval are contained in section 3.2, see also section 1.8.

1.3 The loading instrument is not a substitute for the approved loading manual.

1.4 The loading instrument is ship specific onboard equipment and the results of the calculations are only applicable to the ship for which it has been approved.

1.5 Ships having undertaken major alterations or conversions affecting longitudinal strength, such as lengthening or removal of decks, should be treated as new ships for the purpose of these Recommendations.

1.6 The loading instrument approval process includes the following procedures for each ship;

1. Data verification which results in Endorsed Test Conditions
2. Approval of computer hardware, where necessary
3. Installation Testing which results in a Program Installation Test Certificate

1.7 The loading instrument's calculation program may receive general approval from the Society and be issued with a Certificate of Approval. In such cases, some stages of the data verification procedure may be waived for each specific ship as specified in 2.1.7.

1.8 Hardware approval is intended to ensure that either a single computer is type approved in accordance with section 3.2 or that there are two nominated computers available in case of failure of one. If two nominated computers are available, type approval may be waived but both should be subject to installation testing. In addition, computers which are to be a part of a ship's network should be approved in accordance with the Society's relevant requirements.

1.9 The calculation program may be issued with a Program Installation Test Certificate after a satisfactory installation test of the loading instrument has been carried out onboard the ship in accordance with the recommendations in section 2.3.

2. APPROVAL PROCESS

2.1 Data Verification Approval - Endorsed Test Conditions

2.1.1 BCS should verify the computational results and actual ship data used by the calculation program for the particular ship on which the program will be installed.

2.1.2 Upon application to BCS for data verification, BCS should advise the applicant of a minimum of four loading conditions, taken from the ship's approved loading manual, which are to be used as the test conditions. Within the range of these test conditions each compartment should be loaded at least once. These test conditions normally cover the range of load draughts from the deepest envisaged loaded condition to the light ballast condition.

2.1.3 Read-out points should usually be selected at the position of the transverse bulkheads or other obvious boundaries. Additional read-out points may be required between bulkheads of long holds or tanks or between container stacks.

2.1.4 Where the still water torsion moments are required to be calculated, one test condition should demonstrate such a calculation.

2.1.5 It is important that the data contained in the loading program is consistent with the data specified in the approved loading manual. Particular attention is drawn to the final lightship weight and centres of gravity derived from the inclining experiment or lightweight check.

2.1.6 BCS should verify that the following data, submitted by the applicant, is consistent with the as-built ship:

1. Identification of the calculation program including version number.
2. Main dimensions, hydrostatic particulars and, if applicable, the ship profile.
3. The position of the forward and after perpendiculars, and if appropriate, the calculation method to derive the forward and after draughts at the actual position of the ship's draught marks.
4. Ship lightweight and lightweight distribution along the ship's length.
5. Lines plans and/or offset tables, or bonjean data at 21 stations in the length between perpendiculars.
6. Compartment definitions, including frame spacing, and centres of volume, together with capacity tables(sounding/ullage tables), if appropriate.

7. Deadweight definitions for each loading condition.

2.1.7 The data verification procedure should be considered complete when:

1. The loading program's system specification is found to be satisfactory. See section 3.1.
2. The functionality of the program has been clearly described and the calculation methods and principles are to the satisfaction of BCS.
3. The loading program's functional specification is found to be satisfactory. See section 4.
4. The computational accuracy of the loading program is within acceptable tolerances. See section 2.5 for recommended tolerances.
5. The actual ship's data as described in 2.1.5 is satisfactory.
6. A clear and concise operation manual in accordance with 2.4 has been reviewed and found satisfactory.
7. Details of the minimum hardware specification have been stated.
8. Submitted test conditions have been endorsed.

2.1.8 BCS has the option to issue Approval Certification for the calculation program in accordance with section 2.2. When a calculation program has such an approval, the data verification procedure should be considered complete when:

1. It has been ascertained that the General Approval is applicable for the ship considered.
2. The details specified on the valid Certificate of Approval correspond to the calculation program's identification and version number.
3. The computational accuracy of the calculation program is within acceptable tolerances. See section 2.5.
4. The actual ship's data as described in 2.1.5 is satisfactory.
5. A clear and concise operation manual in accordance with 2.4 has been reviewed and found satisfactory.
6. Details of the minimum hardware specification and operating system software have been stated.
7. Submitted test conditions have been endorsed.

2.1.9 BCS should send the endorsed test conditions to the local surveyor with instructions to carry out an installation test. Where the ship is in service, the endorsed test conditions should be sent to the ship's owner who should arrange for the test conditions to be placed onboard and arrangements for an installation test, witnessed by a BCS surveyor, should be made.

2.2 General Approval - Certificate of Approval of the Calculation Program

2.2.1 The loading instrument's calculation program may be generally approved in accordance with the Guidelines of this section. Upon satisfactory completion, the calculation program may be issued with a Certificate of Approval.

2.2.2 A Certificate of Approval is only valid for the identified, specified version of the calculation program.

2.2.3 Upon application to BCS for general approval of the calculation program, BCS should provide the applicant with test data from at least two different ship types. For calculation programs based on the input of hull form data, test data should be provided for three different ship types. This data should be used by the applicant to run the calculation

program for the test ships. The results obtained (together with the hydrostatic data and cross-curve data developed by the program, if appropriate) should be submitted to BCS for the assessment of the program's computational accuracy. BCS should perform parallel calculations using the same input data and a comparison of these results will be made against the submitted program's results.

2.2.4 A Certificate of Approval may be issued if:

1. The loading program's system specification is found to be satisfactory. See section 3.1.
2. The functionality of the loading program has been clearly described and the calculation methods and principles are to the satisfaction of BCS.
3. The loading program's functional specification is found to be satisfactory. See section 4.
4. The computational accuracy of the loading program is within acceptable tolerances. See section 2.5.
5. A clear and concise operation manual is submitted for review.
6. Details of the minimum hardware specification have been stated.

2.2.5 The certificate of approval should specify, in detail, what calculations the program is approved for as well as important limitations.

2.2.6 The Certificate of Approval should remain valid for a period not exceeding five years. The Certificate of Approval would be revalidated upon confirmation from the manufacturers of the calculation program that the calculation algorithms remain unchanged.

2.2.7 The Certificate of Approval held for any specified calculation program should become invalid if the calculation algorithms have been modified by the manufacturer without the agreement of the issuing Society. In such cases, the revised calculation program should be treated as a new calculation program.

2.3 Installation Testing - Program Installation Test Certificate

2.3.1 Installation tests should be performed soon after the loading instrument has been installed onboard the ship.

2.3.2 During the installation test one of the ship's senior officers should operate the loading instrument and calculate the test conditions. This operation should be witnessed by a BCS surveyor. The results obtained from the loading instrument should be identical to the results stated in the endorsed test conditions. Should the numerical output from the loading instrument be at variance with the endorsed test conditions, no certification should be issued .

2.3.3 An installation test should also be carried out on the second nominated computer, which would be used in the event of failure of the first computer. The results obtained from the loading instrument should be identical to the results stated in the endorsed test conditions. Should the numerical output from the loading instrument be at variance with the endorsed test conditions, no certification should be issued. Where the installation test is carried out on a Type Approved computer, a second nominated computer and test are not required.

2.3.4 Where the hardware is not Type Approved, it should be demonstrated that the Program Installation Test is acceptable on both the first and second nominated computers prior to the issue of a Program Installation Test Certificate.

2.3.5 After completion of satisfactory installation tests, BCS surveyor should attach

the endorsed test conditions to the previously reviewed operations manual. BCS should then issue the Program Installation Test Certificate.

2.4 Operation Manual

2.4.1 A uniquely identified ship specific operation manual should be submitted to BCS for review.

2.4.2 The operation manual should be written in a concise and unambiguous manner. The use of illustrations and flowcharts is recommended.

2.4.3 The operation manual should contain;

1. A general description of the program denoting identification of the program and its version number stated.
2. Where applicable, a copy of the Certificate of Approval, or equivalent, signifying approval of the calculation program;
3. Details of the hardware specification needed to run the loading program;
4. A description of error messages and warnings likely to be encountered and unambiguous instructions for subsequent actions to be taken by the user in each case;
5. Light shipweight and co-ordinates of its centre of gravity;
6. Full deadweight description of each test condition;
7. A list of the permissible still water shear forces and still water bending moments assigned by BCSin addition to the permissible cargo torque, where applicable;
8. Where applicable, the shear force correction factors;
9. Where applicable, local permissible limits for single and two adjacent hold loading as a function of the appropriate draught and the maximum weight for each hold.
10. An example of a calculation procedure supported by illustrations and sample computer output;
11. Example computer output of each screen display, complete with explanatory text.

2.5 Acceptable Tolerances

2.5.1 The computational accuracy of the calculation program should be within the acceptable tolerance band, specified in Table 1, of the results at each read-out point obtained by BCS using an independent program or the approved loading manual with identical input.

Table 1 : Tolerance Band for the Comparison of Computational Accuracy

Computation	Tolerance (Percentage of the approved value)
Still Water Shear Force	± 5%
Still Water Bending Moment	± 5%
Still Water Torsion Moment	± 5%

2.6 Hardware Approval

2.6.1 Where the loading instrument's hardware is to be type approved, the hardware specification should be in accordance with section 3.2, also see paragraph 1.8.

3. SYSTEM SPECIFICATION

3.1 Calculation Program

3.1.1 It is recommended that the design and production of the calculation program should be in accordance with appropriate international quality standards, for example ISO 90003: 2018 or equivalent.

3.1.2 The software should be written to ensure the user can not alter the critical ship data files containing the following information:

1. Light shipweight and lightship weight distribution and associated centres of gravity;
2. The Society's imposed structural limitations;
3. Geometric hull form data;
4. Hydrostatic data;
5. Compartment definitions including frame spacing, and centres of volume, together with capacity tables (sounding/ullage tables), if appropriate.

3.1.3 Any changes made to the software, which may affect the longitudinal strength aspects, should be made by the manufacturer or his appointed representative and BCS should be informed immediately of any changes. Failure to advise of any modifications to the calculation program may invalidate the certification issued. In cases where the certification is considered invalid by BCS, the modified calculation program should be re-assessed in accordance with the approval procedure.

3.2 Stand-alone Computer Hardware

3.2.1 BCS may issue a Certificate of Type Approval for the shipboard hardware, used by the calculation program, when the hardware has been deemed to satisfy the recommendations specified in 3.2.2. BCS may stipulate additional requirements.

3.2.2 The manufacturer should submit details of the hardware to be installed onboard. The following information should be submitted for review and if found satisfactory, the manufacturer will be advised accordingly:

1. The hardware specification;
2. Relevant design drawings with materials specified, catalogues, data sheets, calculations and functional descriptions;
3. Proposed test programme to demonstrate that the performance provisions of the specified standards maybe fulfilled;
4. Certificates and reports for relevant tests previously obtained for the product.

3.2.3 When considering the information described in 3.2.2 BCS may recognise valid certificates or reports issued by another certification body or accredited laboratory.

3.2.4 Performance and environmental testing should be carried out in the presence of BCS Surveyor according to the type testing conditions for type approval detailed in BCS-R E10 Testing Procedure for Electrical, Control and Instrumentation Equipment, Computers and Peripherals covered by Classification. The following tests should be successfully completed;

1. Visual inspection,

2. Performance test,
3. Electric power supply variations,
4. Dry heat,
5. Damp heat,
6. Vibration,
7. Inclination,
8. Insulation resistance,
9. Cold temperatures,
10. Electromagnetic compatibility tests.

3.2.5 BCSshould be advised of any alterations in the hardware specifications

.

4 FUNCTIONAL SPECIFICATION

4.1 General

4.1.1 The computational functions to be encompassed by the calculation program depend upon the specific requirements which are given in the BCS's Rules and Regulations.

4.1.2 The calculation program should be user-friendly and designed such that it limits possible input errors by the user.

4.1.3 The forward, midship and after draughts, at the respective perpendiculars, should be calculated and presented as screen and hardcopy output to the user in a clear and unambiguous manner.

4.1.4 It is recommended that the forward, midship and after draughts, at the actual position of the ship's draught marks should be calculated and presented as screen and hard copy output to the user in a clear and unambiguous manner. Provision should be made available for the introduction of a longitudinal deflection.

4.1.5 The displacement should be calculated for the specified load condition and corresponding draught readings and presented as screen and hardcopy output to the user.

4.1.6 The loading instrument should be capable of producing print-outs of the results in both numerical and graphical form. The numeric values should be in both absolute values and as the percentage of the allowable value. This print-out should include a description of the corresponding load condition.

4.1.7 All screen and hardcopy output data should be presented in a clear and unambiguous manner with an identification of the calculation program (version number should be stated).

4.2 Hull Girder Forces and Moments

4.2.1 The loading program should be capable of calculating the following hull girder forces and moments in accordance with BCS Requirements and, where applicable, the BCS Rules and Regulations:

1. Still Water Shear Force (SWSF) including the shear force correction, where applicable.
2. Still Water Bending Moment (SWBM).
3. Still Water Torsion Moment (SWTM), where applicable.
4. For ships with relatively large deck openings, additional considerations such as

torsional loads should be considered.

4.2.2 The data which should be provided to or accepted by BCS is specified in Table 2
.

Table 2: Data to be Provided to/or Accepted by BCS

Calculation	Data to be Provided to or Accepted by BCS
Still Water Shear Force (SWSF)	1. The read-out points (frame locations) for the SWSF calculations. These points are normally selected at the position of the transverse bulkhead or other obvious boundaries. Additional read-out points may be specified between the bulkheads of long holds or tanks or between container stacks. 2. Shear force correction factors and method of application. 3. The permissible seagoing and harbour SWSF limits at the read-out points specified in (1). Where appropriate, additional sets of permissible SWSF values may be specified.
Still Water Bending Moment (SWBM)	1. The read-out points (frame locations) for the SWBM calculations. These points are normally selected at the position of the transverse bulkhead, mid-hold or other obvious boundaries. 2. The permissible seagoing and harbour SWBM limits at the read-out points specified in (1). Where appropriate, additional sets of permissible SWBM values may be specified.
Still Water Torsion Moment (SWTM), where applicable	1. The read-out points (frame locations) for the SWTM calculations. 2. The permissible limits at the read-out points specified in (1).

4.2.3 The calculated forces and moments should be displayed in both graphical and tabular format, including the percentage of permissible values. The screen and hardcopy output should display the calculated forces or moments, and the corresponding permissible limit, at each specified read-out point.

Alternative limits, e.g. vertical still water bending and torsion may be considered in accordance with the BCS's Rules.

4.3 Permissible Limits

4.3.1 The user should be able to view the following BCS imposed structural limitations in a clear and unambiguous manner;

1. All permissible still water shear forces and still water bending moments:
2. Where applicable, the permissible still water torsion moments:
3. Where applicable, all local loading limits for both one hold and adjacent hold loading:

4. Cargo hold weight;
5. Ballast tank/hold capacities:
6. Filling restrictions.

4.3.2 It should be readily apparent to the user when any of the imposed structural limits have been exceeded.

5 IN SERVICE VERIFICATION

5.1 General

5.1.1 Where an installed shipboard loading instrument is required and has no Program Installation Test Certificate or record of having previously been examined by a BCS, the attending BCS surveyor should advise BCS accordingly.

5.2 Scope of Survey

5.2.1 When testing the loading instrument, the results obtained from the calculation program should be identical to the results stated in the endorsed test conditions. Should the numerical output from the loading instrument be at variance with the endorsed test conditions, a condition of class should be imposed on the ship and the owners advised accordingly. The calculation program should be tested on all specified computers (type approved or nominated).

BCS- G 49 Testing of Protection Devices for Generators and Large Consumers on Board

1. Electronic or computerised protection devices for generators and large consumers are to be provided with:

a) arrangements to readily identify the final settings, in the event of them being adjustable;

b) facilities and instructions for testing on board the settings and functions.

2. The settings of the above protection devices are to be recorded during the vessels “trials” and it is to be verified every 5 years that they are unchanged. The functions of the protection devices are also to be demonstrated.

BCS-G52 Power Supply to Radio Equipment required by SOLAS Chapter IV, and Electrical/Electronic Navigation Equipment required by SOLAS regulation V/19

1. Scope

1.1 This recommendation is applicable to radio equipment required by SOLAS Chapter IV as amended by IMO resolutions up to MSC.436(99) (hereinafter referred to “the radio equipment”) and electrical/electronic navigation equipment required by Regulation 19 of SOLAS Chapter V as amended by IMO resolutions up to MSC.350(92) (hereinafter referred to “the navigation equipment”), and whose power are also to be supplied from the emergency source of electrical power by Regulation 42 or 43 of SOLAS Chapter II-1 as amended by IMO resolutions up to MSC.436(99).

2. Power supply for equipment operated by AC (see Examples 1,2 and 3)

2.1 Power to navigation equipment should be supplied by two circuits, one fed directly from the main source of electrical power, and one fed directly from the emergency source of power. Power to radio equipment should also be supplied by two circuits as described above and is additionally to be supplied by a reserve source of energy.

2.2 The distribution of supplies to navigation equipment should be independent of those for radio equipment. The circuits from the two power sources should be terminated either in one or two distribution panels. When one distribution panel is used, the two circuits supplying power to the panel should be provided with split feeds into two separate bus bars, one for the radio equipment and one for the navigation equipment. The panel(s) should be sited on the navigation bridge or other suitable position on the bridge deck.

2.3 The circuits supplying the board(s) should, as far as practicable, be separated from each other throughout their length. Facilities should be provided in each distribution board for changing over between the main source of power and the emergency source of power. It is preferable that change over be initiated automatically. When a single distribution board is used for both radio and navigation equipment, separate change over switches should be provided for each service.

2.4 Where radio equipment requires an uninterrupted input of information from the ship’s navigational equipment or other equipment, it will be necessary for the equipment providing the data to be supplied from the same distribution board bus serving the radio equipment rather than the bus bar serving the navigation equipment.

2.5 Failure of any power supply to the panel should initiate an audible and visual alarm at the navigation bridge.

2.6 Each consumer should be individually connected to the distribution panel bus bar and individually provided with short circuit protection.

2.7 An indicator should be mounted in a suitable place to indicate when batteries of the reserve source of energy are being discharged.

3. Power supply for equipment operated by DC (see Examples 4,5 and 6)

3.1 The requirements in 2. should be complied with.

3.2 Where the equipment is fed via converters, separate converters should be provided and these should be located on the supply side of changeover facility.

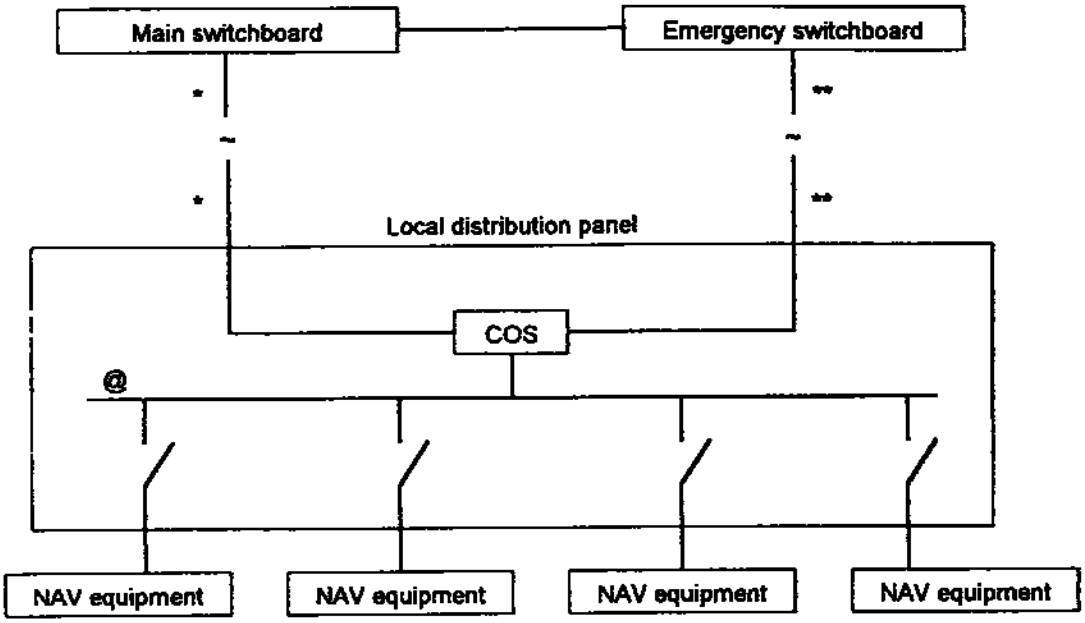
3.3 The radio equipment and the navigation equipment should be provided with separate converters.

4. Power supply for equipment operated by either AC or DC (see Examples 7,8 and 9)

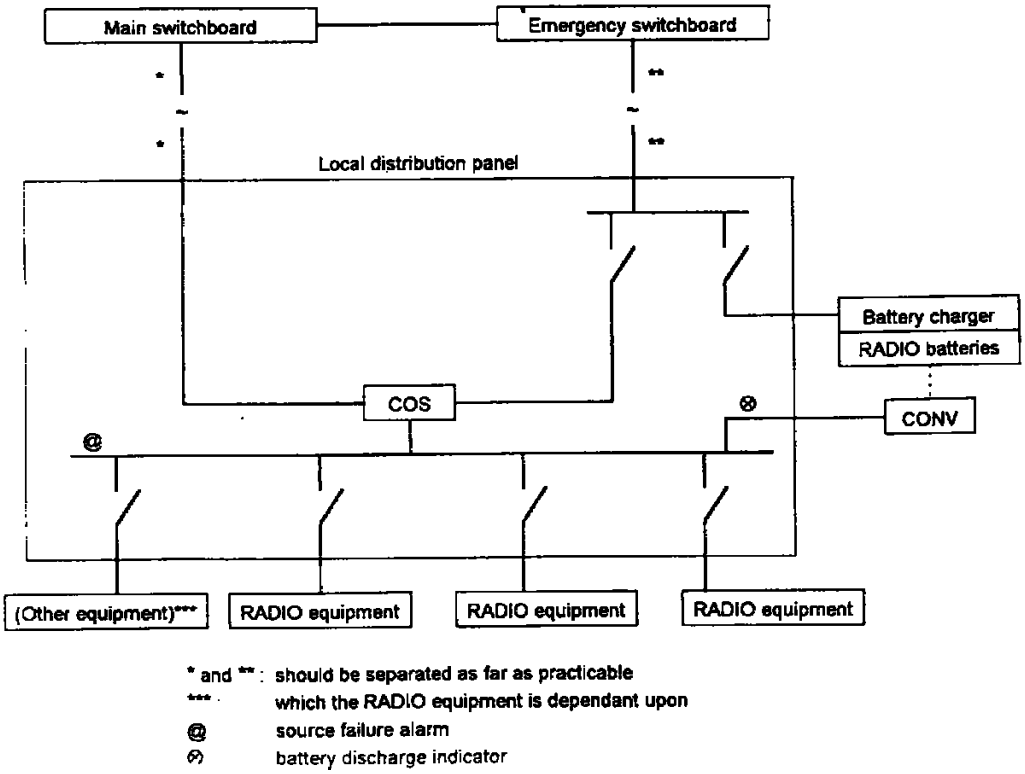
4.1 Each consumer should be individually connected to the main source of electrical power and to a distribution bus bar of the panel which is fed from the emergency source of electrical power and also, in case of the radio equipment, from the reserve source of energy (radio batteries). These two circuits should be separated throughout their length as far as practicable.

4.2 The radio equipment and the navigation equipment should be provided with separate converters.

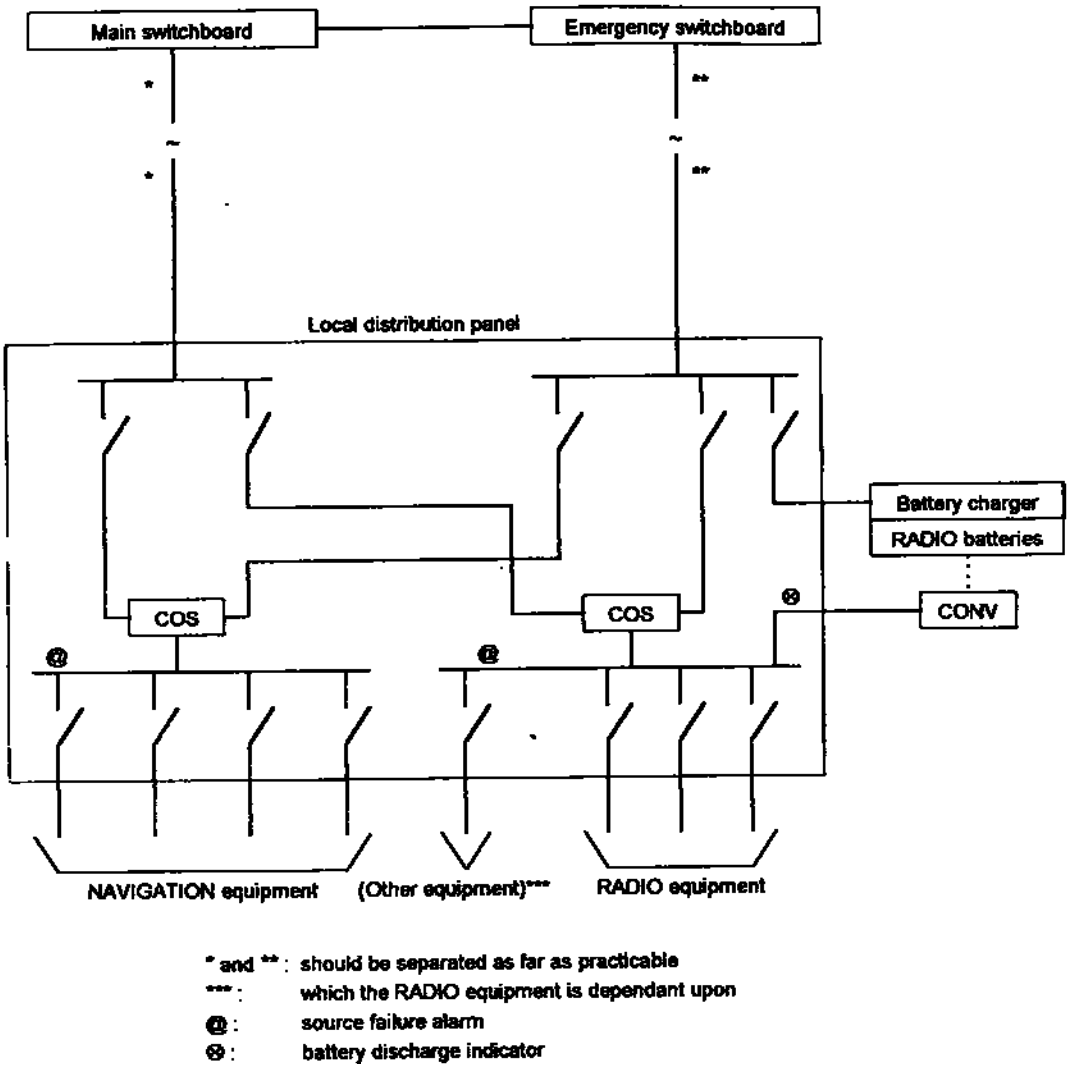
4.3 An indicator should be mounted in a suitable place to indicate when batteries of the reserve source of energy are being discharged visible for responsible member of the crew.



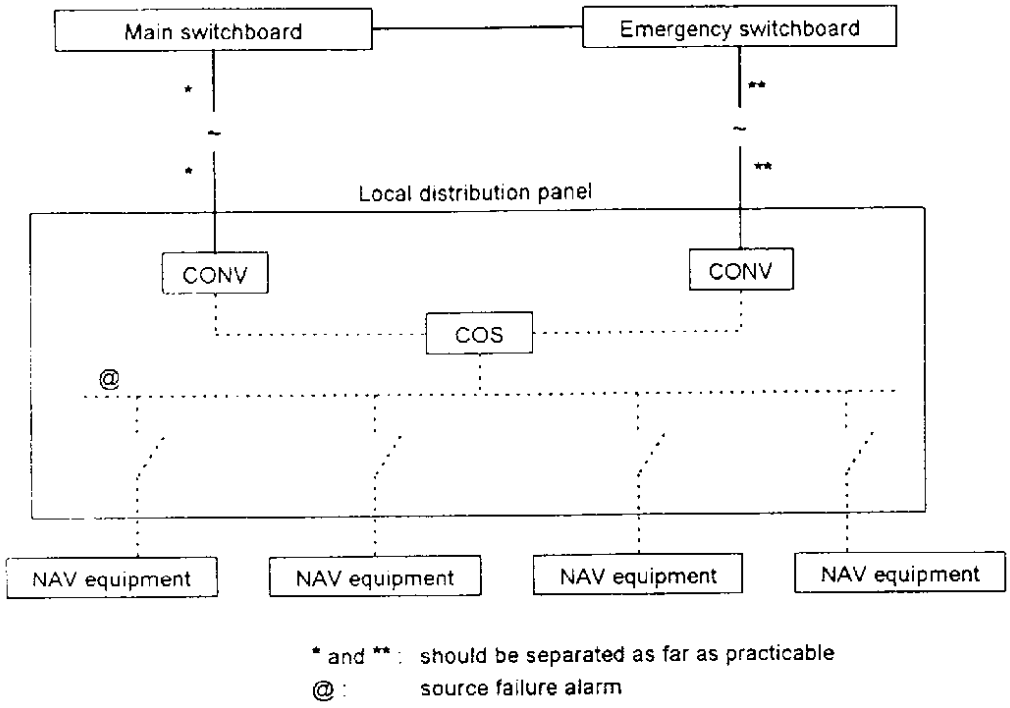
Example 1: Power supply for NAVIGATION equipment operated by AC



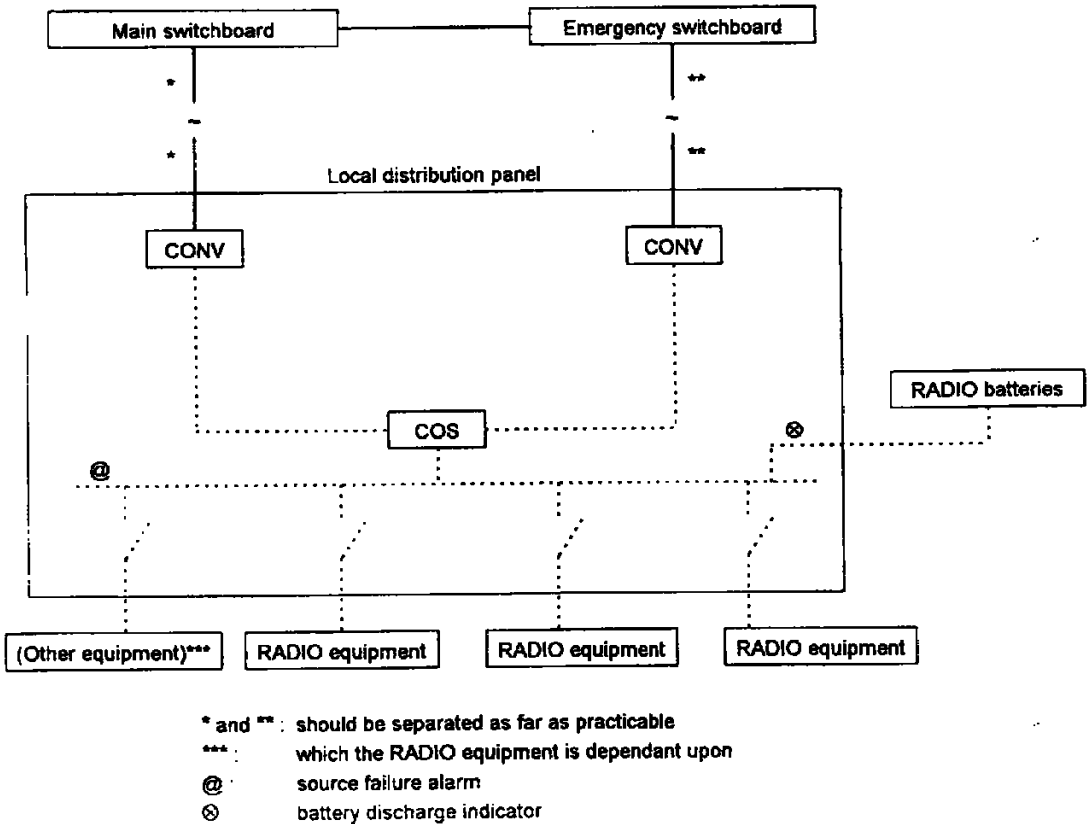
Example 2: Power supply for RADIO equipment operated by AC



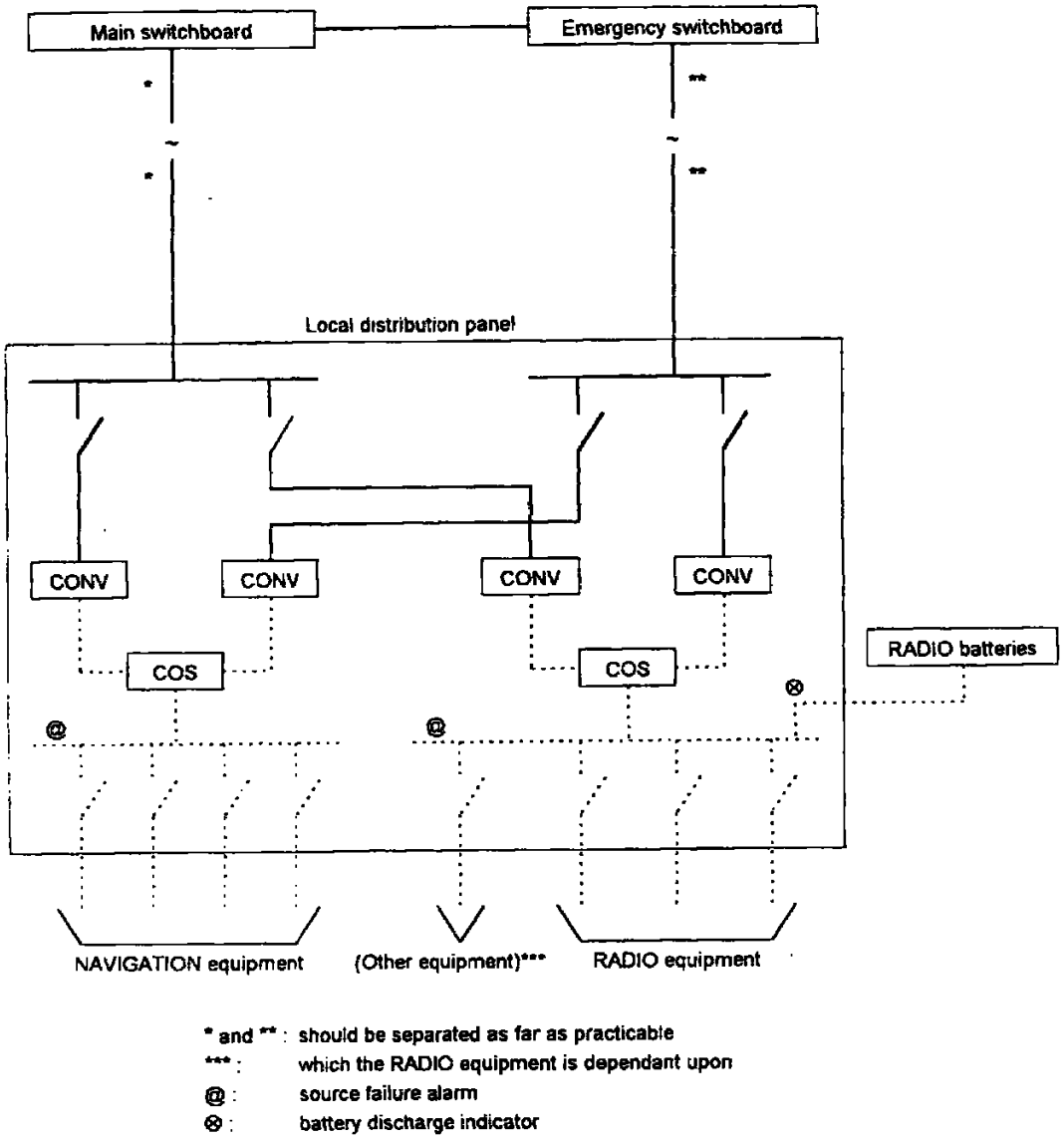
Example 3: Power supply for NAVIGATION and RADIO equipment operated by AC



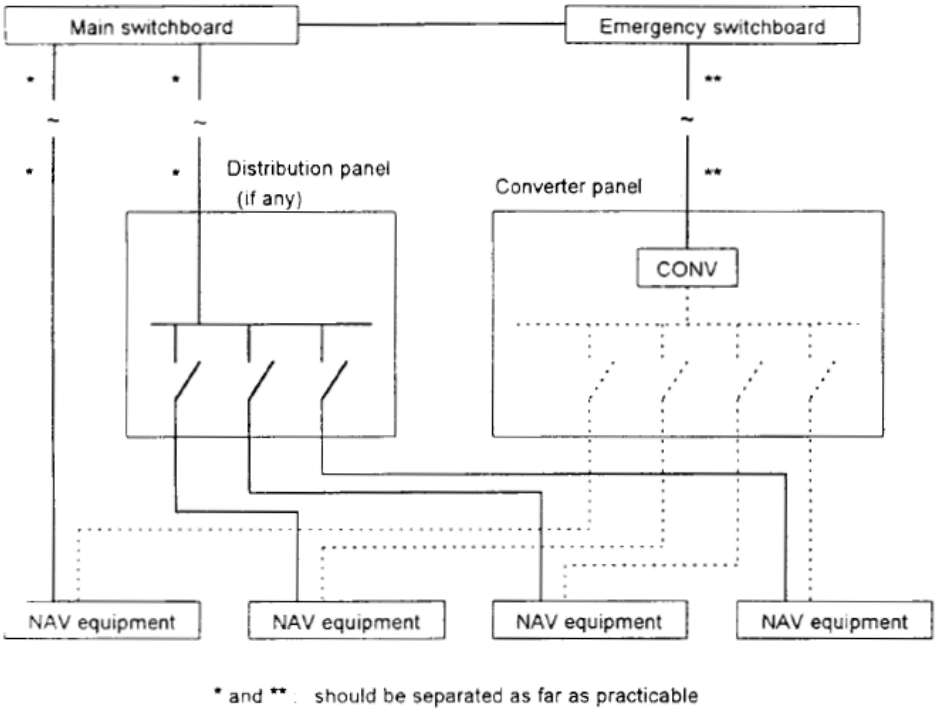
Example 4: Power supply for NAVIGATION equipment operated by DC



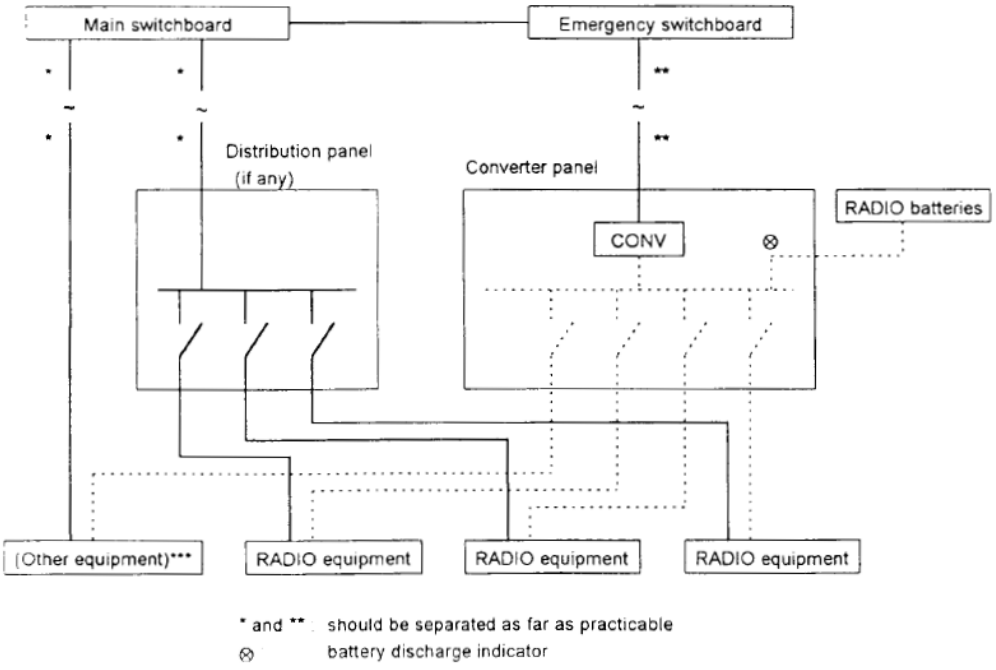
Example 5: Power supply for RADIO equipment operated by DC



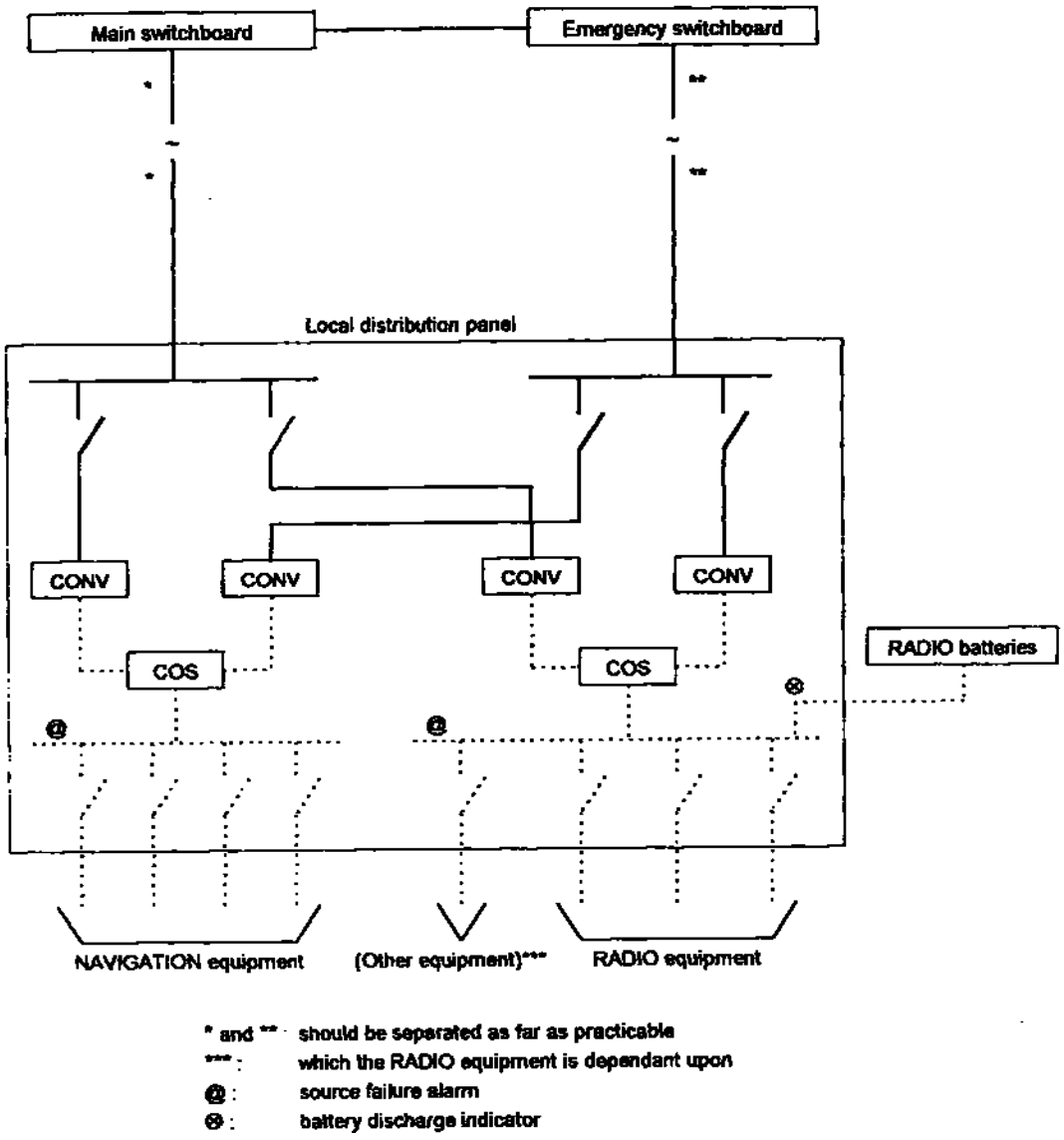
Example 6: Power supply for NAVIGATION and RADIO equipment operated by DC



Example 7: Power supply for NAVIGATION equipment operated by either AC or DC



Example 8: Power supply for RADIO equipment operated by either AC or DC



Example 9: Power supply for NAVIGATION and RADIO equipment operated by either AC or DC

BCS- G 55

GENERAL DRY CARGO SHIPS -

Guidelines for
Surveys, Assessment and Repair
of Hull Structure

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1 Introduction

The International Association of Classification Societies (IACS) is introducing a series of Guidelines with the intention of assisting the Surveyors of IACS Member Societies, and other interested parties involved in the survey, assessment and repair of hull structures for certain ship types.

The Guidelines are intended for a general dry cargo ship, single skin, which is designed with one or more decks specifically for the carriage of diverse forms of dry cargo.

Figure 1 shows a typical general arrangement of a general dry cargo ship with single tween deck.

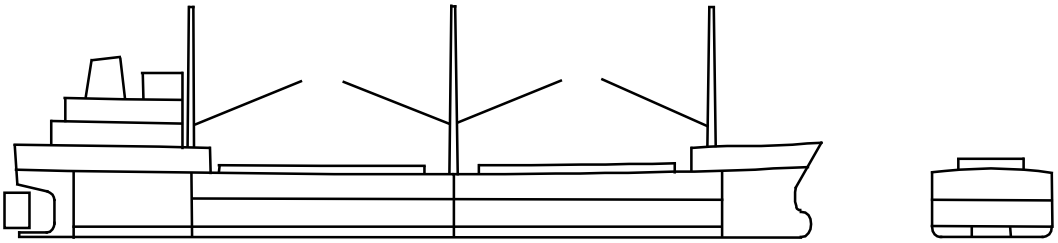


Figure 1 General view of a typical general dry cargo ship

The Guidelines focus on the IACS Member Societies' survey procedures but may also be useful in connection with inspection/examination schemes of other regulatory bodies, owners and operators.

The Guidelines include a review of survey preparation criteria which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the preparation necessary before the surveys can be carried out.

The Guidelines encompass the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

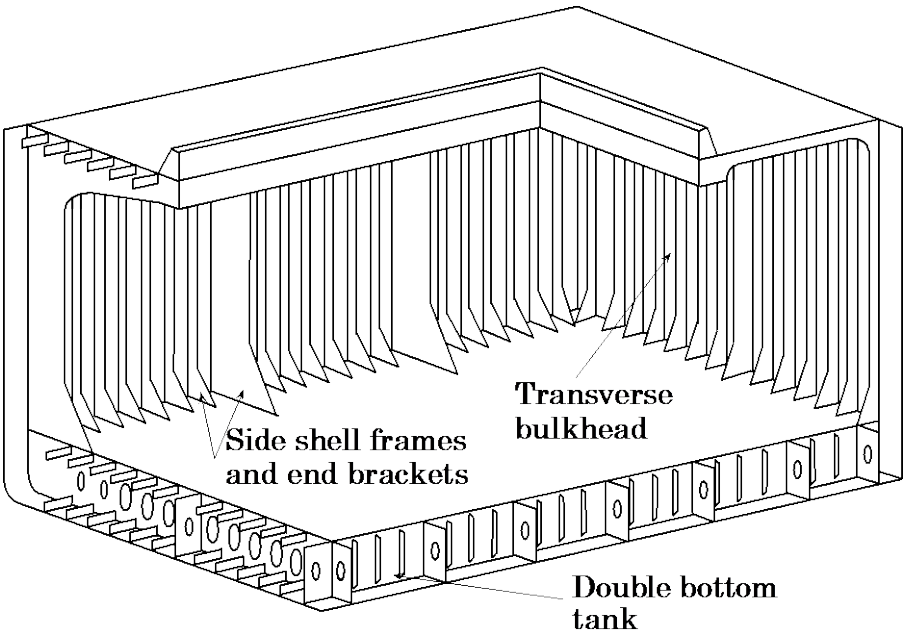
An important feature of the Guidelines is the inclusion of the section which illustrates examples of structural deterioration and damages related to each structural area and gives what to look for, possible cause, and recommended repair methods, when considered appropriate.

The Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents - "Early Warning Scheme - EWS", with the emphasis on the proper reporting of significant hull damages by the respective classification societies, will enable the analysis of problems as they arise, including revisions of these Guidelines.

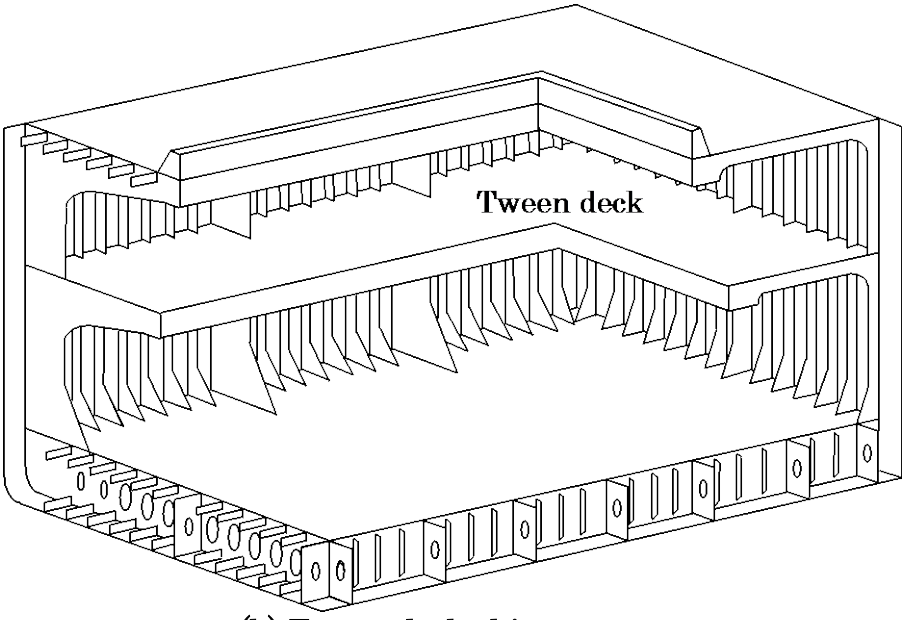
These Guidelines have been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of surveyors, and is to be used at the surveyors' discretion. It is recognized that alternative and satisfactory methods are already applied by surveyors. Should there be any doubt with regard to interpretation or validity in connection with particular applications, clarification should be obtained from the Classification Society concerned.

Figures 2 (a) and **(b)** show cargo hold structural configurations for general dry cargo ships. As many different cargoes are carried by general dry cargo ships, hull structures differ in

accordance with their purpose. These guidelines intend to cover general dry cargo ships.



(a) Single deck ship



(b) Tween deck ship

Figure 2 Cargo hold structural configurations for general dry cargo ships

2 Class survey requirements

2.1 Periodical classification surveys

2.1.1 General

For Class the programme of ***periodical hull surveys*** is of prime importance as far as structural assessment of the cargo holds, and the adjacent tanks is concerned. The programme of ***periodical hull surveys*** consists of ***Annual***, ***Intermediate***, and ***Special Surveys***. The Purpose of the ***Annual*** and ***Intermediate Surveys*** is to confirm that the general condition of the vessel is maintained at a satisfactory level. The ***Special Surveys*** of the hull structure are carried out at five year intervals with the purpose of establishing the condition of the structure to confirm that the structural integrity is satisfactory in accordance with the Classification Requirements, and will remain fit for its intended purpose until the next ***Special Survey***, subject to proper maintenance and operation. The ***Special Surveys*** are also aimed at detecting possible damage and to establish the extent of any deterioration.

The ***Annual***, ***Intermediate***, and ***Special Surveys*** are briefly introduced in the following **2.1.2**- **2.1.4**. The surveys are carried out taking into account the requirements specified in the BCS - R Z7 and Z7.1, alongside the Rules and Regulations of BCS.

2.1.2 Special Survey

The ***Special Survey*** concentrates on examination in association with thickness determination. The report of the thickness measurement is recommended to be retained on board. ***Protective coating condition*** will be recorded for particular attention during the survey cycle. From 1991 it is a requirement for new ships to apply a ***protective coating*** to the structure in ***water ballast tanks*** which form part of the hull boundary.

2.1.3 Annual Survey

At ***Annual Surveys*** overall survey is required. For saltwater ballast tanks, examinations may be required as a consequence of the Intermediate or Special Surveys.

2.1.4 Intermediate Survey

At ***Intermediate Surveys***, in addition to the surveys required for Annual Surveys, examination of cargo holds and ballast tanks is required depending on the ship’s age.

2.1.5 Bottom Survey

Bottom Surveys are requested twice during the Special Survey interval and they should be generally carried out in dry dock. In some cases it may be possible to replace one ***Bottom Survey*** in dry dock with an ***In-Water Survey***. This will depend on the survey requirements of BCS.

2.2 Damage and repair surveys

Damage surveys are occasional surveys which are, in general, outside the programme of Periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or his representative to inform BCS when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages should be inspected and assessed by the BCS’s surveyors and the relevant repairs, if needed, are to be performed. In certain cases,

depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the planned periodical survey.
In cases of repairs intended to be carried out by riding crew during voyage, complete procedure including all necessary surveys is to be submitted to and agreed upon by BCSreasonably in advance.

2.3 Voyage repairs and maintenance

Where repairs to hull, machinery or equipment, which affect or may affect classification, are to be carried out by a riding crew during a voyage they are to be planned in advance. A complete repair procedure including the extent of proposed repair and the need for surveyor's attendance during the voyage is to be submitted to and agreed upon by the Surveyor reasonably in advance. Failure to notify BCS, in advance of the repairs, may result in suspension of the vessel's class. The above is not intended to include maintenance and overhaul to hull, machinery and equipment in accordance with manufacturers' recommended procedures and established marine practice and which does not require BCS's approval; however, any repair as a result of such maintenance and overhauls which affects or may affect classification is to be noted in the ship's log and submitted to the attending Surveyor for use in determining further survey requirements. See BCS- R Z13.

3 Technical background for surveys

3.1 General

3.1.1 The purpose of carrying out the periodical hull surveys is to detect possible structural defects and damages and to establish the extent of any deterioration. To help achieve this and to identify key locations on the hull structure that might warrant special attention, knowledge of any historical problems of the particular ship or other ships of a similar class is to be considered if available. In addition to the periodical surveys, occasional surveys of damages and repairs are carried out. Records of typical occurrences and chosen solutions should be available in the ship's history file.

3.2 Definitions

3.2.1 For clarity of definition and reporting of survey data, it is recommended that standard nomenclature for structural elements be adopted. Typical sections in way of cargo holds are illustrated in **Figures 3 (a)** and **(b)**. These figures show the generally accepted nomenclature.

The terms used in these Guidelines are defined as follows:

(a) **Ballast Tank** is a tank which is being used primarily for salt water ballast.

(b) **Spaces** are separate compartments including holds and tanks.

(c) **Overall Inspection** is an inspection intended to report on the overall condition of the hull structure and determine the extent of additional close-up inspections.

(d) **Close-up Inspection** is an inspection where the details of structural components are within the close visual inspection range of the surveyors, i.e. normally within reach of hand.

(e) **Transverse Section** includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom and inner bottom. For transversely framed vessels, a transverse section includes adjacent frames and their end connections in way of transverse sections.

(f) **Representative Spaces** are those which are expected to reflect the condition of other spaces of similar type and service and with similar corrosion protection systems. When selecting representative spaces, account should be taken of the service and repair history on board.

(g) **Transition Region** is a region where discontinuity in longitudinal structure occurs, e.g. at forward bulkhead of engine room, collision bulkhead and bulkheads of deep tanks in cargo hold region.

(h) **Suspect Areas** are locations showing Substantial Corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

(i) **Substantial Corrosion** is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75% of allowable margins, but within acceptable limits.

(j) **Coating condition** is defined as follows:

GOOD	condition with only minor spot rusting;
FAIR	condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition;
POOR	condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

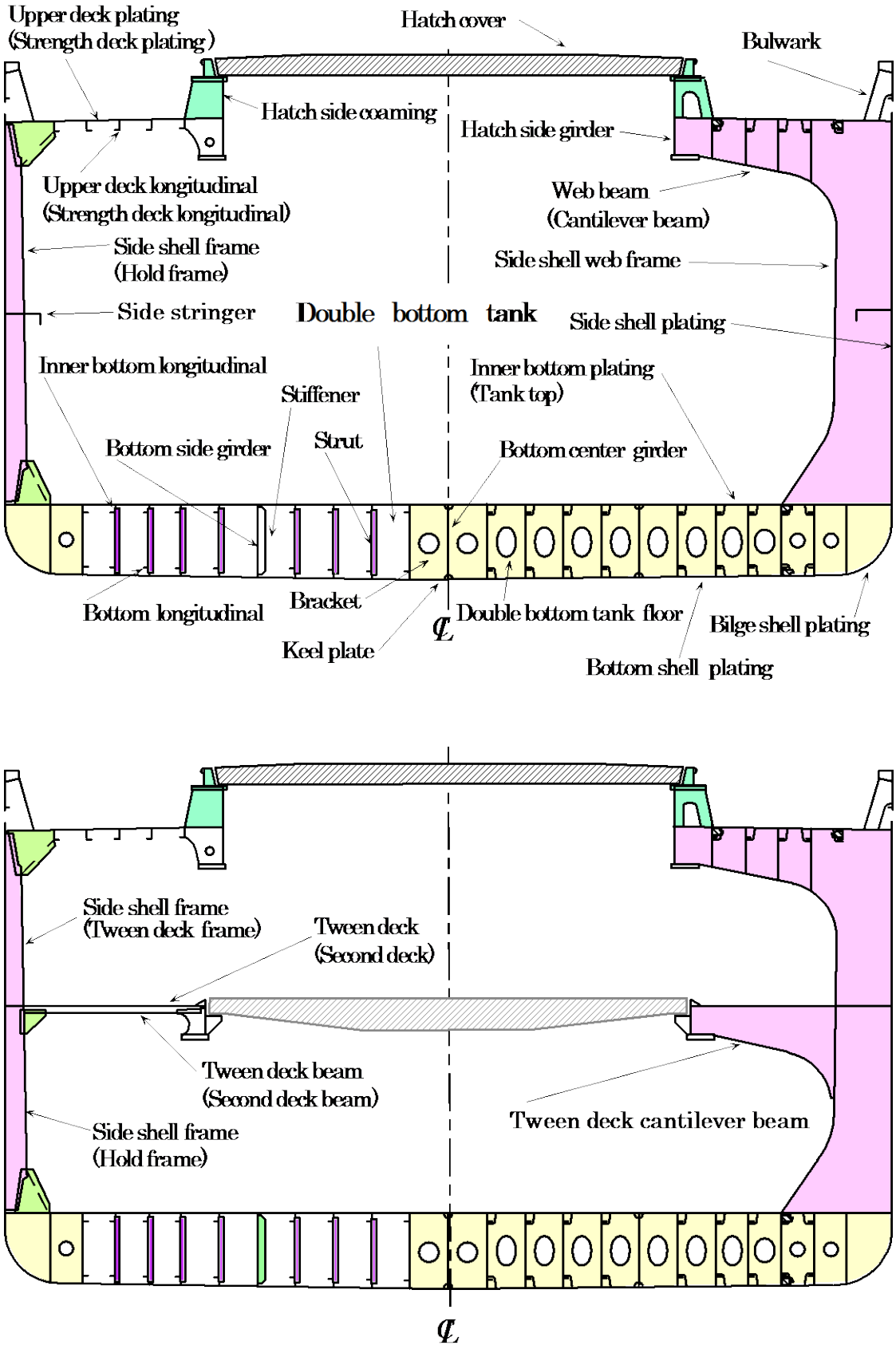


Figure 3 (a) **Nomenclature for typical transverse section in way of cargo hold**

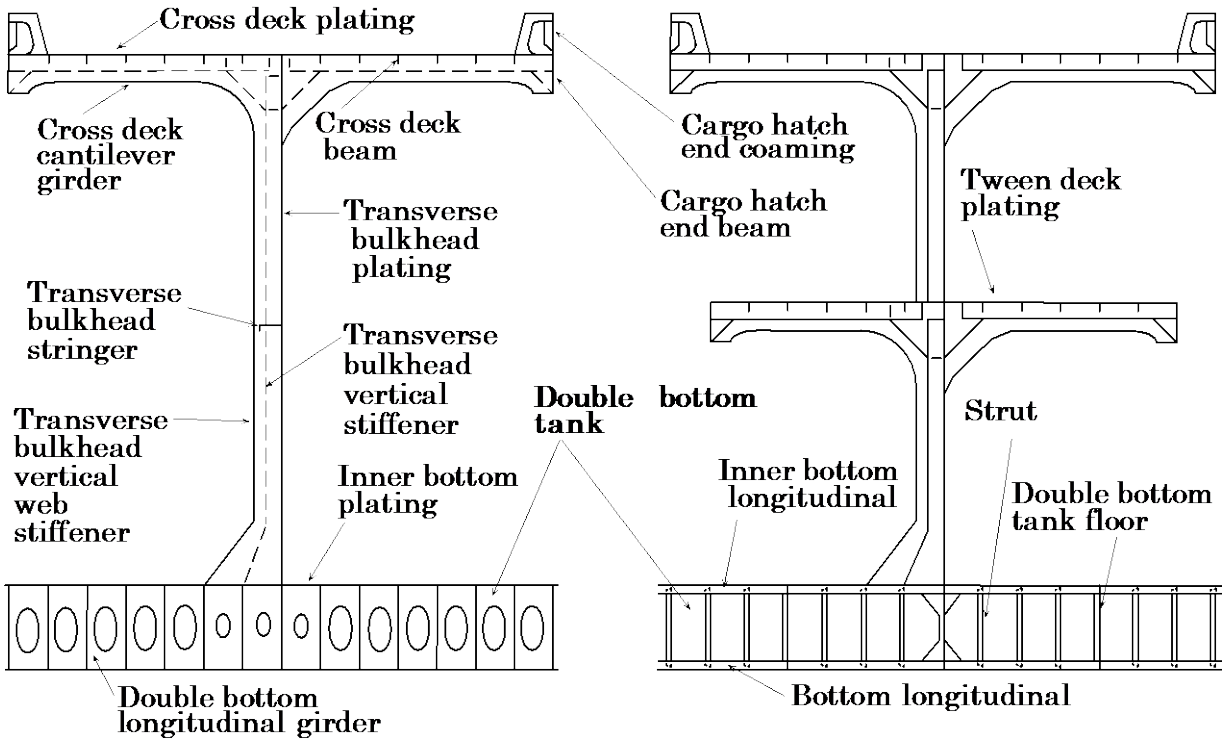


Figure 3 (b) Nomenclature for typical watertight bulkhead

3.3 Structural damages and deterioration

3.3.1 General

In the context of these Guidelines, structural damages and deterioration imply deficiencies caused by:

- excessive corrosion
- design faults
- material defects or bad workmanship
- navigation in extreme weather conditions
- loading and unloading procedure
- wear and tear
- contact (with quay side, ice, touching underwater objects, etc.)

but not as a direct consequence of accidents such as collisions, groundings and fire/explosions.

Deficiencies are normally recognized as:

- material wastage
- fractures
- deformations

The various types of deficiencies and where they may occur are discussed in more detail as follows:

3.3.2 Material wastage

In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible location of corrosion that may occur to the decks, holds, tanks and other structural elements.

General corrosion appears as a non-protective, friable rust which can occur uniformly

on hold or tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred. Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals.

Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to rough surfaces which exacerbate the corrosion. The grooving corrosion may lead to stress concentrations and further accelerate the corrosion. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

Pitting corrosion is often found in the bottom plating of ballast tanks and other horizontal surfaces such as side girders, horizontal platform, etc. If there is a place which is liable to have corrosion due to local breakdown of coating, pitting corrosion starts.

Erosion which is caused by the effect of liquid and ***abrasion*** caused by mechanical effect may also be responsible for material wastage.

3.3.3 Fractures

In most cases fractures are found at locations where stress concentrations occur. Weld defects, flaws, and where lifting fittings used during the construction of the ship are not properly removed are often recognized as areas of stress concentration when fractures are found. If fractures have occurred under repeated stresses which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses caused by wave forces, fatigue fractures are also caused by vibration forces derived from main engine or propeller especially in the afterward part of the hull. If the initiation points of the fractures are not apparent, the structure on the other side of the plating should be examined.

Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify, clean, and closely inspect potential problem areas.

Fracture initiating at latent defects in welding more commonly appear at the beginning or end of a run of welding, or rounding corners at the end of a stiffener, or at an intersection. Special attention should be paid to welding at toes of brackets, cut-outs, and intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations at the ends of each length of weld.

It should be noted that fractures, particularly ***fatigue fractures*** due to repeated stresses, may lead to serious damage, e.g. a fatigue fracture in a frame may propagate into shell plating and affect the watertight integrity of the hull. In extreme weather conditions the shell fracture could extend further resulting in the loss of part of the shell plating and consequent flooding of cargo hold.

3.3.4 Deformations

Deformation of structure is caused by in-plane load, out-of -plane load or combined loads. Such deformation is often identified as local deformation, such as deformation of panel including stiffener, or global deformation; such as deformation of structure including plating, beam, frame, girder, floor, etc.

If a small increase of the in-plane loads cause large deformations, this process is called buckling.

Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to ***bottom slamming and wave impact forces*** are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the after part of the hull.

In the case of ***damages due to contact*** with other objects, special attention should be drawn to the fact that although damages to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic ***buckling*** will not be directly obvious but may be detected by coating damage, stress lines or shedding of scale. Buckling damages are often found in webs of web frames or floors. In many cases this is due to corrosion of webs/floors, too wide a spacing of stiffeners or wrongly positioned lightening holes, man-holes or slots in webs/floors.

Finally, it should be noted that inadvertent overloading may cause significant damages. In general, however, major causes of damages are associated with excessive corrosion and contact damage.

3.4 Structural detail failures and repairs

3.4.1 For examples of structural defects which have occurred in service, attention is drawn to ***Section 5 of these Guidelines***. It is suggested that Surveyors and inspectors should be familiar with the contents of ***Section 5*** before undertaking a survey.

3.4.2 If replacement of defective parts must be postponed, the following temporary measures may be acceptable at the Surveyor's discretion; notwithstanding that carrying out a permanent repair straightaway is the preferable option.

(a) The affected area may be sandblasted and painted in order to reduce corrosion rate.
(b) Doubler may be applied over the affected area. Special consideration should be given to buckled areas under compression.
(c) Stronger members may support weakened stiffeners by applying temporarily connecting elements.
(d) Cement box may be applied over the affected area.

A suitable condition of class should be imposed when temporary measures are accepted.

4 Survey planning, preparation and execution

4.1 General

4.1.1 The owner should be aware of the scope of the forth coming survey and instruct those responsible, such as the master or the superintendent, to prepare necessary arrangements. If there is any doubt, BCS to be consulted.

4.1.2 Survey execution will naturally be heavily influenced by the type of survey to be carried out. The scope of survey will have to be determined prior to the execution.

4.1.3 When deemed prudent and/or required by virtue of the periodic classification survey conducted, the surveyor should study the ship's structural arrangements and review the ship's operating and survey history and those of sister ships, where possible, to determine any known potential problem areas particular to the class of the ship. Sketches of typical structural elements should be prepared in advance so that any defects and/or ultrasonic thickness measurements can be recorded rapidly and accurately.

4.2 Conditions for survey

4.2.1 The owner is to provide the necessary facilities for a safe execution of the survey.

4.2.2 Tanks and spaces are to be safe for access, i.e. gas freed (marine chemist certificate), ventilated, etc.

4.2.3 Tanks and spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. and sufficient illumination is to be provided, to reveal corrosion, deformation, fractures, damages or other structural deterioration. In particular this applies to areas which are subject to thickness measurement.

4.3 Access arrangement and safety

4.3.1 In accordance with the intended survey, measures are to be provided to enable the hull structure to be examined in a safe and practical way.

4.3.2 In accordance with the intended survey in cargo holds and salt water ballast tanks a secure and acceptable means of access is to be provided. This can consist of permanent staging, temporary staging or ladders, lifts and movable platforms, or other equivalent means.

4.3.3 In addition, particular attention should be given to the following guidance:

(a) Prior to entering tanks and other enclosed spaces, e.g. chain lockers, void spaces, it is necessary to ensure that the oxygen content is to be tested and confirmed as safe. A responsible member of the crew should remain at the entrance to the space and if possible communication links should be established with both the bridge and engine room. Adequate lighting should be provided in addition to a hand held torch (flashlight).

(b) In tanks where the structure has been coated and recently deballasted, a thin slippery film may often remain on the surfaces. Care should be taken when inspecting such spaces.

(c) The removal of scale can be extremely difficult. The removal of scale by hammering may cause sheet scale to fall. When using a chipping or scaling hammer care should be taken to protect eyes, and where possible safety glasses should be worn. If the structure is heavily scaled then it may be necessary to request de-scaling before conducting a satisfactory visual examination.

(d) Owners or their representatives have been known to request that a survey be carried out from the top of the cargo during discharging operations. For safety reason, surveys must not to be carried out during discharging operations in the hold.

(e) When entering a cargo hold or tank the bulkhead vertical ladders should be examined prior to descending to ensure that they are in good condition and rungs are not missing or loose. If holds are being entered when the hatch covers are in the closed position, then adequate lighting should be arranged in the holds. One person at a time should descend or ascend the ladder.

(f) If a portable ladder is used for survey purposes, the ladder should be in good condition and fitted with adjustable feet, to prevent it from slipping. Two crew members should be in attendance in order that the base of the ladder is adequately supported during use. The remains of cargo, in particular fine dust, on the tank top should be brushed away as this can increase the possibility of the ladder feet slipping.

(g) If an extending/articulated ladder (frame walk) is used to enable the examination of upper portions of cargo structure, the ladder should incorporate a hydraulic locking system and a built in safety harness. Regular maintenance and inspection of the ladder should be confirmed prior to its use.

(h) If a hydraulic arm vehicle ("Cherry Picker") is used to enable the examination of the upper parts of the cargo hold structure, the vehicle should be operated by qualified personnel and there should be evidence that the vehicle has been properly maintained. The standing platform should be fitted with a safety harness. For those vehicles equipped with a self leveling platform, care should be taken that the locking device is engaged after completion of maneuvering to ensure that the platform is fixed.

(i) Staging is the most common means of access provided especially where repairs or renewals are being carried out. It should always be correctly supported and fitted with handrails. Planks should be free from splits and lashed down. Staging erected hastily by inexperienced personnel should be avoided.

(j) In double bottom tanks there will often be a build up of mud on the bottom of the tank and this should be removed, in particular in way of tank boundaries, suction and sounding pipes, to enable a clear assessment of the structural condition.

4.4 Equipment and tools[1]

4.4.1 Personal protective equipment

The following protective clothing and equipment to be worn as applicable during the surveys:

(a) ***Working clothes***: Working clothes should be of a low flammablility type and be easily visible.

(b) ***Head protection***: Hard hat (metal hats are not allowed) shall always be worn outside office building/unit accommodations.

(c) ***Hand and arm protection***: Various types of gloves are available for use, and these should be used during all types of surveys. Rubber/plastic gloves may be necessary

when working in cargo holds.

(d) ***Foot protection***: Safety shoes or boots with steel toe caps and non slip soles shall always be worn outside office buildings/unit accommodations. Special footwear may be necessary on slippery surfaces or in areas with chemical residues.

(e) ***Ear protection***: Ear muffs or ear plugs are available and should be used when working in noisy areas. As a general rule, you need ear protection if you have to shout to make yourself understood by someone standing close to you.

(f) ***Eye protection***: Goggles should always be used when there is danger of solid particles or dust getting into the eyes. Protection against welding arc flashes and ultraviolet light should also be considered.

(g) ***Breathing protection***: Dust masks shall be used for protection against the inhalation of harmful dusts, paint spraying and sand blasting. Gas masks and filters should be used by personnel working for short periods in an atmosphere polluted by gases or vapour.
(Self-contained breathing apparatus: Surveyors shall not enter spaces where such equipment is necessary due to unsafe atmosphere. Only those who are specially trained and familiar with such equipment should use it and only in case of emergency).

(h) ***Lifejacket***: Recommended to be used when embarking/disembarking ships offshore, from/to pilot boat.

4.4.2 Personnel survey equipment[2]

The following survey equipment is to be used as applicable during the surveys:

(a) ***Torches***: Torches (Flashlights) approved by a competent authority for use in a flammable atmosphere shall be used in gas dangerous areas. A high intensity beam type is recommended for in-tank inspections. Torches are recommended to be fitted with suitable straps so that both hands may be free.

(b) ***Hammer***: In addition to its normal purposes the hammer is recommended for use during surveys inside units, tanks etc. as it may be most useful for the purpose of giving distress signal in case of emergency.

(c) ***Multigas detector***: For verification of acceptable atmosphere prior to tank entry, pocket size instruments which give an audible alarm when unacceptable limits are reached are recommended. Such equipment shall have been approved by national authorities.

(d) ***Safety belts and lines***: Safety belts and lines should be worn where high risk of falling down from more than 3 meters is present.

(e) ***Radiation meter***: For the purpose of detection of ionizing radiation (X or gamma rays) caused by radiographic examination, a radiation meter of the type which gives an audible alarm upon detection of radiation is recommended.

1+2 Reference should also be made to BCS-PR37 and BCS- G 72.

4.4.3 Thickness measurement and fracture detection

(a) Thickness measurement is to comply with the requirements of BCS. Thickness measurement should be carried out at points that adequately represent the nature and extent of any corrosion or wastage of the respective structure (plate, web, etc.).

(b) Thickness measurement is normally carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven as required.

(c) The thickness measurement is to be carried out by a qualified company certified by BCS.

(d) One or more of the following fracture detection procedures may be required if deemed necessary and should be operated by experienced qualified technicians:
- radiographic equipment
- ultrasonic equipment
- magnetic particle equipment
- dye penetrant

4.5 Survey at sea or anchorage[3]

4.5.1 Voyage surveys may be accepted provided the survey party is given the necessary assistance from the shipboard personnel. The necessary precautions and procedures for carrying out the survey are to be in accordance with **4.1** to **4.4** inclusive. Ballasting systems must be secured at all times during tank surveys.

4.5.2 A communication system is to be arranged between the survey party in the spaces under examination and the responsible officer on deck.

4.6 Documentation on board

4.6.1 The following documentation is recommended to be placed on board and maintained and updated by the owner for the life of the ship in order to be readily available for the survey party.

4.6.2 Survey Report File: This file includes Reports of Surveys and Thickness Measurement Report.

4.6.3 Supporting Documents: It is recommended that the following additional documentation be placed on board, including any other information that will assist the inspection.

(a) Main structural plans of cargo holds and ballast tanks,

(b) Previous repair history,

(c) Cargo and ballast history,

(d) Inspection and action taken by ship's personnel with reference to:
- structural deterioration in general
- leakages in bulkheads and piping
- condition of coating or corrosion protection, if any

4.6.4 Prior to inspection, it is recommended that the documents on board the vessel be reviewed as a basis for the current survey.

[3] Reference may also be made to BCS- R Z7.1.

5 Structural detail failures and repairs

5.1 General

5.1.1 The ***catalogue of structural detail failures and repairs*** contained in this section of the ***Guidelines*** collates data supplied by BCS and is intended to provide guidance when considering similar cases of damage and failure. The proposed repairs reflect the experience of the surveyors of BCS, but it is realized that other satisfactory alternative methods of repair may be available. However, in each case the repairs are to be completed to the satisfaction of BCS.

5.2 Catalogue of structural detail failures and repairs

5.2.1 The catalogue has been sub-divided into parts and areas to be given particular attention during the surveys:

Part 1 Cargo hold region
- Area 1 Upper deck structure
- Area 2 Side structure
- Area 3 Transverse bulkhead structure
- Area 4 Tween deck structure
- Area 5 Double bottom structure

Part 2 Fore and aft end regions
- Area 1 Fore end structure
- Area 2 Aft end structure
- Area 3 Stern frame, rudder arrangement and propeller shaft support

Part 3 Machinery and accommodation spaces
- Area 1 Engine room structure
- Area 2 Accommodation structure

Part 1 Cargo hold region

Contents

Area 1 Upper deck structure
Area 2 Side structure
Area 3 Transverse bulkhead structure
Area 4 Tween deck structure
Area 5 Double bottom structure

Area 1 Upper deck structure

Contents

1 General

2 What to look for - On-deck inspection
- **2.1 Material wastage**
- **2.2 Deformations**
- **2.3 Fractures**

3 What to look for - Under-deck inspection
- **3.1 Material wastage**
- **3.2 Deformations**
- **3.3 Fractures**

4 General comments on repair
- **4.1 Material wastage**
- **4.2 Deformations**
- **4.3 Fractures**
- **4.4 Miscellaneous**

Figures and/or Photographs - Area 1	
No.	**Title**
Photograph 1	Heavy corrosion of hatch coaming
Photograph 2	Heavy corrosion of hatch coaming
Photograph 3	Fractures at the hatch corner
Photograph 4	Corrosion at the top of the hatch coaming

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Buckling of deck plating of transverse framing system
2	Fractures at main cargo hatch corner
3-a	Fracture of welded seam between thick plate and thin plate at cross deck
3-b	Plate buckling in thin plate near thick plate at cross deck
3-c	Overall buckling of cross deck plating
3-d	Deformed and fractured deck plating around tug bitt
4	Buckling of web beam
5-a	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket (discontinuous longitudinal hatch coaming)
5-b	Fractures in continuous longitudinal hatch coaming extension bracket
5-c	Fracture in access hole of longitudinal hatch coaming
6	Fractures in web of transverse hatch coaming stay
7-a	Fractures in hatch coaming top plate at the termination of rail for hatch cover
7-b	Fractures in hatch coaming top plate at the termination of rail for hatch cover
8	Fractures in hatch coaming top plate around resting pad
9	Fracture in deck plating at the pilot ladder access of bulwarks

1 General

1.1 Deck structures outside hatches are subjected to longitudinal hull girder bending, caused by cargo distribution and wave actions. Moreover deck structures may be subjected to severe loads due to green seas on deck, excessive deck cargo or improper handling of cargo. Certain areas of the deck may also be subjected to additional compressive stresses caused by slamming or bow flare effect at the fore ship in heavy weather.

1.2 The cross deck structure between the cargo hatches is subjected to transverse compression from the sea pressure on the ship sides and in-plane bending due to torsion distortion of the hull girders under wave action. In association with this, the area around the corner of a main cargo hatch is subjected to high cyclical stress due to the combined effect of hull girder bending moment and transverse and torsional loading.

1.3 Discontinuous cargo hatch side coamings are subjected to considerable longitudinal bending stresses although not taken into account in the strength of hull girders. This will cause additional stresses at the mid length of hatches and stress concentrations at the termination of the side coaming extensions. Continuous cargo hatch side coamings are included in the strength of hull girders and are subjected to high longitudinal bending stress at the top of the coaming amidships. Terminations of continuous side coamings at the fore and aft ends are particularly vulnerable to stress concentrations.

1.4 Hatch cover operations in combination with poor maintenance can result in damage to the cleats and gasket, etc. This can result in the loss of weathertight integrity of the hold spaces. Damage to the covers can also be sustained by overloading when carrying deck cargoes.

1.5 The marine environment, the humid atmosphere due to vaporization from cargo in the cargo hold, and high temperatures on deck and hatch cover plating, from the sun and heat, may result in severe corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above.

1.6 Bulwarks are provided for the protection of crew and cargoes, and lashing of cargoes on deck. Although bulwarks are not taken into account in the strength of hull girders, they are subjected to considerable longitudinal bending stresses. Therefore bulwarks may suffer fractures and corrosion, especially at the termination of bulwarks, such as at pilot ladder access or expansion joints. The fractures may propagate to deck plating and cause serious damage.

1.7 The deterioration of various fittings on deck, such as ventilators, air pipes and sounding pipes, may result in serious problems regarding weather/watertightness and/or firefighting.

1.8 If the ship is assigned timber freeboards, fittings for stowage of timber deck cargo have to be inspected in accordance with ILLC 1966. Deterioration of the fittings may cause cargoes to shift resulting in serious damage to the ship.

2 What to look for - On-deck inspection

2.1 Material wastage

2.1.1 The general condition with regard to corrosion of the deck structure, the cargo hatch coamings and the hatch covers may be observed by visual inspection. Special attention

should be paid to areas where pipes, e.g. fire main, hydraulic pipes, pipes for compressed air, are fitted close to the plating, making proper maintenance of the protective coating difficult to carry out.

2.1.2 Grooving corrosion may occur at the transition between the thicker deck plating outside the line of cargo hatches and the thinner cross deck plating, especially when the difference in plate thickness is large. The difference in plate thickness causes water to gather in this area resulting in corrosion ambience which may subsequently lead to grooving.

2.1.3 Pitting corrosion may occur throughout the cross deck strip plating and on hatch covers. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction.

2.1.4 Wastage/corrosion may seriously affect the integrity of the steel hatch covers, and also the additional moving parts, e.g. cleats, pot-lifts, roller wheels, etc. In some ships pontoon hatch covers together with tarpaulins are used. The tarpaulins are liable to tear due to deck cargo, such as timbers, and cause heavy corrosion to the hatch covers.

2.2 Deformations

2.2.1 Plate buckling (between stiffeners) may occur in areas subjected to in-plane compressive stresses, particularly if corrosion is evident. Special attention should be paid to areas where the compressive stresses are perpendicular to the direction of the stiffening system. Such areas may be in the foreship where deck longitudinals are terminated and replaced by transverse beams (See **Example 1**), but also in the cross deck strips between hatches when longitudinal stiffening is applied (See **Examples 3-b** and **3-c**).

2.2.2 Deformed structures may be observed in areas of the deck, hatch coamings and hatch covers where cargo has been handled/loaded or mechanical equipment, e.g. hatch covers, has been operated. Also in other areas, in particular exposed deck forward, deformation may be a result of green seas loads on the deck.

2.2.3 Sagging plate panel may have been caused by lateral overloading as a consequence of excessive deck cargo, improper distribution /support of deck cargoes, sea water on deck in heavy weather, or a combination of these factors. It is essential that an under-deck inspection is also carried out to assess the extent of such damage (See **Example 4**).

2.2.4 Deformed/twisted exposed structures above deck, such as side-coaming brackets, may result from impact of cargo or cargo handling machinery due to improper handling. Such damages may also be caused by sea water on deck in heavy weather.

2.3 Fractures

2.3.1 Fractures in areas of structural discontinuity and stress concentration will normally be detected by close-up inspection. Special attention should be given to the structures at cargo hatches in general and to corners of deck openings in particular.

2.3.2 Fractures initiated in the deck plating outside the line of hatches (See **Example 2**), may develop across the deck, with the most serious consequences. Also fractures initiated in the deck plating of the cross deck strip, in particular at the transition between the thicker

deck plating outside the line of cargo hatches and the thinner cross deck plating (See **Example 3-a**), may have serious consequences if not repaired immediately.

2.3.3 Other fractures that may occur in the deck plating at hatches and in connected coamings can result/originate from:

(a) Fillet weld connection of the coaming to the deck, particularly at a rounded hatch coaming plate at the hatch corner.
(b) Welded attachment and shedder plate close to or on the free edge of the hatch corner plating.
(c) The geometry of the corners of the hatch openings.
(d) The termination of the side coaming extension brackets (See **Examples 5-a** and **5-b**).
(e) Grooving caused by wire ropes of cargo gear.
(f) Wasted plating.
(g) Attachments, cut-outs and notches for securing devices, and operating mechanisms for opening/closing hatch covers at the top of the coaming and/or coaming top bar, if any, at the mid-length of the hatch (See **Examples 7-a** and **7-b**).
(h) Hatch coaming stays supporting the hatch cover resting pads in case of deck loads on the hatch covers and the connection of resting pad to the top of the coaming as well as the supporting structures (See **Example 8**).

2.3.4 Fractures in deck plating often occur at the termination of bulwarks, such as pilot ladder recess, due to stress concentration. The fractures may propagate resulting in serious casualty when the deck is subject to high longitudinal bending stress.

3 What to look for - Under-deck inspection

3.1 Material wastage

3.1.1 The level of wastage of under-deck stiffeners/structures may have to be established by means of thickness measurements. As mentioned previously the combination of the effects from the marine environment and the local atmosphere will give rise to high corrosion rates.

3.1.2 Severe corrosion of the hatch coaming from inside and of under deck girders may occur due to difficult access for maintenance of the protective coating. This may in turn lead to fractures (See **Photograph 1**).

Photograph 1 Heavy corrosion of hatch coaming

Photograph 2 Heavy corrosion of hatch coaming

Photograph 3 Fractures at the hatch corner

Photograph 4 Corrosion at the top of the hatch coaming

3.2 Deformations

3.2.1 Buckling should be looked for in the primary supporting structure, e.g. hatch end beams and longitudinal girders beneath the longitudinal hatch coamings, if sagging of deck panels has been observed during on-deck inspection. Such buckling may also be the initial observation of damage caused by lateral overloading as a consequence of excessive deck cargo, improper distribution/support of deck cargoes, sea water on deck in heavy weather, or a combination of these causes.

3.2.2 Improper ventilation during ballasting/deballasting of deep ballast tank may cause deformation in deck structure. If such deformation is observed, internal inspection of deep ballast tank should be carried out in order to confirm the nature and the extent of damage.

3.3 Fractures

3.3.1 Fractures in the connection between the transverse bulkheads, girders/stiffeners and the deck plating may occur. This is often associated with a reduction in area of the connection due to corrosion.

3.3.2 Fractures in the primary supporting structure, e.g. hatch end beams may be found in the weld connections at the ends of the beams/girders.

4 General comments on repair

4.1 Material wastage

4.1.1 In the case of grooving corrosion at the transition between the thicker deck plating outside the line of cargo hatches and the cross deck plating, consideration should be given to the renewal of part of, or the entire width, of the adjacent cross deck plating.

4.1.2 In the case of pitting corrosion throughout the cross deck strip plating, consideration should be given to renewal of part of or the entire cross deck plating.

4.1.3 When heavy wastage is encountered on under-deck structure, the whole or part of the structure may be cropped and renewed depending on the permissible diminution levels applied by BCS.

4.1.4 For wastage of cargo hatch covers a satisfactory thickness determination is to be carried out and the plating and stiffeners are to be cropped and renewed as appropriate depending on the extent of the wastage.

4.2 Deformations

4.2.1 When buckling of the deck plating has occurred, although not in association with significant corrosion, appropriate reinforcement is necessary in addition to cropping and renewal.

4.2.2 Where buckling of hatch end beams has occurred because of inadequate transverse strength, the plating should be cropped and renewed and additional panel stiffeners fitted.

4.2.3 Buckled cross deck structure due to loss in strength induced by wastage, is to be cropped and renewed as necessary. If the cross deck is stiffened longitudinally and the buckling results from inadequate transverse strength, additional transverse stiffeners should be fitted.

4.2.4 Deformations of cargo hatch covers should be cropped and partly renewed, or renewed in full, depending on the extent of the damage.

4.3 Fractures

4.3.1 Fractures in way of cargo hatch corners should be carefully considered with respect to the design details (See **Example 2**). Re-welding of such fractures is normally not considered a permanent solution. Where the difference in thickness between an insert plate and the adjacent deck plating is greater than 3 mm the edge of the insert plate should be suitably beveled. In order to reduce the residual stress arising from this repair situation, the welding sequence and procedure is to be carefully monitored and low hydrogen electrodes should be used for welding the insert plate to the adjoining structure. Where welded shedder plates are fitted into the corners of the hatch coamings the deck connection should be left unwelded.

4.3.2 In the case of fractures at the transition between the thicker deck plating outside the line of cargo hatches and the cross deck plating, consideration should be given to renewal of part or the entire width of the adjacent cross deck plating, possibly with increased thickness (See **Example 3-a**).

4.3.3 When fractures have occurred in the connection of transverse bulkheads to the cross deck structure, consideration should be given to renewing and re-welding the connecting structure beyond the damaged area with the aim of increasing the area of the connection, which may be achieved by installation of additional brackets or increasing the brackets size.

4.3.4 Fractures of hatch end beams should be repaired by renewing the damaged structure, and by full penetration welding to the deck.

4.3.5 To reduce the possibility of future fractures in cargo hatch coamings the following details should be observed:

(a) Cut-outs and other discontinuities at the top of coamings and/or coaming top bar should have rounded corners (preferably elliptical or circular in shape) (See **Example 7-b**).
Any local reinforcement should be given a tapered transition in the longitudinal direction and the rate of taper should not exceed 1 in 3 (See **Example 7-a**).

(b) Fractures, which occur in the fillet weld connections to the deck of rounded coaming plates at the corners, should be repaired by replacing existing fillet welds with full penetration welding using low hydrogen electrodes or equivalent. If the fractures are extensive and recurring, the coamings should be modified to form square corners, with the longitudinal side coamings extending in the form of tapered brackets. Continuation brackets also to be arranged transversely in line with the hatch end coamings and the under-deck transverse.

(c) Cut-outs and drain holes are to be avoided in the hatch side coaming extension brackets. For fractured brackets, see **Examples 5-a** and **5-b**.

4.3.6 For cargo hatch covers, fractures of a minor nature may be veed-out and welded. For more extensive fractures, the structure should be cropped and partly renewed.

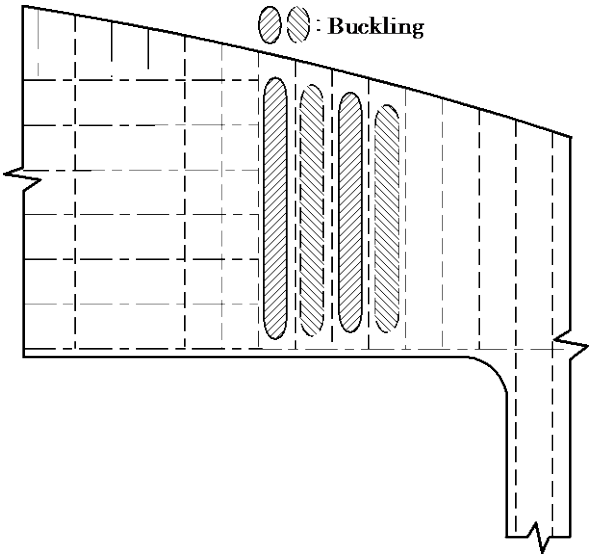
4.3.7 For fractures at the end of bulwarks an attempt should be made to modify the design in order to reduce the stress concentration in connection with general cropping and renewal (See **Example 9**).

4.4 Miscellaneous

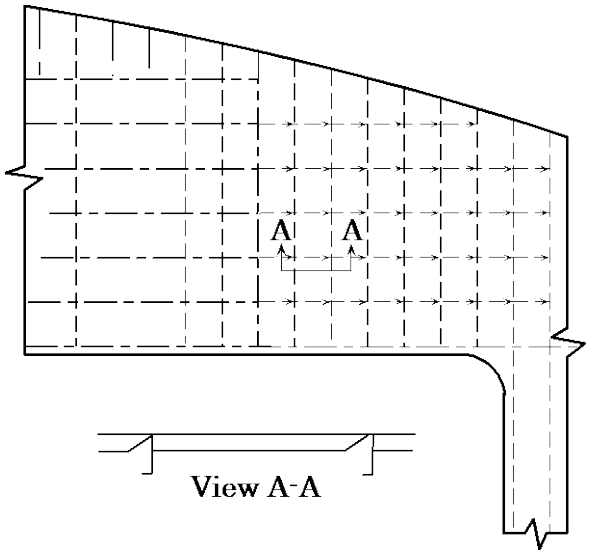
4.4.1 Ancillary equipment such as cleats, rollers etc. on cargo hatch covers is to be renewed when damaged or corroded.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**1**
Detail of damage	Buckling of deck plating of transverse framing system	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

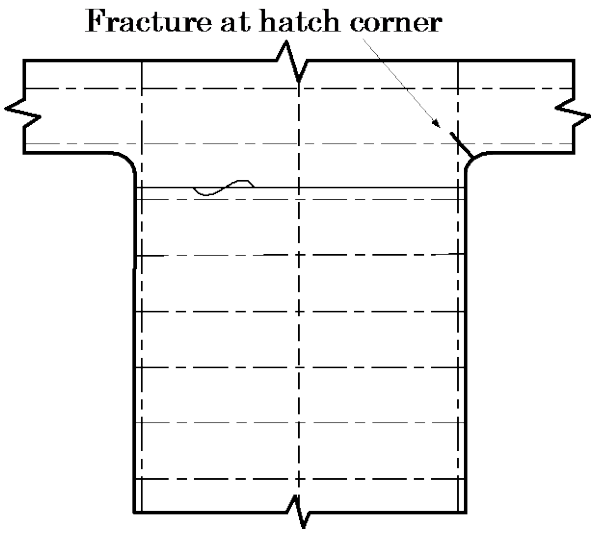
1. Excessive compressive stress due to slamming or bow flare effect.
2. Insufficient longitudinal stiffening of deck plating.

Notes on repairs

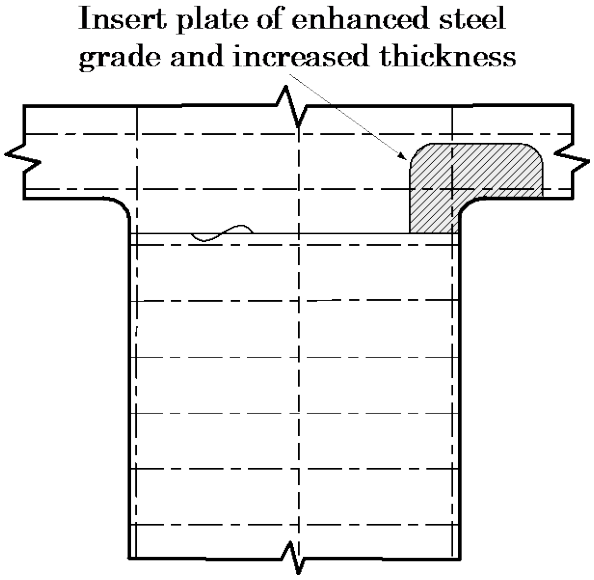
1. Buckled plating should be cropped and renewed. Longitudinal internal stiffeners should be provided.
   (Instead of longitudinal stiffeners, renewal by thicker deck plating can be accepted.)
2. Stress concentration may occur at the end of sniped stiffener resulting in fatigue fracture. For locations where high cyclic stress may occur, appropriate connection such as lug-connection should be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**2**
Detail of damage	Fractures at main cargo hatch corner	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

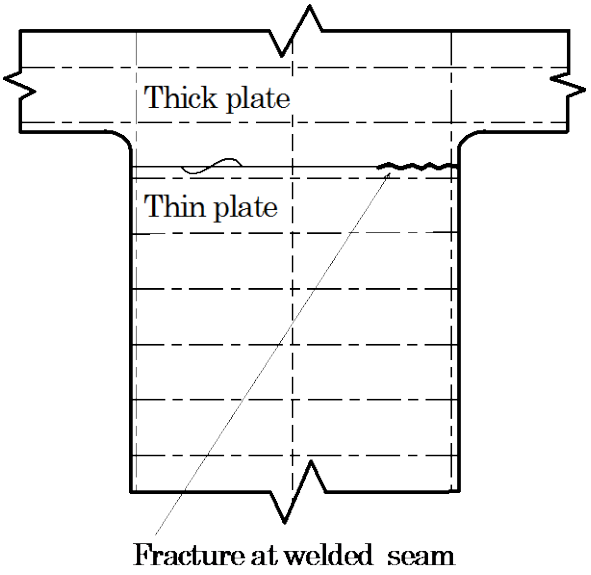
1. Stress concentration at hatch corners, i.e. radius of corner.
2. Welded attachment of shedder plate close to edge of hatch corner.
3. Wire rope groove.

Notes on repairs

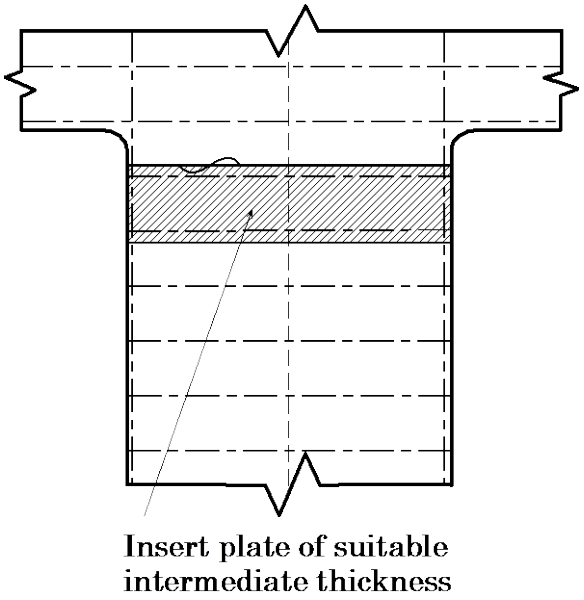
1. The corner plating in way of the fracture is to be cropped and renewed. If stress concentration is primary cause, insert plate should be of increased thickness, enhanced steel grade and/or improved geometry.
   Insert plate should be continued beyond the longitudinal and transverse extent of the hatch corner radius ellipse or parabola, and the butt welds to the adjacent deck plating should be located well clear of the butts in the hatch coaming.
   It is recommended that the edges of the insert plate and the butt welds connecting the insert plates to the surrounding deck plating be made smooth by grinding. In this respect caution should be taken to ensure that the micro grooves of the grinding are parallel to the plate edge.
2. If the cause of fracture is welded attachment of shedder plate, the deck connection should be left unwelded.
3. If the cause of the fracture is wire rope groove, replacement to the original design can be accepted.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure	3-a
Detail of damage	Fracture of welded seam between thick plate and thin plate at cross deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

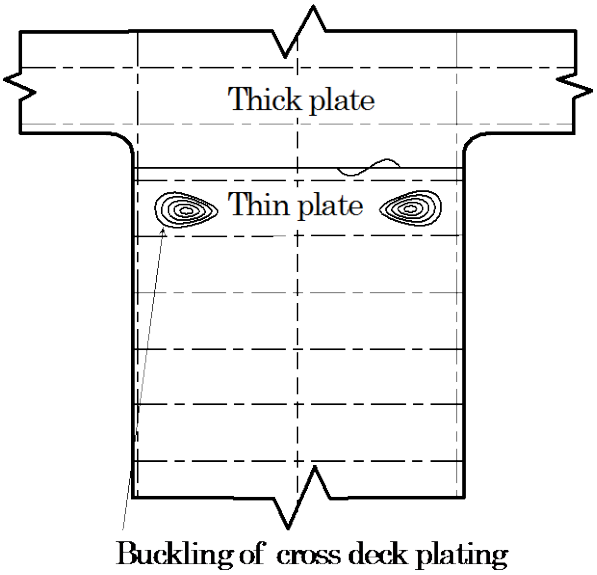
1. Stress concentration created by abrupt change in deck plating thickness.
2. In-plane bending in cross deck strip due to torsional (longitudinal) movements of ship sides.
3. Welded seam not clear of tangent point of hatch corner.

Notes on repairs

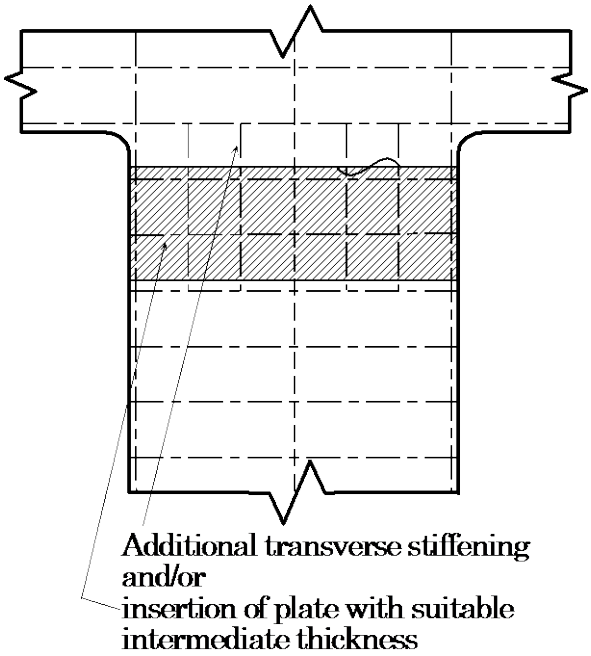
1. Insert plate of intermediate thickness is recommended.
2. Smooth transition between plates (beveling) should be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure	3-b
Detail of damage	Plate buckling in thin plate near thick plate at cross deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

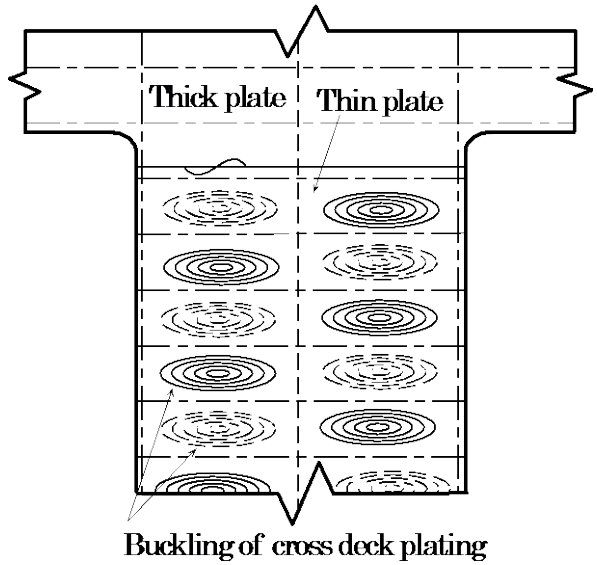
1. In-plane bending of cross deck strip due to torsional (longitudinal) movement of ship sides, often in combination with corrosion.
2. Insufficient transverse stiffening.

Notes on repairs

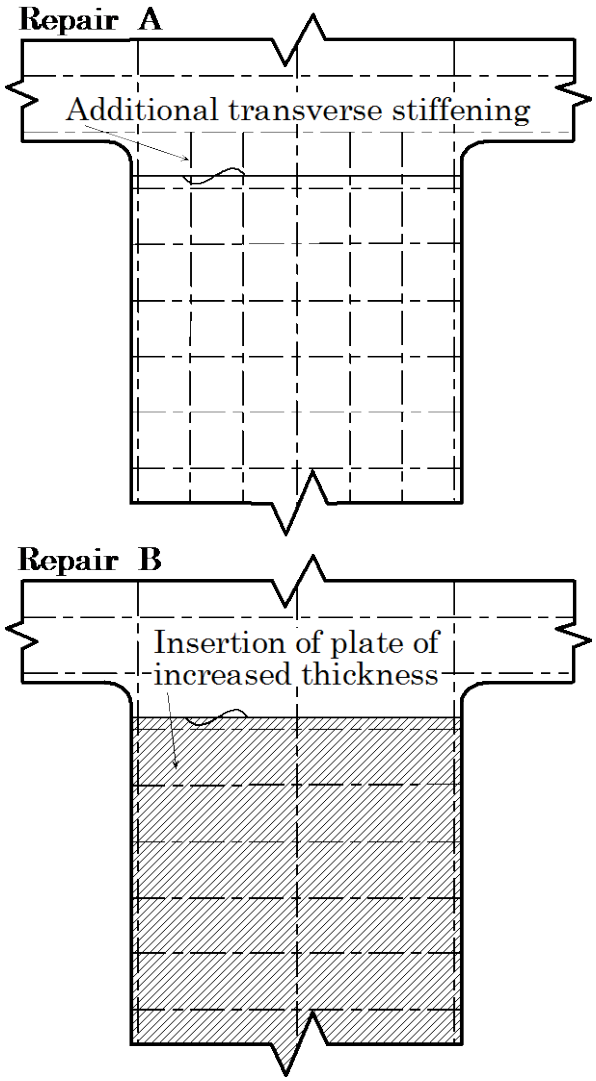
1. Transverse stiffeners extending from hatch sides towards centerline at least 10% of breadth of hatch, and/or increased plate thickness in the same area.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure	3-c
Detail of damage	Overall buckling of cross deck plating	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

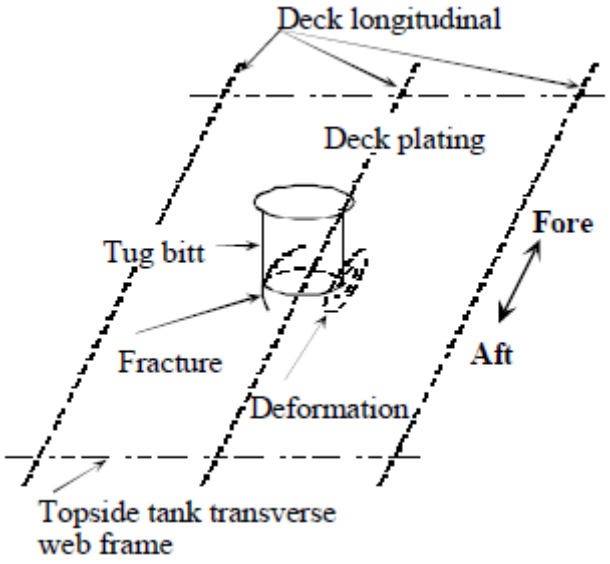
1. Transverse compression of deck due to sea load.
2. Insufficient transverse stiffening.

Notes on repairs

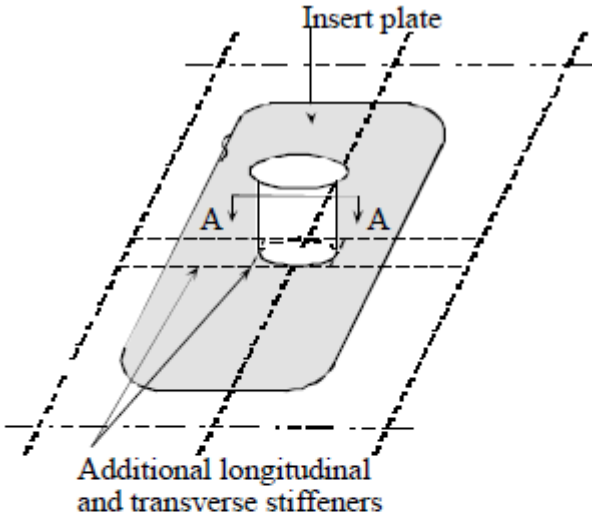
1. **Repair A**
   Plating of original thickness in combination with additional transverse stiffening.
   Repair B
2. Insertion of plating of increased thickness.

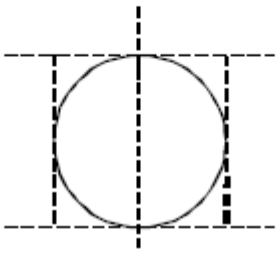
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**3-d**
Detail of damage	Deformed and fractured deck plating around tug bitt	

Sketch of damage



Sketch of repair





View A-A

Notes on possible cause of damage

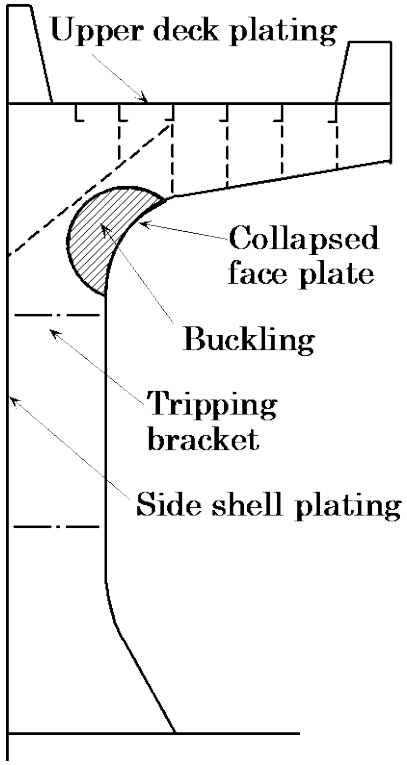
1. Insufficient strength.

Notes on repairs

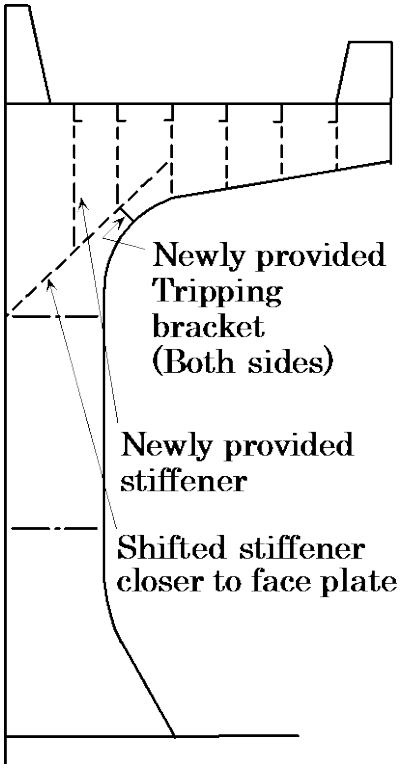
1. Fractured/deformed deck plating should be cropped and part renewed.
2. Reinforcement by stiffeners should be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**4**
Detail of damage	Buckling of web beam	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

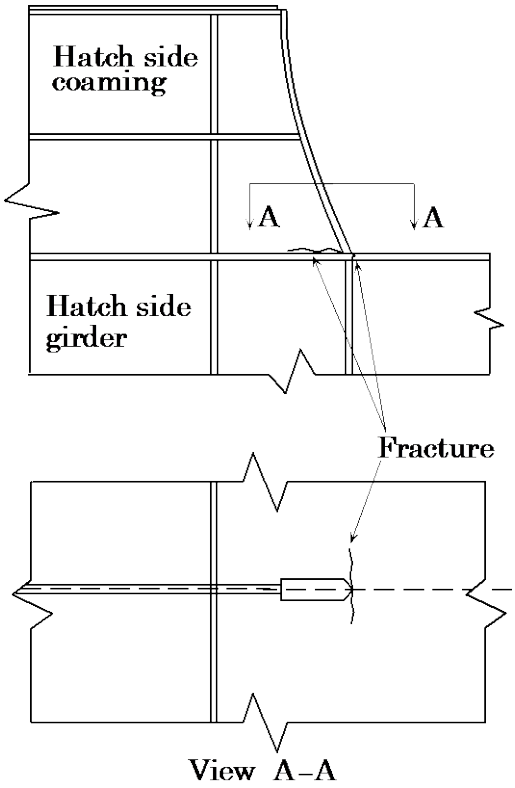
1. Overloading by green sea on deck or by excessive deck cargo.
2. Excessive corrosion.
3. Insufficient/improper web stiffening.

Notes on repairs

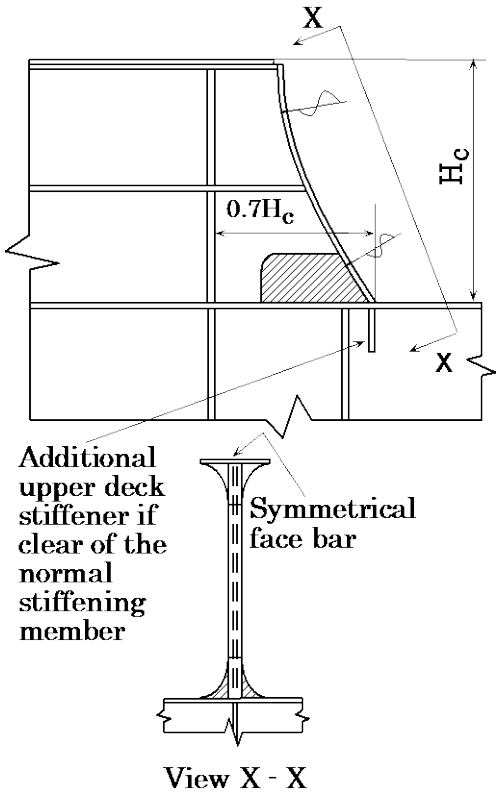
1. Buckled part is to be cropped and renewed.
2. If corrosion is not the cause, renewal by thicker plate (web and/or face) and/or reinforcement by stiffener and tripping bracket should be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**5-a**
Detail of damage	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket (discontinuous longitudinal hatch coaming)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

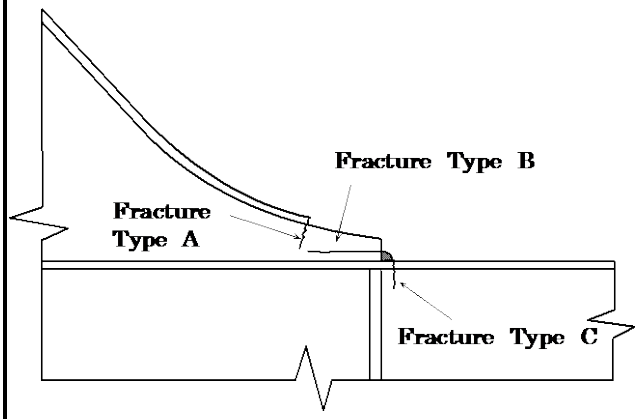
1. This damage is caused by stress concentrations attributed to the design of the bracket.

Notes on repairs

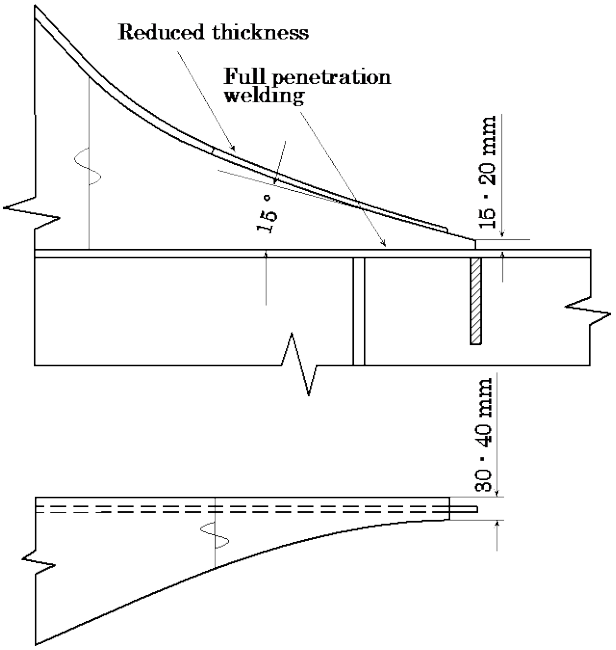
1. The design of the bracket can be altered as shown above, however, it is to be ensured that an additional under deck stiffener is provided at the toe of the termination bracket, where the toe is clear of the normal stiffening member.
   Full penetration weld for a distance of 0.15 H_C
2. from toe of side coaming termination bracket and for connection of athwartship gusset bracket to deck.
   The fracture in deck plating to be veed-out and
3. rewelded or deck plating cropped and part renewed as appropriate, using low hydrogen electrodes for welding.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**5-b**
Detail of damage	Fractures in continuous longitudinal hatch coaming extension bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

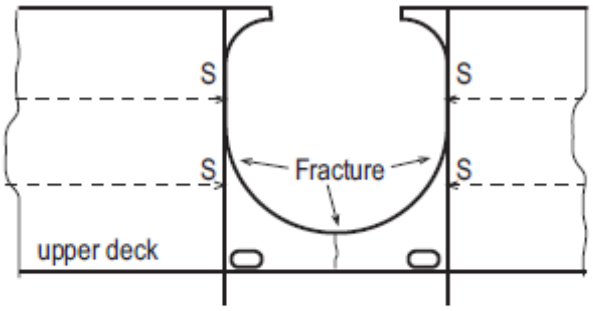
1. Flange force at the end of the flange too high due to insufficient tapering (**Fracture Type A**, propagating in the web).
2. Shear force in the web plate too high due to insufficient reduction of the web height at the end (**Fracture Type B**, propagating in the web at the undercut or HAZ of the fillet weld).
3. Insufficient support of the extension bracket below the deck (**Fracture Type C**, starting from undercut or HAZ of the fillet weld and propagating in the deck plating).

Notes on repairs

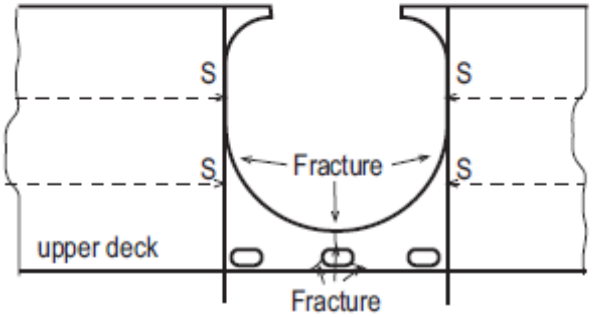
1. Extend the extension bracket as long as possible to arrange a gradual transition.
2. Reduce the web height at the end of the bracket; in case of high stress areas grind smooth the transition to the deck plating welding.
3. Reduce the cross sectional area of the flange at the end as far as possible.
4. Provide longitudinal structure in way of the web of the extension bracket to the next transverse structure or provide a new transverse structure.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**5-c**
Detail of damage	Fracture in access hole of longitudinal hatch coaming	

Sketch of damage

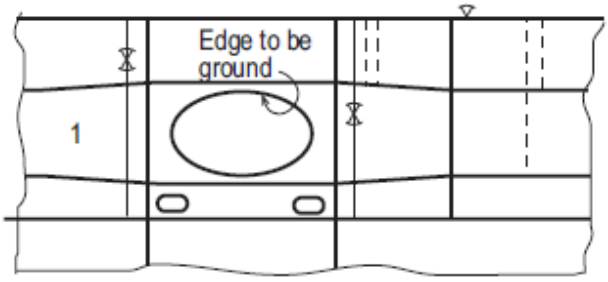


Sketch No. 1 a



Sketch No. 1 b

Sketch of repair



Notes on possible cause of damage

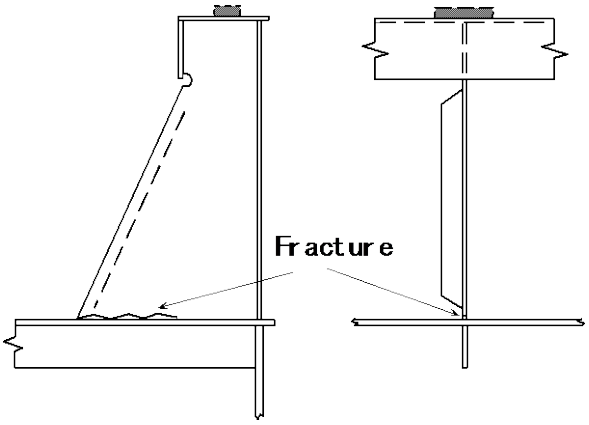
1. Coincidence of maximum increased stress due to the reduction of the hatch coaming with the metallurgical notches due to the welding seams in web and flat bar located at the same position. Insufficient transverse stiffening.

Notes on repairs

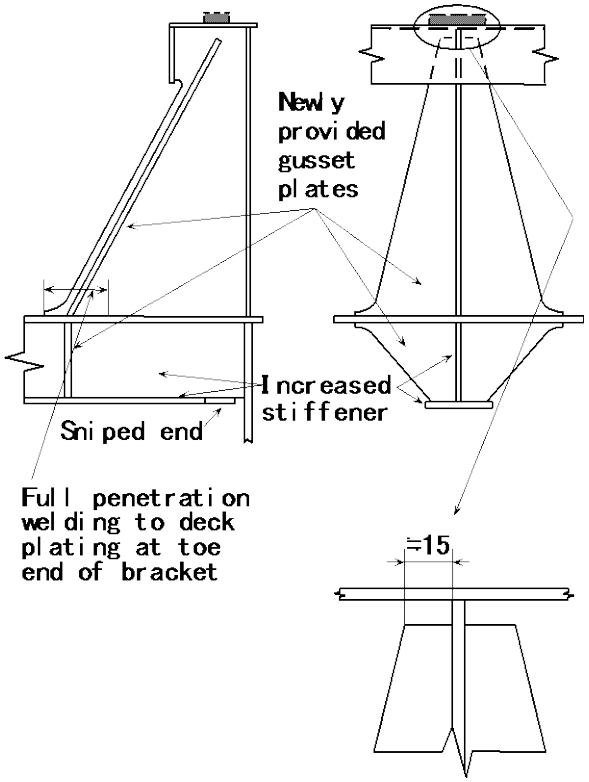
1. Hatch coaming to be continuous.
2. Access opening to be provided.
3. Drain holes to be elliptical and located above fillet weld to deck.
4. Hatch coaming stiffeners of same material as coaming.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**6**
Detail of damage	Fractures in web of transverse hatch coaming stay	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

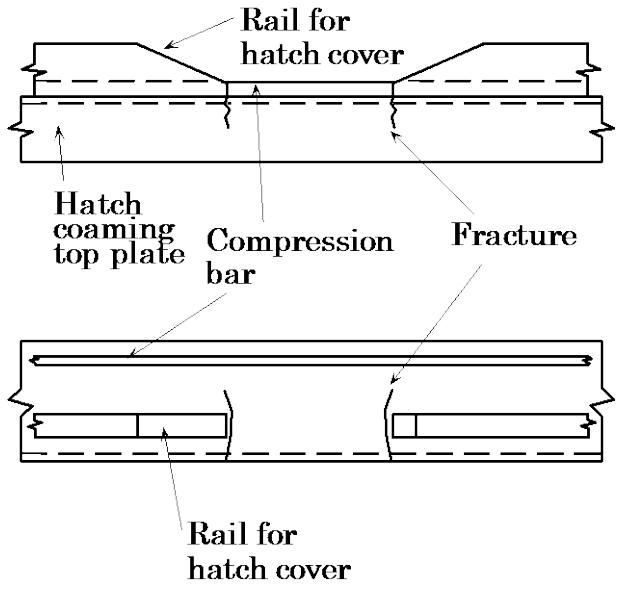
1. Insufficient consideration of the horizontal friction forces in way of the resting pads for hatch cover.

Notes on repairs

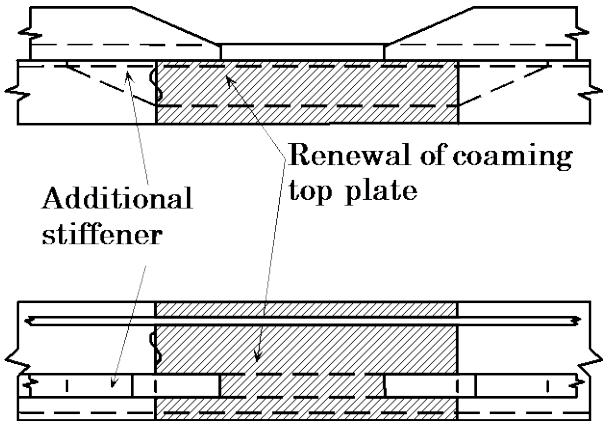
1. Modification of the design of the hatch coaming stay.
2. Full penetration welding between gusset plates and deck plating.
3. Strengthening and continuation of the structure below the deck.
4. Use pads with smaller coefficient of friction.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure	7-a
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

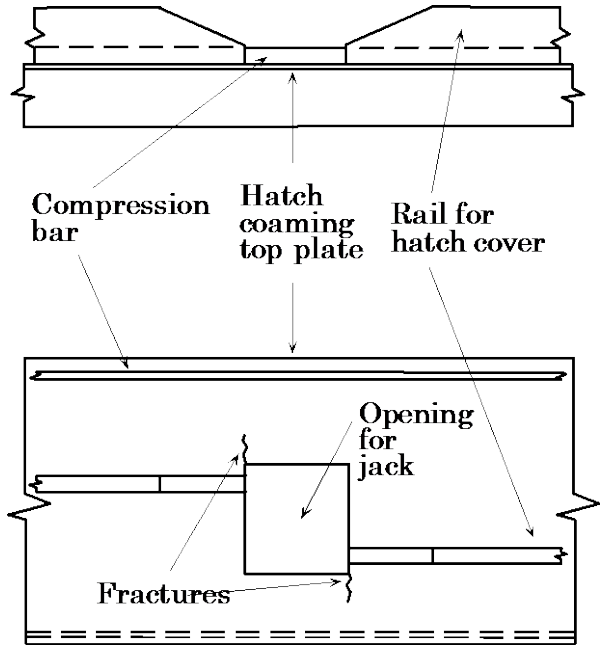
1. Stress concentration at the termination of the rail for hatch cover.

Notes on repairs

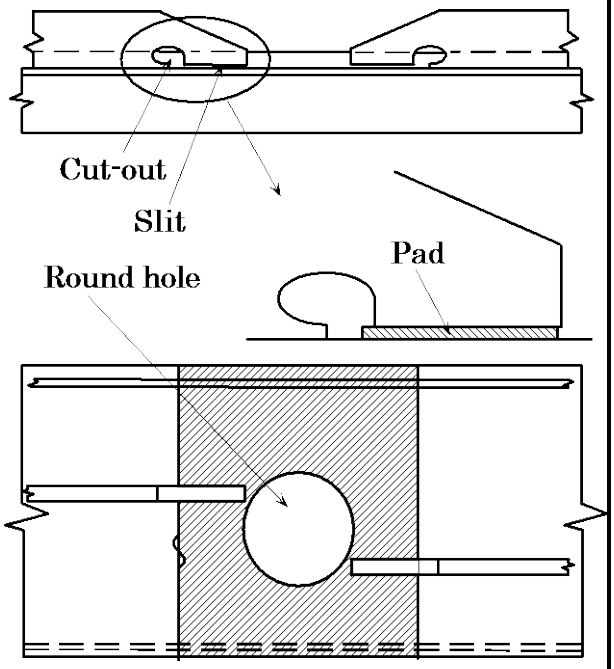
1. Fractured plate is to be cropped and part renewed.
2. Thicker insert plate and/or reinforcement by additional stiffener under the top plate should be considered. Also refer to **Example 7-b**.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure	7-b
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

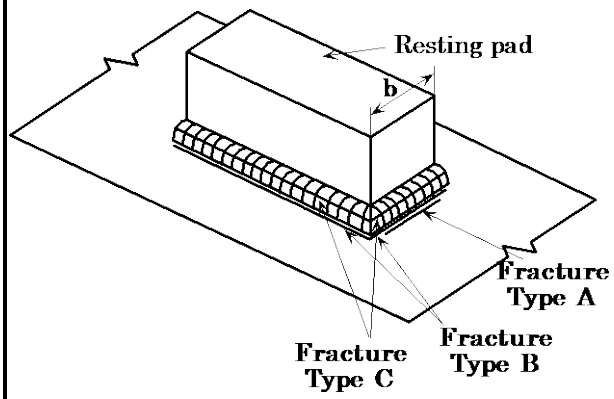
1. Stress concentration at the termination of the rail for hatch cover.

Notes on repairs

1. Fractured plate is to be cropped and part renewed.
2. Thicker insert plate and/or reduction of stress concentration adopting large radius should be considered.
   Or cut-out in the rail and detachment of the welds as shown in the above drawing should be considered in order to reduce the stress of the corner of the opening.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**8**
Detail of damage	Fractures in hatch coaming top plate around resting pad	

Sketch of damage

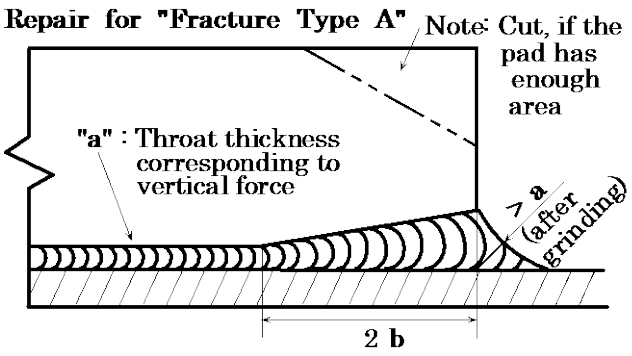


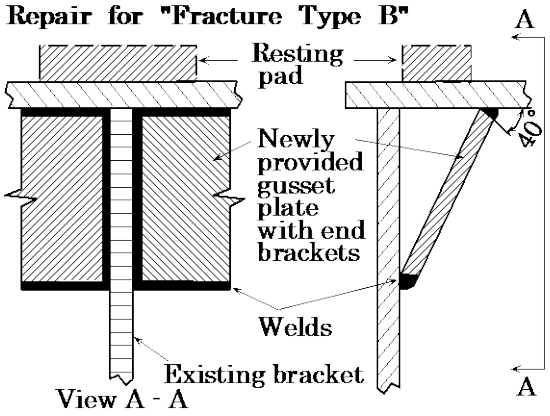
Fracture Type A:
Starting in way of the undercut or HAZ of the transverse fillet weld and propagating in the top plating.

Fracture Type B:
Starting in way of the undercut or HAZ of the longitudinal fillet weld and propagating in the top plating.

Fracture Type C:
Starting and propagating in fillet weld

Sketch of repair





Notes on possible cause of damage

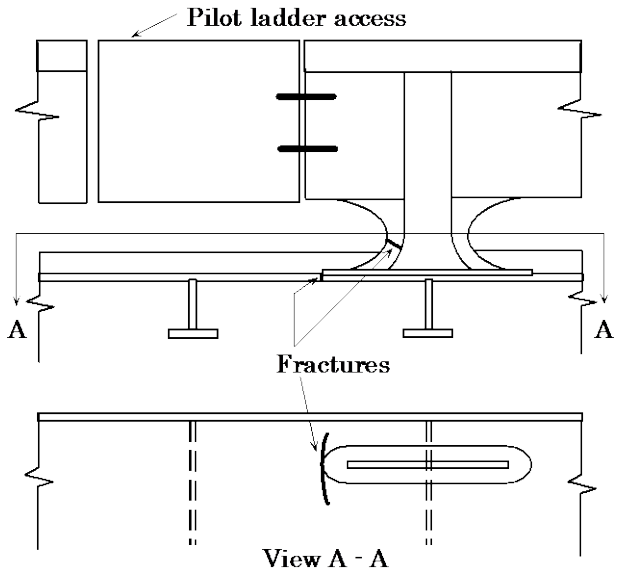
1. **Fracture Type A**:
   Inappropriate transition from the hatch coaming top plating to the resting pad in respect to longitudinal stresses.
2. **Fracture Type B**:
   Insufficient support of the resting pad below the top plating.
3. **Fracture Type C**:
   Insufficient throat thickness of the fillet weld in relation to the vertical forces.

Notes on repairs

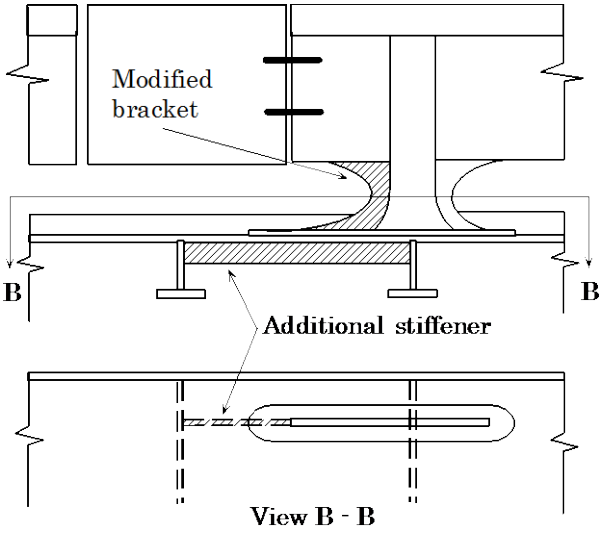
1. **Fracture Type A**:
   Modification of the transverse fillet weld according to the sketch; in some cases smoothing of the transition by grinding is acceptable.
2. **Fracture Type B**:
   Strengthening of the structures below the top plating according to the sketch.
3. **Fracture Type C**:
   Increasing the throat thickness corresponding to the acting vertical forces.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure**	**9**
Detail of damage	Fracture in deck plating at the pilot ladder access of bulwarks	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the termination of bulwarks.

Notes on repairs

1. Fractured deck plating should be cropped and part renewed.
2. Reduction of stress concentration should be considered. In the above figure gusset plate was replaced with soft type for the fracture in gusset plate and pad plate was increased. Additional stiffeners were provided for the fracture in deck plating.

Area 2 Side structure

Contents

1 General

2 What to look for - Internal inspection
- **2.1 Material wastage**
- **2.2 Deformations**
- **2.3 Fractures**

3 What to look for - External inspection
- **3.1 Material wastage**
- **3.2 Deformations**
- **3.3 Fractures**

4 General comments on repair
- **4.1 Material wastage**
- **4.2 Deformations**
- **4.3 Fractures**

Figures and/or Photographs - Area 2	
No.	**Title**
Figure 1	Potential problem areas
Photograph 1	Leakage from side shell plating due to heavy corrosion
Photograph 2	Timber carrier listing due to ingress of water

Examples of structural detail failures and repairs - Area 2	
Example No.	**Title**
1	Fracture in side shell frame at lower bracket
2	Fractures in side shell frame/lower bracket and side shell plating near tank top
3	Adverse effect of corrosion on the frame of forward/afterward hold
4	Fractures at the supporting brackets in way of collision bulkhead (with no side shell panting stringers fitted in hold)
5	Fractures in way of continuation/extension brackets in aftermost hold at the engine room bulkhead
6	Fracture in way of continuation/extension brackets at the end of deep tank

1 General

1.1 The shear capacity is the main contribution of the side shell to the general structural strength of the ship's hull. Shear stresses arise as a consequence of local unbalance longitudinally between the vertical forces of cargo loads and steel-weight, and the up-thrust of buoyancy.

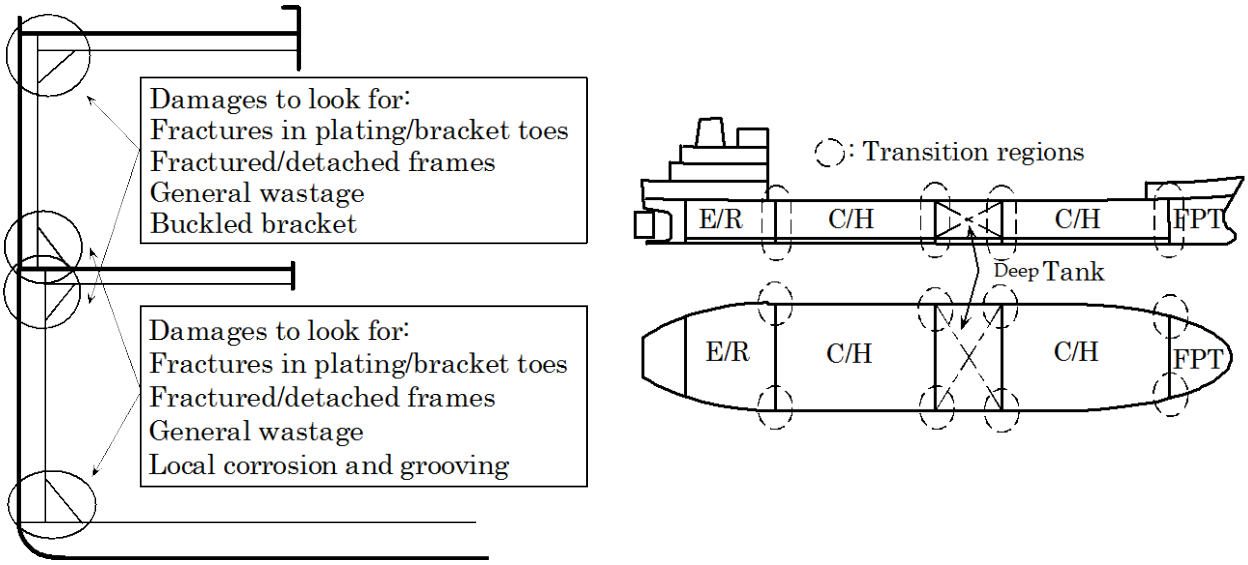
1.2 In addition to the contribution to the general structural strength of the ship's hull, the side shell is the defense against ingress/leakage of sea water, when subjected to static sea pressure and dynamic effects of ship movement and wave actions in heavy weather.

1.3 The ship side may suffer damage due to contact with the quay during berthing and impacts from cargo and/or equipment during cargo handling.

1.4 The marine environment (such as ultraviolet rays, high temperature, alternate wet and dry conditions due to wave or change of loading conditions etc.) in association with the characteristics of certain cargoes (e.g. wet timber loaded from sea water) may result in deterioration of coating and severe corrosion of plating and stiffeners. This situation makes the structure more vulnerable to the exposures described above.

1.5 The transition regions are subject to stress concentrations due to structural discontinuities. The side shell plating in fore and aft transition regions is also subject to panting. The lack of continuity of the longitudinal structure, and the greater slenderness and flexibility of the side structure near the more rigid end structures, can result in damages.

1.6 A summary of potential problem areas is shown in **Figures 1 (a)** and **(b)**. Serious consequences of damaged ship sides are illustrated in **Photographs 1** and **2**.



(a) Side shell frames **(b) Transition regions**

Figure 1 Potential problem areas

Photograph 1 Leakage from side shell plating due to heavy corrosion

Photograph 2 Timber carrier listing due to ingress of water

2 What to look for - Internal inspection

2.1 Material wastage

2.1.1 Attention is drawn to the fact that the tween deck and side shell frames may be significantly weakened by loss of thickness although diminution and deformations may not be apparent. Inspection should be made after the removal of any scale or rust deposit and thickness measurement gauging may be necessary, particularly if the corrosion is smooth and uniform.

2.1.2 It is not unusual to find highly localised corrosion on uncoated side shell frames and their end connections. The loss in the thickness is normally greater close to the side shell plating rather than near the faceplate (See **Example 2**). This situation, if not remedied, can result in loss of support to the shell plating and hence large inboard deflections. In many cases such deflections of the side shell plating can generate fractures in the shell plating and fracturing and buckling of the frame web plates and eventually result in detachment of the end brackets from the tank top.

2.1.3 Heavy wastage and possible grooving of the framing in forward/ aft hold, where side shell plating is oblique to the frames it may have a more severe effect as shown in **Example 3**.

2.2 Deformations

2.2.1 It is normally to be expected that the lower region of the frames will receive some level of damage during operational procedures, e.g. unloading with grabs or loading of logs. This can range from damage of the frame end bracket face plates to large physical deformations of a number of frames and in some cases can initiate fractures.

These individual frames and frame brackets, if rendered ineffective, will place additional load on the adjacent frames and failure by the “domino effect” can in many cases extend over the side shell of a complete hold.

2.3 Fractures

2.3.1 Fractures are more evident at the toes of the upper and lower bracket(s) or at the connections between brackets and frames. In most cases the fractures may be attributed to stress concentrations and stress variations created, in the main, by loads from the seaway. The stress concentrations can be a result of poor detail design and/or bad workmanship. Localised fatigue fracturing, possibly in association with localised corrosion, may be difficult to detect and it is stressed that the areas in question should receive close attention during periodical surveys.

2.3.2 Fractures in shell plating and supporting or continuation/extension brackets at collision bulkheads, deep tank bulkheads, and engine room bulkheads are frequently found by close-up inspection.

3 What to look for - External inspection

3.1 Material wastage

3.1.1 The general condition with regard to wastage of the ship's sides may be observed by visual inspection from the quayside of the area above the waterline. Special attention should be paid to areas where the painting has deteriorated.

3.2 Deformations

3.2.1 The side shell should be carefully inspected with respect to possible deformations. The side shell below water line can usually only be inspected when the ship is dry docked. Therefore special attention with respect to possible deformations should be made during dry-docking taking into account the period until the next dry-docking. When deformation of the shell plating is found, the area should also be inspected internally since even a small deformation may indicate serious damage to the internal structure.

3.3 Fractures

3.3.1 Fractures in the shell plating in way of ballast tanks may be detected above the water line and below the water line during dry-docking in a wet area in contrast to otherwise dry shell plating.

4 General comments on repair

4.1 Material wastage

4.1.1 In general, where part of the hold framing and/or associated end brackets has corroded to the permissible minimum thickness at the time of inspection (judged to have insufficient corrosion margin until next major survey), then the normal practice is to crop and renew the area affected. If the remaining section of the frames/brackets marginally remain within the allowable limit, surveyors should request that affected frames and associated end brackets be renewed. Alignment of end brackets with the structure inside the double bottom or the opposite side of tween deck is to be ensured. It is recommended that repaired areas be coated.

4.2 Deformations

4.2.1 The structure should be restored to its original shape and position either by fairing in

place or by cropping and renewing the affected structure, based on the depth and extent of the deformations.

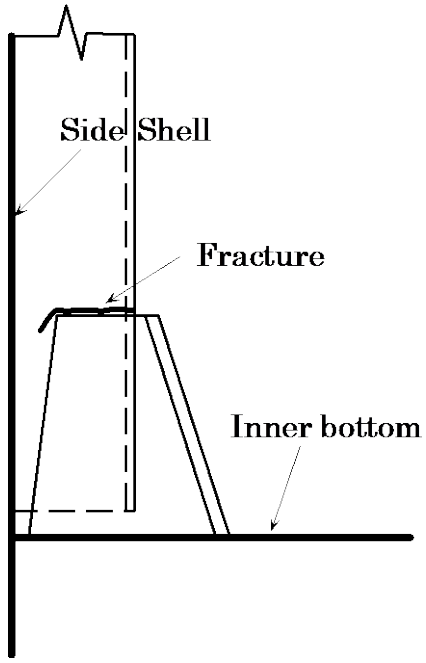
4.3 Fractures

4.3.1 All fractures in side shell frames or their end brackets are to be repaired.

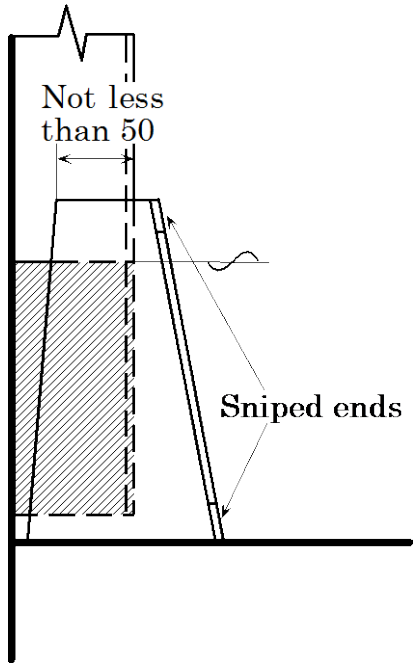
4.3.2 Fractured parts of supporting brackets and continuation/extension brackets at collision bulkhead, deep tank bulkheads, and engine room bulkhead are to be part renewed. Modification of shape and possible extension of the brackets should be considered. Affected shell plating in way of the damaged brackets should be cropped and renewed.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure**	**1**
Detail of damage	Fracture in side shell frame at lower bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

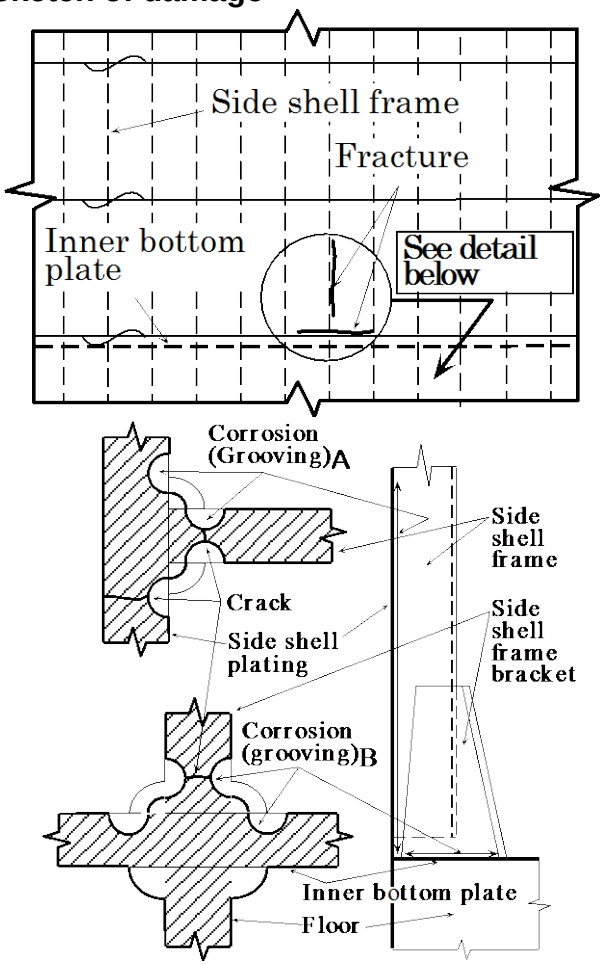
1. This type of damage is caused due to stress concentration.

Notes on repairs

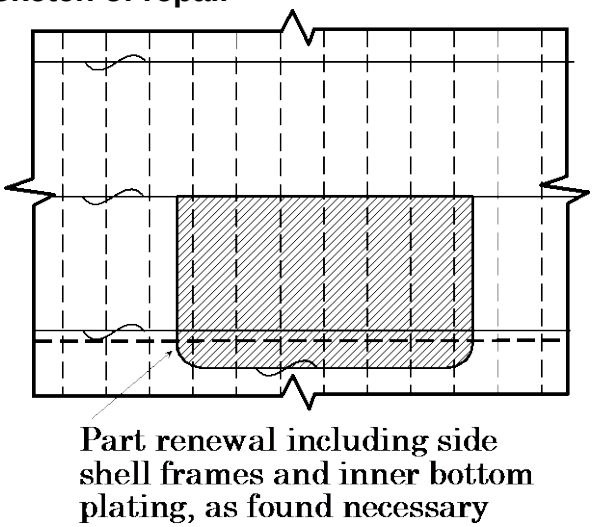
1. For small fractures, e. g. hairline fractures, the fracture can be veed-out, welded up, ground, examined by NDT for fractures, and rewelded. For larger/significant fractures consideration is
2. to be given to cropping and partly renewing/ renewing the frame brackets. If renewing the brackets, end of frames can be sniped to soften them.
   If felt prudent, soft toes are to be incorporated
3. at the boundaries of the bracket to the inner bottom plating.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure**	**2**
Detail of damage	Fractures in side shell frame/lower bracket and side shell plating near tank top	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

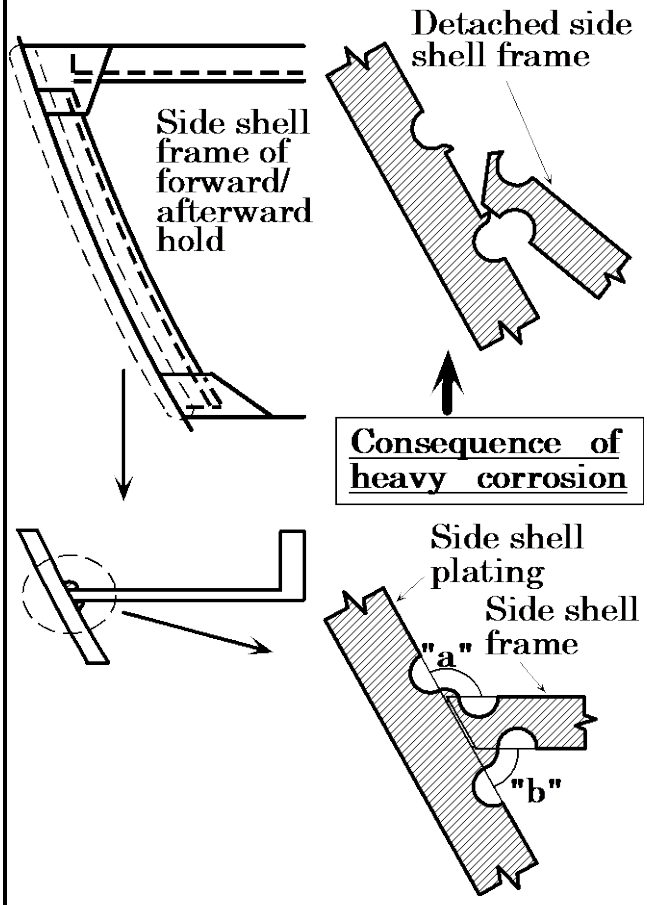
1. Fracture in side shell plating along side shell frame: Heavy corrosion (grooving) along side shell frame (See A).
2. Fracture in side shell plating along tank top: Heavy corrosion (grooving) along tank top (See B) resulting detachment of side shell frame bracket from inner bottom plating.

Notes on repairs

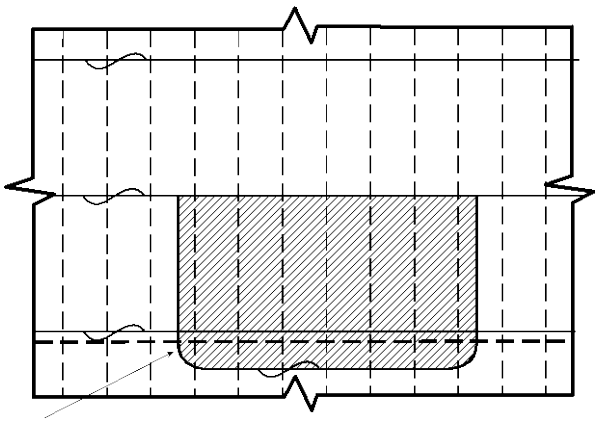
1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure**	**3**
Detail of damage	Adverse effect of corrosion on the frame of forward/afterward hold	

Sketch of damage



Sketch of repair



1. Part renewal including side shell frames and inner bottom plating, as found necessary
2. Deep penetration welding at the connections of side shell frames to side shell plating

Notes on possible cause of damage

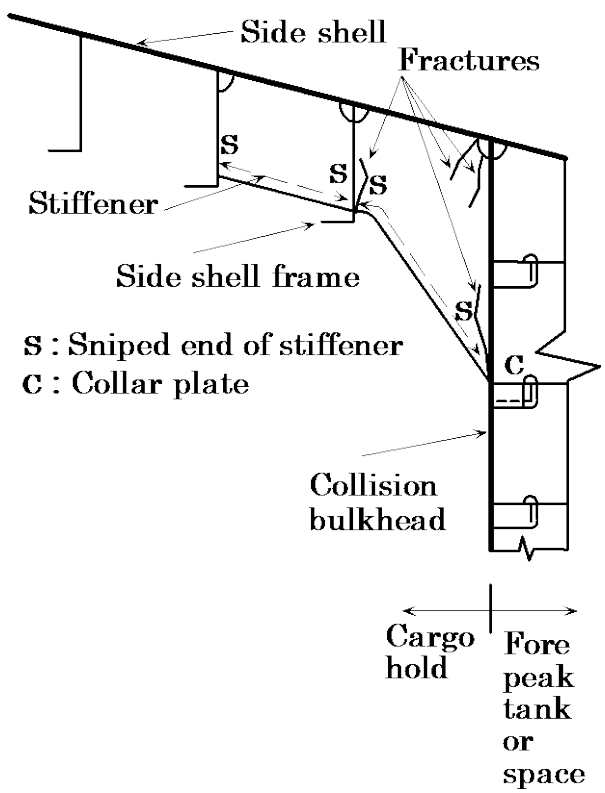
1. Heavy corrosion (grooving) of side shell frame along side shell plating and difference of throat thickness "**a**" from "**b**".
   (Since original throat thickness of "**a**" is usually smaller than that of "**b**", if same welding procedure is applied, the same corrosion has a more severe effect on "**a**", and may cause collapse and/or detachment of side shell frame.)

Notes on repairs

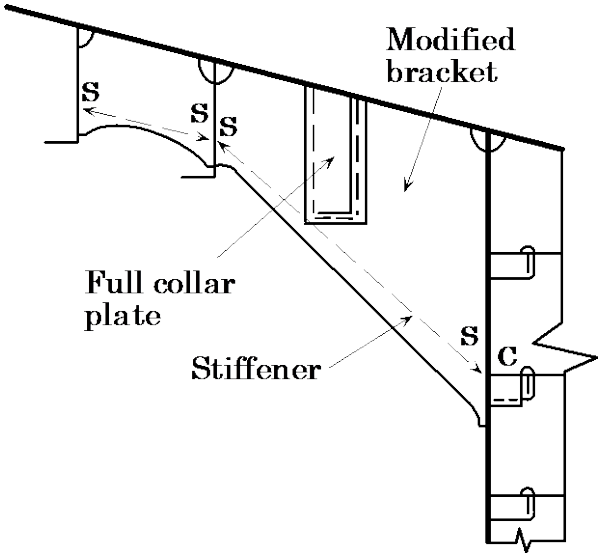
1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure**	**4**
Detail of damage	Fractures at the supporting brackets in way of collision bulkhead (with no side shell panting stringers fitted in hold)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

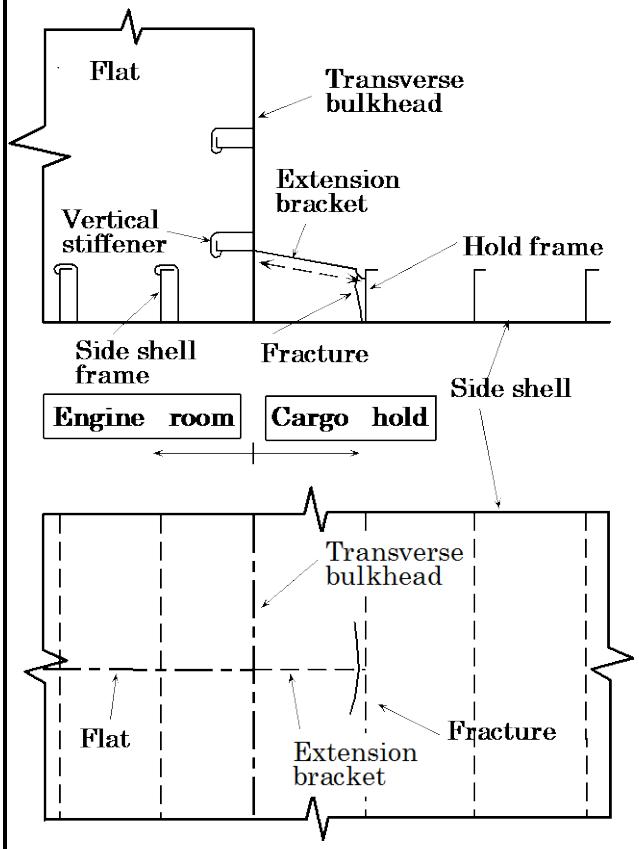
1. Insufficient bracket size resulting in high stress due to load cantilevered from side frame.
2. Stress concentration at toe of bracket and misalignment between bracket and stringer in fore peak tank or space.

Notes on repairs

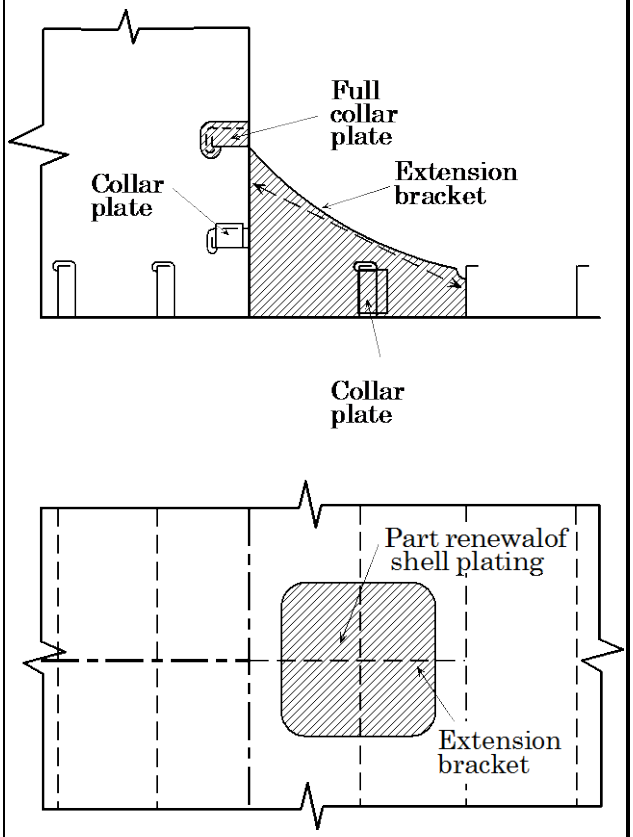
1. The extended bracket arm connection to the collision bulkhead is to have a soft toe, and any cut-outs for stiffeners in the fore peak tank or space are to be collared when situated in the vicinity of the bracket toe. When fractures have extended into the side
2. shell or bulkhead plating, the plating is to be cropped and part renewed.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 2	Side structure	5
Detail of damage	Fractures in way of continuation /extension brackets in aftermost hold at the engine room bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

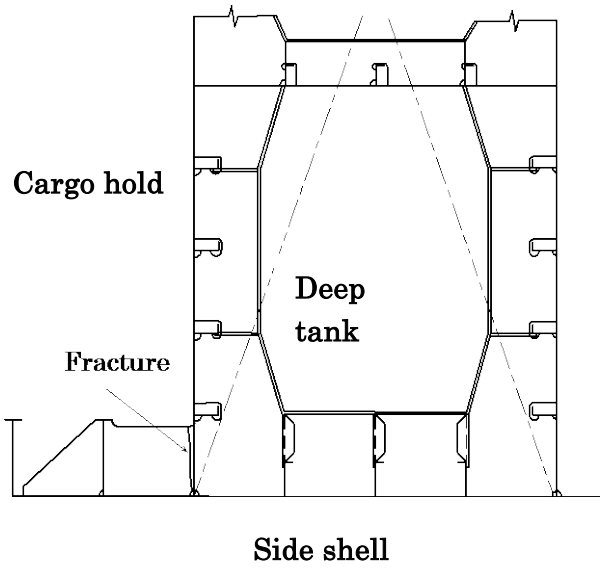
1. Damage caused by stress concentration leading to fatigue fracture on side shell. This will be exacerbated because of the greater flexibility of the hold structure in relation to the engine room structure.

Notes on repairs

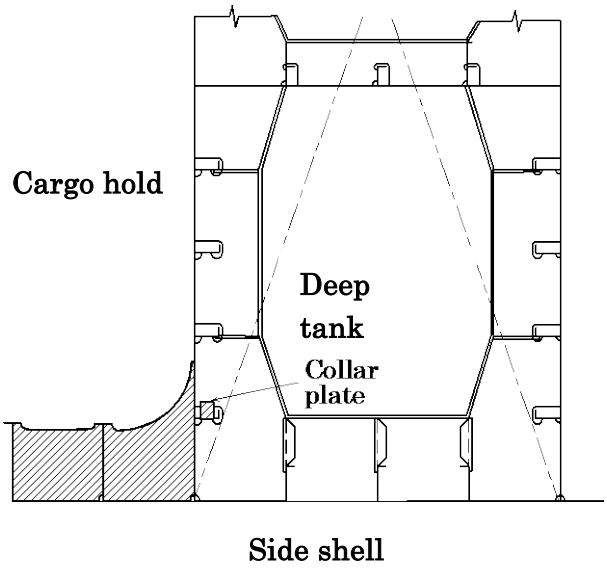
1. The fractured shell plating is to be cropped and part renewed as necessary.
2. Extension bracket is to be modified and collar plates to cut-outs in engine room flat are to be installed.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure**	**6**
Detail of damage	Fractures in way of continuation/extension brackets at the end of deep tank	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage caused by stress concentration leading to fatigue fracture on side shell. This will be exacerbated because of the greater flexibility of the ordinary hold structure in relation to the deep tank structure.

Notes on repairs

1. The fractured shell plate is to be cropped and part renewed as necessary.
2. Brackets should be modified.

Area 3 Transverse bulkhead structure

Contents

1 General

2 What to look for
- **2.1 Material wastage**
- **2.2 Deformations**
- **2.3 Fractures**

3 General comments on repair
- **3.1 Material wastage**
- **3.2 Deformations**
- **3.3 Fractures**

Figures and/or Photographs - Area 3	
No.	**Title**
Figure 1	Transverse bulkhead - Potential problem areas

Examples of structural detail failures and repairs - Area 3	
Example No.	**Title**
1	Corrosion along inner bottom or tween deck plating
2	Shear buckling in transverse bulkhead

1 General

1.1 Watertight transverse bulkheads are usually plane bulkheads stiffened vertically.

1.2 The opportunity is taken to emphasize that for ordinary transverse watertight bulkheads, in addition to withstanding water pressure in an emergency situation, i.e. flooding, the bulkhead structures constitute main structural strength elements in the structural design of the intact ship. Ensuring that acceptable strength is maintained for these structures is therefore of major importance.

The structure may sometimes appear to be in good condition when it is in fact excessively corroded. In view of this, appropriate access arrangements as indicated in **Chapter 4 Survey planning, preparation and execution** of the Guidelines, should be provided to enable a proper close-up inspection and thickness measurement (See **Figure 1**).

1.3 Deformation of the plating may lead to the failure and collapse of the bulkhead under water pressure in an emergency situation.

1.4 It is important to realize that in the event of one hold flooding, the transverse watertight bulkheads should prevent progressive flooding and possible consequent sinking.

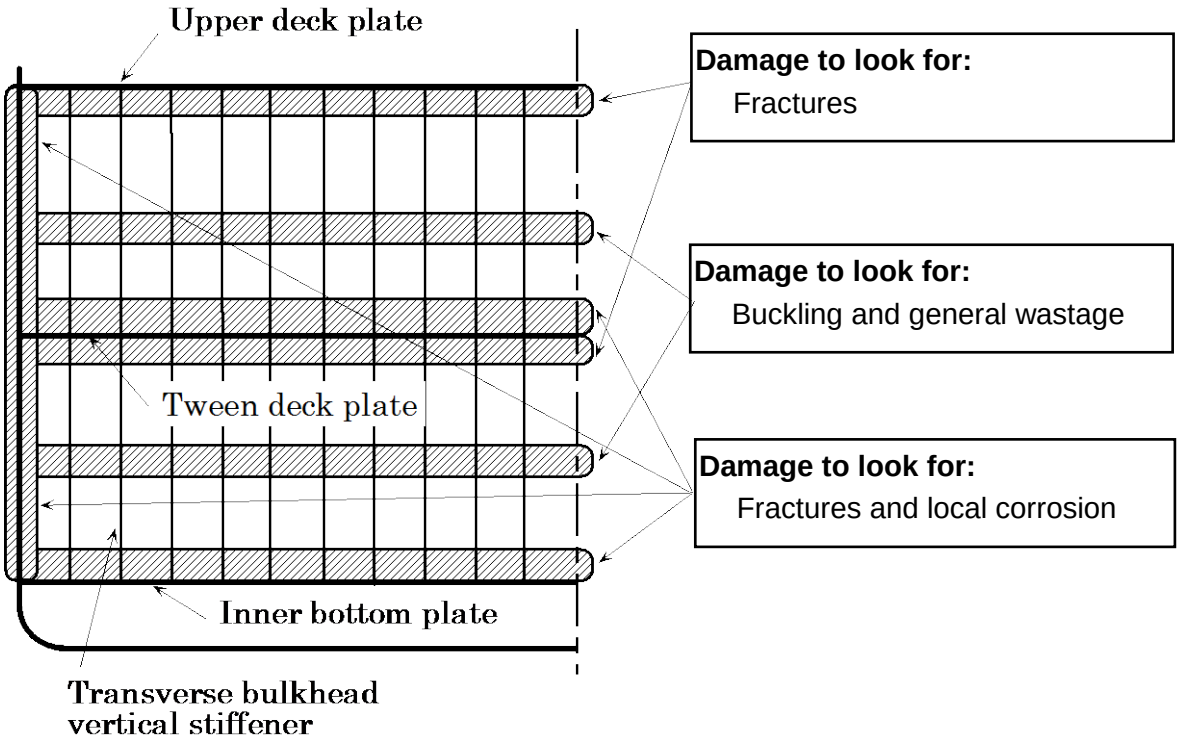


Figure 1 Transverse bulkhead - potential problem areas

2 What to look for

2.1 Material wastage

2.1.1 Excessive corrosion, in particular at the bottom of the bulkheads. This is created by the corrosive effect of cargo and environment, in particular when the structure is not coated.

2.1.2 If coatings have broken down and there is evidence of corrosion, it is recommended that random thickness measurements be taken to establish the level of diminution.

2.1.3 Where the terms and requirements of the periodical survey dictate thickness measurement, or when the Surveyor deems necessary, it is important that the extent of the gauging be sufficient to determine the general condition of the structure.

2.2 Deformations

2.2.1 Deformation due to mechanical damage is often found in bulkhead structure.

2.2.2 When the bulkhead has sustained serious uniform corrosion, the bulkhead may suffer shear buckling. Evidence of buckling may be indicated by the peeling of paint or rust. Where, however, deformation resulting from bending or shear buckling has occurred on a bulkhead with a small diminution in thickness, this could be due to poor design or overloading and this aspect should be investigated before proceeding with repairs.

2.3 Fractures

2.3.1 Fractures occur at the boundaries of bulkheads, particularly in way of tank top and side shell.

3 General comments on repair

3.1 Material wastage

3.1.1 When the scantlings of transverse watertight bulkheads have reached the diminution levels permitted by BCS, the wasted plating and stiffeners are to be cropped and renewed.

3.3 Deformations

3.3.1 If the deformation is local and of a limited extent, it could generally be faired out. Deformed plating in association with a generalized reduction in thickness should be partly or completely renewed.

3.3.2 Buckling of the bulkhead plating can also occur in way of the side shell resulting from contact damage and this is usually quite obvious. In such cases the damaged area is to be cropped and partly renewed. If the deformation is extensive, replacement of the plating, partly or completely, may be necessary. If the deformation is not in association with generalized reduction in thickness or due to excessive loading, additional strengthening should be considered.

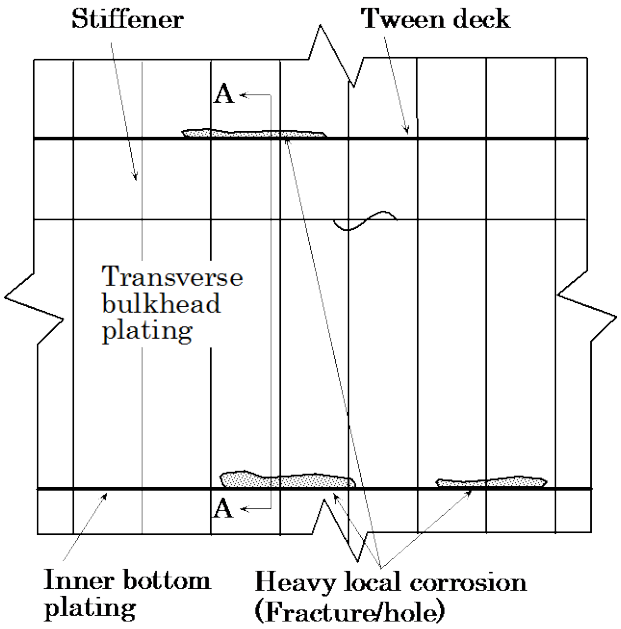
3.2 Fractures

3.2.1 Fractures that occur at the boundary weld connections as a result of latent weld defects should be veed-out, appropriately prepared and re-welded preferably using low hydrogen electrodes or equivalent.

3.2.2 For fractures other than described in **3.2.1** re-welding may not be a permanent solution and an attempt should be made to improve the design and construction in order to obviate a recurrence.

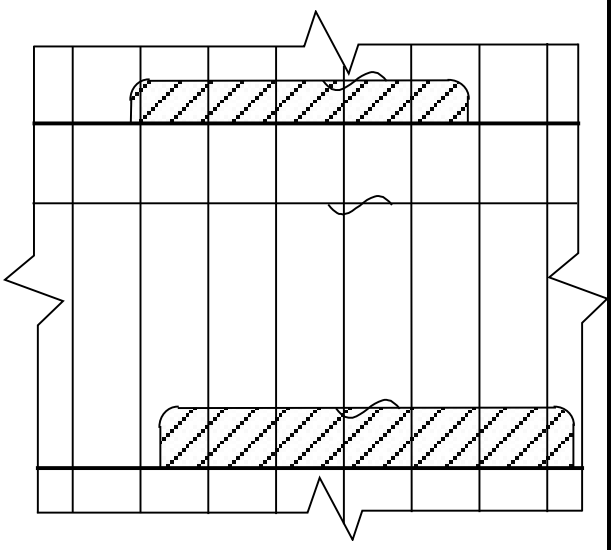
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Transverse bulkhead structure**	**1**
Detail of damage	Corrosion along inner bottom or tween deck plating	

Sketch of damage



Note: Regarding **"View A-A"**, refer to **Example 2** of **Area 2** of this part

Sketch of repair



Notes on possible cause of damage

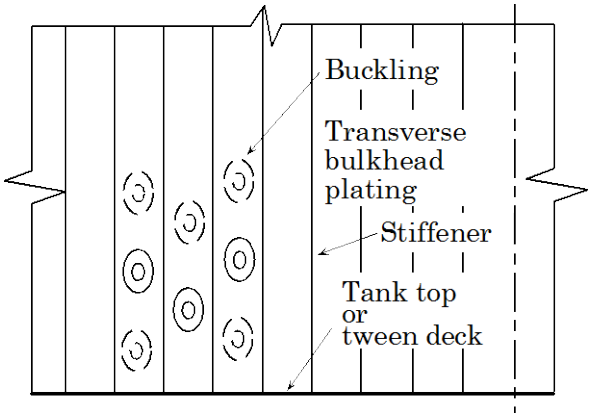
1. Heavy corrosion including grooving along inner bottom plating or tween deck due to poor drainage.

Notes on repairs

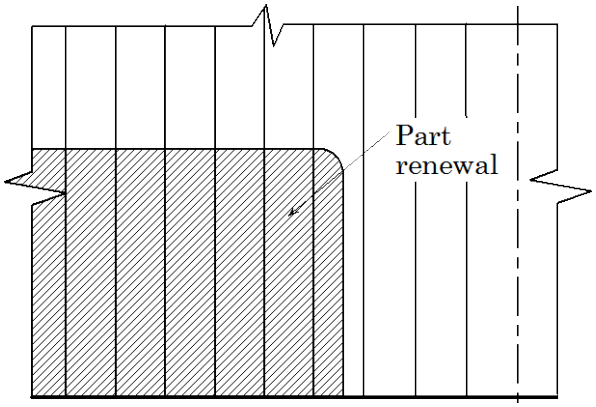
1. The extent of the renewal should be determined carefully. If the renewal plate (original thickness) is welded to thin plate (corroded plate), it may cause stress concentration and cause fracture.
2. Protective coating should be applied.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Transverse bulkhead structure**	**2**
Detail of damage	Shear buckling in transverse bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy general corrosion.

Notes on repairs

1. The extent of the renewal should be determined carefully. If the renewal plating (original thickness) is welded to thin plating (corroded plating), it may cause stress concentration and fracture.
2. Protective coating should be applied.

Area 4 Tween deck structure

Contents

1 General

2 What to look for
- **2.1 Material wastage**
- **2.2 Deformations**
- **2.3 Fractures**

3 General comments on repair
- **3.1 Material wastage**
- **3.2 Deformations**
- **3.3 Fractures**

Examples of structural detail failures and repairs - Area 4	
Example No.	**Title**
1	Sagging of deck panel/buckling of cantilever beam

1 General

1.1 A main design principle of the tween deck is to provide easy access to cargo stowed on and underneath the deck. Therefore obstructions such as hatch coamings and deep under deck supporting girders, are usually avoided. The tween deck's main structure consists of cantilever beams supported only by the ship's side structure and cantilever girders supported only by the transverse bulkhead structure (cantilever girders). In some cases the structure may be additionally supported by pillars.

1.2 The design of the tween deck makes it particularly vulnerable to excess loads of cargo and cargo inertia forces in extreme weather conditions.

2 What to look for

2.1 Material wastage

2.1.1 Heavy wastage along the boundaries at ship's sides and at transverse bulkheads may occur as a result of seawater accumulated from wet cargo due to poor drainage. Such damages are related to those suffered at the lower end of side structures and transverse bulkhead structures (See **Area 2**, **Example 2** and **Area 3**, **Example 1**).

2.2 Deformations

2.2.1 Deformed structure may be observed near hatch openings where cargo and/ or hatch cover pontoons may have bumped into the structure during lift on or lift off operations.

2.2.2 Sagging of plate panels may be caused by lateral overloading as a consequence of excessive cargo loads, improper distribution /support of cargo loads, excessive inertia forces imposed by the cargo in extreme weather conditions, or a combination of these causes. It is essential that an under-deck inspection also be carried out to assess the extent of such damage (See **Example 1**). If the tween deck is supported by pillars, excessive loads could be transmitted to the double bottom structure (inner bottom plating, floors, girders) which could be damaged. Therefore inspection of double bottom tanks may be necessary (See **Area 5**, **Example 2**).

2.3 Fractures

2.3.1 Fatigue fractures are not a common problem on tween decks due to the generally low level of dynamic forces. Fractures may, however, occur in combination with corrosion and deformations described above.

3 General comments on repair

3.1 Material wastage

3.1.1 Where parts of the tween deck plating have corroded to the permissible minimum thickness the normal practice is to crop and renew the area affected. Surveyors should request that adjacent areas that remain marginally within the allowable limit should also be renewed. It is recommended that repaired areas be coated.

3.2 Deformations

3.2.1 For deformations caused by abusive handling or obvious overloading, the damaged structure should be cropped and renewed to original scantlings.

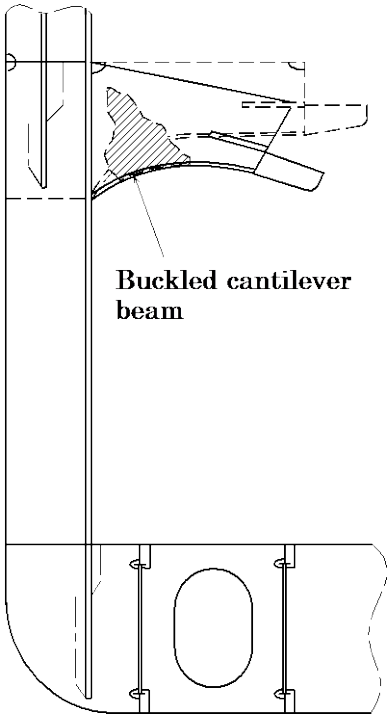
3.2.2 If the cause of the deformations is not clear and design weakness is suspected, an appropriate reinforcement is to be considered in addition to cropping and renewal of the damaged part.

3.3 Fractures

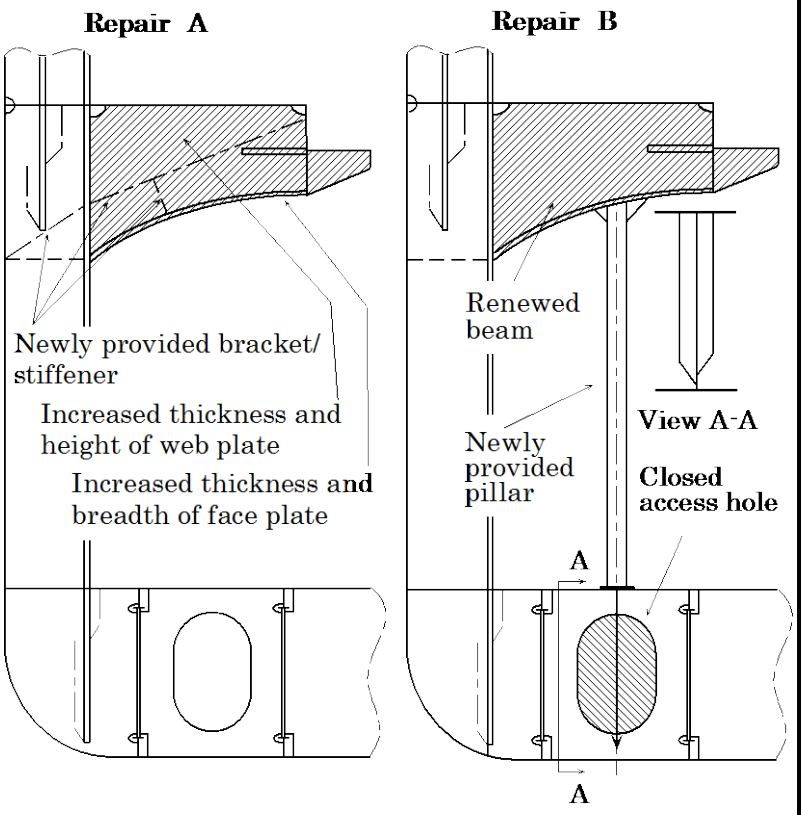
3.3.1 The proposed repair for corrosion and deformations described above also apply when associated fractures occur.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Tween deck structure**	**1**
Detail of damage	Sagging of deck panel/buckling of cantilever beam	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Poor design, overloading and/or excessive inertia force caused in heavy weather.

Notes on repairs

1. The affected structures are to be cropped and renewed.
2. **Repair A**:
   Reinforcement should be considered by increased scantlings of beam and/or additional stiffeners.
3. **Repair B**:
   Pillars may be provided for reinforcement subject to the approval of the owner. In such a case, reinforcement of the floor under the pillar should be considered. (In the above example, access hole was closed.)

Area 5 Double bottom structure

Contents

1 General

2 What to look for - Tank top inspection
- **2.1 Material wastage**
- **2.2 Deformations**
- **2.3 Fractures**

3 What to look for - Double bottom tank inspection
- **3.1 Material wastage**
- **3.2 Deformations**
- **3.3 Fractures**

4 What to look for - External bottom inspection
- **4.1 Material wastage**
- **4.2 Deformations**
- **4.3 Fractures**

5 General comments on repair
- **5.1 Material wastage**
- **5.2 Deformations**
- **5.3 Fractures**

Figures and/or Photographs - Area 5	
No.	**Title**
Photograph 1	Heavy corrosion affecting inner bottom plating
Photograph 2	Damaged inner bottom plating
Photograph 3	Repairs of damaged inner bottom plating
Photograph 4	Grooving corrosion of welding of bottom plating
Photograph 5	Section of the grooving shown in Photograph 4

Examples of structural detail failures and repairs - Area 5	
Example No.	**Title**
1	Fractures in inner bottom plating around container bottom pocket
2	Dented inner bottom plating and buckled/fractured floor under pillar
3-a	Fractures at the connection of bottom/inner bottom longitudinal to floor stiffener
3-b	Fractures at the connection of bottom/inner bottom longitudinal to floor stiffener
4	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member
5	Fractures in bottom shell plating/inner bottom plating at the corner of drain hole/air hole in longitudinal

Examples of structural detail failures and repairs - Area 5	
Example No.	**Title**
6	Fracture in bottom shell plating along side girder and/or bottom longitudinal
7	Fracture in bottom plating below suction head
8	Fracture in shell plating at the termination of bilge keel
9	Corrosion in bottom plating below sounding pipe

1 General

1.1 Double bottom structure is subjected to longitudinal hull girder bending, caused by cargo distribution and wave action. It is also subjected to longitudinal and transverse local bending due to the effects of cargo load from the inside in association with the counteracting forces from the outside. The double bottom structure is also subjected to the effects of cargo loading and unloading. The double bottom structure forward may also be subjected to increased dynamic forces due to slamming.

2 What to look for - Tank top inspection

2.1 Material wastage

2.1.1 The general condition with regard to corrosion of the tank top structure may be observed by visual inspection. The level of wastage of tank top plating may have to be established by means of thickness measurement. Special attention should be given to the intersection of the tank top with the side shell and transverse bulkheads where water may have accumulated and consequently accelerated the rate of corrosion.

2.1.2 When the tank top plating has been covered with dunnage or ceiling the plating may have suffered heavy corrosion, due to high humidity, and lack of proper maintenance (See **Photograph 1**).

2.1.3 The bilge wells should be cleaned and inspected closely since heavy pitting corrosion may have occurred due to accumulated water in the wells. Special attention should be paid to the plating in way of the bilge suction and sounding pipes.

2.1.4 Special attention should also be paid to areas where pipes penetrate the tank top.

Photograph 1 Heavy corrosion affecting inner bottom plating

Photograph 2 Damaged inner bottom plating

Photograph 3 Repairs of damaged inner bottom plating

2.2 Deformations

2.2.1 Buckling of the tank top plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses.

2.2.2 Deformed structures may be observed in areas of the tank top due to overloading of cargo, impact of cargo during loading/unloading operations, or the use of mechanical unloading equipment.

2.2.3 Deformations may also occur at the heel of pillars fitted to support the tween deck structure (See **Example 2**).

2.2.4 Whenever deformations are observed on the tank top, further inspection in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coating, if fitted, within the double bottom, which in turn may lead to accelerated corrosion rate in these unprotected areas.

2.3 Fractures

2.3.1 Fractures will normally be found by close-up inspection paying particular attention to the boundary connections of the tank top and to penetrations through the tank top (See **Example 1**).

2.3.2 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of the double bottom tanks.

3 What to look for - Double bottom tank inspection

3.1 Material wastage

3.1.1 The level of wastage of double bottom internal structure (longitudinals, frames, floors, girders, etc.) may have to be established by means of thickness measurements. The combined effects of the marine environment, the carriage of seawater ballast, cyclical loading etc. may result in high corrosion rates.

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer heavy corrosion. Upper part of the structure of double bottom tanks usually has more severe corrosion than the lower part.

3.1.3 Corrosion in the structure of ballast tanks near heated fuel tanks may be accelerated by the high temperature due to heated fuel oil. The rate of corrosion depends on several factors such as:

- Temperature and heat input to the ballast tank.
- Condition of original coating and its maintenance. (It is preferable for applying the protective coating of ballast tank at the building of the ship, and for subsequent maintenance, that the stiffeners on the boundaries of the fuel tank be fitted within the fuel tank instead of the ballast tank).
- Ballasting frequency and operations.
- Age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.1.4 Shell plating localized wear is caused by erosion and cavitation of the fluid flowing through the suction head. In addition, the suction head will be positioned in the lowest part of the tank and water/mud will cover the area even when the tank is empty. The condition of the shell plating may be established by feeling by hand beneath the suction head. When in doubt, the lower part of the suction head should be removed and thickness measurements taken. If the vessel is docked, the thickness can be measured from below. If the distance between the suction head and the underlying shell plating is too small to permit access, the suction head should be dismantled. The shell plating below the sounding pipe should also be carefully examined. When a striking plate has not been fitted or is worn out, heavy corrosion can be caused by the striking of the weight of the sounding tape (See **Example 2** in **Part 3**).

3.2 Deformations

3.2.1 Deformations may occur due to the overloading of the cargo, dynamic forces due to slamming in the forward part of the vessel, or from the impact of cargo loading/unloading. Special attention should be paid to those areas of deformation identified during the tank top or external bottom inspections. Deformations in the structure not only reduce the strength of the structure but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3.2 In general, the termination of the longitudinal structural members at the collision bulkhead and engine room forward bulkhead is prone to fractures. In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

3.3 Fractures

3.3.1 Fractures may be caused by the cyclic deflection of the double bottom induced by repeated loading from the sea or due to poor “through-thickness” properties of the plating. Scallops in the bottom girders can create areas of stress concentrations which further increase the risk of fractures.

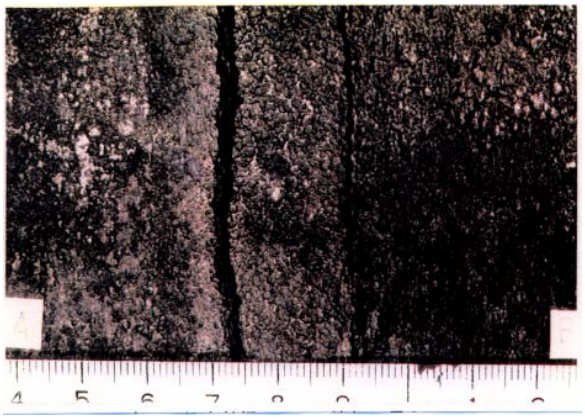
4 What to look for - External bottom inspection

4.1 Material wastage

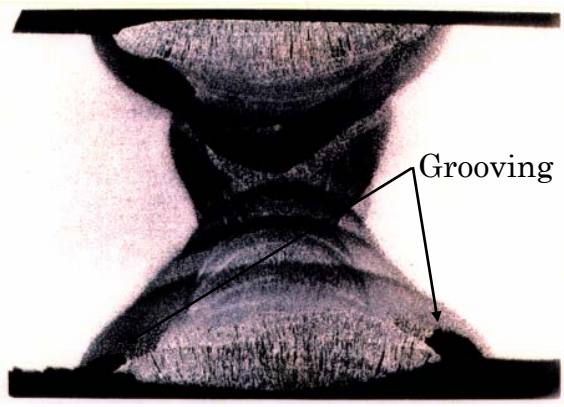
4.1.1 Hull structure below the water line can usually be inspected only when the ship is dry-docked. Therefore, the structure should be inspected carefully, taking into account the period until the next scheduled dry-docking. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See **Photographs 4** and **5)**. This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or “docking” plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating.



Photograph 4
Grooving corrosion of welding of bottom plating



Photograph 5
Section of the grooving shown in Photograph 4

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations may also be attributed to slamming due to wave action in the forward part of the vessel, or contact with an underwater object. When deformation of the shell plating is found, the area should be inspected internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be inspected when it has dried since fractures in shell plating may be easily detected if water comes out of the fracture in clear contrast to the dry shell plating. Therefore if the ship has been inspected while wet, it is recommended that the ship be inspected again when dry.

4.3.2 Fractures in butt welds and fillet welds (particularly at the wrap around at scallops and ends of bilge keels) are sometimes observed and may propagate into the bottom plating. The cause of the fractures in butt welds is usually a weld defect or

grooving. If the bilge keels are divided at the block joints of hull, all ends of the bilge keels are to be inspected.

5 General comments on repair

5.1 Material wastage

5.1.1 In general, where the tank top, double bottom internal structure, and bottom shell plating have wasted to the allowable level, the normal practice is to crop and renew the affected area. Where possible, plate renewals should be for the full width of the plate but in no case should they be less than the minimum set in paragraph 6.2 of Part B of BCS- G 47, to avoid build up of residual stresses due to welding. Repair work in double bottom will require careful planning, accessibility, and gas freeing of fuel oil tanks. Doubler plates are not to be used for compensation of wasted plates.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit for replacement (See **Example 7**). When scattered deep pitting is found it may be repaired by welding.

5.2 Deformations

5.2.1 Extensive deformation should be corrected by replacement of the tank top and bottom shell plating, and the deformed portion of affected girders or floors. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, TLshould be contacted.

5.3 Fractures

5.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

5.3.2 For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.

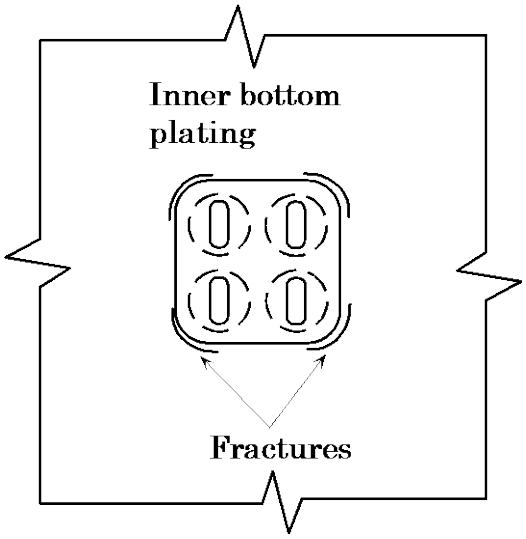
5.3.3 For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

5.3.4 Damaged bilge keels must be promptly repaired if there is distortion or fractures. Since the bilge keel is subjected to the same longitudinal stress level as the bilge plating, propagation of fractures into the shell could result in a serious failure. Fractured butt welds should be repaired using full penetration welds and proper welding procedures.

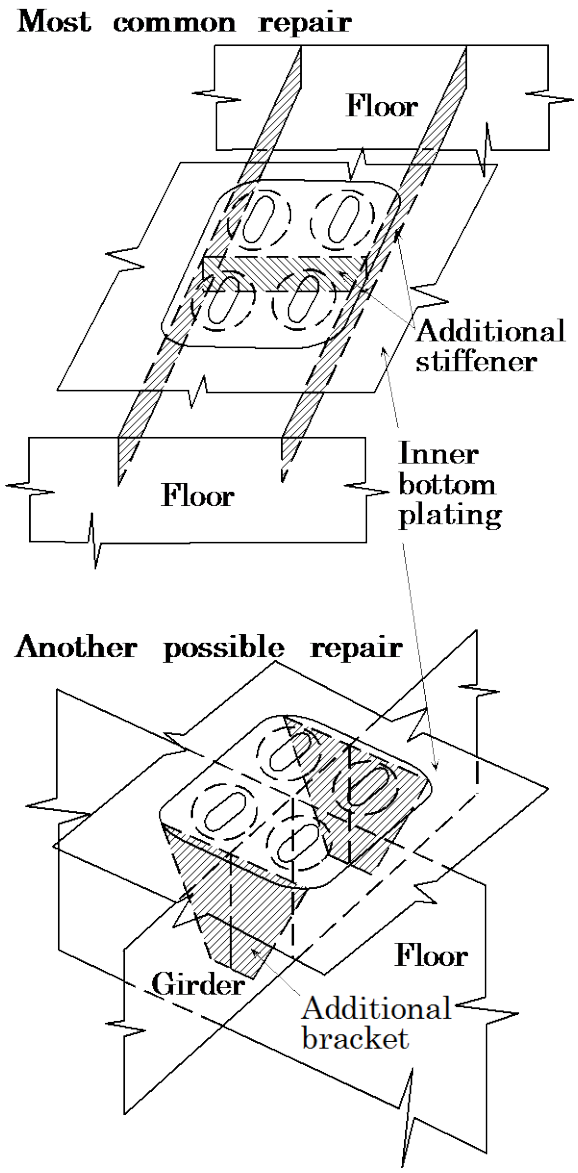
5.3.5 Ends of bilge keels require internal support. This should be taken into account when cropping a damaged part of a bilge keel (See **Example 8**).

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**1**
Detail of damage	Fractures in inner bottom plating around container bottom pocket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

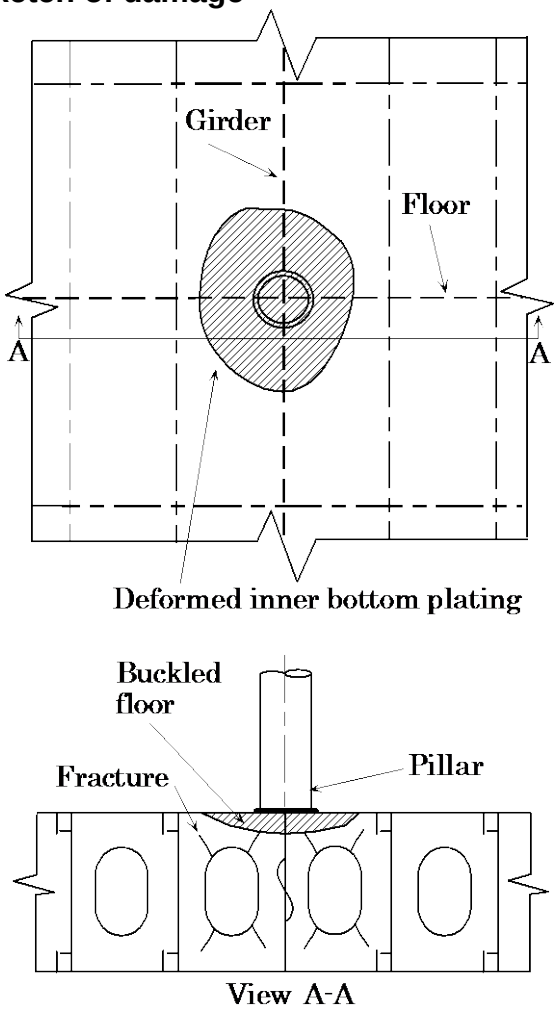
1. Pocket is not supported correctly by floor, longitudinal and/or stiffener.

Notes on repairs

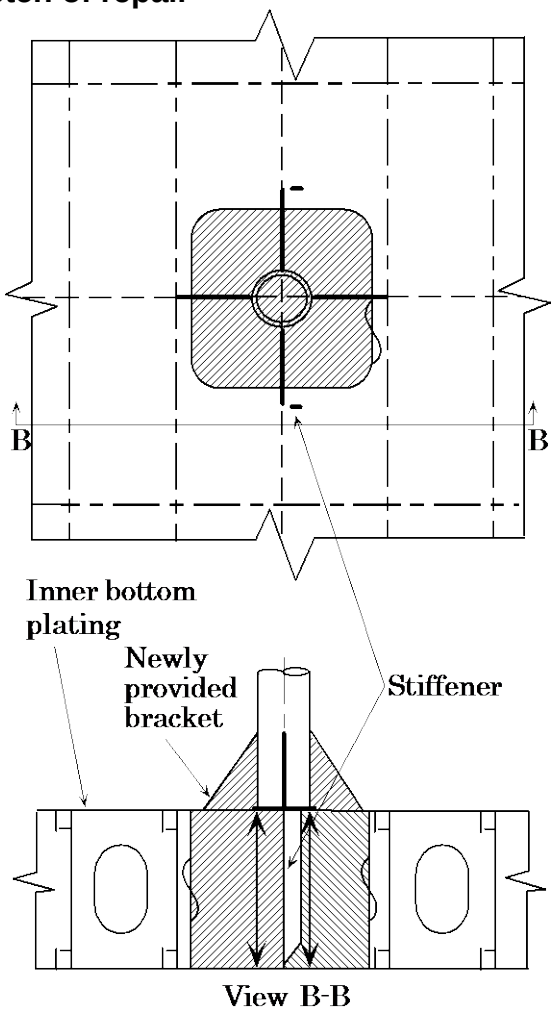
1. Fractured plating should be cropped and part renewed.
2. Adequate reinforcement should be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**2**
Detail of damage	Dented inner bottom plating and buckled/fractured floor under pillar	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

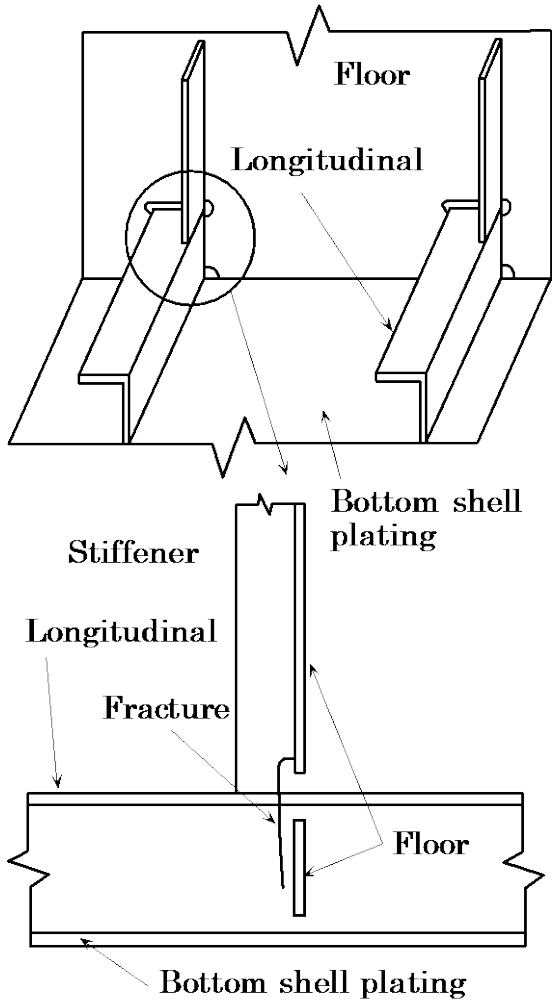
1. Inadequate arrangement and/or reinforcement of access holes.
2. Excessive deck-loading on tween deck.

Notes on repairs

1. Dented inner bottom plating is to be cropped and part renewed.
2. The fractured floor is to be cropped and part renewed.
3. Access holes should be closed by insert plates.
4. Stiffener on floor/girder and/or brackets should be considered. (Fitting of brackets in the hold is subject to the agreement of the owner.)

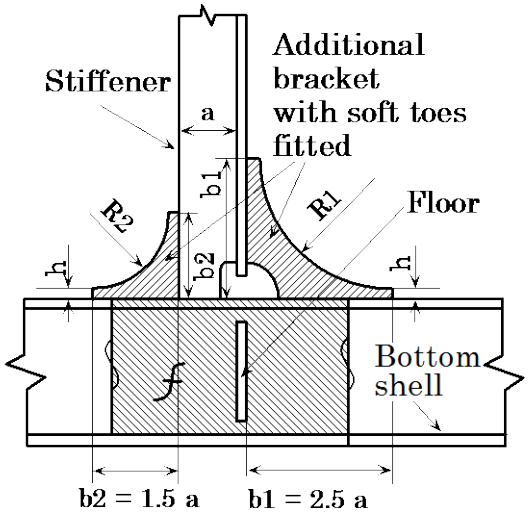
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom structure	3-a
Detail of damage	Fractures at the connection of bottom/inner bottom longitudinal to floor stiffener	

Sketch of damage



Note: same damage may occur at similar connection to inner bottom plating

Sketch of repair



f: Where required, the longitudinal to be cropped and part renewed

1. For a slope at toes max. 1 : 3, R1 = (b1-h) x 1.6 and R2 = (b2-h) x 1.6
2. Soft toe bracket to be welded first to longitudinal
3. Scallop in bracket to be as small as possible, recommended max. 35 mm
4. If toes of brackets are ground smooth, full penetration welds in way to be provided
5. Maximum length to thickness ratio = 50 : 1 for unstiffened bracket edge
6. Toe height, h, to be as small as possible (10- 15 mm)

Notes on possible cause of damage

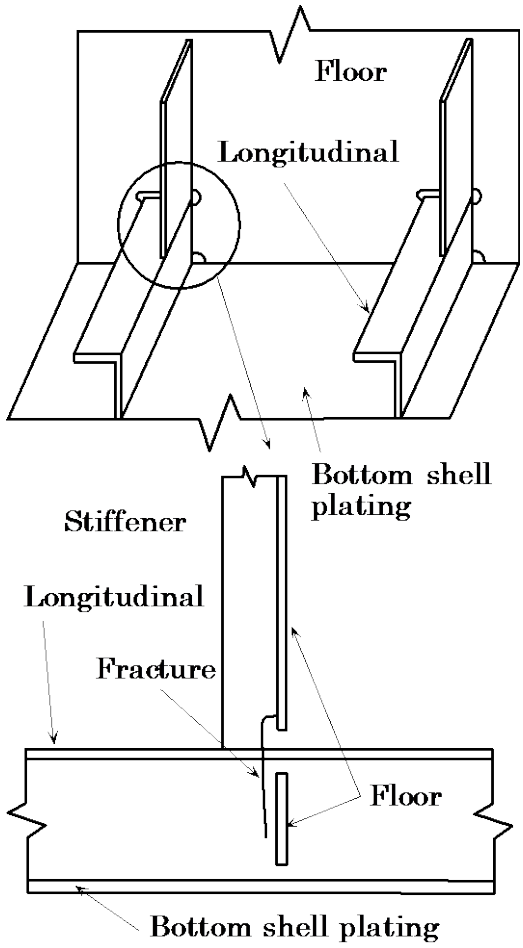
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

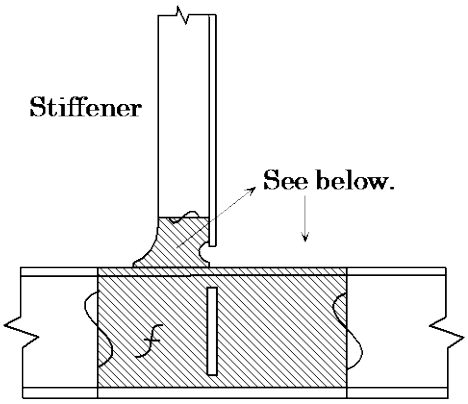
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**3-b**
Detail of damage	Fractures at the connection of bottom/inner bottom longitudinal to floor stiffener	

Sketch of damage

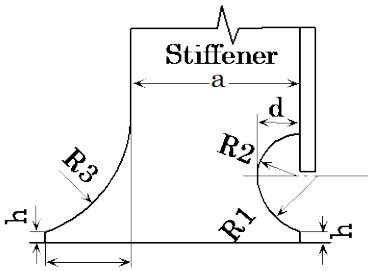


Note: same damage may occur at similar connection to inner bottom plating

Sketch of repair



f: Where required, the longitudinal to be cropped and part renewed



Various cut-out shapes have been developed. The following is one example.

1. Toe height as small as possible (h = 10 - 15 mm)
2. Depth "d" as key hole notch as small a possible, max. 30 mm
3. For a slope at toe max. 1 : 3
4. R1 = 1.5d, R2 = d and R3 = 1.5c

Notes on possible cause of damage

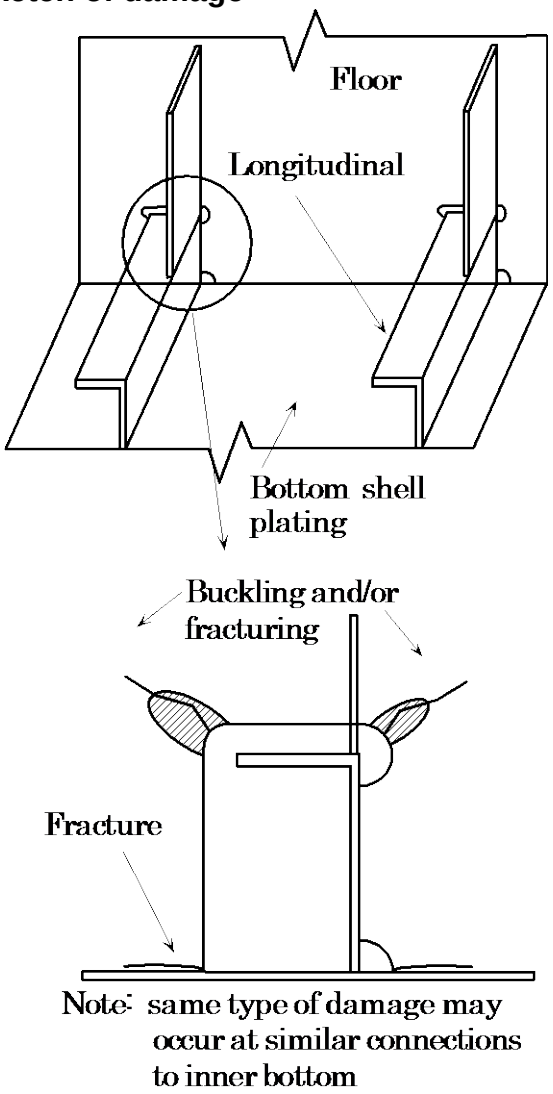
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

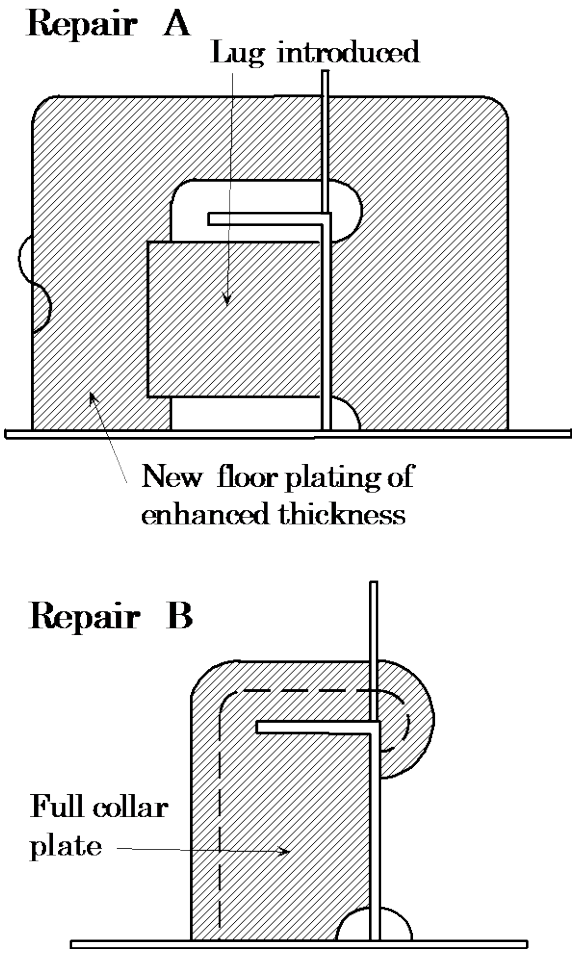
1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**4**
Detail of damage	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

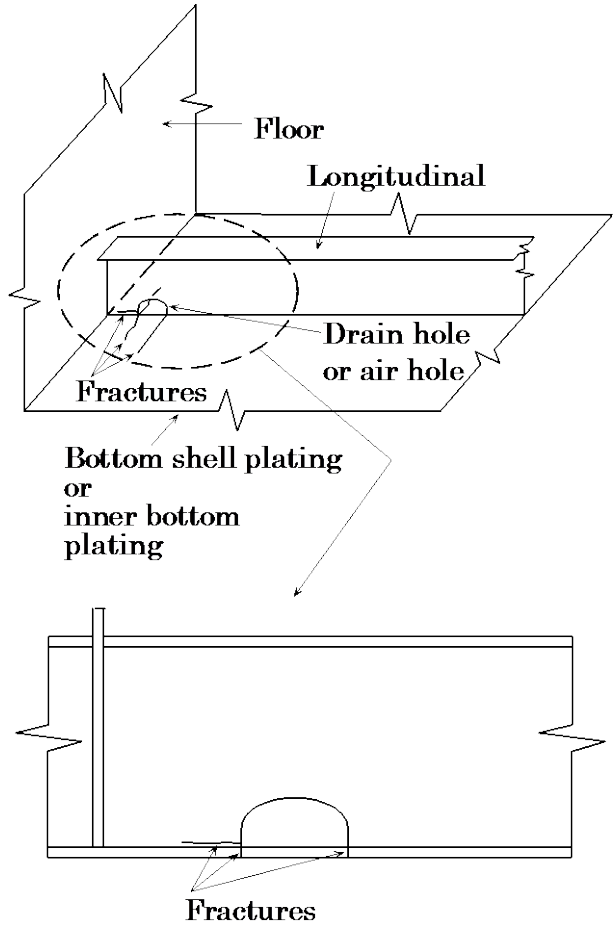
1. Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.

Notes on repairs

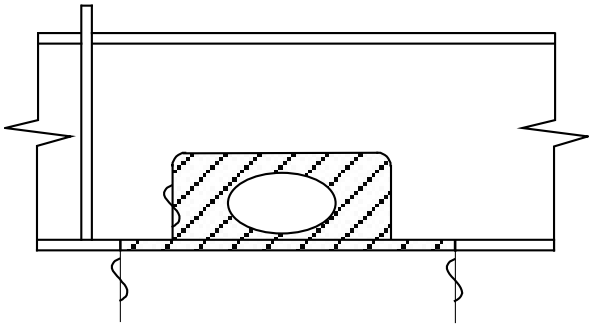
1. If fractures are significant then crop and part renew the floor plating otherwise the fracture can be veed-out and welded provided the plating is not generally corroded.
   Repair B is to be incorporated if the lug
2. proves to be ineffective.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**5**
Detail of damage	Fractures in bottom shell plating/inner bottom plating at the corner drain hole/air hole in longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

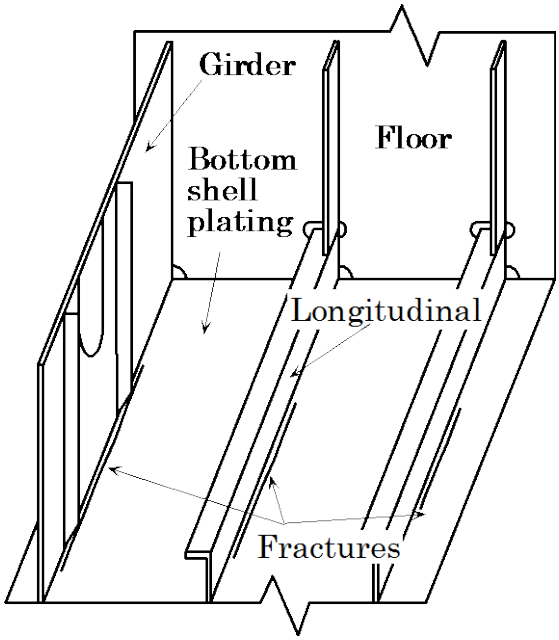
1. Stress concentration and/or corrosion due to stress concentration at the corner of drain hole/air hole.

Notes on repairs

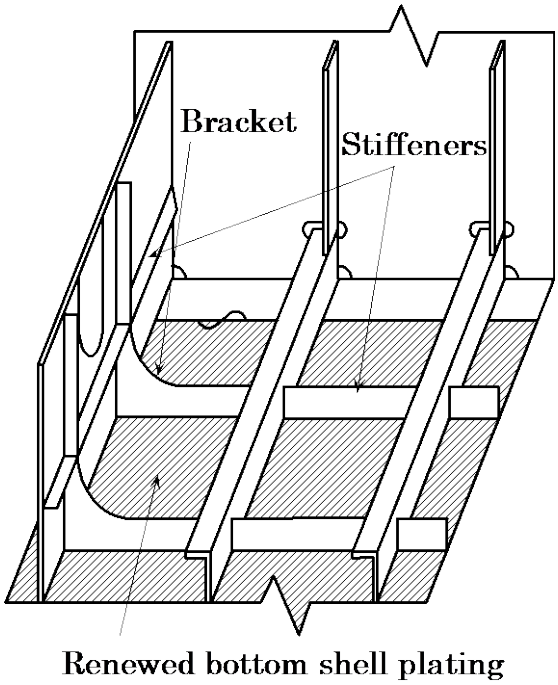
1. Fractured plating should be cropped and part renewed.
2. If fatigue life is to be improved, change of drain hole/air hole shape is to be considered.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom structure	6
Detail of damage	Fracture in bottom shell plating along side girder and/or bottom longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

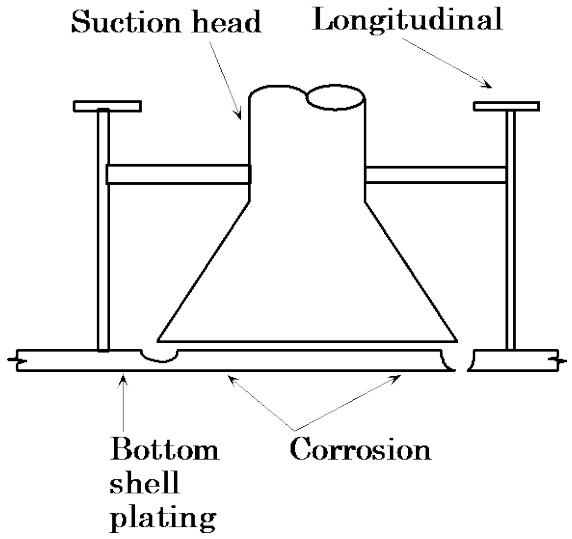
1. Vibration.

Notes on repairs

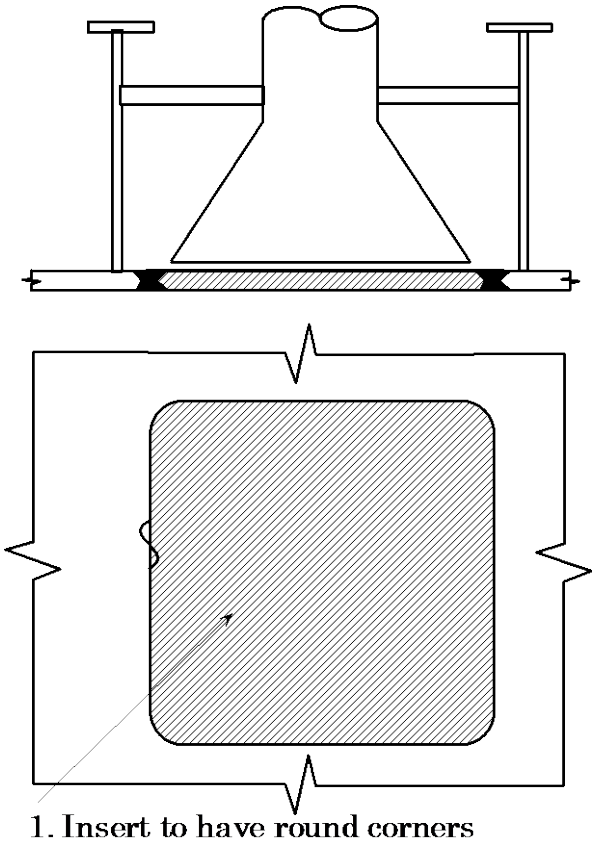
1. Fractured bottom shell plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional stiffener/bracket.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**7**
Detail of damage	Corrosion in bottom plating below suction head	

Sketch of damage



Sketch of repair



1. Insert to have round corners
2. Non-destructive examination to be applied after welding based on the Society's rules

Notes on possible cause of damage

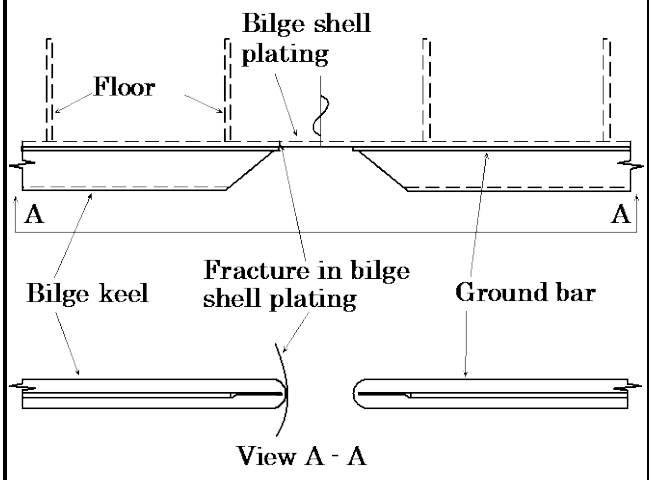
1. High flow rate associated with insufficient corrosion prevention system.
2. Galvanic action between dissimilar metals

Notes on repairs

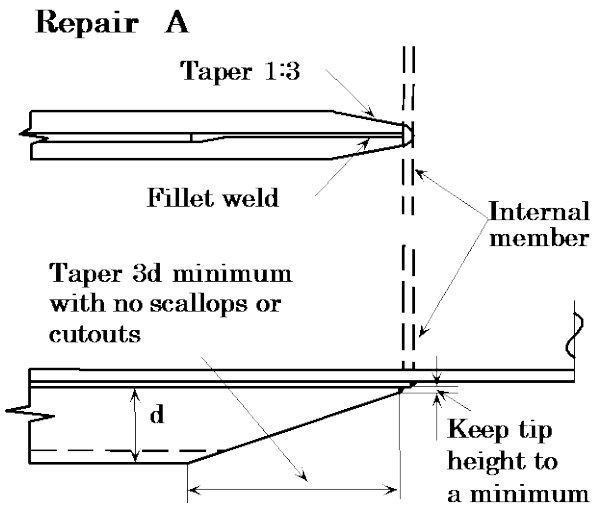
1. Affected plating should be cropped and part renewed. Thicker plate and suitable beveling should be considered.
2. If the corrosion is limited to a small area, i.e. pitting corrosion, repair by welding is acceptable.

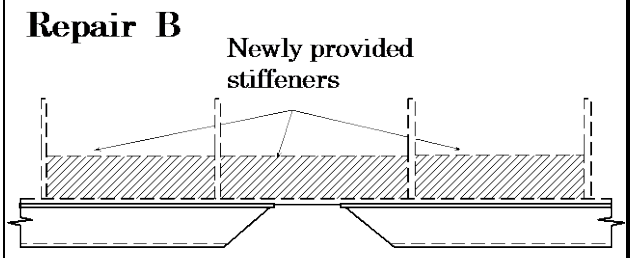
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure**	**8**
Detail of damage	Fracture in shell plating at the termination of bilge keel	

Sketch of damage



Sketch of repair





Notes on possible cause of damage

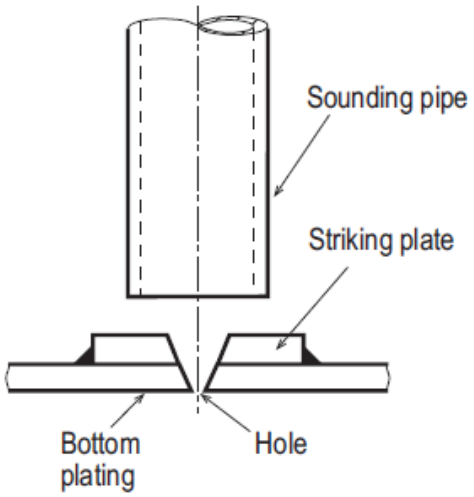
1. Poor design causing stress concentration.

Notes on repairs

1. Fractured plating is to be cropped and renewed.
2. Reduction of stress concentration of the bilge keel end should be considered.
   Repair A: Modification of the detail of end
   Repair B: New internal stiffeners
   Instead of **Repair A** or **B** continuous ground
3. bar and bilge keel should be considered.

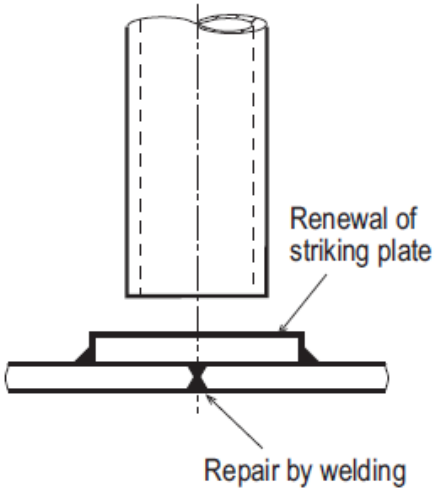
GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom structure	9
Detail of damage	Corrosion in bottom plating below sounding pipe	

Sketch of damage

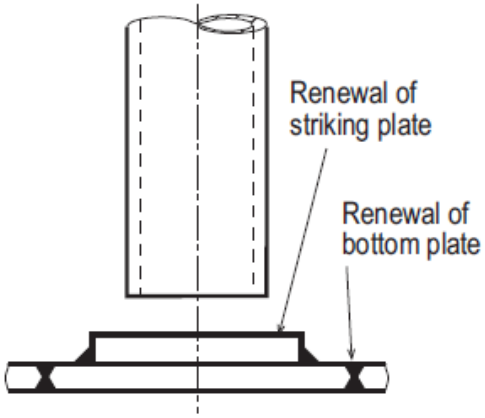


Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

1. Accelerated corrosion of striking plate by the striking of the weight of the sounding tape.

Notes on repairs

1. Corroded bottom plating should be welded or partly cropped and renewed if considered necessary.
2. Corroded striking plate should be renewed.

Part 2 Fore and aft end regions

Contents

Area 1 - Fore end structure
Area 2 - Aft end structure
Area 3 - Stern frame, rudder arrangement and propeller shaft supports

Area 1 Fore End Structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Figures and/or Photographs - Area 1	
No.	**Title**
Figure 1	Fore end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals
2	Fracture at toe of web frame bracket connection to stringer platform bracket
3	Fracture in side shell plating in way of chain locker
4	Deformation of forecastle deck
5	Deformation of side shell plating in way of forecastle space
6	Fracture in forecastle deck plating at bulwark

1 General

1.1 Due to the environmental conditions, wastage of the internal structure of the fore peak tank can be a major problem for many, and in particular ageing, general dry cargo ships. Corrosion may be accelerated in the cases of uncoated tanks or where the coating has not been maintained, and can lead to fractures of the internal structure, and the tank boundaries.

1.2 Deformation can be caused by contact which may result in damage to the internal structure and lead to fractures in the shell plating.

1.3 Fractures to the internal structure in the fore peak tank and spaces can also result from wave impact load due to slamming/panting.

1.4 Forecastle structure is exposed to severe environments and suffers damage, such as deformation of deck structure, deformation and fracture of bulwarks and collapse of masts, etc.

1.5 Shell plating around anchor and hawse pipe may have corrosion, deformation and possible fracture due to movement of improperly stowed anchor.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to show initially in locations as indicated in **Figure 1**. A close-up inspection should be carried out. In addition, a representative selection of thickness measurements should be taken with particular attention being given to locations such as chain lockers.

2.1.2 Structure in chain lockers is liable to have heavy corrosion because of mechanical damage to the protective coating by anchor chains. In some ships, e.g. relatively small ships, side shell plating may form boundaries of the chain lockers. Consequently, heavy corrosion may result in a hole in the side shell plating.

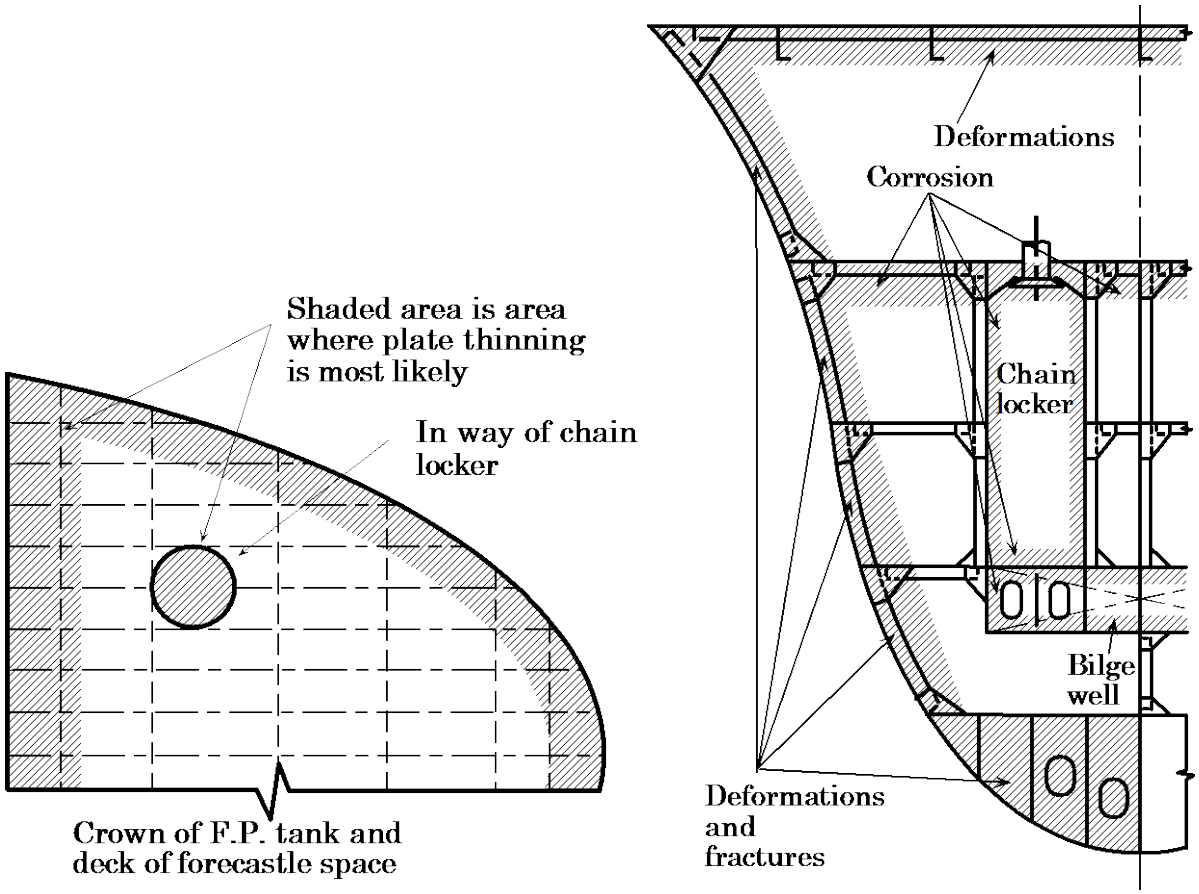
2.2 Deformations

2.2.1 Contact with quaysides, etc. can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. A close-up examination of the damaged area should be carried out.

2.3 Fractures

2.3.1 Fractures in the fore peak tank are normally found by close-up inspection of the internal structure.

2.3.2 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of the double bottom tanks.



(a) plan **(b) Section**

Figure 1 Fore end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The necessary extent of steel renewal can be established when comparing the measured thickness to the original values, or the minimum acceptable values for this part of the structure. The repair work in the tank will require planning, to permit accessibility.

3.2 Deformations

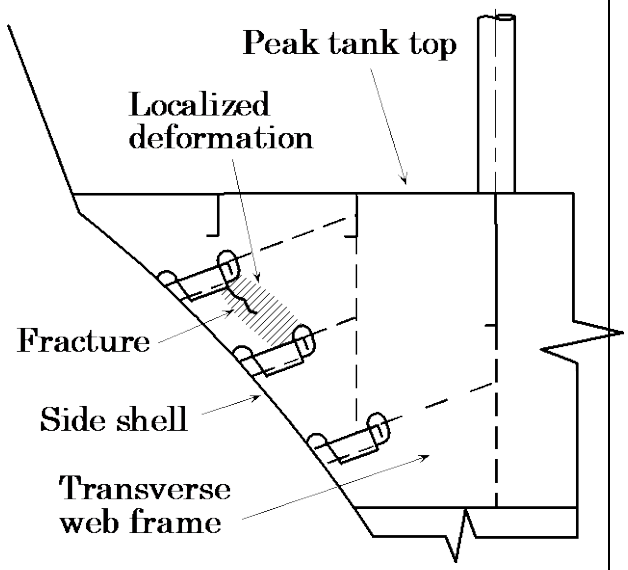
3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the nature and extent of damage.

3.3 Fractures

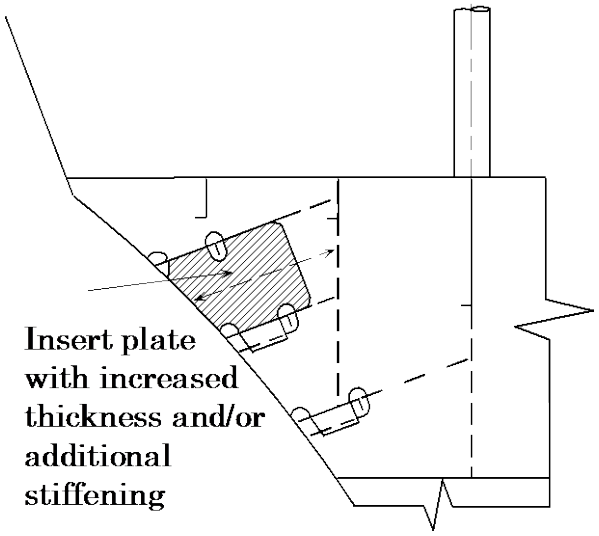
3.3.1 In the case of fractures caused by sea-loads the structure should be cropped and renewed. Increased thickness of plating and/or design modification to reduce stress concentrations should be considered (See **Examples 1**, **2** and **6**).

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**1**
Detail of damage	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

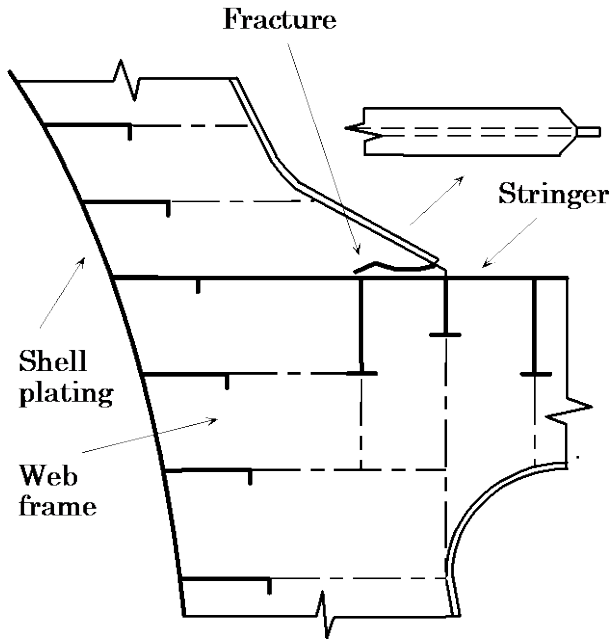
1. Localized material wastage in way of coating failure at cut-outs and sharp edges due to working of the structure.
2. Dynamic seaway loading in way of bow flare.

Notes on repairs

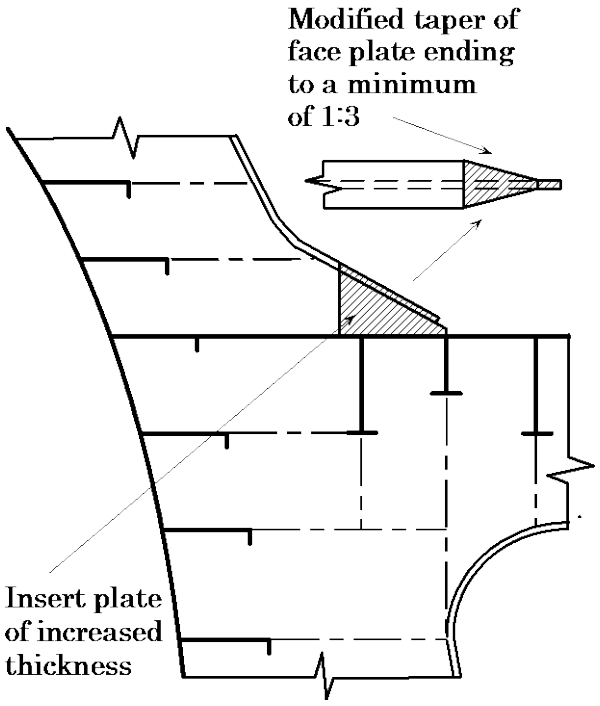
1. Sufficient panel strength to be provided to absorb the dynamic loads enhanced by bow flare shape.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**2**
Detail of damage	Fracture at toe of web frame bracket connection to stringer platform bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

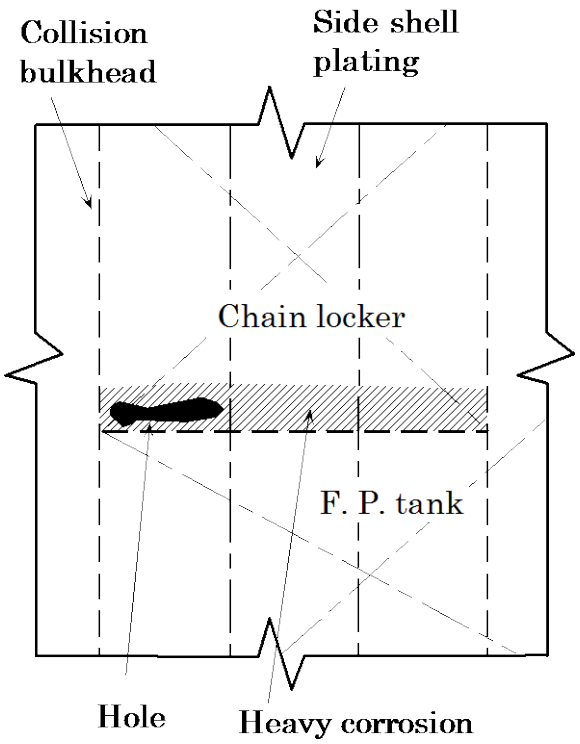
1. Inadequate bracket forming the web frame connection to the stringer.
2. Localized material wastage in way of coating failure at bracket due to flexing of the structure.
3. Dynamic seaway loading in way of bow flare.

Notes on repairs

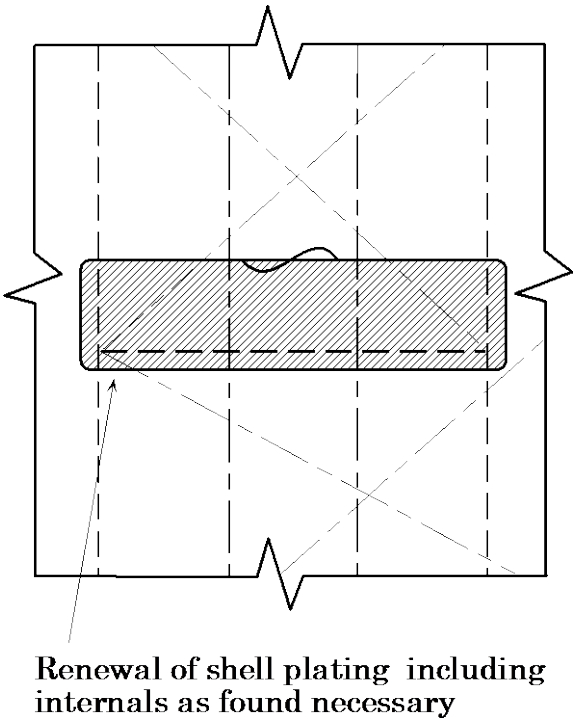
1. Adequate soft nose bracket endings with a face plate taper of at least 1 : 3 to be provided.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	3
Detail of damage	Fracture in side shell plating in way of chain locker	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

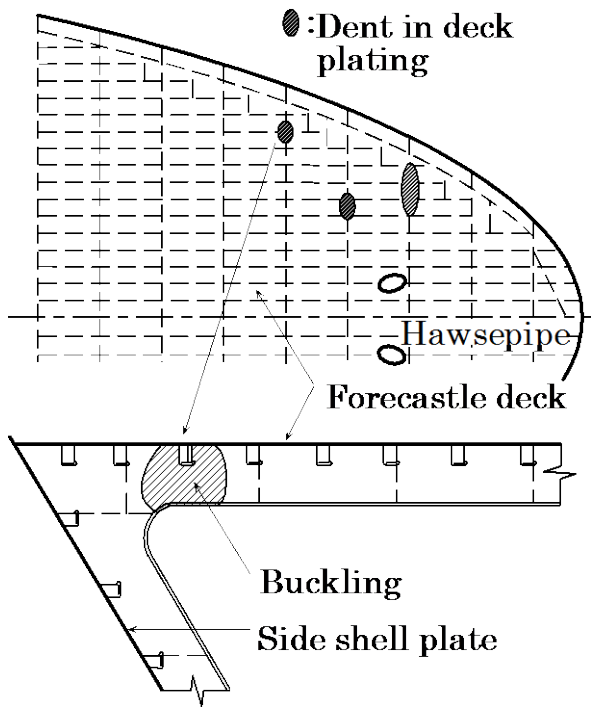
1. Heavy corrosion in region where mud is accumulated.

Notes on repairs

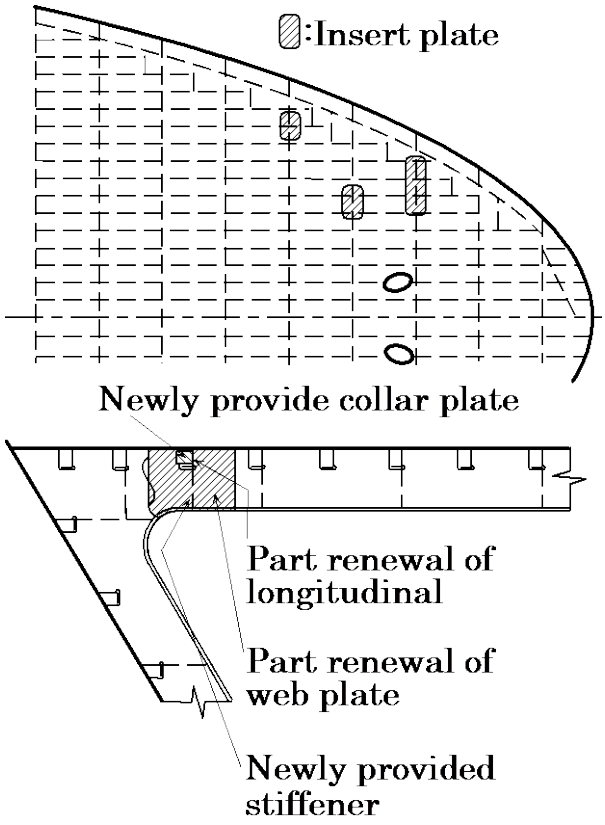
1. Corroded plating should be cropped and renewed.
2. Protective coating should be applied.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	4
Detail of damage	Deformation of forecastle deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

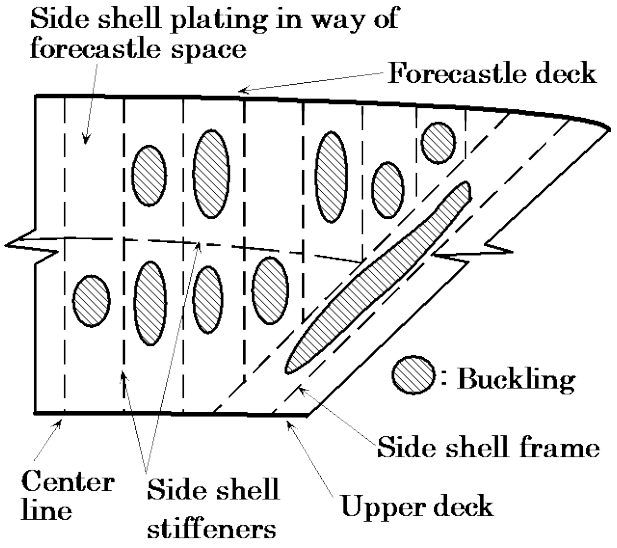
1. Green sea on deck.
2. Insufficient strength.

Notes on repairs

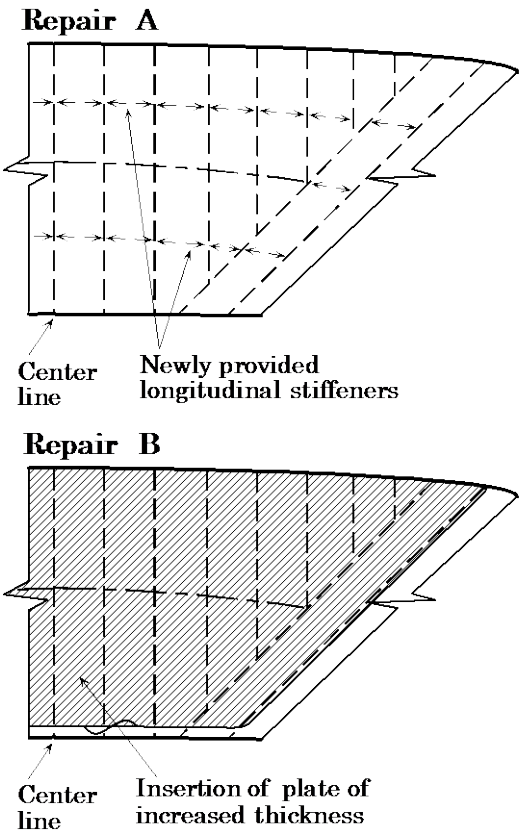
1. Deformed structure should be cropped and renewed.
2. Additional stiffeners on web of beam should be considered for reinforcement.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**5**
Detail of damage	Deformation of side shell plating in way of forecastle space	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

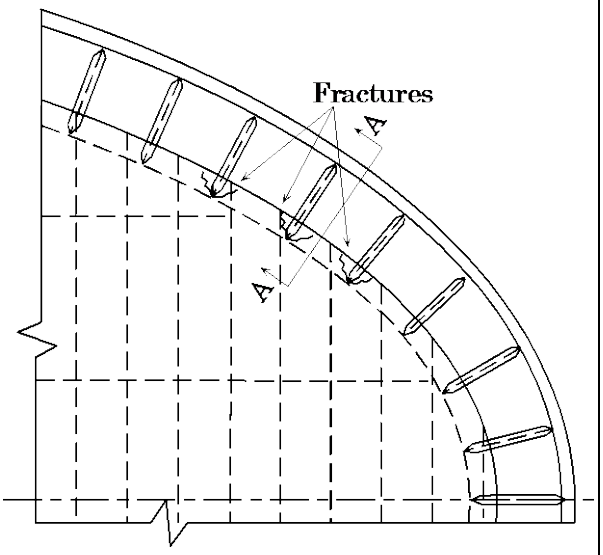
1. Heavy weather.
2. Insufficient strength.

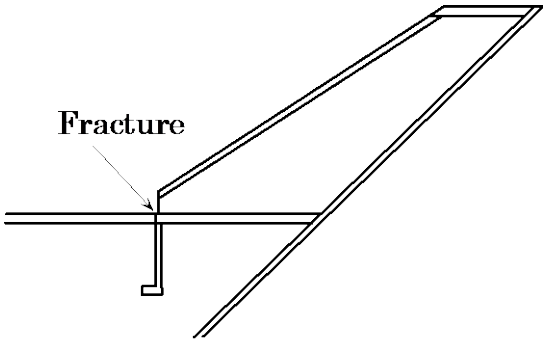
Notes on repairs

1. Deformed part should be cropped and part renewed.
2. **Repair A**
   Additional stiffeners between existing stiffeners should be considered.
   Repair B
   Insertion of plate of increased thickness with additional stiffeners

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**6**
Detail of damage	Fracture in forecastle deck plating at bulwark	

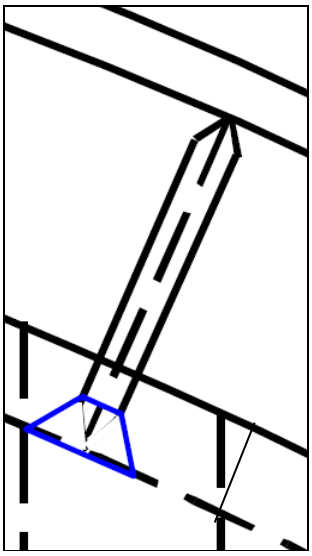
Sketch of damage

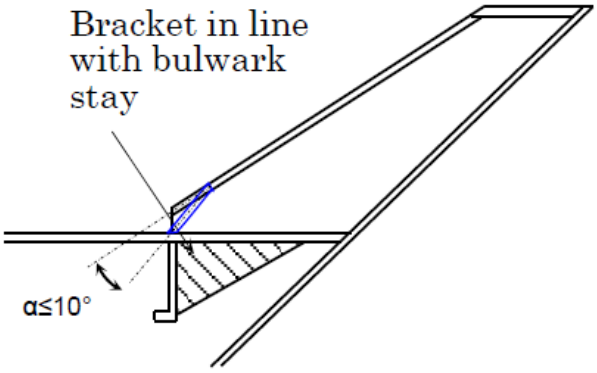




View A-A

Sketch of repair





View A-A

Notes on possible cause of damage

1. Bow flare effect in heavy weather.
2. Stress concentration due to poor design.

Notes on repairs

1. Fractured deck plating should be cropped and renewed.
2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.
3. The lower end of the bulwark bracket flange to be reshaped in order to avoid the sniper end.

Area 2 Aft end structure

Contents

1 General

2 What to look for
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Figures and/or Photographs - Area 2	
No.	**Title**
Figure 1	Aft end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 2	
Example No.	**Title**
1	Fractures in longitudinal bulkhead in way of rudder trunk
2	Fractures at the connection of floors and girder/side brackets
3-a	Fractures in flat where rudder carrier is installed in steering gear room
3-b	Fractures in steering gear foundation brackets and deformed deck plate
3-c	Stern frame, rudder arrangement and propeller shaft support

1 General

1.1 Due to environmental conditions, wastage of the internal structure of the aft peak tanks can be a major problem for many, and in particular ageing, general dry cargo ships. Wastage may be found to be accelerated in the case of uncoated tanks or where the coating has not been maintained, and can lead to fractures of the internal structure, and the tanks boundaries.

1.2 Deformation can be caused by contact or due to wave impact from astern which can result in damage to the internal structure and lead to fractures in the shell plating.

1.3 Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to show initially in locations as indicated in **Figure 1**. A close-up inspection should be carried out. In addition, a representative selection of thickness measurements should be taken with particular attention being given to locations such as bunker tank boundaries and spaces adjacent to heated engine rooms.

2.2 Deformations

2.2.1 Contact with quaysides etc. can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and bulkheads. A close-up examination of the damaged area should be carried out.

2.3 Fractures

2.3.1 Fractures in floor connection welds and in other locations in the aft peak tanks and rudder trunk spaces are normally found by close-up inspection.

2.3.2 The structure supporting the rudder carrier may fracture and/or deform due to the rudder having suffered excessive loads. Bolts connecting the rudder carrier to the steering gear flat may also be damaged due to such loads.

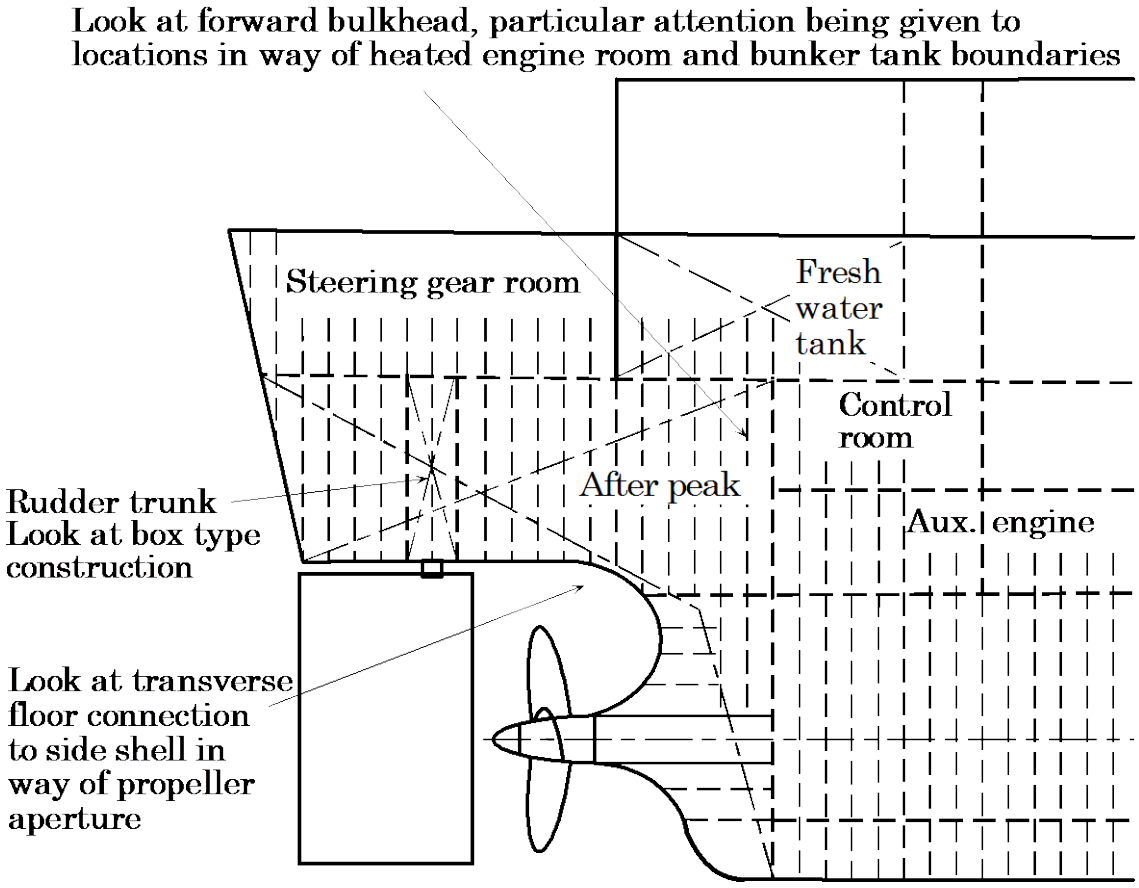


Figure 1 Aft end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The necessary extent of steel renewal can be established when comparing the measured thickness to the original values, or the minimum acceptable values for this part of the structure. The repair work in the peak tanks will require planning to permit accessibility.

3.2 Deformations

3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the extent of damage.

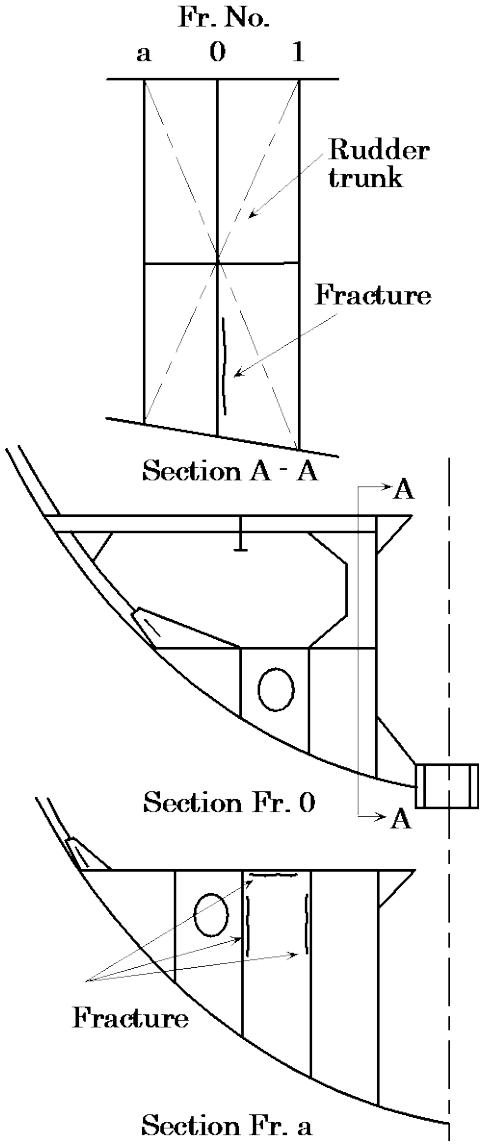
3.3 Fractures

3.3.1 Repairs of main engines and propeller excited vibration damage should be made by returning the structure to its original condition. In order to prevent recurrence of the damage the cause of the vibration should be ascertained and additional reinforcements provided as found necessary (See **Examples 1** and **2**).

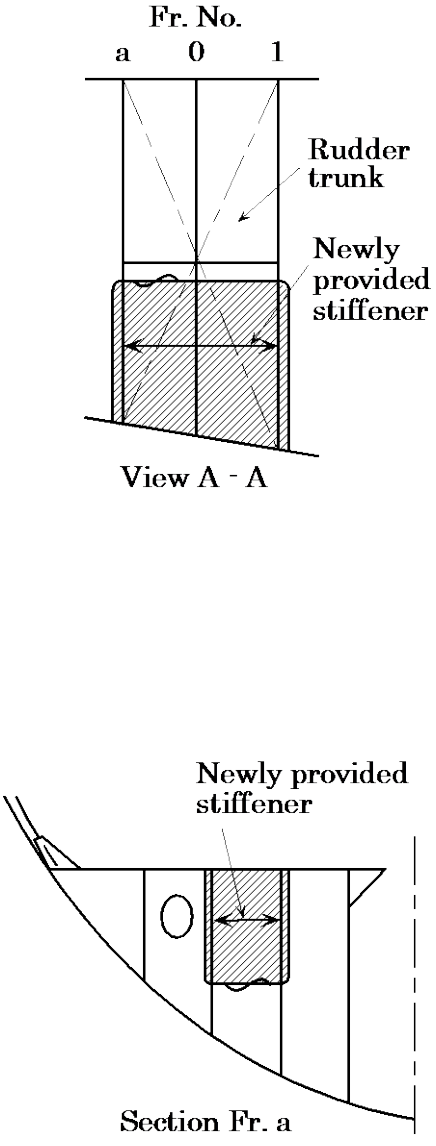
3.3.2 Fractured structure which supports the rudder carrier is to be cropped and renewed, and may have to be reinforced (See **Example 3**).

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**1**
Detail of damage	Fractures in longitudinal bulkhead in way of rudder trunk	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

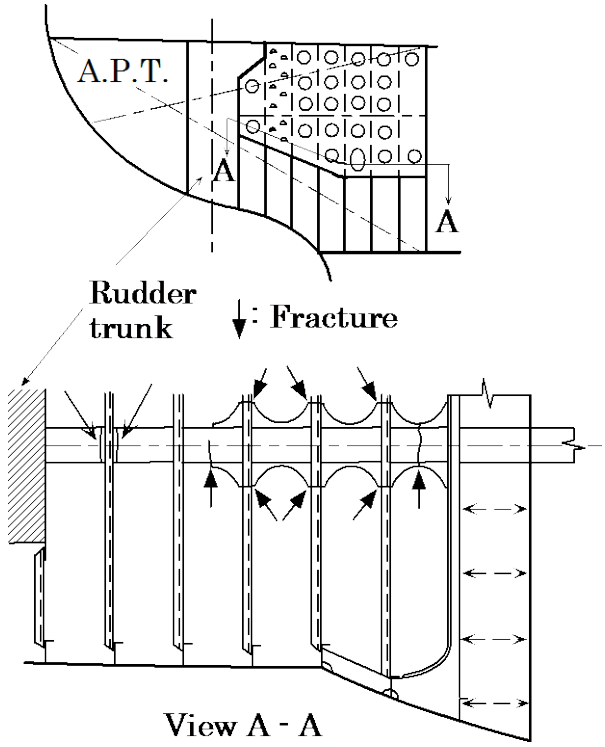
1. Vibration.

Notes on repairs

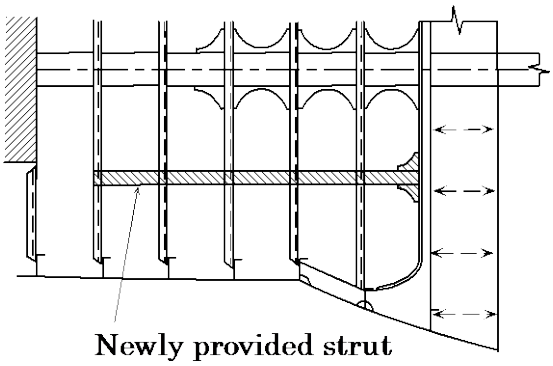
1. The fractured plating should be cropped and renewed.
2. Natural frequency of the plate between stiffeners should be changed, e.g. reinforcement by additional stiffeners.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**2**
Detail of damage	Fractures at the connection of floors and girder/side brackets	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

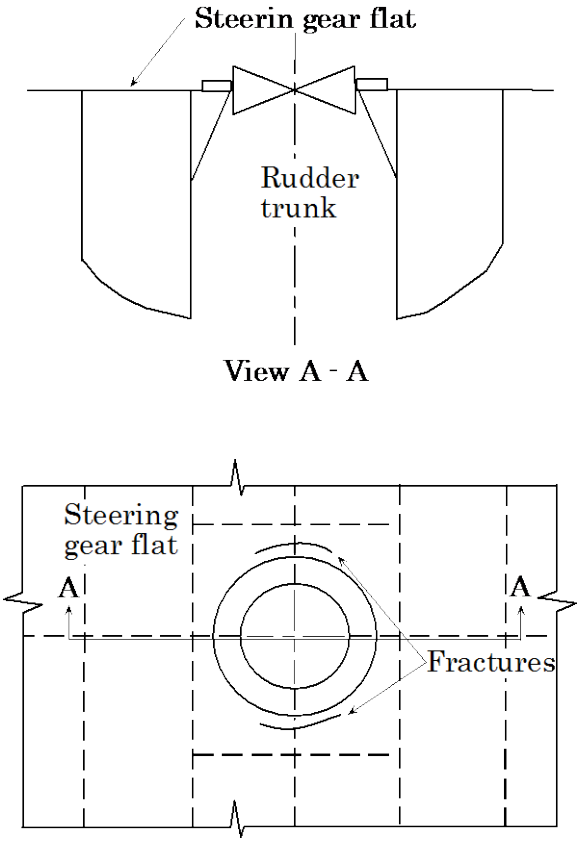
1. Vibration.

Notes on repairs

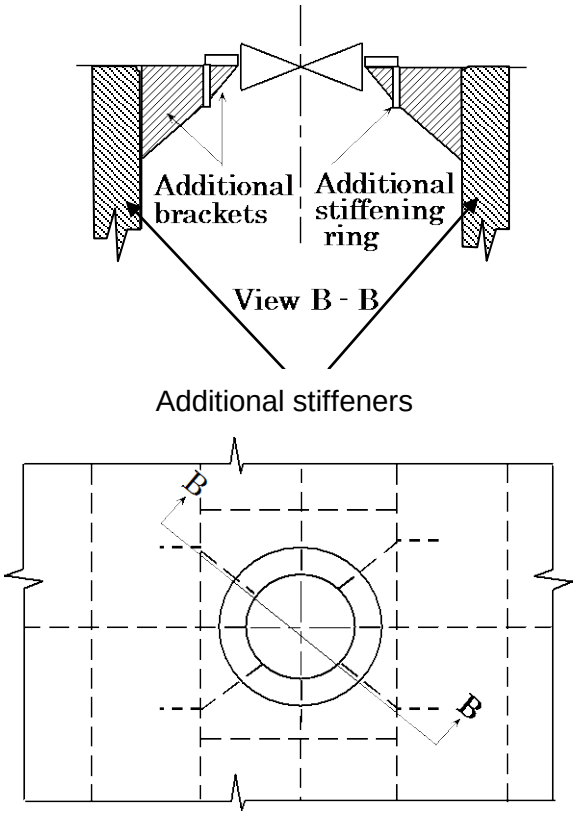
1. The fractured plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional strut.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**3-a**
Detail of damage	Fractures in flat where rudder carrier is installed in steering gear room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

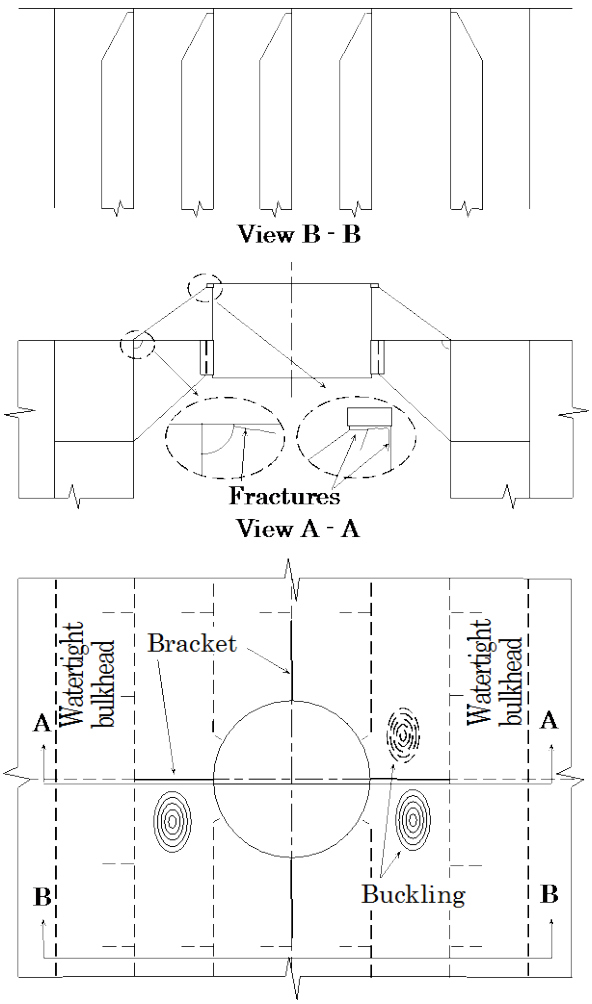
1. Inadequate design.

Notes on repairs

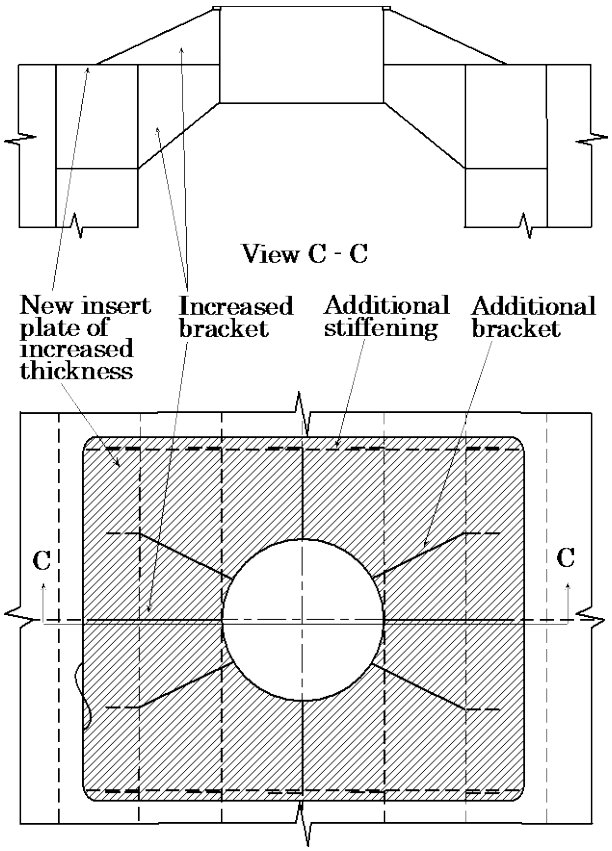
1. Fractured plating should be cropped and renewed.
2. Additional brackets, stiffeners and stiffening ring should be fitted for reinforcement.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**3-b**
Detail of damage	Fractures in steering gear foundation brackets and deformed deck plate	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

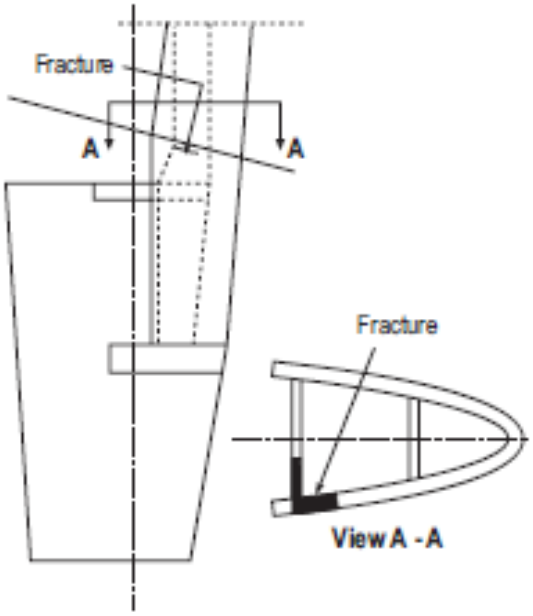
1. Insufficient deck strengthening (missing base plate).
2. Insufficient strengthening of steering gear foundation.
3. Bolts of steering gear were not sufficiently pre-loaded.

Notes on repairs

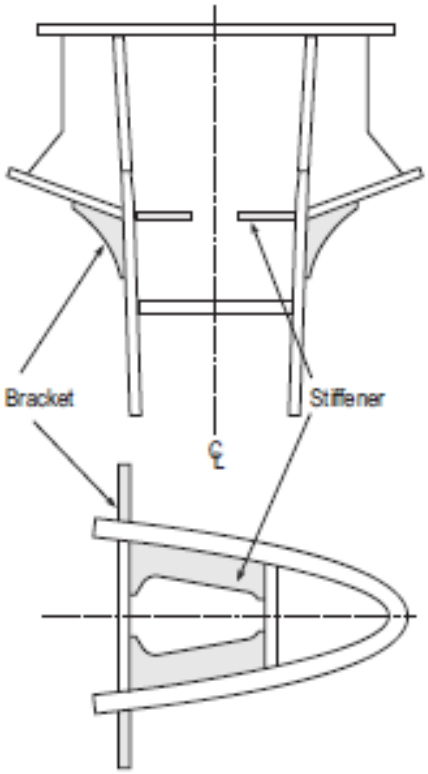
1. New insert base plate of increased plate thickness.
2. Additional longitudinal stiffening at base plate edges.
3. Additional foundation brackets above and under deck (star configuration).

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**3-c**
Detail of damage	Stern frame, rudder arrangement and propeller shaft support	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient strength due to poor design.

Notes on repairs

1. Fractured plating to be veed-out and re-welded.
2. Fractured plating to be cropped and renewed if considered necessary.
3. Reinforcement should be considered if deemed necessary.

Area 3 Stern frame, rudder arrangement and propeller shaft support

Contents

1 General

2 What to look for - Drydock inspection
- **2.1 Deformation**
- **2.2 Fractures**
- **2.3 Corrosion/Erosion/Abrasion**

3 General comments on repair
- **3.1 Rudder**
- **3.2 Repair of plate structures**
- **3.3 Abrasion of bush and sleeve**
- **3.4 Assembling of rudders**
- **3.5 Repair of propeller boss and stern tube**

Figures and/or Photographs - Area 3	
No.	**Title**
Figure 1	Nomenclature for stern frame, rudder arrangement and propeller shaft support
Figure 2	Potential problem areas
Photograph 1	Fractured rudder due to corrosion in rudder plating
Figure 3	Rudder stock repair by welding
Diagram 1	Preheating temperature

Examples of structural detail failures and repairs - Area 3	
Example No.	**Title**
1	Fracture in rudder stock
2	Fracture in connection of palm plate to rudder blade
3	Fracture in rudder plating of semi-spade rudder (short fracture with end located forward of the vertical web)
4	Fracture in rudder plating of semi-spade rudder extending beyond the vertical web
5	Fracture in rudder plating of semi-spade rudder in way of pintle cut-out
6	Fracture in side shell plating at the connection to propeller boss
7	Fracture in stern tube at the connection to stern frame

1 General

1.1 The stern frame, possible strut bearing arrangement and connecting structures are exposed to propeller induced vibrations, which may lead to fatigue cracking in areas where stress concentrations occur.

1.2 The rudder and rudder horn are exposed to an accelerated and fluctuating stream from the propeller, which may also lead to fatigue cracking in areas where stress concentrations occur.

1.3 In extreme weather conditions the rudder may suffer wave slamming forces causing deformations of the rudder stock and the rudder horn as well as of the rudder itself.

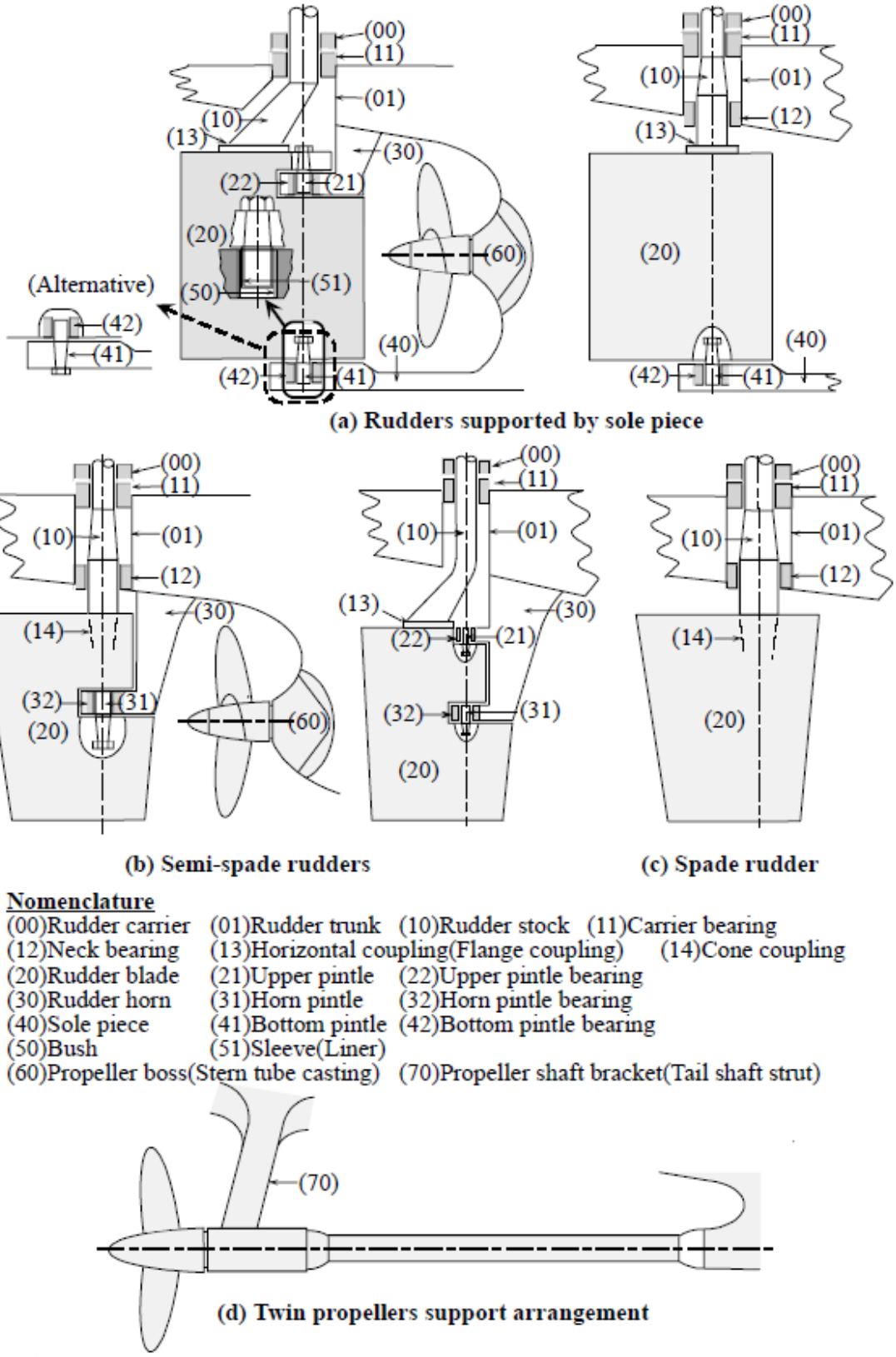
1.4 The rudder and the rudder horn as well as struts (on shafting arrangement with strut bearings) may also come in contacts with floating object such as timber-logs or ice, causing damages similar to those described in **1.3**.

1.5 Since different materials are used in adjacent compartments and structures, accelerated (galvanic) corrosion may occur if protective coating and/or sacrificial anodes are not maintained properly.

1.6 Pre-existing manufacturing internal defects in cast pieces may lead to fatigue cracking.

1.7 A summary of potential problem areas is shown in **Figure 2**.

1.8 A complete survey of the rudder arrangement is only possible in dry dock. However, in some cases a survey including a damage survey can be carried out afloat by divers or with a trimmed ship. (Moved from **2.4**)



(a) Rudders supported by sole piece

(b) Semi-spade rudders

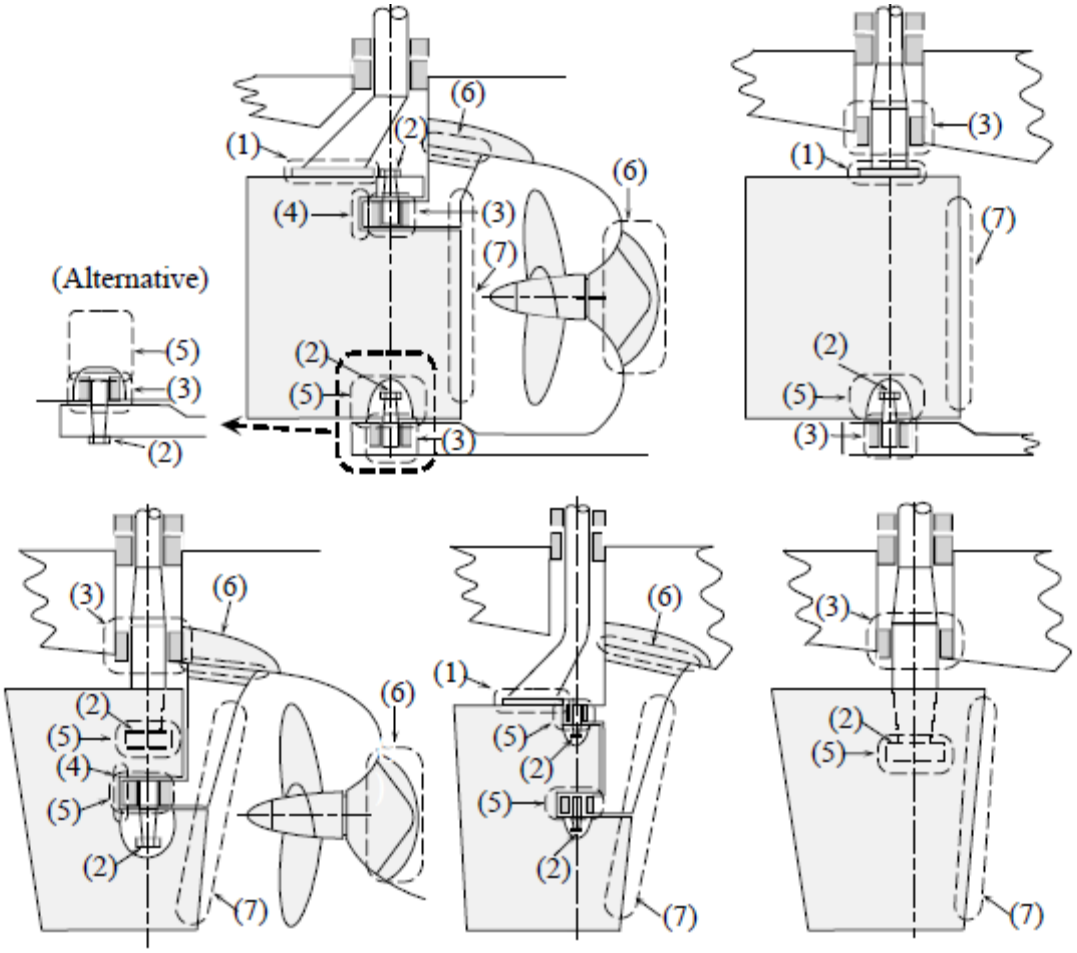
(c) Spade rudder

(d) Twin propellers support arrangement

Nomenclature

(00)Rudder carrier (01)Rudder trunk (10)Rudder stock (11)Carrier bearing
(12)Neck bearing (13)Horizontal coupling(Flange coupling) (14)Cone coupling
(20)Rudder blade (21)Upper pintle (22)Upper pintle bearing
(30)Rudder horn (31)Horn pintle (32)Horn pintle bearing
(40)Sole piece (41)Bottom pintle (42)Bottom pintle bearing
(50)Bush (51)Sleeve(Liner)
(60)Propeller boss(Stern tube casting) (70)Propeller shaft bracket(Tail shaft strut)

Figure 1 Nomenclature for stern frame, rudder arrangement and propeller shaft support



Damage to look for:
(1)Fractures and loose coupling bolts
(2)Loose nut
(3)Wear(excessive bearing clearance)
(4)Fractures in way of pintle cutout
(5)Fractures in way of removable access plate
(6)Fractures
(7)Erosion

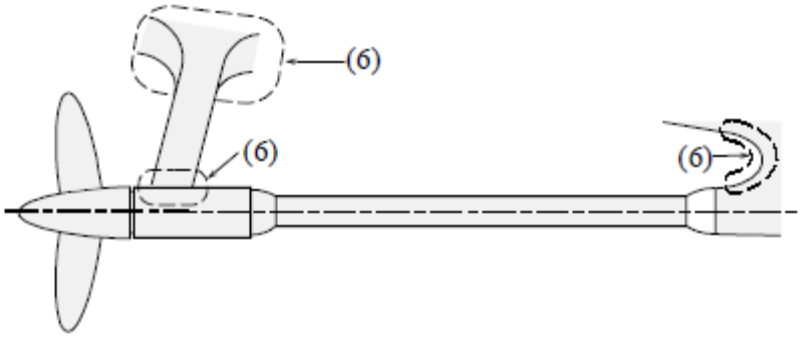


Figure 2 Potential problem areas

2 What to look for - Drydock inspection

2.1 Deformations

2.1.1 The rudder blade, rudder stock, rudder horn and propeller boss/brackets have to be checked for deformations.

2.1.2 Indications of deformation of rudder stock/rudder horn could be found by excessive clearance.

2.1.3 Possible twisting deformation or slipping of cone connection can be observed by the difference in angle between rudder and tiller.

2.1.4 If bending or twisting deformation is found, the rudder has to be dismounted for further inspection.

2.2 Fractures

2.2.1 Fractures in rudder plating should be looked for at slot welds, welds of removable part to the rudder blade, and welds of the access plate in case of vertical cone coupling between rudder blade and rudder stock and/or pintle. Such welds may have latent defects due to the limited applicable welding procedure. Serious fractures in rudder plating may cause loss of rudder.

2.2.2 Fractures should be looked for at weld connection between rudder horn, propeller boss and propeller shaft brackets, and stern frame.

2.2.3 Fractures should be looked for at the upper and lower corners in way of the pintle recess in case of semi-spade rudders. Typical fractures are shown in **Examples 3** to **5**.

2.2.4 Fractures should be looked for at the transition radius between rudder stock and horizontal coupling (palm) plate, and the connection between horizontal coupling plate and rudder blade in case of horizontal coupling. Typical fractures are shown in **Examples 1** and **2**. Fatigue fractures should be looked for at the palm plate itself in case of loosened or lost coupling bolts.

2.2.5 Fractures should be looked for in the rudder plating in way of the internal stiffening structures since (resonant) vibrations of the plating may have occurred.

2.2.6 If the rudder stock is deformed, fractures should be looked for in rudder stock by nondestructive examinations before commencing repair measures, in particular in and around the keyway, if any.

2.3 Corrosion/Erosion/Abrasion

2.3.1 Rudder plating

Corrosion/erosion (such as deep pitting corrosion) should be looked for in rudder/rudder horn, especially in welds. In extreme cases the corrosion /erosion may cause a large fracture as shown in **Photograph 1**.

Photograph 1 Fractured rudder due to corrosion in rudder plating

2.3.2 Rudder stock and pintle

The following should be looked for on the rudder stock and pintle:

- Excessive clearance between sleeve and bush of the rudder stock/pintle beyond the allowable limit specified by BCS.
- Condition of sleeve. If the sleeve is loose, ingress of water may have caused corrosion.
- Deep pitting corrosion in the rudder stock and pintle adjacent to the stainless steel sleeve.
- Slipping of rudder stock cone coupling. For a vertical cone coupling with hydraulic pressure connection, sliding of the rudder stock cone in the cast piece may cause severe surface damages.
- Where a stainless steel liner/sleeve/cladding for the pintle/rudder stock is fitted into a stainless steel bush, an additional check should be made for crevice corrosion.

3 General comments on repair

3.1 Rudder

3.1.1 Rudder stock with deformation

(a) If the rudder stock is twisted due to excessive forces such as contact or grounding and has no additional damages (fractures etc.) or other significant deformation, the stock usually can be used. The need for repair or heat treatment of the stock will depend on the amount of twist in the stock according to the requirements of the Classification Society. The keyway, if any, has to be milled in a new position.

(b) Rudder stocks with bending deformations, not having any fractures, may be repaired depending on the size of the deformation either by warm or by cold straightening in an approved workshop according to a procedure approved by the Classification Society. In the case of warm straightening, as a guideline, the temperature should usually not exceed the heat treatment temperature of

530-580°C.

(c) In the case of fractures on a rudder stock with deformations, the stock may be used again depending on the nature and extent of the fractures. If a welding repair is considered acceptable, the fractures are to be removed by machining/grinding and the welding is to be based on an approved welding procedure together with post weld heat treatment as required by BCS.

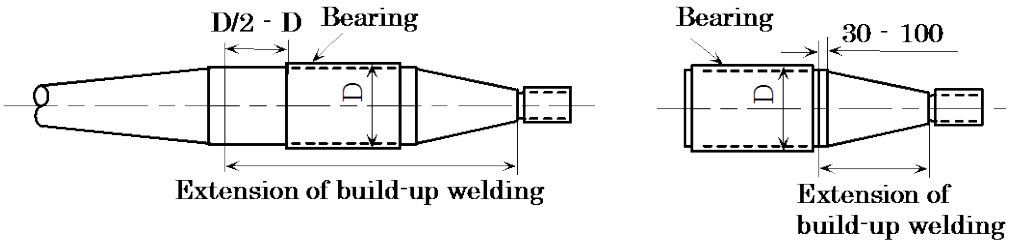
3.1.2 Repair of rudder stocks/pintles by weld cladding

Rudder stocks and/or pintles may be repaired by welding replacing wasted material by similar weld material. After removal of the wasted area (corrosion, scratches, etc.) by machining and/or grinding the build-up welding has to be carried out by an automatic spiral welding according to an approved welding procedure. The welding has to be extended over the area of large bending moments (rudder stocks). In special cases post weld heat treatment has to be carried out according to the requirements of BCS. After final machining, a sufficient number of layers of welding material have to remain on the rudder stock/pintle. A summary of the most important steps and conditions of this repair is shown in the **Figure 3**.

In the case of rudder stocks with bending loads, fatigue fractures in way of the transition radius between the rudder stock and the horizontal coupling plate cannot be repaired by local welding. A new rudder stock with a modified transition geometry has to be manufactured, as a rule (See **Example 1**). In exceptional cases a welding repair can be carried out based on an approved welding procedure. Measures have to be taken to avoid a coincidence of the metallurgical notch of the heat affected zone with the stress concentration in the radius' area. Additional surveys of the repair (including non-destructive fracture examination) have to be carried out at reduced intervals.

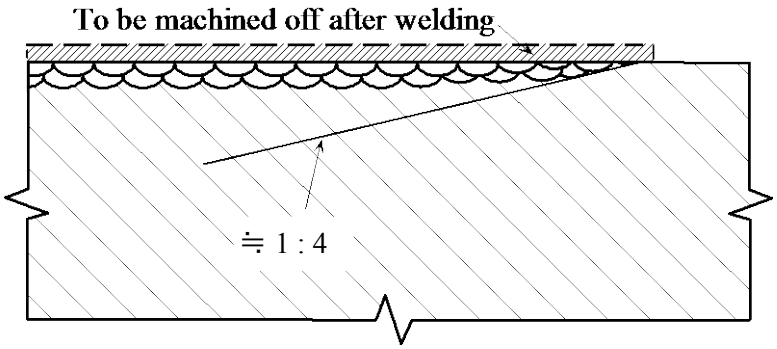
Replacing wasted material by similar ordinary weld material

- Removal of the wasted area by machining and/or grinding, non-destructive examination for fractures (magnetic particle inspection preferred)
- Build-up welding by automatic spiral welding (turning device) according to an approved welding procedure (weld process, preheating, welding consumables, etc.)
- Extension of build-up welding over the area of **large bending moments** (**shafts**) according to the sketch



Rudder stock **Pintle**

- Sufficient number of weld layers to compensate removed material, at least one layer in excess (heat treatment of the remaining layer)
- Transition at the end of the build-up welding according to the following sketch



- Post weld heat treatment if required in special cases (never for stainless steel cladding on ordinary steel)
- Final machining, at least two layers of welding material have to remain on the rudder stock (See the above sketch)
- Non-destructive fracture examination

Figure 3 Rudder stock repair by welding

3.2 Repair of plate structures

3.2.1 Fatigue fractures in welding seams (butt welds) caused by welding failures (lack of fusion) can be gouged out and rewelded with proper root penetration.

3.2.2 In case of fractures, probably caused by (resonant) vibration, vibration analysis of the rudder plating has to be performed, and design modifications have to be carried out in order to change the natural frequency of the plate field.

3.2.3 Short fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that do not propagate into vertical or horizontal stiffening structures may be repaired by gouging out and welding. This procedure according to **Example 3** should be preferred.

In case of longer fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that propagate over a longer distance into the plating, thorough check of the internal structures has to be carried out. The fractured parts of the plating and internal structures, if necessary, have to be replaced by insert plates. A proper welding connection between the insert plate and the internal stiffening structure is very important (See **Examples 4** and **5**).

The area of the pintle recess corners has to be ground smooth after the repair. In many cases a modification of the radius, an increased thickness of plating and an enhanced steel quality may be necessary.

3.2.4 For the fractures at the connection between plating and cast pieces adequate pre-heating is necessary. The pre-heating temperature is to be determined taking into account the following parameters:

- chemical composition (carbon equivalent C_{eq})
- thickness of the structure
- hydrogen content in the welding consumables
- heat input

3.2.5 As a guide, the preheating temperature can be obtained from **Diagram 1** using the plate thickness and carbon equivalent of the thicker structure.

3.2.6 All welding repairs are to be carried out using qualified/approved welding procedures.

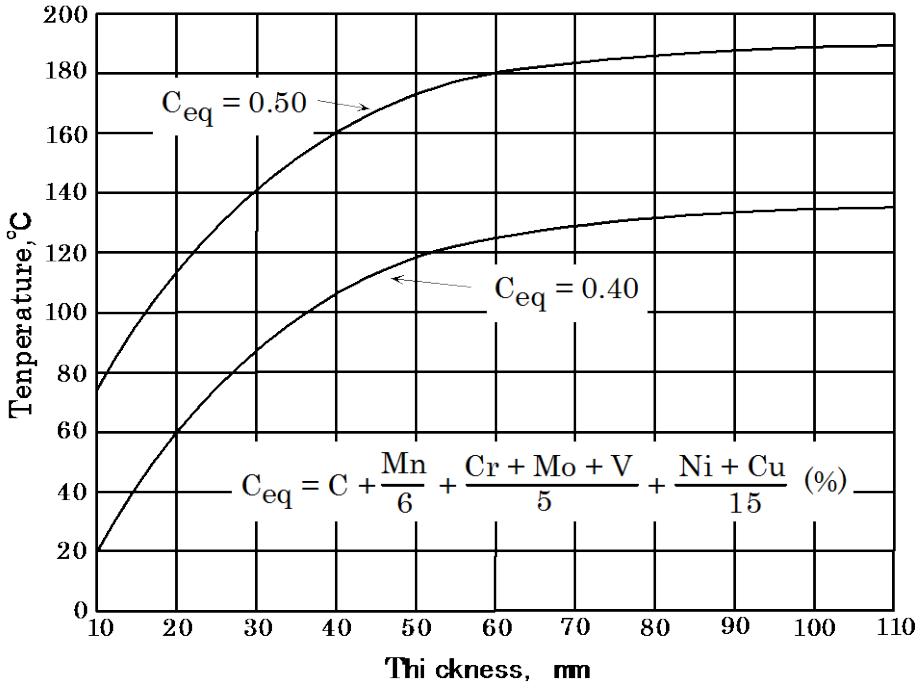


Diagram 1 Preheating temperature

3.3 Abrasion of bush and sleeve

Abrasion rate depends on the features of the ship such as frequency of maneuvering. However, if excessive clearance is found within a short period, e.g. 5 years, alignment of the rudder arrangement and the matching of the materials for sleeve and bush should be examined together with the replacement of the bush.

3.4 Assembling of rudders

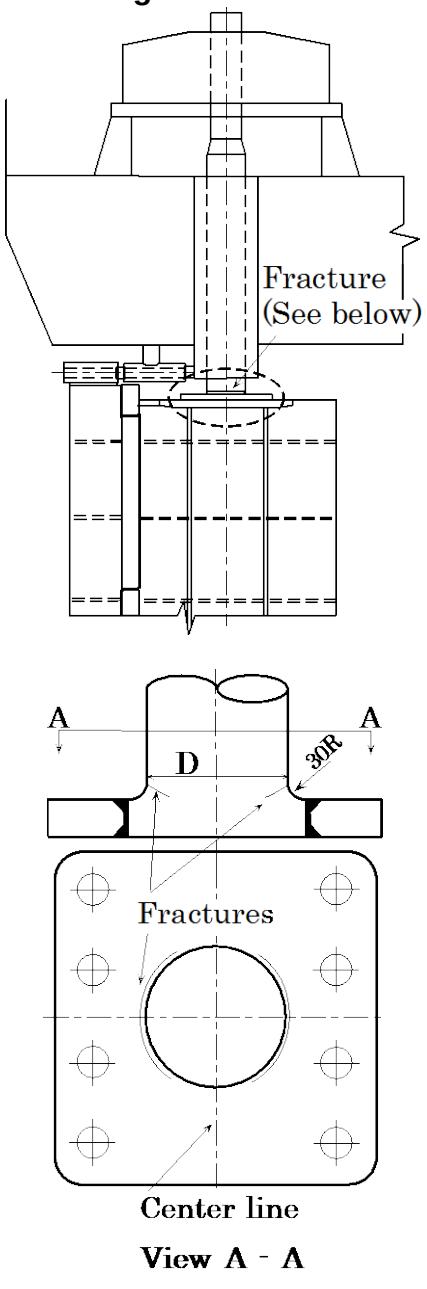
After mounting of all parts of the rudder, nuts of rudder stocks with vertical cone coupling and nuts of pintles are to be effectively secured either against each other or both against the coupling plate.

3.5 Repair of propeller boss and stern tube

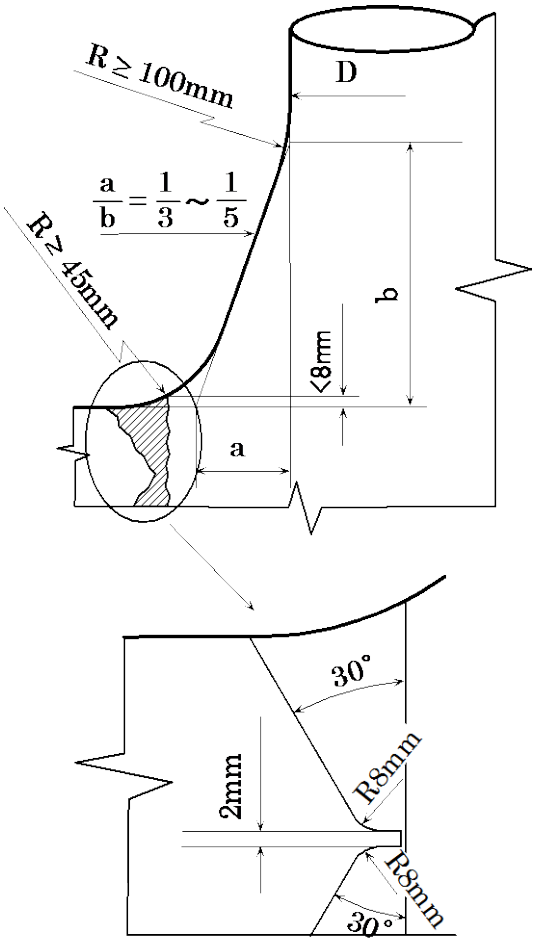
Repair examples for propeller boss and stern tube are shown in **Examples 6** and **7.** Regarding the welding reference is made to **3.1.2**, **3.2.4** and **3.2.5**.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	1
Detail of damage	Fracture in rudder stock	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

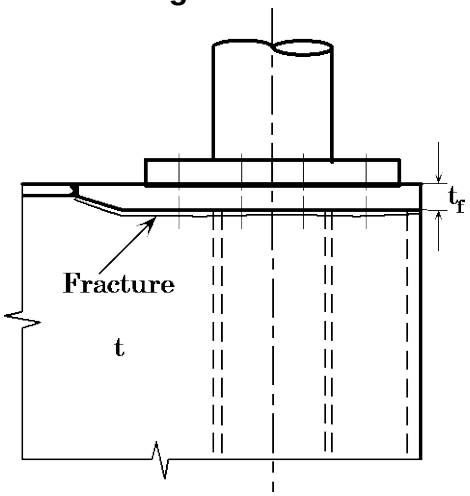
1. Inadequate design for stress concentration in rudder stock.

Notes on repairs

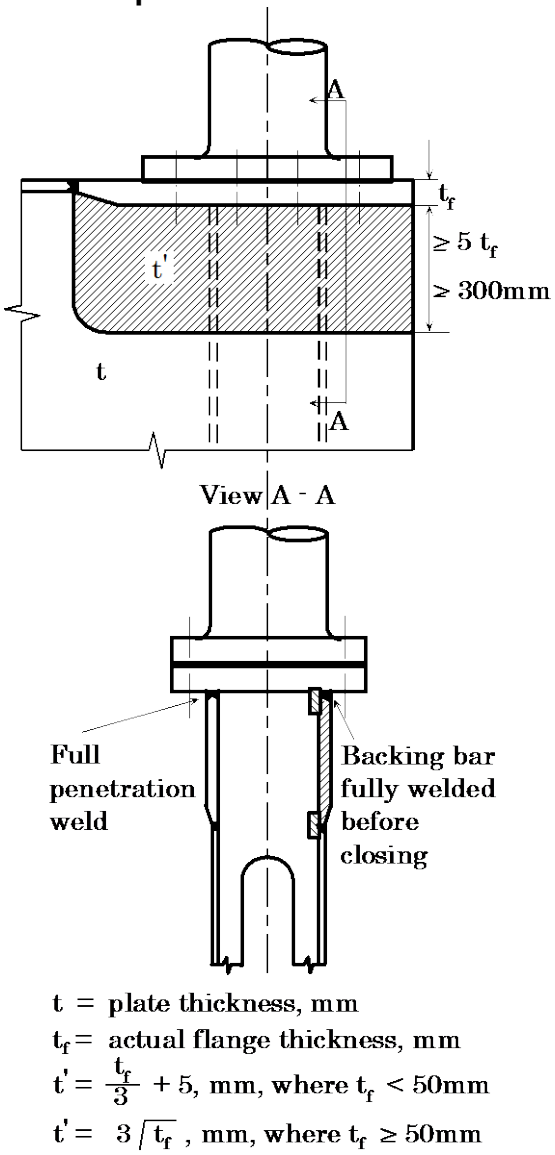
1. Modification of detail design of rudder stock to reduce the stress concentration.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	2
Detail of damage	Fracture in connection of palm plate to rudder blade	

Sketch of damage



Sketch of repair



t = plate thickness, mm

t_f = actual flange thickness, mm

$t' = \frac{t_f}{3} + 5$, mm, where $t_f < 50$mm

$t' = 3\sqrt{t_f}$, mm, where $t_f \geq 50$mm

Notes on possible cause of damage

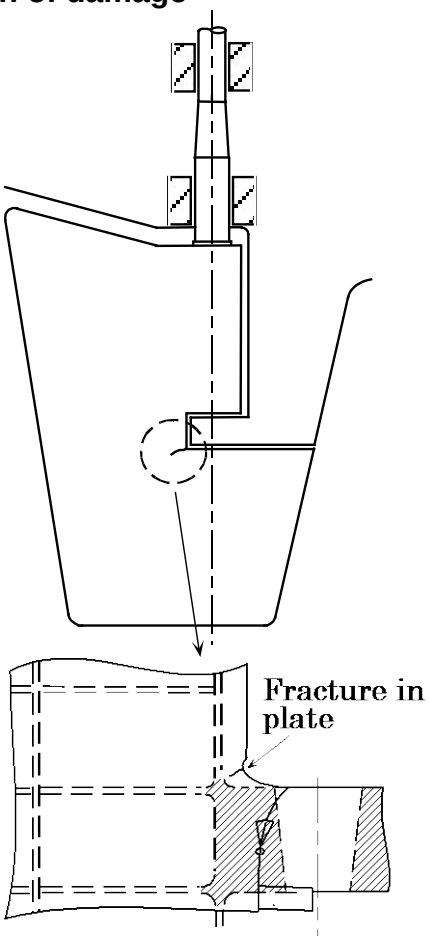
1. Inadequate connection between palm plate and rudder blade plating (insufficient plating thickness and/or insufficient fillet weld).

Notes on repairs

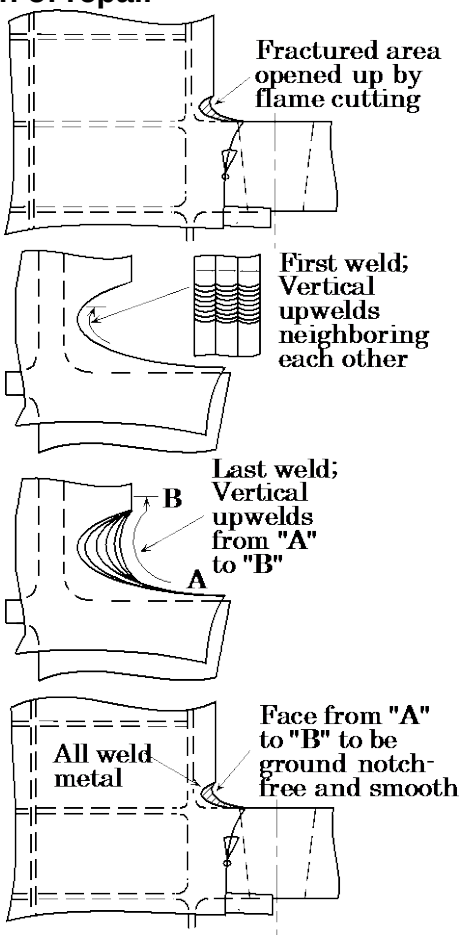
1. Modification of detail design of the connection by increasing the plate thickness and full penetration welding.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	3
Detail of damage	Fracture in rudder plating of semi-spade rudder (short fracture with end located forward of the vertical web)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

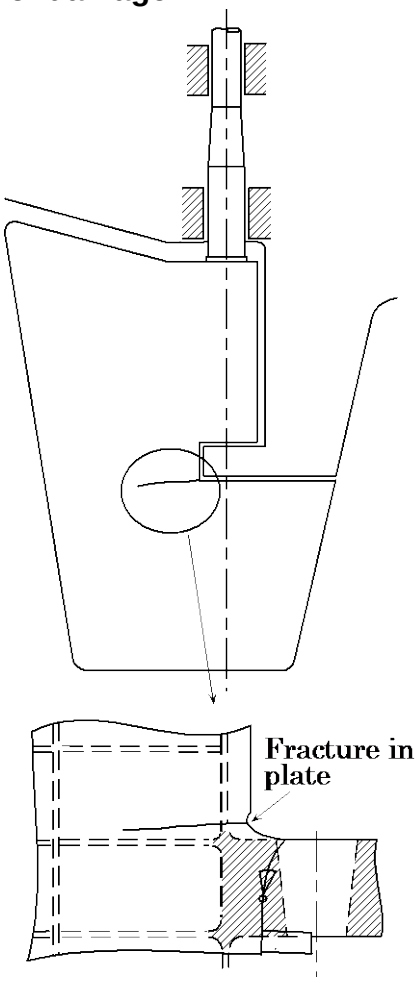
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

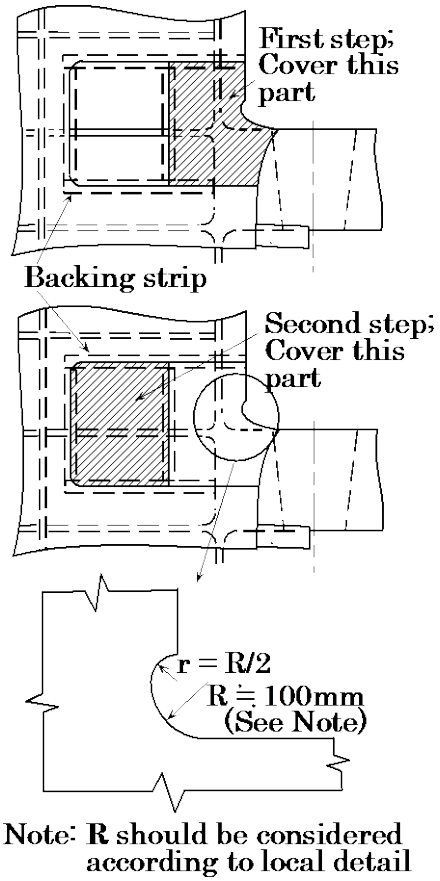
1. Grooving-out and welding of the fracture is not always adequate (metallurgical notch in way of a high stressed area).
2. In the proposed repair procedure the metallurgical notches are shifted into a zone exposed to lower stresses.
3. After welding a modification of the radius according to the proposal in **Example 5** is to be carried out.
4. In case of very small crack it can be ground off by increasing the radius.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	4
Detail of damage	Fracture in rudder plating of semi-spade rudder extending beyond the vertical web	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

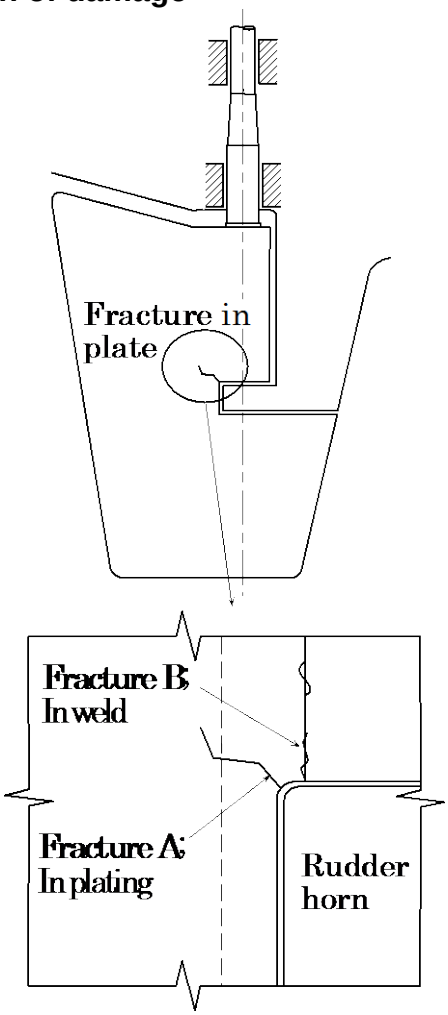
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

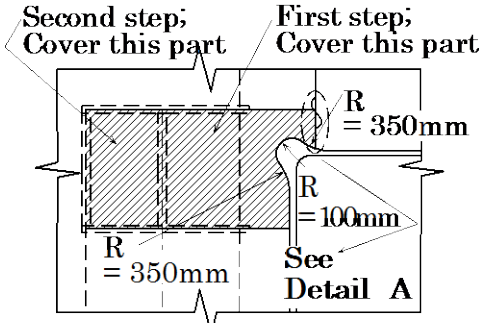
1. Fractured plating is to be cut-out.
2. Internal structures are to be checked.
3. Cut-out is to be closed by an insert plating according to the sketch (welding only from one side is demonstrated).
4. Modification of the radius.
5. In case of a new cast piece, connection with the plating is to be shifted outside the high stress area.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	5
Detail of damage	Fracture in rudder plating of semi-spade rudder in way of pintle cutout	

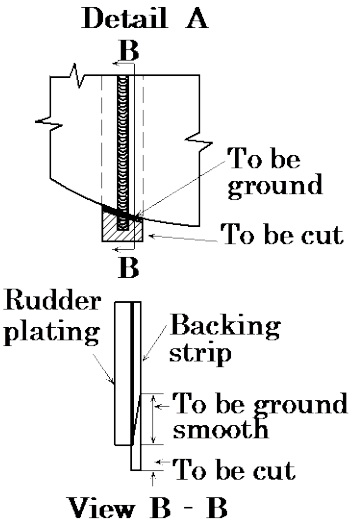
Sketch of damage



Sketch of repair



Note: 1. **R** should be considered according to local detail
2. New contour should be ground smooth.



Notes on possible cause of damage

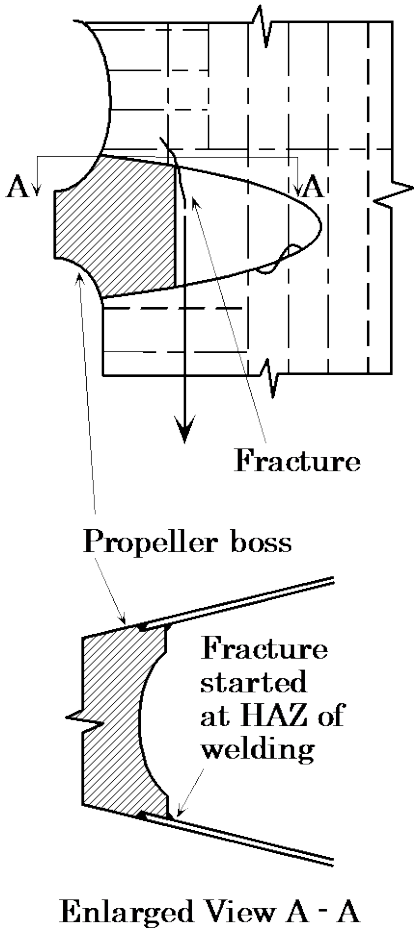
1. Inadequate design for stress concentration in way of pintle bearing (**Fracture A**).
2. Imperfection in welding seam (**Fracture B**).

Notes on repairs

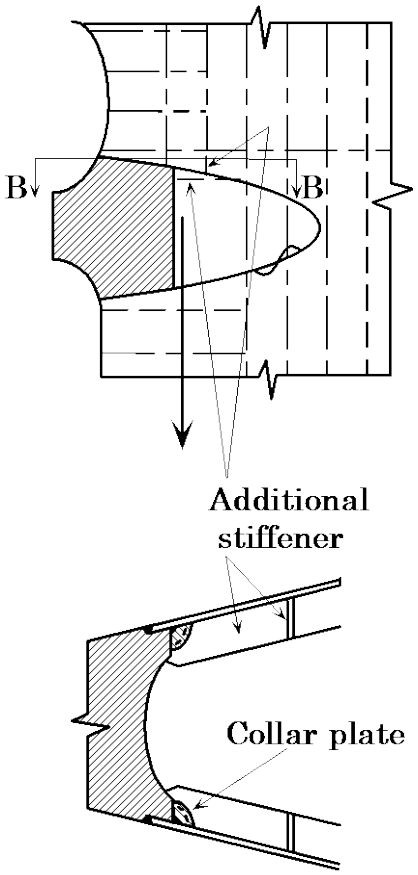
1. Fractured part to be cropped off.
2. Repair by two insert plates of modified, stress releasing contour. For the vertical seam no backing strip is used 100mm off contour, welding from both sides, to be ground after welding.
3. Variant (See **Detail A**): Repair as mentioned under 2 with the use of backing strip for the complete vertical seam. After welding backing strip partly removed by grinding.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	6
Detail of damage	Fracture in side shell plating at the connection to propeller boss	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

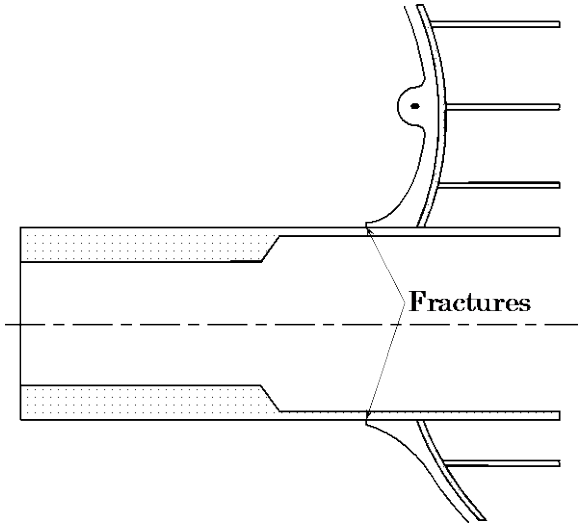
1. Fatigue fracture due to vibration.

Notes on repairs

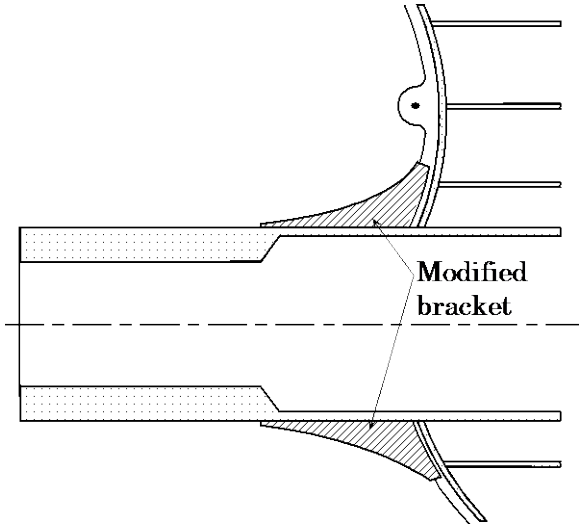
1. Fractured side shell plating is to be cropped and part renewed.
2. Additional stiffeners are to be provided.
3. Collar plate is to be provided.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	7
Detail of damage	Fracture in stern tube at the connection to stern frame	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Fatigue fracture due to vibration.

Notes on repairs

1. Fractured tube is to be welded from both sides.
2. Brackets are to be replaced by modified brackets with soft transition.

Part 3 Machinery and accommodation spaces

Area 1 Engine room structure
Area 2 Accommodation structure

Area 1 Engine room structure

Contents

1 General

2 What to look for
- **2.1 Material wastage**
- **2.2 Fractures**

3 General comments on repair
- **3.1 Fractures**

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Fractures in brackets at main engine foundation
2	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room
3	Corrosion in bottom plating under inlet/suction pipe in way of bilge storage tank in engine room

1 General

1.1 The engine room structure is categorized as follows.

- Boundary structure which consists of upper deck, bulkhead, inner bottom plating, funnel, deckhead below accommodation wet areas etc.
- Deep tank structure
- Double bottom tank structure

The boundary structure can generally be inspected routinely. Therefore, if damage is found, it can be easily rectified. Other structures, however, cannot be inspected routinely and therefore damage is found only when the ship is dry-docked or a problem has occurred.

2 What to look for

2.1 Material wastage

2.1.1 Boundary structure

Tank top plating, shell plating and bulkhead plating adjacent to the tank top plating may have severe corrosion due to sea water which is derived from leakage or lack of maintenance of sea water lines.

In dry dock the bilge well should be cleaned and inspected carefully, because the bilge well may have heavy pitting corrosion due to sea water which is derived from leakage at the gland packing or maintenance operation of machinery.

The funnel consists of part of the boundary structure and it often has serious corrosion which may impair firefighting of engine room in addition to weather tightness.

2.1.2 Double bottom tank

The bilge tank is under relatively severe corrosion environment compared to other double bottom tanks, since oily bilge containing sea water is put into the tank. Severe corrosion may result in a hole in the bottom plating, especially under the sounding pipe. In cofferdam pitting corrosion caused by sea water entering from the air pipe is seldom found.

2.2 Fractures

2.2.1 Deep tank

In general deep tanks for fresh water or fuel oil are provided in the engine room. These tank structures often have fractures due to vibration. Since the double bottom structure in the engine room is extremly rigid, fractures in this structure are very rare.

3 General comments on repair

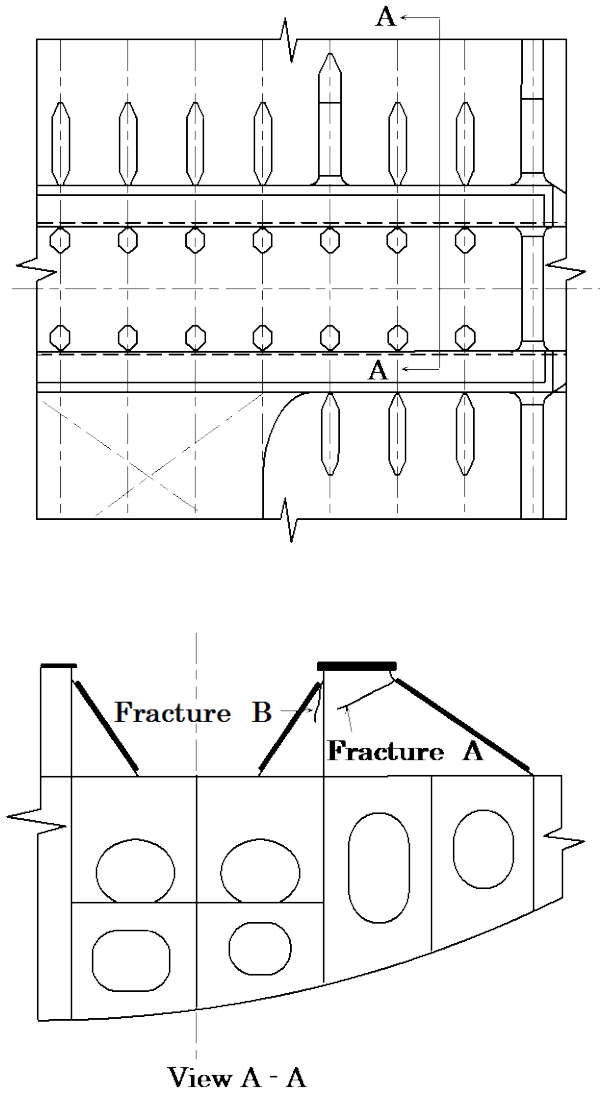
3.1 Fractures

3.1.1 Deep tank

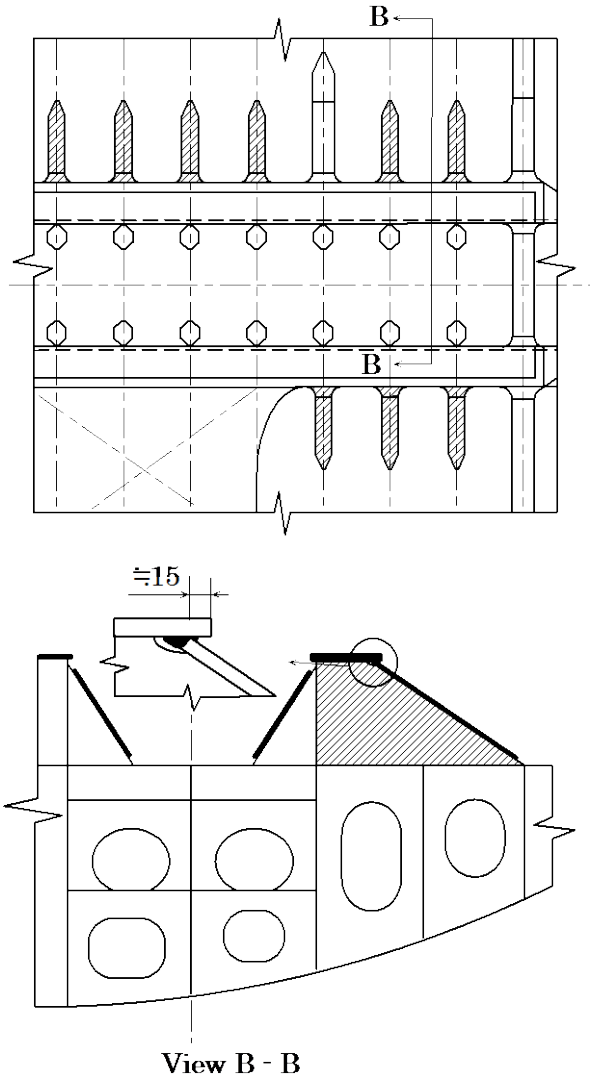
For fractures caused by vibration, consideration should be paid to change the natural frequency of the structure in addition to repairing damage to the structure. This may be achieved by adding proper additional structural members. However, this is often very difficult and many tentative tests may be needed before reaching the desired solution.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	**Machinery and accommodation spaces**	**Example No.**
Area 1	**Engine room structure**	**1**
Detail of damage	Fractures in brackets at main engine foundation	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

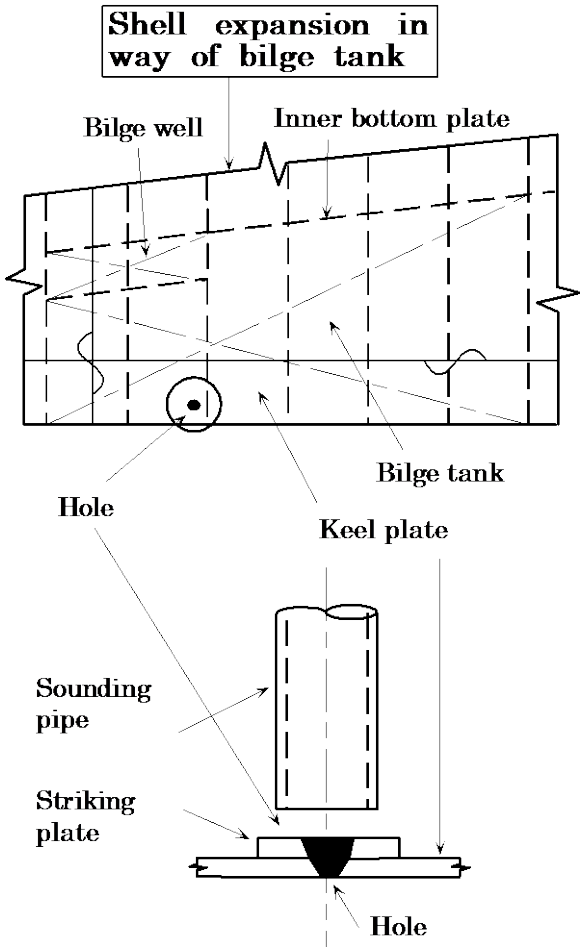
1. Vibration of main engine.
2. Insufficient strength of brackets at main engine foundation.
3. Insufficient pre-load of the bolts.

Notes on repairs

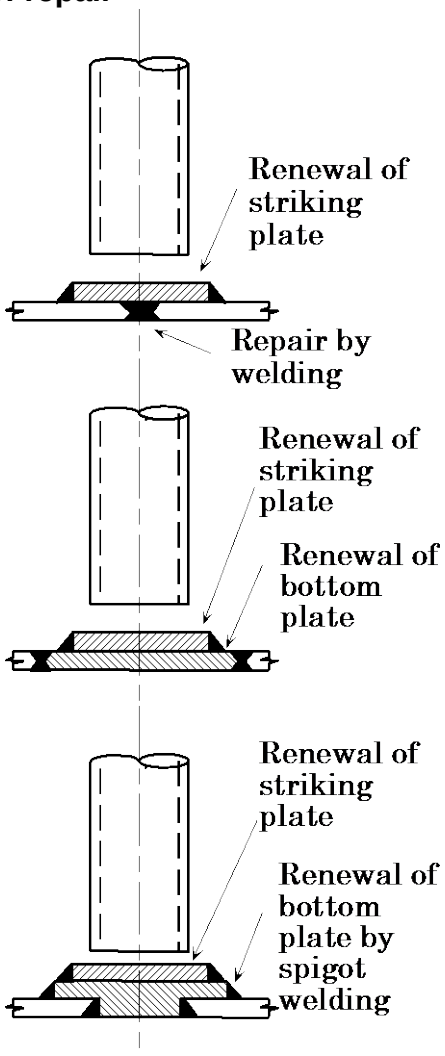
1. Fractures may be veed-out and rewelded.
2. New modified brackets at main engine foundation.
   Or insert pieces and additional flanges to increase section modulus of the brackets.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	2
Detail of damage	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

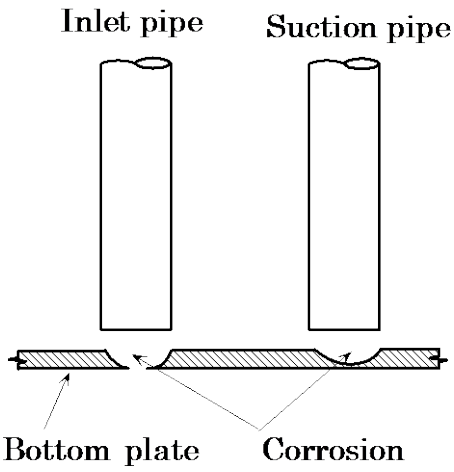
1. Heavy corrosion of bottom plating under sounding pipe.

Notes on repairs

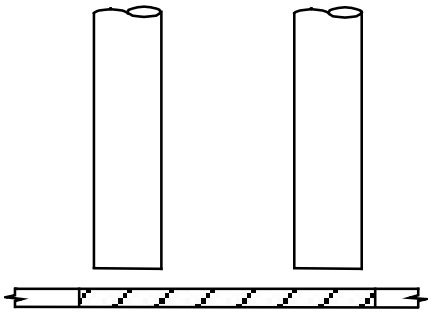
1. Corroded striking plating should be renewed. Bottom plate should be repaired depending
2. on the condition of corrosion.
   (Note)
   Repair by spigot welding can be applied to the structure only when the stress level is considerably low. Generally this procedure cannot be applied to the repair of bottom plating of ballast tanks in cargo hold region.

GENERAL DRY CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	**Machinery and accommodation spaces**	**Example No.**
Area 1	**Engine room structure**	**3**
Detail of damage	Corrosion in bottom plating under inlet/suction/pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion of bottom plating under the inlet/suction pipe.

Notes on repairs

1. Corroded bottom plate is to be cropped and part renewed. Thicker plate is preferable.
2 Replacement of pipe end by enlarged conical opening (similar to suction head in ballast tank) is preferable.

Area 2 Accommodation structure

Contents

1 General/General comments to repair

Figures and/or Photographs - Area 2	
No.	**Title**
Photograph 1	Corroded accommodation house structure

1 General/General comments to repair

1.1 General

Generally accommodation structures have few damages compared to other structures due to low stress levels.

The main damage is corrosion which may cause serious problems since the structure is relatively thin. Serious corrosion may be found in exposed deck plating and its adjoining accommodation house structure where water is liable to collect (See **Photograph 1**). Corrosion is also found in accommodation bulkheads where fittings such as doors, side scuttles, ventilators, etc. are fitted and proper maintenance of the area is relatively difficult. Deterioration of the bulkheads including fittings may impair the integrity of weathertightness.

Fractures caused by vibration may be found, in the structure itself and in various stays for such structures, mast, antenna etc. For such fractures consideration should be paid to change the natural frequency of the structure in addition to the repair.

Photograph 1 Corroded accommodation house structure

BCS- G57 Maintenance and inspection of electrical equipment on the ship

(Main switchboard, propulsion switchboard, emergency switchboard and section boards)

Introduction

The electrical switchboards, section boards and their equipment, on board the ship, are generally subjected to structural, climatic or electrical wear. In order to preserve their integrity throughout the ship's life, it seemed necessary to develop recommendations dealing with their maintenance and inspection.

1. General

1.1 The hereunder recommendations should be regarded as a guide for owners (or their representatives), builders and surveyors. It covers factors directly related to the maintenance and inspection of the electrical equipment fitted to the main switchboards, propulsion switchboards, emergency switchboards and section boards.

1.2 This guide does not replace the maintenance planning recommended by the manufacturers but should be taken into account in the ship’s maintenance scheme.

1.3 The maintenance and inspection operations should be recorded, identifying the examined equipment, obtained results, and any possible investigations and corrections.

1.4 The complete maintenance and inspection operations should be arranged according to table 1 and be co-ordinated with the periodical surveys of the vessel.

2. Definitions

2.1 Maintenance

A combination of any actions carried out to retain an item in, or restore it to, conditions in which it is able to meet the requirements of the relevant specifications and perform its required functions.

2.2 Inspection

An action comprising careful scrutiny of an item carried out with or without dismantling as required, supplemented by means such as measurement, in order to arrive at a reliable conclusion as to the condition of this item.

3. Qualification of personnel

The maintenance and inspection of installations should be carried out by personnel whose training has included instruction on the various types of installations (e.g. verification of medium voltage systems, dynamic positioning systems and other new electrical systems), relevant rules and regulations and on personnel safety.

Qualified personnel responsible for inspection and maintenance works should be appointed by owners and builders, in accordance with the applicable rules and regulations.

Table 1 - Maintenance and inspection actions

Actions		Every Year	Every Five Years
1	Electrical switchboards and section boards are to be visually examined to assess the good operation and maintenance.	x	x
2	Electric equipment is to be examined for cleanliness. Where deemed necessary, cleaning of electrical equipment (dust suction, wiping up oil water deposits).	x	x
3	It is to be checked that:		
3.1	Cables or other electric equipment are still in the original position. Any modification should be to the satisfaction of the Society.	x	x
3.2	Cable penetration devices are still in good condition (e.g. with appropriate compound).	x	x
3.3	No evidence of overheating, burning or tracking.	x	x
3.4	Measuring equipment is in order.	x	x
3.5	Mechanical ventilation, if fitted, operates as required.	x	x
3.6	Where a protection device has been replaced, its rating and, where applicable, settings are to be verified.	x	x
4	Contacts and arc screens, if any, of all concerned devices are to be checked and reconditioned or replaced if necessary in accordance with manufacturer's recommendation. Movable parts of the said devices are to be tested.		x
5	Tightening of connections and assemblies which may slacken is to be checked and tightened, if required, according to the manufacturer's recommendations. Thermograph aids may be considered to detect hot spots.		x
6	Where accumulator batteries may be stored, the condition of connections (salt deposits ...), the fastenings, the ventilation and the tray tightness are to be checked.	x	x

Actions		Every Year	Every Five Years
7	Where fitted, computer based systems (including hardware) are to be examined and tested to confirm their satisfactory condition and operation. Their original functions are to be unchanged.		x
8	An insulation measurement of any circuit in doubt is to be carried out. Any large decrease in values is to be investigated and corrected.	x	
9	All circuits are to be subject to insulation measurements for comparison with the insulation recordings previously established. Corrective actions are to be carried out if the values obtained are under 1kΩ per volt.		x
10	Circuit interlocks, if any, are to be tested.		x
11	Protective devices are to be tested. The electronic protective devices for generators and large consumers are to be tested according to BCS- G 49.		x
12	The operation of all emergency sources of power is to be tested, including their automatic devices if any.	x	x
13	All automatic sequences, e.g. for synchronization, connection, load shedding if any are to be tested as far as practicable.	x	x
14	Fastening, securing and tightness of the switchboard's cooling system, if fitted, is to be checked.	x	x

BCS-G58 Fire Protection of Machinery Spaces

1. Distribution piping for flammable liquids

Cocks or valves should be provided for isolating instruments from the main pipes.

Temperature sensors should be fitted in pockets.

All valves and cocks forming part of the fuel installation should be capable of being operated from readily accessible positions.

2. Leakage containment arrangements for engines, equipment and boilers

Containment provided for areas where frequent leakage may be expected such as oil burners, purifiers, drains and valves under daily service tanks etc. should be fitted with adequate drainage. Where drain pipes are provided from collected leakages, they should be led to a suitable oil drain tank not forming part of an overflow system.

3. Valve for oil fuel pumps

Stop valves or cocks should be fitted on both suction and delivery sides of oil fuel pumps. All oil fuel pumps should be provided with pressure relief valves on the dis- charge side so that the discharged oil may be led to the suction side of the pump.

Pressure relief valves need not be fitted when the system is served only be centrifugal pumps, so designed that the pressure delivered cannot exceed that for which the piping is designed.

4. Overheating and seizure — oil heaters

4.1. Where steam heaters or heaters using other heating media are provided in fuel or lubricating oil systems, they should be fitted with at least a high temperature alarm or low flow alarm in addition to a temperature control, except where the temperature dangerous for the ignition of the medium cannot be reached.

4.2. When electric heaters are fitted, means should be provided to ensure that heating elements are permanently submerged during the operation.

In order to avoid in any case a surface temperature of heating element above 220°C, a safety temperature switch, independent from the automatic control sensor, should be provided. The safety switch should cut off the electrical power supply in the event of excessive temperature and shall be provided with manual reset.

Note: This document should be referenced together with MSC.1/Circ.1321 “Guidelines for measures to prevent fires in engine-rooms and cargo pump-rooms”.

5. Hot surfaces

The insulation of hot surfaces should be of a type and so supported that it will not crack or deteriorate when subject to vibration.

6. Oil spillages coming into contact with hot surfaces, electrical installations or other sources of ignition

6.1. Oil filters fitted in parallel for the purpose of enabling cleaning without disrupting oil supply to engines (e.g. duplex filters) should be provided with arrangements that will minimise the possibility of a filter under pressure being opened by mistake. Filters/filter chambers should be provided with suitable means for:

- venting when put into operation
- depressurising before being opened

Valves or cocks with drain pipes led to a safe location should be used for this purpose.

6.2. Hydraulic units with working pressure above 15 bar should preferably be placed in separate spaces. If it is impracticable to locate such units in a separate space, adequate shielding should be provided.

7. Faults in boiler firing, scavenging manifold, boiler uptakes and exhaust gas uptakes

7.1. The oil burners should be so arranged that they cannot be withdrawn unless the oil supply to the burners is cut off.

7.2. The fuel supply to all burners should be capable of being automatically cut off in case of total lack of flame in the combustion chamber; moreover, this should be warned by a visual audible alarm. The alarms need not be fitted for domestic boilers.

8. Thermal oil installations

8.1. System arrangements

The inlet and outlet valves of oil-fired thermal oil heaters and exhaust-fired thermal oil heaters should be controllable from outside the compartment where they are situated. As an alternative, an arrangement for quick gravity drainage of the thermal oil contained in the system into a collecting tank is acceptable.

Heating of liquid cargoes with flash points below 60°C should be arranged by means of a separate secondary system, located completely within the cargo area.

However, a single circuit system may be accepted on the following conditions:

- system should be so arranged that a positive pressure in the coil should be at least 3 m water column above the static head of the cargo when circulating pump is not in operation.
- the thermal oil system expansion tank should be fitted with high and low level alarms.

- means should be provided in the thermal oil system expansion tank for detection of flammable cargo vapours. Portable equipment may be accepted.

- valves for the individual heating coils should be provided with locking arrangement to ensure that the coils are under static pressure at all times.

The thermal oil circulating pumps should be arranged for emergency stopping from a position outside the space where they are situated.

Vents from expansion tanks and thermal oil storage tanks of thermal oil heating plants should be led to open deck.

8.2. Exhaust-fired thermal oil heaters

The heater should be so designed and installed that all tubes may easily and readily be inspected for signs of corrosion and leakage.

Visual inspection and tightness testing of the heater tubes to not less the working pressure should be carried out annually, and hydraulic testing shall be carried out bi- annually.

The heater should be fitted with temperature sensor(s) and an alarm for fire detection.

A fixed fire extinguishing and cooling system should be fitted. A drenching system providing copious amounts of water may be accepted. The exhaust ducting below the exhaust boiler should be arranged for adequate collection and drainage, to prevent water flowing into the diesel engine. The drain should be led to a suitable location.

9. Segregation of fuel oil purifiers

9.1. Fuel oil purifiers for heated fuel oil should be subject to the following.

9.1.1. The fuel oil purifiers should be placed in a separate room, enclosed by steel bulkheads extending from deck to deck and provided with self-closing steel doors.

9.1.2. The room should be provided with:

1 independent mechanical ventilation or a ventilation arrangement which can be isolated from the machinery space ventilation,

2 fire detecting system,

3 fixed fire extinguishing installation:

The extinguishing installation should be capable of being activated from outside the room.

Closing of ventilation openings should be effected from a position close to where the extinguishing system is activated.

The extinguishing system should be separate for the room, but may be a part of the main fire extinguishing system for the machinery space.

9.2. Where the size and/or design of the engine room makes it impracticable to locate the fuel oil purifiers in a separate space, special consideration should be given with regard to location, containment of possible leakages, and shielding and ventilation.

A local fixed fire extinguishing system should be provided, capable of being activated automatically or activated manually from the machinery control position or from other suitable location. If automatic release is provided, additional manual release should be arranged.

BCS-G60 Intact stability of tankers during liquid transfer operations

Preamble

This recommendation for tankers (i.e. vessels designed to carry liquid in bulk) is developed from MSC/Circ.706 (MEPC/Circ.304) containing recommendations for existing oil tankers. The phenomenon of lolling is considered by IACS to be a safety issue for double hull tankers, as well as for other tankers having exceptionally wide cargo tanks (i.e. having cargo tank breadths greater than 60% of the vessel's maximum beam), which should be solved for every vulnerable tanker. The solutions should not be limited only to tankers subject to MARPOL.

1 This recommendation applies to a tanker which is not subject to MARPOL, Annex I, Reg. 27. [1)]

Liquid transfer operations include cargo loading and unloading, lightering, ballasting and deballasting, ballast water exchange, and tank cleaning operations.

2 Every tanker is to comply with the intact stability criteria specified in subparagraphs 2.1 and 2.2 for any operating draught reflecting actual, partial or full load conditions, including the intermediate stages of liquid transfer operations:

2.1 In port, the initial metacentric height GM_o is not to be less than 0.15m. Positive intact stability is to extend from the initial equilibrium position at which GM_o is calculated over a range of at least 20 degrees to port and to starboard.

2.2 At sea, the intact stability criteria contained in paragraphs 2.2.1 to 2.2.4 of Part A of the 2008 IS Code, or the criteria contained in the national requirements of the flag administration if the national stability requirements provide at least an equivalent degree of safety.

3 For all loading conditions in port and at sea, including intermediate stages of liquid transfer operations, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks. [2)]

4 The intact stability criteria specified in para. 2 preferably is to be met by design of the ship, i.e. the design should allow for maximum free surface effects in all cargo, ballast and consumables tanks during liquid transfer operations.

Footnotes:

[1)] Alternatively MARPOL, Annex I, Reg. 27 could be applied as a matter of equivalence.

[2)] Reference is made to LL61.

Notes:

This guideline was recategorised from BCS-R L3.

5 If the intact stability criteria specified in para. 2 are not met through design of the ship alone, the Master is to be provided with clear instructions covering the operational restrictions and methods necessary to ensure compliance with these criteria during liquid transfer operations. These instructions should be simple and concise, and:

5.1 in a language understood by the officer-in-charge of transfer operations;

5.2 require no more than minimal mathematical calculations by the officer-incharge;

5.3 indicate the maximum number of cargo and ballast tanks which may be slack under any possible condition of liquid transfer, and

5.4 provide pre-planned sequences of cargo/ballast transfer operations; which indicate the cargo and ballast tanks which may be slack to satisfy the stability criteria under any specific condition of liquid transfer, including possible range of cargo densities. The slack tanks may vary during stages of the transfer operations and be any combination which satisfied the stability criteria.

5.5 provide instructions for pre-planning other sequences of cargo/ballast transfer operations, including use of stability performance criteria in graphical or tabular form which enable comparisons of required and attained stability. These instructions for pre-planning other sequences, in relation to individual vessels, should take account of:

i) the degree of criticality with respect to the number of tanks which can simultaneously have maximum free surface effects at any stage of liquid transfer operations;

ii) the means provided to the officer-in-charge to monitor and assess the effects on stability and hull strength throughout the transfer operations;

iii) the need to give sufficient warning of an impending critical condition by reference to suitable margins (and the rate and direction of change) of the appropriate stability and hull strength parameters. If appropriate, the instructions should include safe procedures for suspending transfer operations until a suitable plan of remedial action has been evaluated.

iv) the use of on-line shipboard computer systems during all liquid transfer operations, processing cargo and ballast tank ullage data and cargo densities to continuously monitor the vessel's stability and hull strength and, when necessary, to provide effective warning of an impending critical situation, possibly automatic shut-down, and evaluation of possible remedial actions. The use of such systems is to be encouraged.

5.6 provide for corrective actions to be taken by the officer-in-charge in case of unexpected technical difficulties with recommended pre-planned transfer operations and in case of emergency situations. A general reference to the vessel's shipboard oil pollution emergency plan may be included.

5.7 be prominently displayed:

i) in the approval trim and stability booklet;
ii) at the cargo/ballast transfer control station;
iii) in any computer software by which intact stability is monitored or calculations performed;
iv) in any computer software by which hull strength is monitored or calculations performed.

BCS- G67 Test and Installation of busbar trunking systems

1. Scope

This recommendation is for the test and installation of busbar trunking systems arranged outside of switchboards for supplying section and/or distribution boards or consumers, instead of cables.

They are not recommended to be installed:

- in hazardous areas
- on the exposed weather deck

2. System design

The function of the system is to transfer electrical power; system may consist of:

- electric conductors (busbars), including neutral and earthing conductors and the insulation/isolators
- arrangements for busbars housing
- connectors and tap-off units
- bulkhead and deck penetrations
- protection devices of the busbar trunking system
- bulkhead/deckhead fixing arrangements
- separation units

3. Requirements

3.1 Basic Requirements

The safety standard and availability of ship mains designed to include such systems should

be at least equivalent to those of conventionally cabled ship mains.

3.2 Component Requirements

3.2.1 General

Systems should comply with the relevant requirements of IEC 61439-1 and IEC 61439-6.

3.2.2 Ambient Temperatures

Temperatures should be considered in the range from 0 to 45^0 C.

Note: Reference is made to BCS- R M40

3.2.3 Protection Against Foreign Bodies and Water

Systems should be designed to comply with the following minimum degrees of protection:

- dry spaces, IP 54
- wet spaces, IP 56

3.2.4 Mechanical Design

The system should be designed to withstand a vibration level of 1 mm amplitude in the frequency range of 2 Hz to 13.2 Hz and of 0.7g acceleration in the frequency range of 13.2 Hz to 100 Hz.

It should be suitable for automatic draining where condensation is possible.

The enclosure of the system should be designed to be sufficiently robust, or alternatively additionally protected, to withstand normal mechanical forces which may be expected on board ships.

3.2.5 Fire Protection, Bulkhead and Deck Penetrations

The complete system should comply with the fire test requirements as specified in IEC 60332-1-1 & IEC 60332-1-2.

Bulkhead and deck penetrations of systems should conform to categories laid down by SOLAS and are not to impair the mechanical, watertight and/or fire integrity of the bulkheads or decks through which they pass.

The internal arrangements of the ducts should have the same fire integrity arrangements as the divisions which they pierce.

3.3 System Requirements

3.3.1 Installation Configuration

Redundant essential consumers should be supplied by separate systems. The installation should be such that a failure in one system does not impair the operation of the redundant one.

Where a system is arranged below the uppermost continuous deck, the vessel’s manoeuvrability as well as the safety of the crew and passengers should not be impaired in the event of one more watertight compartments outside the engine room being flooded.

Main and emergency supply should not be installed in a common duct.

System should be fitted with means for separation to enable maintenance works and the segregation of damaged parts.

Where systems are led through fire sections, the separation units should be installed on the supply side.

3.3.2 Protection Devices

The propagation of electric arcs along the busbars should be prevented by arc barriers or other suitable means, such as, in the case of systems with uninsulated busbars, the use of current limiting circuit breakers.

4. Tests

4.1 Type Testing

At least the following tests should be carried out on a typical and representative sample:

Table 1

No.	Test	Test Procedure according to	Notes
1	Temperature rise test	IEC 61439-6	
2	Short-circuit strength test	IEC 61439-6	
3	Verification of resistance and reactance	IEC 61439-6 8.2.8	
4	Verification of structural strength	IEC 61439-6 8.2.9	See 3.2.4 above
5	Insulation resistance test for main and auxiliary circuits	BCS- R E10 test item No. 9	
6	High-voltage test for main and auxiliary circuits	BCS- R E10 test item No. 10	
7	Vibration test	BCS- R E10 test item No. 7	
8	Bulkhead and deck penetrations tests	IMO Res. A.754 (18)	Reference is also made to IMO Resolution MSC.61 (67) Annex 6
9	Fire test	IEC 60332-1-1 & IEC 60322-1-2	
10	Verification of protection degree	IEC 60529	
11	EMC tests	BCS- R E10 test item Nos. 13 to 20	Only if electronic devices form part of the system

4.2 On board survey.

The installation of the system should be to the satisfaction of the surveyor and according to documentation and installation requirements.

The survey cycle and procedure should be according to those required for switch boards (BCS- G 57).

BCS-G 68 Guidelines for non-destructive testing of hull and machinery steel forgings

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3. Volumetric Inspection
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1. General

1.1 Scope and Qualification of Personnel involved in NDT

1.1.1 This Recommendation complements the requirements for steel forgings in BCS-R W 7, BCS-R M72 and BCS-R M68, and contains general guidance for the non-destructive testing (NDT) methods, the extent of testing and the minimum recommended quality levels to be complied with unless otherwise approved or specified. The requirements contained herein may be also applied to the testing of austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings.

1.1.2 This document contains guidelines on "Surface Inspections" (Section 2) by visual examination, magnetic particle testing and penetrant testing and "Volumetric Inspection" (Section 3) by ultrasonic testing.

1.1.3 For steel forgings (e.g. components for couplings, gears, boilers and pressure vessels) other than those specified in these guidelines, the requirements in these guidelines may apply correspondingly considering their materials, kinds, shapes and stress conditions being subjected.

1.1.4 Forgings should be examined in the final delivery condition. For specific requirements see paragraphs 2.5.2 and 3.4.2.

1.1.5 Where intermediate inspections have been performed the manufacturer should provide reports of the results upon the request of the Surveyor.

1.1.6 Where a forging is supplied in semi-finished condition, the manufacturer should take into consideration the quality level of final finished machined components.

1.1.7 Where advanced ultrasonic testing methods are applied, e.g. PAUT or TOFD, reference is made to BCS-R W34 for general approach in adopting and application of these advanced methods. Acceptance levels regarding accept/reject criteria should be as per the applicable section in this Guideline.

1.1.8 Personnel carrying out NDT should be certified to a recognised national or international certification scheme, e.g. ISO 9712:2012. Personnel qualification to an employer based qualification scheme such as SNT-TC-1A, 2016 or ANSI/ASNT CP-189, 2016. Where employer based schemes are applied, personnel qualification to these schemes may be accepted if the written practice is reviewed and found acceptable by BCS. The written practice should align with the main requirements with those of ISO 9712 (apart from the impartiality requirements of a certification body).

1.1.9 The NDT personnel’s certificates and competence should comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors.

1.1.10 Certificates should be made available to BCS for verification, when requested.

1.1.11 Procedures should be approved by level III personnel for the appropriate NDT method.

1.1.12 The operator carrying out the NDT and interpreting indications, should as a minimum, be qualified and certified to Level II in the NDT method(s) concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at level I.
The operator should have adequate knowledge of materials, weld, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

2. Surface Inspections

2.1 General

2.1.1 Surface inspections in these guidelines should be carried out by visual examination and magnetic particle testing or penetrant testing, for the purpose of detecting relevant indications and assessing them against accept/reject criteria stated herein. Personnel engaged in visual examination should have sufficient knowledge and experience, however, may be exempted from formal qualification requirements in this Recommendation.

2.1.2 The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing should comply with ~~the~~ recognized national or international standards.

2.1.3 Other surface inspection methods e.g. eddy current testing, may be required by BCS as a supplementary method, e.g. for confirming the presence of indications, or for detecting the presence of undocumented weld repairs. This Guideline does not include accept/reject criteria for this purpose and is mentioned here for information only.

2.2 Products

2.2.1 The steel forgings specified in W7 should be subjected to a 100% visual examination of all accessible surfaces by the manufacturer and made available to the Surveyor. For mass produced forgings the extent of examination is to be established at the discretion of BCS.

2.2.2. It is noted that W7 does not include every forged component type that may be subject to Classification (for example, forged slewing rings). In such cases where the particular component or type is not included, either in W7 or this Guideline, appropriate national/international standards, or BCS Rules may be applied, to determine the appropriate testing regime and defect acceptance criteria.

2.2.3 Austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings acceptance criteria details are included in the appropriate sections for surface and volumetric inspections, however, other acceptance criteria and national or international standards may be applied, upon agreement with BCS.

2.2.4 Where such standards are used or referenced as a basis for accept and reject criteria, the quality level should provide reasonable equivalence to the allowable criteria stated in the appropriate tables within this Guideline. The quality levels would normally be the highest or most stringent, to provide reasonable equivalence with this Guideline.

2.2.5 Surface inspections by magnetic particle and/or penetrant methods generally apply to the following steel forgings:

(1) All crankshafts;

(2) Propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 100 mm;

(3) Cylinder heads, connecting rods, piston rods and crosshead, as per the engine type and size requirements in BCS-R M72.

(4) Bolts with minimum diameter not less than 50 mm, which are subjected to dynamic stresses such as cylinder cover bolts, coupling bolts for crankshafts, tie rods, crankpin bolts, main bearing bolts, and other items as per the engine type and size requirements in BCS-R M72.

(5) Propeller blade fastening bolts which are subjected to dynamic stresses.

2.3 Zones for Surface Inspections

2.3.1 Magnetic particle, or where permitted penetrant testing, should be carried out in zones I, II and III (as applicable), as indicated in Figures 1 to 4.

2.4 Surface Condition

2.4.1 The surfaces of forgings to be examined should be free from scale, dirt, grease or paint.

2.5 Surface Inspection

2.5.1 Where indicated by Figures 1 to 4, magnetic particle inspection should be carried out with the following exceptions, when penetrant testing would be permitted:

- austenitic and ferritic-austenitic (duplex) stainless steels;
- Interpretation of open visual or magnetic particle indications,
- at the instruction of the Surveyor.

2.5.2 Unless otherwise detailed in the specification, the magnetic particle test should be performed on a forging in the final machined surface condition and final thermally treated condition.

2.5.3 Unless otherwise agreed, the surface inspection should be carried out in the presence of the Surveyor. The surface inspection should be carried out before the shrink fitting, where applicable.

2.5.4 For magnetic particle testing, attention should be paid to the contact between the forging and the clamping devices of stationary magnetization benches in order to avoid local overheating or burning damage in its surface. Prods should not be permitted on finished machined items.

2.5.5 When indications are detected as a result of the surface inspection, acceptance or rejection is to be decided in accordance with clause 2.6.

2.6 Acceptance Criteria and Rectification of Defects

2.6.1 Acceptance Criteria Visual Inspection

2.6.1.1 All forgings should be free of cracks, crack-like indications, laps, seams, folds, or other detrimental indications. At the request of the Surveyor, additional magnetic particle, penetrant and ultrasonic testing may be required for a more detailed evaluation of surface irregularities.

2.6.1.2 The bores of hollow propeller shafts should be visually examined for imperfections uncovered by the machining operation.

2.6.2 Acceptance Criteria Magnetic Particle Testing and ~~Liquid~~ Penetrant Testing

2.6.2.1 The following definitions relevant to indications apply:

Linear indication - an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3\ w$).

Nonlinear indication - an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3w$).

Aligned indication - a) Non-linear indications form an alignment when the distance between indications is less than 2mm and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment.

b) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.

Open indication - an indication visible after removal of the magnetic particles or that can be detected by the use of penetrant testing;

Non-open indication - an indication that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing,

Relevant indication - an indication that is caused by a condition or type of discontinuity that requires evaluation. Only indications which have any dimension greater than 1.5mm shall be considered relevant for the categorization of indications.

2.6.2.2 For the purpose of evaluating indications, the surface should be divided into reference areas of 225cm^2. The area shall be taken in the most unfavourable location relative to the indication being evaluated.

2.6.2.3 The allowable number and size of indications in the reference area is given in Table1 for crankshaft forgings and in Table 2 for other forgings (including austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings), respectively. Cracks are not acceptable. Irrespective of the results of non-destructive examination, the Surveyor may reject the forging if the total number of indications is excessive.

Table 1 - Crankshaft forgings; Allowable number and size of surface indications in a reference area of 225cm^2

Inspection Zone	Max. number of indications	Type of indication	Max. number for each type	Max. dimension (mm)
I (critical fillet area)	0	Linear Nonlinear Aligned	0 0 0	- - -
II (important fillet area)	3	Linear Nonlinear Aligned	0 3 0	- 3.0 -
III (journal surfaces)	3	Linear Nonlinear Aligned	0 3 0	- 5.0 -

Table 2 - Steel forgings excluding crankshaft forgings; Allowable number and size of surface indications in a reference area of 225cm^2

Inspection Zone	Max. number of indications	Type of indication	Max. number for each type	Max. dimension (mm)
I	3	Linear Nonlinear Aligned	0[1)] 3 0[1)]	- 3.0 -
II	10	Linear Nonlinear Aligned	3[1)] 7 3[1)]	3.0 5.0 3.0

Note:

1) Linear or aligned indications should not be permitted on bolts, which receive a direct fluctuating load, e.g. main bearing bolts, connecting rod bolts, crosshead bearing bolts, cylinder cover bolts.

No. 68 (cont)

2.6.3 Rectification of Defects

2.6.3.1 Indications that exceed the requirements of Table 1 and Table 2 should be classed as defects, and should be repaired or rejected as appropriate, according to BCS Rules.

2.6.3.2 Generally it may be permissible to remove shallow indications by light grinding to a maximum depth of 1.5 mm, however, all repairs should be undertaken in accordance with BCS Rules.

2.6.3.3 Complete removal of the defect should be proved by magnetic particle testing or penetrant testing, as appropriate.

2.6.3.4 Repair welding should not be permitted for crankshafts or rotating items subjected to torsional fatigue (such as propeller shafts). Repair welding of other forgings should be subject to prior approval of BCS.

2.6.3.5 Grinding is not permitted in way of finished machined threads.

2.7 Reporting

2.7.1 Test results of surface inspections should be recorded at least with the following items:

(1) Date of testing;

(2) Name(s), signature(s) and qualification level of inspection personnel;

(3) Testing method and testing details, including procedure number;

- for penetrant testing: the penetrant system used and viewing conditions (as appropriate to the penetrant technique and media used)

- for magnetic particle testing: method of magnetizing, test media, magnetic field strength, magnetic flux indicators (where appropriate), and viewing conditions (as appropriate to the magnetizing technique and media used)

(4) Type of product;

(5) Product number and unique identification;

(6) Grade of steel;

(7) Heat treatment;

(8) Stage of testing;

(9) Position (zone) of testing;

(10) Surface condition;

(11) Test standards used, including reference to the appropriate tables for acceptance purposes;

(12) Testing condition;

(13) Results, including documentation regarding the repair and testing history (as appropriate);

(14) Statement of acceptance/non acceptance;

(15) Details of weld repair including sketch (where applicable);

3. Volumetric Inspection

3.1 General

3.1.1 Volumetric inspection in these guidelines should be carried out by ultrasonic testing using the contact method with straight beam and/or angle beam technique. Advanced UT methods (such as PAUT or TOFD) should meet the general requirements of BCS-R W34.

3.1.2 The testing procedures, apparatus and conditions of ultrasonic testing should comply with recognized national or international standards. Generally, the methods of setting test sensitivity and testing evaluation utilise the DAC (distance amplitude correction) or DGS (distance-gain size) methods. The applied methodology should use 2 to 4 MHz straight beam (or normal) probes and/or angle beam probes. For near surface testing (up to a depth of 25 mm) twin crystal 0^o probe should be used, plus a 0^o probe (usually single crystal beyond a depth of 25 mm) for the remaining volume. The appropriate acceptance criteria tables should be used, depending on the sensitivity method selected.

3.1.3 Fillet radii should be examined using 45^o, 60^o or 70^o probes, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probe(s) within this area.

3.1.4 For fabricated forgings and weld repairs, weld testing should be carried out to the appropriate standard, and the acceptance tables contained herein should not be used as a basis for acceptance criteria of welds.

3.1.5 Construction of DAC curves for normal probes should be performed using reference blocks containing suitably sized Flat Bottom Holes (FBH) spaced over the inspection thickness. Reference blocks should be manufactured from similar material, with similar surface condition to that being inspected. Where necessary, allowances should be made for attenuation losses by performing a transfer correction and adjusting the DAC curve as required. The applied transfer correction (measured in decibels (dB)) should become the new reference sensitivity, to which indications are evaluated against, according to the appropriate table contained herein.

3.2 Products

3.2.1 Volumetric inspections by ultrasonic testing generally apply to the following steel forgings:

(1) All crankshafts;

(2) Propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 200 mm,

(3) Cylinder heads, connecting rods, piston rods, crosshead, coupling bolts and studs as per the engine type and size requirements in BCS-R M72.

3.2.2. It is noted that W7 does not include every forged component type that may be subject to Classification (for example, forged slewing rings). In such cases where the particular component or type is not included, either in W7 or this Guideline, appropriate national/international standards, or BCS Rules may be applied, to determine the appropriate testing regime and defect acceptance criteria

3.2.3 Where such standards are used or referenced as a basis for accept and reject criteria, the quality level should provide reasonable equivalence to the allowable criteria stated in the appropriate tables within this Guideline. The quality levels would normally be the highest or most stringent, to provide reasonable equivalence with this Guideline.

3.2.4 Ultrasonic acceptance criteria detailed in Tables 3 to 6 are intended for C, C-Mn, and alloy steel forgings, and do not apply to austenitic stainless steel or ferritic-austenitic (duplex) stainless steel forgings. Examples of standards for acceptance criteria for stainless steel or duplex stainless steel forgings are detailed below, and quality levels should be agreed with BCS. Other national or international standards may be used, as agreed with BCS.

(i) ASTM A745 / A745M – 20

(ii) EN 10228-4:2016

3.3 Zones for Volumetric Inspection

3.3.1 Ultrasonic testing should be carried out in the zones I to III as indicated in Figures 5 to 8. Areas may be upgraded to a higher zone at the discretion of the Surveyors.

3.4 Surface Condition

3.4.1 The surfaces of forgings to be examined should be such that adequate coupling can be established between the probe and the forging and that excessive wear of the probe should be avoided. The surfaces are to be free from scale, dirt, grease or paint.

3.4.2 The ultrasonic testing should be carried out after the steel forgings have been machined to a condition suitable for this type of testing and after the final heat treatment, but prior to the drilling of the oil bores, prior to surface hardening and the machining of bolt threads. Black (or ‘as forged’) forgings should be inspected after removal of the oxide scale by either flame descaling or shot blasting methods.

3.5 Acceptance Criteria

3.5.1 Acceptance criteria of volumetric inspection by ultrasonic testing are shown in Tables 3 to 6.

3.6 Reporting

3.6.1 Test results of volumetric inspection should be recorded at least with the following items:

(1) Date of testing;

(2) Name(s) signature(s) and qualification level of inspection personnel;

(3) Testing method including procedure number, and details of the following items;

- Equipment used (instrument, probes [and any adaptions to probes for curved surfaces], calibration and refence blocks)

- Technique(s) used to set test sensitivity (including sensitivity method, specific reference blocks, reflector size, transfer correction)

- Maximum scanning rate (mm/s)

- Details of any testing restrictions

(4) Type of product;

(5) Product number and unique identification;

(6) Grade of steel;

(7) Heat treatment;

(8) Stage of testing;

(9) Position (zone) of testing;

(10) Surface condition;

(11) Test standards used, including reference to the appropriate tables for acceptance purposes;

(12) Testing condition;

(13) Results, including documentation regarding the repair and testing history (as appropriate);

(14) Statement of acceptance/non acceptance;

(15) Details of weld repair including sketch (where applicable).

Table 3 – Ultrasonic Acceptance Criteria for Crankshafts: DGS Method – Normal Probes

Type of Forging	Zone	Allowable according disc shape to DGS[1)]	Allowable length of indication	Allowable distance between two indications[2)]
Crankshaft	I II III	d≤ 1.0mm[3)] d ≤ 2.0 mm d ≤ 4.0 mm	Not applicable[4)] ≤ 10 mm ≤ 15 mm	Not applicable ≥ 20 mm ≥ 20 mm

Notes:

1) DGS: distance-gain size

2) In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications should be at least the length of the larger indication. This also applies to the distance in axial direction as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.

3) For zone 1 testing, probe selection should take into account the limits of probe beam-path length and depth of beam penetration and should normally be carried out with a minimum probe frequency of 4MHz.

4) For zone 1, indications with an echo height greater than a 1.0mm disc shaped reflector are not acceptable. Indications with an echo height of less than 1.0mm are acceptable if they are deemed as point reflectors and have no measurable length.

Table 4 –Ultrasonic Acceptance Criteria for Crankshafts: DAC Method – Normal Probes

Type of Forging	Zone	DAC reference level, based on 3.0mm FBH [1) 2), 3)]	Allowable length of indication	Allowable distance between two indications [5)]
Crankshaft	I	3.0mm DAC minus 19 dB	Not applicable[4)]	Not applicable
	II	3.0mm DAC minus 7 dB	$\leqslant$ 10.0mm	$\geqslant$ 20mm
	III	3.0mm DAC + 5 dB	$\leqslant$ 15.0mm	$\geqslant$ 20mm

Notes:

1) The requirement of a 3mm FBH is to standardise the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in Table 3, corresponding to the applicable zone.

2) Other size FBH's may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBH's are used, the ultrasonic procedure should state the equivalence using an appropriate calculation formula.

3) For zone 1 testing, probe selection should take into account the limits of probe beam-path length and depth of beam penetration and should normally be carried out with a minimum probe frequency of 4MHz.

4) For zone 1, indications with an echo height greater than the DAC reference level are not acceptable. Indications with an echo height of less than the DAC reference level are acceptable if they are deemed as point reflectors and have no measurable length.

5) In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.

Table 5 – Ultrasonic Acceptance Criteria for Shafts and Machinery Components: DGS Method -Normal Probes

Type of Forging	Zone	Allowable disc shape according to DGS[1) 2)]	Allowable length of indication	Allowable distance between two indications[3)]
Propeller shaft Intermediate shaft	II	outer: d ≤ 2 mm inner: d ≤ 4 mm	≤ 10 mm ≤ 15 mm	≥ 20 mm ≥ 20 mm
Thrust shaft Rudder stock	III	outer: d ≤ 3 mm inner: d ≤ 6 mm	≤ 10 mm ≤ 15 mm	≥ 20 mm ≥ 20 mm
Connecting rod Piston rod Crosshead	II	d ≤ 2 mm	≤ 10 mm	≥ 20 mm
	III	d ≤ 4 mm	≤ 10 mm	≥ 20 mm

Notes:

1) DGS: distance-gain size

2) Outer part means the part beyond one third of the shaft radius from the centre, the inner part means the remaining core area.

3) In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications should be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.

Table 6 – Ultrasonic Acceptance Criteria for Shafts and Machinery Components DAC Method -Normal Probes

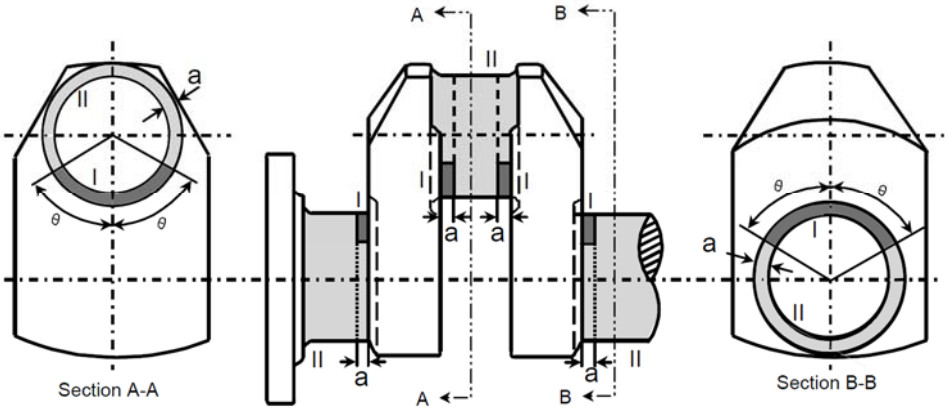
Type of Forging	Zone	DAC reference level, based on 3.0mm FBH [1) 2),]	Allowable length of indication	Allowable distance between two indications [3)]
Propeller shaft Intermediate shaft Thrust shaft Rudder stock	II	Outer : DAC minus 7 dB Inner : DAC + 5 dB	≤ 10.0mm ≤ 15.0mm	≥ 20mm
	III	Outer : + 0 DAC Inner : DAC + 12 dB	≤ 10.0mm ≤ 15.0mm	≥ 20mm
	II	Outer : DAC minus 7 dB Inner : DAC + 5 dB	≤ 10.0mm ≤ 15.0mm	≥ 20mm
	III	Outer : + 0 DAC Inner : DAC + 12 dB	≤ 10.0mm ≤ 15.0mm	≥ 20mm
Connecting rod Piston rod Crosshead	II	DAC minus 7 dB	≤ 10.0mm	≥ 20mm
	III	DAC + 5 dB	≤ 10.0mm	≥ 20mm

Notes:

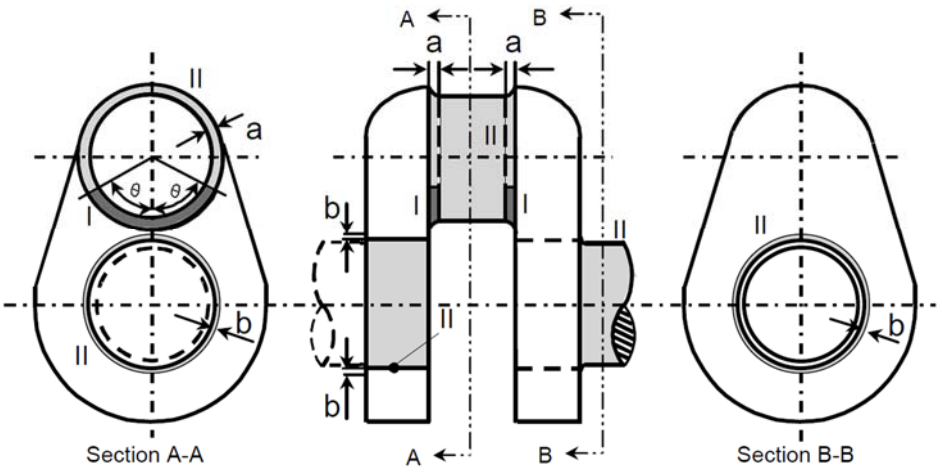
1) The requirement of a 3mm FBH is to standardise the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in Table 3, corresponding to the applicable zone.

2) Other size FBH's may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBH's are used, the ultrasonic procedure should state the equivalence using an appropriate calculation formula.

3) In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications must be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.



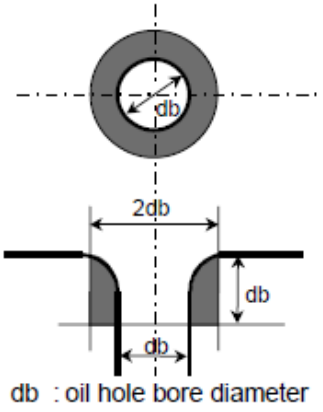
(a) Solid crankshaft



(b) Semi built-up crankshaft

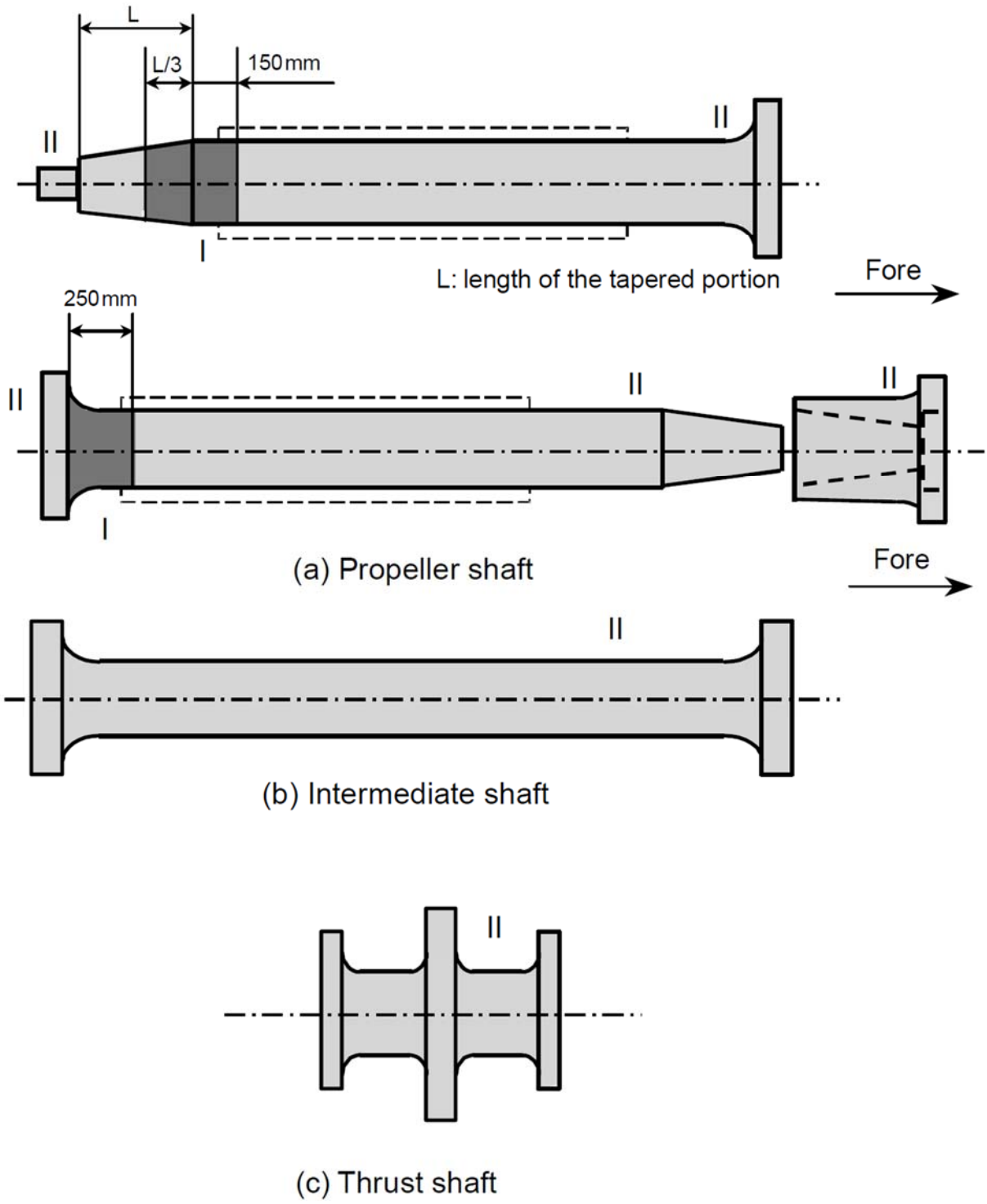
Notes)

1. Where the crankpin or journal has oil holes, the circumferential surfaces of the oil holes are to be treated as Zone I . (See the figure in the right.)
2. In the above figures, "θ", " a" and "b " mean:
   θ = 60°
   a = 1.5 r
   b = 0.05 d (: circumferential surfaces of shrinkage fit)
   where,
   r : fillet radius
   d : journal diameter
3. Identification of the Zones (Similar in Figs. 1 thru 4.) :
   : Zone I
   : Zone II
   : Zone III



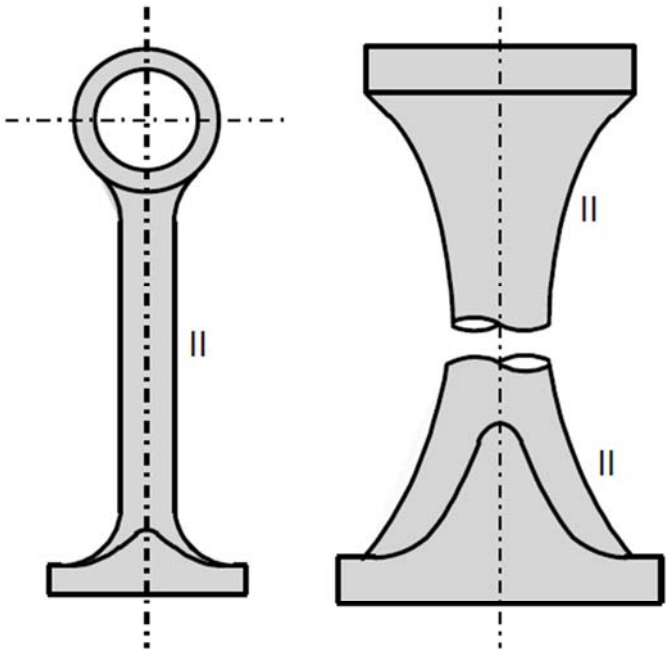
db : oil hole bore diameter

Fig.1 Zones for magnetic particle / penetrant testing on crankshafts



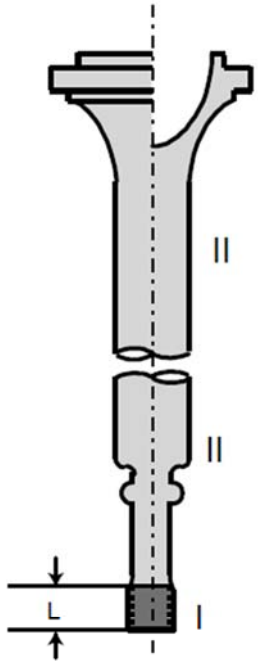
Note) For propeller shaft, intermediate shafts and thrust shafts, all areas with stress raisers such as radial holes, slots and key ways are to be treated as Zone I.

Fig. 2 Zones for magnetic particle / penetrant testing on shafts



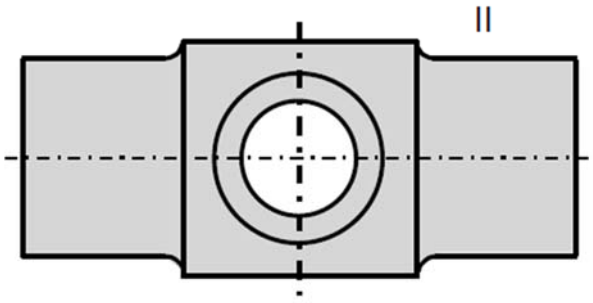
Note) Threads, holes and their circumstances are to be treated as Zone Ⅰ.

(a) Connecting rod

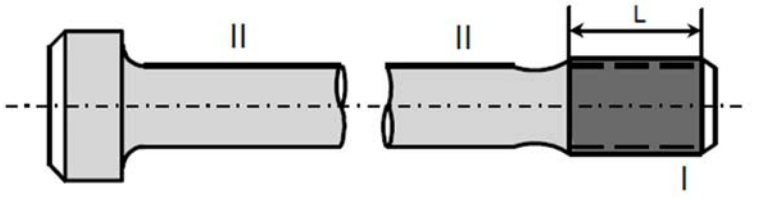


L : length of thread

(b) Piston rod



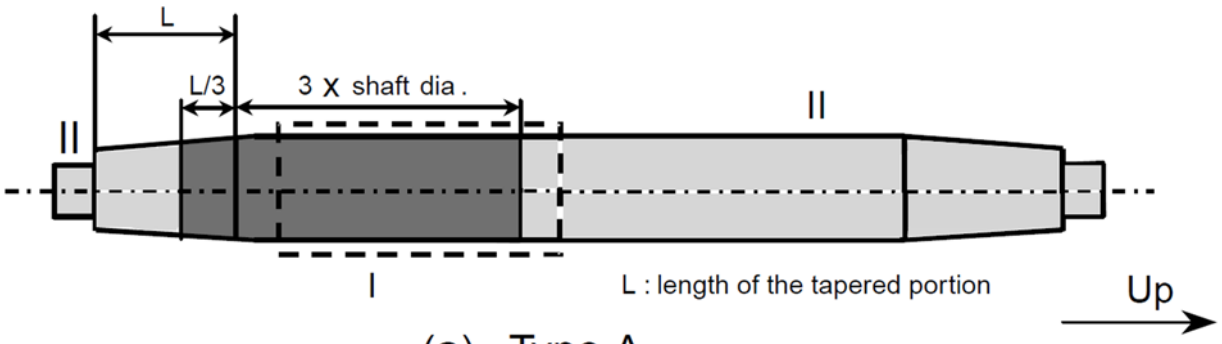
(c) Cross head



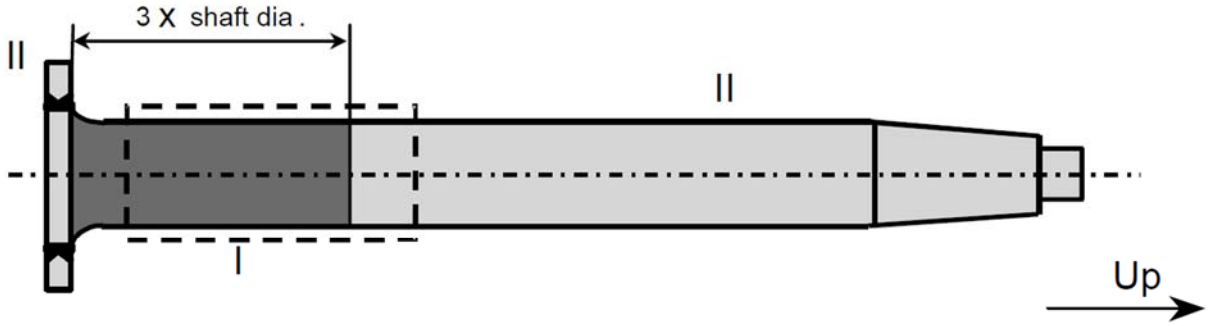
L : length of thread

(d) Bolt

Fig.3 Zones for magnetic particle / penetrant testing on machinery components

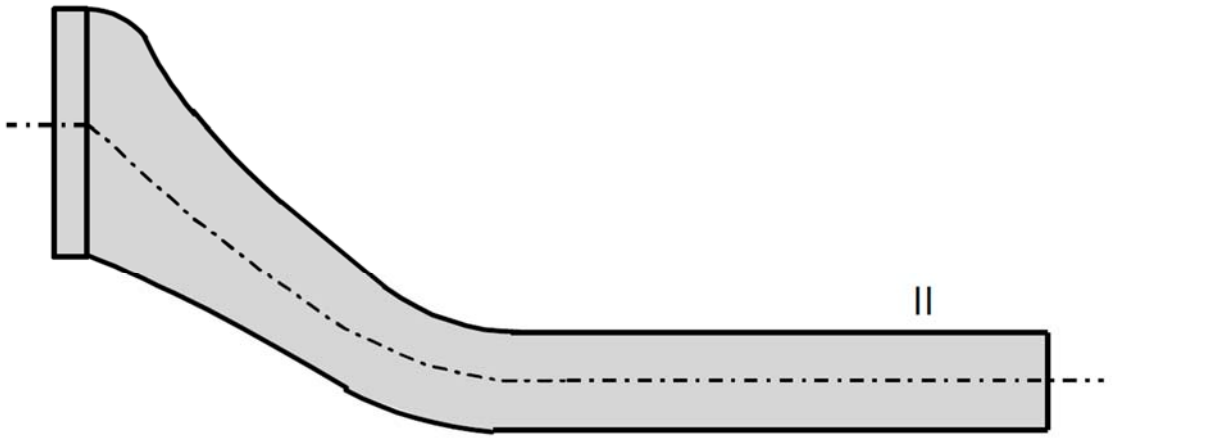


(a) Type A



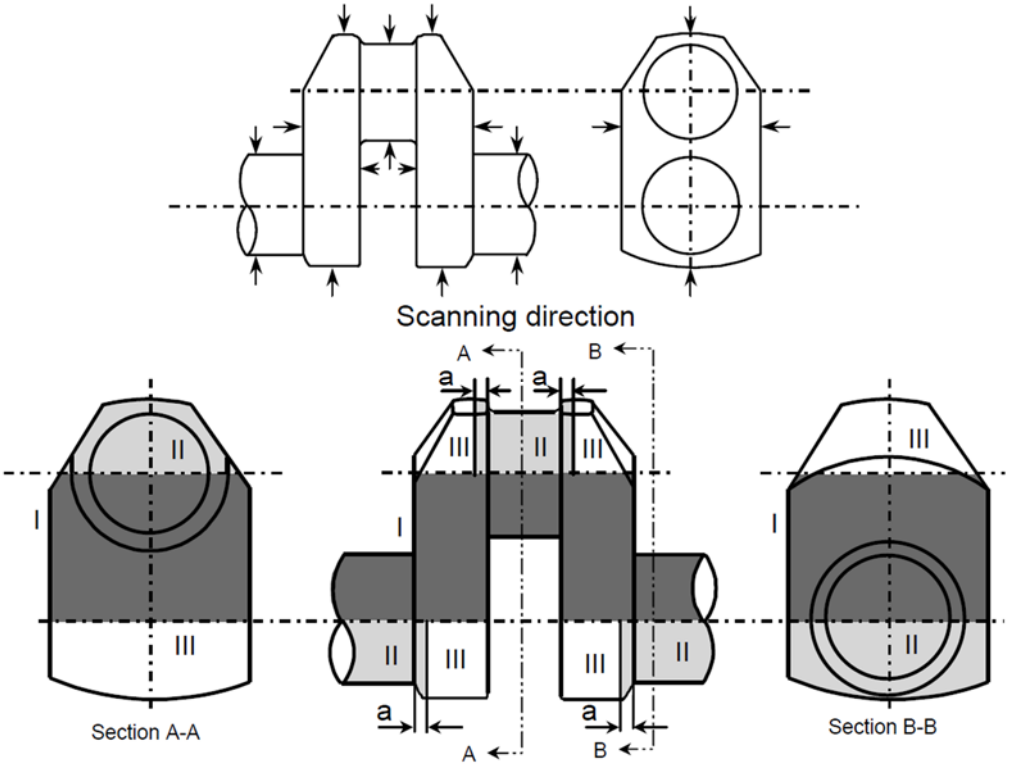
Note) Welded areas are to be treated as Zone I .

(b) Type B

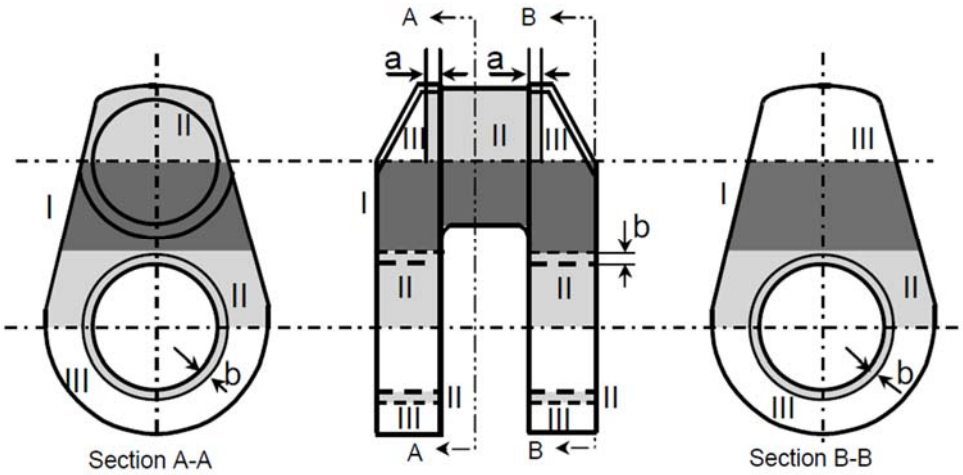


(c) Type C

Fig.4 Zones for magnetic particle / penetrant testing on rudder stocks



(a) Solid crankshaft

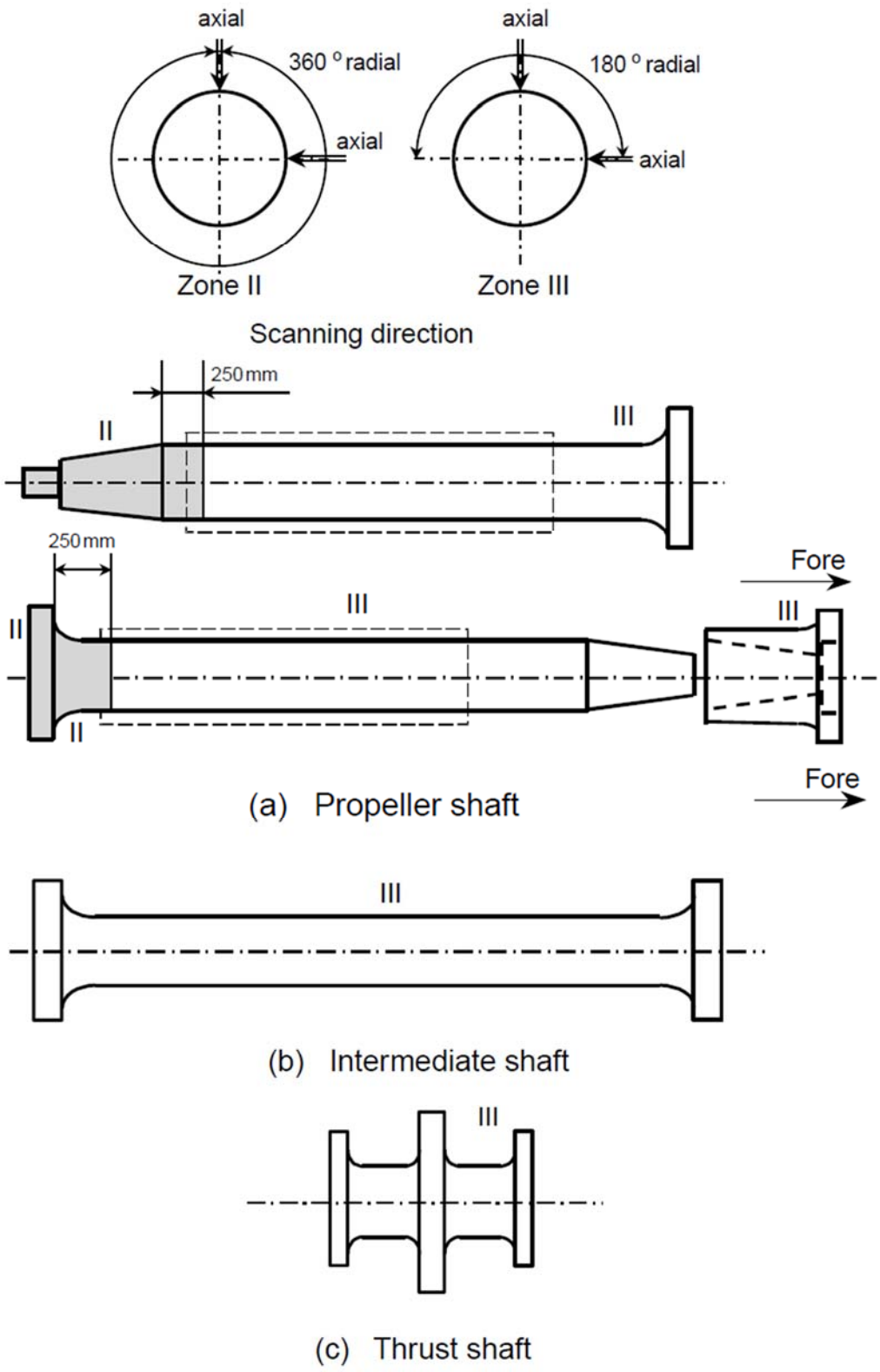


(b) Semi built-up crankshaft

Notes)

1. In the above figures, "a" and "b" mean:
   a = 0.1d or 25mm, whichever greater
   b = 0.05 d or 25mm, whichever greater (: circumstances of shrinkage fit)
   where,
   d : pin or journal diameter
2. Core areas of crank pins and/or journals within a radius of 0.25d between the webs may generally be coordinated to Zone II .
3. Identification of the Zones (Similar in Figs. 5 thru 8.) :
   : Zone I
   : Zone II
   : Zone III

Fig.5 Zones for ultrasonic testing on crankshafts



Notes)
1. For hollow shafts, 360° radial scanning applies to Zone III.
2. Circumferences of the bolt holes in the flanges are to be treated as Zone II.

Fig.6 Zones for ultrasonic testing on shafts

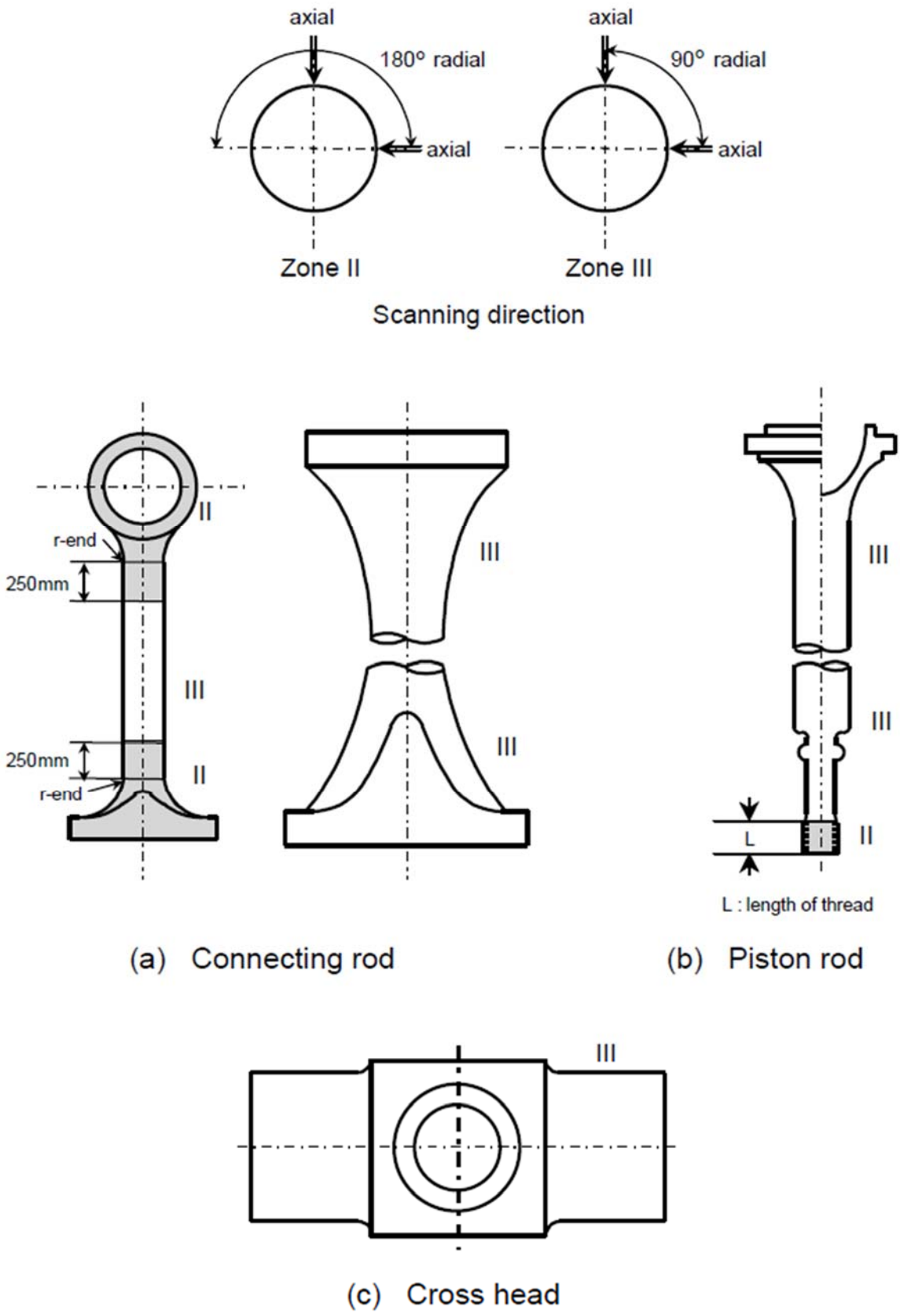


Fig.7 Zones for ultrasonic testing on machinery components

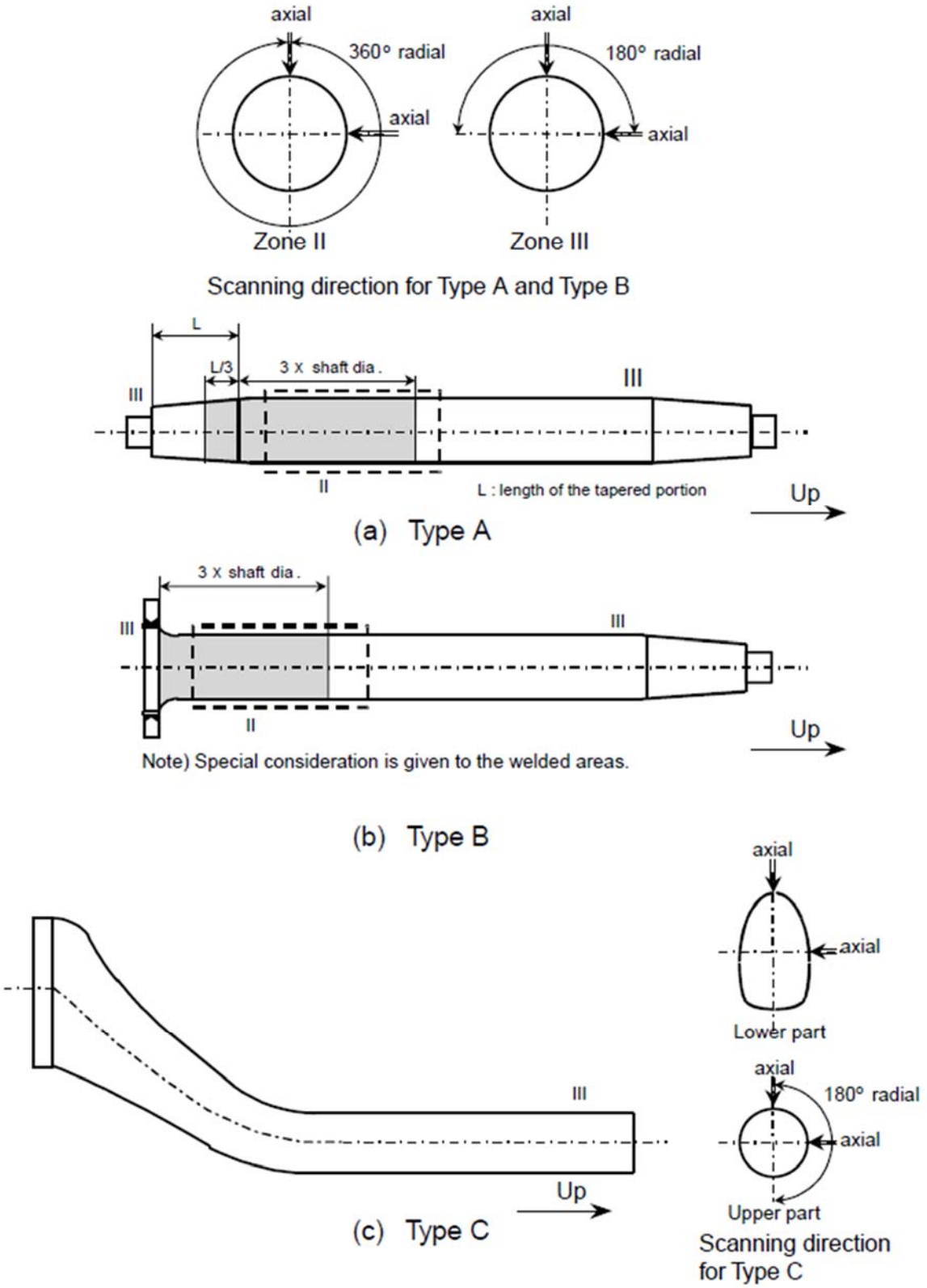


Fig.8 Zones for ultrasonic testing on rudder stocks

BCS-G69 Guidelines for non-destructive testing of marine steel castings

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Annex 1

Extent and methods of non-destructive testing to be applied to typical hull steel castings.

1. General

1.1.1 This document is intended to give general guidance on the extent, methods and recommended quality levels applicable to the non-destructive testing (NDT), of marine steel castings, except in those cases where alternative criteria have been otherwise approved or specified.

1.1.2 Although no detailed guidelines are given for machinery components, the requirements in these guidelines may apply correspondingly considering their materials, kinds, shapes and stress conditions being subjected.

1.1.3 Castings intending to be examined by NDT methods are identified in Annex 1 to this document. The list of castings is not definitive. Criteria for the inspection of other castings not listed in Annex 1 will be subject to agreement.

1.1.4 BCS-R W8 or this Guideline do not include every cast component type that may be subject to Classification. In such cases where the particular component or type is not included, appropriate national/international standards, or other Society requirements may be applied, to determine the appropriate testing regime and defect acceptance criteria.

1.1.5 These guidelines complement and reference the requirements of the following BCS-R's - BCS-R W8, BCS-R W22, BCS-R W29, TLR A1 and BCS-R W34, and contain general guidance for the non-destructive testing methods, the extent of testing and the minimum recommended quality levels that should be complied with unless otherwise approved or specified.

1.1.6 Castings should be examined in the final delivery condition

1.1.7 Where intermediate inspections have been performed the manufacturer should provide reports of the results upon the request of the Surveyor.

1.1.8 Where a casting is supplied in semi-finished condition, the manufacturer should take into account the quality level of final finished machined components.

1.1.9 Where advanced ultrasonic testing methods are applied, e.g. PAUT or TOFD, reference is made to BCS-R W34, for general approach in adopting and application of these advanced methods. Acceptance levels regarding accept/reject criteria are specified in the applicable section in this Guideline.

2. Qualification of Personnel involved in NDT

2.1 Qualifications

2.1.1 Personnel engaged in visual examination are to have sufficient knowledge and experience, however, may be exempted from formal qualifications specified in this Recommendation.

2.1.2 Personnel carrying out NDT should be certified to a recognised national or international certification scheme, e.g. ISO 9712:2012, or an employer based scheme such as SNT-TC-1A: 2016, or ANSI/ASNT CP-189: 2016. Where employer based schemes are applied, personnel qualification to these schemes may be accepted if the written practice is reviewed and found acceptable by **BCS**. The written practice should align with the main requirements with those of ISO 9712 (apart from the impartiality requirements of a certification body).

2.1.3 Personnel responsible for the NDT activity including approval of procedures should be qualified and certified to Level III.

2.1.4 The NDT personnel's certificates and competence should comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors. Certificates should be made available to BCS for verification, when requested.

2.1.5 The operator carrying out the NDT and interpreting indications, should, as a minimum, be qualified and certified to Level II in the NDT method(s) concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at level I.

The operator should have adequate knowledge of materials, weld, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

3. Casting Condition

3.1 Heat Treatment

Non-destructive testing applied for acceptance purposes to support final casting certification should be made after the final heat treatment of the casting. Where intermediate inspections have been performed the manufacturer should provide reports of the results upon request of the Surveyor.

3.2 Surface Condition

3.2.1 Castings should be examined in the final delivery condition free from any material such as scale, dirt, grease or paint that might affect the effectiveness of the inspection. A thin coating of contrast paint is permissible when using magnetic particle techniques. For surface inspection NDT methods, the surface quality should be a minimum value of R_a ≤6.3 µm

3.2.2 Ultrasonic testing should be carried out after the castings have been ground, machined or shot blasted to a suitable condition, with a minimum value surface quality of R_a ≤12,5 µm. The surfaces of castings to be examined should be such that adequate coupling can be established between the probe and the casting and that excessive wear of the probe is avoided.

4. Extent of Inspections

4.1 Zones to be examined

4.1.1 Zones to be examined in nominated castings are identified in Annex 1. Testing should be made in accordance with an inspection plan approved by BCS. The plan should specify the extent of the testing, the testing procedure, the quality level or, if necessary, level for different locations of the castings.

4.1.2 In addition to the areas identified in Annex 1, surface inspections should be carried out in the following locations:

- at all accessible fillets and changes of section,

- in way of fabrication weld preparation, for a band width of 30mm,
- in way of chaplets,
- in way of weld repairs,
- at positions where surplus metal has been removed by flame cutting, scarifying or arc-air gouging.

4.1.3 Ultrasonic testing should be carried out in the zones indicated in Annex 1 and also at the following locations:

- in way of all accessible fillets and at pronounced changes of section,
- in way of fabrication weld preparations for a distance of 50mm from the edge,
- in way of weld repairs where the original defect was detected by ultrasonic testing.
- in way of riser positions,
- in way of machined areas particularly those subject to further machining such as bolt hole positions.

4.1.4 In the case of castings such as rudder horns, which may have a large surface area still untested after the above inspections have been applied, an additional ultrasonic inspection of the untested areas should be made along continuous perpendicular grid lines on nominal 225 mm centres, scanning from one surface only.

5. Examination Procedures

5.1 Visual Inspection

5.1.1 Steel castings nominated for NDT should be subjected to a 100% visual examination of all accessible surfaces by the manufacturer and made available to the Surveyor. Viewing conditions at the inspected surfaces should be in accordance with a nationally or internationally recognised standard. Unless otherwise agreed, the visual and surface inspections should be carried out in the presence of the Surveyor.

5.2 Surface Inspection

5.2.1 The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing should comply with recognised national or international standards. Magnetic particle testing is preferable to penetrant testing except in the following cases;

- austenitic stainless steels,
- interpretation of open visual or magnetic particle indications,
- at the instruction of the Surveyor, where a particular need for penetrant testing has been identified.

5.2.2 For magnetic particle testing, attention is to be paid to the contact between the casting and the clamping devices of stationary magnetisation benches in order to avoid local overheating or burning damage in its surface. Prods should not be permitted on finished machined items. Note that the use of solid copper at the prod tips must be avoided due to the risk of copper contamination into the casting. The pole of the magnets should have close contact with the component.

5.2.3 AC magnetisation method should normally be used, as it is more sensitive for detecting surface indications. Where DC magnetisation method is used, this should be in agreement with BCS, and the reason for use clearly stated.

5.2.4 When indications have been detected as a result of the surface inspection, acceptance or rejection should be decided in accordance with Section 6.

5.3 Volumetric Inspection

5.3.1 Volumetric inspection in accordance with these guidelines is normally to be carried out by ultrasonic testing using the contact method with normal (0°) beam and/or angle beam technique. The testing procedures, apparatus and conditions of ultrasonic testing should comply with the recognised national or international standards.

5.3.2 In some cases, due to the shape, nature, complexity of casting, or defect type or orientation, there may be a need for radiographic testing. In such cases, radiographic testing may be carried out on the basis of prior agreement with BCS. Where radiographic testing is to be applied, national or international standards for both the testing method, and the quality or severity level to be applied, should be agreed with BCS.

Guidance on standards:

- ASTM E446 – 15
- ASTM E186 – 15 (2019) e1
- ASTM E280 – 15 (2019) e1
- ISO 4993:2015

These examples are suitable national or international standards as appropriate to the radiographic testing of castings, and casting thickness.

A suitable quality level for marine castings would normally be severity level 2 or 3 (of the above standards), depending on the location zone and type of casting. Other severity levels may be applied, and should be agreed with BCS.

5.3.3 Only those areas shown in the agreed inspection plan should be tested, however, the inspections may reveal indications that require further evaluation or an extension of testing. In such cases, this should be agreed with BCS. The plan should include those locations nominated in section 4.2.3 together with the scanning zones identified for the relevant casting in Annex 1.

5.3.4 Ultrasonic scans should be made using a 0º probe of 1 - 4MHz (usually 2MHz) frequency, and angle probes, where required. Whenever possible scanning is to be performed from both surfaces of the casting and from surfaces perpendicular to each other.

5.3.5 The backwall echo obtained on parallel sections should be used to monitor variations in probe coupling and material attenuation. Any reduction in the amplitude of the back wall echo due to material properties should be corrected. Attenuation in excess of 30dB/m could be indicative of an unsatisfactory annealing heat treatment and may render the effectiveness of the testing as unsuitable. In such cases of excessive attenuation, this should be investigated, and suitable mitigation measures carried out for effective ultrasonic testing to continue, where possible.

5.3.6 Machined surfaces, especially those in the vicinity of riser locations and in the bores of stern boss castings, should also be subject to a near surface (approximately 25mm) scan using a twin crystal 0º probe.

Additional scans on machined surfaces are of particular importance in cases where boltholes are to be drilled or where surplus material such as 'padding' has been removed by machining thus moving the scanning surface closer to possible areas of shrinkage.

Additionally, it is good practice to examine the machined bores of castings using circumferential scans with 70º probes in order that axial radial planar flaws such as hot tears can be detected. Fillet radii should be examined using 45º, 60º, or 70º probes scanning from the surfaces/direction likely to give the best reflection, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probe(s) within this area.

5.3.7 In the examinations of those zones nominated for ultrasonic examination the reference sensitivity for the 0° probe should be established against a 6mm reflector. Sensitivity can be calibrated either against 6mm diameter flat bottomed hole(s) in a reference block (or series of blocks) corresponding to the thickness of the casting provided that a transfer correction is made, using the DAC (distance-amplitude-correction) method, or by using the DGS (distance-gain-size) method.

5.3.8 The reference sensitivity of angle probes (where required for testing) should be established against an appropriate 6mm reflector (e.g. reference reflectors angled perpendicular to the sound beam) for the DAC method, or equivalent using the DGS method.

5.3.9 The DGS diagrams issued by a probe manufacturer identify the difference in dB between the amplitude of a back wall echo and that expected from a 6mm diameter disk reflector. By adding this difference to the sensitivity level initially set by adjusting a back wall echo to a reference height e.g. 80%, the amended reference level will be representative of a 6mm diameter disk reflector. Similar calculations can be used for evaluation purposes to establish the difference in dB between a back wall reflector and disk reflectors of other diameters such as 12 or 15 mm.

5.3.10 Having made any necessary corrections for differences in attenuation or surface condition between the reference block and the casting, any indications received from the nominated zones in the casting that exceed the 6mm reference level should be marked for evaluation against the criteria given in 6.3 below. Evaluation should include additional scans with angle probes in order that the full extent of the discontinuity can be plotted.

6. Acceptance Criteria

6.1 Visual Inspection

6.1.1 All castings should be free of cracks, crack-like indications, hot tears, cold shuts or other detrimental indications. Thickness of the remains of sprues or risers should be within the casting dimensional tolerance.

6.1.2 Additional magnetic particle, penetrant or ultrasonic testing may be required for a more detailed evaluation of surface irregularities at the request of the Surveyor.

6.2 Surface Inspection

6.2.1 The following definitions relevant to indications apply:

- Linear indication = an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3\ w$).

- Non-linear indication = an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3w$).

- Aligned indication = three or more indications in a line, separated by 2mm or less edge-to-edge, which results in a unique indication, defined as follows:

  a) Non-linear indications form an alignment when the distance between indications is less than 2mm and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment.

  b) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.

- Open indication = an indication visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.

- Non-open indication = an indication that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing.

- Relevant indication = an indication that is caused by a condition or type of discontinuity that requires evaluation. Only the indications which have any dimension greater than 1.5mm should be considered relevant for the categorization of indications.

6.2.2 For the purpose of evaluating indications, the surface should be divided into reference band length of 150 mm for level MT1/PT1 and into reference areas of 22500mm^2 for level MT2/PT2. The band length and/or area should be taken in the most unfavourable location relative to the indications being evaluated.

6.2.3 The following quality levels recommended for magnetic particle testing (MT) and/or penetrant testing (PT) are;

Level MT1/PT1 - fabrication weld preparation and weld repairs.

Level MT2/PT2 - other locations nominated for surface inspection in Annex 1.

The allowable numbers and sizes of indications in the reference band length and/or area are given in Table 1. The required quality level should be shown on the

manufacturer's inspection plan. Cracks and hot tears should not be accepted.

Table 1 Allowable number and size of indications in a reference band length/area

Quality Level	Total maximum number of all indications	Type of indication	Maximum number of each type of indication	Maximum dimension, (e.g. width, length, diameter) of single indication, mm [2)]
MT1/PT1	4 in 150 mm length	Non-linear	4[1)]	5
		Linear	4[1)]	3
		Aligned	4[1)]	3
MT2/PT2	20 in 22500 mm^2 area	Non-linear	10	7
		Linear	6	5
		Aligned	6	5
Notes: 1) 30 mm minimum (measured in any direction) between relevant indications, 2) In weld repairs, the maximum dimension is 2mm.				

6.3 Volumetric Inspection

6.3.1 Acceptance criteria for ultrasonic testing are identified in Table 2 as UT1 and UT2. As stated in 4.2.1 the quality levels applicable to the zones to be examined should be identified on an inspection plan. The following quality levels are nominated for the castings identified in Annex 1.

Level UT1 is applicable to:

- fabrication weld preparations for a distance of 50mm,
- 50mm depth from the final machined surface including boltholes,
- fillet radii to a depth of 50mm and within distance of 50mm from the radius end,
- castings subject to cyclic bending stresses e.g. rudder horn, rudder castings and rudder stocks - the outer one third of thickness in the zones nominated for volumetric inspection by Annex 1,
- discontinuities within the examined zones interpreted to be cracks or hot tears.

Level UT2 is applicable to:

- other locations nominated for ultrasonic testing in Annex 1 or on the inspection plan.
- positions outside locations nominated for level UT1 inspection where feeders and gates have been removed.

- castings subject to cyclic bending stresses - at the central one third of thickness in the zones of nominated for volumetric inspection by Annex 1.

6.3.2 For near surface testing (to an approximate depth of 25 mm) twin crystal 0° (normal beam) probe should be used, plus a 0° probe (usually single crystal beyond a depth of 25 mm) for the remaining volume.

6.3.3 Ultrasonic acceptance criteria for other casting areas not nominated in Annex 1 should be subject to special consideration based on the anticipated stress levels and the type, size and position of the discontinuity.

6.3.4 Table 2 describes the acceptance criteria for both methods of applied sensitivity (DGS and DAC)

6.3.5 DGS and DAC methods may be used for determining sensitivity. The DAC method for normal beam probes may be based on a 6.0mm diameter reflector or flat bottomed hole (FBH). A DAC curve should be produced using reference blocks containing 6.0mm FBH reflectors over a range representative of the inspection thickness, after adjustment for transfer and attenuation losses,

6.3.6 For quality level UT 1, any discontinuity producing a signal amplitude in excess of the 6.0 mm DAC curve is unacceptable.

6.3.7 For quality level UT2, the sensitivity may be based on actual size FBH (of 12mm and 15 mm) or based on equivalent 6mm FBH, and the sensitivity adjusted to obtain equivalent amplitudes, as described in 6.3.8.

6.3.8 For use of FBH of 6mm for setting sensitivity, adjustment of signal amplitudes (measured in dB above 6mm DAC) can be determined for 12mm and 15mm FBH reflectors: to be DAC + 12dB and DAC + 16dB (plus any compensation for transfer and attenuation losses). This is illustrated in Figure 1. The increase in dB to the indicated levels represent the equivalent FBH sizes (for 12 mm and 15mm), and their respective corresponding ultrasonic response amplitudes.

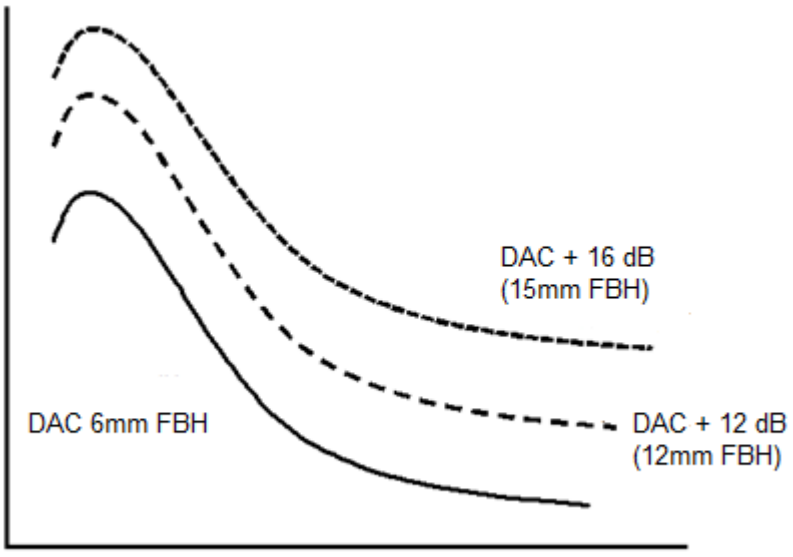


Figure 1 DAC curve produced from 6.0mm FBH reflector and DAC curves adjusted to represent equivalent 12.0mm and 15.0mm FBH reflectors.

Explanatory note for DAC and Figure 1:

The bottom curve (DAC) represents a sensitivity based on 6mm FBH, and the two additional curves (DAC + 12 and DAC + 16dB) above this represent the equivalent sensitivities converted for larger FBH's (12mm and 15mm).

When scanning using these curves, and applying Table 2 acceptance criteria, for UT2, any indication below DAC +12mm should be disregarded, and any indication above DAC +16mm should be rejected.

Any indication between these two curves should be evaluated according to its size, as per Table 2.

Table 2 Ultrasonic Acceptance Criteria for steel castings – Using DGS or DAC system

Quality Level	Allowable disc shape according to DGS[1)] [mm] or diameter of FBH according to DAC[2), 3)] Curve [mm]	Maximum number of indications to be registered [4)]	Allowable size of all relevant indications [mm][5),6)]
UT1	>6	0	0
UT2	12-15 >15	5 0	50 0

Notes:

1) DGS: distance-gain size.

2) DAC: Distance Amplitude Correction

3) The corresponding DAC level to each of the FBH reflectors is at 100% DAC

4) grouped in an area measuring 300 x 300 mm

5) measured on the scanning surface

6) the measured indication is regarded as the longest dimension, as measured in the scanning process

6.3.9 The maximum number of indications to be registered and the maximum length of indications permissible for quality level 2 (as stated in Table 2) apply to normal probes.

6.3.10 For quality level UT 2, any discontinuity producing a signal amplitude in excess of the 15.0 mm DAC curve should be regarded as unacceptable.

6.3.11 Any signal between 12 + 15 curve should be evaluated for length of defect, and referred to table 2 for acceptance

7. Reporting

7.1 General

All reports of non-destructive examinations should include the following items;

(1) Date of testing.

(2) Name(s), signature(s) and qualification level of inspection personnel.

(3) Type of casting.

(4) Product number and unique identification.

(5) Grade of steel.

(6) Heat treatment.

(7) Stage of testing.

(8) Locations for testing.

(9) Surface condition.

(10) Test standards used~~.~~ including reference to the appropriate tables for acceptance purposes

(11) Results, including documentation regarding the repair and testing history (as appropriate);

(12) Statement of acceptance / non-acceptance.

(13) Locations of reportable indications.

(14) Details of weld repairs including sketches (where applicable).

7.2 In addition to the items listed in 7.1, reports of surface inspections should include at least the following items:

- for penetrant testing; the penetrant system used,
- for magnetic particle testing: method of magnetising, test media and magnetic field strength and magnetic flux indicators (where appropriate).
- viewing conditions (as appropriate to the penetrant or magnetic technique and media used)
- testing details and procedure number
- details of any test restrictions

7.3 In addition to the items listed in 7.1, reports of ultrasonic inspection should include at least the following items:

- flaw detector, probe type, size, angle and frequency (and any adaptions to probes for curved surfaces), calibration and reference blocks, sensitivity method (including reflector size, transfer correction), maximum scanning rate (mm/s), and couplant.

8. Rectification of Defects

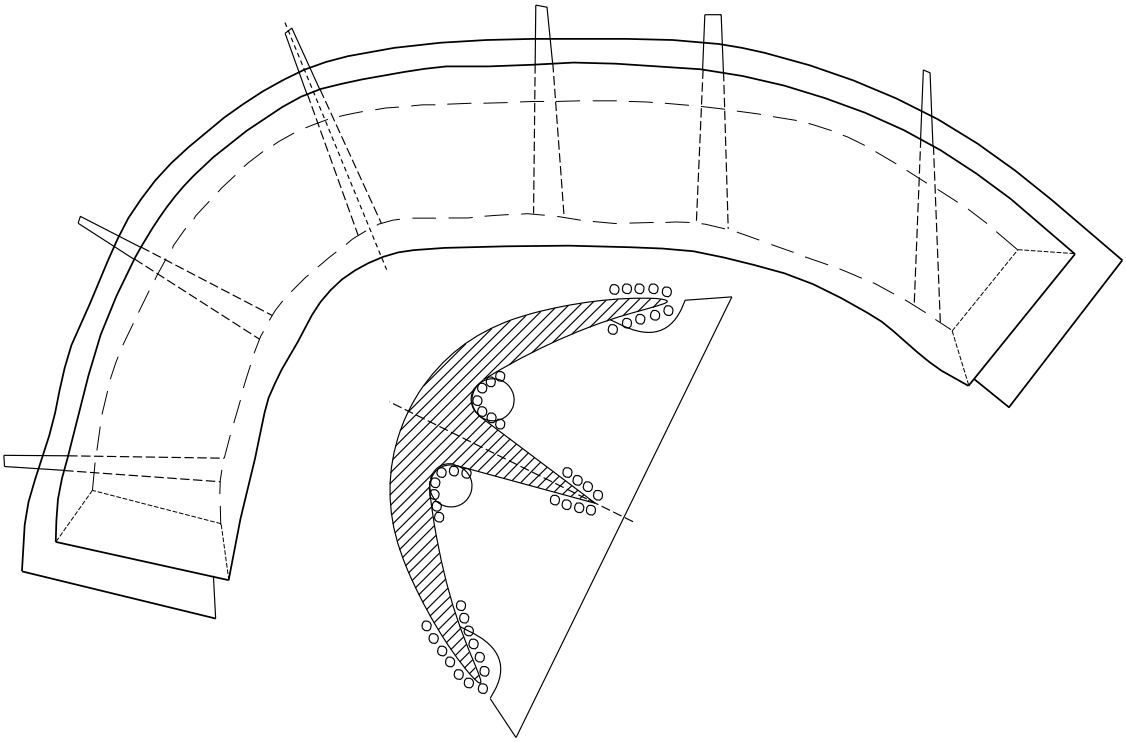
8.1 Indications that exceed the requirements of Table 1 and Table 2, should be classed as defects, and should be repaired or rejected as appropriate, according to BCS Rules.

8.2 Generally it may be permissible to remove shallow indications by light grinding, however, all repairs should be undertaken in accordance with BCS Rules.

8.3 Complete removal of the defect should be proved by magnetic particle testing or penetrant testing, as appropriate.

8.4 Castings which are repaired should be examined by the same method as at initial inspection, as well as by any additional methods as requested by the Surveyor.

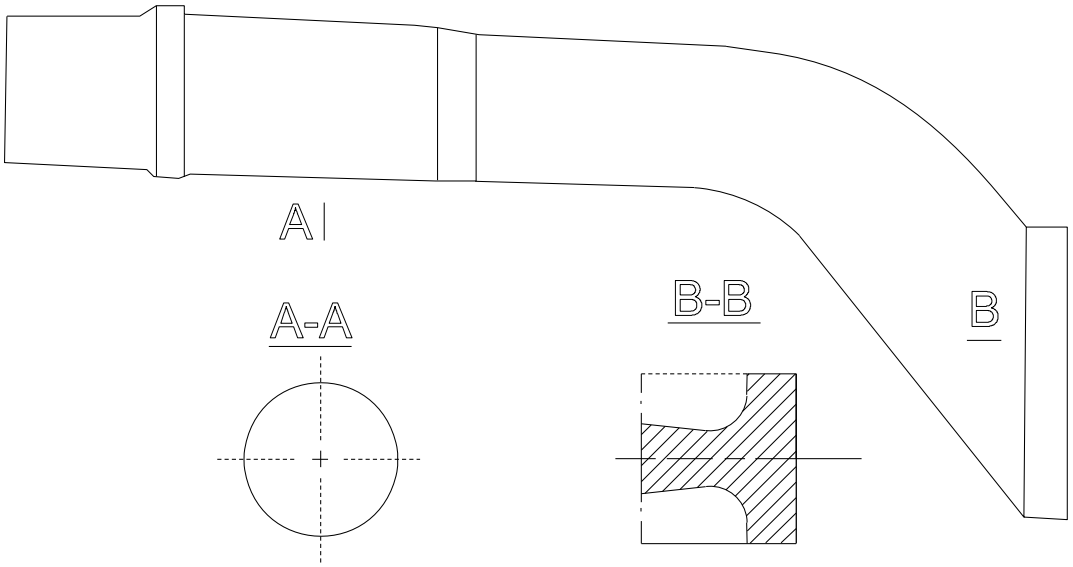
Annex 1 Extent and methods of non-destructive testing that should be applied to typical hull steel castings



Notes: Location of non-destructive examination

1) All surfaces: Visual examination
2) Location indicated with (OOO): Magnetic particle and Ultrasonic testing
3) The detailed extents of examinations and quality levels are given in Sections 4 and 6.

Fig. A1 Stern Frame

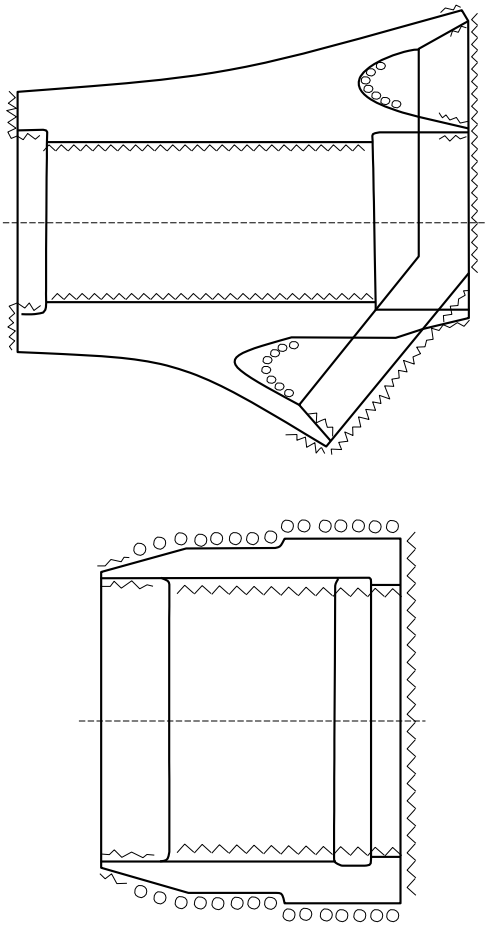


Notes: Location of non-destructive examination

1) All surfaces: Visual examination.
Magnetic particle and Ultrasonic testing.

2) The detailed extents of examinations and quality levels are given in Sections 4 and 6.

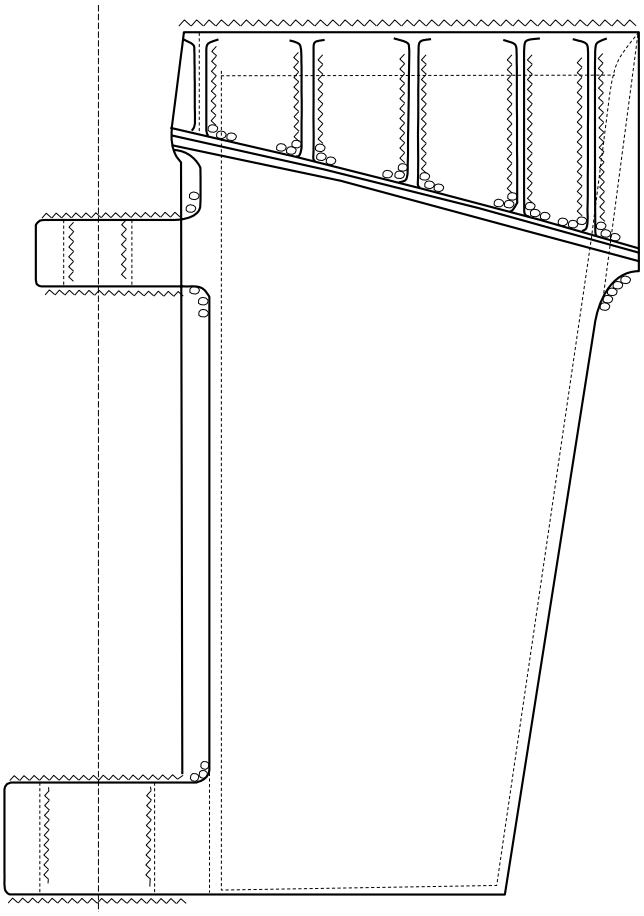
Fig. A2 Rudder stock



Notes: Location of non-destructive examination

1) All surfaces: Visual examination
2) Location indicated with (OOO): Magnetic particle and Ultrasonic testing
3) Location indicated with (^^^^): Ultrasonic testing
4) The detailed extents of examinations and quality levels are given in Sections 4 and 6.

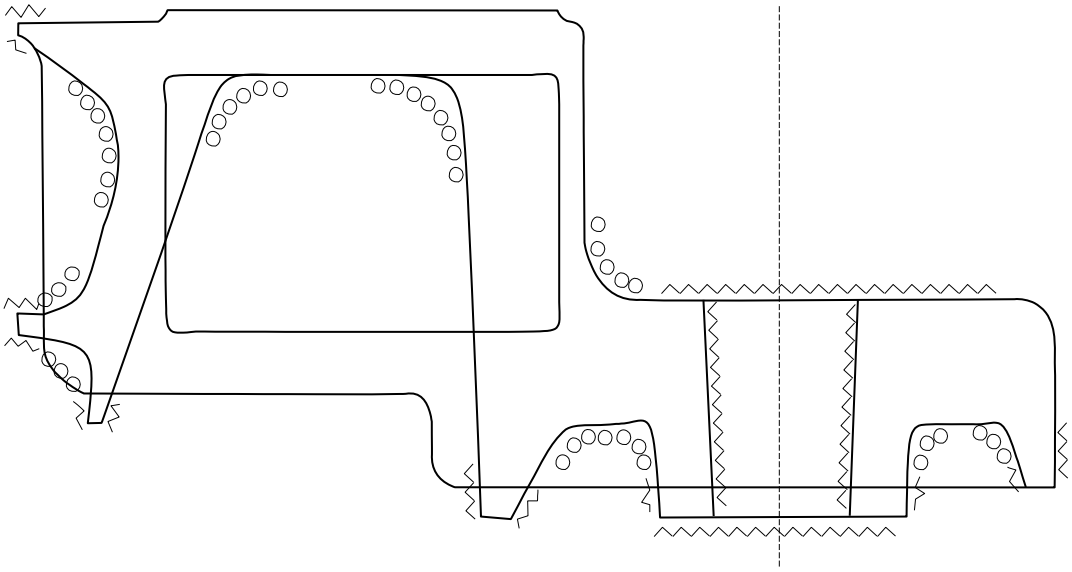
Fig. A3 Stern Boss



Notes: Location of non-destructive examination

1) All surfaces: Visual examination
2) Location indicated with (OOO): Magnetic particle and Ultrasonic testing
3) Location indicated with (^^^^): Ultrasonic testing
4) The detailed extents of examinations and quality levels are given in Sections 4 and 6.

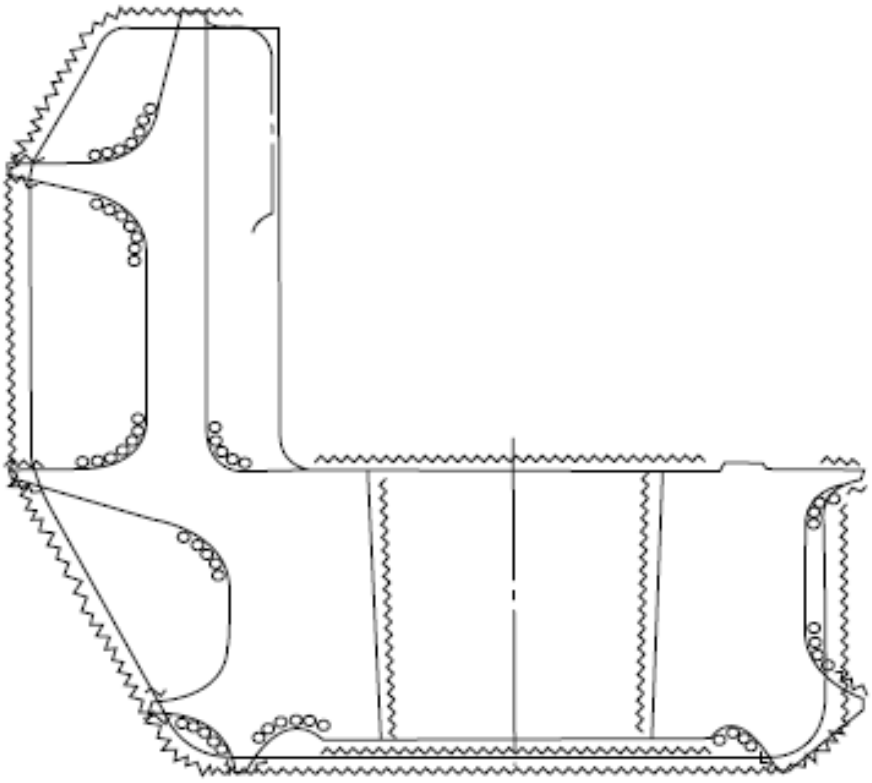
Fig. A4 Rudder Hangings



Notes: Location of non-destructive examination

1) All surfaces: Visual examination
2) Location indicated with (OOO): Magnetic particle and Ultrasonic testing
3) Location indicated with (∧∧∧∧): Ultrasonic testing
4) The detailed extents of examinations and quality levels are given in Sections 4

Fig. A5 Rudder (Upper Part)



Notes: Location of non-destructive examination

1)	All surfaces:	Visual examination
2)	Location indicated with (OOO):	Magnetic particle and Ultrasonic testing
3)	Location indicated with (ʌʌʌʌ):	Ultrasonic testing
4)	The detailed extents of examinations and quality levels are given in Sections 4 and 6.	

Fig. A6 Rudder (Lower Part)

BCS-G 70 Guidelines on welding procedure qualification tests of aluminium alloys for hull construction and marine structures

1. Scope of application

This document gives general guidance for the qualification tests of the welding procedures intended to be used for the aluminium alloys for hull construction and marine structures specified in the BCS-R W25.
This document specifically excludes the welding procedure intended for LNG containment.

2. Welding procedure

2.1 Welding processes

The welding processes below indicated, together with their relevant numbering according to ISO 4063:2009, are in general used for welding aluminium alloys.

- 131 - metal-arc inert gas welding (MIG welding)
- 141 - tungsten inert gas arc welding (TIG welding)
- 15 - plasma arc welding

2.2 Welding consumable

The welding consumables should be approved in accordance with the requirements specified in BCS-R W 26.
Where non approved welding consumables are used at the discretion of BCS, the requirements for the qualification of the welding procedures should be established on a case by case basis. In general additional tests on deposited weld metal are required in accordance with BCS-R W26.

2.3 Welding procedure specification

A welding procedure specification should be prepared by the shipyard or manufacturer and proposed for acceptance; this document is also referred to as preliminary welding procedure specification (pWPS) and can be modified and amended during the procedure tests as deemed necessary.

In its final version the welding procedure specification (WPS) should be used as a basis for the production welds and should include all the parameters characterizing the welding process, in particular:

- type of welding process and equipment as appropriate
- type of joint, preparation and backing material, if any
- parent metal and thickness range
- welding consumable
- welding position/s
- minimum pre-heat and maximum interpass temperature
- postweld heat treatment if applicable
- shielding gas
- welding parameters
- other information relevant to the welding procedure as applicable.

2.4 Welding procedure qualification

Welding procedure tests, according to the proposed pWPS, should be carried out for the qualification of the welding procedure.

The test pieces should be chosen so as to cover all the production welds in accordance with the range of approval given in clause 5.

The actual parameters used for welding the qualification test pieces and the results of the inspection and tests carried out should be recorded in the WPAR (welding procedure approval record).

The qualification tests (welding and testing) should be witnessed by the Surveyor.

The WPAR should in general be issued by the shipyard or manufacturer and should be signed by the Surveyor.

2.5 Certificate of approval of the welding procedure

Upon the satisfactory completion of the qualification tests, a certificate of approval of the welding procedure should in general be issued by BCS to the shipyard or manufacturer stating the conditions of the approval of the WPS such as thickness range, positions, type of Al alloy/ s, welding consumable, etc.

3. Qualification of welding procedures

3.1 Butt weld

3.1.1 Assembly and welding

The test pieces should be of sufficient size to ensure a reasonable heat distribution during welding and to provide for the required test specimens, after sufficient discard at the ends, see Fig. 1.

The edge preparation and fit up should be in accordance with the pWPS.

If tack welds are to be fused into the production joint they should be included in the test pieces.

The test assembly should have the following minimum size:

- manual and semiautomatic welding: length L = 350 mm; width W = 300 mm,
- automatic welding: length L = 1000 mm; width W = 400 mm.

The cleaning of the parts to be welded should be carried out in accordance with the welding procedure.

The welding should be carried out in accordance with the pWPS and under the general conditions of production welding which it represents.

3.1.2 Examinations and tests

Non destructive examinations and destructive tests should be carried out in accordance with the requirements of Table 1.

Test specimens should be taken in accordance with Figure No. 2.

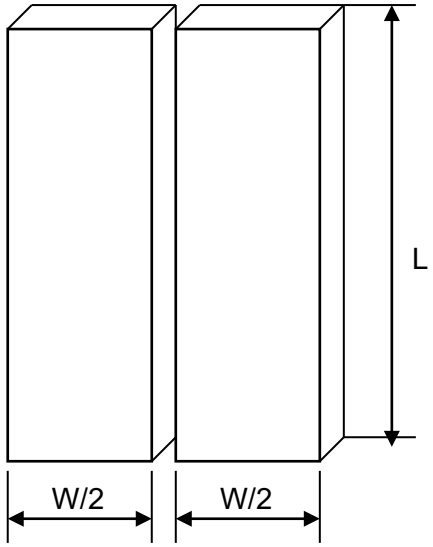


Fig. 1 Test assembly for butt weld

Table 1

Type of test	Extent of testing
Visual examination	100%
Radiographic or ultrasonic examination	100%
Penetrant test	100%
Transverse tensile test	2 specimens
Transverse bend test (1)	2 root and 2 face specimens
Macro examination	1 specimen
(1): 2 root and 2 face bends can be substituted by 4 sides bends for t ≥ 12 mm	

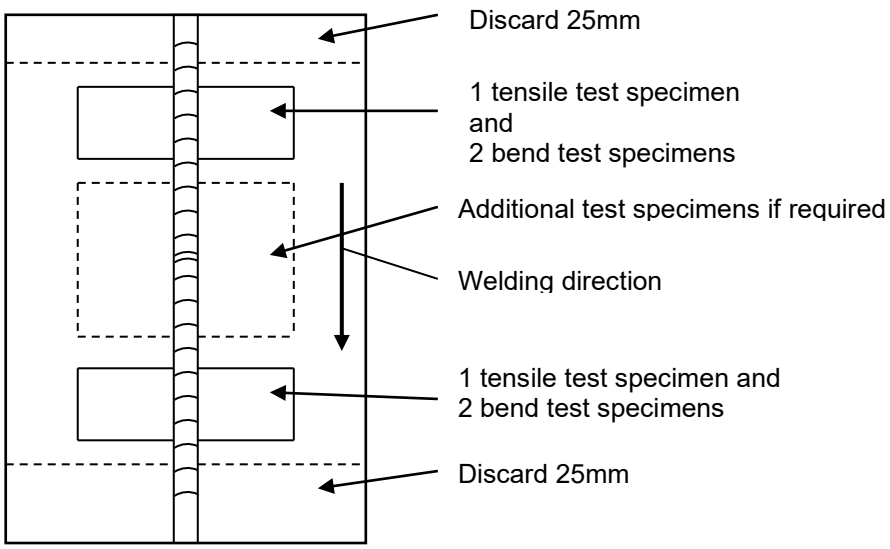


Fig.2 Location of test specimens for a butt joint in plate

3.1.3 Non destructive examination

Non destructive examinations should be carried out after any required post weld heat treatment, natural or artificial ageing, and prior to the cutting of the test specimens.

Welds should be free from cracks. Imperfections detected by visual or non-destructive testing should be assessed in accordance with ISO 10042:2018, level B, except for excess weld metal or convexity, excess throat thickness and excess of penetration for which the level C applies.

3.1.4 Transverse tensile test

The specimens for transverse tensile tests should be machined to the dimensions given in BCS-R W2.
The tensile strength should meet the requirements stated in Table 2.

Table 2

Grade (Alloy designation)	Minimum tensile strength (N/mm^2)
5754	190
5086	240
5083	275
5383	290
5059	330
5456	290
6005A	170
6061	170
6082	170

3.1.5 Bend test

The specimens for bend tests should be machined to the dimensions given in BCS-R W2. For dissimilar or heterogeneous butt joints longitudinal bend tests may be required instead of transverse bend tests.

The bend test specimens should be bent on a mandrel with maximum diameter as given in the formula below. The bending angle shall be 180°.

$$d = \frac{(100 x t_s)}{A} - t_s$$

where

d is the maximum former diameter

t_s is the thickness of the bend test specimen (this includes side bends)

A is the minimum tensile elongation required by the alloy grade, temper condition and thickness (for combination between different alloys, the lowest individual value should be used).

After testing the test specimens should not reveal any open defect in any direction greater than 3 mm. Defects appearing at the corner of the specimens may be disregarded, unless there is evidence that they result from lack of fusion.

Note: Wrap around method bend tests are recommended for the above mandrel diameter for each alloy.

3.1.6 Macro examination

The test specimen should be prepared and etched on one side to clearly reveal the fusion line, the HAZ and the build up of the runs and the unaffected base metal. The examination should reveal a regular weld profile, thorough fusion between adjacent layers of weld and base metal and the absence of defects such as cracks and lack of fusion.
The acceptance levels specified in 3.1.3 apply.

3.2 T-fillet weld

3.2.1 Assembly and welding

The minimum size of the test assemblies should be as follows:

- manual and semiautomatic welding: length L = 350 mm; width W = 150 mm,
- automatic welding: length L = 1000 mm; width W = 150 mm.

The two plates should be positioned and tack welded edgewise so as to constitute a T assembly without clearance.

Welding on one or both sides and fit up should be as detailed in the pWPS.

In general for manual and semiautomatic welding a stop/restart position should be included in the test length and should be clearly marked for subsequent examination.

The cleaning of the parts to be welded should be carried out in accordance with the welding procedure.

3.2.2 Examination and tests

Non destructive examination and destructive tests should be carried out in accordance with the requirements of Table 3

Table 3

Type of test	Extent of testing
Visual examination	100%
Penetrant test	100%
Macro examination (1)	2 specimens
Fracture test	1 specimen
(1): One of the macro sections should be taken at the position of the stop/restart (see 3.2.1)	

3.2.3 Visual examination and surface crack detection

The requirements specified in 3.1.3 should be complied with.

3.2.4 Macro examination and fracture test

The fracture test as well as the macro examination should, in general, satisfy the acceptance level specified in 3.1.3.

Dimension of leg size, throat and penetration should in general be reported.

4. Re-testing

If the test assembly fails to comply with any of the requirements for visual examination or NDE, one further test assembly should be welded and subjected to the same examination.

If any test specimen fails to comply with the relevant requirements, two additional test specimens should be obtained for each one that failed. These specimens can be taken from the same assembly, if there is sufficient material, or from a new test assembly. For the acceptance both tests should give satisfactory results.

Where failed in the above re-testing, the pWPS should be modified before further consideration by the Surveyor is given to a new test assembly for re-qualification.

5. Range of approval

5.1 General

The approval of the WPS obtained by a shipyard or a manufacturer is valid for welding in all its workshops under the same technical and quality control.

All the conditions of validity stated below should be met independently of each other. Changes outside of the ranges specified may require a new welding procedure test.

5.2 Parent metal

The aluminium alloys are grouped into three groups:

- Group A: aluminium-magnesium alloys with Mg content ≤ 3.5% (alloy 5754)
- Group B: aluminium-magnesium alloys with 4% ≤ Mg ≤ 5.6% (alloys 5059, 5083, 5086, 5383 and 5456)
- Group C: aluminium-magnesium-silicon alloys (alloys 6005A, 6061 and 6082)

For each Group, the qualification made on one alloy qualifies the procedure also for the other alloys of the same Group with equal or lower specified tensile strength after welding.

The qualification made on Group B alloy qualifies the procedure also for Group A alloys.

5.3 Thickness

The qualification of a WPS carried out on a test assembly of thickness t is valid for the thickness range given in Table 4.

In case of butt-joints between dissimilar thickness, t is the thickness of the thinner material.

In case of fillet joints between dissimilar thickness, t is the thickness of the thicker material.

Table 4 Range of qualification for parent material thickness

Thickness of the test piece, t (mm)	Range of qualifications
$t \leq 3$	0.5 to 2 t
$3 < t \leq 20$	3 to 2 t
$t > 20$	≥ 0.8 t

In addition to the requirements of Table 4, the range of qualification of the throat thickness *a* is given in Table 5.

Table 5 Range of qualifications for the throat thickness of fillet welds

Throat thickness of the test piece, *a* (mm)	Range of qualifications
$a < 10$	0.75 a to 1.5 a
$a \geq 10$	≥ 7.5

Where a fillet weld is qualified by means of a butt weld test, the throat thickness range qualified should be based on the thickness of the deposited weld metal.

Where the majority of production work is fillet welding, an additional fillet weld test may be required.

5.4 Welding position

Provided that comparable welding parameters are used for the included welding positions a test in any one position qualifies for welding in all positions except for vertical downwards (PG) position where in any case separate welding procedure test is required.

5.5 Type of joint

The range of approval for the types of joint in relation to the type of joint used in the procedure qualification test is as follows:

- butt-joint welded from one side with backing qualifies also for welding from both sides with gouging;
- butt-joint welded from one side without backing qualifies also for welding from one side with backing, from both sides with gouging and from both sides without gouging;
- butt-joint welded from both sides with gouging only qualifies that condition,
- butt-joint welded from both sides without gouging qualifies also for welding from both sides with gouging and from one side with backing.

5.6 Welding process

The approval is valid only for the welding process used in the welding procedure test. It is not permitted to change a multi run deposit into a single run (or single run on each side) or viceversa for a given process. In the case of a multi-process procedure, the approval is only valid for applying the processes in the order used during the procedure qualification tests.

Note: For multi-process procedures each welding process may be approved separately or in combination with other processes. Similarly one or more processes may be deleted from an approved WPS provided the joint thickness is within the approved thickness range of the relevant welding process to be applied.

5.7 Welding consumables

The welding consumable used in the qualification tests qualifies:

1) Approved welding consumables of the same strength as the consumable used in the procedure qualification tests.
2) Approved welding consumables of higher strength than the consumable used in the procedure qualification tests.

The qualification given to shielding gas and backing gas is restricted to the gas/gas mixture used in the welding procedure test, see ISO 14175:2008 or other recognised standards for gas designations.

5.8 Type of current

Changes in the type of current (AC, DC, pulsed) and polarity require a new welding procedure qualification.

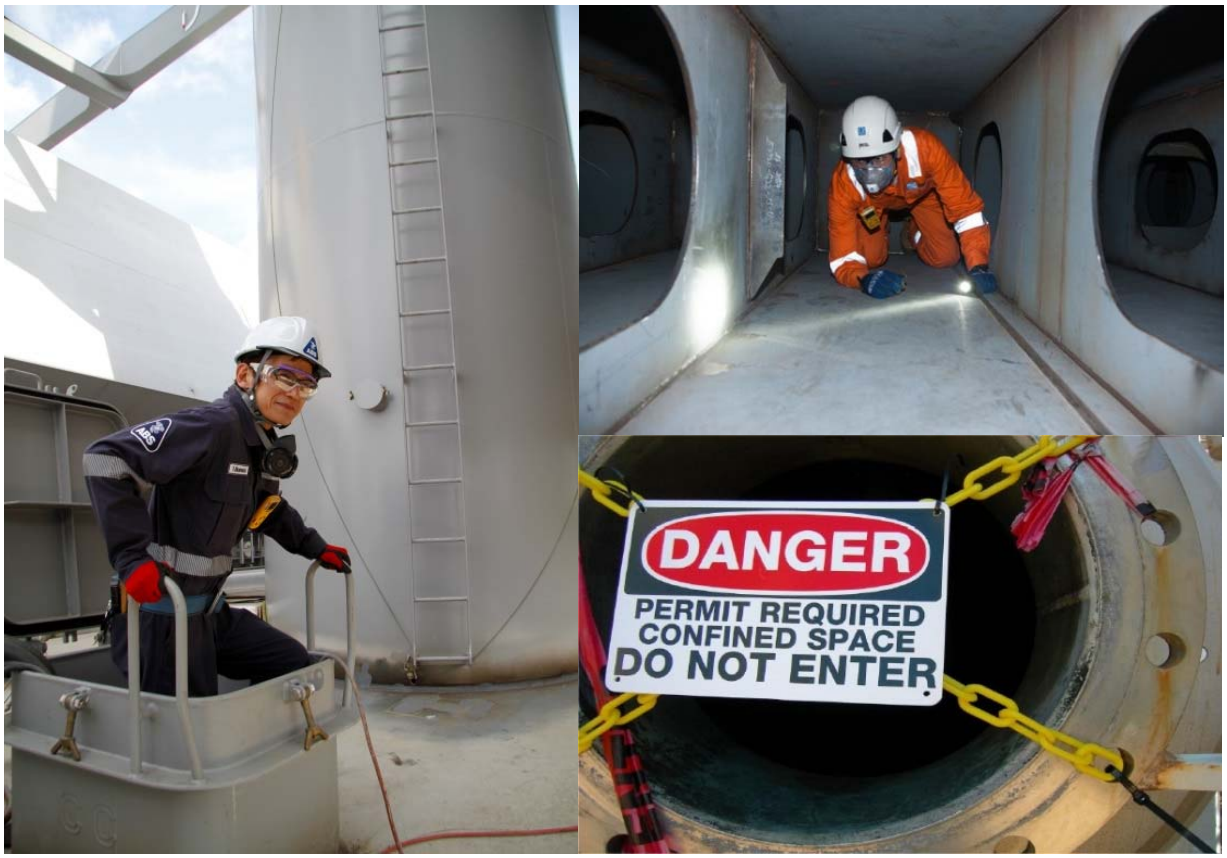
5.9 Preheat and interpass temperature

The lower limit of approval is the preheat temperature applied at the start of the welding procedure test.

The upper limit of approval is the interpass temperature reached in the welding procedure test.

5.10 Post-weld heat treatment or ageing

Addition or deletion of post weld heat treatment or ageing is not permitted except that artificial ageing for 6000 series alloys gives approval for prolonged natural ageing.



Confined Space Safe Practice

BCS- G 72 - Rev.3 Dec 2018

BCS- G72 Confined Space Safe Practice

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Introduction

The Guideline is structured in two parts. In the first part, general information concerning definitions and requirements to safely enter and work in Confined Spaces are summarized.

The second part helps the worker to recognize the hazards associated with confined spaces and gives detailed guidelines for a safe survey preparation and entry.

A Checklist for Entry into Confined Space is also included.

PART ONE - Confined Space Practices

1 Definitions

1.1 Confined Space

Confined space means a space that has any of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not intended for continuous worker occupancy.

It may include, but is not limited to, boilers, pressure vessels, cargo spaces (cargo holds or cargo tanks), cargo space stairways, ballast tanks, double bottoms, double hull spaces, fuel oil tanks, lube oil tanks, sewage-tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases, excavations and pits.

1.2 Confined Space Entry

Confined space entry is the process of entering, working in and exiting a confined space.

1.3 Competent Person

Competent Person means a person with sufficient theoretical knowledge and practical experience to make an informed assessment of the likelihood of a oxygen deficient/enriched or a dangerous atmosphere being present or subsequently arising in the space. Competent persons must be trained and qualified in the hazards of Confined Spaces and in use of atmospheric monitoring devices. The Competent Persons role may be performed by a Marine Chemist.

1.4 Responsible person

Responsible person means a person authorised to permit entry into a confined space and having sufficient knowledge of the procedure to be followed and other activities that are being undertaken that could impact on the safety of those in a confined space.

1.5 Attendant (may also be referred to as ‘Standby Person’)

Attendant is a person who is suitably trained and responsible for maintaining a watch over

those entering the confined space, for maintaining communications with those inside the space and for initiating the emergency procedures in the event of an incident occurring.

1.6 Marine Chemist

A Marine Chemist is a person holding a valid and suitably recognised qualification as a marine chemist or equivalent.

1.7 Adjacent Space

An Adjacent Space is any space bordering the confined space in any directions, including all points of contact, corners, diagonals, decks, tank tops and bulkheads.

1.8 Toxic Product

A Toxic Product means any chemical liquid, gas or solid material, which can give toxic vapour and which is assigned with suffix "T" in column "k" of table given in Chapter 17 of IBC Code, or assigned with suffixes "T" or “F+T” in column "f" of table given in Chapter 19 of IGC Code, or classified as a Toxic Substance (Class/Division 6.1) within the part 2 of IMDG Code, or any other product which has a toxic symbol in the data sheet or is a hazard classified as a toxic.

1.9 Surveyor

A surveyor is any person employed by BCS conducting activities within a confined space on behalf of BCS.

1.10 Permit to Enter / Permit to Work

A Permit to Enter or Permit to Work is a documented authorization that has been signed and dated, including time of issue by the Responsible Person, which states that the space has been tested by a Competent Person and the space is safe for entry; what precautions, equipment, etc. are required and what works is to be done.

2 General Hazards

Entry to and working within confined spaces presents the possibility of fatalities, severe injuries and illness. The key hazards associated with confined spaces are:

- serious risk of fire or explosion;
- loss of consciousness from asphyxiation arising from dust, gas, fumes, vapour or lack of oxygen;
- drowning arising from increased fluid levels;
- loss of consciousness arising from a change in body temperature;
- asphyxiation or suffocation arising from free flowing solid (engulfment) or the inability to reach a breathable atmosphere due to entrapment.

Surveyors will routinely enter confined spaces that are difficult to access due to small and/or narrow openings. There may be physical constraints within the space which must be considered, and the dimensions of the space itself may allow only restricted mobility.
Given the usual enclosed and darkened nature of a confined space this activity ideally should not be carried out by personnel suffering from phobias (such as claustrophobia) or who are

susceptible to panic or anxiety attacks.

For further details regarding hazards in confined spaces see Part two.

3 Requirements

3.1 Training

All surveyors who are expected to enter and work in confined spaces should be trained in Occupational Safety and Health requirements for such activities. This should include the following:

- Recognising a confined space
- Role of the Competent Person, Responsible Person, Attendant and Marine Chemist
- How to recognise the hazards and manage the risks associated with Confined Space Entries
- PERMIT TO ENTER (PTW or PTE) systems/control procedures at the workplace
- Requirements for atmosphere testing and the interpretation of their results
- Use of personal multi gas meter.
- Access, exit and safe working requirements
- Emergency arrangements.

Competency in the areas covered by the training identified above should be periodically assessed and appropriate refresher training should be provided.

3.2 Confined Space Entry Policy

A confined space should be entered only when a PERMIT TO ENTER (PTW or PTE) has been issued and if it is safe to do so. Surveyors should remain inside a confined space only for as long as it is necessary to perform the related work.

It is the full responsibility of the Owner or Owner Representative of the confined space (i.e. Ship, Shipyard) to ensure that the confined space is safe to enter.

- Surveyors should not enter a space alone unless the physical dimensions of the space prevent entry by more than one person.

3.3 Confined Space Entry Procedures

3.3.1 General

Societies should include in their procedures the requirements that Surveyors should refuse to enter a confined space (or should exit the space) if:

- Safe entry procedures (such as entry permit, “safe for workers” certificate, “safe for hot work” certificate, etc.) are not in place, have time expired or are not being followed.

- The Responsible and Competent Persons are not identified.

- The access and exit arrangements to and within the confined space are not considered safe (where available, multiple entry and exits ways should be opened)

- Communications arrangements are not adequate

- The confined space is not adequately clean to allow safe working

- Lighting is not adequate for entry and exit and to allow safe working in the confined space

- The atmosphere has not been demonstrated as being safe (safe limits are: atmospheric oxygen the range of 20.6% to 22% by volume, combustible gases less than 5% of lower explosive limit, toxics within acceptable limits)

- Adequate ventilation arrangements are not in place or not functioning

- Isolation of the confined space, as applicable, from other tanks, cargo spaces, pipes, etc. and of machinery in the space, is not confirmed

- They are required to wear breathing apparatus

- The surveyor may wear a respirator or other escape device if required by an Owner’s policy but only if sufficiently trained in the use of such equipment. However, the space should be safe first.

- Effective communication is adversely impacted by the surrounding noise

- Extreme temperature effects are not adequately considered

- Electrical equipment in the confined space is not suitable or not in acceptable condition

- Toxic Product is contained in an adjacent space, until the followings are carried out:

  1) A risk assessment is completed by the vessel’s Management Company and the risk is mitigated.

  2) All identified controls are confirmed in place prior to tank entry.

- A dedicated Attendant is not provided by the vessel’s management or the management of the facility where the surveyor’s activities are carried out for the complete duration of the time spent working in the confined space and/or the Attendant does not have suitable means of initiating emergency response

- Adequate emergency response arrangements are not in place

- In any other situation where the surveyor has a valid concern over the safety of the confined space

The points addressed above should be considered and reviewed as changes occur during any Confined Space Entry.

No surveyor should be the first to enter a confined space, and they should be accompanied at all times where the size of the space permits.

No surveyor should be part of a rescue team

Surveyors should immediately leave a confined space, by the nearest safe exit, if any alarms sound, or any physical impairment or distress is experienced by the surveyor.

In addition to the above prior to entry into a confined space the following procedure should be adopted:

a) A Safety meeting should be held prior to the survey to discuss all aspects of safety measures.

b) Entry Permit should be obtained for the space to be entered.

c) Identify potentially unsafe conditions by reviewing the following information provided by the owner:

   - Latest content of the spaces to be surveyed.

   - Contents of adjacent spaces.

   - For Gas Carriers: a data sheet for the last cargo.

   - For Chemical Tankers: a data sheet for the previous three cargoes.

d) Evaluate ventilation of the space:

   - Check that the confined space or tank is empty, cleaned and ventilated.

e) Evaluate need for isolation of the space.

f) Ensure that an Attendant is in place.

g) Ensure that a standby person and/or a rescue team is in place.

h) It is strongly recommended that Emergency Escape Breathing Devices (EEBD) are placed at the entry points of the space to be entered for use in emergency situation or recovery of a surveyor from the space.

i) Check and evaluate gas measurements taken by the Owner Representative. For testing limit values see item 4 below.

   - as a minimum, oxygen measurements should be carried out before entry into the enclosed space. The Surveyor may request to carry out measurements under his supervision, when deemed necessary.

   - a set of additional control measures should be evaluated depending on what type of confined space is to be surveyed. See Annex, Checklist for Entry into

Confined Spaces.
The surveyor should always use their personal gas measuring equipment during the survey, but this is not intended to substitute the measurements taken by the Owner or Owner Representative.

j) Evaluate need for precaution against extreme temperature. See Part two.

k) Evaluate the lighting arrangements. See Part two.

l) Evaluate if special clothing and/or equipment is required.

A checklist with the items above is recommended to be used for evaluation if the space is safe to enter.

If extensive work is to be carried out within a large space, such as a cargo tank, it is recommended that a full assessment of the tank atmosphere is undertaken after the initial tests have been satisfactorily carried out and recorded. The tank atmosphere should be checked frequently during this entry, with particular attention being placed on testing the work location(s) and places that are inaccessible for testing from the entry point.

3.3.2 Entering confined spaces adjacent to loaded tanks

It is important to be aware that confined spaces may be, or have been, subject to leakage from the adjacent space. The risk is that such leakage often remains undetected because the space is not subject to regular gas measurements and ventilation.

Confined spaces adjacent to loaded tanks may be entered provided the procedure for entry as given in item 4 below is completed.

Spaces adjacent to cargo tanks, like cofferdams and double bottom tanks may contain accumulated residues from previous cargoes and information about these cargoes is needed to determine proper test methods for the atmosphere in the adjacent spaces.

If a tank is loaded with cargoes having a toxic product hazard identified, or with a toxic symbol in the Data Sheet, no survey should be carried out in a confined space adjacent to that tank.

Be aware that toxicants produced by work (like coating, sandblasting and hydro blasting) in the area of a confined space can enter and accumulate in the confined space.

3.3.3 Entering confined spaces adjacent to inerted tanks

When other tanks in an inert condition are either adjacent or interconnected (e.g. pipeline) to the space to be entered, personnel should be alert to the possibility of inert gas leaking into that space through, for example, bulkhead fractures or defective valves. The risk of this occurring can be minimized by maintaining a small but positive pressure in the space to be entered relative to the inert gas pressure. At all times the procedures on the vessel are to be followed.

3.3.4 Entering confined spaces adjacent to loaded tanks on double hull tankers – additional requirements

The compartmentalized structure in double hull and double bottom tanks makes them more difficult to gas free than conventional tanks and particular care should be taken to monitor the tank atmosphere.

Although entry into double hull or double bottom tanks with adjacent tanks loaded should be kept to a minimum, tank entry will on occasion be required for such purpose as tank inspections.

In relation to the entry procedure above, the following additional recommendations should be strictly enforced.

Once the tank atmosphere meets the entry criteria at each sampling point, actual entry by personnel should be undertaken in two stages.

First stage

The first stage should be for the purpose of atmosphere verification and a general safety review. The Owner personnel making the entry should be equipped with:

- an emergency escape breathing set,
- personal gas detector capable of monitoring at least hydrocarbon and oxygen,
- portable radio,
- emergency light source,
- a retrieval harness,
- an alternative means of attracting attention, e.g. a whistle.

Second stage

Only after the first stage has verified that the atmosphere throughout the tanks is safe for the surveyor may enter the confined space for survey activities.

3.3.5 Permit-to-work and permit-to-enter

The ISM code requires the Company to establish safe practices in ship operation and a safe working environment. This is commonly provided for by a permit-to-work system that is drawn up to provide a formal written safety control system. Non convention vessels , new construction shipyards and repair facilities, etc. not covered by ISM code may have a similar permit-to-work system.

A permit-to-work should:

- set out the work to be done, the location and the precautions to be taken;
- predetermine safe methods of work;
- provide a clear record that all foreseeable risks have been considered;
- define the precautions to be taken and their sequence;
- provide written authority for the confined space to be entered and the work to start and the time when the work should cease.

Entry into a confined space should only be allowed after a separate permit-to-enter has been issued. This permit should only be issued after tests have taken place to ensure that the atmosphere is safe for entry.

Note:

Use of non-explosion proof equipment like cameras, torches, chipping hammers, may be allowed provided that it is stated in the Entry permit issued and the space is safe for hot work or safe for workers and LEL is measured to 0%.

4 Confined Space Entry

4.1 Testing of the atmosphere

Initial testing should be carried out by a certified “Marine Chemist” or a “Competent person” or similar accredited person who will issue a certificate stating whether the space is ‘safe for man’ and/or work, and if any special conditions should be observed.

On a vessel this may be the Chief Officer, or a Competent person onboard. If in doubt of the officer’s qualification, documentation should be shown. In no case should the surveyor be considered to be a “Competent Person” - even if the surveyor is equipped with own personal testing equipment.

Ventilation should be stopped about 10 minutes before tests are made and not restarted until the tests are completed.

The testing should be carried out immediately before entry into the confined space and in the following sequence

- Oxygen-deficient or -enriched atmospheres
- Flammable atmospheres
- Toxic atmospheres when considered necessary

To evaluate the measurements taken, the following limit values should be used.

Testing for oxygen

Any atmosphere with less than 20.6% or greater than 22% oxygen by volume should not be entered.

Testing for flammable atmosphere

A space with an atmosphere with more than 5% of the “Lower Flammable Limit” (LFL) or “Lower Explosive Limit” (LEL), on a combustible gas indicator should not be entered.

The Flammability indicator shows the percentage within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Combustible gas detectors have normally two measuring ranges 0-100% LEL and 0-10% LEL.

Testing for toxic atmospheres

Toxins are, in general, measured in parts per million (PPM). Under no circumstances should the surveyor enter a confined space exceeding the limits specified by national or international

regulations. Different testing bodies throughout the world may, however, have different acceptance limits. Value limits are included below for three substances found often by the surveyors in the field:

Gas	Limit 8 Hour work shift [ppm]	Limit 15 min working [ppm]
Benzene (C_6H_6)	1	5
Hydrogen Sulphide (H_2S)	5	10
Carbon Monoxide (CO)	35	50

Sources: IMO-MSC/Circ.1095; OCIMF; National Institute for Occupational Safety and Health (NIOSH)

Note:

Never trust one's own senses to determine if the air in a confined space is safe! Many toxic gases and vapours can neither be seen nor smelled, nor can the level of oxygen present be determined.

Be aware that some chemicals have a lower "Threshold Limit Value" (TLV) than odour value. Gases from these substances will not be traceable by smell before they are dangerous to health.

De-ballasting a tank does not guarantee a safe atmosphere. Testing of the atmosphere is still required.

Testing instruments

For further details, see Personal Protection Equipment (PPE), Part One, section 4.3, and Testing Instruments, Part Two, section 3.2.

Note:

In all cases testing instruments should be operated in line with manufacturer's instructions.

4.2 Preparation for Entering Confined Spaces

4.2.1 Ventilation

Ventilation should be continuous where possible because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped. All openings should be opened for ventilation including emergency exit.

The inert gas fans should not be used to provide fresh air ventilation because contaminants from the inert gas lines could be introduced into the tanks.

For further details, see Part Two, section 4, Ventilation.

4.2.2 Isolation of Space

The surveyor should confirm that the isolation of the space has been considered and performed where necessary.

For further details regarding isolation of spaces from service, see Part Two, section 5, Isolation of space.

Ballast and cargo operations should be stopped when personnel are entering ballast and cargo tanks.

4.2.3. Attendant Rescue Team

An attendant should be assigned to remain on the outside of the confined space and be in constant contact (visual or two-way voice communication e.g. walkie-talkie) with the survey team inside. Routines for communication intervals with the survey team should be established.

The attendant:

- should not have any other duties than to serve as standby and know who should be notified in case of emergency;

- should never leave his post even after help has arrived and is a key communication link to others on board;

- should be able to communicate effectively in a relevant common language.

Communication between watch personnel (Bridge, Cargo Control Room or Engine Control Room) and attendant should be established.

Rescue

Rescuers should be trained in and follow established emergency procedures and use appropriate equipment and techniques (such as EEBD, lifelines, respiratory protection).

Emergency and evacuation procedures should be agreed and understood by all parties involved in a potential rescue operation. Steps for safe rescue should be included in all confined space entry procedures. Rescue should be well planned and evidence should be made available that indicates drills have been frequently conducted on emergency procedures.

Note:
Unplanned rescue, such as when someone instinctively rushes in to help a downed co-worker, can easily result in a double fatality or even multiple fatalities if there is more than one would-be rescuer.

A significant number of fatalities in confined spaces occur when an unprotected crew member is attempting to rescue another.

An unplanned rescue could be the last!

4.3 Personal Protection Equipment (PPE)

PPE is traditionally regarded as the last line of protection with the emphasis being placed on avoidance and appropriate managerial control methods. However, the potentially hazardous nature and isolated position of those entering a confined space means that, for the surveyor, PPE may be the first line of protection.

Each confined space will present different hazards and degrees of risk to health and safety, the final provision of PPE should therefore be based on an assessment of risk.

As a general rule the following guidance is offered.

Basic surveyor PPE should include:

- Body protection (hard wearing overalls with suitable pockets for notebook, etc);
- Foot protection (steel toecaps (200 joules), steel midsoles, good grip, oil resistant);
- Head protection (hard hat with chinstraps if required);
- Hand protection (hard wearing gloves);
- Eye protection (protective glasses, goggles);
- Ear protection (ear defenders or ear plugs – worn subject to communication system);
- Gas meter - multi-gas meter[1] for measuring of LEL, H_2S, CO, O_2 (in good working order, serviced and calibrated as per the manufacturer's instructions);
- A flashlight, appropriate to the nature of the confined space to be entered, and in good working order.
- Respiratory protection (e.g. dust mask).

4.3.1 The surveyor should always use the necessary personal safety equipment according to the specific conditions and the survey being carried out.

Reference List

- ISGOTT International Safety Guide for Oil Tankers and Terminals, fifth edition.
- Tanker Safety Guide Chemicals, third edition
- Tanker Safety Guide Liquid Gas, second edition 1995
- OCIMF - Health, Safety and Environment at New-building and Repair Shipyards and During - Factory acceptance testing (01 July 2003)
- BCS- G 39 - Safe use of Rafts or Boats for Survey

[1] Referring to ISO 19891-1:2017(en) "Ships and marine technology — Specifications for gas detectors intended for use on board ships — Part 1: Portable gas detectors for atmosphere testing of enclosed spaces".

PART TWO - Guidelines for Safe entry of Confined Spaces

1 General

If a Survey is required to be carried out in a:

- boiler or pressure vessel,
- cargo tank,
- ballast tank,
- double hull space,
- fuel oil tank,
- lube oil tank,
- cargo hold,
- void space, or
- similar type of enclosure,

the work will take place in a confined space.

How to Identify a Confined Space?

A confined space is a space that has any one of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not designed for continuous worker occupancy.

Limited openings for entry and exit:

Confined space openings are limited primarily by size or location. Openings are usually small in size, perhaps as small as 450 mm (18 inches) in diameter, and are difficult to move through easily. Small openings may make it very difficult to get needed equipment in or out of the spaces, especially life-saving equipment when rescue is needed. However, in some cases openings may be very large, for example open-topped spaces such as ships' holds. Access to open-topped spaces may require the use of ladders, hoists, or other devices, and escape from such areas may be very difficult in emergency situations.

Unfavourable natural ventilation:

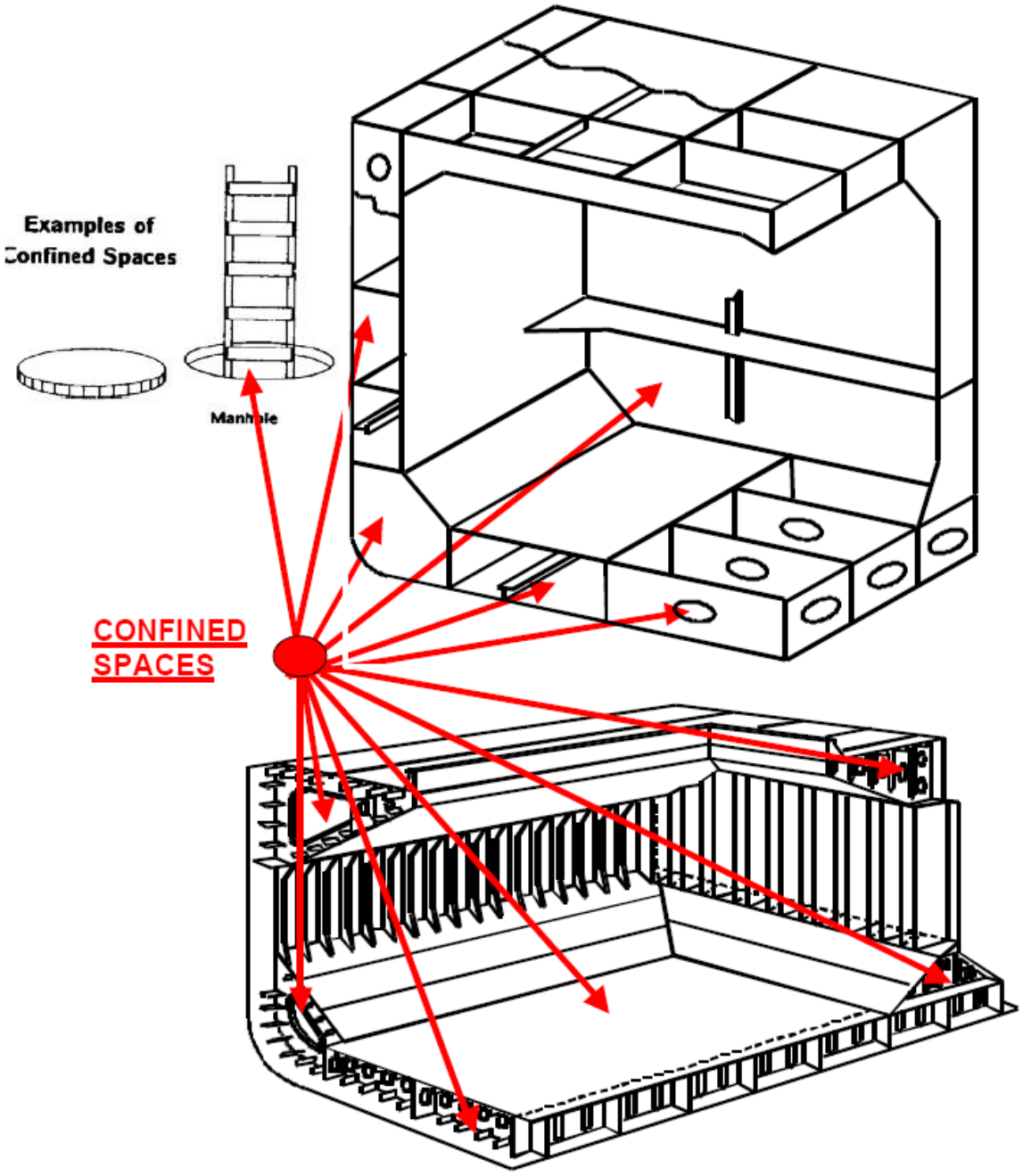
Because air may not move in and out of confined spaces freely due to the design, the atmosphere inside a confined space can be very different from the atmosphere outside. Deadly gases may be trapped inside, particularly if the space is used to store or process chemicals or organic substances which may decompose. There may not be enough oxygen inside the confined space to support life, or the air could be so oxygen-rich that it is likely to increase the chance of fire or explosion if a source of ignition is present.

Not designed for continuous worker occupancy:

Most confined spaces are not designed for workers to enter and work in them on a routine basis. They are designed to store a product, enclose materials and processes, or transport products or substances. Therefore, occasional worker entry for survey, inspection, maintenance, repair, cleanup, or similar tasks is often difficult and dangerous due to chemical or physical hazards within the space.

A confined space found in the workplace may have a combination of these three characteristics, which can complicate working in and around these spaces as well as rescue operations during emergencies.

> ***Note:***
> **If a survey requires entry to one or more work spaces with the characteristics listed above, read the following information – some day it may save life.**



2 Confined Space Hazards

2.1 Hazardous atmospheres from the containment in the tank

The atmosphere in a confined space may be extremely hazardous because of the lack of natural air movement. This characteristic of confined spaces can result in:

- oxygen-deficient atmosphere,
- flammable atmospheres, including oxygen enrichment, and/or
- toxic atmospheres

2.1.1 Oxygen-deficient atmosphere

General

The health effects and consequences because of lack of oxygen in a confined space are listed in the table below. These effects will take place without any warning such as odour or physical symptoms.

Health effects from lack of oxygen	
O_2 level	Effects
20.8%	Normal level – Safe for Entry (± 0.2%)
19.5%	Oxygen deficient atmosphere
16%	Impaired judgement and breathing
14%	Rapid fatigue and faulty judgement
11%	Difficult breathing and death in a few minutes

Lack of oxygen leads very quickly to unconsciousness and death. Lack of oxygen may be a problem in all kinds of confined spaces, it is therefore considered as the most dangerous factor when considering dangers in a confined space.

The oxygen level in a confined space can decrease because of work being done, such as welding, cutting, or brazing; or, it can be decreased by certain chemical reactions like: rusting, paint drying or through bacterial action (fermentation).

In tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O_2-content, and where rescue operations may be difficult, the use of a portable oxygen meter with audible alarm is strongly recommended.

Inert gas, N_2 and exhaust

Inert gas is a non-reactive gas used to prevent possible explosive atmosphere from different cargo vapours.

On Oil Tankers the most common inert gas is the exhaust from oil fired boilers, main- or auxiliary engines. On Chemical Tankers the most common inert gas is nitrogen.

Pure nitrogen is not poisonous itself, but it causes displacement of the natural breathing environment.

Exhaust contains hundreds of chemical compositions. Main components are: carbon monoxide, oxygen, nitrogen, water vapour, sulphur dioxide, nitrogen oxides and

hydrocarbons. The exhaust as described above may cause reduced lung capacity and increased respiratory in addition to irritating mucous membrane in eye, nose and throat. Total dilution of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death.

Bulk Cargoes

A number of bulk cargoes may cause low level of oxygen in the cargo hold. This is mainly with cargoes like vegetables, grain, timber, forestry products, iron metals, metal sulphide concentrates and coal.

Some bulk cargoes may oxidize which may result in reduced level of oxygen, poisonous gases, or self ignition. Other bulk cargoes may produce poisonous gases without oxidation, especially when they are wet.

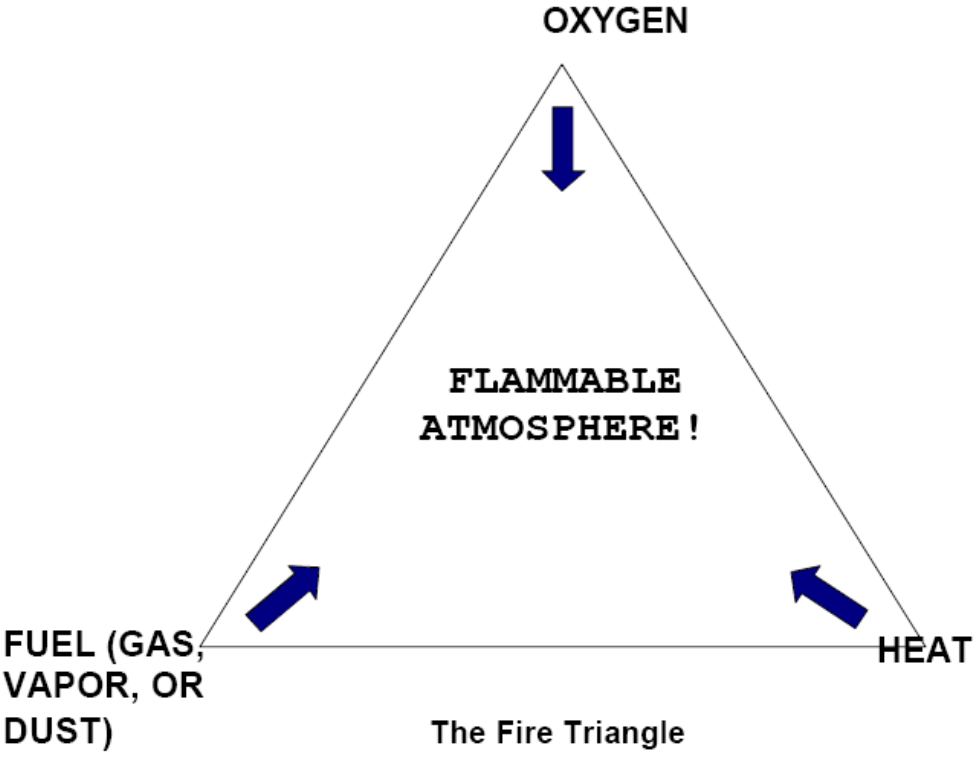
2.1.2 Flammable atmospheres

Two things make an atmosphere flammable:

- the oxygen in air, and
- a flammable gas, vapour, chemical reaction or dust in a proper mixture.

Different gases have different flammable ranges. If a source of ignition (e.g. a sparking or electrical tool, static electricity, sand blasting) is introduced into a space containing a flammable atmosphere, an explosion will result. An oxygen-enriched atmosphere (above 22%) will cause flammable materials, such as clothing and hair, to burn violently when ignited. Therefore, never use pure oxygen to ventilate a confined space. Ventilate with normal air.

Some bulk cargoes may produce health toxic dust which also will represent an explosive hazard, especially during cargo handling and cleaning.



The Fire Triangle

2.1.3 Toxic atmosphere

Unless a certified Marine Chemist or a competent person has certified a space as safe, assume that any substance (liquids, vapours, gases, mists, solid materials and dust) in a confined space can be hazardous. Toxic substances may range from fast acting poisons to long term cancer causing carcinogens. Toxic substances can come from the following:

-the product stored in the space;

-the work being performed in a confined space;

-areas adjacent to the confined space.

Some bulk cargoes will act in a corrosive manner on skin, eye and mucous membrane.

Products stored in the space:

Chemical products

In cargo tanks for chemicals it is possible to find all types of chemicals. It is very important that the customer provides a Data Sheet for the product that has been stored in the tank and follows the instructions for safety measures according to this.

Health effects as a result of exposure from chemicals in general may cause immediate headache, nausea, fainting and possible death. Long-term exposure to benzene can result in serious blood disorders such as allergy, anaemia and leukaemia.

Chemicals can be absorbed into the structure and/or tank coatings and give off toxic gases at a later stage. When removed or when cleaning out the residue of a stored product, toxic gases can be given off.

It is very important to follow the marking and recommendations as given in the Data Sheet to reduce immediate damage as well as the risk for long term damage.

Petroleum products

Most petroleum products are distilled from crude oil which is a product with very high complexity regarding composition of different substances. The composition of crude oil and the products distilled from crude may vary depending on what part of the world the production of crude took place.

Petroleum products may be absorbed into the body by inhalation, absorbed through skin or ingested. Effects to health will depend on how high exposure and for how long. Immediate effects of high exposure can include headaches, tiredness, nausea and dizziness. Unconsciousness may occur if exposure is very high. Long-term exposure can result in serious blood disorders such as anaemia and leukaemia.

Be aware that several of the fuels on the market have different additives to prevent e.g. bacteria growth in diesel. These additives may be highly toxic. When the additives are above a certain percentage they are supposed to be included in the Data Sheet. If the amount of additives is very small it does not need to be a part of the Data Sheet.

Be aware that several of the fuel producers are very reluctant to reveal what kind of additives they are using in fuels, because this is considered to be business sensitive. Extra care should then be taken with respect to cleaning and measuring for the correct toxic product in

diesel and fuel oil tanks.

When testing for toxins in a confined space that has contained petroleum products, it may be very difficult to decide what toxic gas to measure for. In general, testing for the most dangerous toxic product in the composition should be carried out.

If not otherwise stated on the Data Sheet, benzene is the most toxic part in petroleum products and measuring for this product should be done. If the readings for benzene are within the limits, all the other natural parts of the petroleum product should be within the acceptance limits.

Hydrogen sulphide, H_2S

Hydrogen sulphide is highly toxic and also flammable and is created by the decay of organic matter that is found in sewers and sewage treatment plants. H_2S may also be found in crude oil tanks, ballast tanks, void spaces and other tanks that have been empty and decomposition of organic material has taken place.

Hydrogen sulphide is heavier than air and has no colour but does have a strong “rotten egg” odour at low concentrations.

Hydrogen sulphide can affect when inhaled and when passed through the skin. Contact can irritate the eyes. Long-term exposure to low levels can cause pain and redness of the eyes with blurred vision. Breathing hydrogen sulphide can irritate the nose, throat and irritate the lungs causing coughing and/or shortness of breath.

Higher exposures can cause a build-up of fluid in the lungs (pulmonary oedema), a medical emergency with severe shortness of breath. Exposure can cause nausea, dizziness, confusion, headache and trouble with sleeping. Very high levels can cause immediate death.

Hydrogen Sulphide is a highly flammable gas and a dangerous fire hazard.

At high concentrations H_2S paralyses neurons inside the nose and the odour cannot be smelled, hence smelling should not be used as an indicator that the tank is free from hydrogen sulphide.

Example: Removal of sludge or mud from a tank-decomposed material can give off deadly hydrogen sulphide gas and/or methane gas.

Benzene

Benzene is a highly flammable liquid which occurs naturally in crude oil, natural gas and some ground waters. It is also manufactured from crude oil and is present in crude oil vapours.

Benzene evaporates easily, and most people can just detect its distinctive smell at concentrations between 2.5 and 5 ppm in air. Exposure to benzene may occur in oil refineries, chemical and petrochemical plants including offshore installations. Benzene can be absorbed into the body by inhalation, absorbed through skin or ingested.

Benzene can affect human beings when inhaled and when passed through the skin. It can irritate the eyes and skin with drying and scaling of the skin. Exposure can irritate the nose and throat. Benzene can cause symptoms of dizziness, light-headedness, headache and vomiting. Convulsions and coma, or sudden death from irregular heart beat, may follow high exposure. Repeated exposure can cause damage to the blood cells (aplastic anaemia).

Methane

Methane is an odourless, colourless gas, or liquid under pressure. It is used as a fuel and in the manufacture of organic chemicals, acetylene, hydrogen cyanide, and hydrogen. Methane is a highly flammable gas and a dangerous fire and explosion hazard.

In addition to being an explosion hazard, very high levels of methane can cause suffocation from lack of oxygen. Skin contact with liquid methane can cause frostbite.

Solvents

Many solvents, such as kerosene, gasoline, paint strippers, degreasers, are not only flammable, but if inhaled at high concentrations can cause central nervous system (CNS) effects. CNS effects can include dizziness, drowsiness, lack of concentration, confusion, headaches, coma and death.

Solvents should never be used as cleaners for the purpose of removing paint or similar from hands. If liquid solvents are in contact with skin, they are absorbed through the skin 10 times more efficiently compared to high content solvent gas absorbed into the body through breathing.

LSA's

Naturally occurring radioactive materials have been known to be present in varying concentrations in hydrocarbon reservoirs in a number of areas of the world. It is now recognised that these materials can give rise to radioactive scales (and sludge), which are usually referred to as Low Specific Activity (LSA) scale.

The scales tend to be barium sulphate and strontium sulphate, which co-precipitate with naturally occurring radium leached out of the reservoir rock; such scales emit alpha, beta and gamma radiation and this, together with the physical properties of the LSA scale, can give rise to problems if such scales or sludge have to be removed, handled or disposed.

Levels of radioactivity can vary from just above background radiation to those requiring restricted areas and classified workers.

Others

Fibre: Synthetic mineral fibre is a common description for fibrous inorganic products mainly represented from rock, clay, slag and/or glass. These fibres can be classified as follows:

- fibre glass (glass wool/ fibreglass);
- mineral wool (rock wool/ slag-wool);
- ceramic fibre.

Long term exposure in high concentrations may increase risk of lung cancer. This is observed among workers fabricating such products. Surveyors will normally not be exposed to concentration levels or time periods which are considered to be of high risk. However, low concentrations may lead to skin- and respiratory irritation.

Leakage of refrigerating system

Ammonia: Ammonia is used as refrigerant, distributed within cooling system for fish-factory vessel and hold area. Normal pressure is approximately 20 bars. Ammonia does have a characteristic odour, even for low concentration levels. The health effect and consequences of ammonia are listed in the table below:

Concentration: (ppm)	Health effect:
20-50	Characteristic odour
40-100	Eye and respiratory irritation
400-700	Serious eye and respiratory irritation – possible irreparable damage
1700	Convulsive coughing, bronchial spasm, deadly after ½ h exposure
5000-10000	Deadly

CO_2: CO_2 is natural occurrence in exhaled air, however high concentrations can be hazardous. CO_2 is odourless and is heavier than normal air. Concentrations may occur in the lower part of the tanks, close to the bottom. Low concentrations – below 5% are not considered as hazardous. Concentrations above 5% may lead to increased breath intensity and death. Also long term exposure may lead to unconsciousness and death.

Propane/ butane: Because of huge fire hazard related to these two products, they will normally not be found onboard vessels except from vessels carrying high risk fire hazardous products i.e. gas carriers. Inhalation of high concentrations may lead to heart arrhythmia (heart rate interruption), and feel suffocating.

Group 1 refrigerant: These refrigerants are non-poisonous and non-fire hazardous. The most common name for these products is Freon. Group 1 refrigerants consist of a number of chlorofluorocarbon combinations. Distribution onboard vessels are mainly within cooling system for fish factory- and hold area.

CFC = chlorofluorocarbon (i.e. R-11, R-12). These refrigerants are no longer allowed onboard new-buildings, but still exist onboard existing vessels.

HCFC = hydro-chlorofluorocarbon (i.e. R-22). These refrigerants may still be found onboard, but a phase out program has started.

HFC = hydro-fluoro-carbon (i.e. R-134a, R-404a, R410a, R-507). These refrigerants are presently used for most new refrigerating plant installations.

Exposure to Group 1 refrigerant may cause eye- and/ or skin irritation. High concentrations may cause dizziness, spasm and may affect the central nervous system and lead to heart rate interruption. Be aware of the fact that refrigerants will displace O_2. Refrigerant gases are odourless.

Ammonia in fish holds:

Note the hazards of ammonia in fish holds where nets are stored when in a period of refit or from fish, and/or by fish products in fishing vessel bilge wells.

Hydrogen emission from anodes and/or accumulators:

Hydrogen gas (H_2) is produced from an electrolytic reaction from zincous-/carbon and alkaline accumulators. A mix of hydrogen gas (H_2) and oxygen (O_2) may form a highly explosive mixture. Hydrogen gas (H_2) is a light gas which displaces oxygen (O_2). Oxygen

measuring equipment is recommended to be used when entering accumulator room and other enclosures where accumulators are kept.

2.2 Work being performed in a confined space

Examples of such include welding, cutting, brazing, painting, scraping, sand blasting and degreasing. Toxic atmospheres are generated in various processes. For example, cleaning solvents are used in many industries for cleaning/degreasing. The vapours from these solvents are very toxic in a confined space. It is also important to be aware that hot work carried out consumes oxygen.

Welding

Hot work on all surfaces with coating will create several gases which may be very toxic. This gas may come from hot work being carried out in a tank adjacent to the space being surveyed.

Coating

Special attention should be paid when spray coating is carried out in the area of the survey. Spray coating where small size particles are mixed with air will lead to high toxic exposure if inhaled.

Grinding

Grinding may cause miscellaneous compositions of dust. Absorption of metal dust into the body through inhalation is dependent on the physical and chemical properties and the size of the particles. Dust like this may cause metal fume fever and bronchitis.

Sandblasting

The dangers connected to sandblasting very much depend on the object's substance and the size and containment of grit. Several grits used for sandblasting contain carcinogenic substances like quartz, nickel, lead and lead compound.

During sandblasting the containment of carcinogenic chemicals may increase depending on the surface of the sandblasted area.

Hydro blasting

Hydro blasting may create aerosols. Aerosols are dispersion of solid or liquid particles in air which are small enough to stay in the air for a long period of time. Aerosols may transport reactive chemicals deep into the lungs in a way that causes very high exposure.

Aerosols may be produced from dust, dirt and cleaning chemicals in the process of high-pressure cleaning of miscellaneous surfaces.

NDT operations

Chemicals from NDT operations may also be dangerous. Most ultrasonic thickness measuring equipment is not intrinsically safe.

3 Testing

3.1 General

It is important to understand that some gases or vapours are heavier than air and will settle to the bottom of a confined space. Also, some gases are lighter than air and will be found around the top of the confined space.

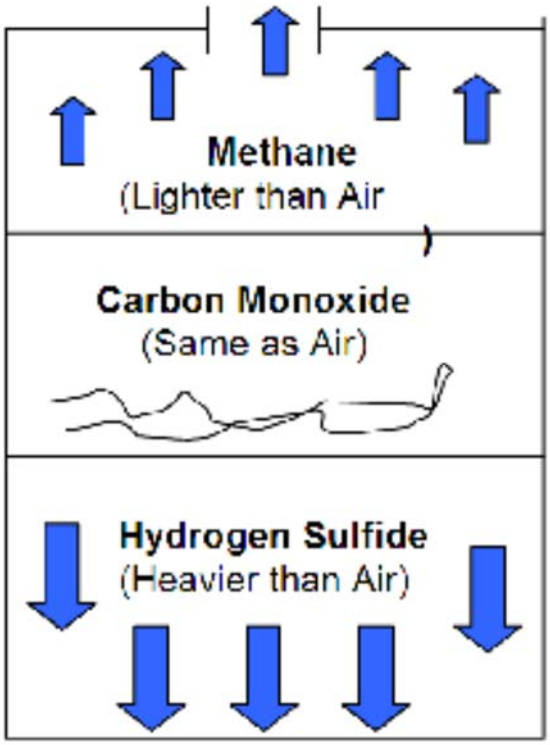
Therefore, it is necessary to test all areas (top, middle and bottom) of a confined space with properly calibrated testing instruments to determine what gases are present. Atmospheres may be different in individual bays of the same tank. If testing reveals oxygen-deficiency, or the presence of toxic gases or vapours, the space must be ventilated and re-tested before entering.

If in doubt whether the gas to be measured is lighter or heavier than air, consider the properties for the possible gas in question and compare it with the molecule weight of air.

Weight of air: 28.8 mol

Methane, CH_4 is lighter than air.

All gases from liquids under normal conditions are heavier than air (except ammonia).



No tank is to be entered until the tank atmosphere has been thoroughly tested with approved and calibrated instruments. Following tests are to confirm that all areas of the tank, bottom in particular, are safe for entry, i.e.:

- oxygen-deficient atmosphere,
- flammable atmospheres, and/or
- toxic atmospheres.

It is important to start the measurement of the tank atmosphere by measuring the HC (Hydrocarbon) content in % by volume and that the combustible gas detector is not used before the atmosphere content is less than Lower Explosive Limit (LEL). If measurement is started at a higher level the catalytic metal filament in the combustible gas detector may be destroyed. Combination instruments are available with a measuring range 0-100% by volume and 0-100% LEL.

3.2 Testing instruments

Testing instruments for oxygen and flammability read in percent. The oxygen meter should indicate 20.6% to 22% oxygen in the space being tested. The flammability indicator shows the percent within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Testing instruments are available in several different forms, hand powered by squeezing a rubber bulb or bellows, and battery powered giving the indication either on an analogue gauge or digital read-out.

Be aware that in cases where Draeger tube or equal is used for detecting toxic gases the sampling gas should have sufficient time to pass through the sampling hose. It is important to follow the instructions for use given by the manufacturer of the instrument.

As a rule, if a manual hand rubber pump is used, approximately 4 squeezes are needed for each metre of the sampling hose. If battery driven pumps are used, approximately 10 seconds for each metre of sampling hose should be sufficient.

4 Ventilation

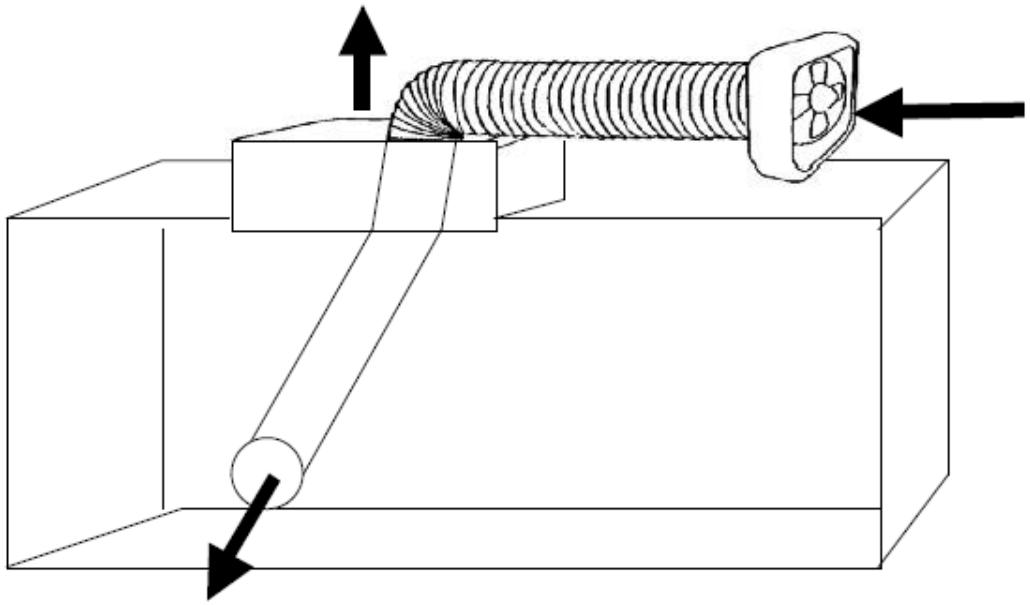
Ventilation by a blower, eductor or fan may be necessary to remove harmful gases and vapours from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen are dependent upon the size of the confined space openings, the gases to be diluted (e.g. are they flammable?), and the source of make-up air.

Under certain conditions where flammable gases or vapours have displaced the oxygen level, but are too rich to burn, forced air ventilation may dilute them until they are within the explosive range. Also, if inert gases (e.g. carbon dioxide, nitrogen) are used in the confined space, the space should be well ventilated and re-tested before a surveyor may enter.

A common method of ventilation requires a large hose, one end attached to a fan and the other lowered into a manhole or opening. For example, a manhole would have the ventilating hose run to the bottom (see figure) to dilute or displace all harmful gases and vapours.

The air intake should be placed in an area that will draw in fresh air only.

Schematic principles for ventilation:



Ventilation should be continuous where possible, because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped.

All openings are to be opened for ventilation and emergency exit.

5 Isolation of space

Isolation of a confined space is a process where the space is removed from service by one or more of the following.

Locking out:

Electrical sources, preferably at disconnect switches remote from the equipment.

Blanking and bleeding, securing valves:

Cargo, ballast, IGS, pneumatic and hydraulic lines. The inert gas branch should be blanked off. The appropriate blanking is to be checked at each tank if entry is required while inerting, or gas freeing of other tanks is taking place, or if any other tanks are inerted or contain hydrocarbons. An alternative to pipe blanking would be to remove a section of the branch line.

Disconnecting:

Mechanical linkages on shaft-driven equipment where possible.

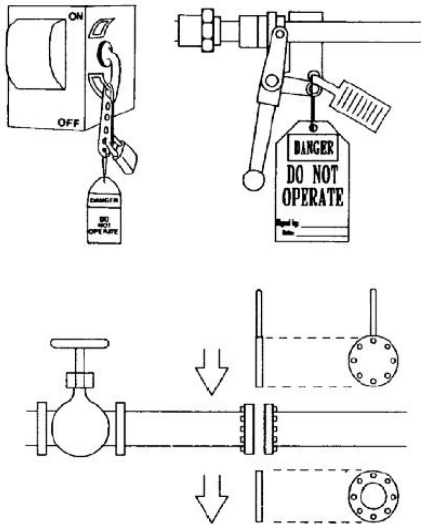
Securing:

Mechanical moving parts within confined spaces with latches, chains, chocks, blocks, or other devices.

Notice boards:

Appropriate notices, which clearly specify which space and prevailing requirements agreed upon for confined space entry, should be displayed in prominent locations such as bridge, cargo control room, and/or engine control room.

Blanking, locking and securing of equipment:



6 General and physical hazards

6.1 Temperature extremes

Extremely hot or cold temperature can present problem for the surveyor.

Cold temperature: At very cold temperatures, the most serious concern is the risk of hypothermia or dangerously low body temperature. Another serious effect of cold exposure is frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia could be fatal in absence of immediate medical attention.

Warning signs of hypothermia can include complaints of nausea, fatigue, dizziness, irritability or euphoria. Surveyors can also experience pain in their extremities (for example hands, feet, ears) and severe shivering. Surveyors should be moved to a heated shelter and seek medical advice when appropriate.

Heat: A person working in a very hot environment loses water and salt through sweat. This loss should be compensated by water and salt intake. Fluid intake should equal fluid loss. On average, about one litre of water each hour may be required to replace the fluid loss. Plenty of drinking water should be available on the job site and persons should be encouraged to drink water every 15 to 20 minutes even if they do not feel thirsty. Drinks specially designed to replace body fluids and electrolytes may be taken. Alcoholic drinks should never be taken as alcohol dehydrates the body.

An acclimatized surveyor loses relatively little salt in their sweat and therefore the salt in the normal diet is usually sufficient to maintain the electrolyte balance in the body fluids. For un-acclimatized surveyors who may sweat continuously and repeatedly, additional salt in the food may be used. Salt tablets are not recommended because the salt does not enter the body system as fast as water or other fluids. Too much salt can cause higher body temperatures, increased thirst and nausea. Persons on salt-restricted diets should discuss the need for supplementary salt with their doctor.

When working at extreme temperatures the working hours should be adjusted to avoid the most extreme temperatures during the day. Working in the evenings and early in the morning is often a good solution to avoid the most extreme conditions. How the body reacts to extreme temperatures is very individual. Never take any chances and pay careful attention when performing work in extreme temperature environment. Working speed and rest schedule should be adjusted according to the temperature.

6.2 Engulfment hazards

Loose, granular material stored in holds or tanks, such as grain, sand, coal, or similar material, can engulf and suffocate a person. The loose material can crust or bridge over and break loose under the weight of a person.

6.3 Noise

Noise within a confined space can be amplified by the design and acoustic properties of the space. Excessive noise cannot only damage hearing, but can also affect communication, such as causing a shouted warning to go unheard.

6.4 Falling objects

Workers in confined spaces should be mindful of the possibility of falling objects, particularly in spaces, which have a topside opening for entry, and where work is being done above the worker.

6.5 Slick/Wet Surfaces

Slips and falls can occur on a wet surface causing injury or death to workers. Also, a wet surface will increase the likelihood for and effect of electric shock in areas where electrical circuits, equipment, and tools are used.

7 Guidelines for use of personal gas detectors

For detection of any local pockets of gas or lack of oxygen the surveyor should use his portable oxygen or multi-gas meter with audible alarm features.

This is especially important when entering tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O_2-content, and where rescue operations may be difficult.

Preferably a multi-gas meter should be used, capable of simultaneous monitoring of oxygen, combustible gases and hydrogen sulphide and carbon monoxide.

Note that CO sensors may also be sensitive to low concentrations of hydrogen (H_2) therefore it is important to evaluate the possibility for CO/hydrogen in the space. Anodes will generate hydrogen when in use.

Most measuring equipment is sensitive apparatus with limitations for the range they are capable of measuring. Sensors in all measuring equipment may be destroyed if exposed to extreme measurements (e.g. above 100% LEL), clogged filters or catalyst poison (silicone, lead, sulphur and chlorous)

The personal protective instrument should be turned on before tank entry.

7.1 Function test and full calibration

The difference between a function (bump) test and a full calibration:

- A function (bump) test is defined as a means of verifying calibration by using a known concentration of test gas to demonstrate that an instrument's response to the test gas is within acceptable limits.

- A full calibration is defined as the adjustment of an instrument's response to match

desired value compared to a known concentration of test gas.

A function (bump) test or full calibration of direct reading portable gas monitors should be made before each day's use in accordance with the manufacturer's instructions using appropriate test gas.

Any instrument that fails a function (bump) test must be adjusted by means of a full calibration procedure before further use.

Various standard types of calibration gases are available in handy size bottles. For calibration of all gas measuring equipment at least 2 points along the measuring range are needed to determine the accuracy.

Note:
Surveyors should never use their personal gas detectors to test a space for entry. Owner is responsible to make the space safe for entry.

8 Survey preparations

8.1 Cleaning

Tanks and spaces to be surveyed must be sufficiently clean and free from water, scale, dirt and oil residues to reveal excessive corrosion, significant deformation, fractures, damage and other structural deterioration. There is no point in entering a tank if the bottom of the tank is not visible and the intention of the survey is to survey those areas. Tank cleaning can be performed with an existing fixed tank cleaning system.

However, in shadow areas portable washing machines may have to be used in order to achieve sufficient degree of cleanliness.

Generally, tank surveys should be avoided in tanks in which de-sludging operations are taking place since these operations can potentially raise gas levels.

When entering into a HFO, lube oil or diesel fuel tank, extra care should be taken when considering cleanliness and atmosphere. Long term effects of exposure to substances found in these tanks are not well documented.

8.2 Lighting

Whenever possible, natural lighting should be provided in the tank during inspection by opening all tank hatches. A flashlight should be carried when working in confined spaces. Lighting in confined spaces may not be good and will normally be temporary arrangements cabled into the space or by torchlight.

ANNEX - Checklist for Entry into Confined Spaces

DO NOT ENTER A CONFINED SPACE UNTIL YOU HAVE CONSIDERED EVERY QUESTION AS WELL AS ANY OTHER ITEM OF CONCERN, AND HAVE DETERMINED THE SPACE TO BE SAFE.

THE FINAL DECISION IS YOURS.

YES	NO	
		1. SAFETY MEETING
❑	❑	Safety meeting is carried out prior to survey to discuss all aspects of safety measures?
❑	❑	Will someone accompany you into the space?
		2. PERMIT
		(The permit is an authorization, usually in writing, that states that the space has been tested by a Competent or Responsible person and that the space is safe for entry; what precautions, equipment, etc. are required; and what work is to be done.)
❑	❑	Has a confined space entry permit been issued?
❑	❑	Is the permit up to date?
		3. VERIFICATION
❑	❑	Are the instruments used in atmospheric testing properly calibrated?
❑	❑	Was the person performing the tests a certified Marine Chemist, a Competent Person, or equivalent?
❑	❑	Was the atmosphere in the confined space tested?
		4. TESTING
❑	❑	Has the monitor been calibrated before any reading is performed?
❑	❑	Was Oxygen at least 20.6 % but not more than 22%?
❑	❑	Were toxic, flammable, or oxygen-diluting gases / vapours present? - Hydrogen sulphide - Carbon monoxide - Methane - Benzene - Other (list) _____ _____

YES	NO	
		5. MONITORING
❑	❑	Will the atmosphere in the space be monitored while the space is occupied and after work breaks? **Remember – atmospheric changes occur due to the work procedure or the product stored and vessel movements and temperature changes. The atmosphere may change very quickly.**
		6. VENTILATION
❑	❑	Has the space been ventilated before entry?
❑	❑	Will ventilation be continued during entry?
❑	❑	Is the air intake for the ventilation system located in an area that is free of combustible dusts and vapours and toxic substances?
❑	❑	If atmosphere was found unacceptable and then ventilated, was it re-tested before entry?
		7. ISOLATION
❑	❑	Has the space been cleaned up before entry?
❑	❑	Has the space been isolated from other systems?
❑	❑	Has electrical equipment been locked out?
❑	❑	Have disconnects been used where possible?
❑	❑	Has mechanical equipment been blocked, chocked, and disengaged where necessary?
❑	❑	Have lines under pressure been blanked and bled?
❑	❑	Have the necessary Notice boards been placed in the operations locations and at the confined space entry point?
		8. CLOTHING/EQUIPMENT (PPE)
❑	❑	Is special clothing required (boots, chemical suits, glasses, etc.)?
❑	❑	Is special equipment required (e.g. rescue equipment, communications equipment, heavy duty raft, life vests, etc.)?
❑	❑	Are special tools required (e.g. spark proof, intrinsically safe)?
		9. TRAINING
❑	❑	Have you been trained in confined space entry and do you know what to look for?

YES NO

10. STANDBY/RESCUE

❑	❑	Is an attendant on the outside in constant visual or auditory communication with the person on the inside?
❑	❑	Will the attendant be able to see and/or hear the person inside at all times?
❑	❑	Are rescue EEBD in place at the space entry point?
❑	❑	Is there a rescue team in place?

Note:

The surveyor shall not enter a tank, a compartment or a confined space if air supplied breathing apparatus is required.

BCS-G73 Type approval procedure for cable trays/protective casings made of plastics materials

1. General Design Requirements

1.1. Ambient Temperatures

Cable tray/protective casings should be designed to the following ambient temperatures*:

- 25 °C to 90 °C for outdoor use
+ 5 °C to 90 °C for indoor use.

1.2. Safe Working Load

Cable tray/protective casings should be assigned a Safe Working Load.

2 Mechanical Requirements

2.1 Impact Resistance Test

The test should be performed according to IEC 60068-2-75:2014 using the pendulum hammer.

a) The test should be carried out on samples of cable tray lengths or cable ladder lengths, of 250 mm ± 5 mm long. Samples of ladder should consist of two side-members with one rung positioned centrally. Samples of mesh trays should be prepared in such a way that there will be a wire in the centre.

b) Before the test, plastics components should be aged at a temperature of 90 °C ± 2 °C for 240 h continuously.

c) The samples should be mounted on wooden fibreboard of thickness 20 mm ± 2 mm.

d) The samples to be tested should be placed in a refrigerator, the temperature within which is maintained at the declared temperature according to 1.1 above with a tolerance of ± 2 °C.

e) After 2 h, the samples should, in turn, be removed from the refrigerator and immediately placed in the test apparatus.

f) At 10 s ±1 s after removal of each sample from the refrigerator the hammer should be allowed to fall with impact energy, the mass of the hammer and the fall height :

Approximate energy (J)	Mass of hammer (kg)	Fall height (mm)
10	5.0	200 ± 2

Note: * Consideration will be given to the use of plastics cable trays/protective casings in the cold environment where the ambient temperature is below -25°C provided the mechanical properties of the plastics can be maintained for the intended purpose and the installation location. In this particular instance, the cold bend and cold impact properties of the material should also be considered.

g) The impact should be applied to the base, or the rung, in the first sample, to one of the side members in the second sample, and to the other side member in the third sample.

In each case, the impact should be applied to the centre of the face being tested.

h) After the test, the samples should show no signs of disintegration and/or defor-mation that will impair the safety.

2.2. Safe Working Load (SWL) Test

a) Cable trays/protective casings and joints should be assigned a Safe Working Load (SWL) satisfying the following criteria, tested at the declared temperatures according to 1.1 above (see note) :

- the maximum deflection should not exceed L/100 where L is the distance between the supports,

- no mechanical defects or failure are observed when tested to 1.7 x SWL.

b) All loads should be uniformly distributed (UDL) over the length and width of the samples as shown in Appendix 1.

The loads should be applied in such a way that a UDL is ensured even in the case of extreme deformation of the samples.

To allow for settlement of the samples, a pre-load of 10 % of the test load unless oth-erwise specified, should be applied and held for at least 5 min, after which the mea-surement apparatus should be calibrated to zero.

c) The load should then be gradually increased evenly longitudinally and trans-versely up to the test load continuously or when a continuous increase is impractical, the load may be increased by increments.

These increments should not exceed about a quarter of the safe working load. The load increments should be distributed through the load plates longitudinally and trans-versely as evenly as is practical.

d) After loading, the deflection should be measured at the points specified to give a practical mid-span deflection.

e) The samples should be left and the deflections measured every 5 minutes until the difference between two consecutive sets of readings is less than 2 % with regard to the first set of the two consecutive sets of readings. The first set of readings mea-sured at this point is the set of deflections measured at the test load.

f) When subject to the test load the samples, their joints and internal fixing devices, should show no damage or crack visible to normal view or corrected vision without magnification.

g) The load should then be increased to 1.7 times the test load.

The samples should be left and the deflections measured every 5 min until the differ-ence between two consecutive sets of readings is less than 2 % with regard to the first set of the two consecutive sets of readings. The samples should sustain the increased

loading without collapsing. Buckling and deformation of the samples is permissible at this loading.

Note: Alternatively, tests can be carried out:

- at any temperature within the declared range if documentation is available which states that the relevant structural properties of the materials as used within the system do not differ by more than 5%of the average between the maximum and minimum property values, or,

- only at maximum temperature within the range, if documentation is available, which states that the relevant structural properties of the materials, as used within the system decrease when the tempera ture is increasing, or

- at maximum and minimum temperature only.

Tests should be carried out for the smallest and largest sizes of cable trays lengths or cable ladder lengths, having the same material, joint and topological shape.

3. Fire Properties

3.1 Flame Retardant Test:

The cable trays/protective casings should be at least flame retardant. They should be tested in accordance with BCS-R E10, test 21.

3.2 Smoke and Toxicity Test

The cable tray/protective casings should be tested in accordance with Part 2 of 2010 FTP Code adopted by IMO Resolution MSC.307(88) as amended by IMO Resolution MSC.437(99), or any international or national standard.

4. Special Requirements

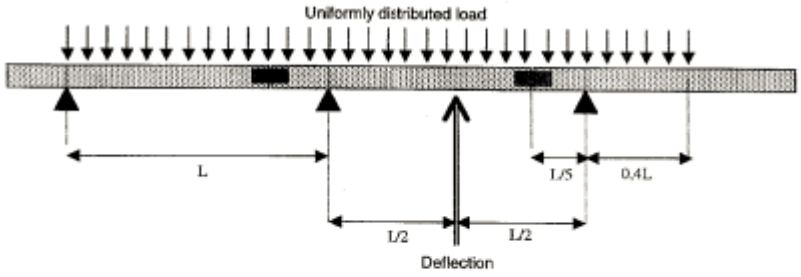
4.1 Resistivity Test

Cable trays/protective casings passing through a hazardous area should be electrically conductive.

The volume resistivity level of the cable trays/protective casings and fittings should be below 10^5 ohm meter [Ωm] and the surface resistivity should be below 10^6 ohm [Ω]. The cable tray/protective casings should be tested in accordance with IEC 62631-3-1:2016 and IEC 62631-3-2:2015.

Note: The resistance to earth from any point in these appliances should not exceed 10^6 ohm [Ω].

Appendix 1 IEC 61537:2006 Loading test procedure summary



L Supporting distance

Supporting system

Cable tray junction

BCS- G76 Guidelines for Surveys, Assessment and Repair of Hull Structure – Bulk Carriers

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1 Introduction

The International Association of Classification Societies (IACS) is introducing a series of manuals with the intention of giving guidelines to assist the surveyors of IACS Member Societies, and other interested parties involved in the survey, assessment and repair of hull structures for certain ship types.

This manual gives guidelines for a bulk carrier type ship which is constructed with a single deck, single skin, double bottom, hopper side tanks and topside tanks in cargo spaces, and is intended primarily to carry dry cargo, including ore, in bulk. **Figure 1** shows the general view of a typical single skin bulk carrier with 9 cargo holds.

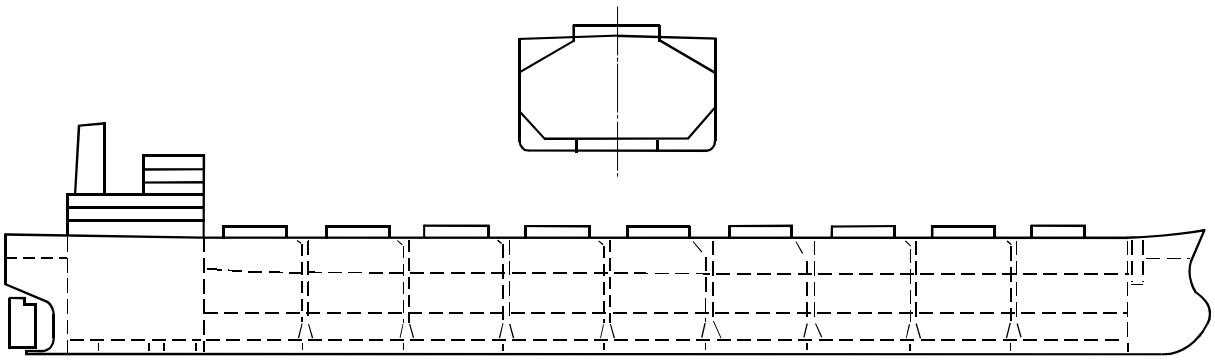


Figure 1 General view of a typical single skin bulk carrier

The guidelines focus on the IACS Member Societies' survey procedures but may also be useful in connection with inspection/examination schemes of other regulatory bodies, owners and operators.

The manual includes a review of survey preparation guidelines, which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the preparation necessary before the surveys can be carried out.

The survey guidelines encompass the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

An important feature of the manual is the inclusion of the section which illustrates examples of structural deterioration and damages related to each structural area and gives what to look for, possible cause, and recommended repair methods, when considered appropriate.

The "IACS Early Warning Scheme (EWS)", with the emphasis on the proper reporting of significant hull damages by the respective Classification Societies, will enable the analysis of problems as they arise, including revisions of these Guidelines.

This manual has been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of

surveyors, and is to be used at the surveyors' discretion. It is recognized that alternative and satisfactory methods are already applied by surveyors. Should there be any doubt with regard to interpretation or validity in connection with particular applications, clarification should be obtained from the Classification Society concerned.

Figure 2 shows a typical cargo hold structural arrangement in way of cargo hold region.

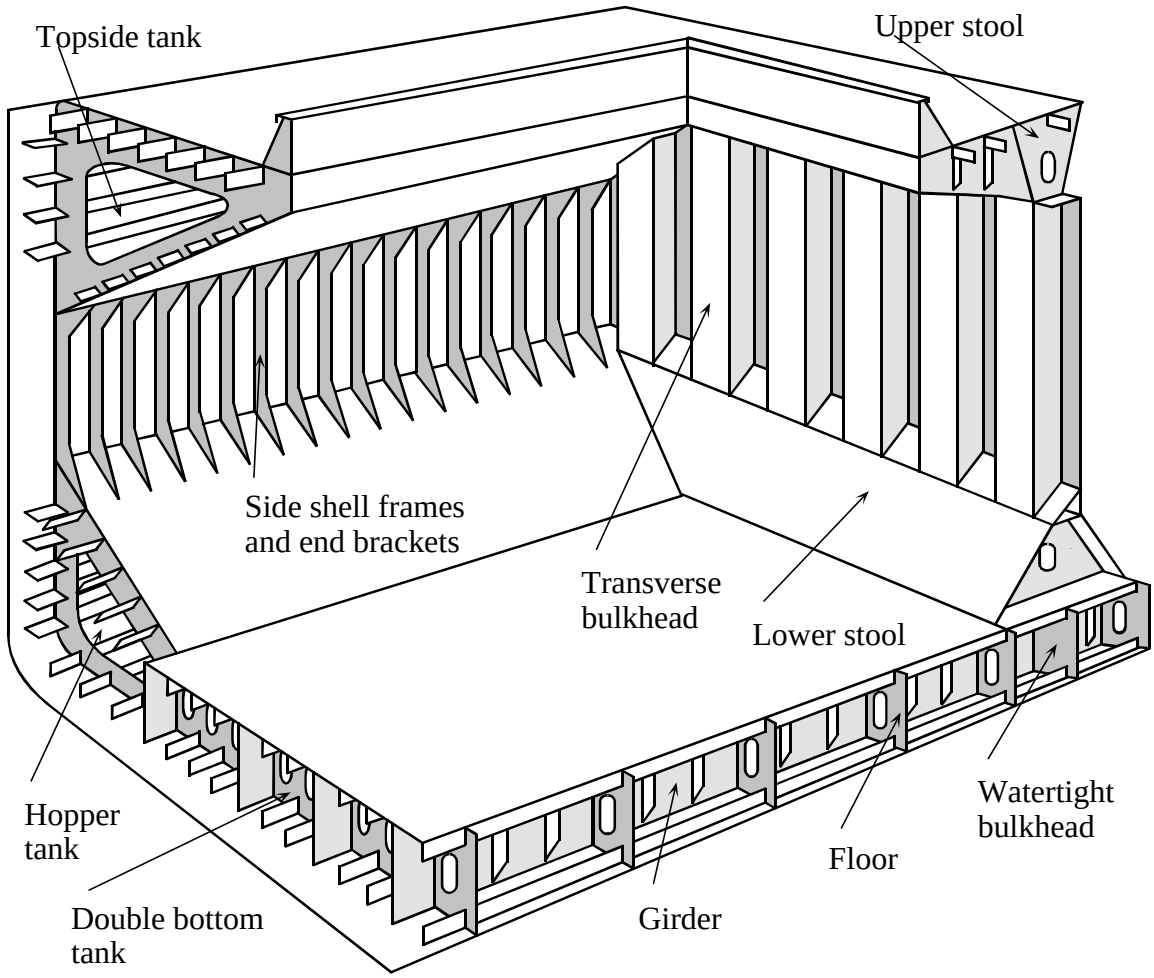


Figure 2 Typical cargo hold configuration for a single skin bulk carrier

2 Class survey requirements

2.1 General

2.1.1 The programme of periodical surveys is of prime importance as a means for assessment of the structural condition of the hull, in particular, the structure of cargo holds and adjacent tanks. The programme consists of Special (or Renewal) Surveys carried out at five-year interval with Annual and Intermediate Surveys carried out in between Special Surveys.

2.1.2 Since 1991, it has been a requirement for new bulk carriers to apply a protective coating to the structure in water ballast tanks which form part of the hull boundary, and, since 1993, to part of the side shell and transverse watertight bulkheads structures in way of the cargo holds.

2.1.3 The International Maritime Organization (IMO), in 1997 SOLAS Conference, adopted structural survivability standards for new and existing bulk carriers carrying the high density cargoes. All new single side skin bulk carriers, defined as ships built on or after 1st July 1999, are required to have sufficient strength to withstand the flooding of any one cargo hold taking dynamic effects into account. All existing single side skin bulk carriers, defined as ships built before 1 July 1999, must comply with the relevant BCS criteria for assessing the vertically corrugated transverse watertight bulkhead between the first two cargo holds and the double bottom in way of the first cargo hold with the first cargo hold assumed flooded. The relevant IMO adopted standards, BCS-R S19 and S22 for existing ships, and recommended standards, BCS-R S17, S18 and S20 for new ships, and the extent of possible repairs and/or reinforcements of vertically corrugated transverse watertight bulkheads on existing bulk carriers are freely available.

2.1.4 From 1 July 2001, bulk carriers of 20,000 DWT and above, to which the Enhanced Survey Programme (ESP) requirements apply, starting with the 3rd Special Survey, all Special and Intermediate hull classification surveys are to be carried out by at least two exclusive surveyors. Further, one exclusive surveyor is to be on board while thickness measurements are taken to the extent necessary to control the measurement process.

2.1.5 The detailed survey requirements complying with ESP are specified in the Rules and Regulations of BCS.

2.1.6 The ESP is based on two principal criteria: the condition of the coating and the extent of structural corrosion. Of primary importance is when a coating has been found to be in a "poor" condition (more than 20% breakdown of the coating or the formation of hard scale in 10 % more of the area) or when a structure has been found to be *substantially* corroded (i.e. a wastage between 75 % and 100 % of the allowable diminution for the structural member in question.).

2.2 Annual Surveys

2.2.1 The purpose of an Annual Survey is to confirm that the general condition of the hull is maintained at a satisfactory level.

2.2.2 As the ship ages, cargo holds are required to be subjected to more extensive overall and close-up examinations at Annual Surveys.

2.2.3 In addition, overall and close-up examinations may be required for ballast tanks as a consequence of either the coating deteriorating to a *poor* condition or the structure being found to be *substantially* corroded at previous Intermediate or Special Surveys.

2.3 Intermediate Surveys

2.3.1 The Intermediate Survey replaces the second or third Annual Survey in each five year Special Survey cycle and requires that, in addition to the Annual Survey requirements, extended overall and close-up examinations including thickness measurements of cargo holds and ballast tanks used primarily for salt water ballast, are carried out.

2.3.2 The survey also includes re-examination and thickness measurements of any suspect areas which have substantially corroded or are known to be prone to rapid wastage.

2.3.3 Areas in ballast tanks and cargo holds found suspect at the previous Special Survey are subject to overall and close-up surveys, the extent of which becomes progressively more extensive commensurate with the age of the vessel.

2.3.4 As of 1 July 2001, for bulk carriers exceeding 15 years of age, the requirements of the Intermediate Survey are to be of the same extent as the previous Special Survey, except for pressure testing of cargo/ballast holds and ballast tanks which is not required unless deemed necessary by the attending surveyor.

2.4 Special Surveys

2.4.1 The Special (or Renewal) Surveys of the hull structure are carried out at five-year intervals for the purpose of establishing the condition of the structure to confirm that the structural integrity is satisfactory in accordance with the Classification Requirements, and will remain fit for its intended purpose for another five-year period, subject to proper maintenance and operation of the ship and to periodical surveys carried out at the due dates.

2.4.2 The Special Survey concentrates on close-up examination in association with thickness determination and is aimed at detecting fractures, buckling, *substantial* corrosion and other types of structural deterioration.

2.4.3 Thickness measurements are to be carried out upon agreement with the

Classification Society concerned in conjunction with the Special Survey. The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date.

2.4.4 Deteriorated protective coating in salt water ballast spaces and structural areas showing substantial corrosion and/or considered by the surveyor to be prone to rapid wastage will be recorded for particular attention during the following survey cycle, if not repaired at the survey.

2.5 Drydocking (Bottom) Surveys

2.5.1 A **Drydocking Survey** is required in conjunction with the **Special Survey** to examine the external underwater part of the ship and related items. Two Bottom surveys are required to be carried out during the five year period of validity of SOLAS Cargo Ship Safety Construction (SC) Certificate, and the maximum interval between any two successive Bottom Survey is not to exceed three years.

2.5.2 From 1 July 2002, for bulk carriers of 15 years of age and over, inspection of the outside of the ship's bottom is to be carried out with the ship in dry dock. For bulk carriers less than 15 years of age, alternative inspections of the ship's bottom not conducted in conjunction with the Special Survey may be carried out with the ship afloat. Inspection of the ship afloat is only to be carried out when the conditions are satisfactorily and the proper equipment and suitably qualified staff are available.

2.6 Damage and repair surveys

2.6.1 Damage surveys are occasional surveys which are, in general, outside the programme of periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or owner's representative to inform BCS when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages should be inspected and assessed by BCS's surveyors and the relevant repairs, if needed, are to be performed. In certain cases, depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the planned periodical survey.

Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the surveyor, will affect the vessel's structural watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered to are to include:

Side shell frames, their end attachments and adjacent shell plating, deck structure and deck plating, watertight bulkheads, and hatch covers and coamings.

2.6.2 In cases of repairs intended to be carried out by riding crew during voyage, the complete procedure of the repair, including all necessary surveys, is to be submitted to and agreed upon by BCS reasonably in advance.

2.6.3 BCS- **R** Z 13 "Voyage Repairs and Maintenance" provides useful guidance for repairs to be carried out by a riding crew during a voyage.

2.6.4 For locations of survey where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage. A suitable condition of class will be imposed when temporary measures are accepted.

3 Technical background for surveys

3.1 General

3.1.1 The purpose of carrying out the periodical hull surveys is to detect possible structural defects and damages and to establish the extent of any deterioration. To help achieve this and to identify key locations on the hull structure that might warrant special attention, knowledge of any historical problems of the particular ship or other ships of a similar class is to be considered if available. In addition to the periodical surveys, occasional surveys of damages and repairs are carried out. Records of typical occurrences and chosen solutions should be available in the ship's history file.

3.2 Definitions

3.2.1 For clarity of definition and reporting of survey data, it is recommended that standard nomenclature for structural elements be adopted. Typical sections in way of cargo holds are illustrated in **Figures 3 (a)** and **(b)**. These figures show the generally accepted nomenclature.

The terms used in these guidelines are defined as follows.

(a) Ballast Tank is a tank which is used primarily for salt water ballast.

(b) Spaces are separate compartments including holds and tanks.

(c) Overall examination is an examination intended to report on the overall condition of the hull structure and determine the extent of additional close-up examinations.

(d) Close-up examination is an examination where the details of structural components are within the close visual examination range of the surveyors, i.e. normally within reach of hand.

(e) Transverse Section includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom and inner bottom, hopper side tanks and top wing tanks.

(f) Representative Spaces are those which are expected to reflect the condition of other spaces of similar type and service and with similar corrosion protection systems. When selecting representative spaces, account should be taken of the service and repair history on board.

(g) Suspect Areas are locations showing Substantial Corrosion and/or are considered by the surveyor to be prone to rapid material wastage.

(h) Substantial Corrosion is an extent of corrosion such that assessment of corrosion pattern indicates a material wastage in excess of 75 per cent of allowable margins, but within acceptable limits.

(i) Coating Condition is defined as follows:

Good – condition with only minor spot rusting.

Fair – condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20 per cent or more of areas under consideration, but less than as defined for Poor condition.

Poor – condition with general breakdown of coating over 20 per cent or more of areas or hard scale at 10 per cent or more of

areas under consideration.

(j) Transition Region is a region where discontinuity in longitudinal structure occurs, e.g. at forward bulkhead of engine room and collision bulkhead.

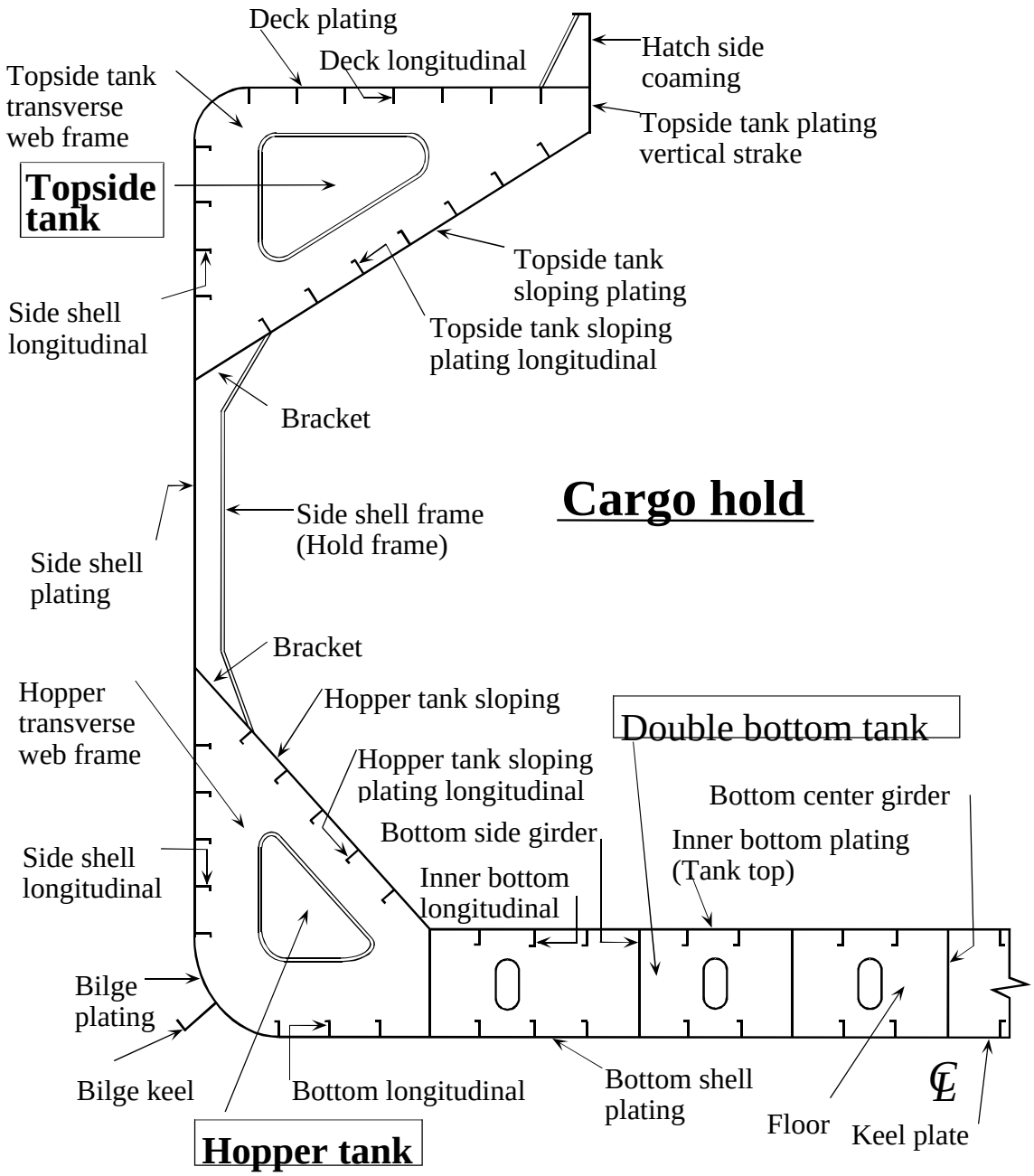


Figure 3 (a) Nomenclature for typical transverse section in way of cargo hold

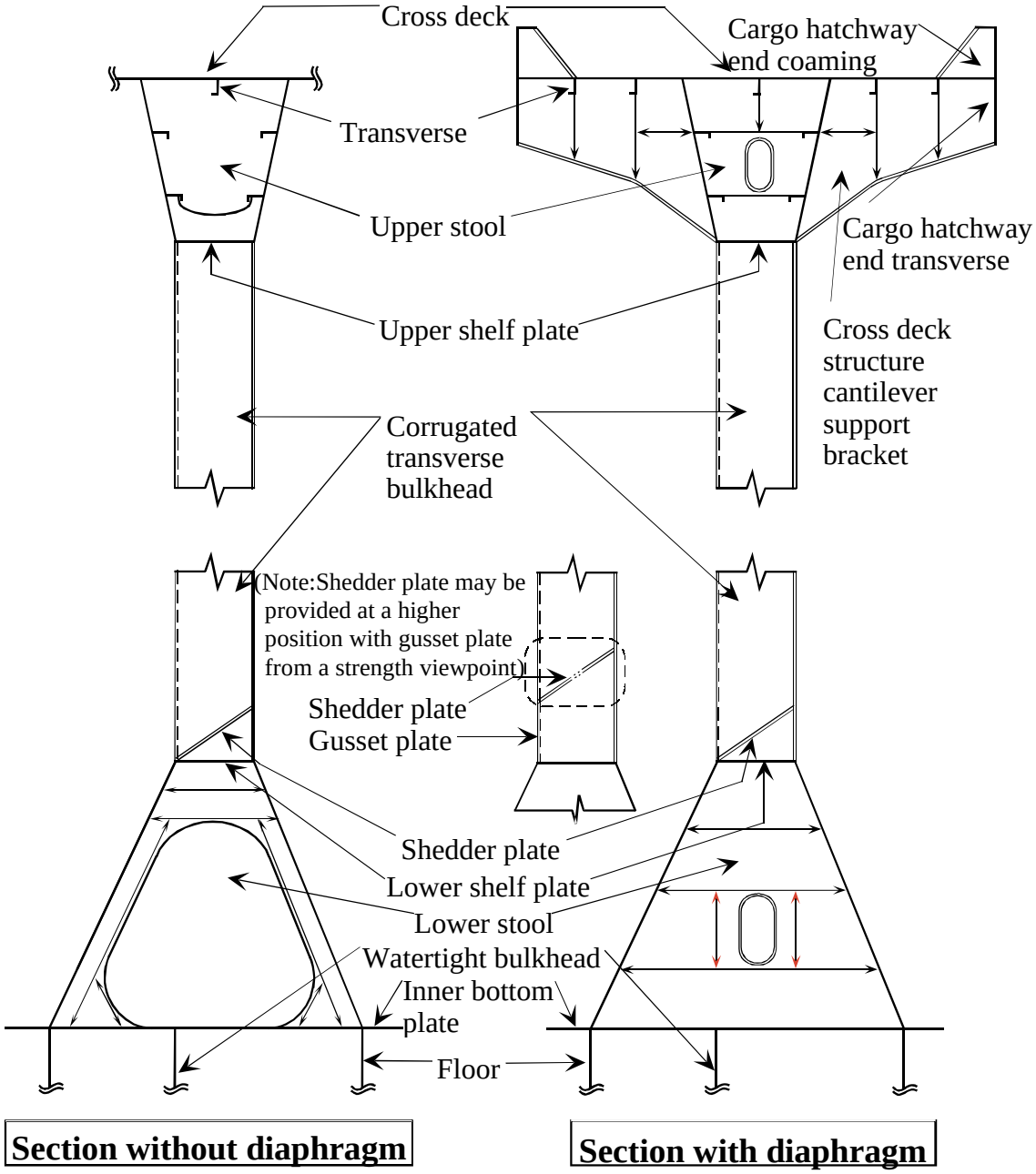


Figure 3 (b) Nomenclature for typical watertight bulkhead

3.3 Structural damages and deterioration

3.3.1 General

In the context of this manual, structural damages and deterioration imply deficiencies caused by:

- excessive corrosion
- design faults
- material defects or bad workmanship
- navigation in extreme weather conditions
- loading and unloading operations, water ballast exchange at sea
- wear and tear
- contact (with quay side, ice, touching underwater objects, etc.)

but not as a direct consequence of accidents such as collisions,

groundings and fire/explosions.
Deficiencies are normally recognized as:
- material wastage
- fractures
- deformations
The various types of deficiencies and where they may occur are discussed in more detail as follows:

3.3.2 Material wastage

In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible location of corrosion that may occur to the structural members on decks, in holds, and in tanks.

General corrosion appears as a non-protective, friable rust which can occur uniformly on hold or tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred. Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals.

Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

Pitting corrosion is often found in the bottom plating or in horizontal surfaces, such as face plates, in ballast tanks and is normally initiated due to local breakdown of coating. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.

Erosion which is caused by the wearing effect of flowing liquid and abrasion which is caused by mechanical actions may also be responsible for material wastage.

3.3.3 Fractures

In most cases fractures are found at locations where stress concentration occurs. Weld defects, flaws, and where lifting fittings used during ship construction are not properly removed are often areas where fractures are found. If fractures occur under repeated stresses which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses induced by wave forces, fatigue fractures can also result from vibration forces introduced by main engine(s) or propeller(s), especially in the afterward part of the

hull.

Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify, clean, and closely inspect potential problem areas. If the initiation points of a fracture is not apparent, the structure on the other side of the plating should be examined.

Fracture initiating at latent defects in welds more commonly appears at the beginning or end of a run of welds, or rounding corners at the end of a stiffener, or at an intersection. Special attention should be paid to welds at toes of brackets, at cut-outs, and at intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations at the ends of each length of weld.

It should be noted that fractures, particularly fatigue fractures due to repeated stresses, may lead to serious damages, e.g. a fatigue fracture in a frame may propagate into shell plating and affect the watertight integrity of the hull. In extreme weather conditions the shell fracture could extend further resulting in the loss of part of the shell plating and consequent flooding of cargo hold.

3.3.4 Deformations

Deformation of structure is caused by in-plane load, out-of-plane load or combined loads. Such deformation is often identified as local deformation, i.e. deformation of panel or stiffener, or global deformation, i.e. deformation of beam, frame, girder or floor, including associated plating.

If in the process of the deformation large deformation is caused due to small increase of the load, the process is called buckling.

Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to bottom slamming and wave impact forces are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the after part of the hull.

In the case of damages due to contact with other objects, special attention should be drawn to the fact that although damages to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic buckling will not normally be directly obvious but may be detected by evidence of coating damage, stress lines or shedding of scale. Buckling damages are often found in webs of web frames or floors. In many cases, this may be attributed to corrosion of webs/floors, wide stiffener spacing or wrongly positioned lightening holes, man-holes or slots in

webs/floors.

Finally, it should be noted that inadvertent overloading may cause significant damages. In general, however, major causes of damages are associated with excessive corrosion and contact damage.

3.4 Structural detail failures and repairs

3.4.1 For examples of structural defects which have occurred in service, attention is drawn to **Section 5** of these guidelines. It is suggested that surveyors and inspectors should be familiar with the contents of **Section 5** before undertaking a survey.

3.4.2 Any damage to or excessive wastage of the following structures that are considered affecting the ship's Classification is to be promptly and thoroughly repaired:

(a) Side shell frames, their end attachments and adjacent shell plating

(b) Deck structure and deck plating between hatches

(c) Watertight bulkheads

(d) Hatch covers and coamings

3.4.3 In general, where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Doubler plates must not be used for the compensation of wasted plate. Repair work in tanks requires careful planning in terms of accessibility.

3.4.4 If replacement of defective parts must be postponed, the following temporary measures may be acceptable at the surveyor's discretion:

(a) The affected area may be sandblasted and painted in order to reduce corrosion rate.

(b) Doubler may be applied over the affected area. Special consideration should be given to areas buckled under compression.

(c) Stronger members may support weakened stiffeners by applying temporarily connecting elements.

(d) Cement box may be applied over the affected area.

A suitable condition of class should be imposed when temporary measures are accepted.

3.5 IACS Early Warning Scheme (EWS) for reporting of significant hull damage

3.5.1 IACS has organised and set up a system to permit the collection, and dissemination amongst Member Societies of information (while excluding a ship's identity) on significant hull damages.

3.5.2 The principal purpose of the IACS Early Warning Scheme is to enable a Classification Society with experience of a specific damage to make this information available to the other societies so that action can be implemented to avoid repetition of damage to hulls where similar structural arrangements are employed.

3.5.3 These guidelines incorporated the experience gained from IACS EWS Scheme.

4 Survey planning, preparation and execution

4.1 General

4.1.1 The owner should be aware of the scope of the coming survey and instruct those who are responsible, such as the master or the superintendent, to prepare necessary arrangements. If there is any doubt, BCS should be consulted.

4.1.2 Survey execution will naturally be heavily influenced by the type of survey to be carried out. The scope of survey will have to be determined prior to the execution.

4.1.3 The surveyor should study the ship's structural arrangements and review the ship's operation and survey history and those of sister ships where possible, to identify any known potential problem areas particular to the type of ships. Sketches of typical structural elements should be prepared in advance so that any defects and/or ultrasonic thickness measurements can be recorded rapidly and accurately.

4.2 Survey Programme

4.2.1 It is mandatory that a specific Survey Programme be worked out in advance of the Special Survey by the owner in cooperation with BCS .

4.2.2 The Survey Programme should account for and comply with the requirements for close-up examinations, thickness measurements and tank testing, and take into consideration the conditions for survey, access to structures and equipment for survey.

4.2.3 The close-up survey and thickness measurement in this Survey Programme may be augmented by a Planning Document as described in **4.3** and which should be agreed with BCS.

4.2.4 The Survey Programme should take into account the information included in the documentation on board, as described in **4.9**.

4.2.5 In developing the Survey Program, BCS will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

4.3 Principle for Planning Document

4.3.1 A Planning Document is intended to identify critical structural areas and to stipulate the extent and locations for close-up survey and thickness measurements with respect to sections and internal structures as well as nominated suspect areas. Minimum requirements regarding close-up surveys and thickness measurements are stipulated in BCS- R Z10.2.

4.3.2 The planning Document is to be worked out by the owner in cooperation

with BCS well in advance of the survey.

4.3.3 The basis for nomination of spaces and areas in **4.3.1** above is a technical assessment and consideration of possible deterioration where the following elements on the particular ship are taken into account:

(a) Design features such as extent of high tensile steel and local details;

(b) Former history available at owner's and BCS's offices with respect to material wastage, fractures, deformations and repairs for the particular ship as well as similar vessels.

(c) Information from same offices with respect to type of cargo, use of different spaces for cargo/ballast, protection of spaces and condition of coating, if any.

4.3.4 The Planning Document is to contain relevant information pertaining to at least the following information:

(a) Main particulars

(b) Main structural plans (scantling drawings), including information regarding use of high tensile steels

(c) Plan of tanks/holds

(d) List of tanks/holds with information on use, protection and condition of coating

(e) Conditions for survey (e.g. information regarding hold and tank cleaning, gas freeing, ventilation, lighting, etc)

(f) Provisions and methods for access

(g) Equipment for surveys

(h) Corrosion risk nomination of holds and tanks

(i) Design related damages on the particular ship, and similar vessels, where available.

(j) Selected holds and tanks and areas for close-up survey

(k) Selected sections for thickness measurements

(l) Acceptable corrosion allowance

(m) Damage experience related to the ship in question

4.4 Conditions for survey

4.4.1 The owner is to provide the necessary facilities for a safe execution of the survey.

4.4.2 Tanks and spaces are to be safe for access, i.e. gas freed (marine chemist certificate), ventilated, illuminated, etc.

4.4.3 Tanks and spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. and sufficient illumination is to be provided, to reveal corrosion, deformation, fractures, damages or other structural deterioration. In particular this applies to areas which are subject to thickness measurement.

4.5 Access arrangement and safety

4.5.1 In accordance with the intended survey, measures are to be provided to enable the hull structure to be examined and thickness measurement carried out in a safe and practical way.

4.5.2 For close-up surveys in a cargo hold and salt water ballast tanks, one or more of the following means for access, acceptable to the Surveyor, are to be provided:

a) permanent staging and passages through structures;
b) temporary staging, e.g. ladders and passages through structures;
c) lifts and movable platforms; and
d) other equivalent means.

4.5.3 In addition, particular attention should be given to the following guidance:

(a) Prior to entering tanks and other closed spaces, e.g. chain lockers, void spaces, it is necessary to ensure that the oxygen content is to be tested and confirmed as safe. A responsible member of the crew should remain at the entrance to the space and if possible communication links should be established with both the bridge and engine room. Adequate lighting should be provided in addition to a hand held torch (flashlight).

(b) In tanks where the structure has been coated and recently deballasted, a thin slippery film may often remain on the surfaces. Care should be taken when inspecting such spaces.

(c) The removal of scale may be extremely difficult. The removal of scale by hammering may cause sheet scale to fall, and in cargo holds this may result in residues of cargo falling from above. When using a chipping or scaling hammer care should be taken to protect eyes, and where possible safety glasses should be worn.
If the structure is heavily scaled then it may be necessary to request de-scaling before conducting a satisfactory visual examination.

(d) Owners or their representatives have been known to request that a survey be carried out from the top of the cargo during discharging operations. For safety reason, surveys must not ~~to~~ be carried out during discharging operations in the hold.

(e) In bulk carriers fitted with vertical ballast trunks connecting the topside and lower hopper tanks, the trunks and associated hull structure are normally surveyed in conjunction with the tanks. Space within the trucks is very limited and access is by ladder or individual rungs which can become heavily corroded and in some cases detached or missing. Care needs to be taken when descending these trunks.

(f) When entering a cargo hold or tank the bulkhead vertical ladders should be examined prior to descending to ensure that they are in good condition and rungs are not missing or loose. If holds are being entered when the hatch covers are in the closed position, then adequate lighting should be arranged in the holds. One person at a

time should descend or ascend the ladder.

(g) Sloping ("Australian Style") bulkhead ladders are prone to cargo handling damage and it is not uncommon to find platforms and ladders in poor condition with rails and stanchions missing or loose.

(h) If a portable ladder is used for survey purposes, the ladder should be in good condition and fitted with adjustable feet, to prevent it from slipping. Two crew members should be in attendance in order that the base of the ladder is adequately supported during use. The remains of cargo, in particular fine dust, on the tank top should be brushed away as this can increase the possibility of the ladder feet slipping.

(i) If an extending/articulated ladder (frame walk) is used to enable the examination of upper portions of cargo hold structure, the ladder should incorporate a hydraulic locking system and a built in safety harness. Regular maintenance and inspection of the ladder should be confirmed prior to its use.

(j) If a hydraulic arm vehicles ("Cherry Picker") is used to enable the examination of the upper parts of the cargo hold structure, the vehicle should be operated by qualified personnel and there should be evidence that the vehicle has been properly maintained. The standing platform should be fitted with a safety harness. For those vehicles equipped with a self leveling platform, care should be taken that the locking device is engaged after completion of maneuvering to ensure that the platform is fixed.

(k) Staging is the most common means of access provided especially where repairs or renewals are being carried out. It should always be correctly supported and fitted with handrails. Planks should be free from splits and lashed down. Staging erected hastily by inexperienced personnel should be avoided. In topside and lower hopper tanks it may be necessary to arrange staging to provide close-up examination of the upper parts of the tank particularly the transverse web frames, especially where protective coatings have broken down or have not been applied.

(l) In double bottom tanks there will often be a build up of mud on the bottom of the tank and this should be removed, in particular in way of tank boundaries, suction and sounding pipes, to enable a clear assessment of the structural condition.

4.6 Personal equipment

4.6.1 The following protective clothing and equipment to be worn as applicable during the surveys:

(a) Working clothes: Working clothes should be of a low flammability type and be easily visible.

(b) Head protection: Hard hat (metal hats are not allowed) shall always be worn outside office building/unit accommodations.

(c) Hand and arm protection: Various types of gloves are available for use, and these should be used during all types of surveys. Rubber/plastic gloves may be necessary when working in cargo holds.

(d) Foot protection: Safety shoes or boots with steel toe caps and non slip soles shall always be worn outside office buildings/unit accommodations. Special footwear may be necessary on slippery surfaces or in areas with chemical residues.

(e) Ear protection: Ear muffs or ear plugs are available and should be used when working in noisy areas. As a general rule, you need ear protection if you have to shout to make yourself understood by someone standing close to you.

(f) Eye protection: Goggles should always be used when there is danger of getting solid particles or dust into the eyes. Protection against welding arc flashes and ultraviolet light should also be considered.

(g) Breathing protection: Dust masks shall be used for protection against the breathing of harmful dusts, paint spraying and sand blasting. Gas masks and filters should be used by personnel working for short periods in an atmosphere polluted by gases or vapour.

(Self-contained breathing apparatus: Surveyors shall not enter spaces where such equipment is necessary due to unsafe atmosphere. Only those who are specially trained and familiar with such equipment should use it and only in case of emergency).

(h) Lifejacket: Recommended used when embarking/disembarking ships offshore, from/to pilot boat.

4.6.2 The following survey equipment is to be used as applicable during the surveys:

(a) Torches: Torches (Flashlights) approved by a competent authority for use in a flammable atmosphere shall be used in gas dangerous areas. High intensity beam type is recommended for in-tank inspections. Torches are recommended to be fitted with suitable straps so that both hands may be free.

(b) Hammer: In addition to its normal purposes the hammer is recommended for use during surveys inside units, tanks etc. as it may be most useful for the purpose of giving distress signal in case of emergency.

(c) Oxygen analyser/Multigas detector: For verification of acceptable atmosphere prior to tank entry, pocket size instruments which give audible alarm when unacceptable limits are reached are recommended. Such equipment shall have been approved by national authorities.

(d) Safety belts and lines: Safety belts and lines should be worn where high risk of falling down from more than 3 meters is present.

(e) Radiation meter: For the purpose of detection of ionizing radiation (X or gamma rays) caused by radiographic examination, radiation meter of the type which gives audible alarm upon detection of radiation is recommended.

4.7 Thickness measurement and fracture detection

4.7.1 Thickness measurement is to comply with the requirements of BCS .

Thickness measurement should be

carried out at points that adequately represent the nature and extent of any corrosion or wastage of the respective structure (plate, web, etc.)

4.7.2 Thickness measurement is normally carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven as required.

4.7.3 The required thickness measurements, if not carried out by the class society itself, are to be carried out by a qualified company certified by BCS, and are to be witnessed by a surveyor on board to the extent necessary to control the process . The report is to be verified by the surveyor in charge.

4.7.4 The thickness measurement company should be part of the survey planning meeting to be held prior to the survey.

4.7.5 One or more of the following fracture detection procedures may be required if deemed necessary and should be operated by experienced qualified technicians:

(a) radiographic equipment
(b) ultrasonic equipment
(c) magnetic particle equipment
(d) dye penetrant

4.8 Survey at sea or at anchorage

4.8.1 Voyage surveys may be accepted provided the survey party is given the necessary assistance from the shipboard personnel. The necessary precautions and procedures for carrying out the survey are to be in accordance with **4.1** to **4.7** inclusive. Ballasting system must be secured at all times during tank surveys.

4.8.2 A communication system is to be arranged between the survey party in the spaces under examination and the responsible officer on deck.

4.9 Documentation on board

4.9.1 The following documentation is to be placed on board and maintained and updated by the owner for the life of ship in order to be readily available for the survey party.

4.9.2 Survey Report File: This file includes Reports of Structural Surveys, Executive Summary and Thickness Measurement Report.

4.9.3 Supporting Documents: The following additional documentation is to be placed on board, including any other information that will assist in identifying Suspect Areas requiring examination.

(a) Main structural plans of cargo holds and ballast tanks
(b) Previous repair history
(c) Cargo and ballast history
(d) Inspection and action taken by ship's personnel with reference to:
- structural deterioration in general

- leakages in bulkheads and piping
- condition of coating or corrosion protection, if any

(e) Survey Planning Document according to principles given in **4.3**

4.9.4 Prior to inspection, the completeness of the documentation onboard, and its contents as a basis for the survey should be examined.

5 Structural detail failures and repairs

5.1 General

5.1.1 The **catalogue of structural detail failures and repairs** contained in this section of the **Guidelines** collates data supplied by the IACS Member Societies and is intended to provide guidance when considering similar cases of damage and failure. The proposed repairs reflect the experience of the surveyors of the Member Societies, but it is realized that other satisfactory alternative methods of repair may be available. However, in each case the repairs are to be completed to the satisfaction of BCS surveyor concerned.

5.2 Catalogue of structural detail failures and repairs

5.2.1 The catalogue has been sub-divided into parts and areas to be given particular attention during the surveys:

Part 1 Cargo hold region

Area 1 Deck structure
Area 2 Topside tank structure
Area 3 Side structure
Area 4 Transverse bulkheads including stool structure
Area 5 Double bottom including hopper tank structure

Part 2 Fore and aft end regions

Area 1 Fore end structure
Area 2 Aft end structure
Area 3 Stern frame, rudder arrangement and propeller shaft support

Part 3 Machinery and accommodation spaces

Area 1 Engine room structure
Area 2 Accommodation structure

Part 1 Cargo hold region

Contents

Area 1 Deck structure
Area 2 Topside tank structure
Area 3 Side structure
Area 4 Transverse bulkheads including stool structure
Area 5 Double bottom including hopper tank structure

Area 1 Deck structure

Contents

1 General

2 What to look for - On-deck inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for - Under-deck inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Deformations
4.3 Fractures
4.4 Miscellaneous

Figures and/or Photographs - Area 1	
No.	**Title**
Photograph 1	Heavy corrosion of hatch coaming and topside tank plating vertical strake

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Fractures at main cargo hatch corner
2-a	Fracture of welded seam between thick plate and thin plate at cross deck
2-b	Plate buckling in thin plate near thick plate at cross deck
2-c	Overall buckling of cross deck plating
3-a	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket
3-b	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket
4	Fractures in deck plating initiated from weld of access manhole
5	Deformed and fractured deck plating around tug bitt
6	Fractures around cut-outs in cross deck girder
7-a	Buckling of hatch coaming and hatch end beam
7-b	Fractures in hatch end beam at knuckle joint

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
8	Fractures in hatch end beam at the joint to topside tank
9	Fractures in hatch end beam around feeding holes
10-a	Fractures in hatch coaming top plate at the termination of rail for hatch cover
10-b	Fractures in hatch coaming top plate at the termination of rail for hatch cover
11	Fractures in hatch coaming top plate initiated from butt weld of compression bar
12	Fractures in deck plating at the pilot ladder access of bulwarks

1 General

1.1 Deck structure outside hatches is subjected to longitudinal hull girder bending, caused by cargo distribution and wave actions. Moreover deck structure may be subjected to severe load due to green sea on deck, excessive deck cargo or improper cargo handling. Certain areas of the deck may also be subjected to additional compressive stresses caused by slamming or bow flare effect at the fore ship in heavy weather.

1.2 The cross deck structure between cargo hatches is subjected to transverse compression from the sea pressure on the ship sides and in-plane bending due to torsional distortion of the hull girder under wave action. Area around the corners of a main cargo hatch can be subjected to high cyclical stress due to the combined effect of hull girder bending moments, transverse and torsional loading.

1.3 Discontinuous cargo hatch side coamings can be subjected to significant longitudinal bending stress. This introduces additional stresses at the mid-length of hatches and stress concentrations at the termination of the side coaming extensions.

1.4 Hatch cover operations, in combination with poor maintenance, can result in damage to cleats and gasket, leading to the loss of weathertight integrity of the hold spaces. Damage to hatch covers can also be sustained by mishandling and overloading of deck cargoes.

1.5 The marine environment, the humid atmosphere due to the water vapour from the cargo in cargo holds, and the high temperature on deck and hatch cover plating due to heating from the sun may result in accelerated corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above.

1.6 Bulwarks are provided for the protection of crew and cargoes, and lashing of cargoes on deck. Although bulwarks are not normally considered as a structural item which contributes to the longitudinal strength of the hull girder, they can be subjected to significant longitudinal bending stress which can lead to fracture and corrosion, especially at the termination of bulwarks, such as at pilot ladder access or expansion joints. These fractures may propagate to deck plating and cause serious damage.

1.7 The deterioration of fittings on deck, such as ventilators, air pipes and sounding pipes, may cause serious deficiency in weathertightness/ watertightness and during fire fighting.

1.8 If the ship is assigned timber freeboards, fittings for stowage of timber deck cargo have to be inspected in accordance with ILLC 1966. Deterioration of the fittings may cause cargo to shift resulting in damage to the ship structure.

2 What to look for - On-deck inspection

2.1 Material wastage

2.1.1 The general corrosion condition of the deck structure, cargo hatch covers and coamings may be observed by visual inspection. Special attention should be paid to areas where pipes, e.g. fire main pipes, hydraulic pipes and pipes for compressed air, are fitted close to the plating, making proper maintenance of the protective coating difficult to carry out.

2.1.2 Grooving corrosion may occur at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, especially when the difference in plate thickness is large. The difference in plate thickness causes water to gather in this area resulting in corrosion ambience which may subsequently lead to grooving.

2.1.3 Pitting corrosion may occur throughout the cross deck strip plating and on hatch covers. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction.

2.1.4 Wastage/corrosion may affect the integrity of steel hatch covers and the associated moving parts, e.g. cleats, pot-lifts, roller wheels, etc. In some ships pontoon hatch covers with tarpaulins are used. The tarpaulins are liable to tear due to deck cargo, such as timbers, and cause heavy corrosion to the hatch covers.

2.2 Deformations

2.2.1 Plate buckling (between stiffeners) may occur in areas subjected to in-plane compressive stresses, in particular if corrosion is in evidence. Special attention should be paid to areas where the compressive stresses are perpendicular to the direction of the stiffening system. Such areas may be found in the cross deck strips between hatches when longitudinal stiffening is applied (See **Examples 2-b** and **2-c**).

2.2.2 Deformed structure may be observed in areas of the deck, hatch coamings and hatch covers where cargo has been handled/loaded or mechanical equipment, e.g. hatch covers, has been operated. In exposed deck area, in particular deck forward, deformation of structure may result from shipping green water.

2.2.3 Deformation/twisting of exposed structure above deck, such as side-coaming brackets and bulwarks, may result from impact due to improper handling of cargo and cargo handling machinery. Such damages may also be caused by shipping of green sea water on deck in heavy weather.

2.3 Fractures

2.3.1 Fractures in areas of structural discontinuity and stress concentration will normally be detected by close-up inspection. Special attention should be given to the structures at cargo hatches in general and to corners of deck openings in particular.

2.3.2 Fractures initiated in the deck plating outside the line of hatch (See **Example 1**) may propagate across the deck resulting in serious damage to hull structural integrity. Fractures initiated in the deck plating of the cross deck strip, in particular at the transition between the thicker deck plating and the thinner cross deck plating (See **Example 2-a**), may cause serious consequences if not repaired immediately.

2.3.3 Other fractures that may occur in the deck plating at hatches and in connected coamings can result/originate from:

(a) The geometry of the corners of the hatch openings.
(b) Grooving caused by wire ropes of cargo gear.
(c) Welded attachment and shedder plate close to or on the free edge of the hatch corner plating.
(d) Fillet weld connection of the coaming to deck, particularly at a radiused coaming plate at the hatch corner plating.
(e) Attachments, cut-outs and notches for securing devices, and operating mechanisms for opening/closing hatch covers at the top of the coaming and/or coaming top bar, if any, at the mid-length of hatch (See **Examples 10-a**, **10-b** and **11**).
(f) The termination of the side coaming extension brackets (See **Examples 3-a** and **b**).

2.3.4 Fractures in deck plating often occur at the termination of bulwarks, such as pilot ladder recess, due to stress concentration. The fractures may propagate resulting in serious casualty when the deck is subject to high longitudinal bending stress (See **Example 12**).

3 What to look for - Under-deck inspection

3.1 Material wastage

3.1.1 The level of wastage of under-deck stiffeners/structure in cross deck may have to be established by means of thickness measurements. The combined effect of the marine environment and the high humidity atmosphere within cargo hold s will give rise to a high corrosion rate.

3.1.2 Severe corrosion of the hatch coaming plating inside cargo hold and topside tank plating vertical strake may occur due to difficult access for the maintenance of the protective coating. This may lead to fractures in the structure (See **Photograph 1**).

Photograph 1 **Heavy corrosion of hatch coaming and topside tank plating vertical strake**

3.2 Deformations

3.2.1 Buckling should be looked for in the primary supporting structure, e.g. hatch end beams and topside tank plating vertical strake. Such buckling may be caused by:

(a) Loading deviated from loading manual (block loading).
(b) Excessive sea water pressure in heavy weather.
(c) Excessive deck cargo.
(d) Sea water on deck in heavy weather.
(e) Combination of these causes.

3.2.2 Improper ventilation during ballasting/deballasting of topside tank/ballast hold may cause deformation in deck structure. If such deformation is observed, internal inspection of topside tank/ballast hold should be carried out in order to confirm the nature and the extent of damage.

3.3 Fractures

3.3.1 Fractures may occur at the connection between the deck plating, transverse bulkhead and

girders/stiffeners. This is often associated with a reduction in area of the connection due to corrosion.

3.3.2 Fractures in primary supporting structure, e.g. hatch end beams, may be found in the weld connections to the topside tank plating vertical strake and to the girders.

4 General comments on repair

4.1 Material wastage

4.1.1 In the case of grooving corrosion at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, consideration should be given to renewal of part of, or the entire width of, the adjacent cross deck plating.

4.1.2 In the case of pitting corrosion throughout the cross deck strip plating, consideration should be given to renewal of part of or the entire cross deck plating.

4.1.3 When heavy wastage is found on under-deck structure, the whole or part of the structure may be cropped and renewed depending on the permissible diminution levels allowed by the Classification Society concerned.

4.1.4 For wastage of cargo hatch covers a satisfactory thickness determination is to be carried out and the plating and stiffeners are to be cropped and renewed as appropriate depending on the extent of the wastage.

4.2 Deformations

4.2.1 When buckling of the deck plating has occurred, appropriate reinforcement is necessary in addition to cropping and renewal regardless of the corrosion condition of the plating.

4.2.2 Where buckling of hatch end beams has occurred due to inadequate transverse strength, the plating should be cropped and renewed with additional panel stiffeners fitted.

4.2.3 Buckled cross deck structure, due to loss in strength caused by wastage, is to be cropped and renewed as necessary. If the cross deck is stiffened longitudinally and the buckling results from inadequate transverse strength, additional transverse stiffeners should be fitted (See **Example 2-b** and **2-c**).

4.2.4 Deformations of cargo hatch covers should be cropped and part renewed, or renewed in full, depending on the extent of the damage.

4.3 Fractures

4.3.1 Fractures in way of cargo hatch corners should be carefully examined in conjunction with the design details (See **Example 1**). Re-welding of such fractures is normally not considered to be a permanent solution. Where the difference in thickness between an insert plate and the adjacent deck plating is greater than 3 mm, the edge of the insert plate should be suitably beveled. In order to reduce the residual stress arising from this repair situation, the welding sequence and procedure is to be carefully monitored and low hydrogen electrodes should be used for welding the insert plate to the adjoining structure.

4.3.2 Where welded shedder plates are fitted into the corners of the hatch coamings and the stress concentration at the deck connection is considered to be the cause of the fractures, the deck connection should be left unwelded

4.3.3 In the case of fractures at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, consideration should be given to renewal of part or the entire width of the adjacent cross deck plating, possibly with increased thickness (See **Example 2-a**).

4.3.4 When fractures have occurred in the connection of transverse bulkhead to the cross deck structure, consideration should be given to renew and re-weld the connecting structure beyond the damaged area with the aim of increasing the area of the connection.

4.3.5 Fractures of hatch end beams should be repaired by renewing the damaged structure, and by full penetration welding to the deck.

4.3.6 To reduce the possibility of future fractures in cargo hatch coamings the following details should be observed:

(a) Cut-outs and other discontinuities at top of coaming and/ or coaming top bar should have rounded corners (preferably elliptical or circular in shape) (See **Example 10-b**).
Any local reinforcement should be given a tapered transition in the longitudinal direction and the rate of taper should not exceed 1 in 3 (See **Example 10-a**).

(b) Fractures, which occur in the fillet weld connection to the deck of radiused coaming plates at the corners, should be repaired by replacing existing fillet welds with full penetration welding using low hydrogen electrodes or equivalent. If the fractures are extensive and recurring, the coamings should be redesigned to form square corners with the side coaming extending in the form of tapered brackets. Continuation brackets are to be arranged transversely in line with the hatch end coamings and the under-deck transverse.

(c) Cut-outs and drain holes are to be avoided in the hatch side coaming extension brackets. For fractured brackets, see **Examples 3 a** and **b**.

4.3.7 For cargo hatch covers, fractures of a minor nature may be veed-out and welded. For more extensive fractures, the structure should be cropped and part renewed.

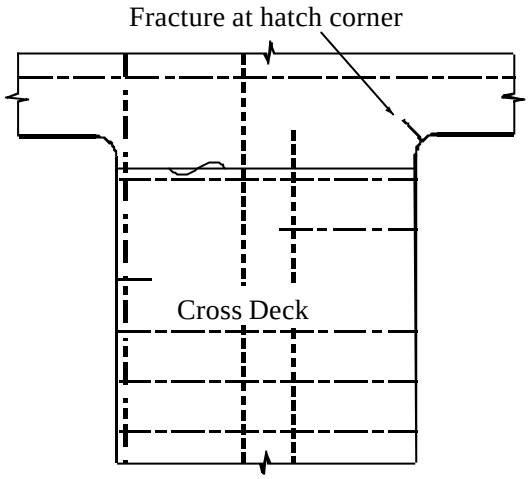
4.3.8 For fractures without significant corrosion at the end of bulwarks, an attempt should be made to modify the design in order to reduce the stress concentration in connection with general cropping and renewal (See **Example 12**).

4.4 Miscellaneous

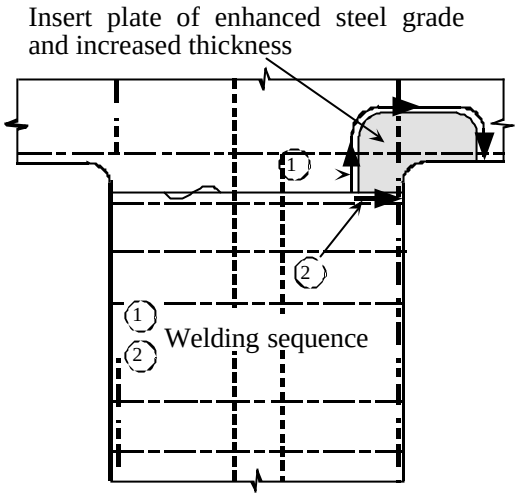
4.4.1 Ancillary equipment such as cleats, rollers etc. on cargo hatch covers is to be renewed as necessary when damaged or corroded.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**1**
Detail of damage	Fractures at main cargo hatch corner	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

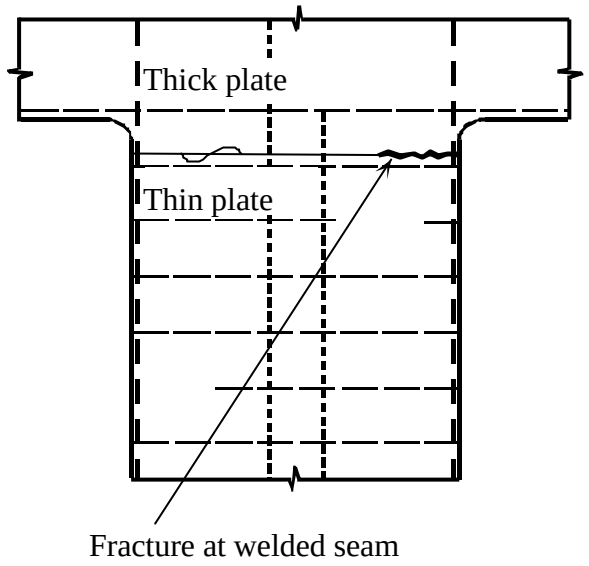
1. Stress concentration at hatch corners, i.e. radius of corner.
2. Welded attachment of shedder plate close to edge of hatch corner.
3. Wire rope groove.

Notes on repairs

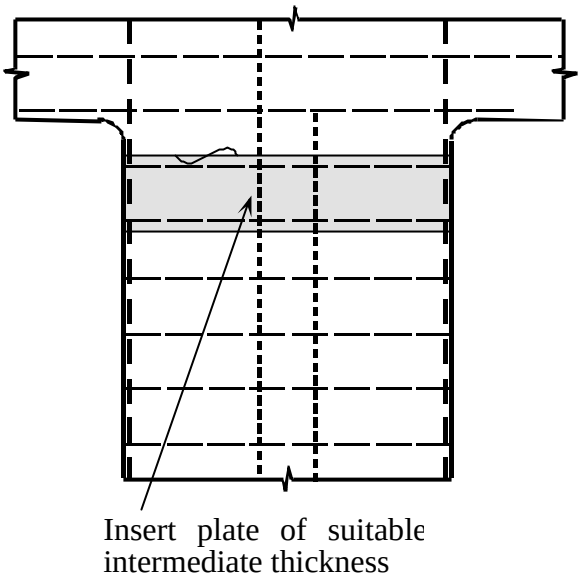
1. The corner plating in way of the fracture is to be cropped and renewed. If stress concentration is primary cause, insert plate should be increased thickness, enhanced steel grade and/or improved geometry.
   Insert plate should be continued beyond the longitudinal and transverse extent of the hatch corner radius ellipse or parabola, and the butt welds to the adjacent deck plating should be located well clear of the butts in the hatch coaming.
   It is recommended that the edges of the insert plate and the butt welds connecting the insert plates to the surrounding deck plating be made smooth by grinding. In this respect caution should be taken to ensure that the micro grooves of the grinding are parallel to the plate edge.
2. If the cause of fracture is welded attachment of shedder plate, the deck connection should be left unwelded.
3. If the cause of the fracture is wire rope groove, replacement to the original design can be accepted.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**2-a**
Detail of damage	Fractures of welded seam between thick plate and thin plate at cross deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

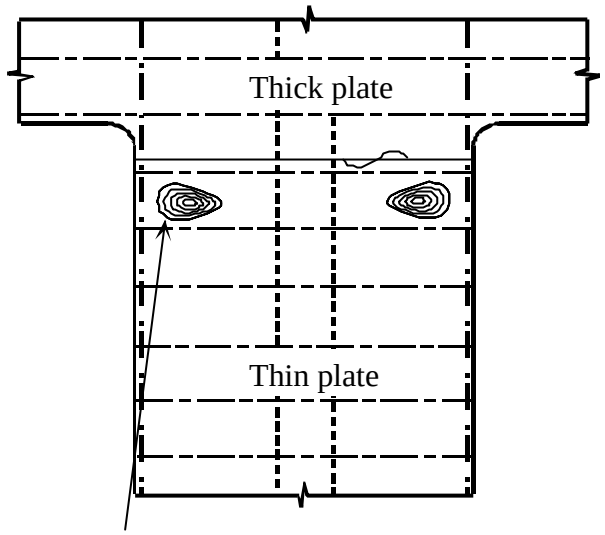
1. Stress concentration created by abrupt change in deck plating thickness.
2. In-plane bending in cross deck strip due to torsional (longitudinal) movements of ship sides.
3. Welded seam not clear of tangent point of hatch corner.

Notes on repairs

1. Insert plate of intermediate thickness is recommended.
2. Smooth transition between plates (beveling) should be considered.

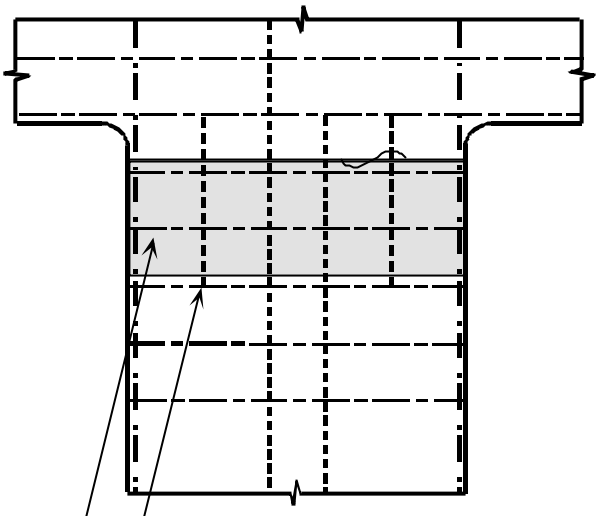
BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**2-b**
Detail of damage	Plate buckling in thin plate near thick plate at cross deck	

Sketch of damage



Buckling of cross deck plating (Buckling of hatch end structure should be examined. Refer to **Example 7-a**.)

Sketch of repair



Additional transverse stiffening and/or insertion of plate with suitable intermediate thickness

Notes on possible cause of damage

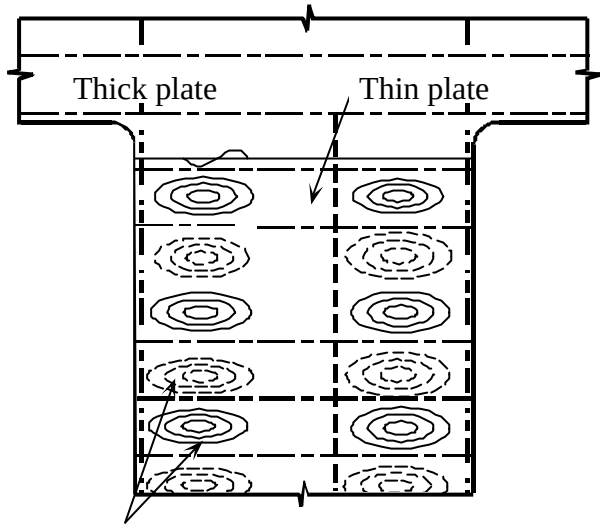
1. In-plane bending of cross deck strip due to torsional (longitudinal) movement of ship sides, often in combination with corrosion.
2. Insufficient plate thickness and/or transverse stiffening.

Notes on repairs

1. Transverse stiffeners extending from hatch sides towards centerline at least 10% of breadth of hatch, and/or increased plate thickness in the same area.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**2-c**
Detail of damage	Overall buckling of cross deck plating	

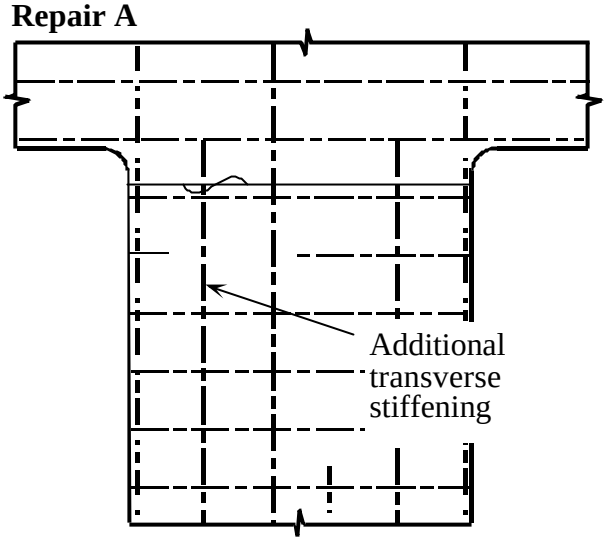
Sketch of damage



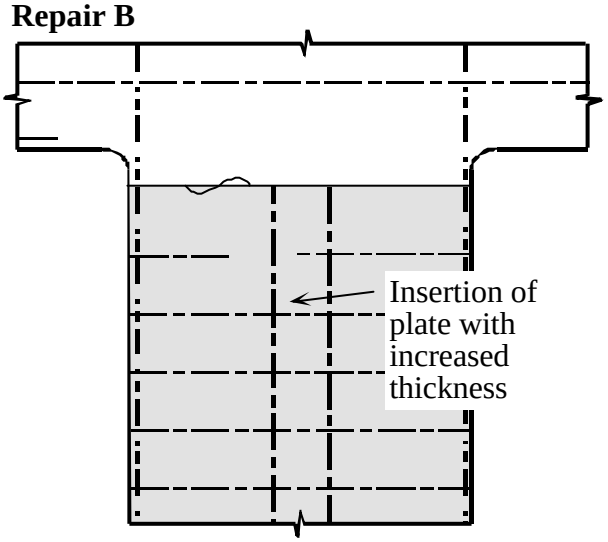
Buckling of cross deck plating (Buckling of hatch end structure should be examined. Refer to **Example 7-a.**)

Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

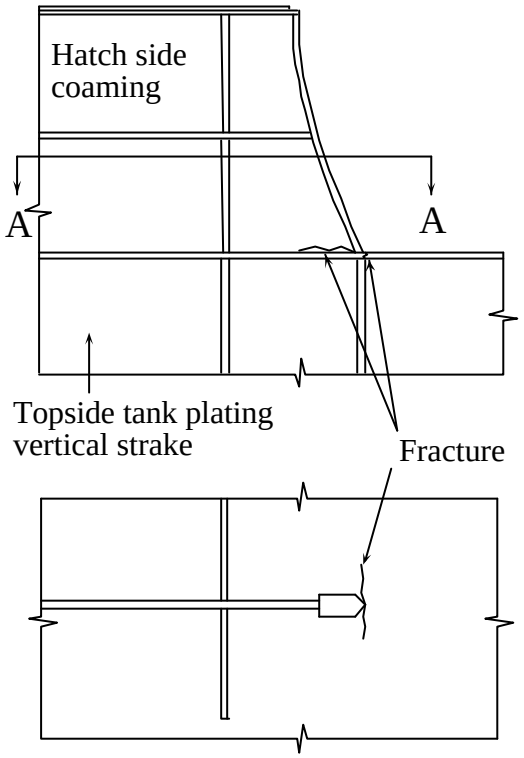
1. Transverse compression of deck due to sea load.
2. Transverse compression of deck due to excessive loading in two adjacent holds.
3. Insufficient plate thickness and/or transverse stiffening.

Notes on repairs

1. **Repair A** Plating of original thickness in combination with additional transverse stiffening.
2. **Repair B** Insertion of plating of increased thickness.

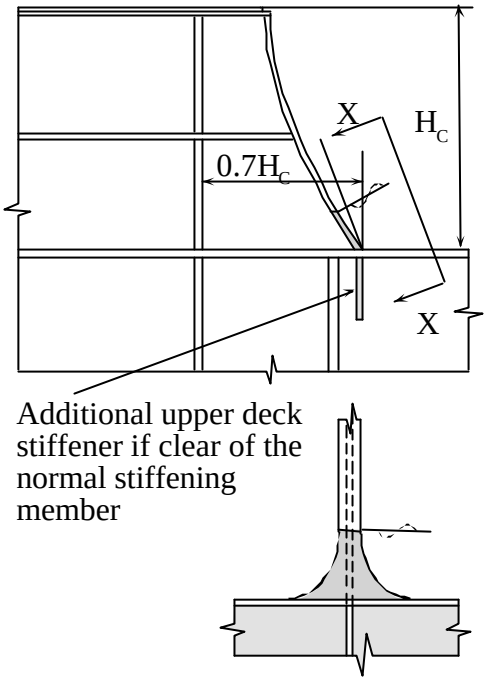
BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**3-a**
Detail of damage	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket	

Sketch of damage



View A-A

Sketch of repair



View X-X

Notes on possible cause of damage

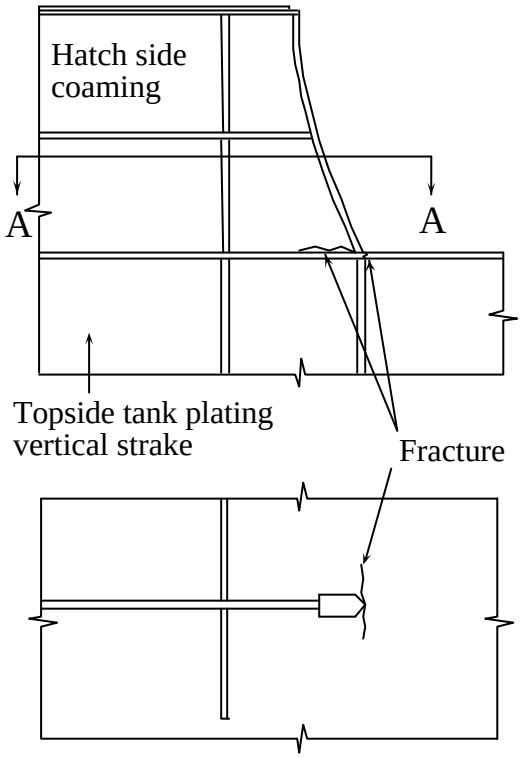
1. This damage is caused by stress concentrations attributed to the design of the bracket.

Notes on repairs

1. The design of the bracket can be altered as shown above, however, it is to be ensured that an additional under deck stiffener is provided at the toe of the termination bracket, where the toe is clear of the normal stiffening member.
2. Full penetration weld for a distance of 0.15 H_C from toe of side coaming termination bracket and for connection of athwartship gusset bracket to deck.
3. The fracture in deck plating to be veed-out and rewelded or deck plating cropped and part renewed as appropriate, using low hydrogen electrodes for welding.

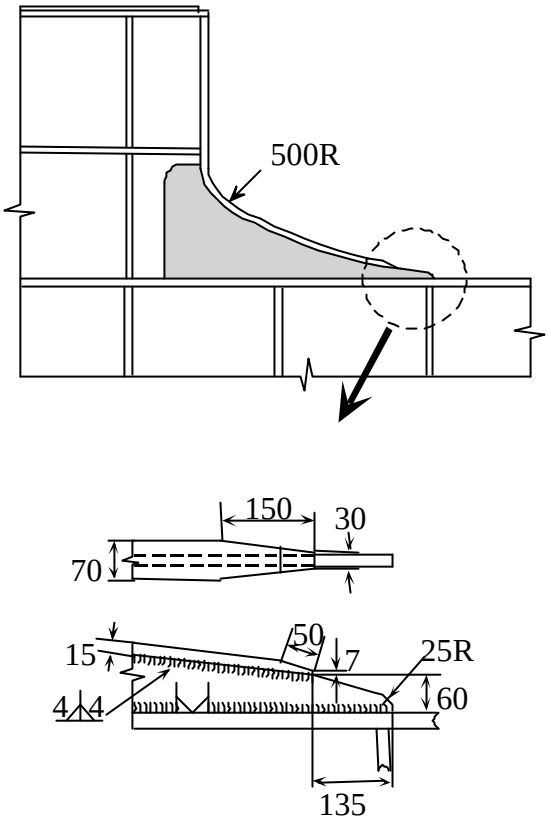
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**3-b**
Detail of damage	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket	

Sketch of damage



View A-A

Sketch of repair



Notes on possible cause of damage

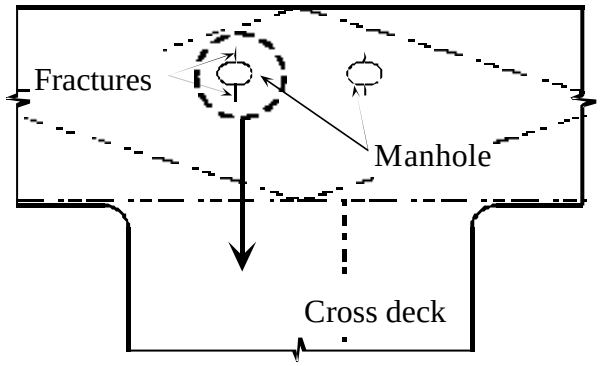
1. This damage is caused by stress concentrations attributed to the design of the bracket.

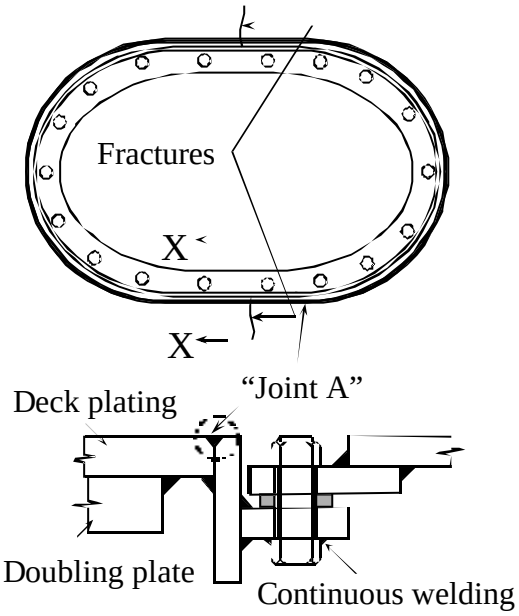
Notes on repairs

1. The design of the bracket can be altered as shown above, however, it is to be ensured that an additional under deck stiffener is provided at the toe of the termination bracket, where the toe is clear of the normal stiffening member.
2. The fracture in deck plating to be veed-out and rewelded or deck plating cropped and part renewed as appropriate, using low hydrogen electrodes for welding.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**4**
Detail of damage	Fractures in deck plating initiated from weld of access manhole	

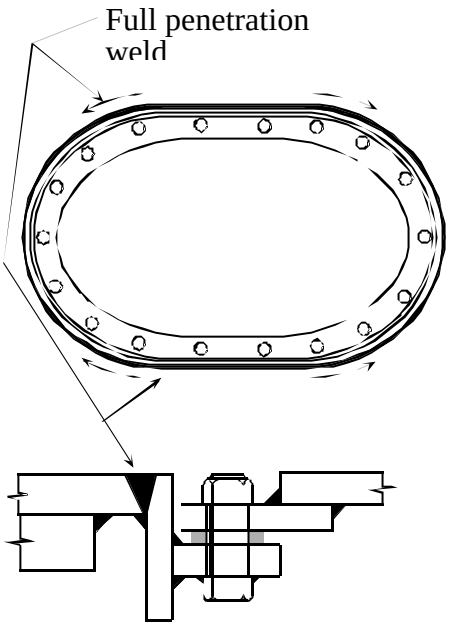
Sketch of damage





Section X-X

Sketch of repair



Notes on possible cause of damage

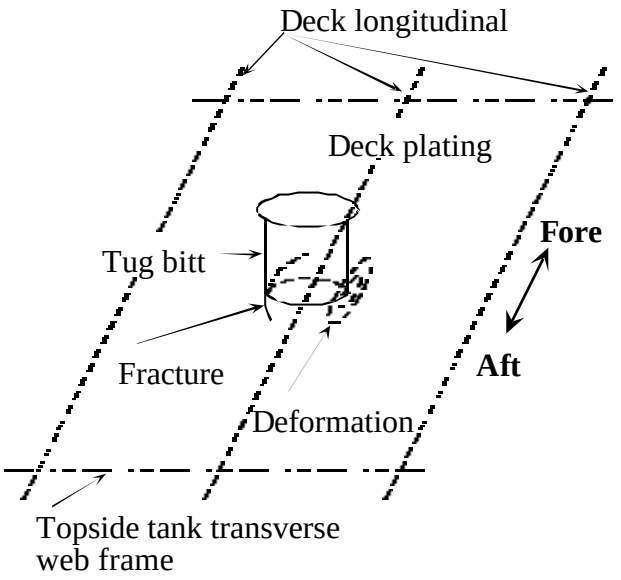
1. Heavy weather.
2. Improper welding of joint "A".

Notes on repairs

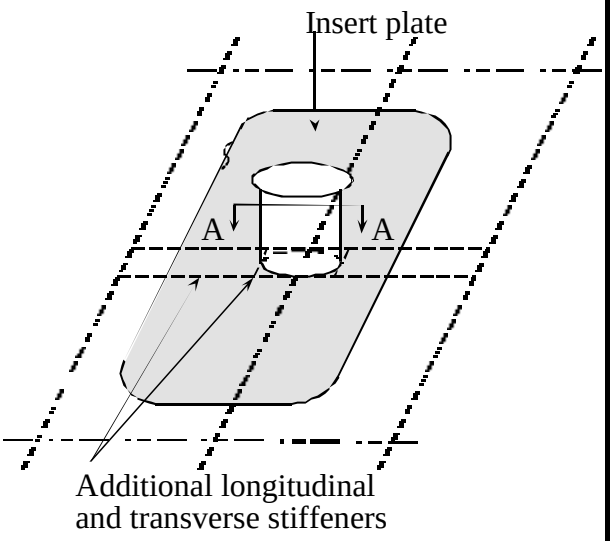
1. The fracture in deck plating to be veed-out and rewelded, or deck plating cropped and part renewed if considered necessary.
2. Full penetration of joint "A" should be considered.

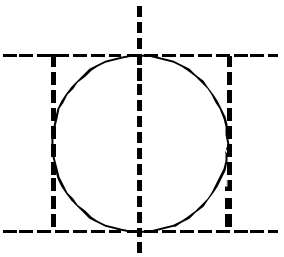
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**5**
Detail of damage	Deformed and fractured deck plating around tug bitt	

Sketch of damage



Sketch of repair





View A-A

Notes on possible cause of damage

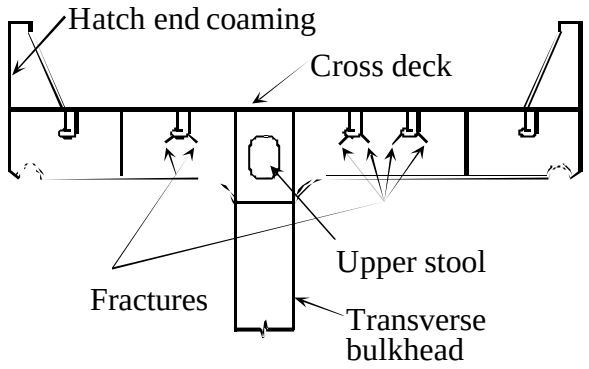
1. Insufficient strength

Notes on repairs

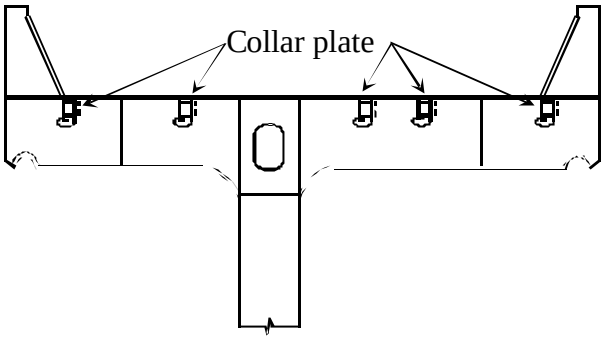
1. Fractured/deformed deck plating should be cropped and part renewed.
2. Reinforcement by stiffeners should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**6**
Detail of damage	Fractures around cut-outs in cross deck girder	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

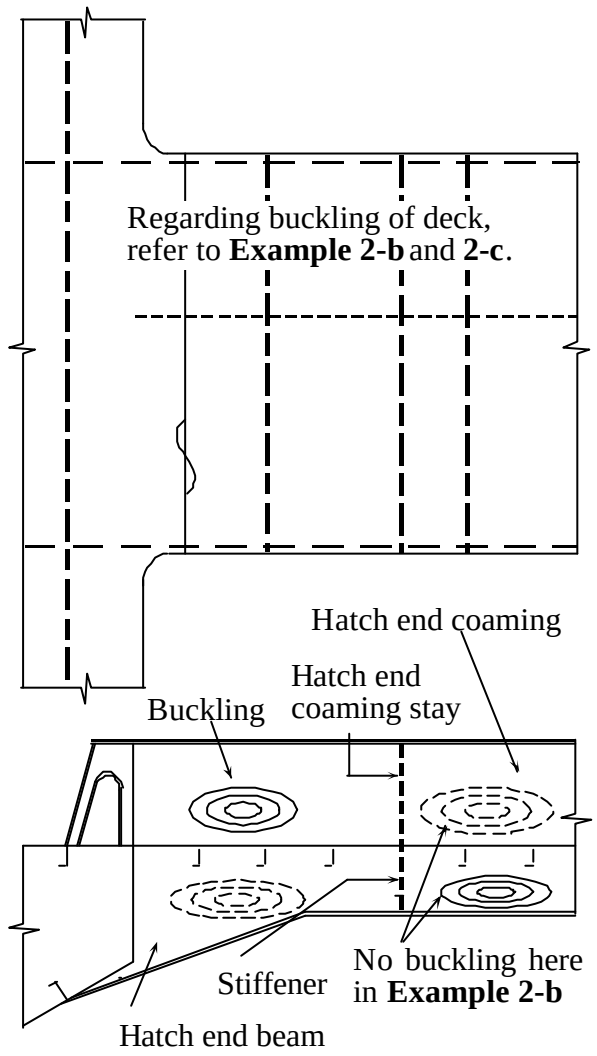
1. Stress concentration at the cut-outs in cross deck girder.

Notes on repairs

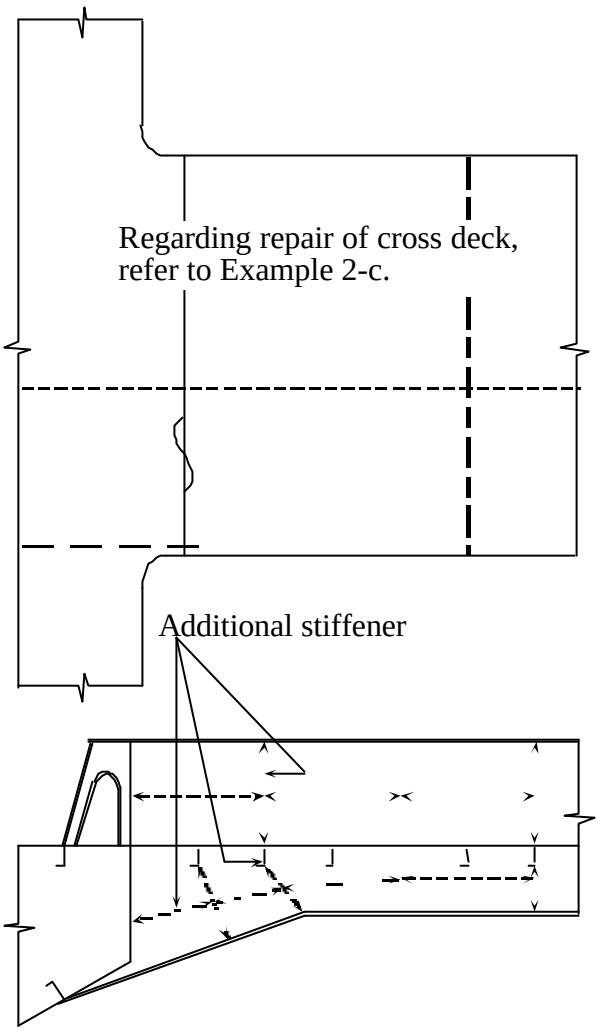
1. Fractured web plate of cross deck girder to be cropped and part renewed.
2. Collar plates to be provided.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**7-a**
Detail of damage	Buckling of hatch coaming and hatch end beam	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

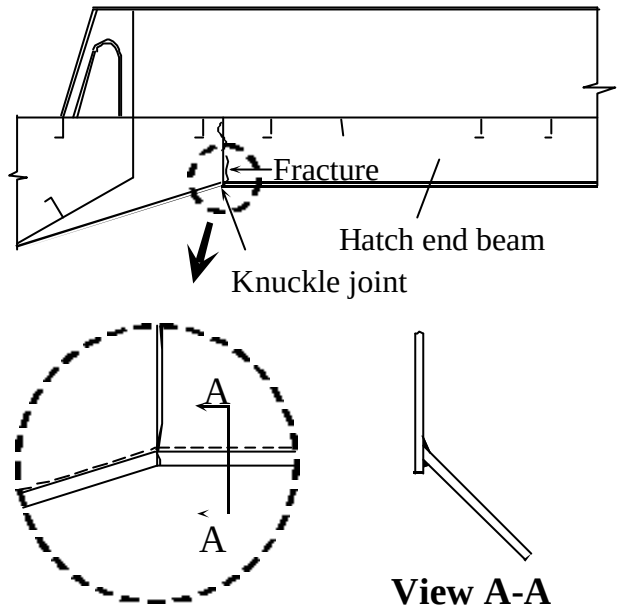
1. Additional transverse forces due to heavy seas, and torsional loading.
2. Inadvertent overloading of cargo spaces.

Notes on repairs

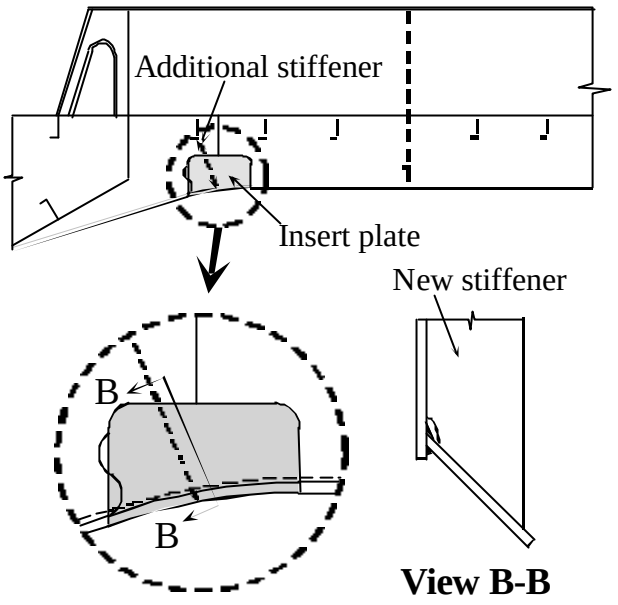
1. If buckling is due to loss in strength induced by corrosion, the buckled zone to be cropped and renewed as necessary.
2. If buckling results from inadequate strength, stiffeners should be fitted in addition to cropping and renewal of buckled zone.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**7-b**
Detail of damage	Fractures in hatch end beam at knuckle joint	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

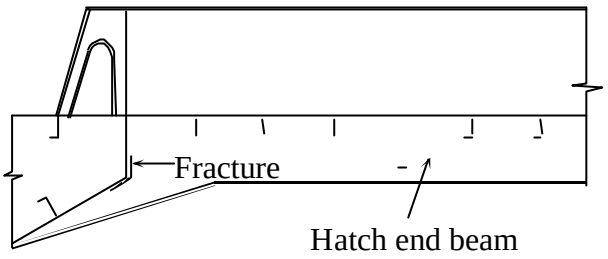
1. Stress concentration at knuckle joint.

Notes on repairs

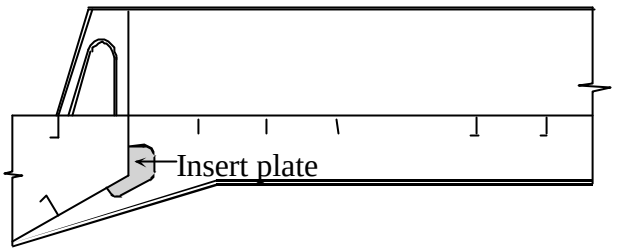
1. Fractured part to be cropped and renewed.
2. Improvement to avoid stress concentration at knuckle joint should be considered.

BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**8**
Detail of damage	Fractures in hatch end beam at the joint to topside tank	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

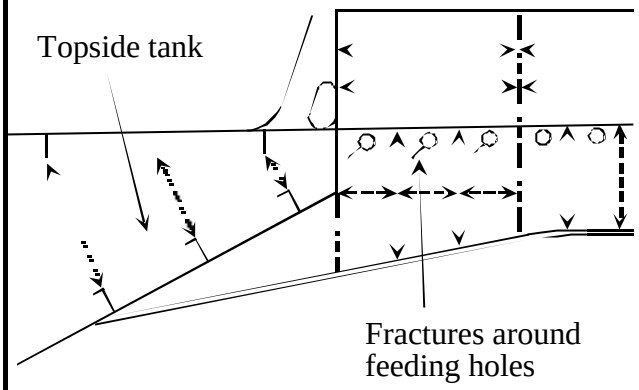
1. Misalignment of the hatch end beam with transverse web frame in topside tank.
2. Stress concentration.

Notes on repairs

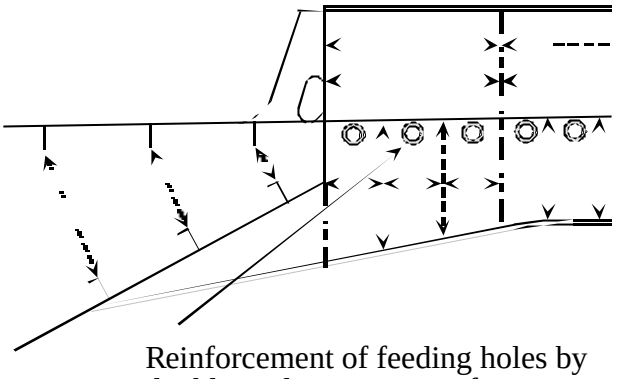
1. Fractured part to be cropped and renewed.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**9**
Detail of damage	Fractures in hatch end beam around feeding holes	

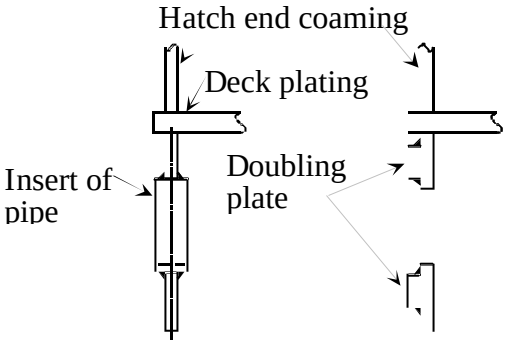
Sketch of damage



Sketch of repair



Reinforcement of feeding holes by doubling plate or insert of pipe. See "Detail" below.



Detail

Notes on possible cause of damage

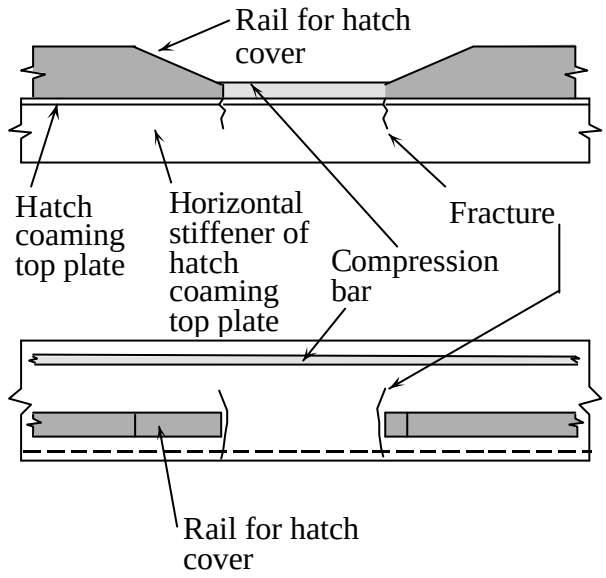
1. Inadequate reinforcement around feeding hole.
2. Corrosion.

Notes on repairs

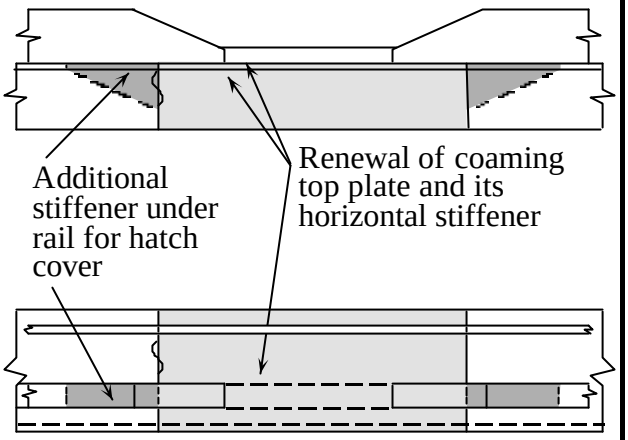
1. Fractured part to be veed-out or cropped and renewed.
2. If the fractured part is free from corrosion, reinforcement should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**10-a**
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

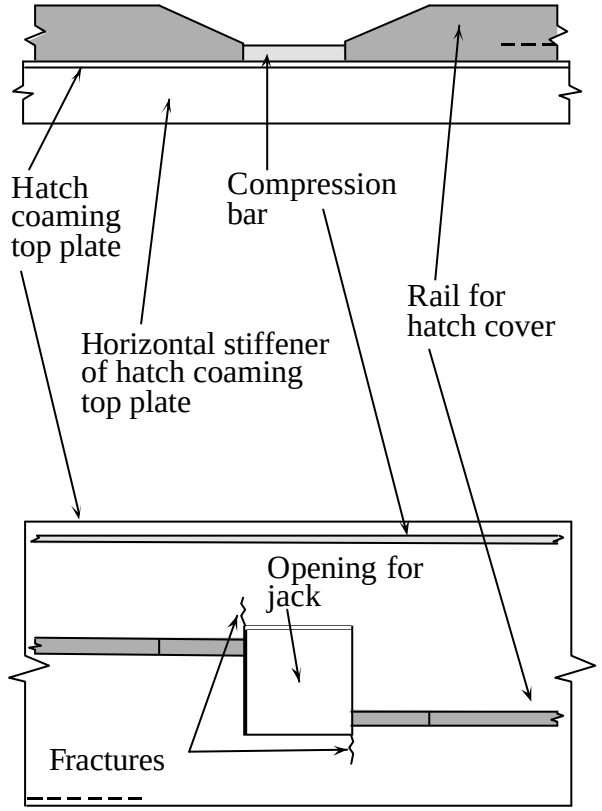
1. Stress concentration at the termination of the rail for hatch cover due to poor design.

Notes on repairs

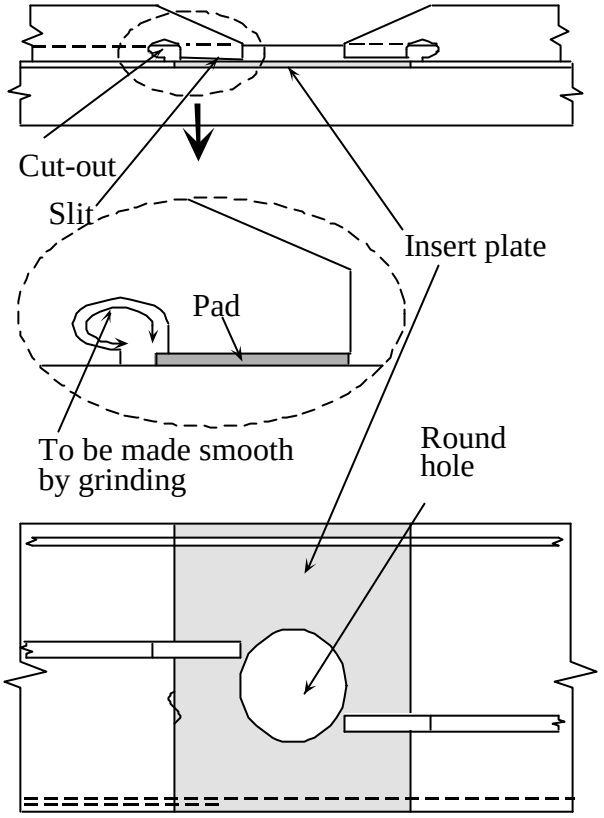
1. Fractured plate is to be cropped and part renewed.
2. Thicker insert plate and/or reinforcement by additional stiffener under the top plate should be considered. Also refer to **Example 10-b**.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**10-b**
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

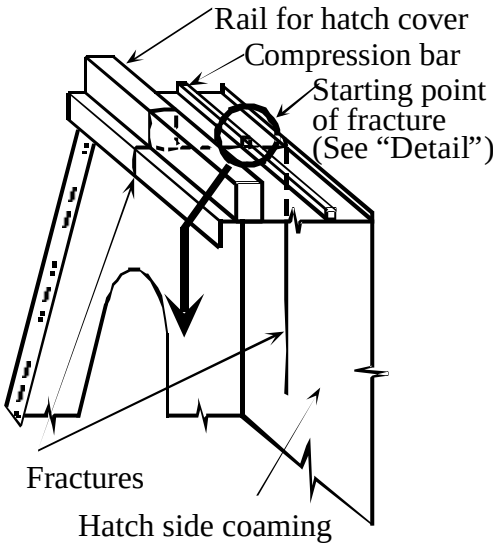
1. Stress concentration at the termination of the rail for hatch cover due to poor design of opening.

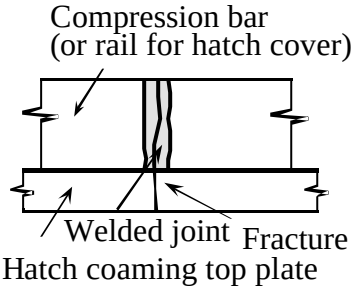
Notes on repairs

1. Fractured plate is to be cropped and part renewed.
2. Thicker insert plate and/or reduction of stress concentration adopting large radius should be considered. Or cut-out in the rail and detachment of the welds as shown in the above drawing should be considered in order to reduce the stress of the corner of the opening.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**11**
Detail of damage	Fractures in hatch coaming top plate initiated from butt weld of compression bar	

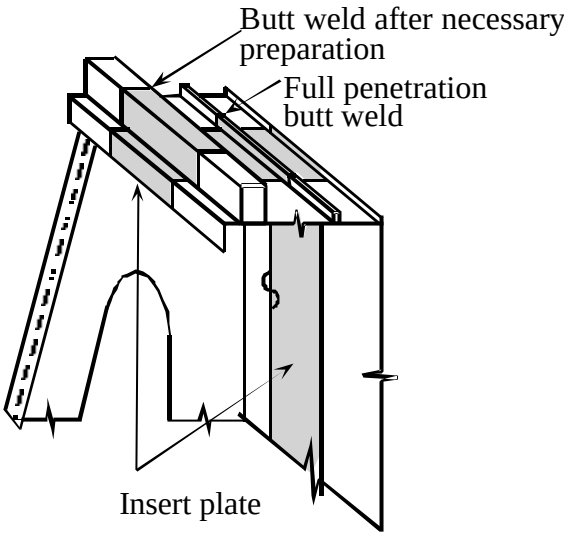
Sketch of damage





Detail

Sketch of repair



Notes on possible cause of damage

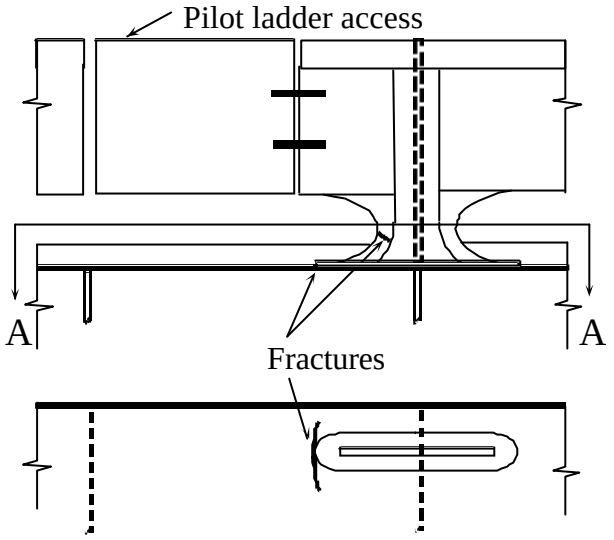
1. Heavy weather
2. Insufficient preparation of weld of compression bar and/or rail (Although the compression bar and rail are not longitudinal strength members, they subject same longitudinal stress as longitudinal members)
3. Crack may initiate from insufficient penetration of weld of rail for hatch cover.

Notes on repairs

1. Loading condition of the ship and proper welding procedure should be carefully considered.
2. Fractured structure is to be cropped and renewed if considered necessary. (Small fracture may be veed-out and rewelded.)
3. Full penetration welding should be applied to the butt weld of compression bar and rail.

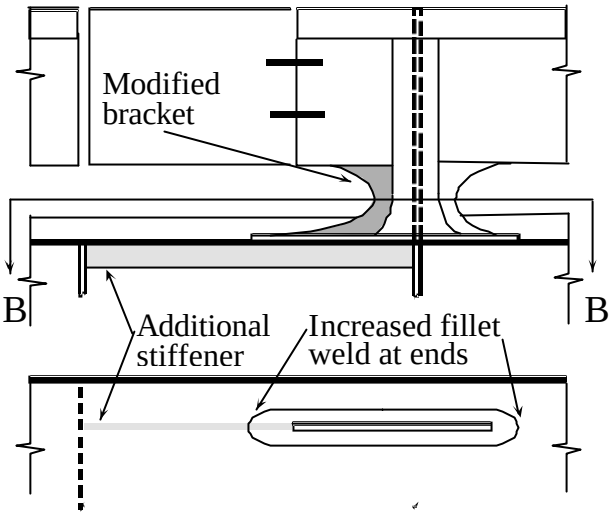
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Deck structure**	**12**
Detail of damage	Fractures in deck plating at the pilot ladder access of bulwarks	

Sketch of damage



View A-A

Sketch of repair



View B-B

Notes on possible cause of damage

1. Stress concentration at the termination of bulwarks.

Notes on repairs

1. Fractured deck plating should be cropped and part renewed.
2. Reduction of stress concentration should be considered. In the above figure gusset plate was replaced with soft type for the fracture in gusset plate and pad plate was increased. Additional stiffeners were provided for the fracture in deck plating.

Area 2 Topside tank structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Figures and/or Photographs - Area 2	
No.	**Title**
Figure 1	Topside tank - Potential problem areas

Examples of structural detail failures and repairs - Area 2	
Example No.	**Title**
1	Fractures around unstiffened lightening holes and manholes in wash bulkhead
2-a	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
2-b	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
2-c	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
3	Fractures in transverse web at sniped end of stiffener
4-a	Fractures at slots in way of transverse web frame
4-b	Fractures and buckling at slots in way of transverse web frame
5	Fractures in longitudinal at transverse web frame or bulkhead
6	Fractures in the lowest longitudinal at transverse web frame
7-a	Fractures in transverse brackets
7-b	Fractures in transverse bracket
7-c	Fractures at toes of transverse bracket
8	Fractures in sloping plating and vertical strake initiated from the connection of topside tank to hatch end beam
9	Fractures in sloping plating at knuckle

Examples of structural detail failures and repairs - Area 2	
Example No.	**Title**
10	Fractures in way of collision bulkhead at intersection with topside tank structure in foremost cargo hold
11	Fractures in way of engine room forward bulkhead at intersection with topside tank structure in aftermost cargo hold

1 General

1.1 Topside tanks are highly susceptible to corrosion and wastage of the internal structure. This is a major problem for all bulk carriers, particularly for ageing ships and others where the coatings have broken down. Coatings, if applied and properly maintained, serve as an indication as to whether the structure remains in satisfactory condition and highlights any structural defects.

In some ships topside tanks are protected by sacrificial anodes in addition to coatings. This system is not effective for the upper parts of the tanks since the system requires the structure to be fully immersed in sea water, and the tanks may not be completely filled during ballast voyages.

Other major factors contributing to damages of the topside tank structure are those associated with overpressurisation and sloshing in partially filled adjacent ballast tanks / holds due to ship rolling in heavy weather.

1.2 Termination of longitudinals in the fore and aft regions of the ship, in particular at the collision and engine room bulkheads, is prone to fracture due to high stress concentration if the termination detail is not properly designed. Knuckle joint in topside tanks in the fore and aft regions of the ship may suffer from fractures if the structure is not properly reinforced, see **Example 10**.

2 What to look for

2.1 Material wastage

2.1.1 The combined effect of the marine environment and the high humidity atmosphere within a topside tank hold will give rise to a high corrosion rate.

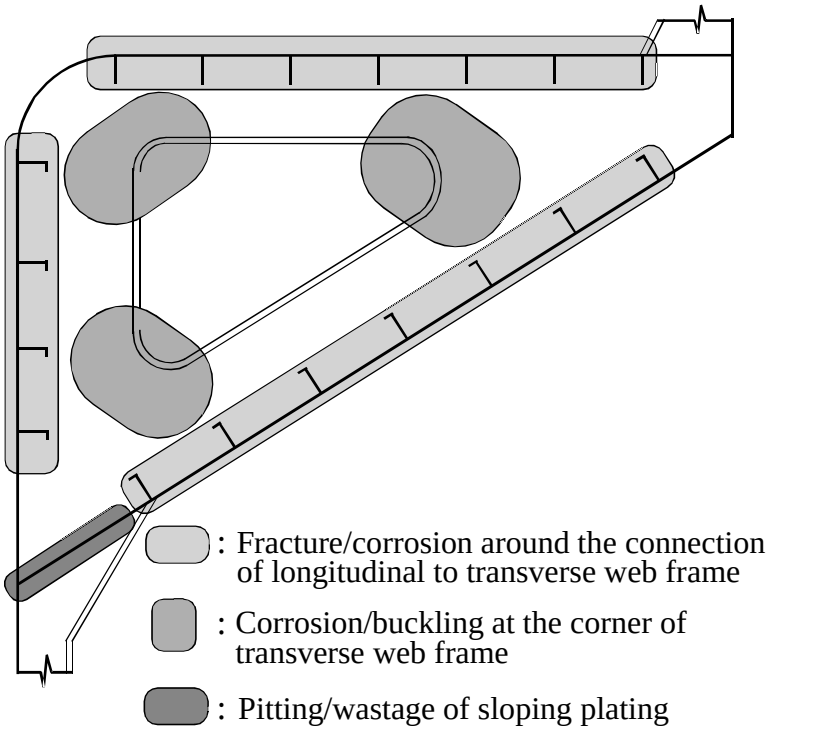
2.1.2 Rate and extent of corrosion depends on the environmental conditions, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (See **Figure 1**).

(a) Structure in corrosive environment
Deck plating and deck longitudinal
Transverse bulkhead adjacent to heated fuel oil tank
Lowest part of sloping plating

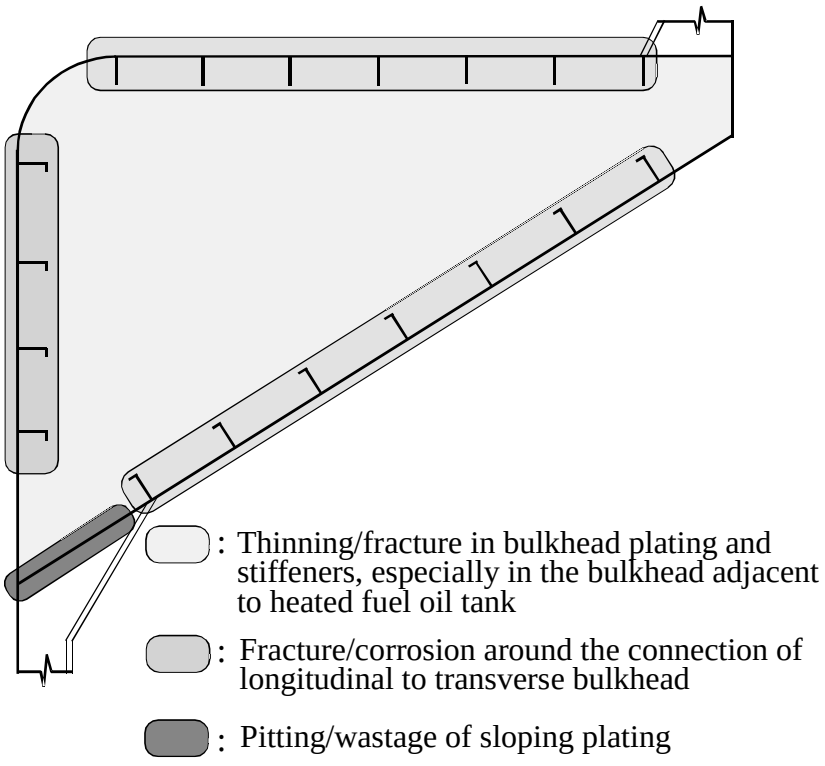
(b) Structure subject to high stress
Face plates and web plates of transverse at corners
Connection of side longitudinal to transverse

(c) Areas susceptible to coating breakdown
Back side of face plate of longitudinal
Welded joint
Edge of access opening

(d) Areas subjected to poor drainage
Web of side and sloping longitudinals



(a) Transverse web frame section



(b) Transverse bulkhead section

Figure 1 Topside tank - Potential problem areas

2.2 Deformations

2.2.1 Deformation of structure may be caused by contact (with quay side, ice, touching underwater objects, etc.), collision, mishandling of cargo and high stress. Attention should be paid to the following areas during inspection::

(a) Structure subjected to high stress
Buckling of transverse webs at corners

(b) Structure adjacent to a ballast hold
Deformations may be found in the following structural members caused by sloshing in partially filled ballast hold and/or by improper carriage of ballast water (See Note):

- Buckling of transverse web and/or collapse of transverse attached to sloping plating
- Deformation of sloping plating and/or collapse of sloping plating longitudinals
- Buckling of diaphragm, if provided

Note: In some bulk carriers the topside tanks in way of a ballast hold are designed to be filled when the hold is used for the carriage of water ballast. In such ships, if the topside tanks are not filled in the ballast condition, the structural members in the topside tanks may suffer fracture/deformation as a result of increased stress.

2.2.2 Improper ventilation during ballasting/deballasting of topside tank/ballast hold may cause deformation in deck structure and damage to topside tank structure. If such deformation is observed during on-deck inspection, internal inspection of topside tank should be carried out in order to confirm the nature and the extent of damage.

2.3 Fractures

2.3.1 Attention should be paid to the following areas during inspection for fracture damage:

(a) Areas subjected to stress concentration
- Welded joints of face plate of transverse at corners
- Connection of sniped ends of stiffener to transverse web, near or at corners of the transverse
- Connection of the lowest longitudinal to transverse web frame, especially with reduced scantlings (See **Example 6**).
- Termination of longitudinal in fore and aft topside tanks
- Knuckle joint of sloping plating in foremost and aftermost topside tanks (See **Example 9**).
- Transition regions in foremost and aftermost topside tanks (Refer to **2.3.2**)
- Connection in line with hold transverse bulkhead corrugations and transverse stools
- Connection in line with the side shell transverse framing, and end brackets, particularly at the bracket toes

(b) Areas subjected to dynamic wave loading
- Connection of side longitudinal to watertight bulkhead
- Connection of side longitudinal to transverse web frame

2.3.2 The termination of the following structural members at the collision bulkhead or engine room forward bulkhead is prone to fracture damage due to discontinuity of the structure:

- Topside tank sloping plating
- Topside tank plating vertical strake
- Fore peak tank top plating (Boatswain's store deck plating)
- Longitudinal bulkhead of fuel tank in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

3 General comments on repair

3.1 Material wastage

3.1.1 If the corrosion is caused by high stress concentration, renewal with original thickness is not sufficient to avoid reoccurrence.
Renewal with increased thickness and/or appropriate reinforcement should be considered in conjunction with appropriate corrosion protective measures.

3.2 Deformations

3.2.1 The cause of damage should always be identified. If the damage is due to negligence in operation, the ship representative should be notified. If the deformation is caused by inadequate structural strength, appropriate reinforcement should be considered. Where the deformation is related to corrosion, appropriate corrosion protective measures should be considered.

3.3 Fractures

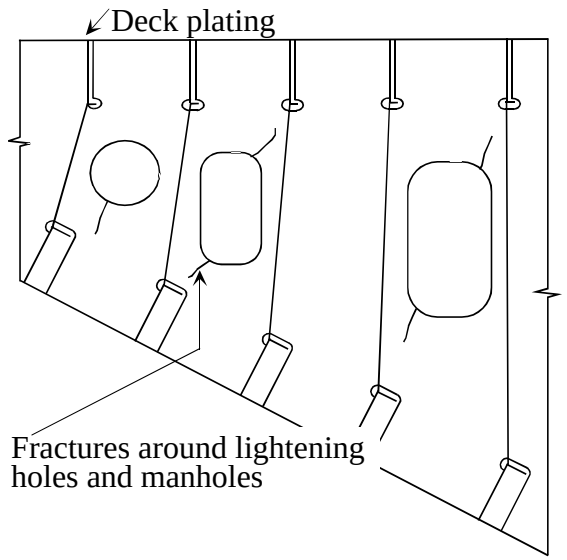
3.3.1 If the cause of the fracture is fatigue under the action of cyclic wave loading, consideration should be given to the improvement of structural detail design, such as provision of soft toe bracket, to reduce stress concentration. If the fatigue fracture is vibration related, the damage is usually associated with moderate stress levels at high cycle rate, improvement of structural detail may not be effective. In this case, measures for increasing structural damping and avoidance of resonance, such as providing additional stiffening, may be considered.

Where fracture occurs due to material under excessive stress, indicating inadequate structural strength, renewal with thicker plate and/or providing appropriate reinforcement should be considered.

Where fracture is found in the transition region, measures for reducing the stress concentration due to structural discontinuity should be considered.

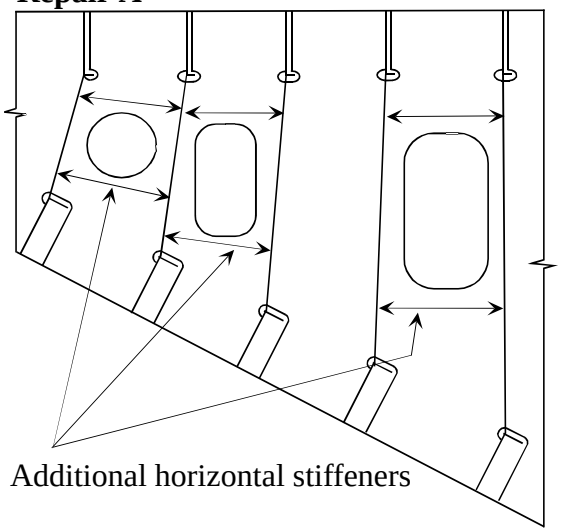
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**1**
Detail of damage	Fractures around unstiffened lightening holes and manholes in wash bulkhead	

Sketch of damage

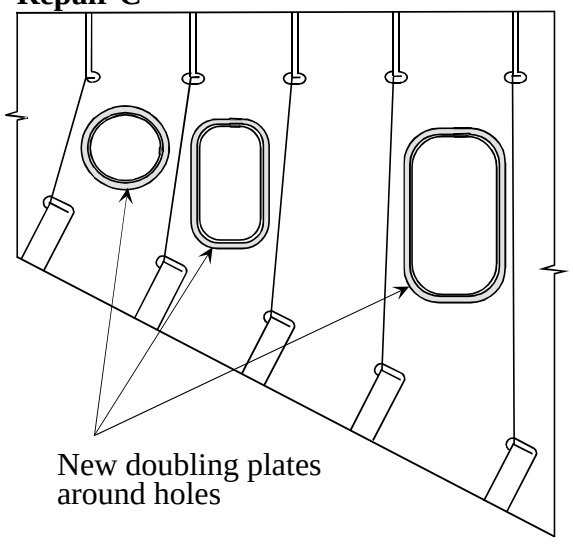


Sketch of repair

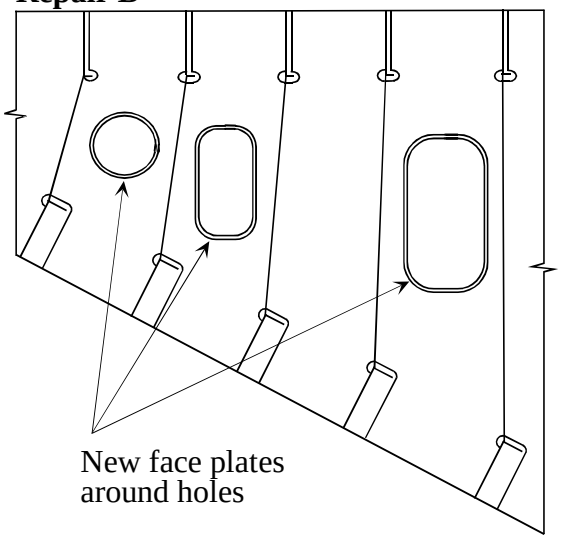
Repair A



Repair C



Repair B



Notes on possible cause of damage

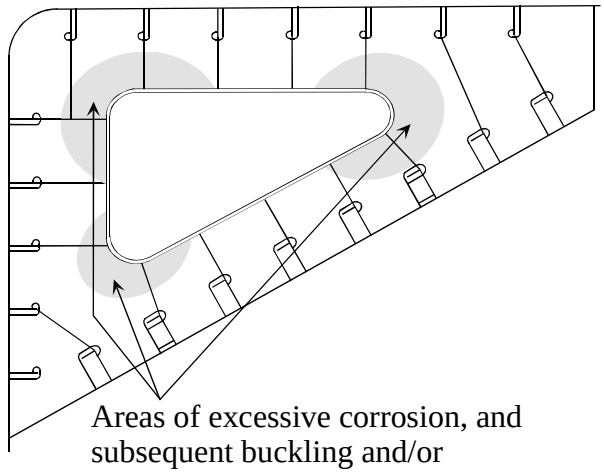
1. General levels of corrosion and presence of stress concentration.

Notes on repairs

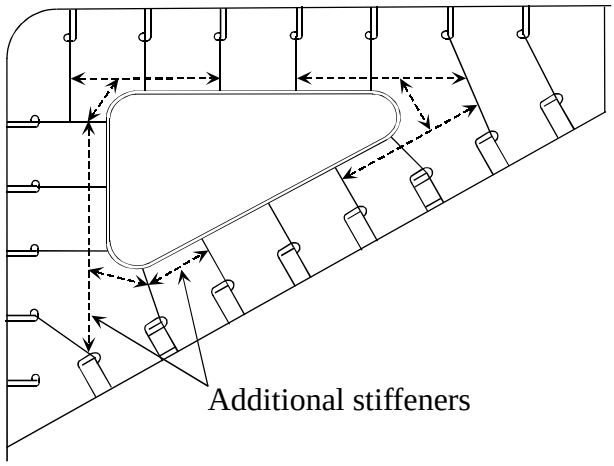
1. Corroded/fractured plate should be cropped and renewed with plating of enhanced thickness.
2. Reinforcement should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**2-a**
Detail of damage	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

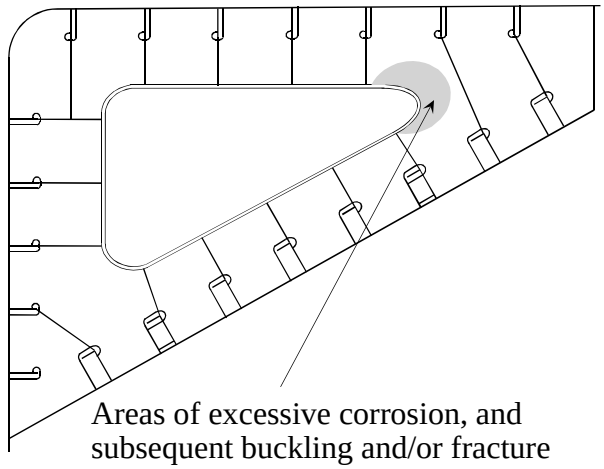
1. Insufficient buckling strength.
2. Corrosion due to stress concentration at corners.

Notes on repairs

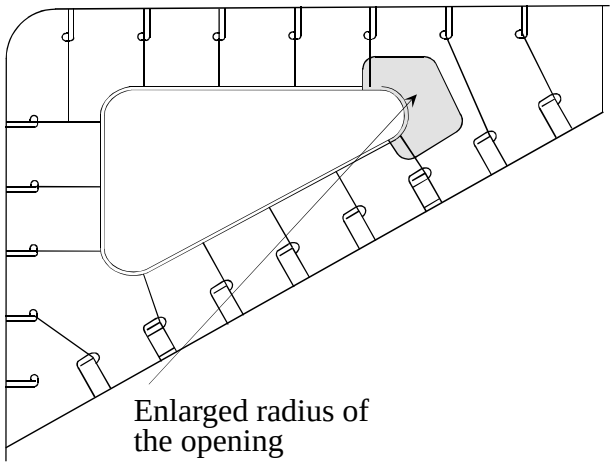
1. Buckled plating is to be cropped and parts renewed, if necessary.
2. Additional stiffeners as shown above and/or renewal with plating of increased thickness should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**2-b**
Detail of damage	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

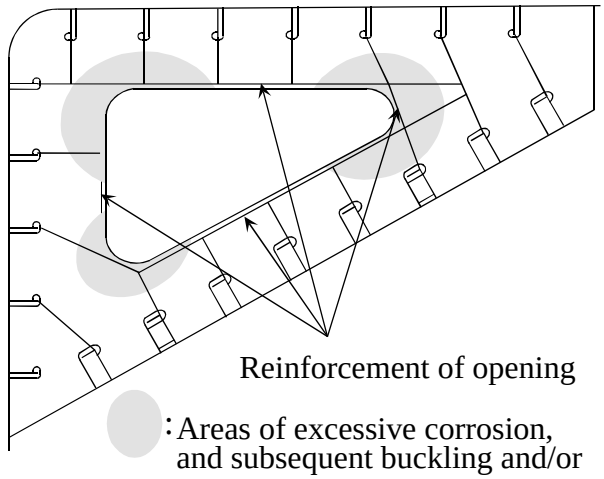
1. Corrosion caused by stress concentration at the corner due to insufficient radius for the opening.

Notes on repairs

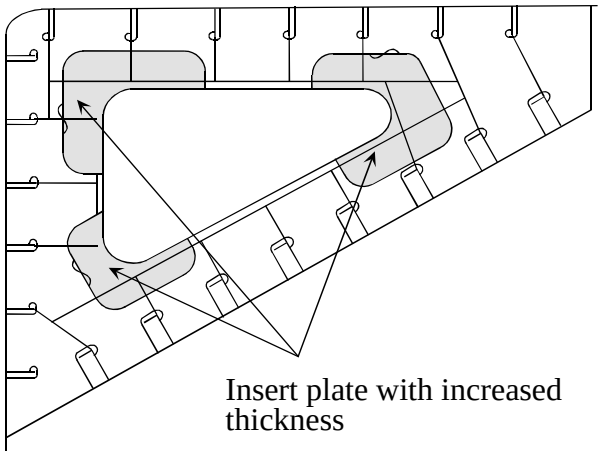
1. Corroded/buckled plating is to be cropped and part~~s~~ renewed with plating of increased thickness and additional stiffeners are preferable to minimize deflection.
2. An attempt should be made to improve the design of the radius if felt necessary.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**2-c**
Detail of damage	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

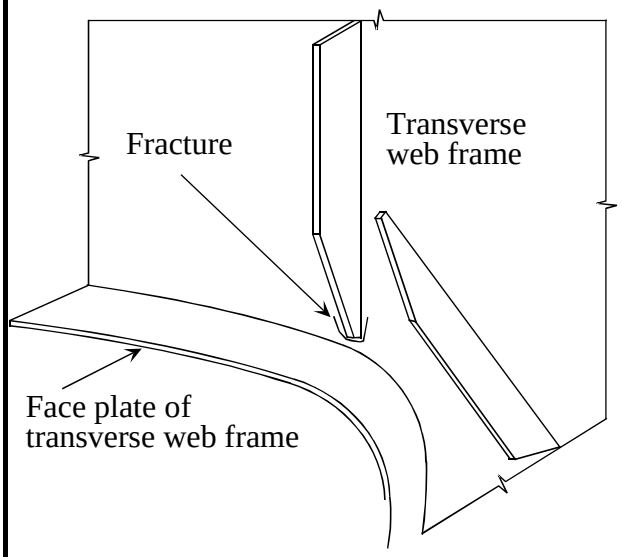
1. Additional stresses at the free edge of transverse web. (In **Example 2-a - 2-c** face plate is provided for the reinforcement of the opening.)

Notes on repairs

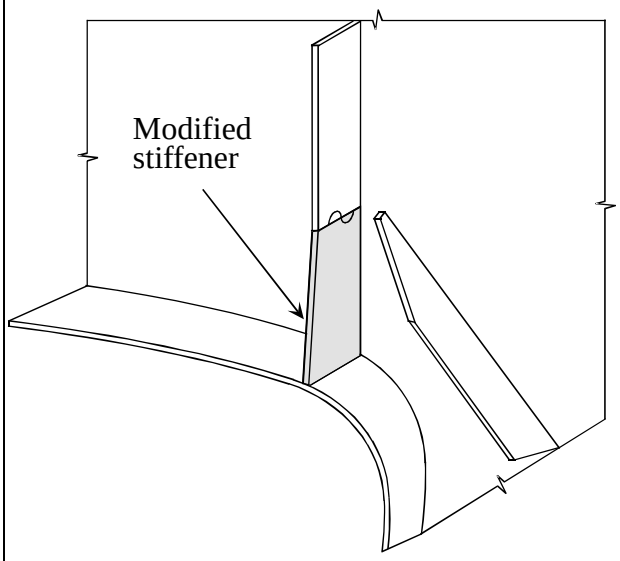
1. Corroded/buckled plating is to be cropped and part renewed with plating of increased thickness.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**3**
Detail of damage	Fractures in transverse web at sniped end of stiffener	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

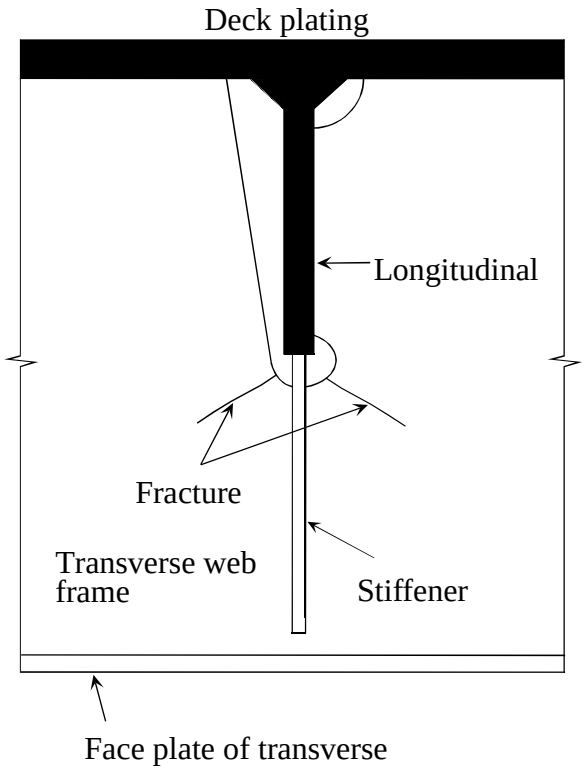
1. Stress concentration.

Notes on repairs

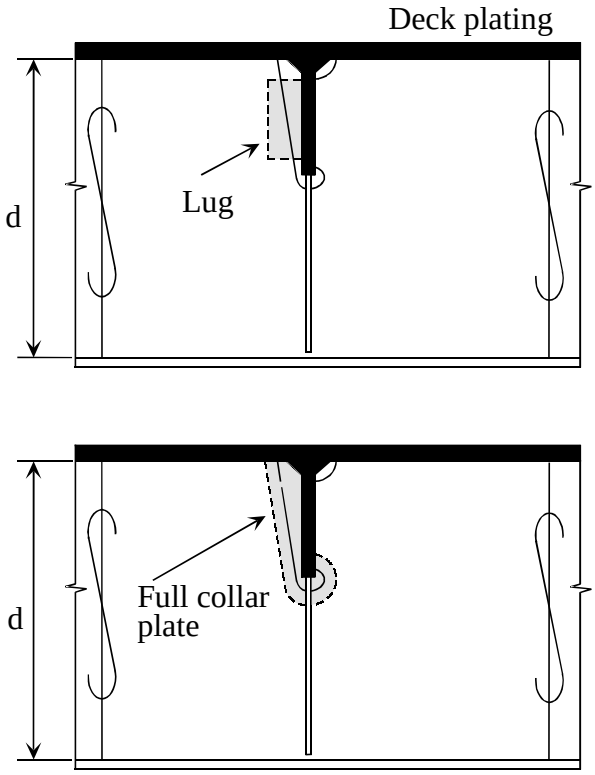
1. Fracture can be veed-out and welded provided the plating is not generally corroded. If necessary, fractured plating should be cropped and renewed.
2. Excessive stress concentration at the end of stiffener should be avoided.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**4-a**
Detail of damage	Fractures at slots in way of transverse web frame	

Sketch of damage



Sketch of repair



(Note) Full collar plate where the depth of cut-out is more than 0.4 times the depth of web frame (0.4d) and in an area~~s~~ of high shear stress

Notes on possible cause of damage

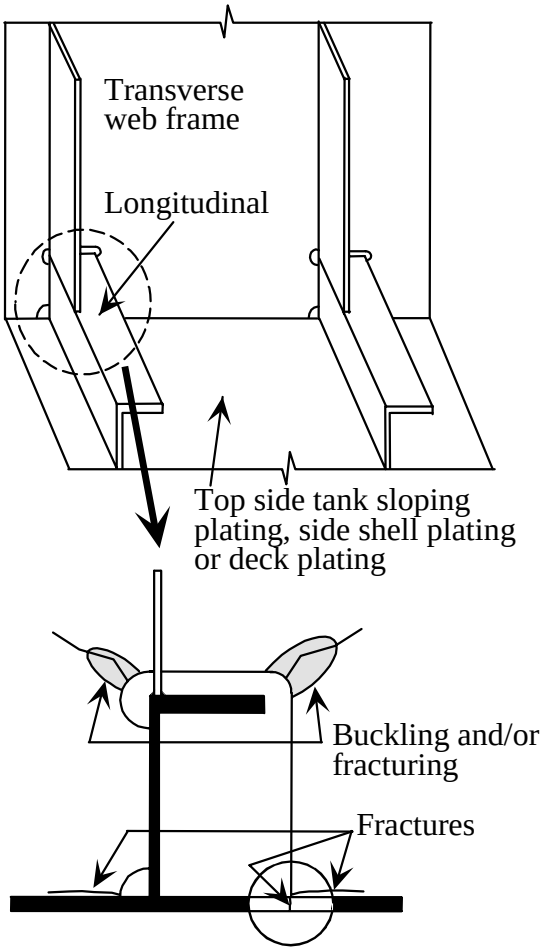
1. Damage may be created by local shear stress concentrations due to large cut-outs for notch.
2. Also deficient welds (fillet welds between deck longitudinal and stiffener).

Notes on repairs

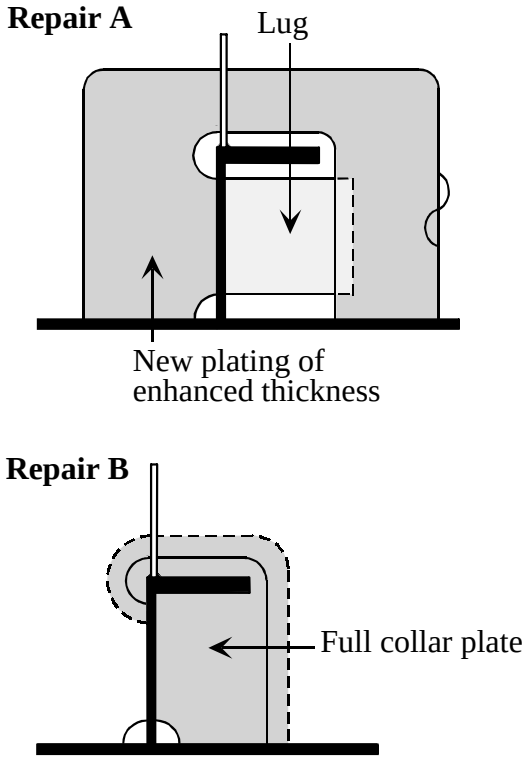
1. Crop and part renew the web plating.
2. Close the cut-out by introducing a lug or alternatively fit a full collar plate.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**4-b**
Detail of damage	Fractures and buckling at slots in way of transverse web frame	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

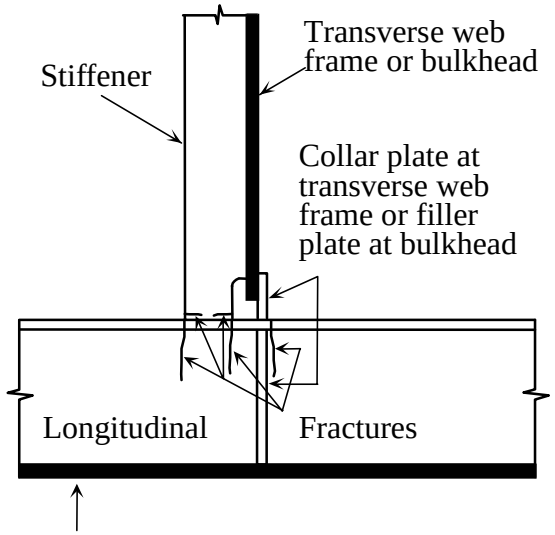
1. Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.

Notes on repairs

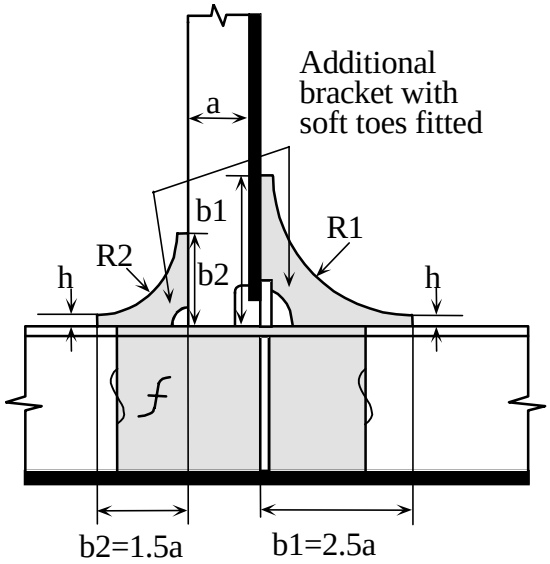
1. If fractures are significant then crop and part renew the plating otherwise the fracture can be veed-out and welded provided the plating is not generally corroded.
2. **Repair A** Lug should be considered.
3. **Repair B** Full collar plate should be considered where the depth of cut-out is more than 0.4 times the depth of web frame and in an area of high shear stress or the existing lug proves to be ineffective.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**5**
Detail of damage	Fractures in longitudinal at transverse web frame or bulkhead	

Sketch of damage



Sketch of repair



f: Where required, the longitudinal to be cropped and part renewed

1. For a slope at toes max. 1:3, R1=(b1-h)x 1.6 and R2=(b2-h)x 1.6
2. Soft toe bracket to be welded first to longitudinal
3. Scallop in bracket to be as small as possible, recommended max. 35mm
4. If toes of brackets are ground smooth, full penetration welds in way to be provided
5. Maximum length to thickness ratio =50:1 for unstiffened bracket edge
6. Toe height, h, to be as small as possible (10-15mm)

Notes on possible cause of damage

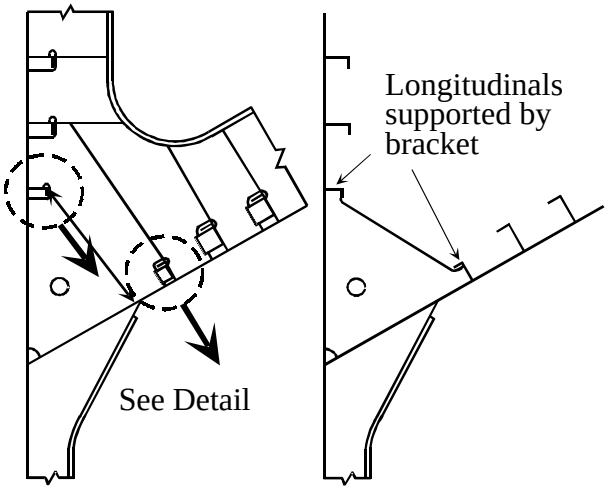
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

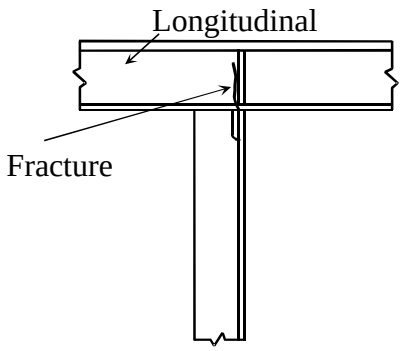
Notes on repairs

1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

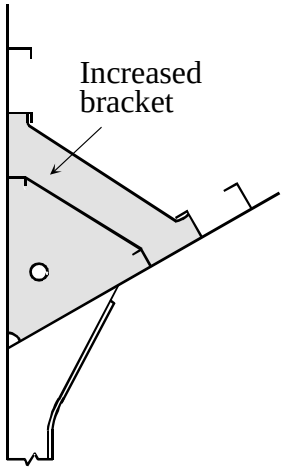
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**6**
Detail of damage	Fractures in the lowest longitudinal at transverse web frame	

Sketch of damage





Detail



Notes on possible cause of damage

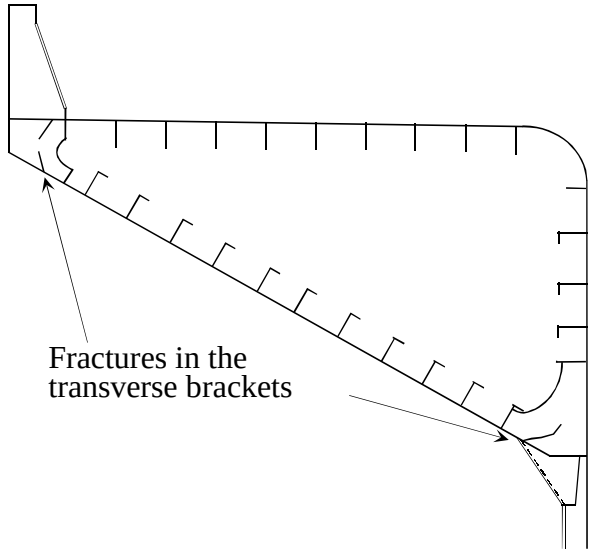
1. Insufficient scantling for torsional rigidity (The lowest longitudinal is usually supported by bracket(s) as shown in the above and smaller scantling may be adopted. However, the lowest longitudinal undergoes torsion from side shell frame through bracket(s) and may suffer fracture.)

Notes on repairs

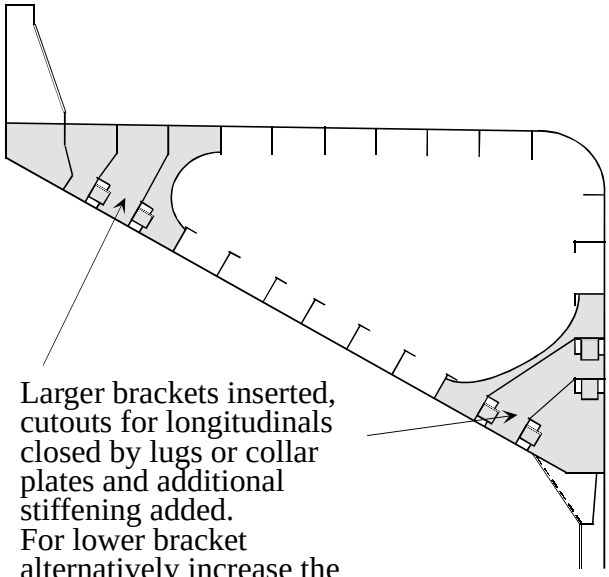
1. Fractured part to be cropped and renewed.
2. Size of bracket should be increased

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**7-a**
Detail of damage	Fractures in transverse brackets	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

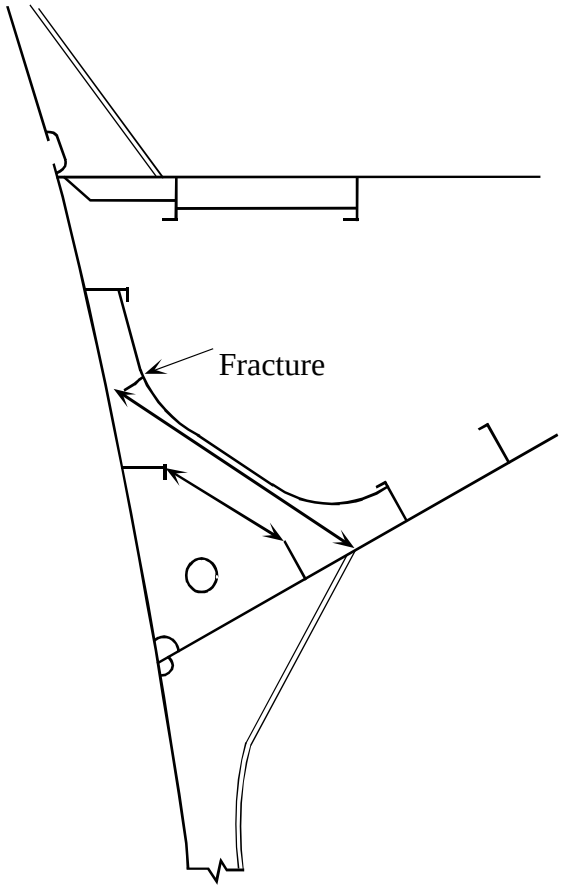
1. General levels of corrosion and presence of stress concentrations.
2. Misalignment of the brackets with adjoining structure, e.g. side shell frame brackets and/or coaming brackets.
3. High shear stresses due to insufficient bracket size.
4. Inadvertent overloading.

Notes on repairs

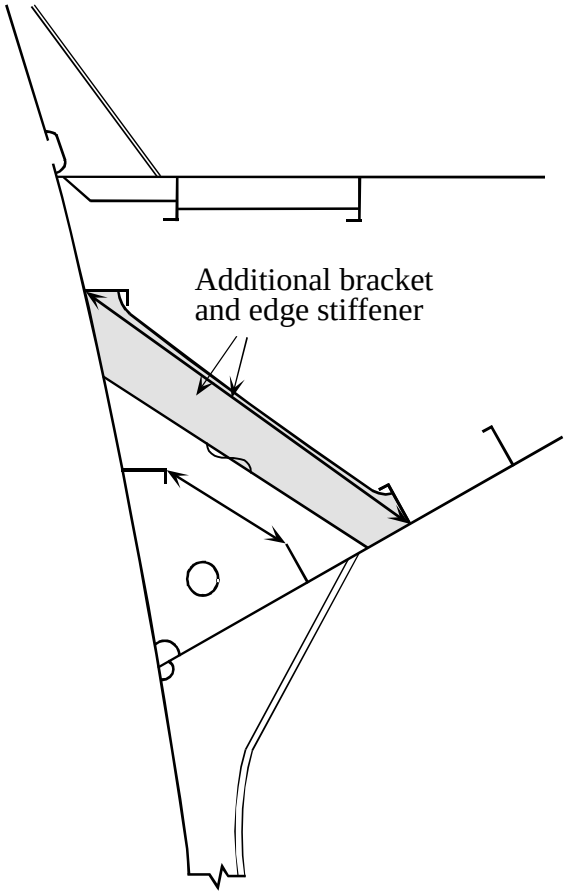
1. If the damage is caused by misalignment with the side shell frame brackets or the hatch coaming brackets the misalignment is to be rectified and the replacement by larger brackets incorporated only if considered necessary.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**7-b**
Detail of damage	Fractures in transverse bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

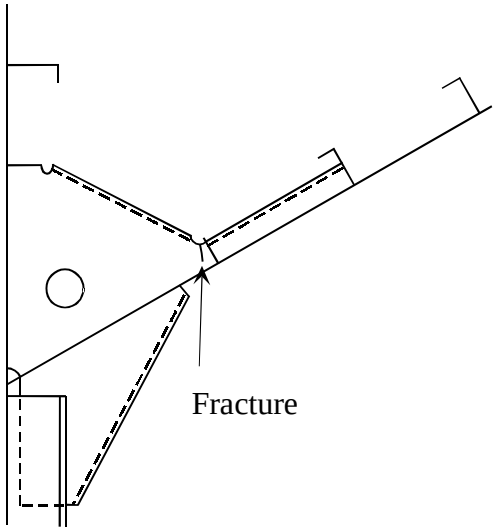
1. Insufficient strength.
2. Corrosion.

Notes on repairs

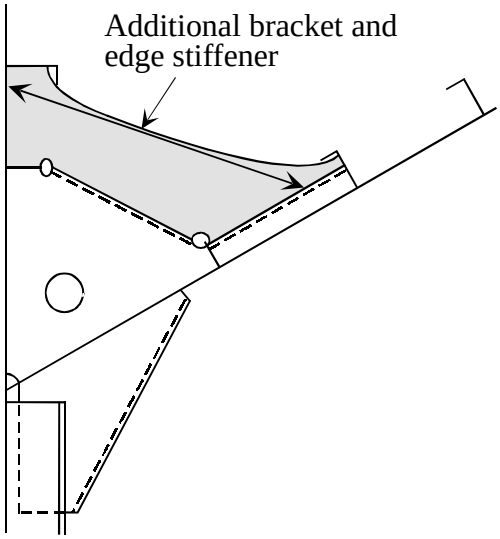
1. Fractured part to be cropped and renewed.
2. If the fractured part is free from corrosion, increased size and thickness should be considered. Partial renewal of the bracket may be accepted depending on the nature of the fracture.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**7-c**
Detail of damage	Fractures at toes of transverse bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

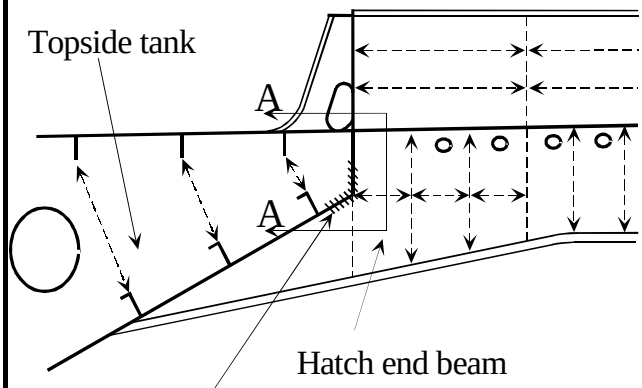
1. Stress concentration due to the shape of the bracket.

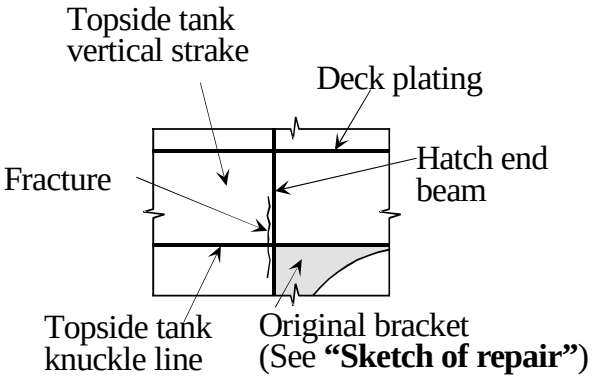
Notes on repairs

1. Cracked weld to be veed-out and rewelded.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**8**
Detail of damage	Fractures in sloping plating and vertical strake initiated from the connection of topside tank to hatch end beam	

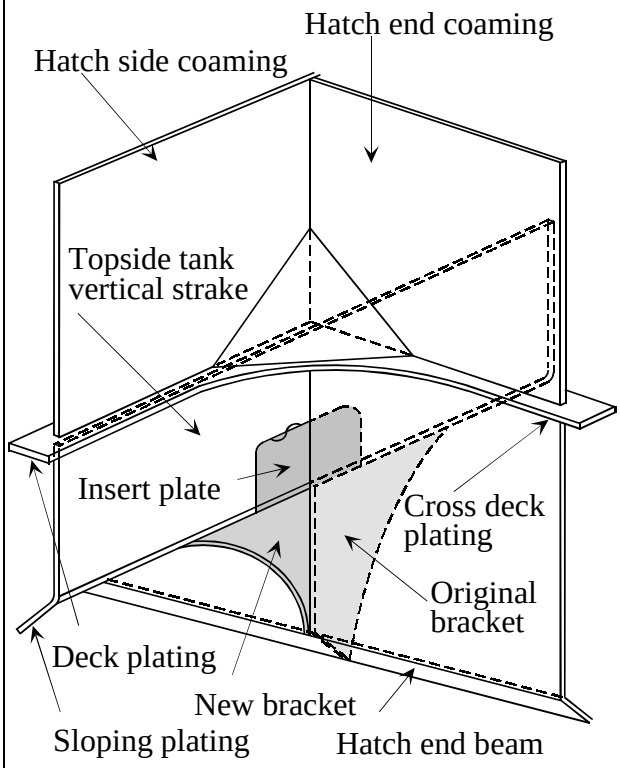
Sketch of damage





View A-A

Sketch of repair



Notes on possible cause of damage

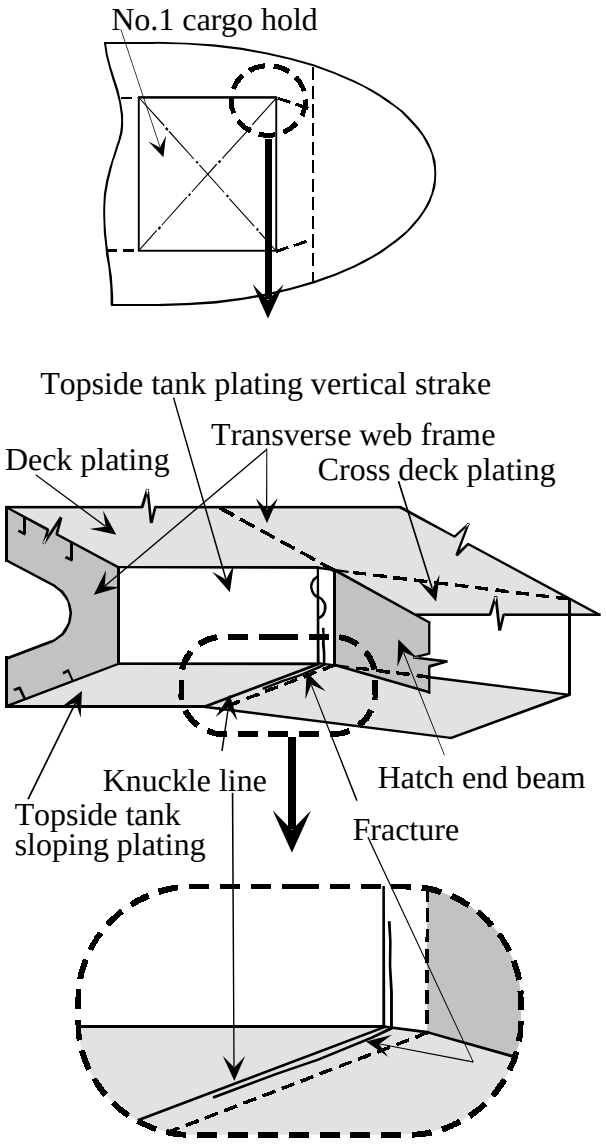
1. Stress concentration at the connection of hatch end beam to topside tank.

Notes on repairs

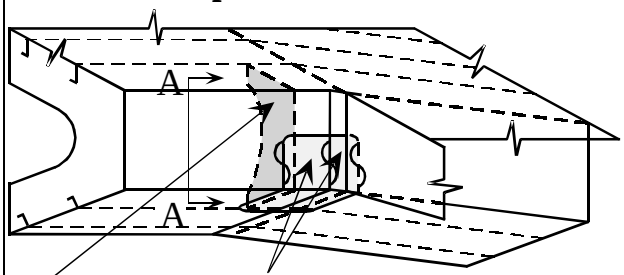
1. Fractured part to be cropped and renewed with increased thickness.
2. Additional bracket should be considered for reinforcement.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**9**
Detail of damage	Fractures in sloping plating at knuckle	

Sketch of damage

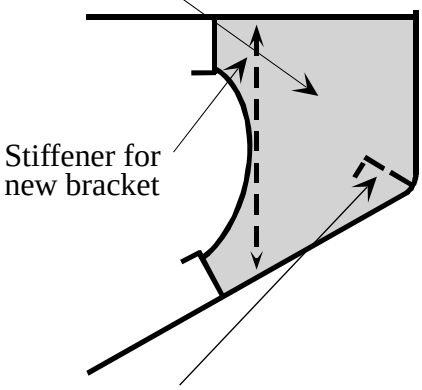


Sketch of repair



New additional bracket (See **View A-A**)

Insert plates should be assembled where welding is easy to be performed before inserted in topside tank for quality of butt welded joint and the joint should be grounded.



Insert plate provided between new additional bracket and adjacent original transverse web frame

View A-A

Notes on possible cause of damage

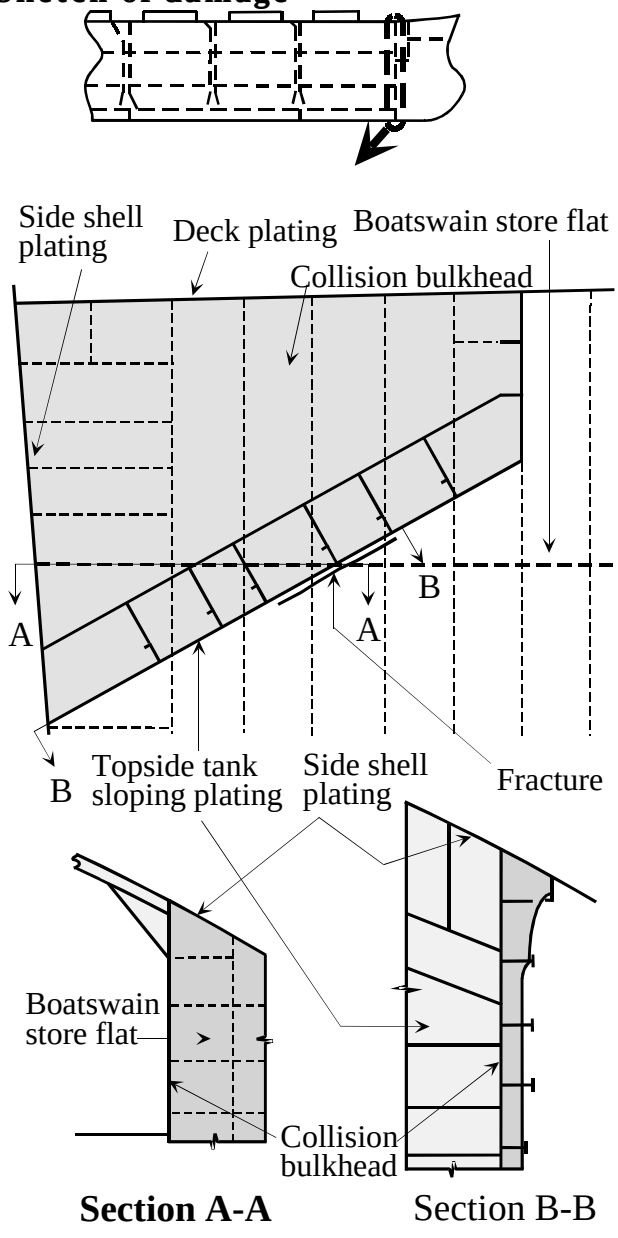
1. Insufficient strength.
2. Additional stress induced by knuckle.

Notes on repairs

1. Knuckle part should be reinforced appropriately.

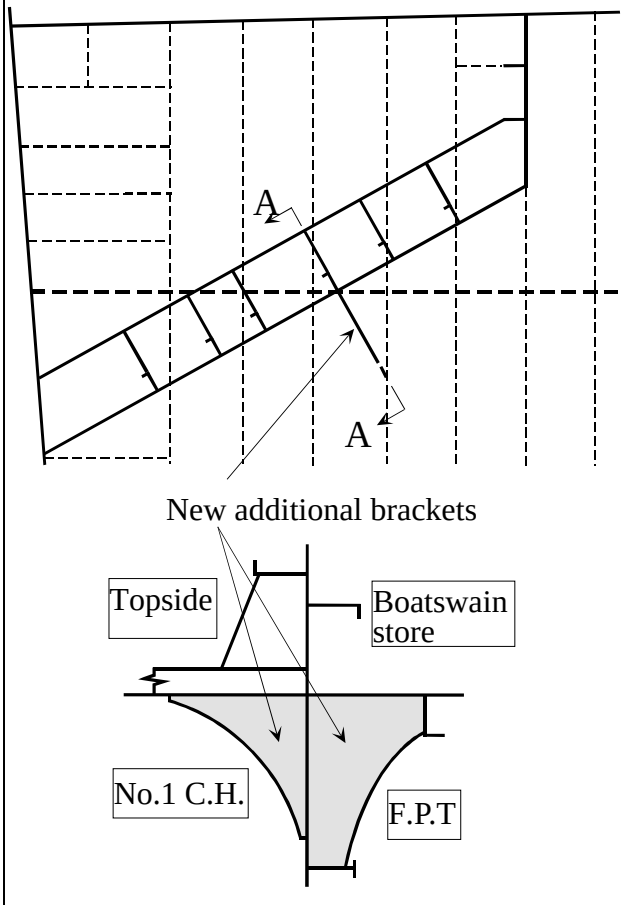
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Topside tank structure**	**10**
Detail of damage	Fractures in way of collision bulkhead at intersection with topside tank structure in foremost cargo hold	

Sketch of damage



Section A-A Section B-B

Sketch of repair



Section A-A

Notes on possible cause of damage

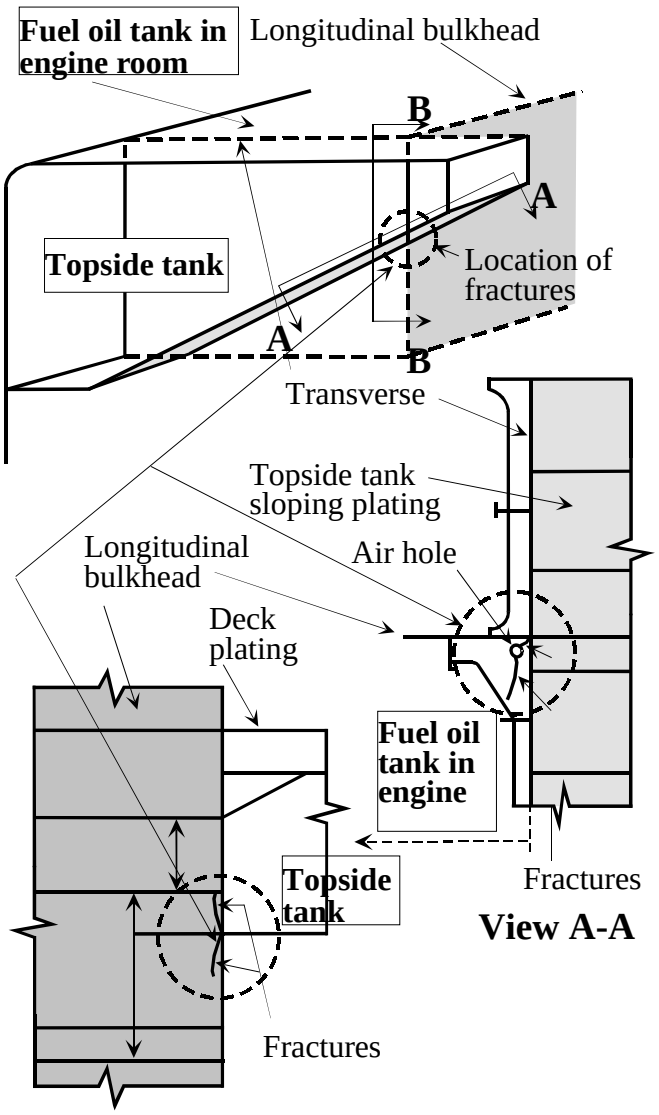
1. Damage caused by hard spot at intersection of the topside tank sloping plating and boatswain's store deck plating (fore peak tank top plating).

Notes on repairs

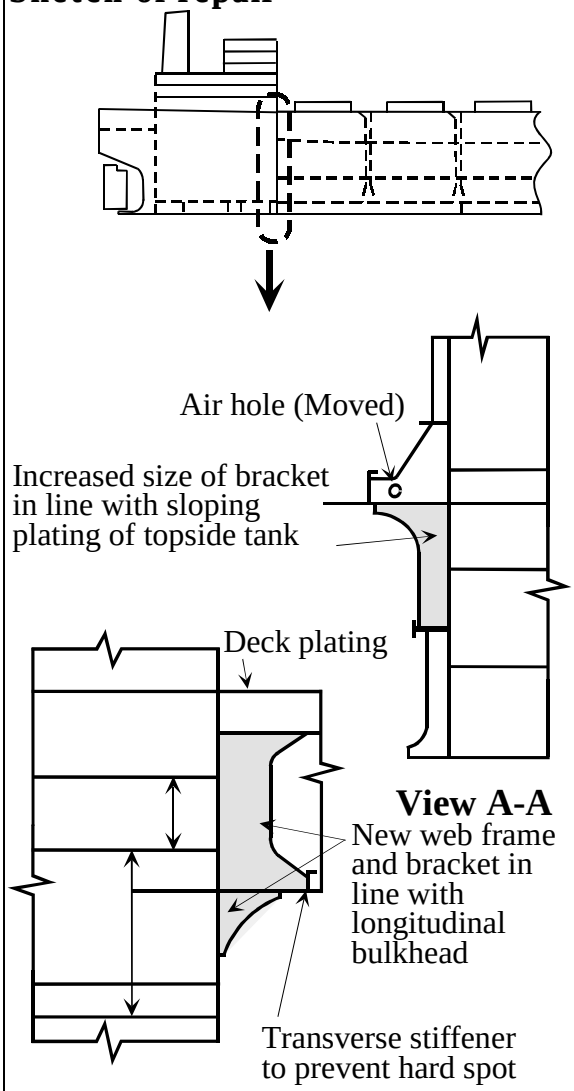
1. Fractured plates to be cropped and renewed.
2. Stress concentration should be considered (Brackets were fitted on both sides for reinforcement).

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 2	Topside tank structure	11
Detail of damage	Fractures in way of engine room forward bulkhead at intersection with topside tank structure in aftermost cargo hold	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage caused by hard spot at intersection of the topside tank sloping plating and longitudinal bulkhead of the fuel oil tank in engine room.

Notes on repairs

1. Fractured plates to be cropped and renewed as necessary and reinforcement fitted as shown shaded above. The position of the air-hole to be relocated.

Area 3 Cargo hold side structure

Contents

1 General

2 What to look for - Internal inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for - External inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Deformations
4.3 Fractures

Figures and/or Photographs - Area 3	
No.	**Title**
Figure 1	Side shell frame - Potential problems areas
Figure 2	Damages to side shell frame - Potential problem areas
Figure 3	Representative gauging locations on the side shell frame - Potential problem areas
Figure 4	Transition regions - Potential problem areas
Figure 5	Uniform corrosion of side shell frame
Photograph 1	Collapsed side shell frames
Photograph 2	Missing side shell structure

Examples of structural detail failures and repairs - Area 3	
Example No.	**Title**
1-a	Fractures in brackets at termination of frame
1-b	Fractures in side shell frame at bracket's toe
2	Fractures in side shell frame at bracket's toe
3	Fractures in side shell frame/lower bracket and side shell plating near hopper
4	Deformation of side shell plating
5	Adverse effect of corrosion on the frame of forward/afterward hold

Examples of structural detail failures and repairs - Area 3	
Example No.	**Title**
6	Buckling and fractures of side shell plating in foremost cargo hold
7	Fractures at the supporting brackets in way of the collision bulkhead
8	Fractures at the supporting brackets in way of the collision bulkhead with no side shell panting stringer in hold
9	Fractures in way of horizontal diaphragm in the connecting trunk between topside tank and hopper double bottom tank, on after side of collision bulkhead
10	Fractures in way of continuation/extension bracket in aftermost hold at the engine room bulkhead

1 General

1.1 In addition to contributing to the shear strength of the hull girder, the side shell forms the external boundary of a cargo hold and is naturally the first line of defense against ingress/leakage of sea water when the ship hull is subjected to wave and other dynamic loading in heavy weather. The integrity of the side structure is of prime importance to the safety of the ship and this warrants very careful attention during survey and inspection.

1.2 The ship side structure is prone to damage caused by contact with the quay during berthing and impacts of cargo and cargo handling equipment during loading and discharging operations.

1.3 The marine environment in association with the handling and characteristics of certain cargoes (e.g. wet timber loaded from sea water and certain types of coal) may result in deterioration of coating and severe corrosion of plating and stiffeners. This situation makes the structure more vulnerable when exposed to heavy weather.

1.4 Bulk carriers carry various cargoes and one of the common cargoes is coal, especially for large bulk carriers. Certain types of coal contains sulphur impurities and when they react with water produce sulfuric acid which can cause severe corrosion to the structure if suitable coating is not applied and properly maintained.

1.5 The structure at the transition regions at the fore and aft ends of the ship are subject to stress concentrations due to structural discontinuities. The side shell plating at the transition regions is also subject to panting. The lack of continuity of the longitudinal structure, and the increased slenderness and flexibility of the side structure, makes the structure at the transition regions more prone to fracture damages.

1.6 A summary of potential problem areas is shown in **Figures 1** - **4**. Examples of failure and damaged ship side structure are illustrated in **Photographs 1**- **2**.

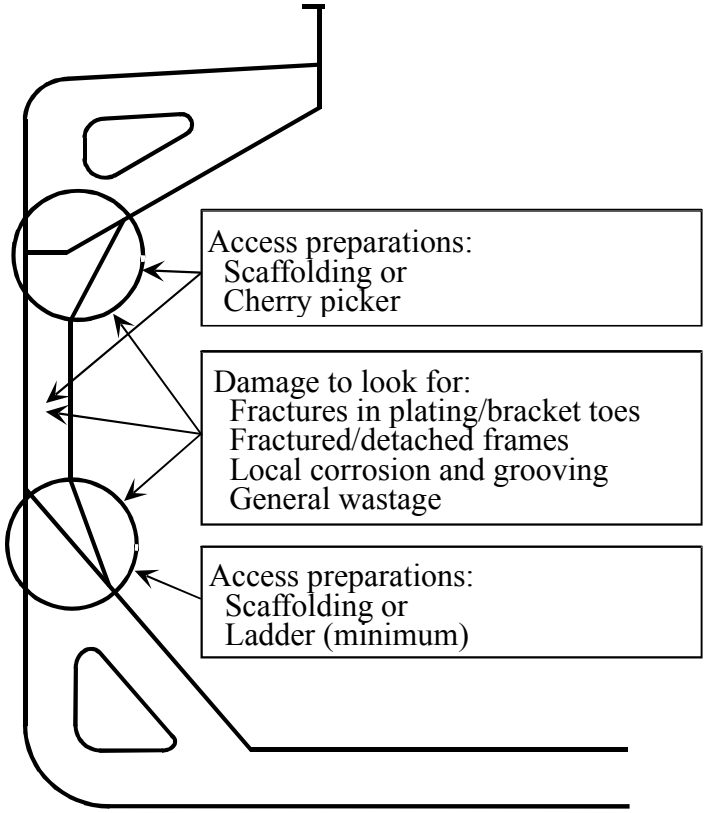
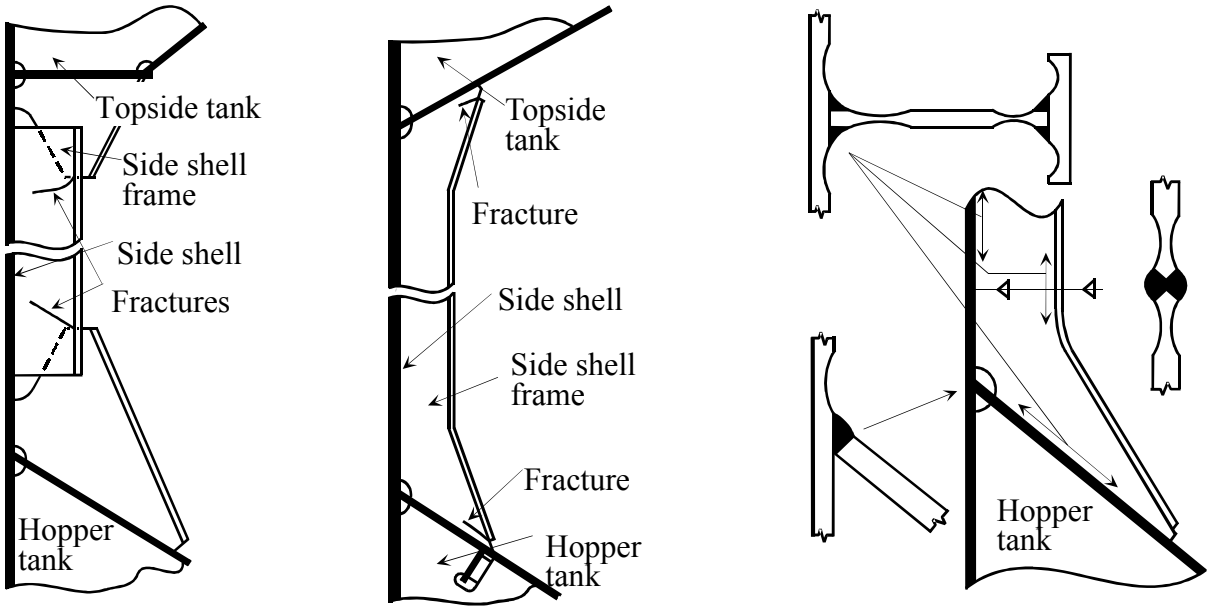


Figure 1
Side shell frame - Potential problem areas



(a) Separate bracket configuration **(b) Integral bracket configuration** **(c) Examples of grooving**

Figure 2 Damages to side shell frame - Potential problem areas

(Note) The type of bracket configuration used will, to a large extent, dictate the location and extent of fracture. Where separate brackets are employed, the fracture location is normally at the bracket toe position on the frames, whereas with integral brackets the location is at the toe position on the hopper and topside tank.

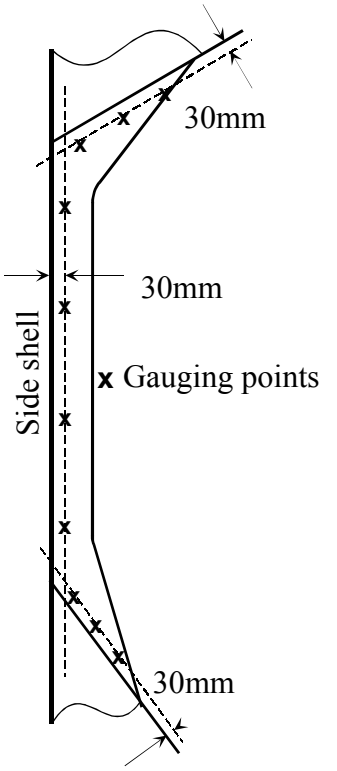


Figure 3
Representative gauging locations on the side shell frame - Potential problem areas

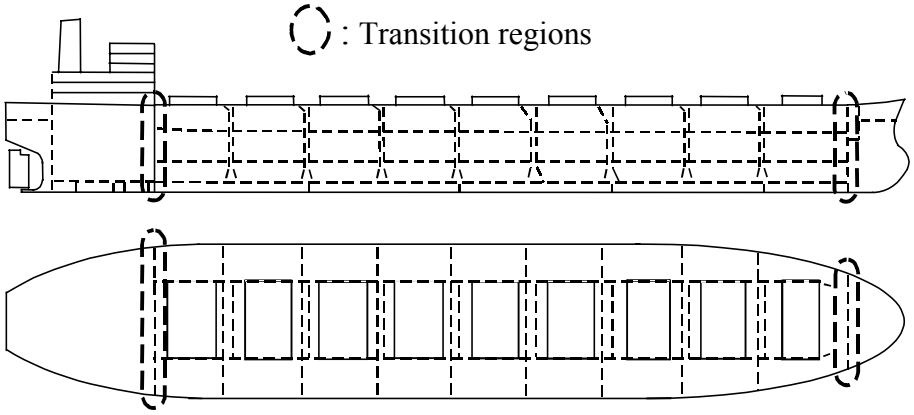


Figure 4 Transition regions - Potential problem area

Photograph 1 Collapsed side shell frames (See Example 4)

Photograph 2 Missing side shell structure (See Examples 4 and 5)

2 What to look for - Internal inspection

2.1 Material wastage

2.1.1 Attention is drawn to the fact that side shell frames may be significantly weakened by loss of thickness although diminution and deformations may not be apparent. Inspection should be made after the removal of any scale or rust deposit. Thickness measurements may be necessary, particularly if the corrosion is smooth and uniform, to determine the condition of the structure (See **Figure 5**).

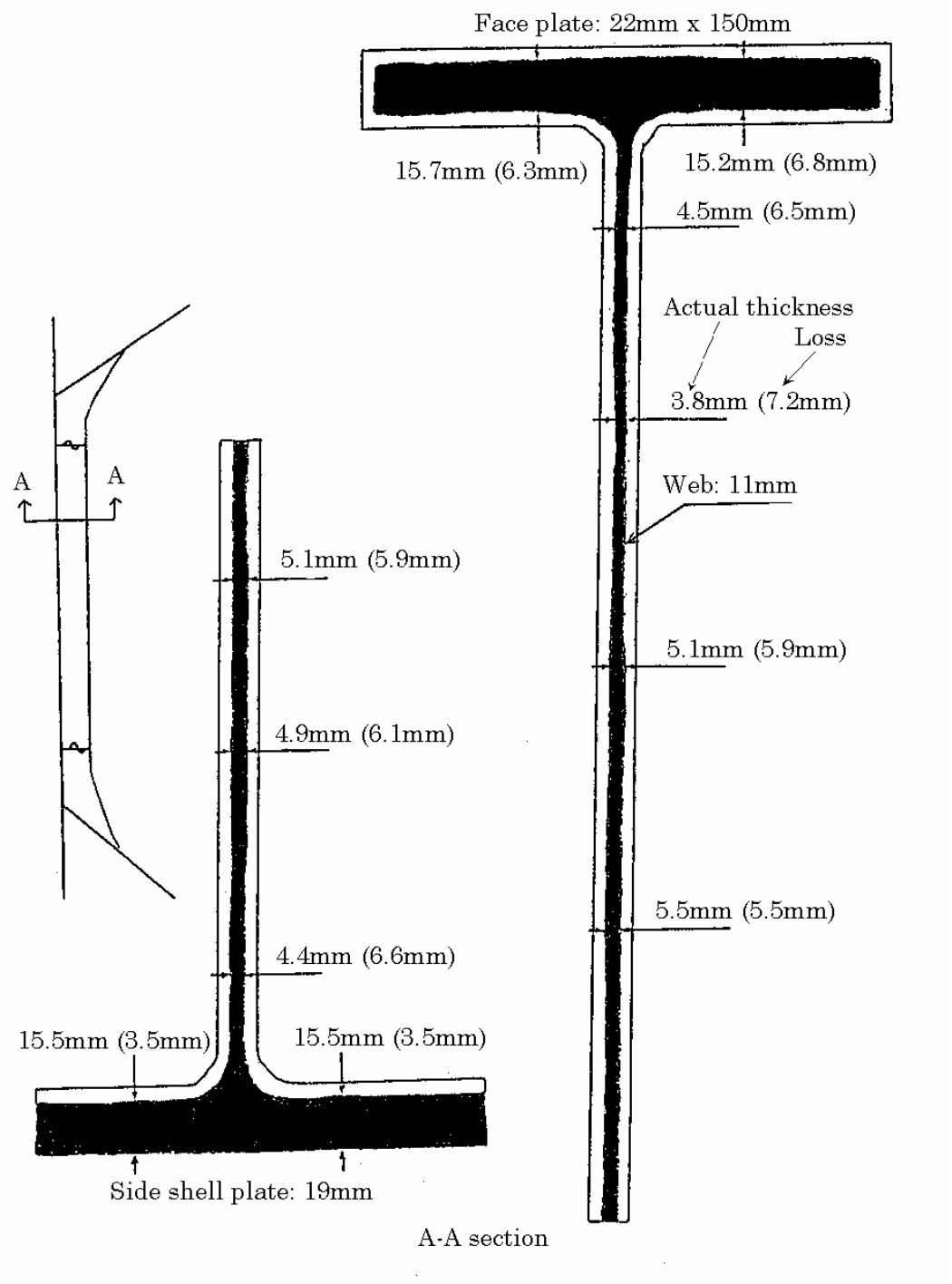


Figure 5 Uniform corrosion of side shell frame

2.1.2 It is not unusual to find highly localised corrosion on uncoated side shell frames and their end connections. The loss in the thickness is normally greater close to the side shell plating rather than near the faceplate, and consequently representative thickness measurements should be in that area (See **Figure 3**). This situation, if not remedied, can result in loss of support to the shell plating and hence large inboard deflections. In many cases such deflections of the side shell plating can generate fractures in the shell plating and fracturing and buckling of the frame web plates and eventually result in detachment of the end brackets from the hopper tank.

2.1.3 Heavy wastage and possible grooving of the framing in the forward/aft hold, where side

shell plating is oblique to frames, may result in fracture and buckling of the shell plating as shown in **Example 5**.

2.1.4 Pitting corrosion may be found under coating blisters which need to be removed before inspection.
It should be noted that the middle part of a frame may be wasted even if the upper and / or lower parts of the frame are not.
The following should be considered (and may be included as a surveyor's checklist):

- Hold Frame scantling drawings for each hold and allowable diminution level
- Repair history of Hold Frames
- Previous thickness measurement reports.
- Diminution of Hold Frames would normally be equal or greater than that of transverse cargo hold bulkheads.
- Note history of cargoes carried, especially that of coal or similar corrosive cargo.
- Record of any coating previously applied.
- Safe means of survey access (staging / cherry picker / portable ladder etc.)

Visual examination should take account of the following:

- The diminution of the face plate can be an indication of diminution level on the webs.
- Thickness of the Web may be estimated from edge condition of scallops.
- Fillet welding between Web and Shell plate and heat affected zone
- Fillet welding between Web and Face plate and heat affected zone
- Fillet welding between Upper Bracket and Top side tank, between Lower Bracket and Bilge Hopper Tank and heat affected zone
- Scallop at Upper and Lower part of Web

Experience with Bulk Carriers 100,000 dwt and above has shown that side shell frames in No.3 hold are more susceptible to damages. Therefore it is recommended that side shell frames in this hold are specially considered.

2.2 Deformations

2.2.1 It is normally to be expected that the lower region of the frames will receive some level of damage during operational procedures, e.g. when unloading with the aid of grabs and bulldozers or during loading of logs. This can range from damage of the side frame end bracket face plates to large physical deformations of a number of frames and in some cases can initiate fractures.

These individual frames and frame brackets, if rendered ineffective, will place additional load on the adjacent frames and failure by the “domino effect” can in many cases extend over the side shell of a complete hold.

2.3 Fractures

2.3.1 Fractures are more evident at the toes of the upper and lower bracket(s) or at the connections between brackets and frames. In most cases the fractures may be attributed to stress concentrations and stress variations created, in the main, by loads from the seaway. The stress concentrations can be a result of poor detail design and/or bad workmanship. Localised fatigue fracturing, possibly in association with localised corrosion, may be difficult to detect and it is stressed that the areas in question should receive close attention during periodical surveys.

2.3.2 Fractures are more often found at the boundary structure of a cargo/ballast hold than other cargo holds. This area should be subjected to close-up examination.

2.3.3 Fractures in shell plating and supporting or continuation/extension brackets at collision bulkhead and engine room forward bulkhead are frequently found by close-up examination.

3 What to look for – External inspection

3.1 Material wastage

3.1.1 The general condition with regard to wastage of the ship's sides may be observed by visual inspection from the quay side of the area above the waterline. Special attention should be paid to areas where the painting has deteriorated.

3.2 Deformations

3.2.1 The side shell should be carefully inspected with respect to possible deformations. The side shell below water line can usually only be inspected when the ship is dry docked. Therefore special attention with respect to possible deformations should be paid during dry-docking. When deformation of the shell plating is found, the area should also be inspected internally since even a small deformation may indicate serious damage to the internal structure.

3.2.2 Side shell plating in foremost cargo hold may suffer buckling. Since the shell plating in fore body has curvature in longitudinal direction due to the slenderness, external loads, such as static and dynamic water pressure cause compressive stress in side shell. Therefore the ships of which side shell plating is high tensile steel or has become thin due to corrosion may suffer buckling resulting in fracture along collision bulkhead or side shell frames.

3.3 Fractures

3.3.1 Fractures in the shell plating above and below the water line in way of ballast tanks may be detected during dry-docking as wet area in contrast to otherwise dry shell plating.

4 General comments on repair

4.1 Material wastage

4.1.1 In general, where part of the hold framing and/or associated end brackets have deteriorated to the permissible minimum thickness level, the normal practice is to crop and renew the area affected. However, if the remaining section of the frames/brackets marginally remain within the allowable limit, surveyors should request that affected frames and associated end brackets be renewed. Alignment of end brackets with the structure inside hopper tank or topside tank is to be ensured. It is recommended that repaired areas be coated.

4.1.2 If pitting intensity is lower than 15% in area (see **Figure 6**), pitting greater than ¼ of the original thickness can be welded flush with the original surface.

If deep pits are clustered together or remaining thickness is less than 6 mm, the plate should be renewed by plate inserting instead of repairing by welding.

4.2 Deformations

4.2.1 Depending on the extent of the deformation, the structure should be restored to its original shape and position either by fairing in place or by cropping and renewing the affected structure.

4.3 Fractures

4.3.1 Because of the interdependence of structural components it is important that all fractures and other significant damage to the side shell, frames and their end brackets, however localised, are repaired.

4.3.2 Fractured part of supporting brackets and continuation/extension brackets at collision bulkhead, deep tank bulkheads, and engine room bulkhead are to be part renewed with consideration given to the modification of the shape and possible extension of the brackets to reduce stress concentration. Affected shell plating in way of the damaged brackets should be cropped and renewed.

4.3.3 Repair of fractures at the boundary of a cargo hold should be carefully considered, taking into account necessary structural modification, enhanced scantlings and material, to prevent recurrence of the fractures.

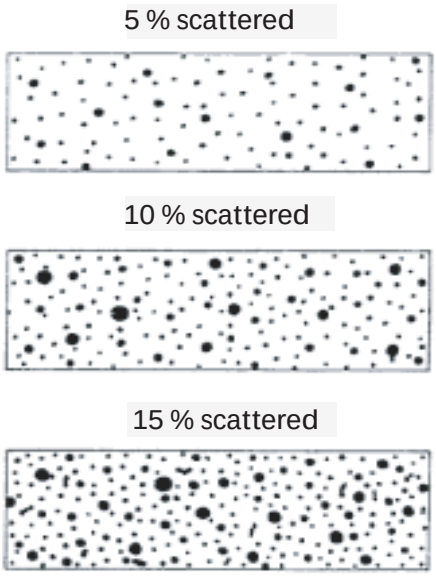
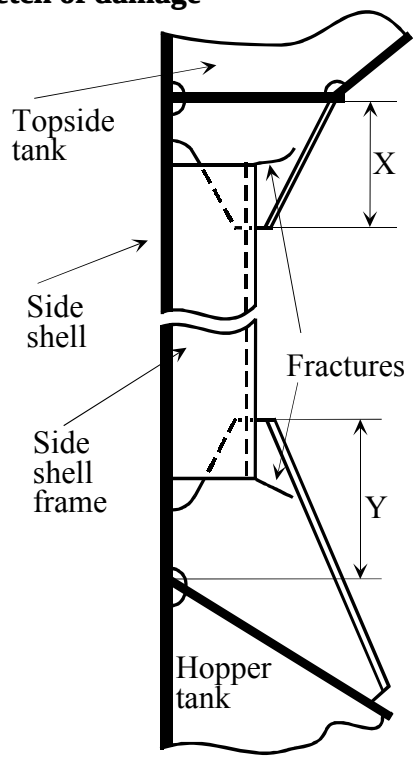


Figure 6 Pitting intensity diagrams (from 5% to 15% intensity)

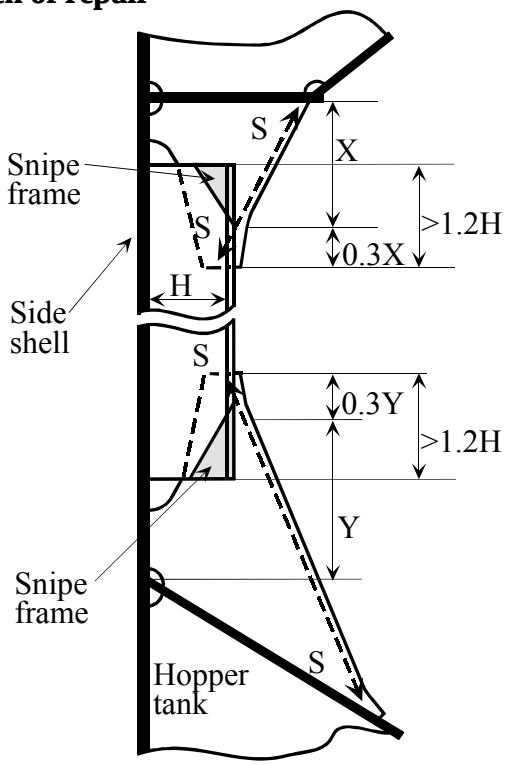
BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**1-a**
Detail of damage	Fractures in brackets at termination of frame	

Sketch of damage



Separate bracket configuration

Sketch of repair



S=Snipped end

Notes on possible cause of damage

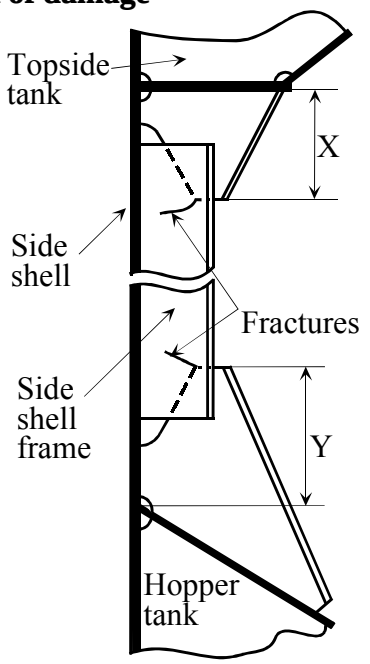
1. This type of damage is caused due to stress concentration.

Notes on repairs

1. For small fractures, e. g. hairline fractures, the fracture can be veed-out, ground, examined by NDT for fractures, and rewelded.
2. For larger/significant fractures consideration is to be given to cropping and partly renewing/ renewing the frame brackets. If renewing the brackets, end of frames can be sniped to soften them.
3. If felt prudent, soft toes are to be incorporated at the boundaries of the bracket to the hopper plating.
4. Attention to be given to the structure in wing tanks in way of the extended bracket arm. i.e. reinforcement provided in line with the bracket.

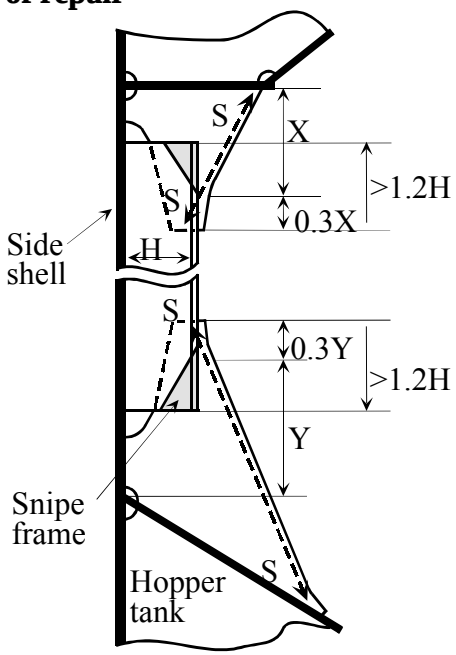
BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**1-b**
Detail of damage	Fractures in side shell frame at bracket's toe	

Sketch of damage



Separate bracket configuration

Sketch of repair



S=Snipped end

Notes on possible cause of damage

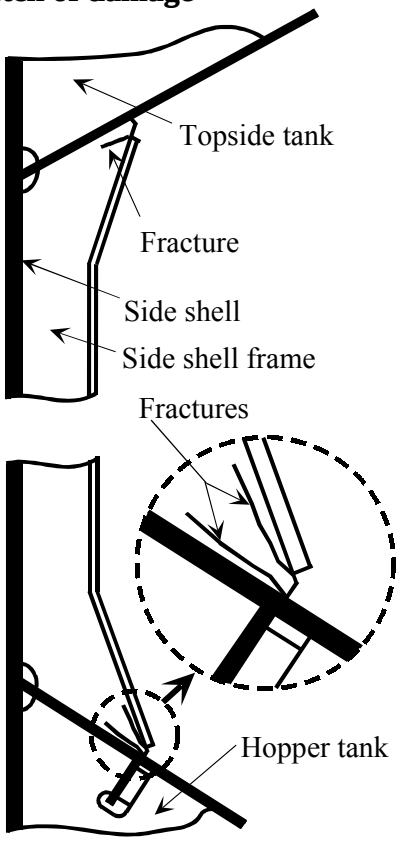
1. This type of damage is caused due to stress concentration.

Notes on repairs

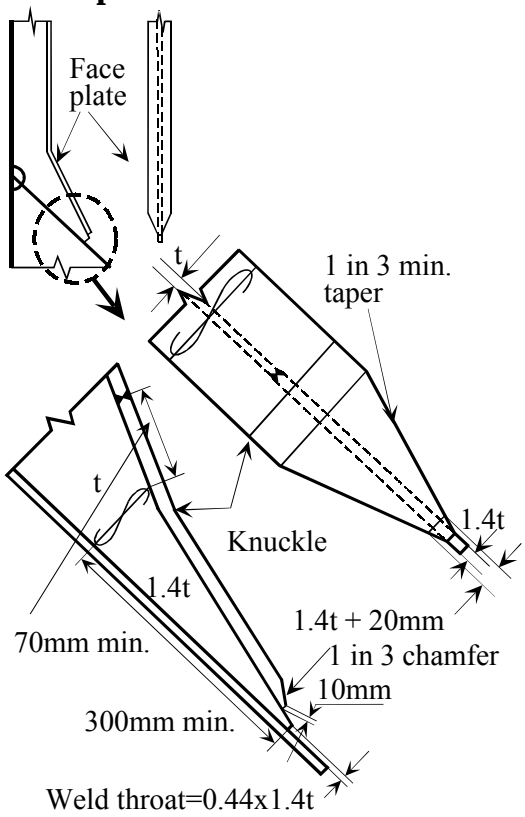
1. For small fractures, e. g. hairline fractures, the fracture can be veed-out, welded up, ground, examined by NDT for fractures, and rewelded.
2. For larger/significant fractures consideration is to be given to cropping and partly renewing/ renewing the frame brackets. If renewing the brackets, end of frames can be sniped to soften them.
3. If felt prudent, soft toes are to be incorporated at the boundaries of the bracket to the hopper plating.
4. Attention to be given to the structure in wing tanks in way of the extended bracket arm. i.e. reinforcement provided in line with the bracket.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**2**
Detail of damage	Fractures in side shell frame at bracket's toe	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

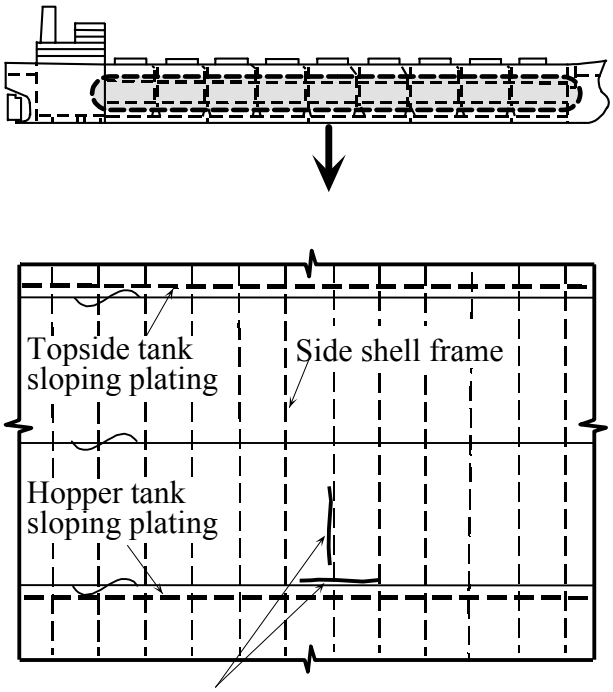
1. This type of damage is caused due to stress concentration.

Notes on repairs

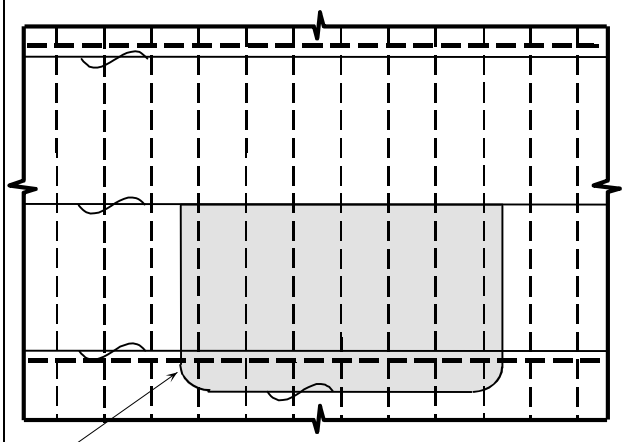
1. Repair is to incorporate a design similar to the one shown on the sketch and in addition:-
   - 1.1. The arm of the bracket along the hopper/ topside plating should be increased by altering the angle of the bracket face plate. A face plate taper of 1 in 3 should be arranged.
   - 1.2. The local thickness of the bracket web plating over the length of the new face plate taper should be increased by about 40% above that originally fitted.
   - 1.3. The face plate thickness should be chamfered 1 in 3 to a thickness at its extremity.
   - 1.4. Welding of the new bracket toe should be based on a weld factor of 0.44 applied to the increased thickness.
2. Attention to be given to the structure in wing tanks in way of the extended bracket arm. i.e. reinforcement provided in line with the bracket.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**3**
Detail of damage	Fractures in side shell frame/lower bracket and side shell plating near hopper	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

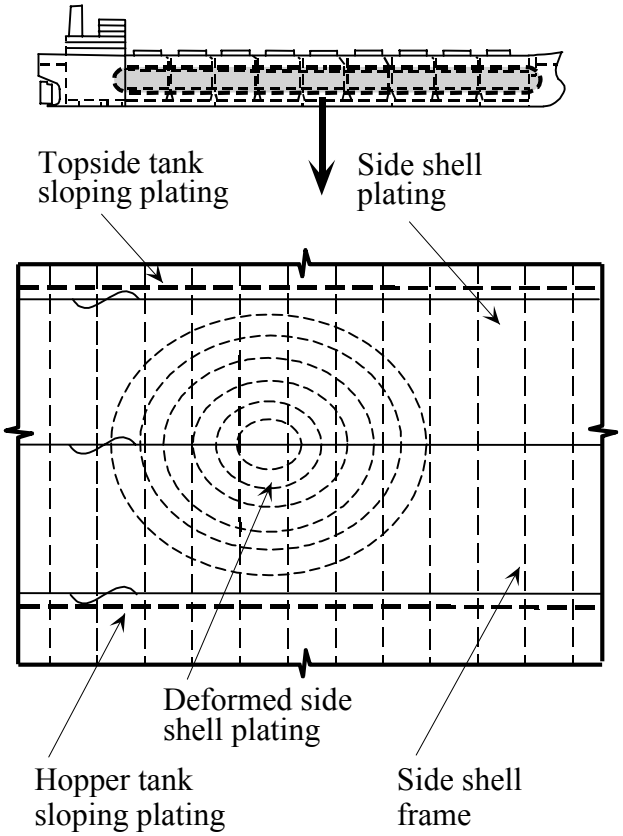
1. Heavy corrosion (grooving). Refer to **Figure 2 (c)**.

Notes on repairs

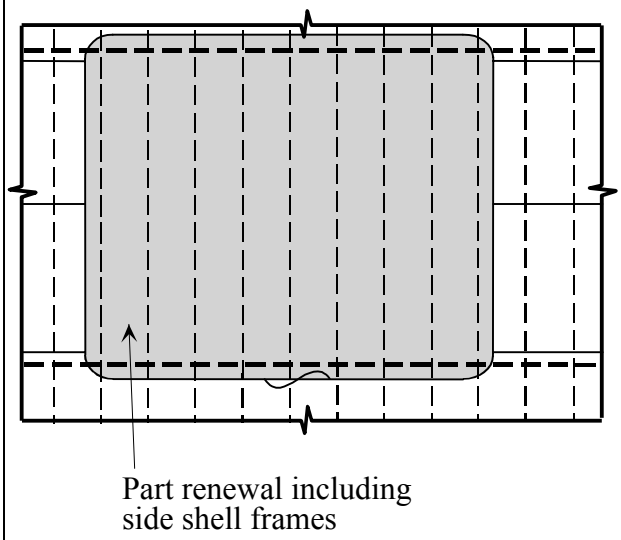
1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**4**
Detail of damage	Deformation of side shell plating	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

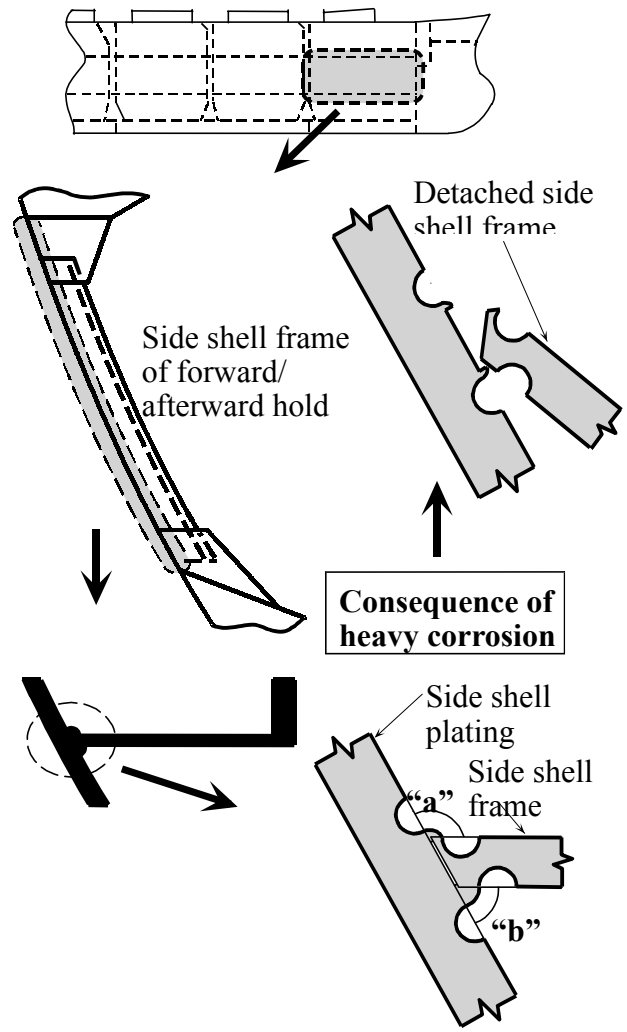
1. Insufficient stiffness of side shell frames due to buckling and/or detachment of side shell frames due to corrosion.
2. Heavy weather.

Notes on repairs

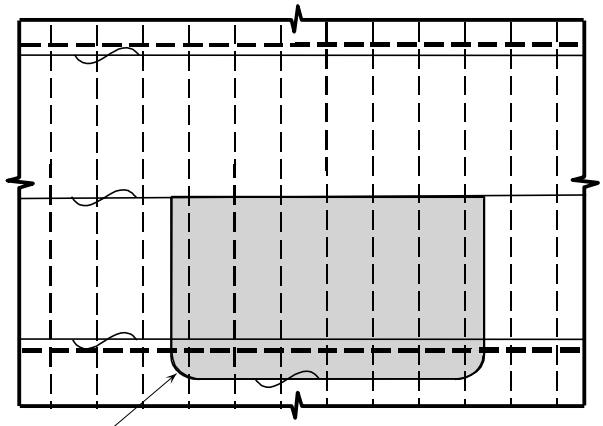
1. Deformed side shell plating including side shell frames should be cropped and renewed.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**5**
Detail of damage	Adverse effect of corrosion on the frame of forward/afterward hold	

Sketch of damage



Sketch of repair



1. Part renewal including side shell frames and hopper plating, as found necessary
2. Deep penetration welding at the connections of side shell frames to side shell plating

Notes on possible cause of damage

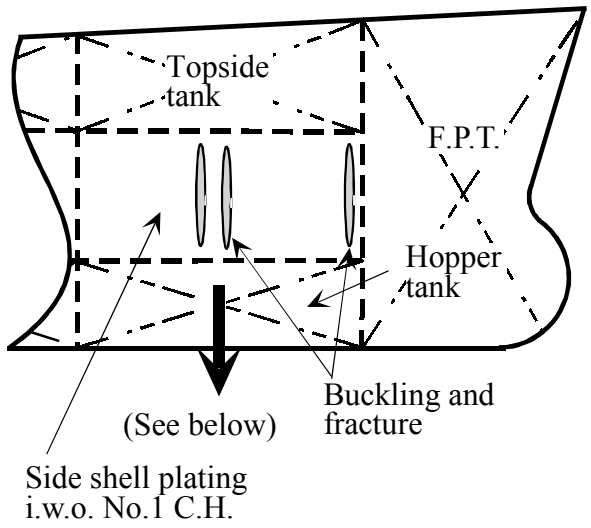
1. Heavy corrosion (grooving) of side shell frame along side shell plating and difference of throat thickness "**a**" from "**b**". (Since original throat thickness of "**a**" is usually smaller than that of "**b**", if same welding procedure is applied, the same corrosion has a more severe effect on "**a**", and may cause collapse and/or detachment of side shell frame.)

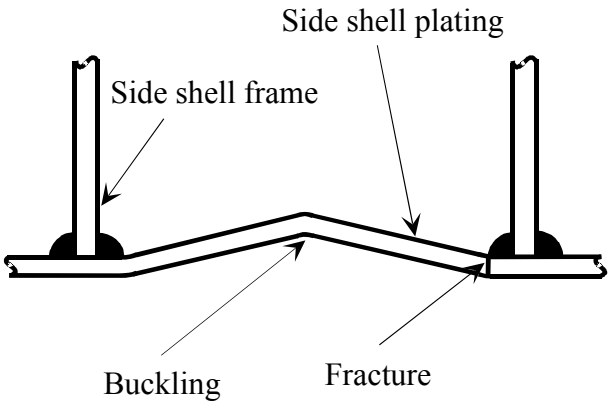
Notes on repairs

1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

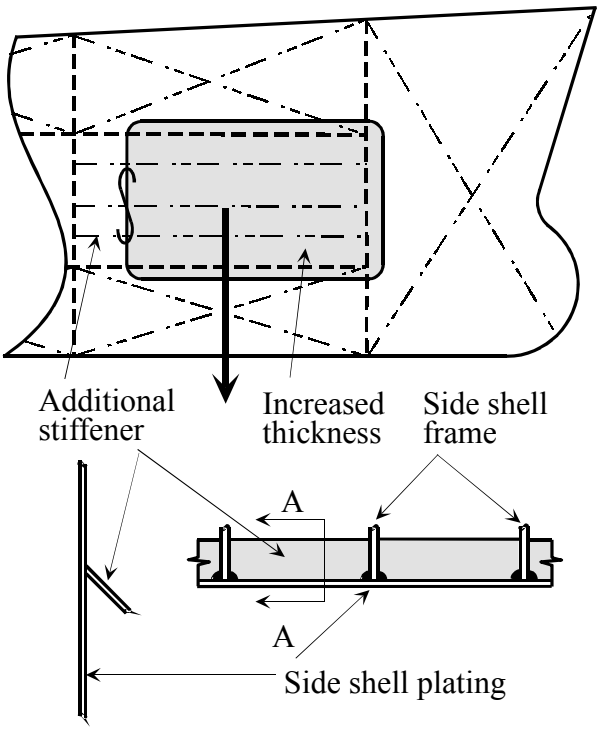
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**6**
Detail of damage	Buckling and fractures of side shell plating in foremost cargo hold	

Sketch of damage





Sketch of repair



View A-A

Notes on possible cause of damage

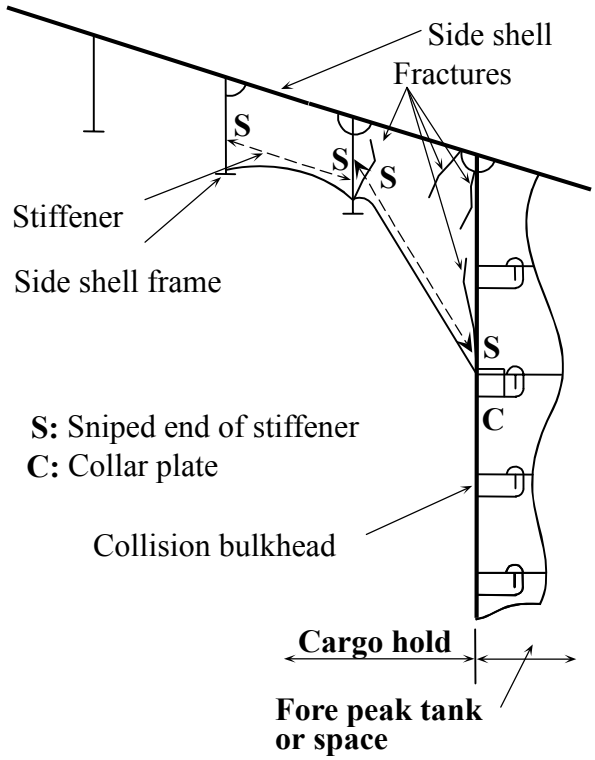
1. Heavy weather.
2. Insufficient buckling strength due to high tensile steel or heavy uniform corrosion.
3. Inadequate transition structure.

Notes on repairs

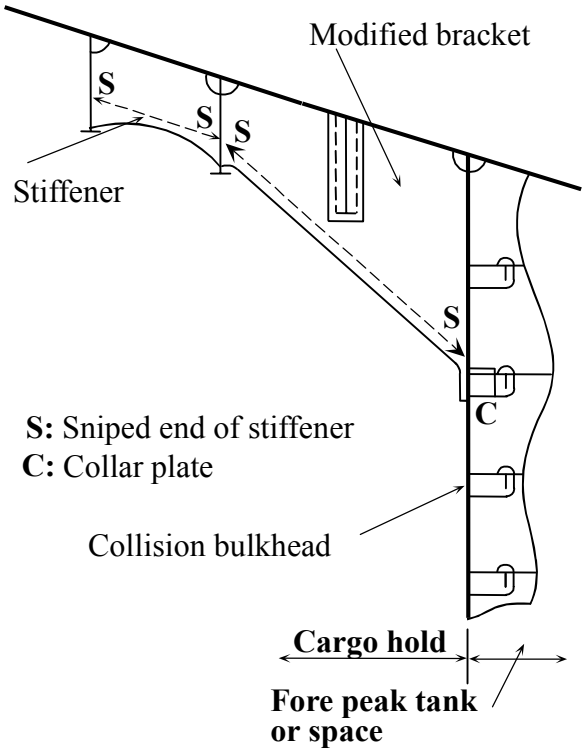
1. Buckled/fractured side shell plating is to be cropped and renewed.
2. Reinforcement by thicker side shell plating and/or additional stiffeners should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**7**
Detail of damage	Fractures at the supporting brackets in way of the collision bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

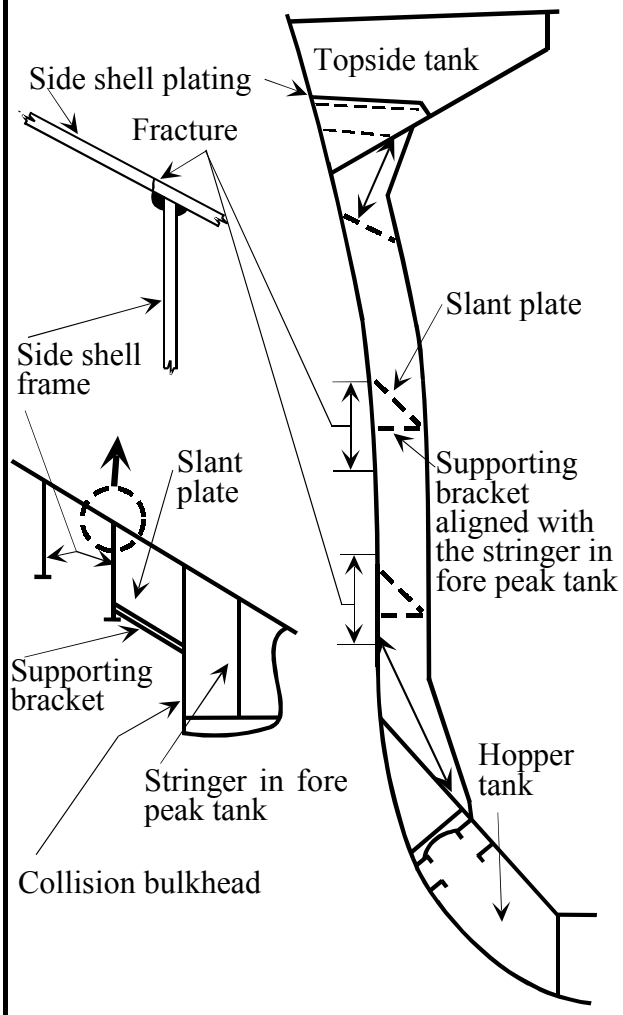
1. Insufficient bracket size resulting in high stress due to load cantilevered from side frame.
2. Stress concentration at toe of bracket and misalignment between bracket and stringer in fore peak tank or space.

Notes on repairs

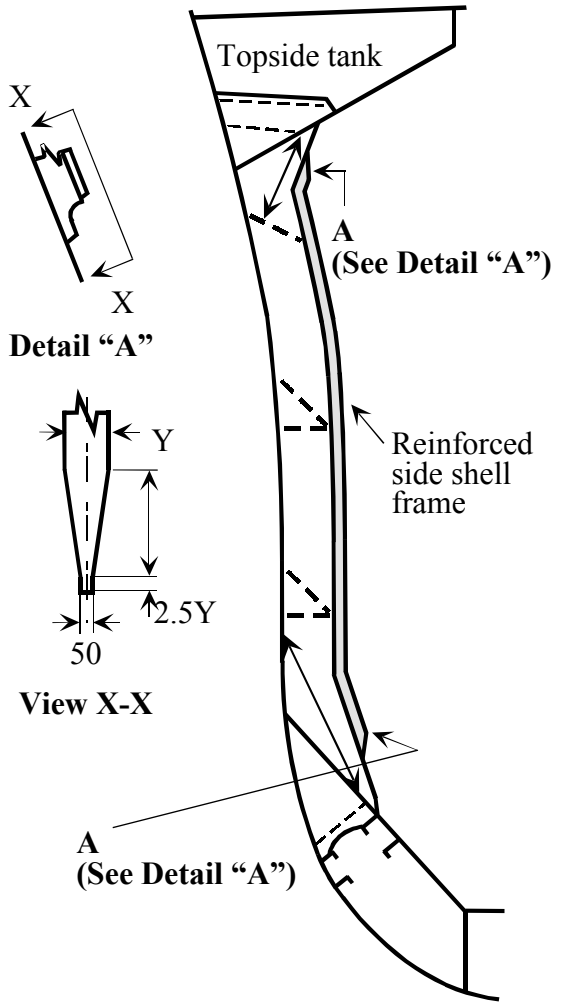
1. The extended bracket arm connection to the collision bulkhead is to have a soft toe, and any cut-outs for stiffeners in the fore peak tank or space are to be collared when situated in the vicinity of the bracket toe.
2. When fractures have extended into the side shell or bulkhead plating, the plating is to be cropped and part renewed.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**8**
Detail of damage	Fractures at the supporting brackets in way of the collision bulkhead with no side shell panting stringer in hold	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

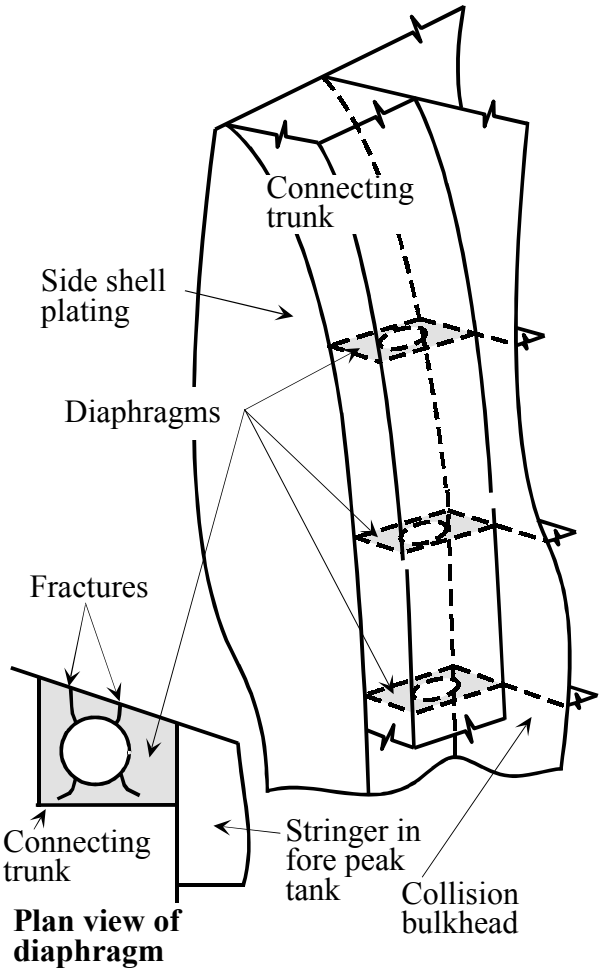
1. Damage caused by stress concentration leading to fatigue fracture in side shell. This has been exacerbated because of the greater flexibility of the hold structure in relation to the structure forward of the collision bulkhead.

Notes on repairs

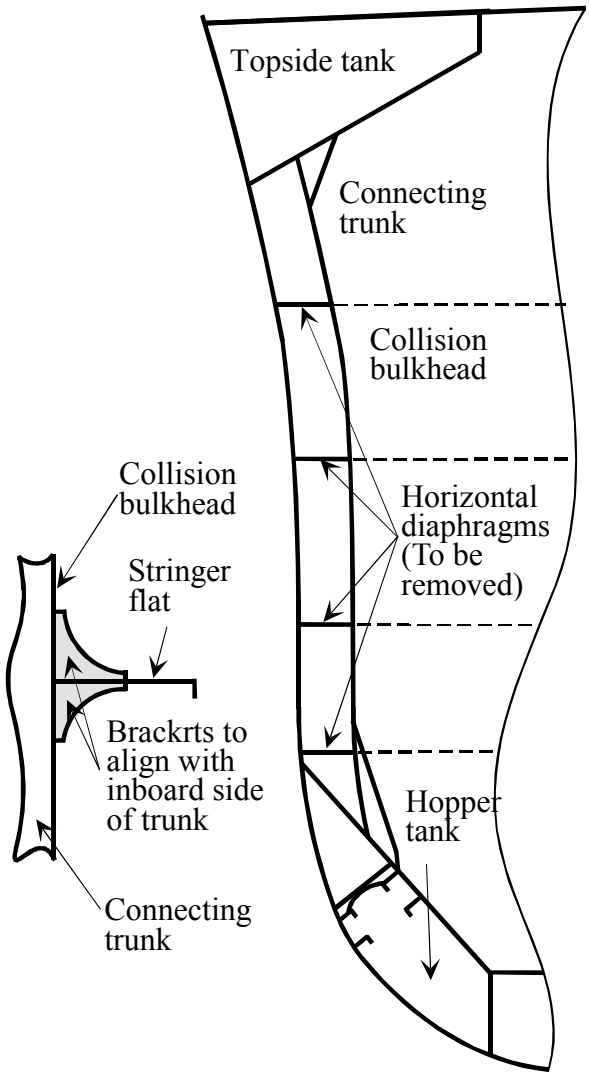
1. Fractured shell plates to be cropped and part renewed, and side shell frame/frames in the vicinity of the damage to be reinforced as required by BCS

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**9**
Detail of damage	Fractures in way of horizontal diaphragm in the connecting trunk between topside tank and hopper double bottom tank, on after side of collision bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

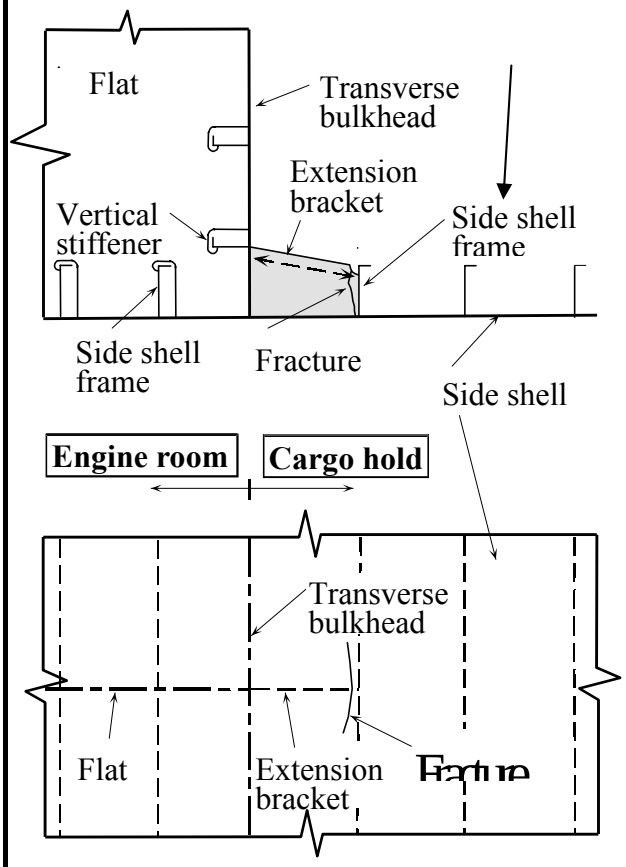
1. Damage caused by stress concentration resulting from the discontinuity created by the trunk and diaphragm structure. This has been exacerbated because of the greater flexibility of the hold structure in relation to the trunk and structure forward of the collision bulkhead.

Notes on repairs

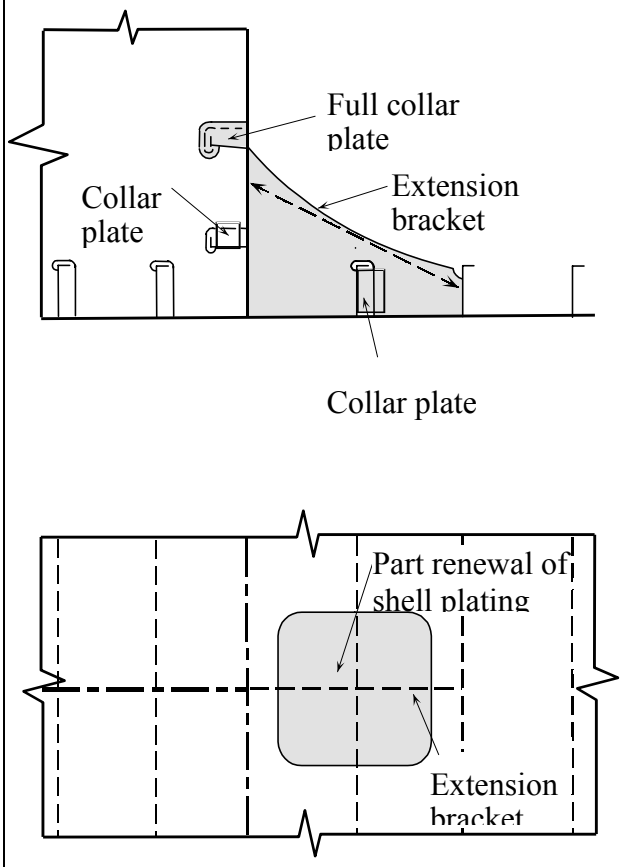
1. Diaphragm to be removed permanently and fractured shell plated cropped and part renewed, or veed and weld as necessary in way of damage. Brackets with softened to toes are to be fitted on forward side of collision bulkhead in way of stringers/flats to align with inboard side of trunk in order to remove hard-spots.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Cargo hold side structure**	**10**
Detail of damage	Fractures in way of continuation/extension brackets in aftermost hold at the engine room bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage caused by stress concentration leading to fatigue fracture on side shell. This will be exacerbated because of the greater flexibility of the hold structure in relation to the engine room structure.

Notes on repairs

1. The fractured shell plating is to be cropped and part renewed as necessary.
2. Extension bracket is to be modified and collar plates to cut-outs in engine room flat are to be installed.

Area 4 Transverse bulkhead including stool structure

Contents

1 General

2 What to look for - Hold inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for - Stool inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Deformations
4.3 Fractures

Figures and/or Photographs - Area 4	
No.	**Title**
Figure 1	Transverse bulkhead - Potential problems areas
Figure 2	Typical fracturing at the connection of transverse bulkhead structure
Photograph 1	Collapsed and detached transverse bulkhead

Examples of structural detail failures and repairs - Area 4	
Example No.	**Title**
1-a	Fractures at weld connections to stool shelf plate
1-b	Fractures at weld connections to stool shelf plate
2	Fractures at the upper boundaries to topside tank
3	Indentation and buckling of vertical corrugations
4	Fractures in the web of the corrugation initiating at intersection of adjacent shedder plates
5	Fractures at welded connections of lower stool plating to inner bottom plating in way of duct keel
6	Fractures at connection of lower stool to hopper
7	Buckling of strut supporting hatch end beam

1 General

1.1 The transverse bulkheads at the ends of dry cargo holds are mainly ordinary watertight bulkheads serving two main functions:

(a) As main transverse strength elements in the structural design of the ship.

(b) As subdivision to prevent progressive flooding in an emergency situation.

1.2 The transverse bulkheads at the ends of a combined ballast/ cargo hold are deep tank bulkheads which, in addition to the functions given in 1.1, are designed to withstand the water pressure from a hold fully filled with water ballast.

1.3 The bulkheads are commonly constructed as vertically corrugated with a lower stool, and with or without an upper stool (See **Chapter 3 Technical background for surveys - Figure 3 (b)**). Other constructions may be:
Plane bulkhead plating with one sided vertical stiffeners.
Double plated bulkhead with internal stiffening, with or without stool(s).

1.4 Dry cargo holds, not designed as ballast holds, may sometimes be partially filled with water ballast in order to achieve a satisfactory air draught at the loading/discharging berths.
The filling is restricted to a level that corresponds to the dry cargo hold scantlings, in particular the transverse bulkheads scantlings, and must only be carried out in port. In no case should these cargo holds be partially filled during voyage to save time at the berth. Such filling at sea may cause sloshing resulting in catastrophic failure such as indicated in **Photograph 1**.

1.5 Heavy corrosion may lead to collapse of the structure under extreme load, such as indicated in **Photograph 1** if it is not rectified properly.

1.6 A summary of potential problem areas is shown in **Figure 1**. It is emphasised that appropriate access arrangement as indicated in **Chapter 4 Survey planning, preparation and execution** of the guidelines, should be provided to enable a proper close-up inspection and thickness measurement as necessary.

Photograph 1
Collapsed and detached transverse bulkhead

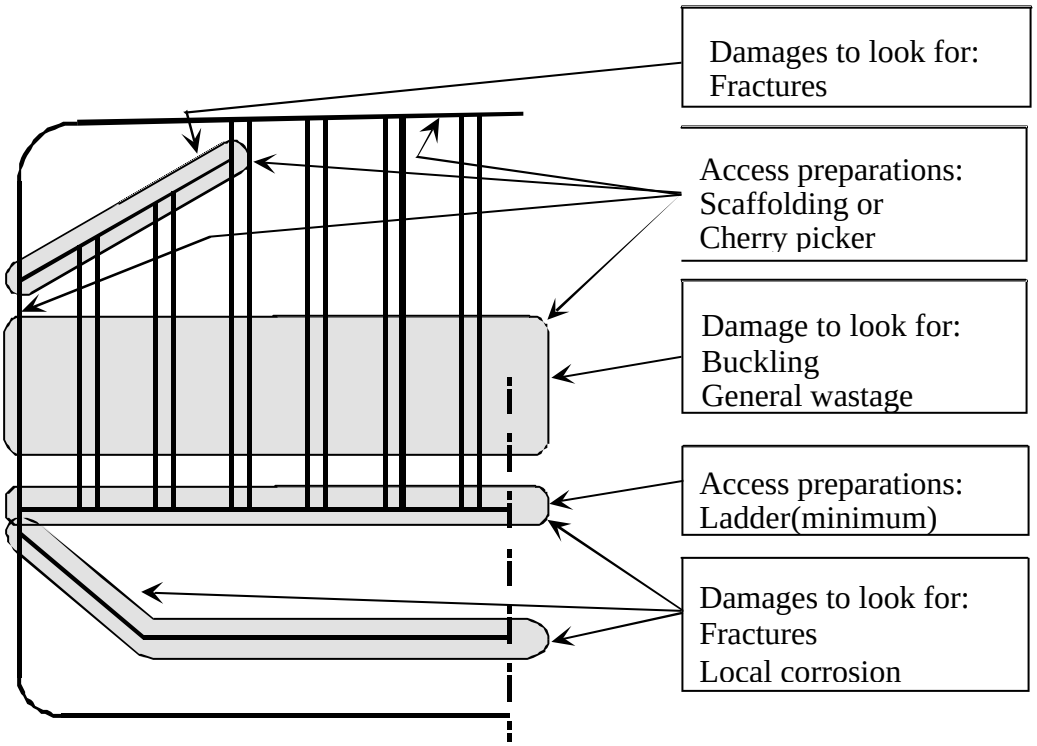


Figure 1 Transverse bulkhead - Potential problem areas

2 What to look for - Hold inspection

2.1 Material wastage

2.1.1 Excessive corrosion may be found in the following locations.

(a) At the mid-height and at the bottom of the bulkheads. The structure may look in deceptively good condition but in fact may be heavily corroded. The corrosion is created by the corrosive effect of cargo and environment, in particular when the structure is not coated.

(b) Bulkhead plating adjacent to the shell plating

(c) Bulkhead trunks which form part of the venting, filling and discharging arrangements between the topside tanks and the hopper tanks.

(d) Bulkhead plating and weld connections to the lower/upper stool shelf plates and inner bottom.

(e) In way of weld connections to topside tanks and hopper tanks.

2.1.2 If coatings have broken down and there is evidence of corrosion, it is recommended that random thickness measurements be taken to establish the level of diminution.

2.1.3 Where the terms and requirements of the periodical survey dictate thickness measurement, or when the surveyor deems necessary, it is important that the extent of the gauging be sufficient to determine the general condition of the structure.

2.2 Deformations

2.2.1 Deformation due to mechanical damage is often found in bulkhead structure.

2.2.2 When the bulkhead has sustained serious uniform corrosion, the bulkhead may suffer shear buckling. Evidence of buckling may be indicated by the peeling of paint or rust. However, where deformation resulting from bending or shear buckling has occurred on a bulkhead with a small diminution in thickness, this could be due to poor design or overloading and this aspect should be investigated before proceeding with repairs.

2.3 Fractures

2.3.1 Fractures usually occur at the boundaries of corrugations and bulkhead stools particularly in way of shelf plates, shedder plates, deck, inner bottom, etc. (See **Figure 2**).

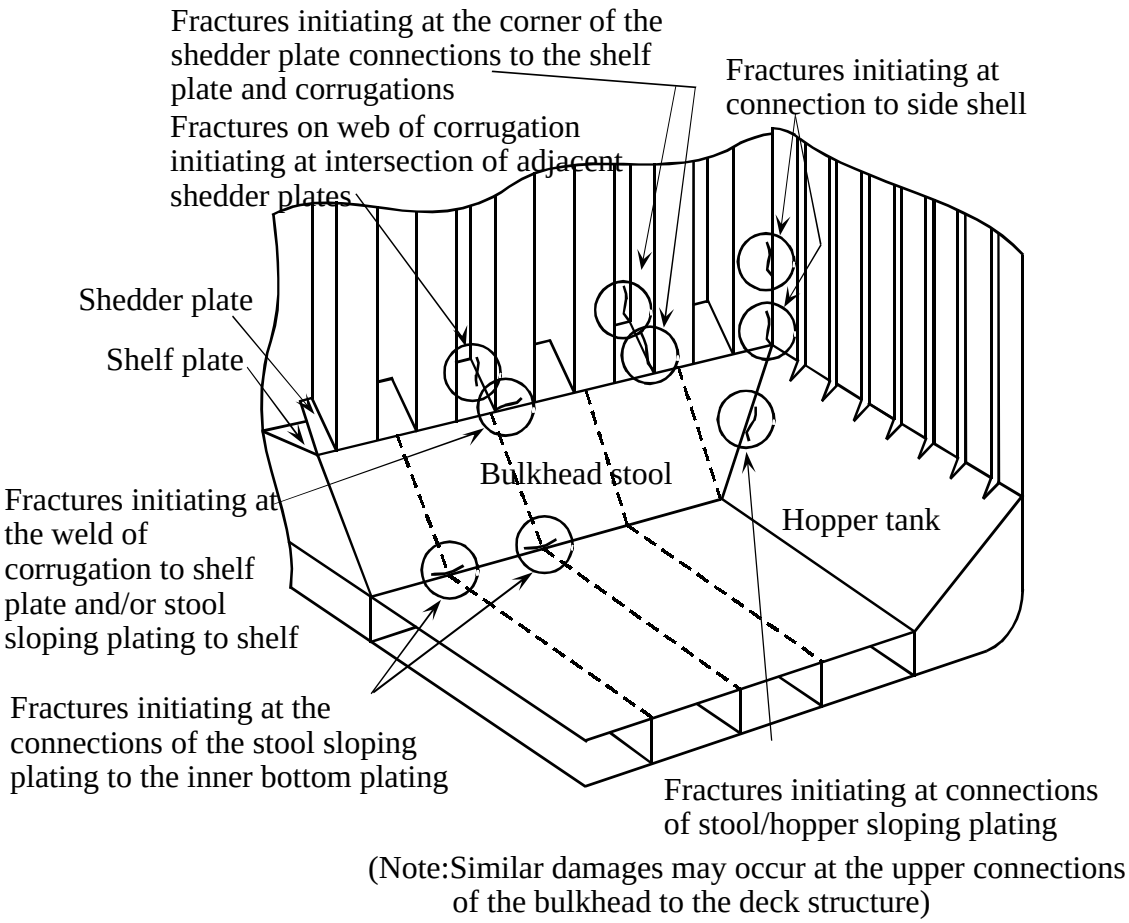


Figure 2 Typical fracturing at the connection of transverse bulkhead structure

3 What to look for - Stool inspection

3.1 Material wastage

3.1.1 Excessive corrosion may be found on diaphragms, particularly at their upper and lower weld connections.

3.2 Deformations

3.2.1 Damage to the stool structure should be checked when deformation due to mechanical damage is observed during hold inspection.

3.3 Fractures

3.3.1 Fractures observed at the connection between lower stool and corrugated bulkhead during hold inspection may have initiated at the weld connection of the inside diaphragms (See **Example 1**).

3.3.2 Misalignment between bulkhead corrugation flange and sloping stool plating may also cause fractures at the weld connection of the inside diaphragms (See **Example 2**).

4 General comments on repair

4.1 Material wastage

4.1.1 When the reduction in thickness of plating and stiffeners has reached the diminution levels permitted by BCS, the wasted plating and stiffeners are to be cropped and renewed.

4.2 Deformations

4.2.1 If the deformation is local and of a limited extent, it could generally be faired out. Deformed plating in association with a generalized reduction in thickness should be partly or completely renewed.

4.2.2 Buckling of the bulkhead plating can also occur in way of the side shell resulting from contact damage and this is usually quite obvious. In such cases the damaged area is to be cropped and partly renewed. If the deformation is extensive, replacement of the plating, partly or completely, may be necessary. If the deformation is not in association with generalized reduction in thickness or due to excessive loading, additional strengthening should be considered.

4.3 Fractures

4.3.1 Fractures that occur at the boundary weld connections as a result of latent weld defects should be veed-out, appropriately prepared and re-welded preferably using low hydrogen electrodes or equivalent.

4.3.2 For fractures other than those described in **4.3.1**, re-welding may not be a permanent solution and an attempt should be made to improve the design and construction in order to obviate a recurrence. Typical examples of such cases are as follows:

(a) **Fractures in the weld connections of the stool plating to the shelf plate in way of the scallops in the stool's internal structure**

The scallops should be closed by fitting over-lap collar plates and the stool weld connections repaired as indicated in **4.3.1**. The over-lap collar should have a full penetration weld connection to the stool and shelf plate and should be completed using low hydrogen electrodes prior to welding the collar to the stool diaphragm/bracket.

(b) **Fractures in the weld connections of the corrugations and/or stool plate to the shelf plate resulting from misalignment of the stool plate and the flange of the corrugation (Similarly misalignment of the stool plate with the double bottom floor)**

It is recommended that the structure be released, the misalignment rectified, and the stool, floor and corrugation weld connection appropriately repaired as indicated in **4.3.1**. Other remedies to such damages include fitting of brackets in the stool in line with the webs of the corrugations. In such cases both the webs of the corrugations and the brackets underneath are to have full penetration welds and the brackets are to be arranged without scallops. However, in many cases this may prove difficult to attain.

(c) **Fractures in the weld connections of the corrugation to the**

lower shelf plate resulting from fractured welding of the adjacent shedder plate

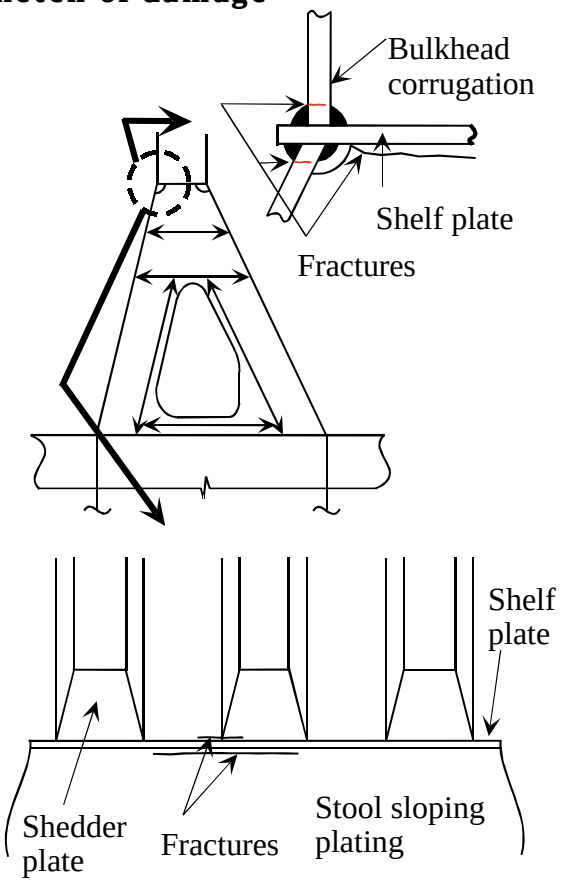
It is recommended that suitable scallops be arranged in the shedder plate in way of the connection, and the weld connections of the corrugations be repaired as indicted in **4.3.1**.

(d) **Fractures in the weld connections of the corrugations to the hopper tank, topside tank or to the deck in the vicinity of the hatchway opening**

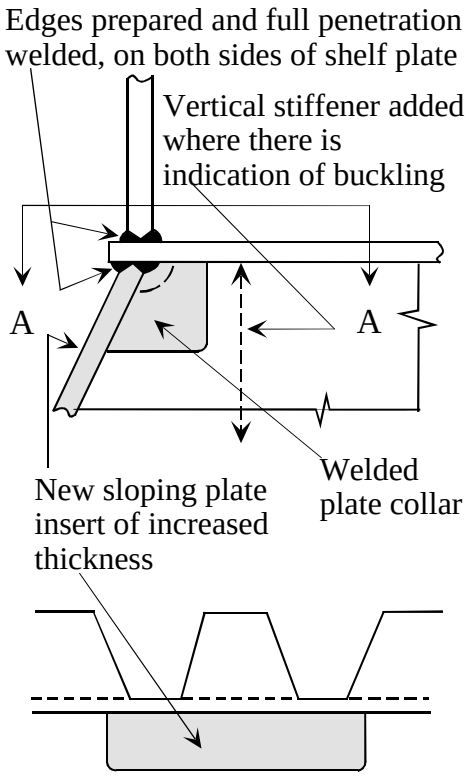
It is recommended that the weld connection be repaired as indicated in **4.3.1** and, where possible, additional stiffening be fitted inside the tanks to align with the flanges of the corrugations, or on the under deck clear of the tanks.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	1-a
Detail of damage	Fractures at weld connections to stool shelf plate	

Sketch of damage



Sketch of repair



View A-A

Notes on possible cause of damage

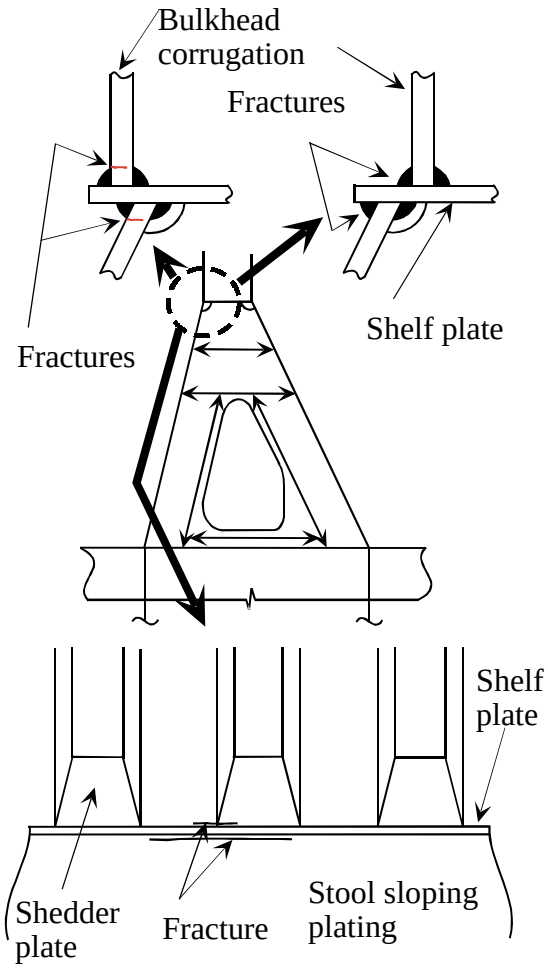
1. Stress concentrations at welds adjacent to the scallops.
2. Inadequate welding area connecting corrugation flange to shelf plate or similarly sloping stool plating to shelf plate.
3. Inadequate thickness of sloping plating in relation to corrugation flange thickness.
4. Stress concentration at knuckle of corrugation where web is not supported by bracket inside the stool.

Notes on repairs

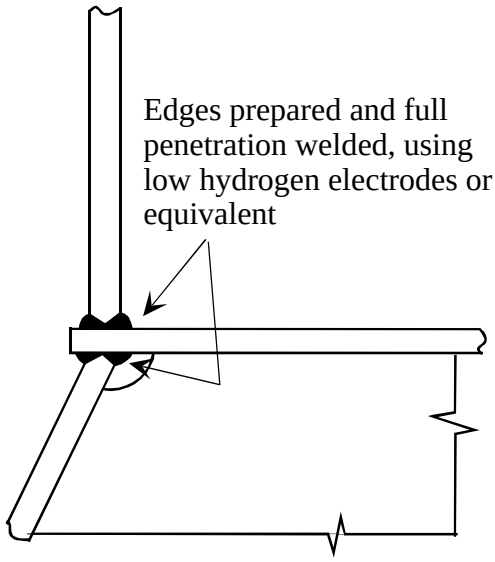
1. Fractures to be veed-out and rewelded.
2. Reductions in stress concentration by fitting welded plate collars in way of the scallop.
3. Where necessary an insert plate to be arranged in stool plating and/or diaphragm.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	1-b
Detail of damage	Fractures at weld connections to stool shelf plate	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

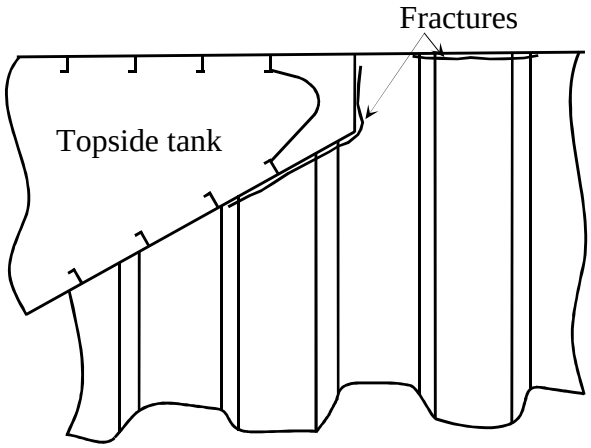
1. Misalignment between corrugation flange and sloping stool plating.
2. Inadequate welding area connecting corrugation flange to shelf plate or similarly sloping stool plating to shelf plate.

Notes on repairs

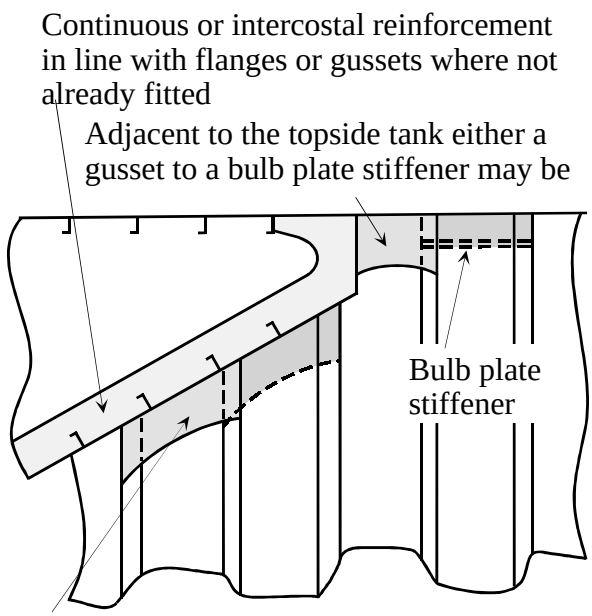
1. Fractures to be veed-out and rewelded.
2. Structure to be released and misalignment rectified.
3. Edge of the corrugated bulkhead and the stool plating on both sides of shelf plate to have full penetration welds.
4. Where necessary an insert plate to be arranged in stool plating.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	2
Detail of damage	Fractures at the upper boundaries to topside tanks	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage due to poor design and/or defective welds.

Notes on repairs

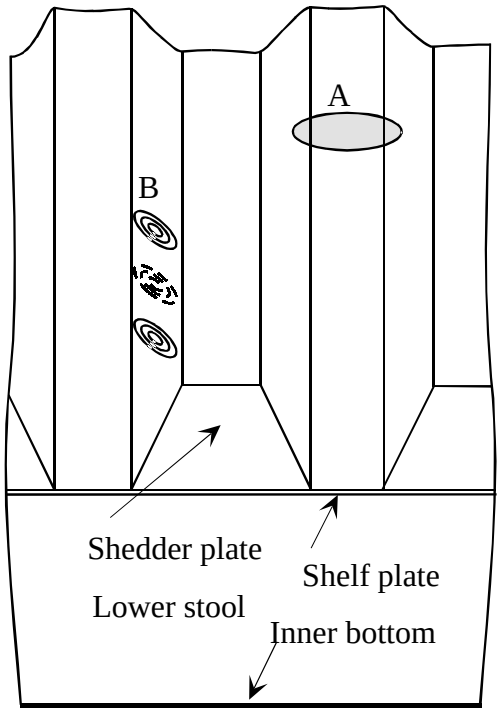
1. Fractures may be veed-out and rewelded. If necessary corrugated plating cropped and renewed.
2. It is recommended that reinforcement as shown above be incorporated, giving due consideration to the following criteria:

2.1 It is important to have the gusset plates well aligned with the transverse structure inside the tank. Gusset plates may be joggled to obtain this alignment.

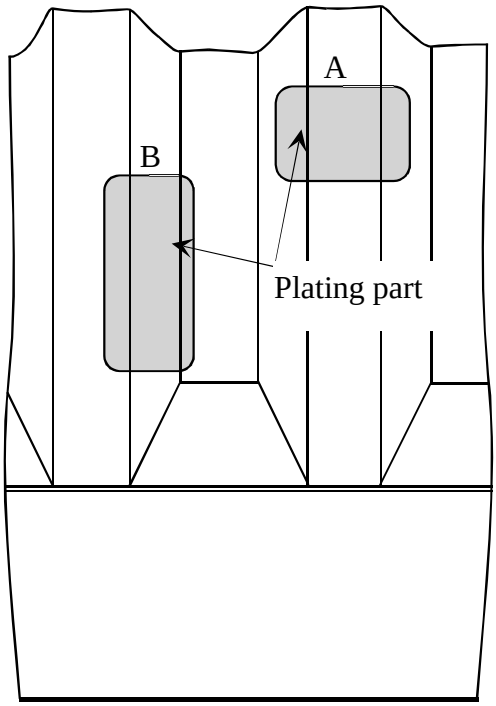
2.2 If there is no transverse web already existing inside the topside tank and in line with the flanges of corrugation or gusset plates, reinforcement as shown above to be fitted.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Transverse bulkhead and associated structure in cargo hold**	**3**
Detail of damage	Indentation and buckling of vertical corrugation	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

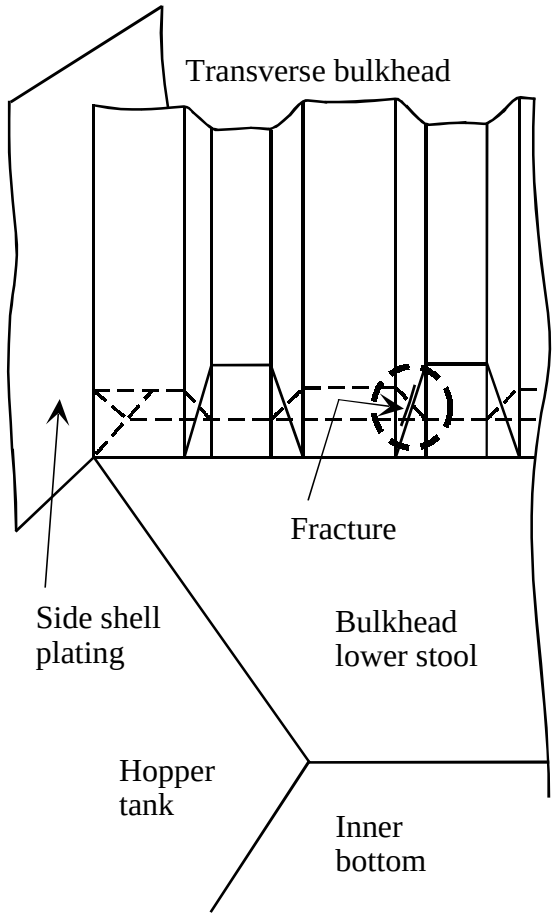
1. Damages by mechanical abuse during cargo handling e.g. grab damage.
2. Damage resulting from thickness reduction by corrosion.
3. Buckling caused by bending or shear, see locations A and B respectively above, with a minimum reduction in thickness could be caused by underdesign or overloading. If this cause is suspected, BCS concerned shall be contacted before proceeding with repairs.

Notes on repairs

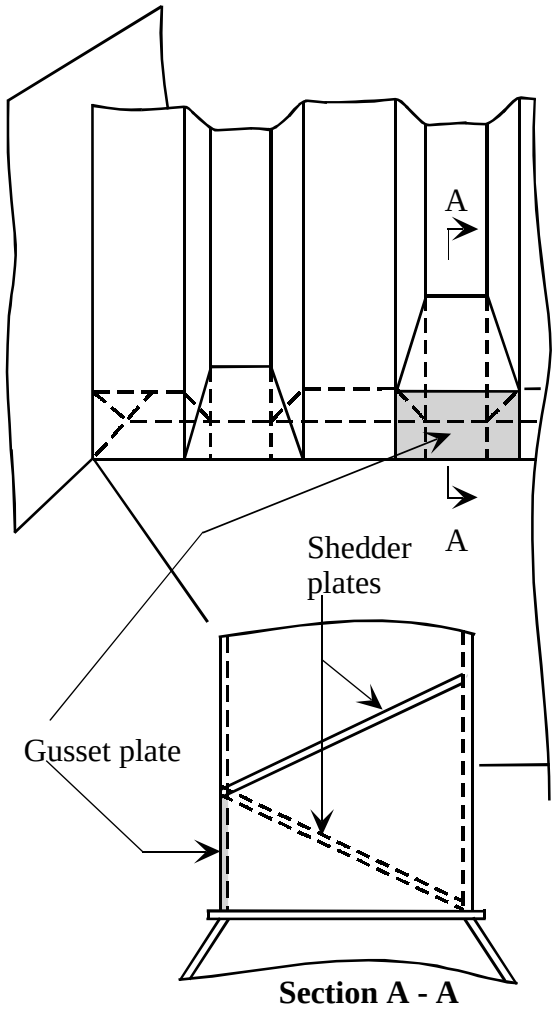
1. Damage by mechanical abuse
   If the indentation/buckling is local and of a minor nature, the plating can be faired in place.
   If the deformation is more pronounced and/or in association with a generalized reduction in thickness the plating is to be cropped and renewed, as shown at locations A and B above.
2. Damage resulting from corrosion
   In this case thickness measurements are to be taken at mid-span and top and bottom of corrugations, and corrugations renewed or part renewed as necessary. Particular attention is to be given to the fit and alignment at corners of flanged corrugations when being partly renewed.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	4
Detail of damage	Fractures in the web of the corrugation initiating at intersection of adjacent shedder plates	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

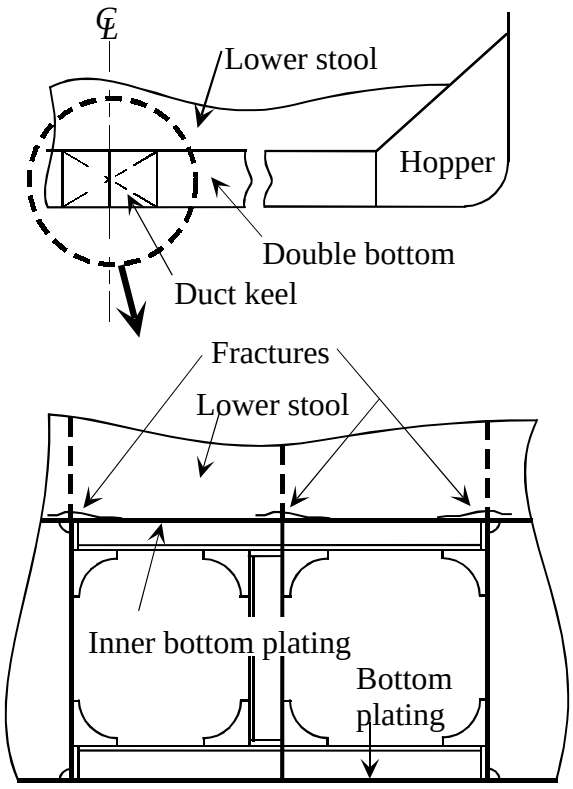
1. Damage due to stress concentrations at intersection of shedder plates. This can be exacerbated by corrosion and reduction in thickness of the corrugation web plating.

Notes on repairs

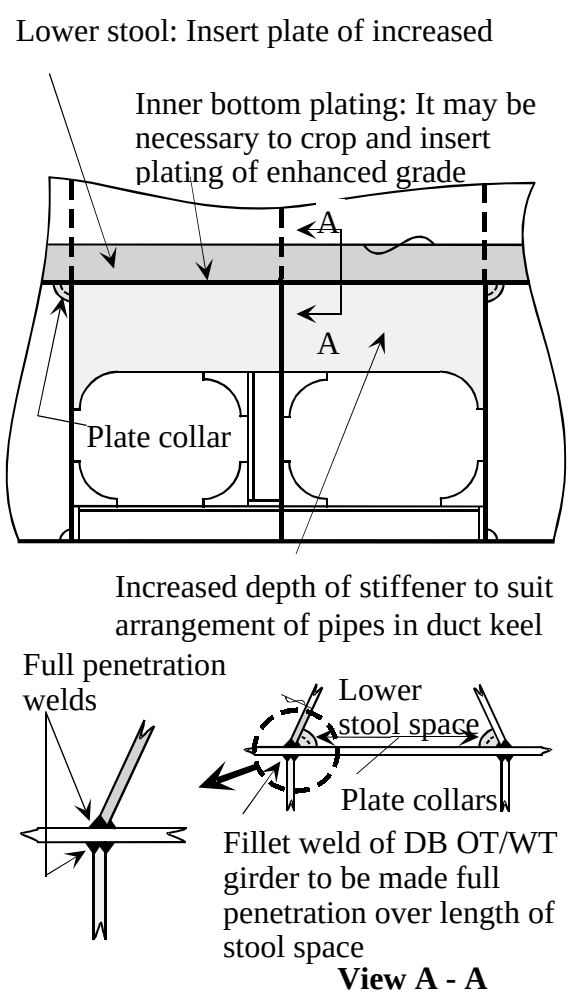
1. If due to wastage, corrugation plating and shedder plates to be part renewed/renewed as necessary.
2. Where renewals are being carried out it may be prudent to fit the extension pieces shown above to change the location of the point of intersection, and hence reduce the stress concentration.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	5
Detail of damage	Fractures at weld connection of lower stool plating to inner bottom in way of duct keel	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

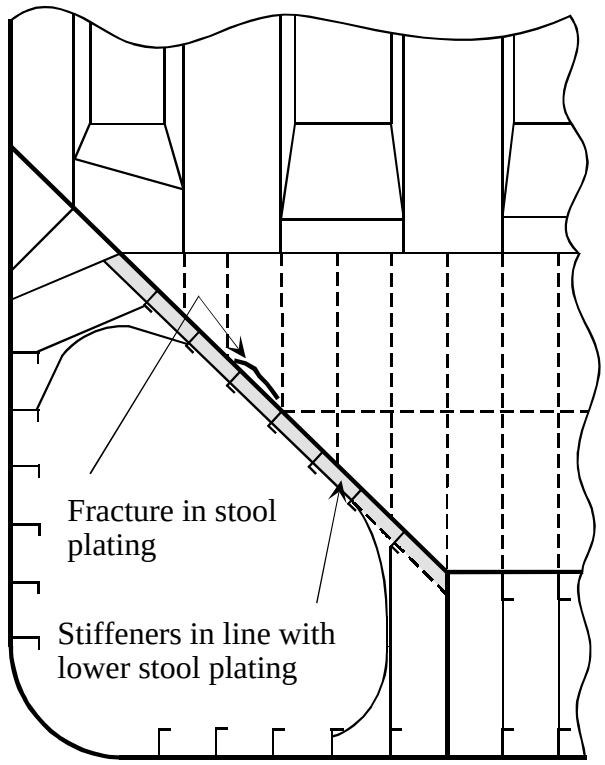
1. This type of failure is more likely to occur at the boundaries of the ballast hold.
2. The fractures arise because of stress concentration in way of cut-outs and exacerbated by the flexibility of the inner bottom structure in way of the duct keel.

Notes on repairs

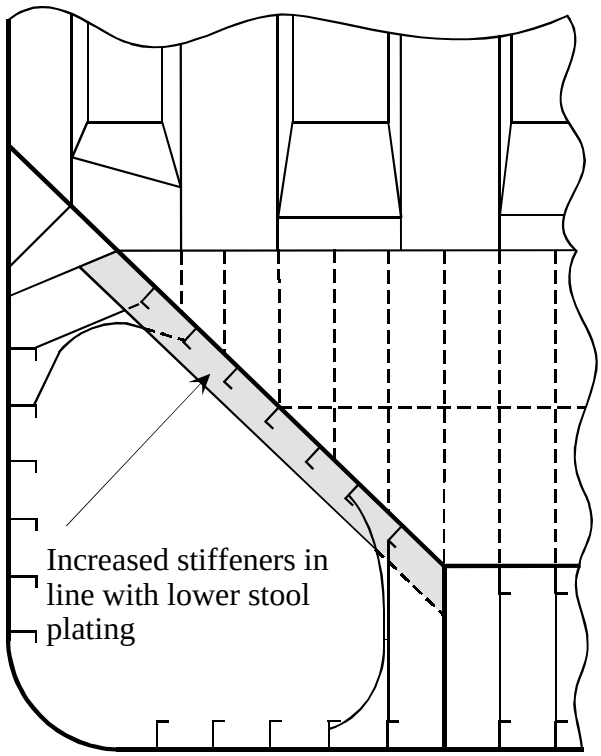
1. In order to prevent recurrence of the damage, the additional reinforcement shown should be fitted.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 4	Transverse bulkhead and associated structure in cargo hold	6
Detail of damage	Fractures at the connection of lower stool to hopper	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

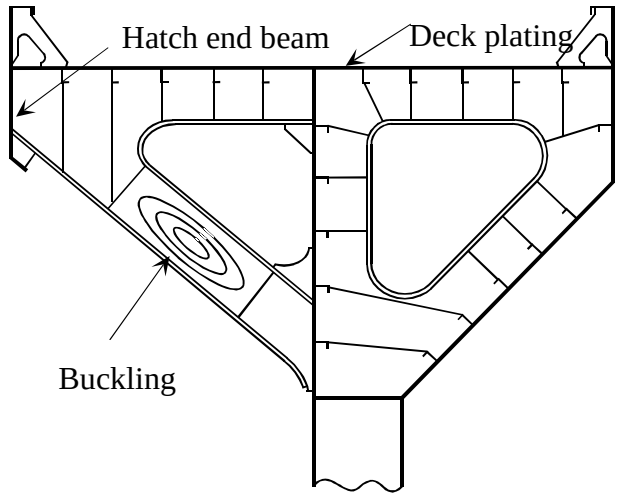
1. Insufficient strength of the connection
2. Corrosion

Notes on repairs

1. Fractured stool plating should be partly cropped and renewed (thicker plate) if considered necessary.
2. If the damage occurred due to insufficient strength, stiffeners in line with stool plating should be increased.

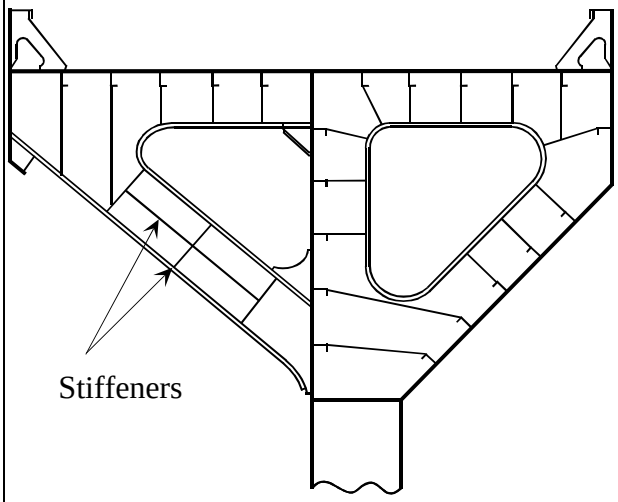
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Transverse bulkhead and associated structure in cargo hold**	**7**
Detail of damage	Buckling of strut supporting hatch end beam	

Sketch of damage



Upper stool

Sketch of repair



Notes on possible cause of damage

1. Insufficient strength
2. Partial ballast loading in ballast cargo hold (sloshing)
3. Corrosion

Notes on repairs

1. Deformed part to be cropped and renewed if considered necessary.
2. If the damage occurred due to insufficient strength, appropriate reinforcement is to be considered (thicker plate/additional stiffener(s)).

Area 5Double bottom tank structure including hopper

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1 General

2 What to look for - Tank top inspection
2.1 Material wastage
2.2 Deformations
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3 What to look for - Double bottom and hopper tank inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 What to look for - External bottom inspection
4.1 Material wastage
4.2 Deformations
4.3 Fractures

5 General comments on repair
5.1 Material wastage
5.2 Deformations
5.3 Fractures

Figures and/or Photographs - Area 5	
No.	**Title**
Figure 1	Typical fractures in the connection of hopper plating and inner bottom plating
Photograph 1	Grooving corrosion of weld of bottom plating
Photograph 2	Section of the grooving shown in Photograph 1

Examples of structural detail failures and repairs - Area 5	
Example No.	**Title**
1	Fractures in inner bottom plating around container bottom pocket
2	Fractures, corrosion and/or buckling of floor/girder around lightening hole
3	Fractures at weld connections of floors in way of hopper/inner bottom interface (radiused knuckle)
4	Fractures at weld connections of floors in way of hopper/inner bottom interface (welded knuckle)

Examples of structural detail failures and repairs - Area 5	
Example No.	**Title**
5	Fractures at weld connections of floors in way of inner bottom and side girders, and plating of bulkhead stool
6	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member
7	Fractures in longitudinal at floor/transverse web frame or bulkhead
8	Fractures in bottom and inner bottom longitudinals in way of inner bottom and bulkhead stool boundaries
9	Fractures in longitudinals in way of bilge well
10	Buckling of transverse web
11	Fractures at weld connection of the transverse brackets
12	Fractures in bottom shell/side shell/hopper sloping plating at the corner of drain hole/air hole in longitudinal
13	Fractures in bottom shell plating along side girder and/or bottom longitudinal
14	Corrosion in bottom shell plating below suction head
15	Corrosion in bottom shell plating below sounding pipe
16	Deformation of forward bottom shell plating due to slamming
17	Fractures in bottom shell plating at the termination of bilge keel

1 General

1.1 In addition to contributing to the longitudinal bending strength of the hull girder, the double bottom structure provides support for the cargo in the holds. The tank top structure is subjected to impact forces of cargo and mechanical equipment during cargo loading and unloading operations. The bottom shell at the forward part of the ship may sustain increased dynamic forces caused by slamming in heavy weather.

1.2 Double bottom tank structure in way of combined cargo/ballast hold(s) is more prone to fractures and deformation compared to the structure in way of holds dedicated for carriage of cargo.

1.3 The weld at the connections of the tank top/hopper sloping plate and tank top/bulkhead stool may suffer damage caused by the use of bulldozers to unloading cargo.

2 What to look for - Tank top inspection

2.1 Material wastage

2.1.1 The general corrosion condition of the tank top structure may be observed by visual inspection. The level of wastage of tank top plating may have to be established by means of thickness measurement.

2.1.2 The bilge wells should be cleaned and inspected closely since heavy pitting corrosion may have occurred due to accumulated water/corrosive solution in the wells. Special attention should be paid to the plating in way of the bilge suction and sounding pipes.

2.1.3 Special attention should also be paid to areas where pipes penetrate the tank top.

2.2 Deformations

2.2.1 Buckling of the tank top plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses.

2.2.2 Deformed structures may be observed in areas of the tank top due to overloading of cargo, impact of cargo during loading/unloading operations, or the use of mechanical unloading equipment.

2.2.3 Whenever deformations are observed on the tank top, further inspection in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coating within the double bottom, which in turn may lead to accelerated corrosion rate in these unprotected areas.

2.3 Fractures

2.3.1 Fractures will normally be found by close-up inspection. Fractures that

extend through the thickness of the plating or through the welds may be observed during pressure testing of the double bottom tanks (See **Figure 1** and **2** of **Area 4**).

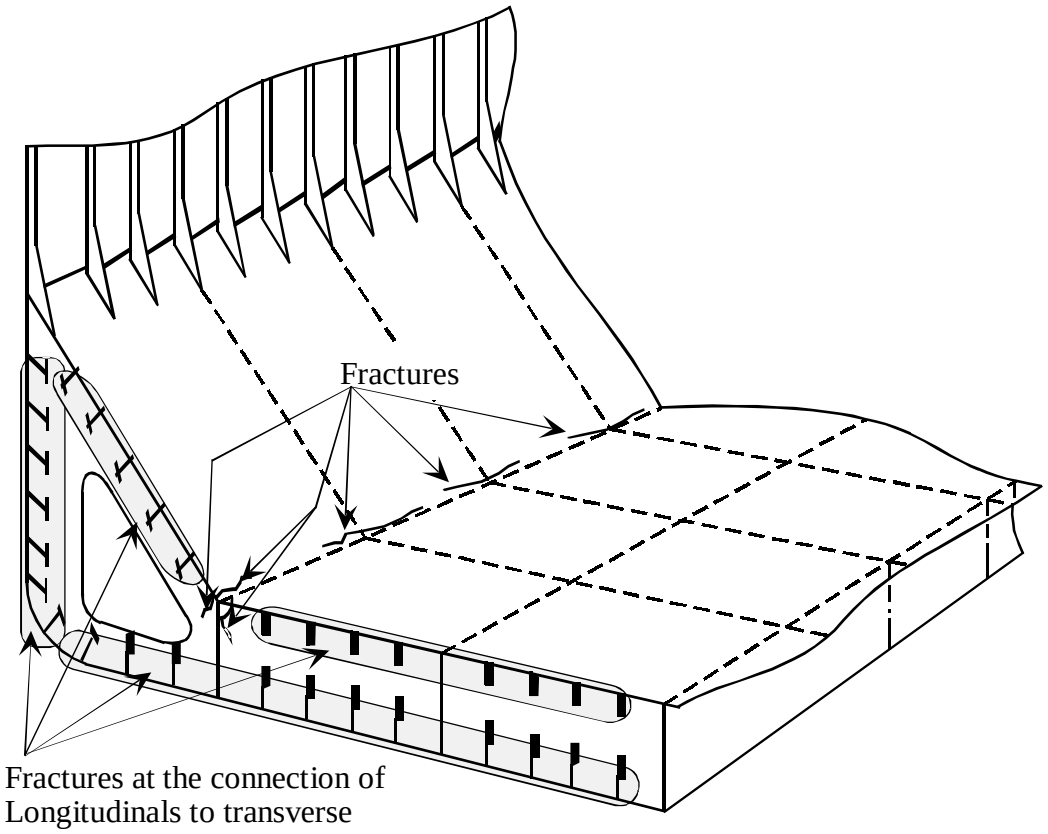


Figure 1 Typical fractures in the connection of hopper sloping plating to inner bottom (tank top) and longitudinals to transverse (or transverse bulkhead)

3 What to look for - Double bottom and hopper tank inspection

3.1 Material wastage

3.1.1 The level of wastage of double bottom internal structure (longitudinals, transverses, floors, girders, etc.) may have to be established by means of thickness measurements.

Rate and extent of corrosion depends on the corrosive environment, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (also see **3.1.2 - 3.1.4**).

(a) Structure in corrosive environment
Back side of inner bottom plating and inner bottom longitudinal
Transverse bulkhead and girder adjacent to heated fuel oil tank

(b) Structure subject to high stress
Face plates and web plates of transverse at corners

Connection of longitudinal to transverse
(c) Areas susceptible to coating breakdown
Back side of face plate of longitudinal
Welded joint
Edge of access opening
(d) Areas subject to poor drainage
Web of side longitudinals

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer severe localised corrosion. In general, structure at the upper part of the double bottom tank usually has more severe corrosion than that at the lower part. Transverse webs in the hopper tanks may suffer severe corrosion at their corners where high shearing stresses occur, especially where collar plate is not fitted to the slot of the longitudinal.

3.1.3 The high temperature due to heated fuel oil may accelerate corrosion of ballast tank structure near heated fuel tanks. The rate of corrosion depends on several factors such as:
- Temperature and heat input to the ballast tank.
- Condition of original coating and its maintenance. (It is preferable for applying the protective coating of ballast tank at the building of the ship, and for subsequent maintenance, that the stiffeners on the boundaries of the fuel tank be fitted within the fuel tank instead of the ballast tank).
- Ballasting frequency and operations.
- Age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.1.4 Shell plating below suction head often suffers localized wear caused by erosion and cavitation of the fluid flowing through the suction head. In addition, the suction head will be positioned in the lowest part of the tank and water/mud will cover the area even when the tank is empty. The condition of the shell plating may be established by feeling by hand beneath the suction head. When in doubt, the lower part of the suction head should be removed and thickness measurements taken. If the vessel is docked, the thickness can be measured from below. If the distance between the suction head and the underlying shell plating is too small to permit access, the suction head should be dismantled. The shell plating below the sounding pipe should also be carefully examined. When a striking plate has not been fitted or is worn out, heavy corrosion can be caused by the striking of the weight of the sounding tape (See **Example 2** in **Part 3**).

3.2 Deformations

3.2.1 Where deformations are identified during tank top inspection (See **2.2**) and external bottom inspection (See **4.2**), the deformed areas should be subjected to in tank inspection to determine the extent of the damage to

the coating and internal structure.

Deformations in the structure not only reduce the structural strength but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3 Fractures

3.3.1 Fractures will normally be found by close-up inspection.

3.3.2 Fractures may occur in way of the welded or radiused knuckle between the inner bottom and hopper sloping plating if the side girder in the double bottom is not in line with the knuckle and also when the floors below have a large spacing, or when corner scallops are created for ease of fabrication. The local stress variations due to the loading and subsequent deflection may lead to the development of fatigue fractures which can be categorised as follows (See **Figure 1**).

(a) Parallel to the knuckle weld for those knuckles which are welded and not radiused.
(b) In the inner bottom and hopper plating and initiated at the centre of a radiused knuckle.
(c) Extending in the hopper web plating and floor weld connections starting at the corners of scallops, where such exist, in the underlying hopper web and floor.
(d) Extending in the web plate as in (c) above but initiated at the edge of a scallop.

3.3.3 The fractures in way of connection of inner bottom plating/hopper sloping plating to stool may be caused by the cyclic deflection of the inner bottom induced by repeated loading from the sea or due to poor "through-thickness" properties of the inner bottom plating. Scallops in the underlying girders can create stress concentrations which further increase the risk of fractures. These can be categorised as follows (See **Figure 1** and **Examples**).

(a) In way of the intersection between inner bottom and stool. These fractures often generate along the edge of the welded joint above the centre line girder, side girders, and sometimes along the duct keel sides.
(b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with the watertight floors below the transverse bulkhead stools in way of the ballast hold, especially in way of suction wells.
(c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets on the floors, as well as at the corners of the duct keel.
(d) Lamellar tearing of the inner bottom plate below the weld connection with the stool in the ballast hold caused by large bending stresses in the connection when in heavy ballast condition. The size of stool and lack of full penetration welds could also be a contributory factor, as well as poor "through-thickness" properties of the tank top plating.

3.3.4 Transition region

In general, the termination of the following structural members at the collision bulkhead and engine room forward bulkhead is prone to fractures:

- Hopper tank sloping plating
- Panting stringer in fore peak tank
- Inner bottom plating in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

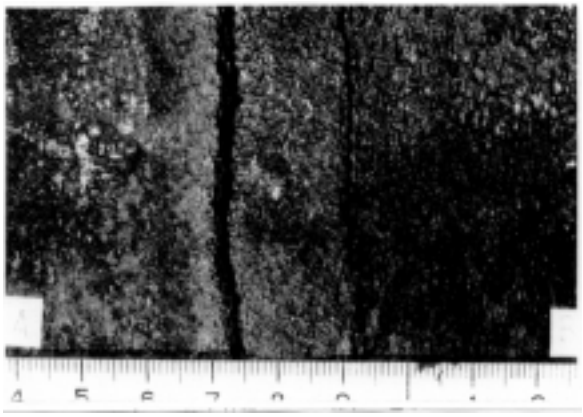
4 What to look for - External bottom inspection

4.1 Material wastage

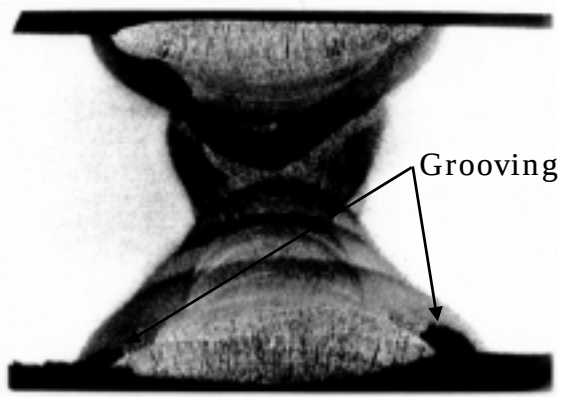
4.1.1 Hull structure below the water line can usually be inspected only when the ship is dry-docked. The opportunity should be taken to inspect the external plating thoroughly. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See **Photographs 1** and **2**). This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or "docking" plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating.



Photograph 1
Grooving corrosion of welding of bottom plating



Photograph 2
Section of the grooving shown in Photograph 1

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations of bottom plating may also

be attributed to dynamic force caused by wave slamming action at the forward part of the vessel, or contact with underwater objects. When deformation of the shell plating is found, the affected area should be inspected internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be inspected when the hull has dried since fractures in shell plating can easily be detected by observing leakage of water from the cracks in clear contrast to the dry shell plating.

4.3.2 Fractures in butt welds and fillet welds, particularly at the wrap around at scallops and ends of bilge keel, are sometimes observed and may propagate into the bottom plating. The cause of fractures in butt welds is usually related to weld defect or grooving. If the bilge keels are divided at the block joints of hull, all ends of the bilge keels should be inspected.

5 General comments on repair

5.1 Material wastage

5.1.1 Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit (See **Examples 14** and **15**). When scattered deep pitting is found, it may be repaired by welding.

5.2 Deformations

Extensively deformed tank top and bottom plating should be replaced together with the deformed portion of girders, floors or transverse web frames. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, BCS should be contacted.

5.3 Fractures

5.3.1 Repair should be carried out in consideration of nature and extent of the fractures.

(a) Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

(b) For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.

(c) For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

5.3.2 The fractures in the knuckle connection between inner bottom plating

and hopper sloping plating should be repaired as follows.

(a) Where the fracture is confined to the weld, the weld is to be veed-out and renewed using full penetration welding, with low hydrogen electrodes or equivalent.

(b) Where the fracture has extended into the plating of any tank boundary, then the fractured plating is to be cropped, and part renewed.

(c) Where the fracture is in the vicinity of the knuckle, the corner scallops in floors and transverses are to be omitted, or closed by welded collars. The sequence of welding is important, in this respect every effort should be made to avoid the creation of locked in stresses due to the welding process.

(d) Where the floor spacing is 2.0m or greater, brackets are to be arranged either in the vicinity of, or mid-length between, floors in way of the intersection. The brackets are to be attached to the adjacent inner bottom and hopper longitudinals. The thickness of the bracket is to be in accordance with the Rules of BCS

(e) If the damage is confined to areas below the ballast holds and the knuckle connection is of a radiused type, then in addition to rectifying the damage (i.e. weld or crop and renew), consideration is to be given to fitting further reinforcement, e.g. longitudinals or scarfing brackets, in the vicinity of the upper tangent point of the radius.

5.3.3 The fractures in the connection between inner bottom plating/hopper sloping plating and stool should be repaired as follows.

(a) Fractures in way of section of the inner bottom and bulkhead stool in way of the double bottom girders can be veed out and welded. However, reinforcement of the structure may be required, e.g. by fitting additional double bottom girders on both sides affected girder or equivalent reinforcement. Scallops in the floors should be closed and air holes in the non-watertight girders re-positioned.

If the fractures are as a result of differences in the thickness of adjacent stool plate and the floor below the inner bottom, then it is advisable to crop and part renew the upper part of the floor with plating having the same thickness and mechanical properties as the adjacent stool plating.

If the fractures are as a result of misalignment between the stool plating and the double bottom floors, the structure should be released with a view to rectifying the misalignment.

(b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with watertight floors are to be cropped and partly renewed. In addition, brackets with soft toes are to be fitted in order to reduce the stress concentrations at the floors or stiffener.

(c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets are to be cropped and longitudinal part

renewed if the fractures extend to over one third of the depth of the longitudinal. If fractures are not extensive these can be veed out and welded. In addition, reinforcement should be provided in the form of modification to existing bracket toes or the fitting of additional brackets with soft toes in order to reduce the stress concentration.

(d) Fractures at the corners of the transverse diaphragm/stiffeners are to be cropped and renewed. In addition, scallops are to be closed by overlap collar plates. To reduce the probability of such fractures recurring, consideration is to be given to one of the following reinforcements or modifications.
- The fitting of short intercostal girders in order to reduce the deflection at the problem area.
- The depth of transverse diaphragm/stiffener at top of duct keel is to be increased as far as is practicable to suit the arrangement of pipes.

(e) Lamellar tearing may be eliminated through improving the type and quality of the weld, i.e. full penetration using low hydrogen electrodes and incorporating a suitable weld throat.

Alternatively the inner bottom plating adjacent to and in contact with the stool plating is substituted with plating of "Z" quality steel which has good "through-thickness" properties.

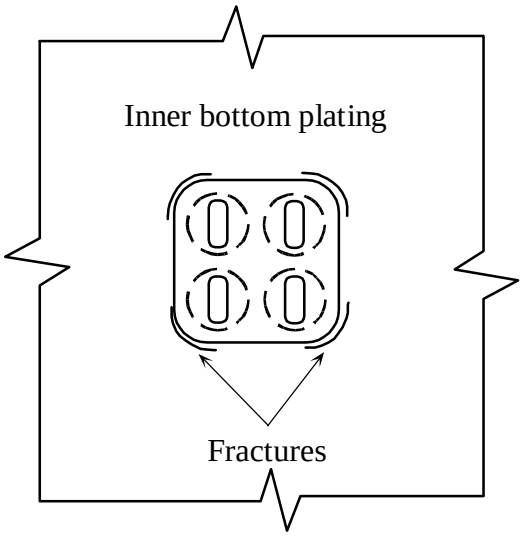
5.3.4 Bilge keel should be repaired as follows.

(a) Fractures or distortion in bilge keels must be promptly repaired. Fractured butt welds should be repaired using full penetration welds and proper welding procedures. The bilge keel is subjected to the same level of longitudinal hull girder stress as the bilge plating, fractures in the bilge keel can propagate into the shell plating.

(b) Termination of bilge keel requires proper support by internal structure. This aspect should be taken into account when cropping and renewing damaged parts of a bilge keel (See **Example 17**).

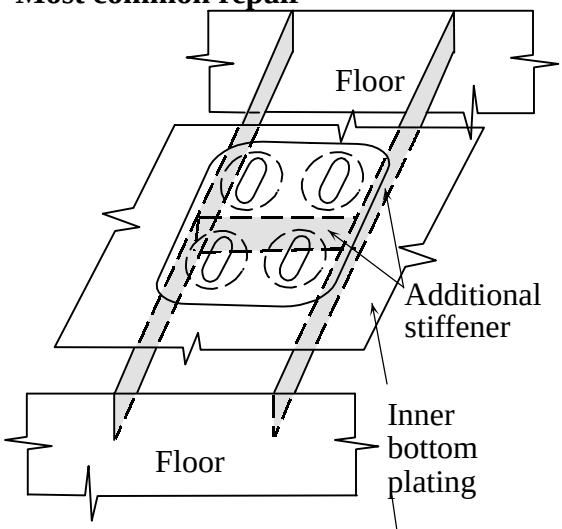
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure including hopper**	**1**
Detail of damage	Fractures in inner bottom plating around container bottom pocket	

Sketch of damage

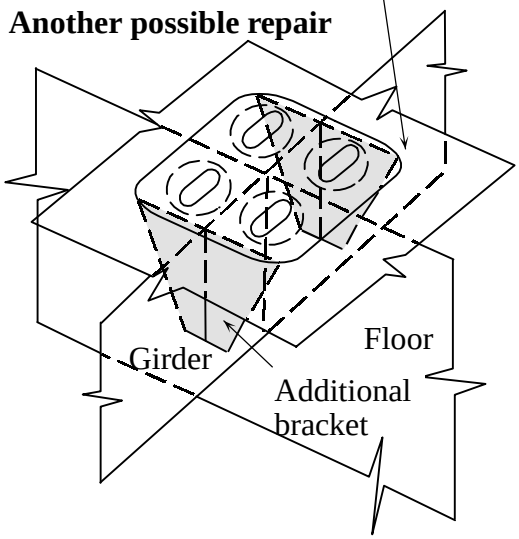


Sketch of repair

Most common repair



Another possible repair



Notes on possible cause of damage

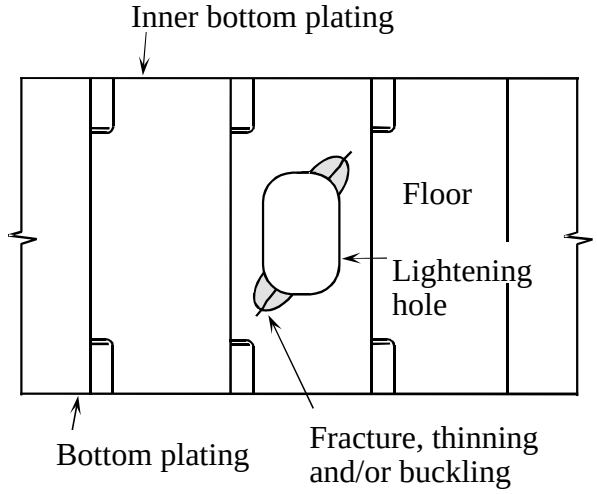
1. Pocket is not supported correctly by floor, longitudinal and/or stiffener.

Notes on repairs

1. Fractured plating should be cropped and part renewed.
2. Adequate reinforcement should be considered.

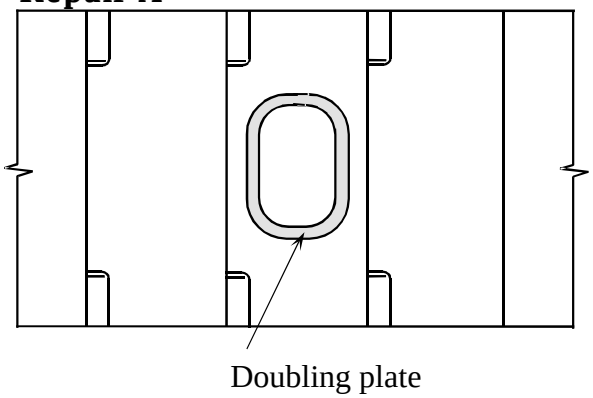
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom structure including hopper	2
Detail of damage	Fractures, corrosion and/or buckling of floor/girder around lightening hole	

Sketch of damage

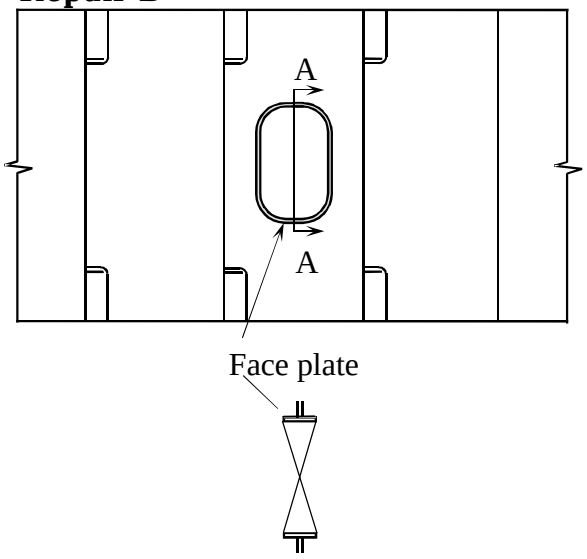


Sketch of repair

Repair A



Repair B



Section A-A

Notes on possible cause of damage

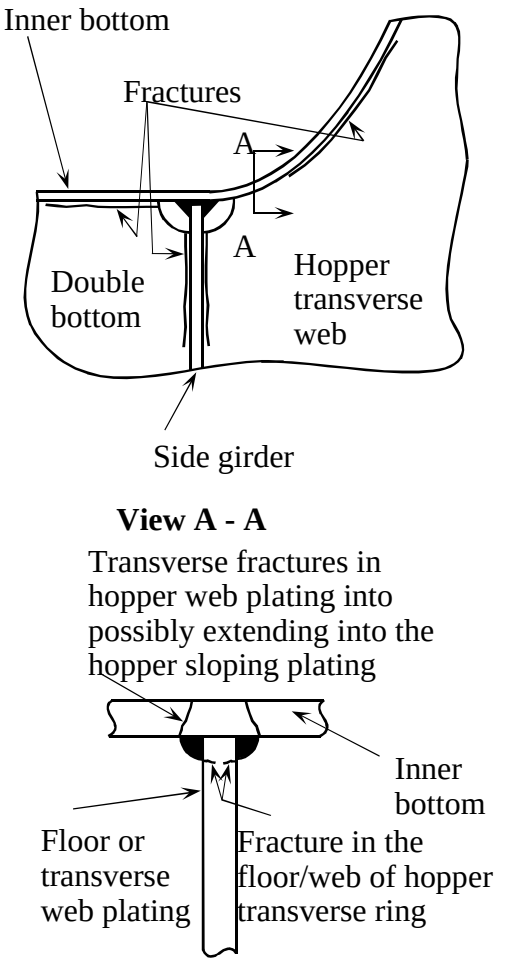
1. Insufficient strength due to lightening hole.
2. Fracture, corrosion and/or buckling around lightening hole due to high stress.

Notes on repairs

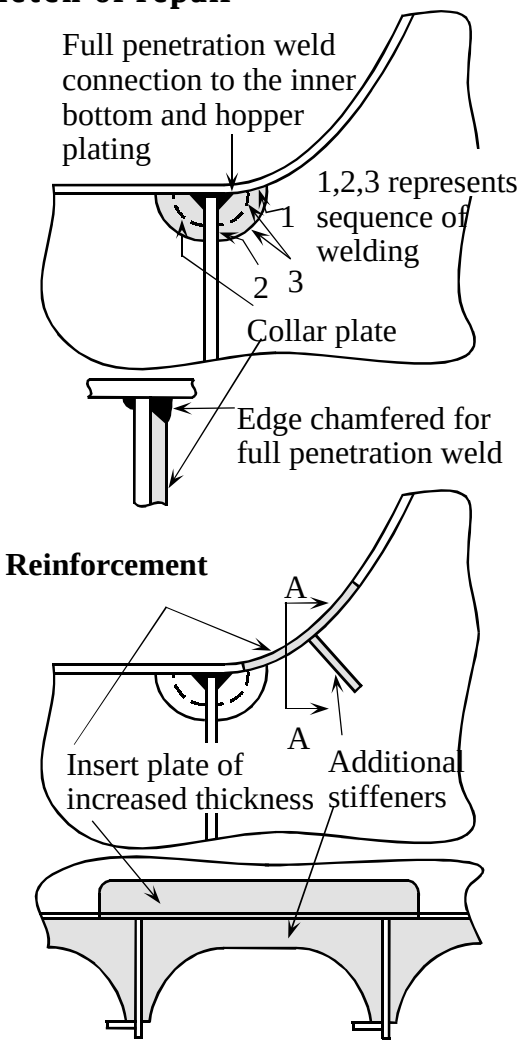
1. Fractured, corroded and/or buckled plating should be cropped and renewed if considered necessary.
2. Appropriate reinforcement should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	3
Detail of damage	Fractures at weld connections of floors in way of hopper/inner bottom interface (radiused knuckle)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

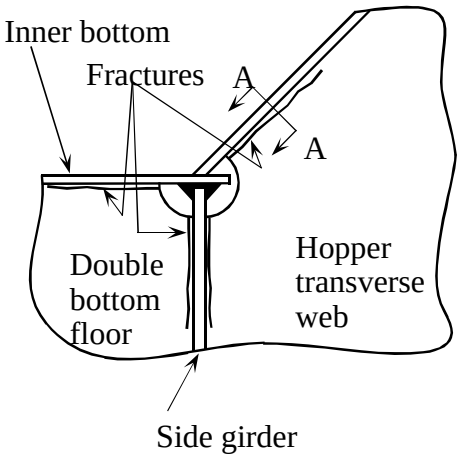
1. The damage is partly due to stress concentrations at the edges of the weld created by the presence of cut-outs and local stress variations caused by the deflections in the inner bottom/hopper plating.

Notes on repairs

1. The fracture in the weld and/or plating is veed-out/cropped and renewed as appropriate.
2. The cut-outs are eliminated by introducing suitable collar plate with emphasis on edge preparation and sequence of welding as shown above.
3. Further reinforcements may need to be carried out as shown above, however, after consultation with BCS

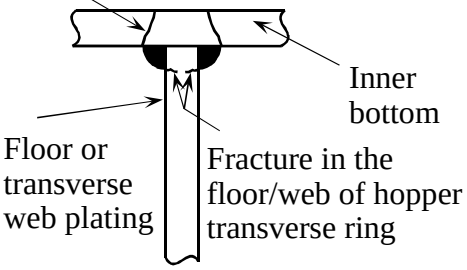
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	4
Detail of damage	Fractures at weld connections of floors in way of hopper/inner bottom interface (welded knuckle)	

Sketch of damage

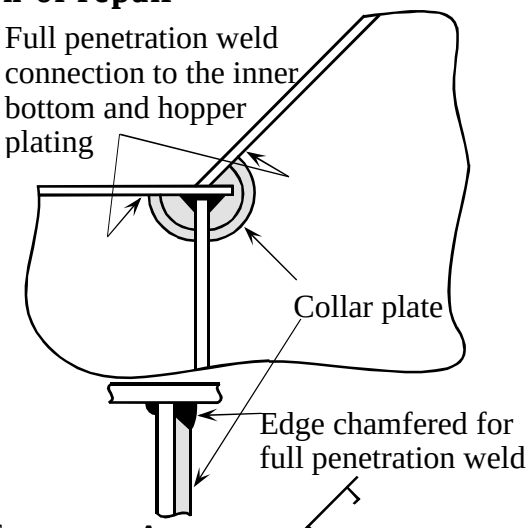


View A - A

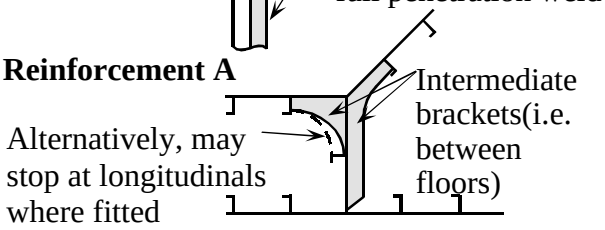
Transverse fractures in hopper web plating into possibly extending into the hopper sloping plating



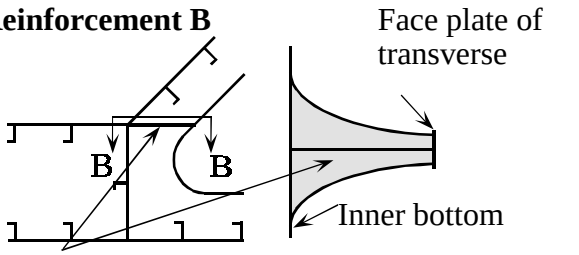
Sketch of repair



Reinforcement A



Reinforcement B



View B - B

Notes on possible cause of damage

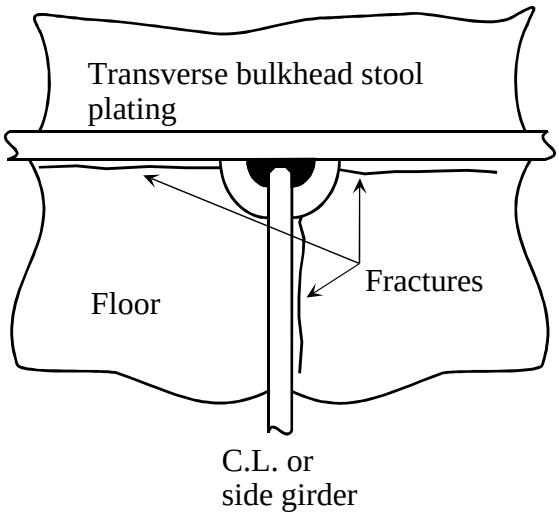
1. The damage is partly due to stress concentration at the edges of the weld .created by the presence of the deflections in the inner bottom/hopper plating.

Notes on repairs

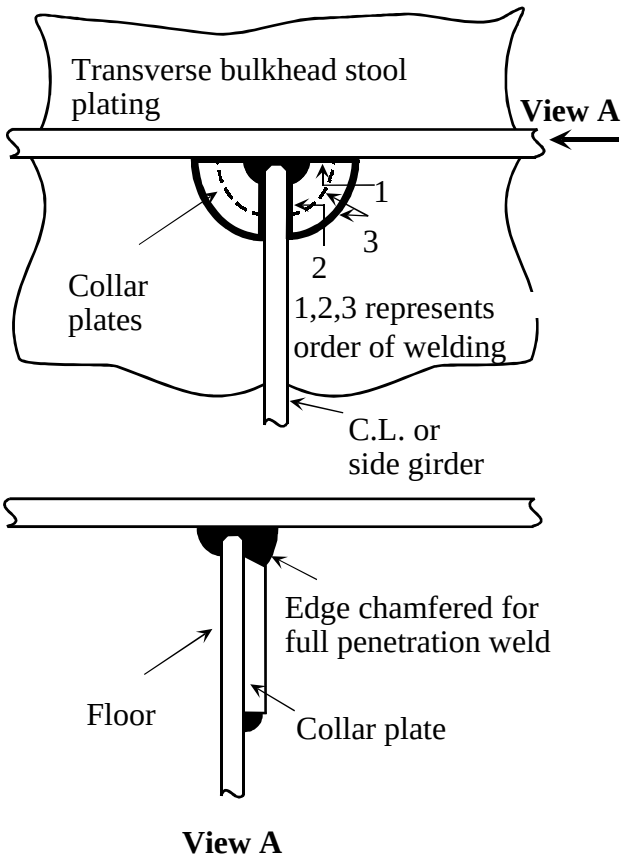
1. The fracture in the weld and/or plating is veed-out/cropped and renewed as appropriate.
2. The cut-outs are eliminated by introducing suitable collar plates with emphasis on edge preparation and sequence of welding as shown above.
3. Further reinforcements may be incorporated as shown above and depending on the judged cause of damage.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	5
Detail of damage	Fractures at weld connections of floors in way of inner bottom and side girders, and plating of bulkhead stool	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

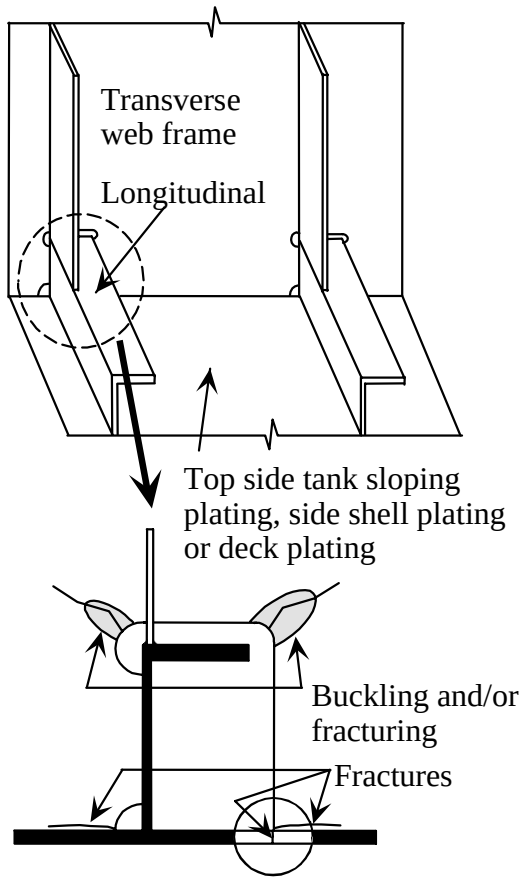
1. Stress concentration at the welds due to scallops.

Notes on repairs

1. The scallops will require to be fitted with welded collar plates to reduce stresses in the area.

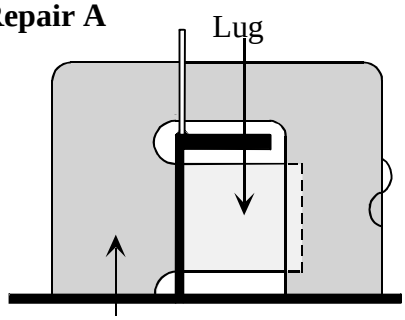
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	6
Detail of damage	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member	

Sketch of damage

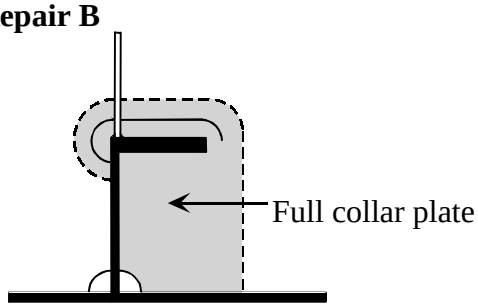


Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

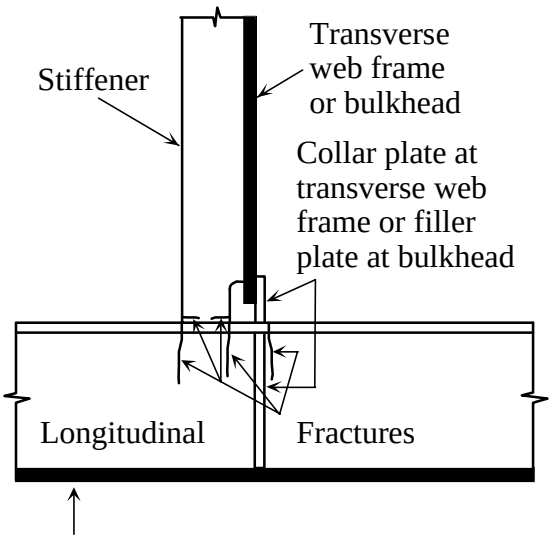
1. Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.

Notes on repairs

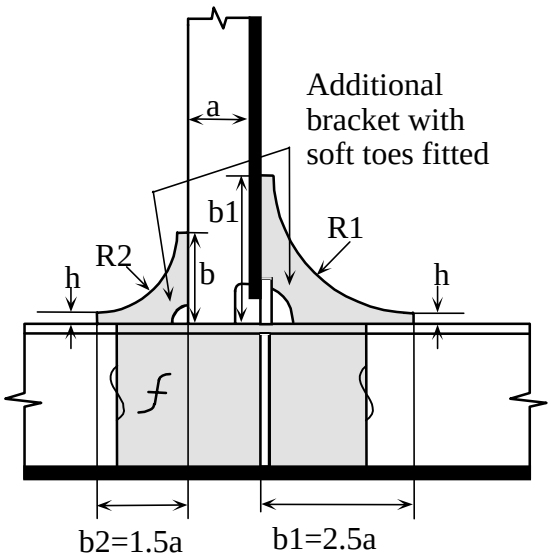
1. If fractures are significant then crop and part renew the floor plating/transverse web otherwise the fracture can be veed-out and welded provided the plating is not generally corroded.
2. **Repair B** is to be incorporated if the lug proves to be ineffective.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	7
Detail of damage	Fractures in longitudinal at floor/transverse web frame or bulkhead	

Sketch of damage



Sketch of repair



f:Where required, the longitudinal to be cropped and part renewed

1.For a slope at toes max.1:3, R1=(b1-h) x 1.6 and R2=(b2-h) x 1.6
2.Soft toe bracket to be welded first to longitudinal
3.Scallop in bracket to be as small as possible, recommended max.35mm
4.If toes of brackets are ground smooth, full penetration welds in way to be provided
5,Maximum length to thickness ratio = 50:1 for unstiffened bracket edge
6,Toe height, h, to be as small as possible (10-15mm)

Notes on possible cause of damage

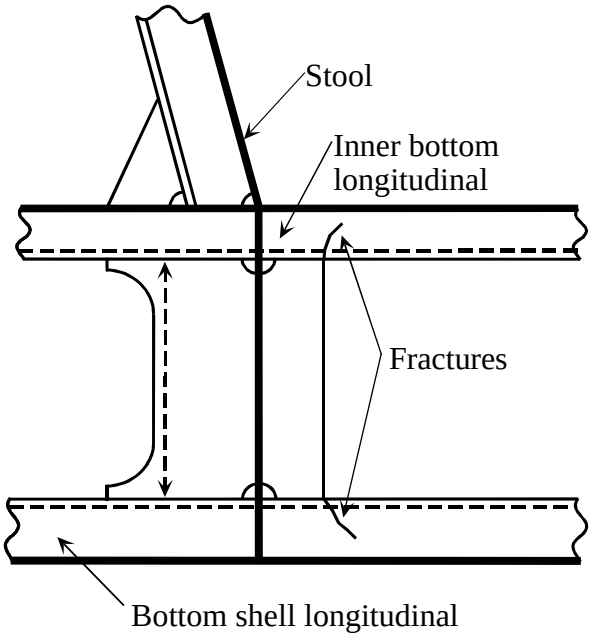
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

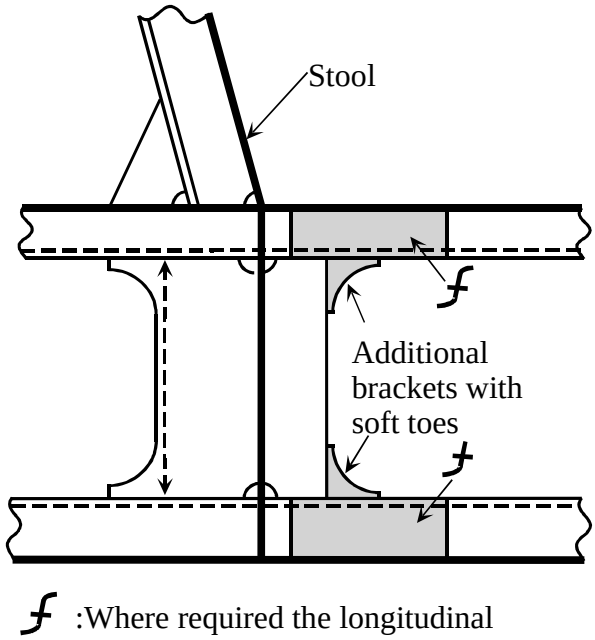
1. If fractures are not extensive e.g. hairline fractures, they can be veed-out and welded.
2. If fracture extends to over one third of the depth of the longitudinal then crop and part renew.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	8
Detail of damage	Fractures in bottom and inner bottom longitudinals in way of inner bottom and bulkhead stool boundaries	

Sketch of damage



Sketch of repair



ƒ :Where required the longitudinal to be cropped and part renewed

Notes on possible cause of damage

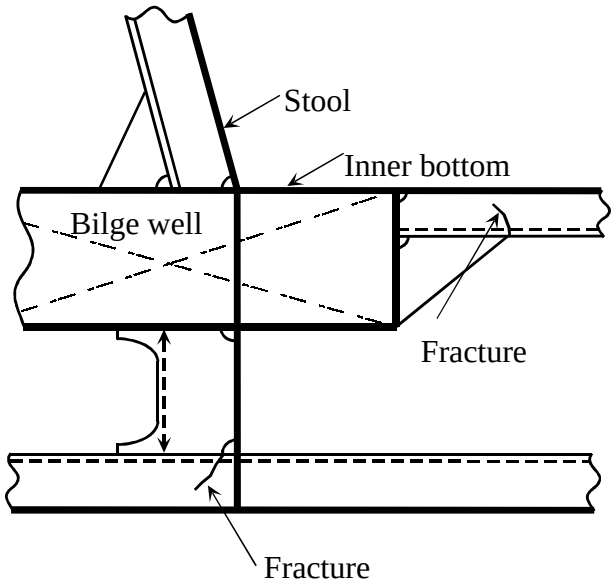
1. Damage can be caused by stress concentration leading to accelerated fatigue in this region.

Notes on repairs

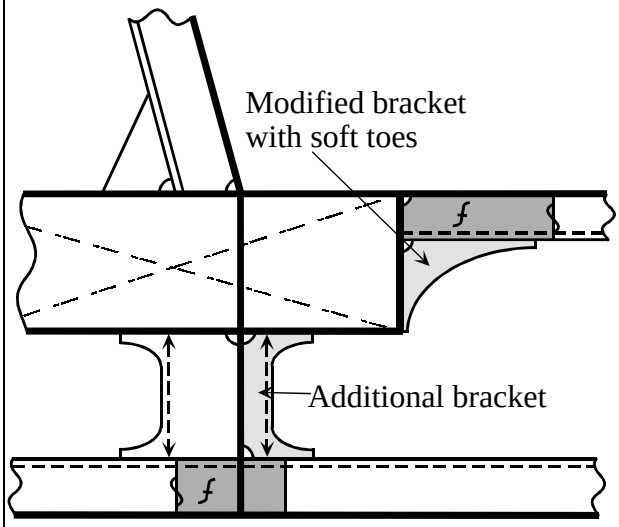
1. If fractures are not extensive e.g. hairline fractures then these can be veed-out and welded.
2. If fracture extended to over one third of the depth of the longitudinal depth then crop and part renew.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	9
Detail of damage	Fractures in longitudinal in way of bilge well	

Sketch of damage



Sketch of repair



ƒ:Where required the longitudinals to be cropped and part renewed

Notes on possible cause of damage

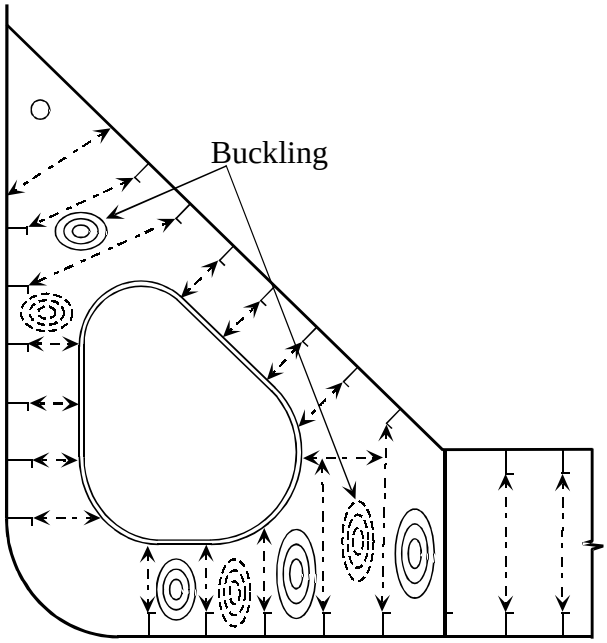
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

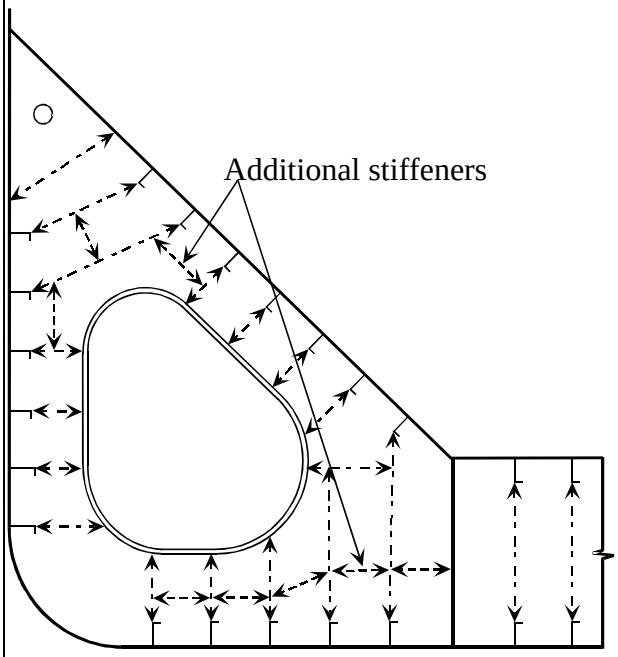
1. If fractures are not extensive e.g. hairline fractures then these can be veed-out and welded.
2. If the fracture extended to over one third of the depth of the longitudinal then crop and part renew.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	10
Detail of damage	Buckling of transverse web	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

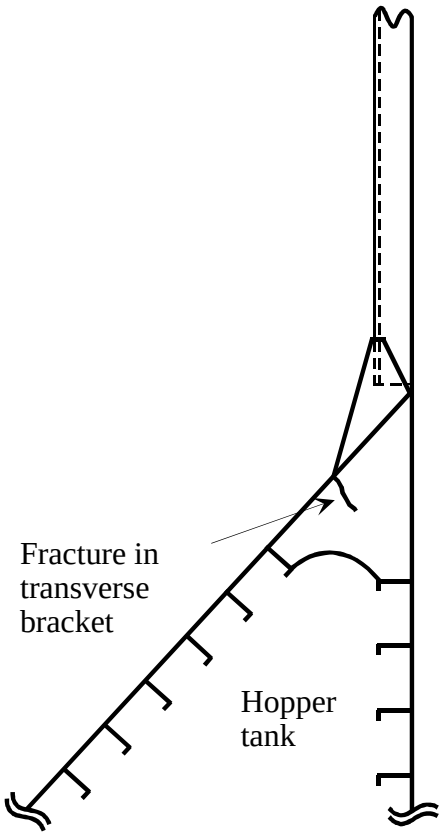
1. Insufficient buckling strength of transverse web plating.
2. Corrosion of high stress area.

Notes on repairs

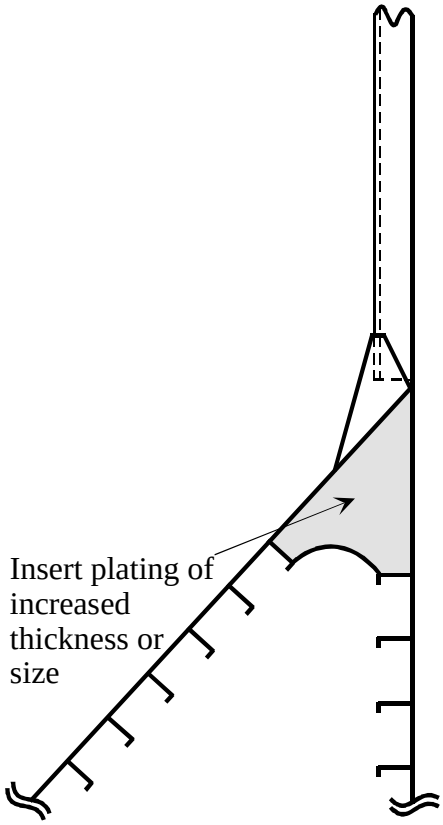
1. If the buckling occurred without significant corrosion, adequate reinforcement is to be carried out.
2. If the buckling occurred due to corrosion of high stress (shear stress) area, damaged area is to be cropped and part renewed. Adequate reinforcement and protective measures should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	11
Detail of damage	Fractures at weld connection of transverse brackets	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

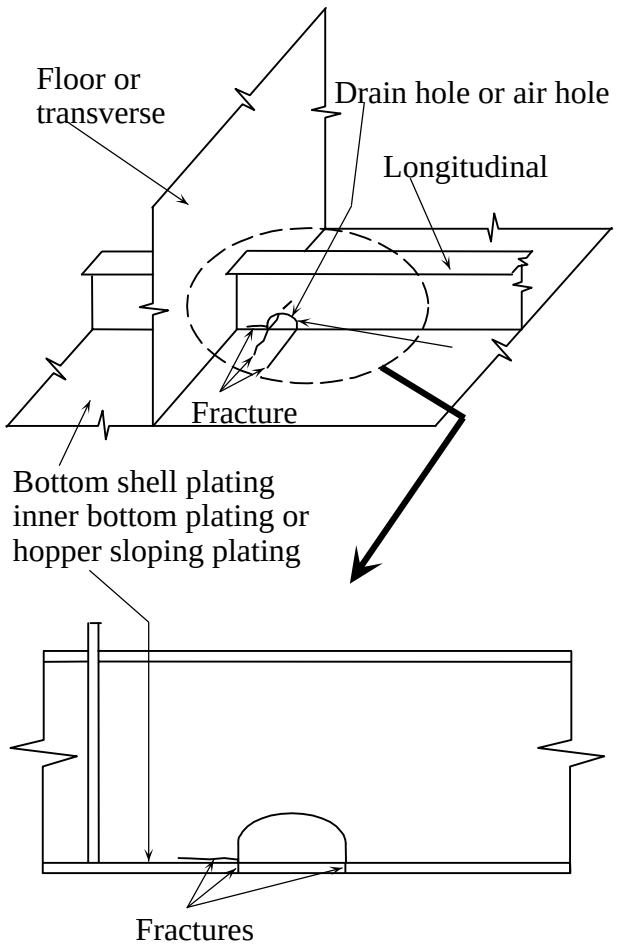
1. General levels of corrosion and presence of stress concentration.
2. Misalignment of the brackets with adjoining structure e.g. frame brackets.
3. High shear stresses due to insufficient bracket.
4. Inadvertent overloading.

Notes on repairs

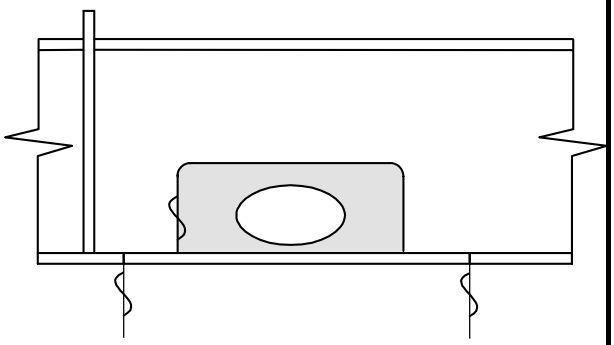
1. If the damage is caused by misalignment with the frame bracket above, the misalignment is to be rectified.
2. Replacement by a bracket of increased thickness or size should be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	12
Detail of damage	Fractures in bottom shell/side shell/hopper sloping plating at the corner drain hole/air hole in longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

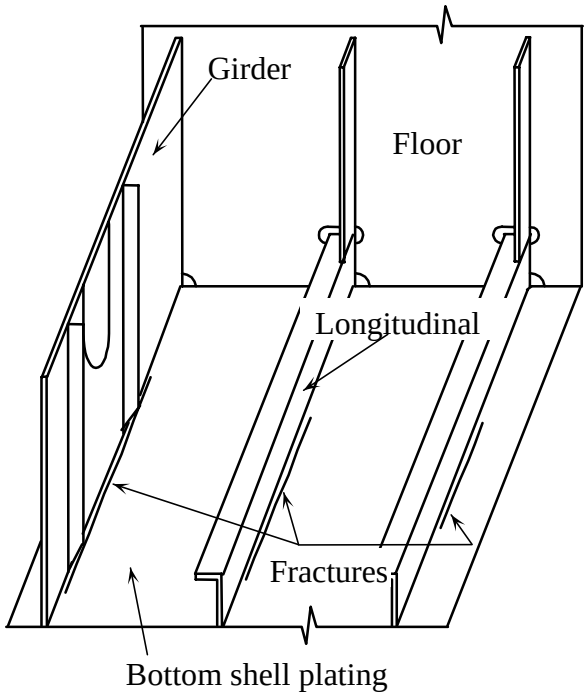
1. Stress concentration and/or corrosion due to stress concentration at the corner of drain hole/air hole.

Notes on repairs

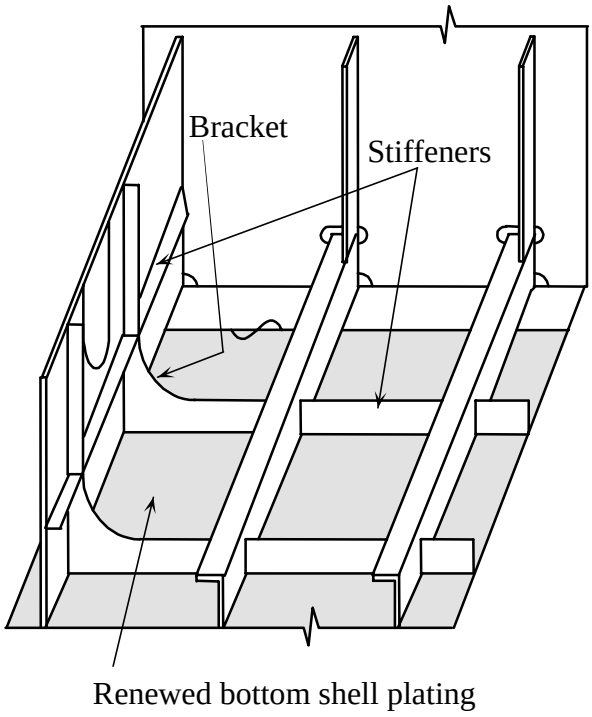
1. Fractured plating should be cropped and part renewed.
2. If fatigue life is to be improved, change of drain hole/air hole shape is to be considered.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	13
Detail of damage	Fractures in bottom plating along side girder and/or bottom longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

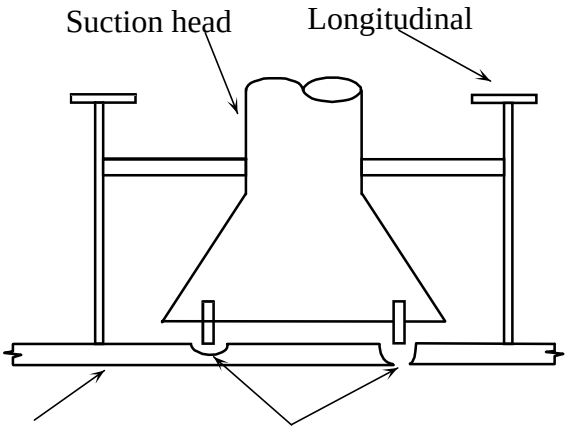
1. Vibration.

Notes on repairs

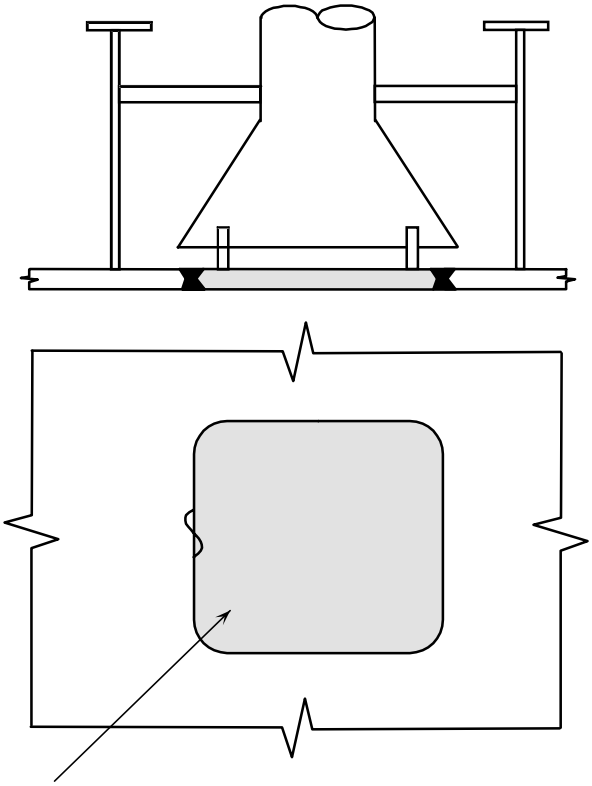
1. Fractured bottom shell plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional stiffener/bracket.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom tank structure including hopper**	**14**
Detail of damage	Corrosion in bottom plating below suction head	

Sketch of damage



Sketch of repair



1.Insert to have round corners
2.Non-destructive examination to be applied after welding based on the Society's rules

Notes on possible cause of damage

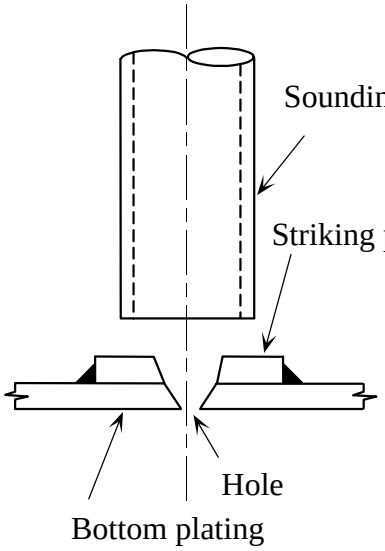
1. High flow rate associated with insufficient corrosion prevention system.
2. Galvanic action between dissimilar metals.

Notes on repairs

1. Affected plating should be cropped and part renewed. Thicker plate and suitable beveling should be considered.
2. If the corrosion is limited to a small area,
   i. e. pitting corrosion, repair by welding is acceptable.

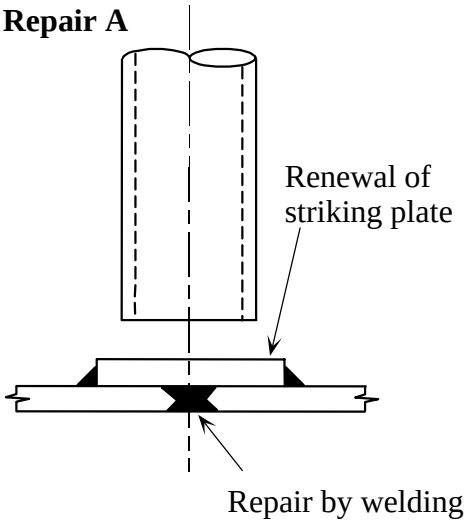
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	15
Detail of damage	Corrosion in bottom plating below sounding pipe	

Sketch of damage

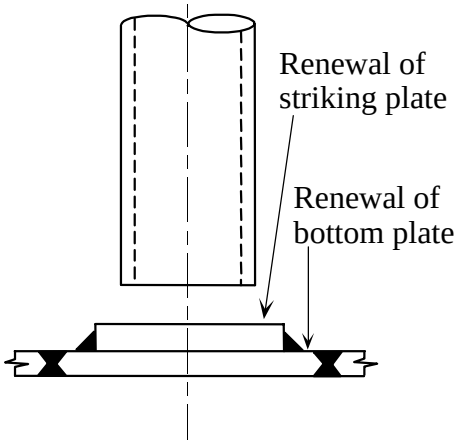


Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

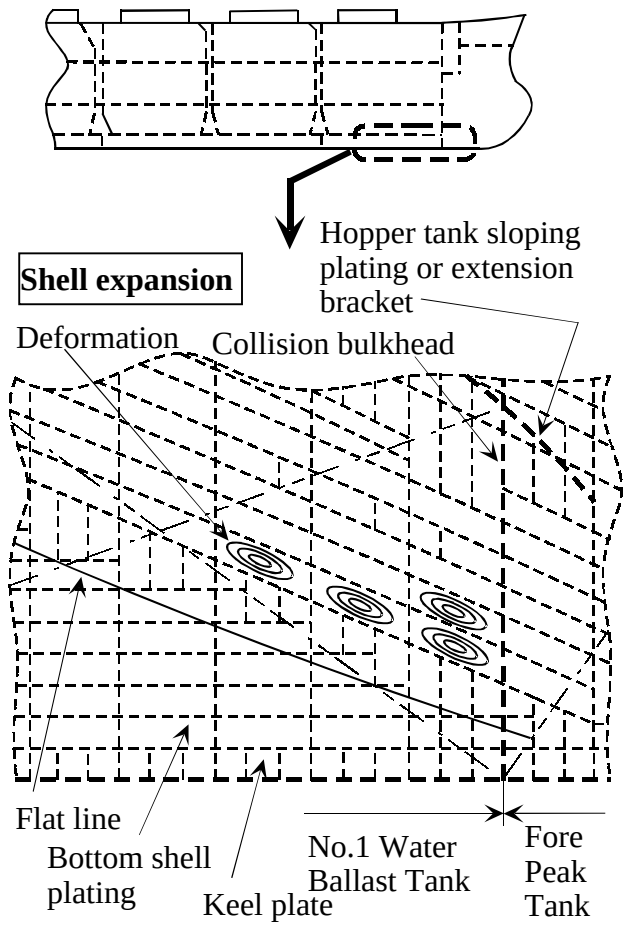
1. Accelerated corrosion of striking plate by the striking of the weight of the sounding tape.

Notes on repairs

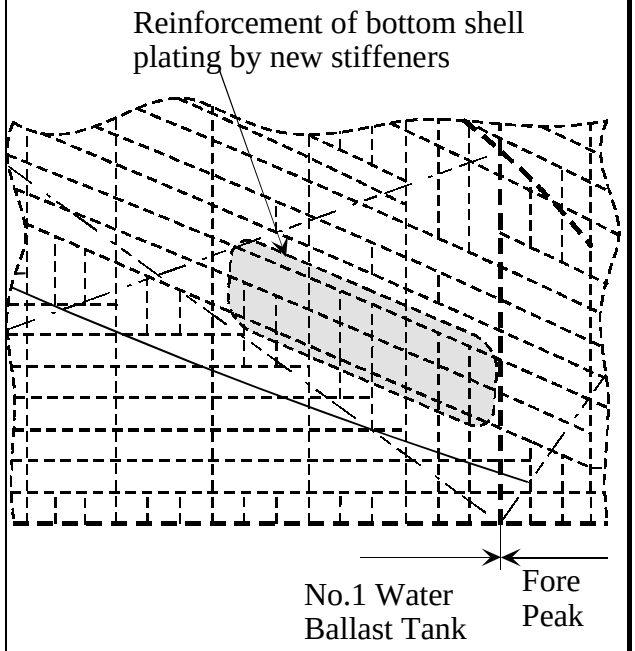
1. Corroded bottom plating should be welded or partly cropped and renewed if considered necessary.
2. Corroded striking plate should be renewed.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure including hopper**	**16**
Detail of damage	Deformation of forward bottom shell plate due to slamming	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

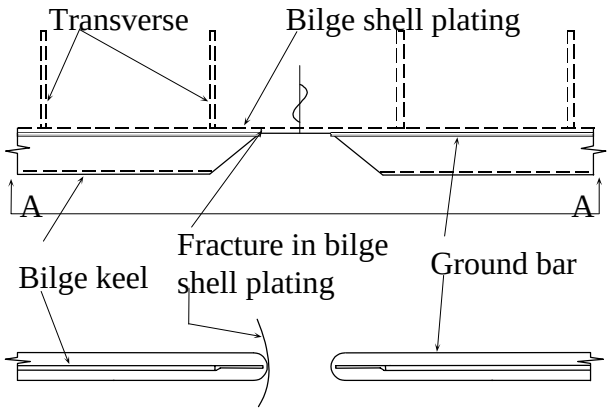
1. Heavy weather.
2. Poor design for slamming.
3. Poor operation, i.e. negligence of heavy ballast.

Notes on repairs

1. Deformed bottom shell plating should be faired in place, or partly cropped and renewed if considered necessary.
2. Bottom shell plating should be reinforced by stiffeners.

BULK CARRIERS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 1	**Cargo hold region**	**Example No.**
Area 5	**Double bottom structure including hopper**	**17**
Detail of damage	Fractures in shell plating at the termination of bilge keel	

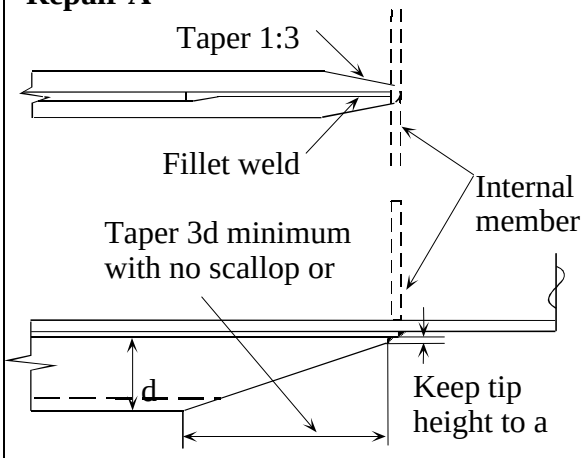
Sketch of damage



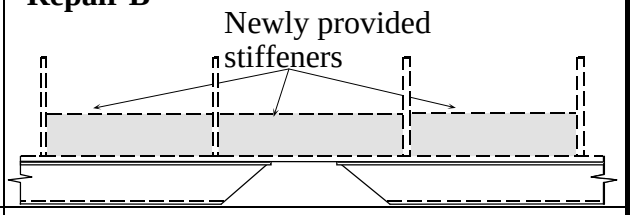
View A - A

Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

1. Poor design causing stress concentration.

Notes on repairs

1. Fractured plating is to be cropped and renewed.
2. Reduction of stress concentration of the bilge keel end should be considered.
   Repair A: Modification of the detail of end
   Repair B: New internal stiffeners
   Repair C: Continuous ground bar (in connection with **Repair A**)
3. Instead of **Repair A** or **B** continuous ground bar and bilge keel should be considered.

Part 2 Fore and aft end regions

Contents

Area 1 Fore end structure
Area 2 Aft end structure
Area 3 Stern frame, rudder arrangement and propeller shaft supports

Area 1 Fore End Structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Figures and/or Photographs - Area 1	
No.	**Title**
Figure 1	Fore end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Deformation of forecastle deck
2	Fractures in forecastle deck plating at bulwark
3	Fractures in side shell plating in way of chain locker
4	Deformation of side shell plating in way of forecastle space
5	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals
6	Fractures at toe of web frame bracket connection to stringer platform bracket

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the fore peak ballast tank can be a major problem for many, and in particular ageing ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fracture~~s~~ of the internal structure and the tank boundaries.

1.2 Deformation can be caused by contact which can result in damage to the internal structure leading to fractures in the shell plating.

1.3 Fracture~~s~~ of internal structure in the fore peak tank and spaces ~~can~~ also result from wave impact load due to slamming and panting.

1.4 Forecastle structure is exposed to green water and can suffer~~s~~ damage such as deformation of deck structure, deformation and fracture of bulwarks and collapse of mast~~,~~ etc.

1.5 Shell plating around anchor and hawse pipe may suffer corrosion, deformation and possible fracture due to movement of improperly stowed anchor.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at the locations as indicated in **Figure 1** and particular attention should be given to these areas. A close-up inspection should be carried out with selection of representative thickness measurements to determine the extent of corrosion.

2.1.2 Structure in chain locker is liable to have heavy corrosion due to mechanical damage of ~~to~~ the protective coating caused by the action of anchor chains. In some ships, especially smaller ships, the side shell plating may form boundaries of the chain locker and heavy corrosion may consequently result in holes in the side shell plating.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. A close-up examination of the damaged area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in the fore peak tank are normally found by close-up inspection of the internal structure.

2.3.2 Fractures are often found in transition region and reference should be made to **Part 1**, **Area 2** and **3**.

2.3.3 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of tanks.

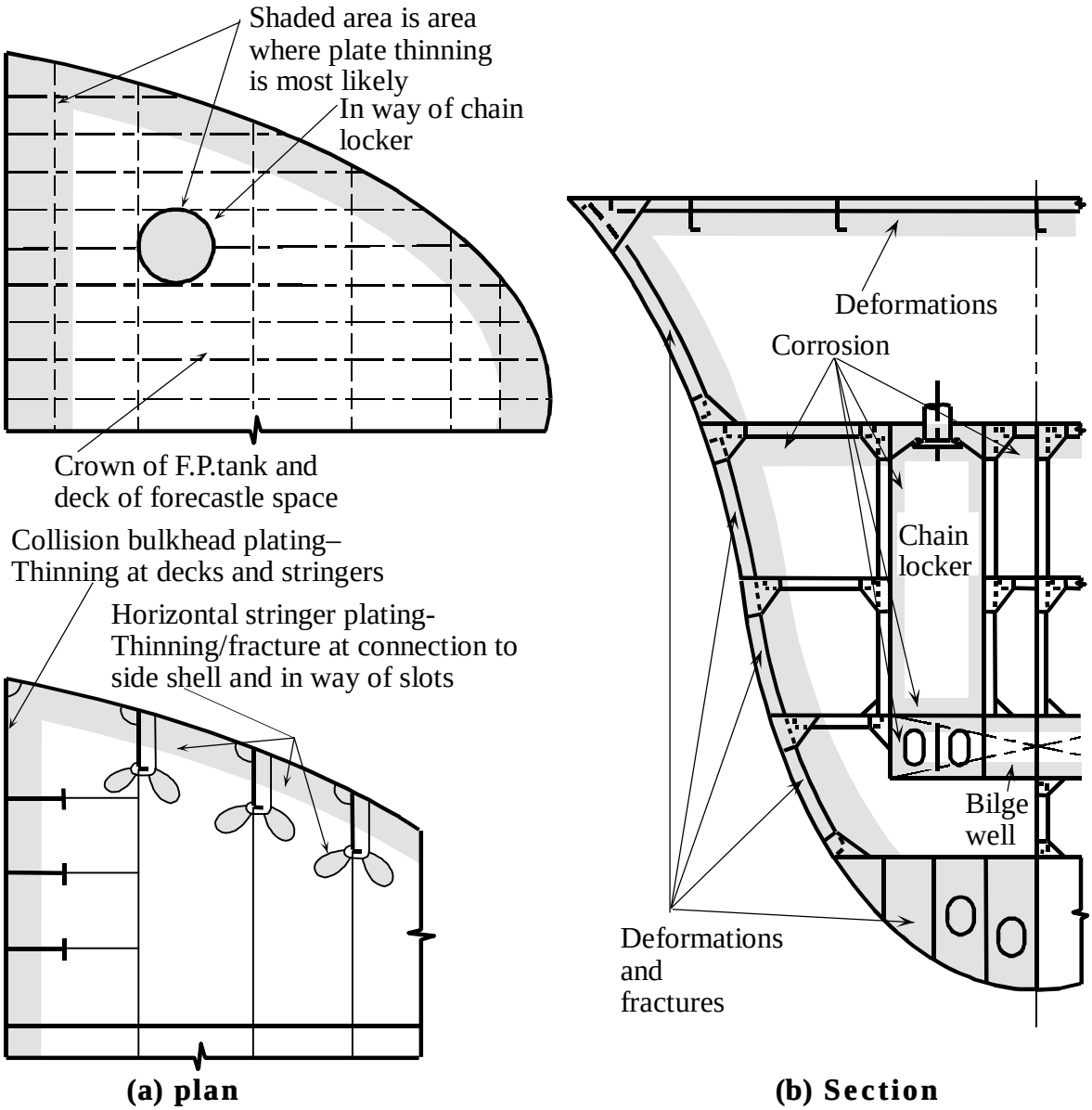


Fig 1 Fore end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

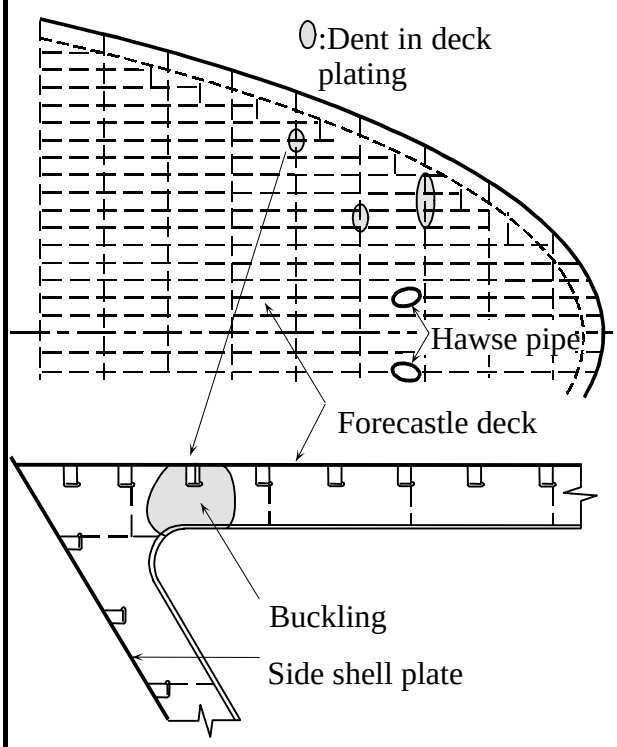
3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the nature and extent of damage.

3.3 Fractures

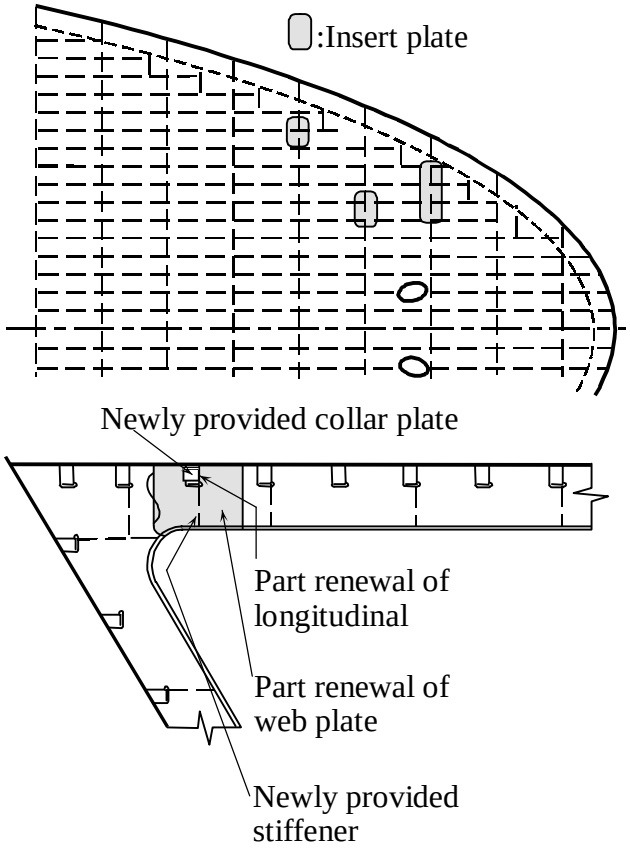
3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed. In the case of fractures caused by sea loads, increased thickness of plating and/or design modification to reduce stress concentrations should be considered (See **Examples 1**, **2** and **6**).

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**1**
Detail of damage	Deformation of forecastle deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

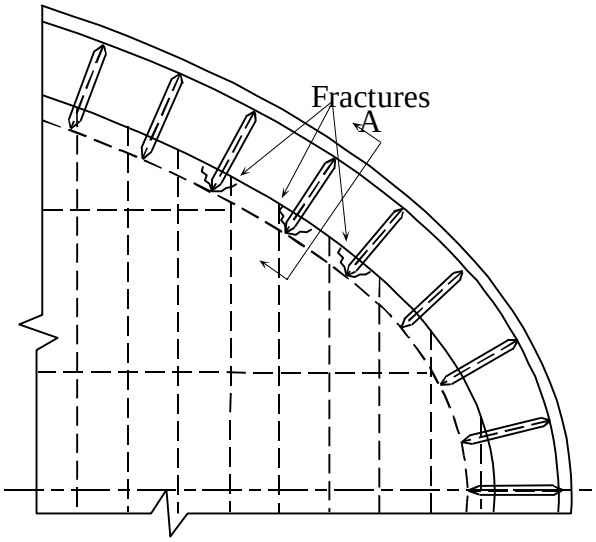
1. Green sea on deck.
2. Insufficient strength.

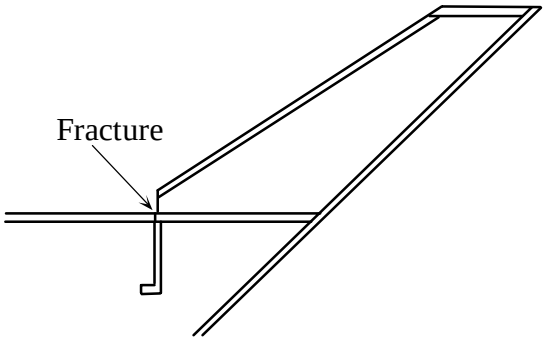
Notes on repairs

1. Deformed structure should be cropped and renewed.
2. Additional stiffeners on web of beam should be considered for reinforcement.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**2**
Detail of damage	Fractures in forecastle deck plating at bulwark	

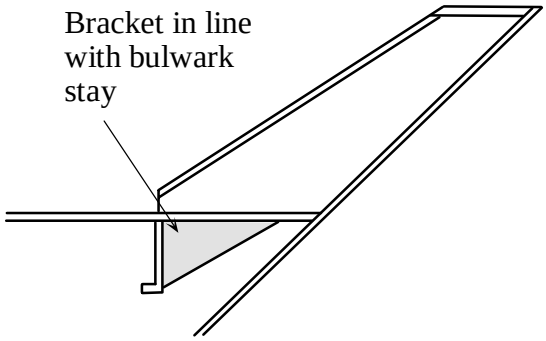
Sketch of damage





View A - A

Sketch of repair



View A - A

Notes on possible cause of damage

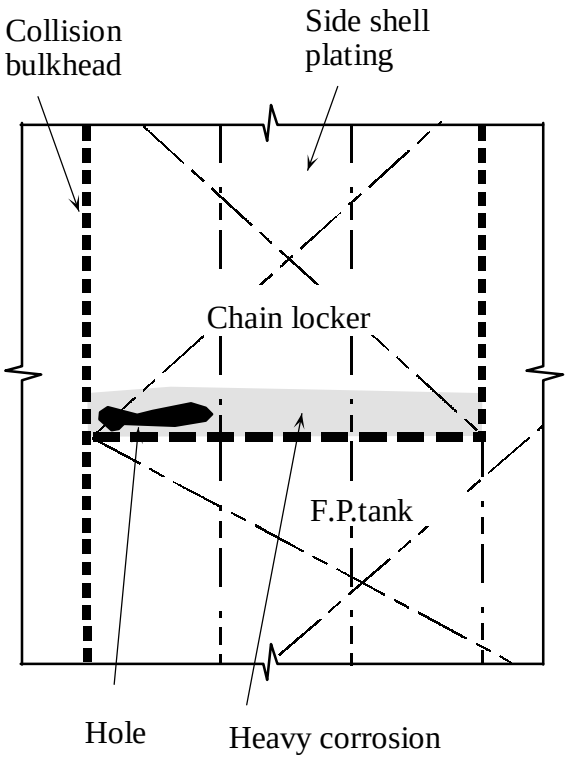
1. Bow flare effect in heavy weather.
2. Stress concentration due to poor design.

Notes on repairs

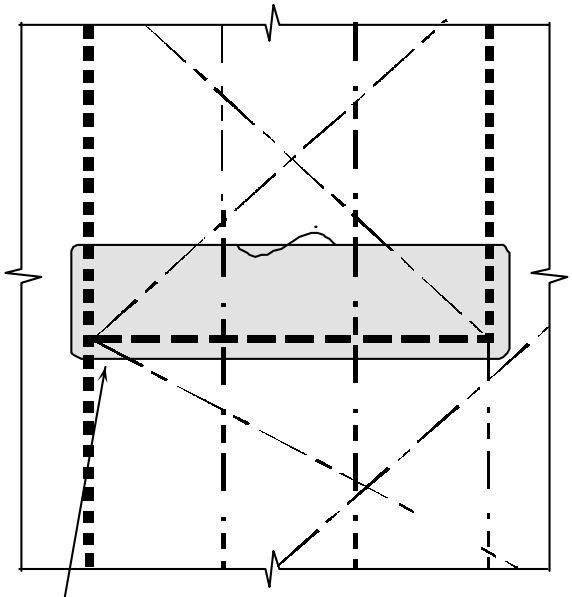
1. Fractured deck plating should be cropped and renewed.
2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	3
Detail of damage	Fractures in side shell plating in way of chain locker	

Sketch of damage



ketch of repair



Notes on possible cause of damage

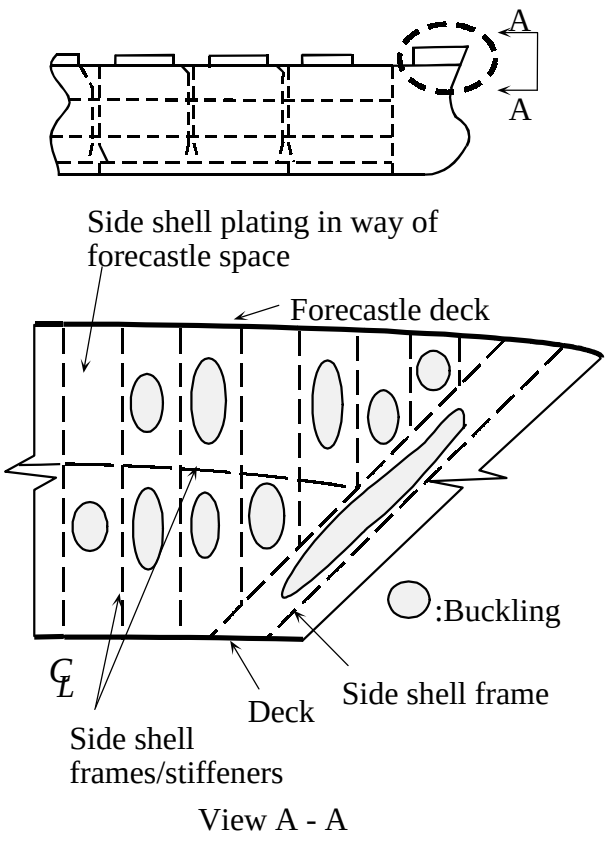
1. Heavy corrosion in region where mud is accumulated.

Notes on repairs

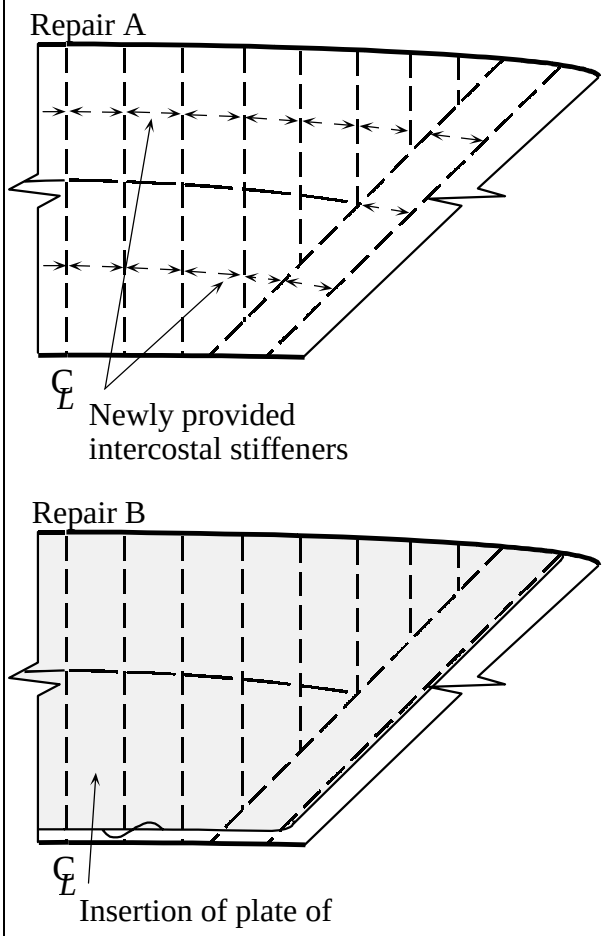
1. Corroded plating should be cropped and renewed.
2. Protective coating should be applied.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**4**
Detail of damage	Deformation of side shell plating in way of forecastle space	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

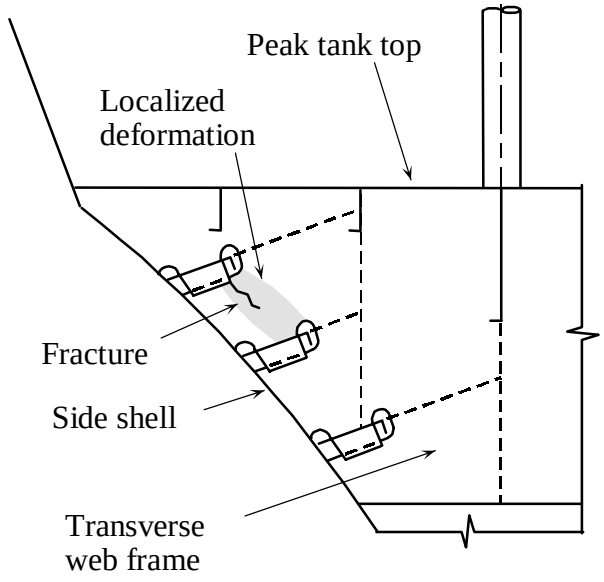
1. Heavy weather.
2. Insufficient strength.

Notes on repairs

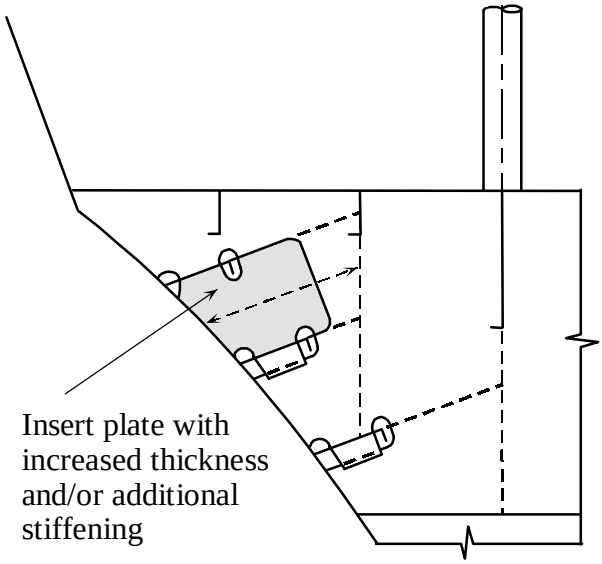
1. Deformed part should be cropped and part renewed.
2. **Repair A**
   Additional stiffeners between existing stiffeners should be considered.
   Repair B
   Insertion of plate of increased thickness with additional stiffeners.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**5**
Detail of damage	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

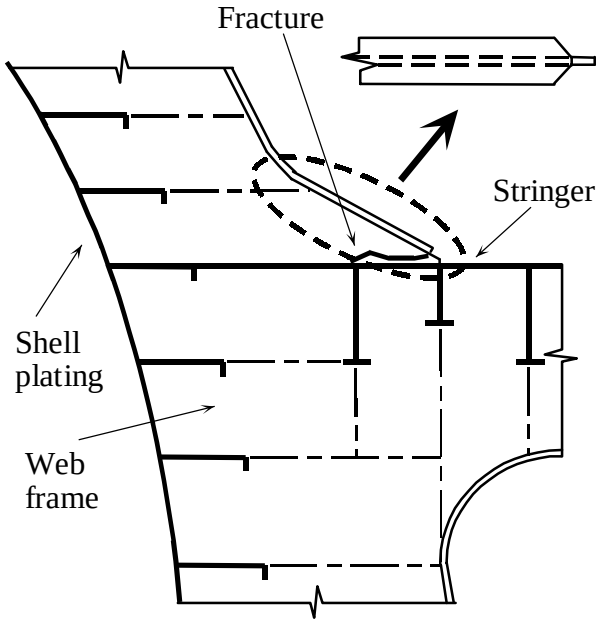
1. Localized material wastage in way of coating failure at cut-outs and sharp edges due to working of the structure.
2. Dynamic seaway loading in way of bow flare.

Notes on repairs

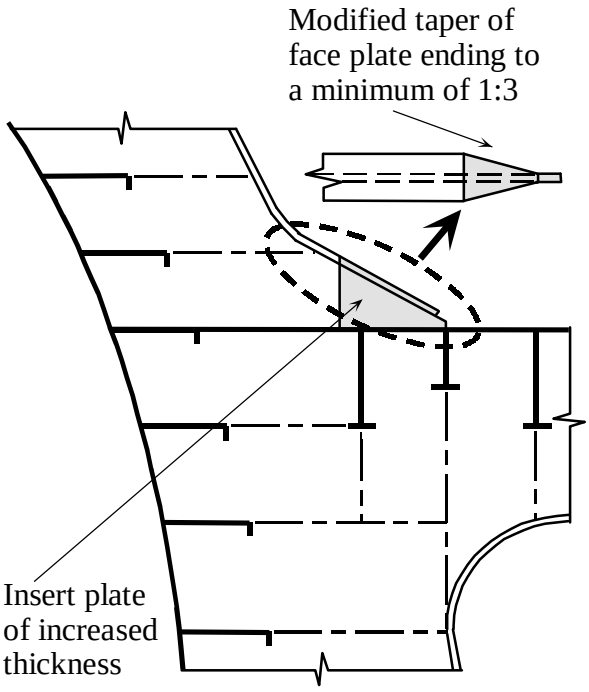
1. Sufficient panel strength to be provided to absorb the dynamic loads enhanced by bow flare shape.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	6
Detail of damage	Fractures at toe of web frame bracket connection to stringer platform bracket	

Sketch of damage



ketch of repair



Notes on possible cause of damage

1. Inadequate bracket forming the web frame connection to the stringer.
2. Localized material wastage in way of coating failure at bracket due to flexing of the structure.
3. Dynamic seaway loading in way of bow flare.

Notes on repairs

1. Adequate soft nose bracket endings with a face plate taper of at least 1 : 3 to be provided.

Area 2 Aft end structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Figures and/or Photographs - Area 2	
No.	**Title**
Figure 1	Aft end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 2	
Example No.	**Title**
1	Fractures in longitudinal bulkhead in way of rudder trunk
2	Fractures at the connection of floors and girder/side brackets
3-a	Fractures in flat where rudder carrier is installed in steering gear room
3-b	Fractures in steering gear foundation brackets and deformed deck plate

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the aft peak ballast tank can be a major problem for many, and in particular ageing, ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.

1.1 Deformation can be caused by contact or wave impact action from astern (which can result in damage to the internal structure leading to fractures in the shell plating.

1.3 Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at in the locations as indicated in **Figure 1**. A close-up inspection should be carried out with selection of representative thickness measurements to determine the extent of corrosion. Particular attention should be given to bunker tank boundaries and spaces adjacent to heated engine room.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and bulkheads. A close-up examination of the deformed area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in weld at floor connections and other locations in the aft peak tank and rudder trunk space can normally only be found by close-up inspection.

2.3.2 The structure supporting the rudder carrier may fracture and/or deform due to excessive load on the rudder. Bolts connecting the rudder carrier to the steering gear flat may also suffer damage under such load.

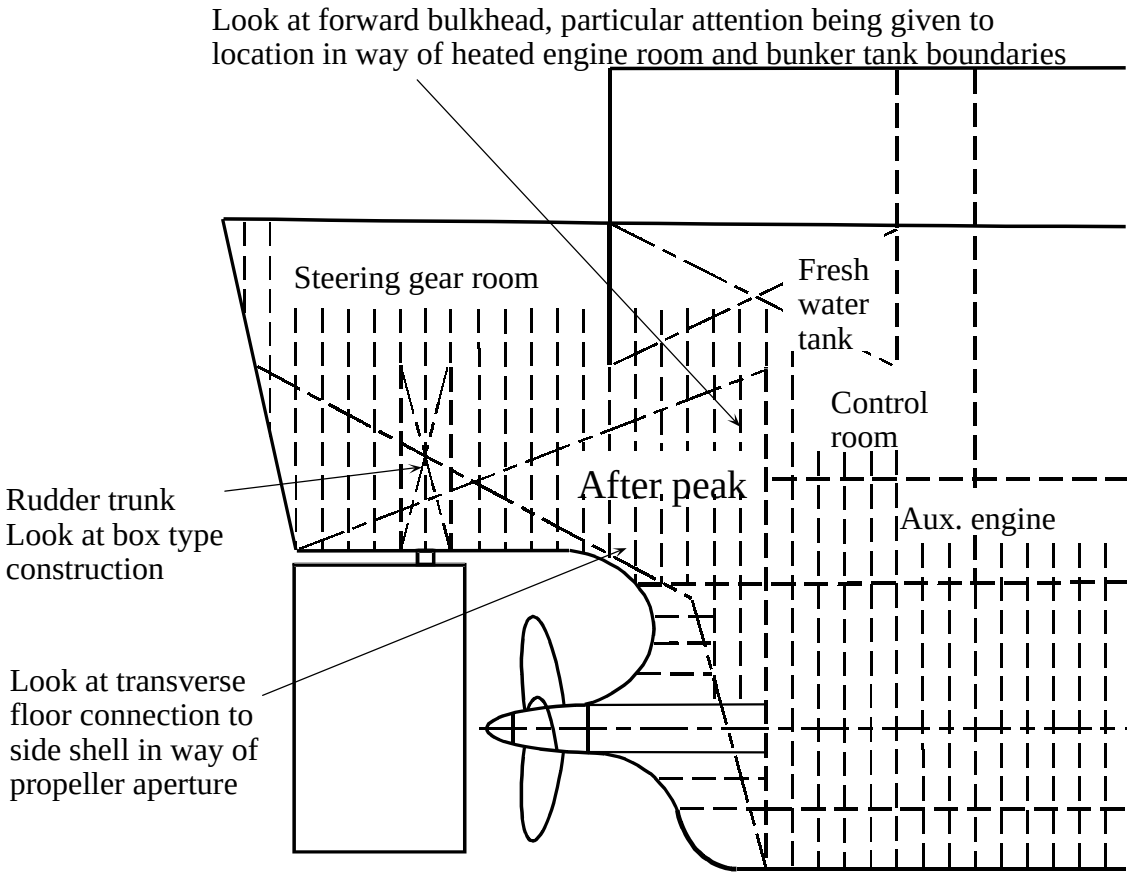


Figure 1 Aft end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the extent of damage.

3.3 Fractures

3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

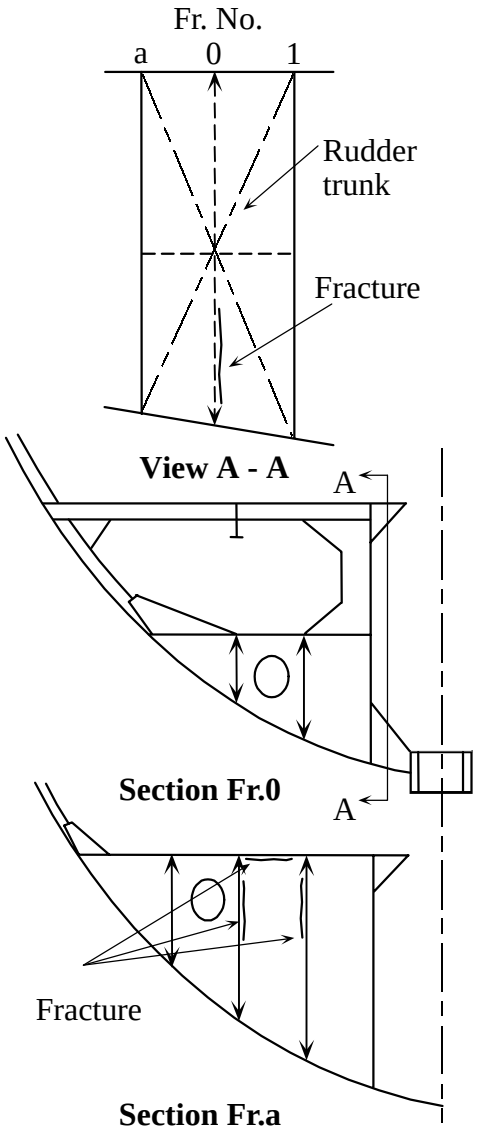
3.3.2 In order to prevent recurrence of damages suspected to be caused by main engine or propeller excited vibration, the cause of the vibration should be ascertained and additional reinforcements provided as found necessary (See **Examples 1** and **2**).

3.3.3 In the case of fractures caused by sea loads, increased thickness of plating and/or design modifications to reduce stress concentrations should be considered.

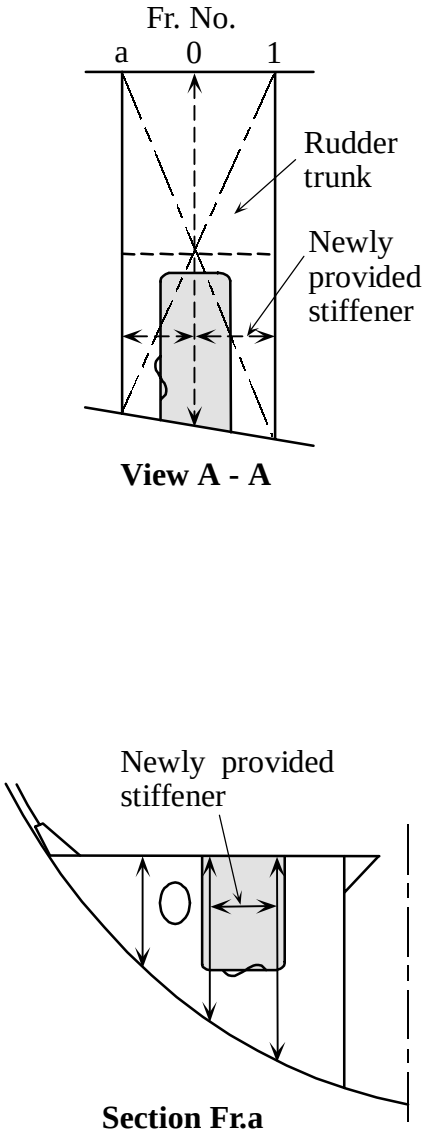
3.3.4 Fractured structure which supports rudder carrier is to be cropped, and renewed, and may have to be reinforced (See **Examples 3-a** and **3-b**).

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**1**
Detail of damage	Fractures in bulkhead in way of rudder trunk	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

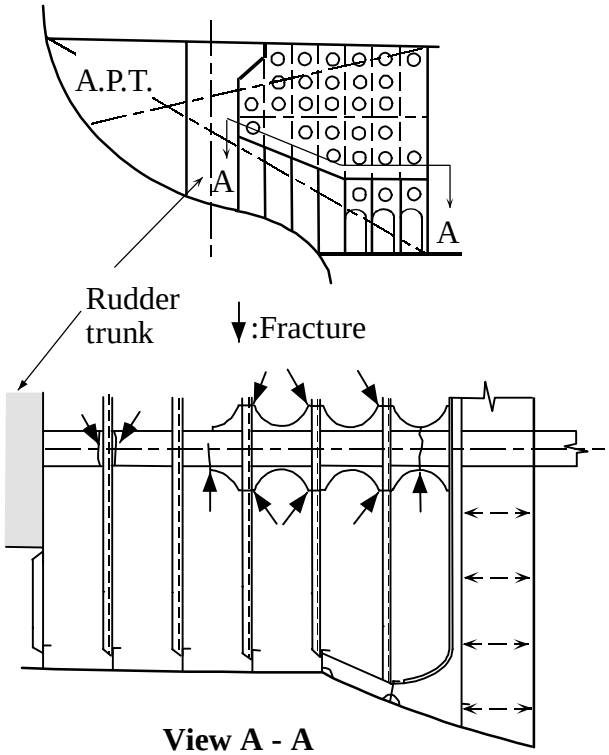
1. Vibration.

Notes on repairs

1. The fractured plating should be cropped and renewed.
2. Natural frequency of the plate between stiffeners should be changed, e.g. reinforcement by additional stiffeners.

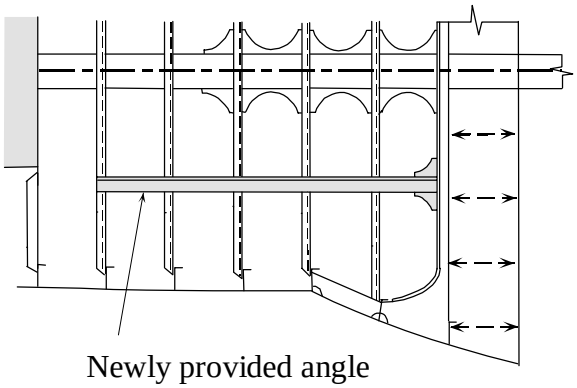
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**2**
Detail of damage	Fractures at the connection of floors and girders / side brackets	

Sketch of damage



View A - A

Sketch of repair



Notes on possible cause of damage

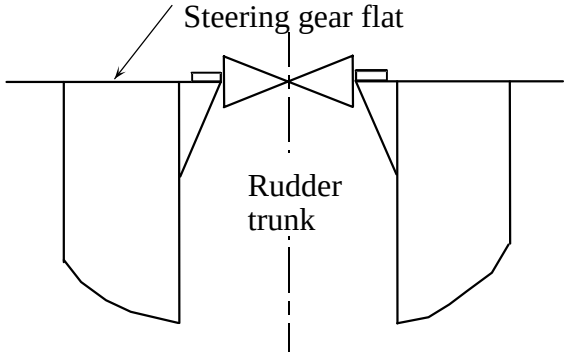
1. Vibration.

Notes on repairs

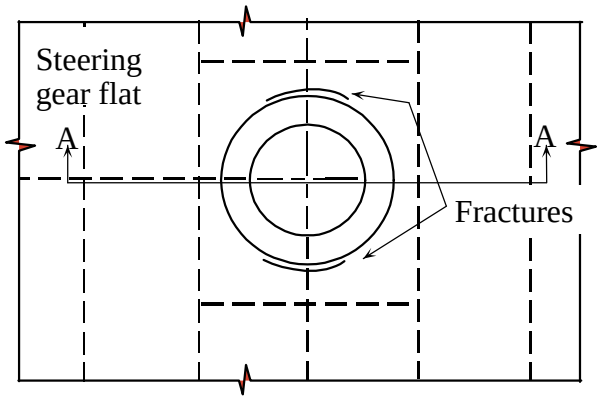
1. The fractured plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional strut.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 2	Aft end structure	3-a
Detail of damage	Fractures in flat where rudder carrier is installed in steering gear room	

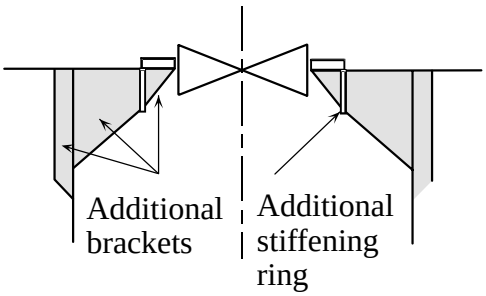
Sketch of damage



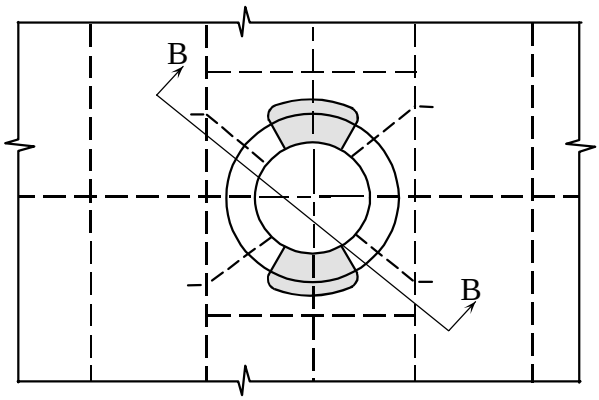
View A - A



Sketch of repair



View B - B



Notes on possible cause of damage

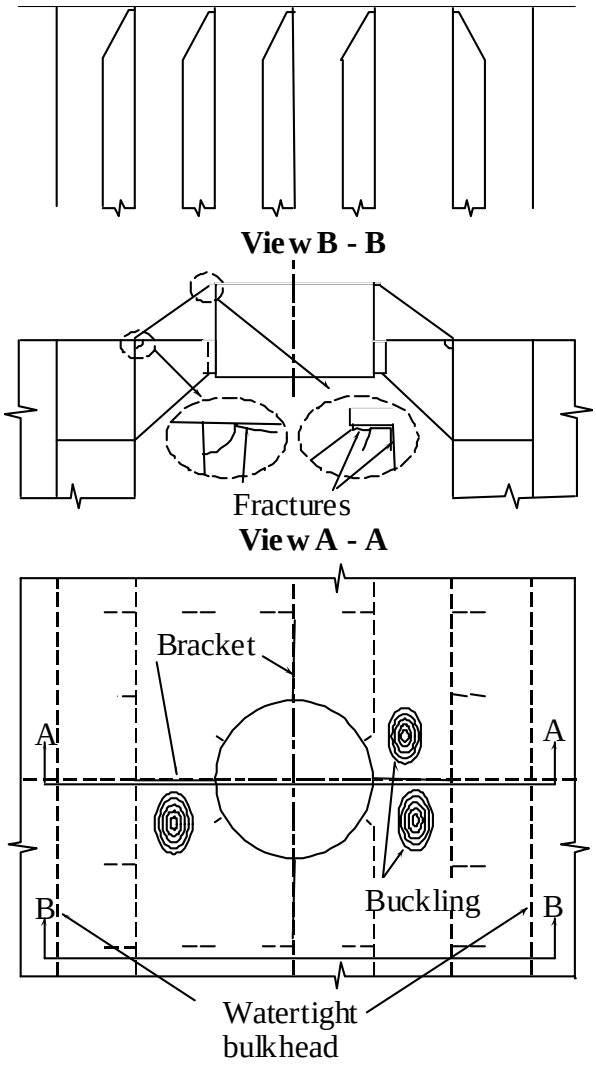
1. Inadequate design.

Notes on repairs

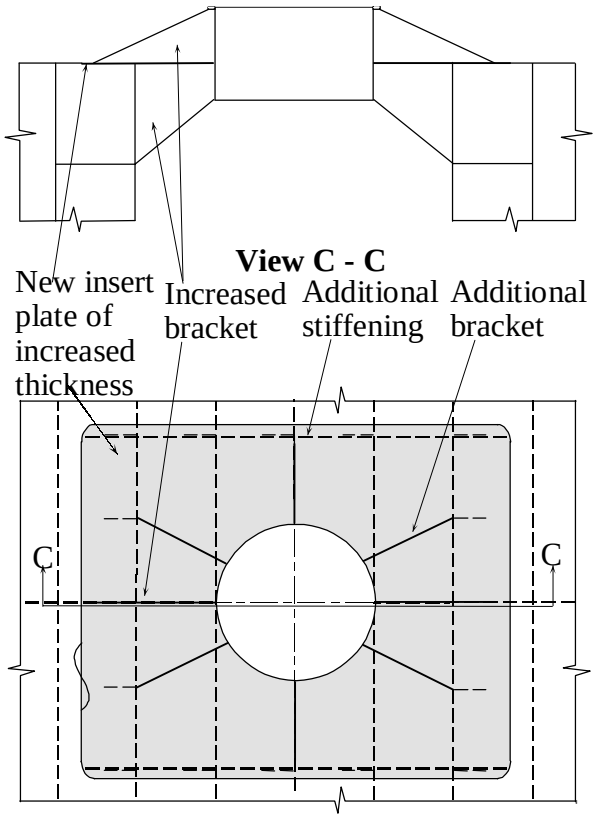
1. Fractured plating should be cropped and renewed.
2. Additional brackets and stiffening ring should be fitted for reinforcement.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 2	Aft end structure	3-b
Detail of damage	Fractures in steering gear foundation brackets and deformed deck plate	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient deck strengthening (missing base plate).
2. Insufficient strengthening of steering gear foundation.
3. Bolts of steering gear were not sufficiently pre-loaded.

Notes on repairs

1. New insert base plate of increased plate thickness.
2. Additional longitudinal stiffening at base plate edges.
3. Additional foundation brackets above and under deck (star configuration).

Area 3 Stern frame, rudder arrangement and propeller shaft support

Contents

1 General

2 What to look for - Drydock inspection
2.1 Deformation
2.2 Fractures
2.3 Corrosion/Erosion/Abrasion

3 General comments on repair
3.1 Rudder stock and pintles
3.2 Plate structure
3.3 Abrasion of bush and sleeve
3.4 Assembling of rudders
3.5 Repair of propeller boss and stern tube

Figures and/or Photographs - Area 3	
No.	**Title**
Figure 1	Nomenclature for stern frame, rudder arrangement and propeller shaft support
Figure 2	Potential problem areas
Photograph 1	Fractured rudder
Figure 3	Rudder stock repair by welding
Diagram 1	Preheating temperature

Examples of structural detail failures and repairs - Area 3	
Example No.	**Title**
1	Fractures in rudder horn along bottom shell plating
2	Fractures in rudder stock
3	Fractures in connection of palm plate to rudder blade
4	Fractures in rudder plating of semi-spade rudder (short fractures with end located forward of the vertical web)
5	Fractures in rudder plating of semi-spade rudder extending beyond the vertical web
6	Fractures in rudder plating of semi-spade rudder in way of pintle cutout
7	Fractures in side shell plating at the connection to propeller boss
8	Fractures in stern tube at the connection to stern frame

1 General

1.1 The stern frame, possible strut bearing arrangement and connecting structures are exposed to propeller induced vibrations, which may lead to fatigue cracking in areas where stress concentrations occur.

1.2 The rudder and rudder horn are exposed to accelerated and fluctuating stream from the propeller, which may also lead to fatigue cracking in areas where stress concentrations occur.

1.3 In extreme weather conditions the rudder may suffer wave slamming forces causing deformations of rudder stock and rudder horn as well as of the rudder itself.

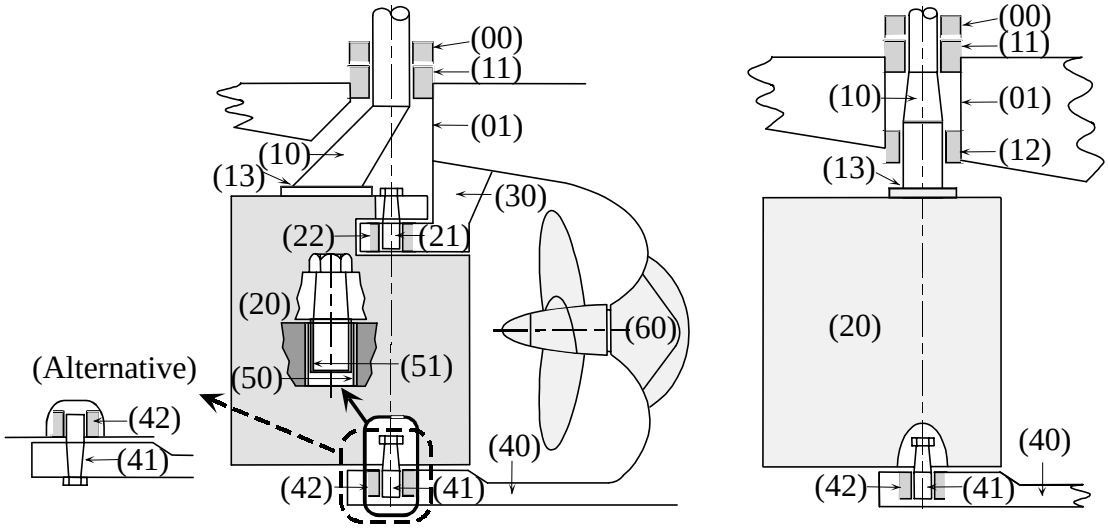
1.4 Rudder and rudder horn as well as struts (on shafting arrangement with strut bearings) may also come in contact with floating object such as timber-log or ice causing damages similar to those described in **1.3**.

1.5 Since different materials are used in adjacent compartments and structures, accelerated (galvanic) corrosion may occur if protective coating and/or sacrificial anodes are not maintained properly.

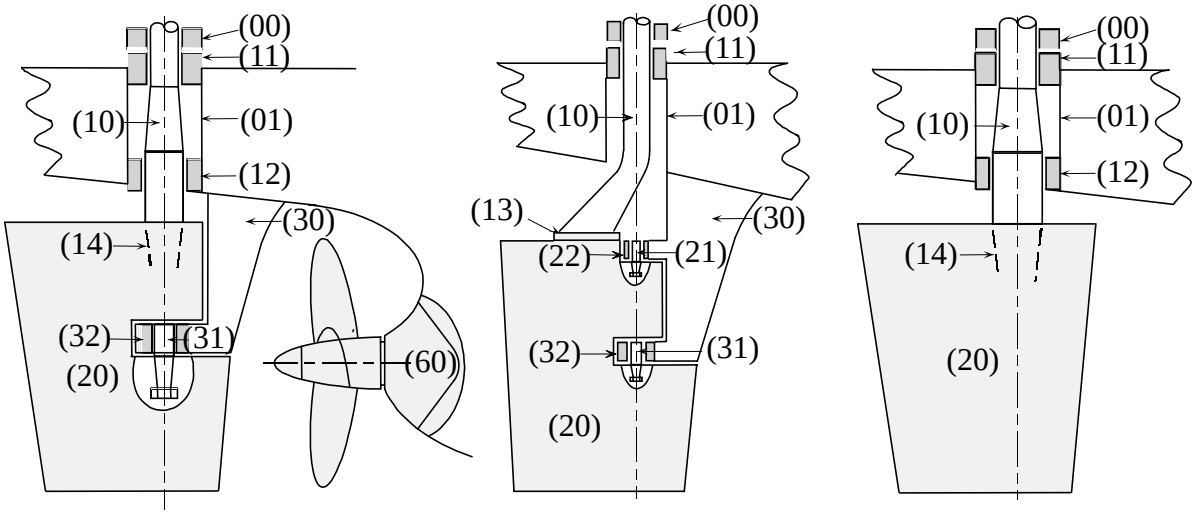
1.6 Pre-existing manufacturing internal defects in cast pieces may lead to fatigue cracking.

1.7 A summary of potential problem areas is shown in **Figure 2**.

1.8 A complete survey of the rudder arrangement is only possible in drydock. However, in some cases a survey including a damage survey can be carried out afloat by divers or with a trimmed ship.



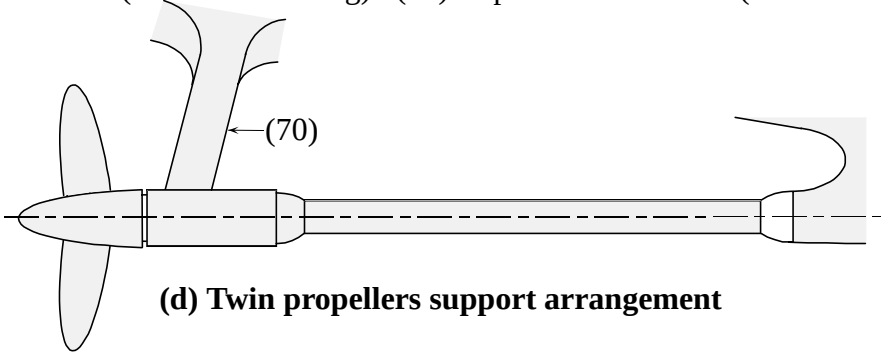
(a) Rudders supported by sole piece



(b) Semi-spade rudders **(c) Spade rudder**

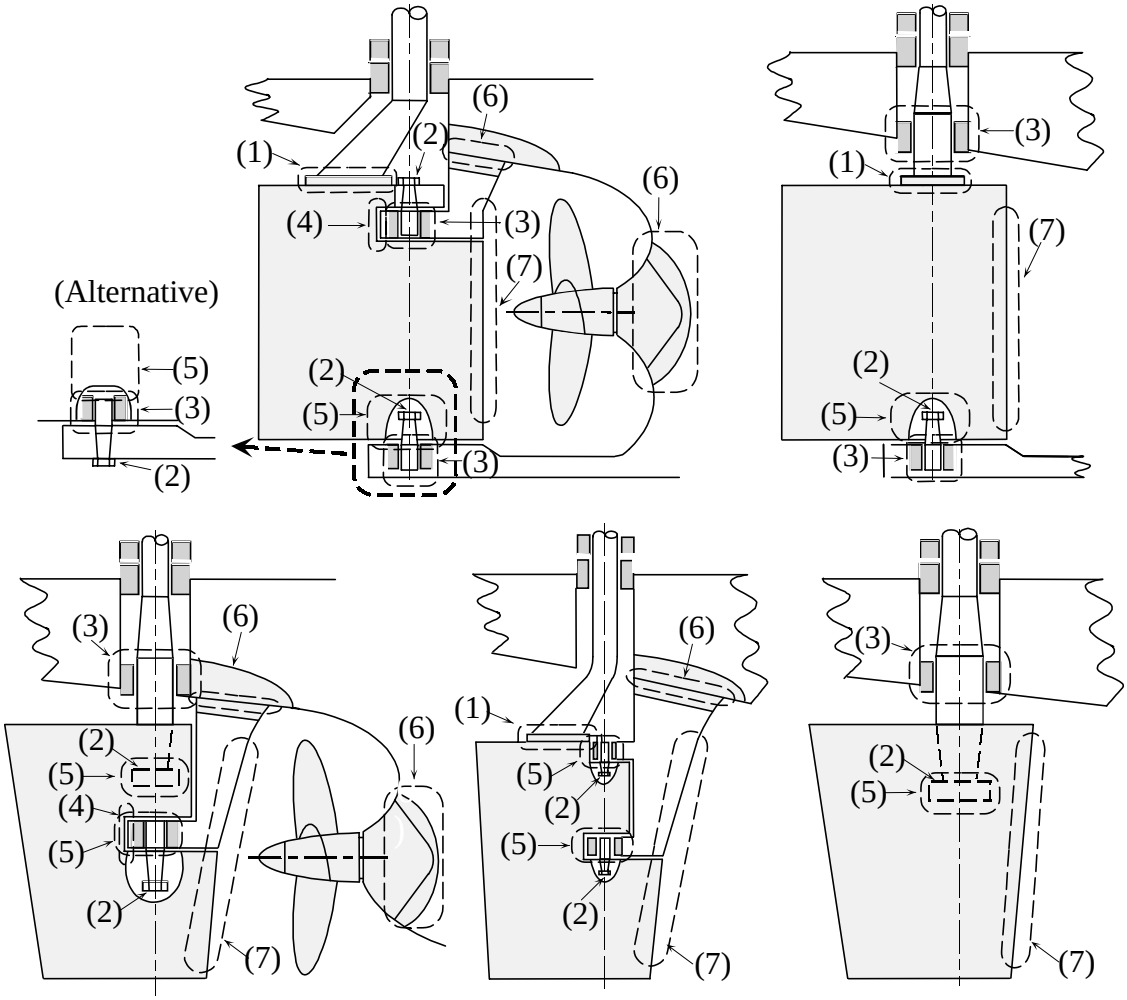
Nomenclature

(00)Rudder carrier (01)Rudder trunk (10)Rudder stock (11)Carrier bearing
(12)Neck bearing (13)Horizontal coupling(Flange coupling) (14)Cone coupling
(20)Rudder blade (21)Upper pintle (22)Upper pintle bearing
(30)Rudder horn (31)Horn pintle (32)Horn pintle bearing
(40)Sole piece (41)Bottom pintle (42)Bottom pintle bearing
(50)Bush (51)Sleeve(Liner)
(60)Propeller boss(Stern tube casting) (70)Propeller shaft bracket(Tail shaft strut)



(d) Twin propellers support arrangement

Figure 1 Nomenclature for stern frame, rudder arrangement and propeller shaft support



Damage to look for:
(1)Fractures and loose coupling bolts
(2)Loose nut
(3)Wear(excessive bearing clearance)
(4)Fractures in way of pintle cutout
(5)Fractures in way of removable access plate
(6)Fractures
(7)Erosion

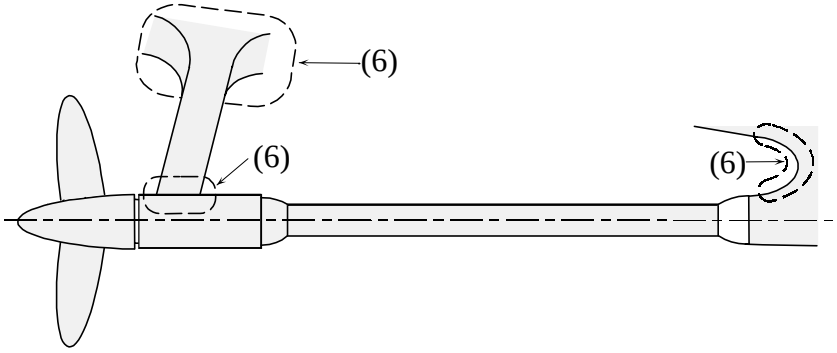


Figure 2 Potential problem areas

2 What to look for - Drydock inspection

2.1 Deformations

2.1.1 Rudder blade, rudder stock, rudder horn and propeller boss/brackets have to be checked for deformations.

2.1.2 Indications of deformation of rudder stock/rudder horn could be found by excessive clearance.

2.1.3 Possible twisting deformation or slipping of cone connection can be observed by the difference in angle between rudder and tiller.

2.1.4 If bending or twisting deformation is found, the rudder has to be dismounted for further inspection.

2.2 Fractures

2.2.1 Fractures in rudder plating should be looked for at slot welds, welds of removable part to the rudder blade, and welds of the access plate in case of vertical cone coupling between rudder blade and rudder stock and/or pintle. Such welds may have latent defects due to the limited applicable welding procedure. Serious fractures in rudder plating may cause loss of rudder.

2.2.2 Fractures should be looked for at weld connection between rudder horn, propeller boss and propeller shaft brackets, and stern frame.

2.2.3 Fractures should be looked for at the upper and lower corners in way of the pintle recess in case of semi-spade rudders. Typical fractures are shown in **Examples 3** to **5**.

2.2.4 Fractures should be looked for at the transition radius between rudder stock and horizontal coupling (palm) plate, and the connection between horizontal coupling plate and rudder blade in case of horizontal coupling. Typical fractures are shown in **Examples 1** and **2**. Fatigue fractures should be looked for at the palm plate itself in case of loosened or lost coupling bolts.

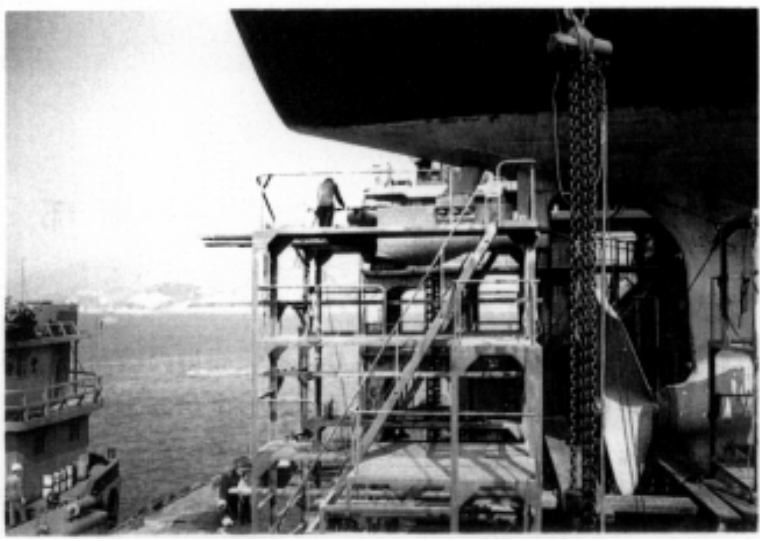
2.2.5 Fractures should be looked for in the rudder plating in way of the internal stiffening structures since (resonant) vibrations of the plating may have occurred.

2.2.6 If the rudder stock is deformed, fractures should be looked for in rudder stock by nondestructive examinations before commencing repair measures, in particular in and around the keyway, if any.

2.3 Corrosion/Erosion/Abrasion

2.3.1 Corrosion/erosion (such as deep pitting corrosion) should be looked for in rudder/rudder horn plating, especially in welds. In extreme cases the corrosion /erosion may cause a large fracture as shown in **Photograph**

1.



Photograph 1
Fractured rudder

2.3.2 The following should be looked for on rudder stock and pintle:
- Excessive clearance between sleeve and bush of rudder stock/pintle beyond the allowable limit specified by the Classification Society.
- Condition of sleeve. If the sleeve is loose, ingress of water may have caused corrosion.
- Deep pitting corrosion in the rudder stock and pintle adjacent to the stainless steel sleeve.
- Slipping of rudder stock cone coupling. For a vertical cone coupling with hydraulic pressure connection, sliding of the rudder stock cone in the cast piece may cause severe surface damages.
- Where a stainless steel liner/sleeve/cladding for the pintle/rudder stock is fitted into a stainless steel bush, an additional check should be made for crevice corrosion.

3 General comments on repair

3.1 Rudder stock and pintles

3.1.1 If rudder stock is twisted due to excessive forces such as contact or grounding and has no additional damages (fractures etc.) or other significant deformation, the stock usually can be used. The need for repair or heat treatment of the stock will depend on the amount of twist in the stock according to the requirements of BCS. The keyway, if any, has to be milled in a new position.

3.1.2 Rudder stocks with bending deformations, not having any fractures may be repaired depending on the size of the deformation either by warm or by cold straightening in an approved workshop according to a procedure approved by BCS. In case of warm straightening, as a guideline, the temperature should usually not exceed the heat treatment temperature of 530-580°C.

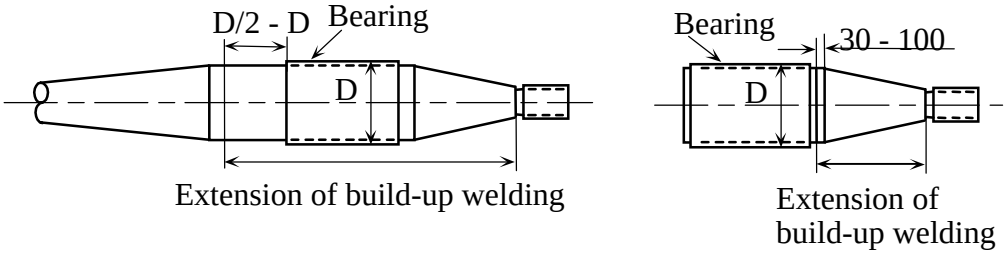
3.1.3 In case of fractures on a rudder stock with deformations, the stock may be used again depending on the nature and extent of the fractures. If a welding repair is considered acceptable, the fractures are to be removed by machining/grinding and the welding is to be based on an approved welding procedure together with post weld heat treatment as required by BCS.

3.1.4 Rudder stocks and/or pintles may be repaired by welding replacing wasted material by similar weld material provided its chemical composition is suitable for welding, i.e. the carbon content must usually not exceed 0.25%. The welding procedures are to be identified in function of the carbon equivalent (Ceq). After removal of the wasted area (corrosion, scratches, etc.) by machining and/or grinding the build-up welding has to be carried out by an automatic spiral welding according to an approved welding procedure. The welding has to be extended over the area of large bending moments (rudder stocks). In special cases post weld heat treatment has to be carried out according to the requirements of BCS. After final machining, a sufficient number of layers of welding material have to remain on the rudder stock/pintle. A summary of the most important steps and conditions of this repair is shown in the **Figure 3**.

3.1.5 In case of rudder stocks with bending loads, fatigue fractures in way of the transition radius between the rudder stock and the horizontal coupling plate can not be repaired by local welding. A new rudder stock with a modified transition geometry has to be manufactured, as a rule (See **Example 1**). In exceptional cases a welding repair can be carried out based on an approved welding procedure. Measures have to be taken to avoid a coincidence of the metallurgical notch of the heat affected zone with the stress concentration in the radius' area. Additional surveys of the repair (including non-destructive fracture examination) have to be carried out in reduced intervals.

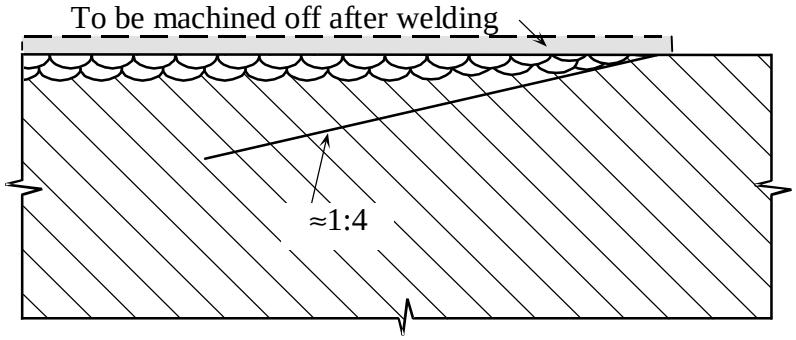
Replacing wasted material by similar ordinary weld material

- Removal of the wasted area by machining and/or grinding, non-destructive examination for fractures (magnetic particle inspection preferred)
- Build-up welding by automatic spiral welding (turning device) according to an approved welding procedure (weld process, preheating, welding consumables, etc.)
- Extension of build-up welding over the area of **large bending moments** (**shafts**) according to the sketch



Rudder stock **Pintle**

- Sufficient number of weld layers to compensate removed material, at least one layer in excess (heat treatment of the remaining layer)
- Transition at the end of the build-up welding according to the following sketch



- Post weld heat treatment if required in special cases (never for stainless steel cladding on ordinary steel)
- Final machining, at least two layers of welding material have to remain on the rudder stock (See the above sketch)
- Non-destructive fracture examination

Figure 3 Rudder stock repair by welding

3.2 Plate structure

3.2.1 Fatigue fractures in welding seams (butt welds) caused by welding failures (lack of fusion) can be gouged out and rewelded with proper root penetration.

3.2.2 In case of fractures, probably caused by (resonant) vibration, vibration analysis of the rudder plating has to be performed, and design modifications have to be carried out in order to change the natural frequency of plate field.

3.2.3 Short fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that do not propagate into vertical or horizontal stiffening structures may be repaired by gouging out and welding. The procedure according to **Example 3** should be preferred.

In case of longer fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that propagate over a longer distance into the plating, thorough check of the internal structures has to be carried out. The fractured parts of the plating and of the internal structures, if necessary, have to be replaced by insert plates. A proper welding connection between the insert plate and the internal stiffening structure is very important (See **Examples 4** and **5**).

The area of the pintle recess corners has to be ground smooth after the repair. In many cases a modification of the radius, an increased thickness of plating and an enhanced steel quality may be necessary.

3.2.4 For the fractures at the connection between plating and cast pieces an adequate preheating is necessary. The preheating temperature is to be determined taking into account the following parameters:

- chemical composition (carbon equivalent C_{eq})
- thickness of the structure
- hydrogen content in the welding consumables
- heat input

3.2.5 As a guide, the preheating temperature can be obtained from **Diagram 1** using the plate thickness and carbon equivalent of the thicker structure.

3.2.6 All welding repairs are to be carried out using qualified/approved welding procedures.

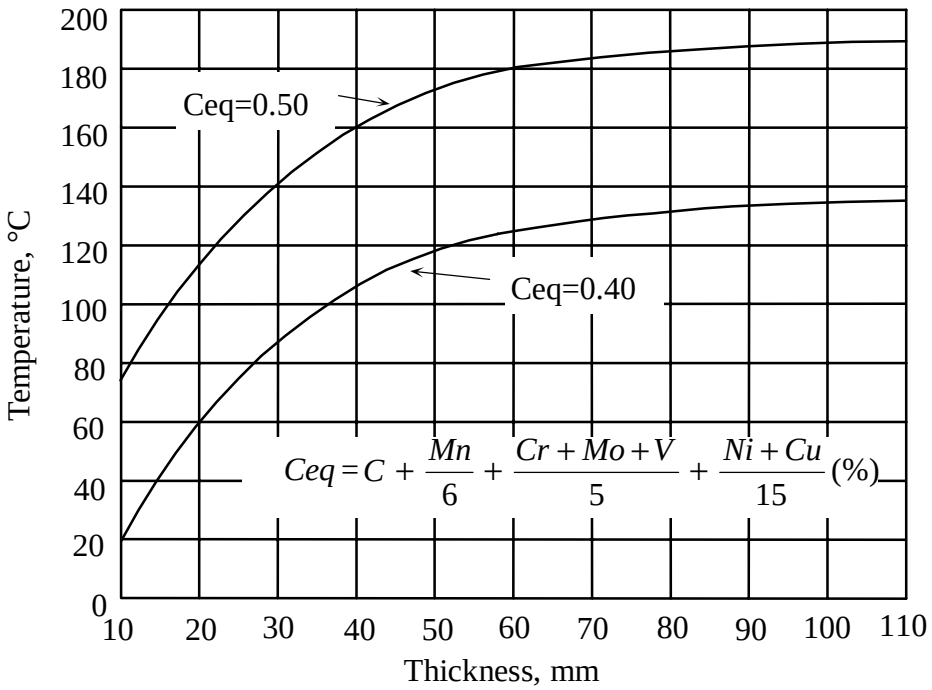


Diagram 1 Preheating temperature

3.3 Abrasion of bush and sleeve

Abrasion rate depends on the features of the ship such as frequency of maneuvering. However, if excessive clearance is found within a short period, e.g. 5 years, alignment of the rudder arrangement and the matching of the materials for sleeve and bush should be examined together with the replacement of the bush.

3.4 Assembling of rudders

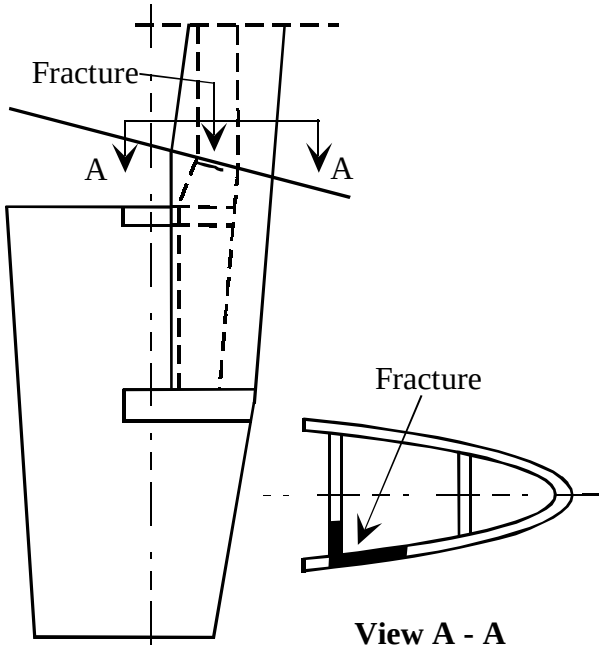
After mounting of all parts of the rudder, nuts of rudder stocks with vertical cone coupling plates and nuts of pintles are to be effectively secured. In case of horizontal couplings, bolts and their nuts are to be secured either against each other or both against the coupling plates.

3.5 Propeller boss and stern tube

Repair examples for propeller boss and stern tube are shown in **Examples 7**and **8.** Regarding the welding reference is made to **3.1.4**, **3.2.4** and **3.2.5**.

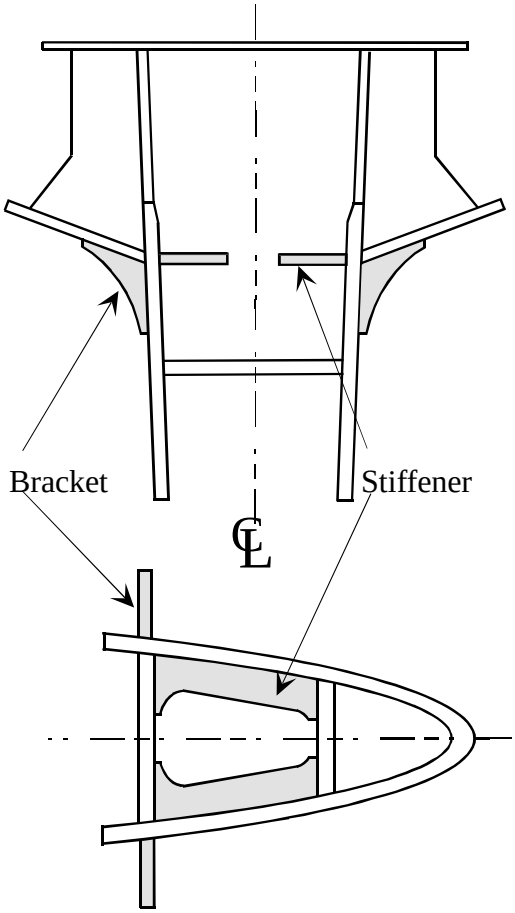
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	1
Detail of damage	Fractures in rudder horn along bottom shell plating	

Sketch of damage



View A - A

Sketch of repair



Notes on possible cause of damage

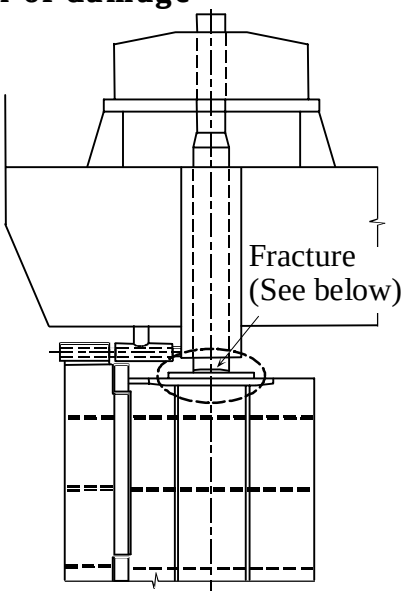
1. Insufficient strength due to poor design.

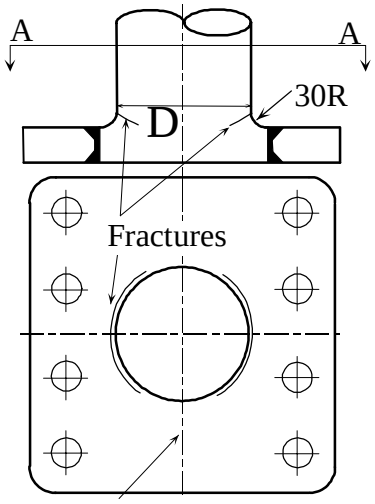
Notes on repairs

1. Fractured plating to be veed-out and rewelded.
2. Fractured plating to be cropped and renewed if considered necessary.
3. Reinforcement should be considered if considered necessary.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	2
Detail of damage	Fractures in rudder stock	

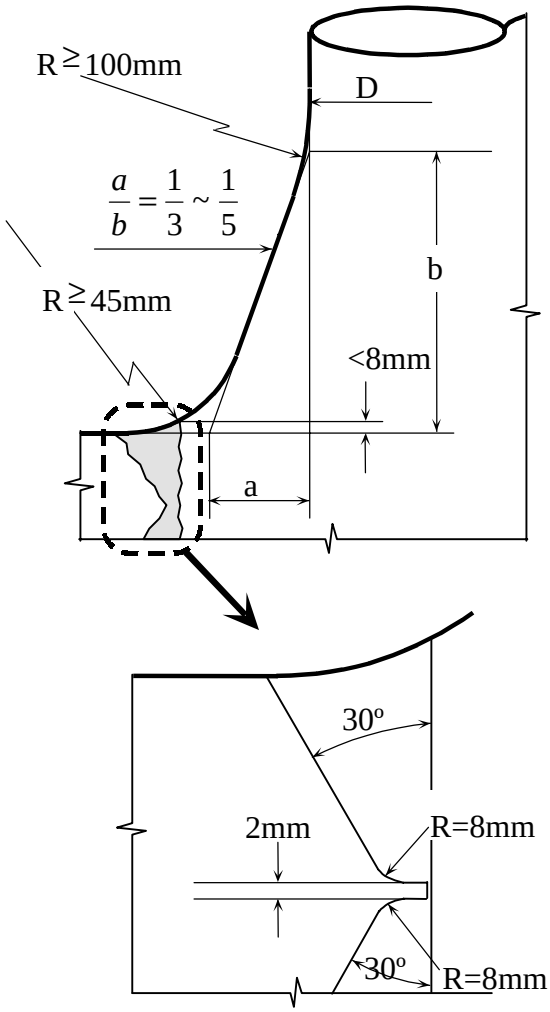
Sketch of damage





View A - A

Sketch of repair



Notes on possible cause of damage

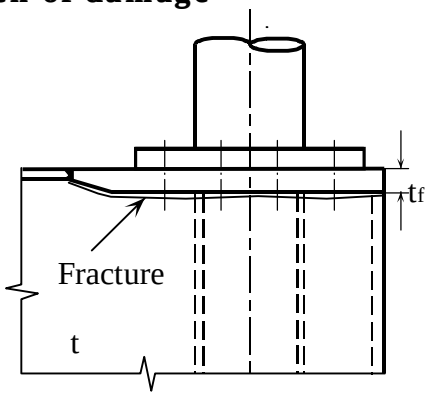
1. Inadequate design for stress concentration in rudder stock.

Notes on repairs

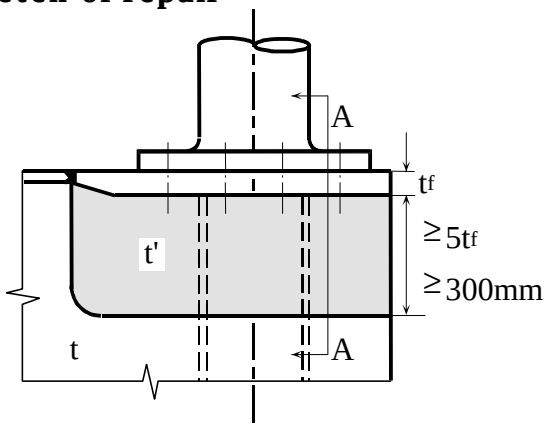
1. Modification of detail design of rudder stock to reduce the stress concentration.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	3
Detail of damage	Fractures in connection of palm plate to rudder blade	

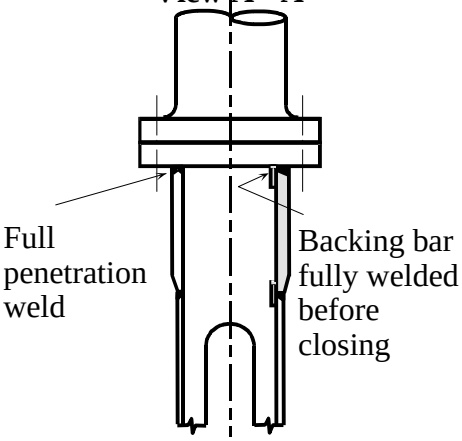
Sketch of damage



Sketch of repair



View A - A



t = plate thickness, mm

t_f = actual flange thickness, mm

$t = \frac{tf}{3} + 5$, mm, where $t_f \leq 50$mm

$t = 3\sqrt{tf}$, mm, where $t_f \geq 50$mm

Notes on possible cause of damage

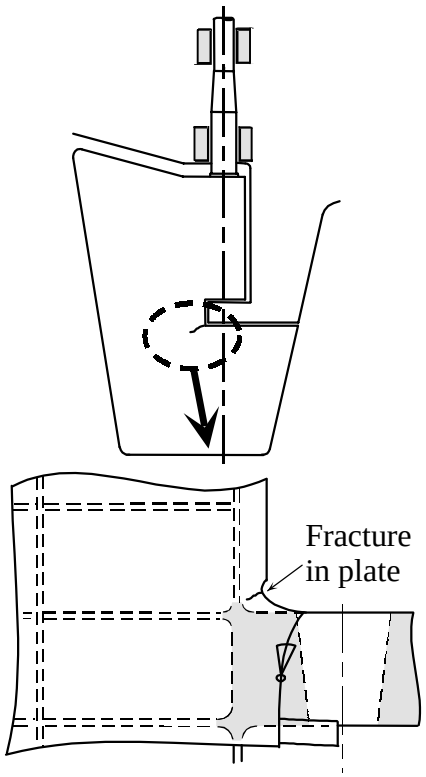
1. Inadequate connection between palm plate and rudder blade plating (insufficient plating thickness and/or insufficient fillet weld).

Notes on repairs

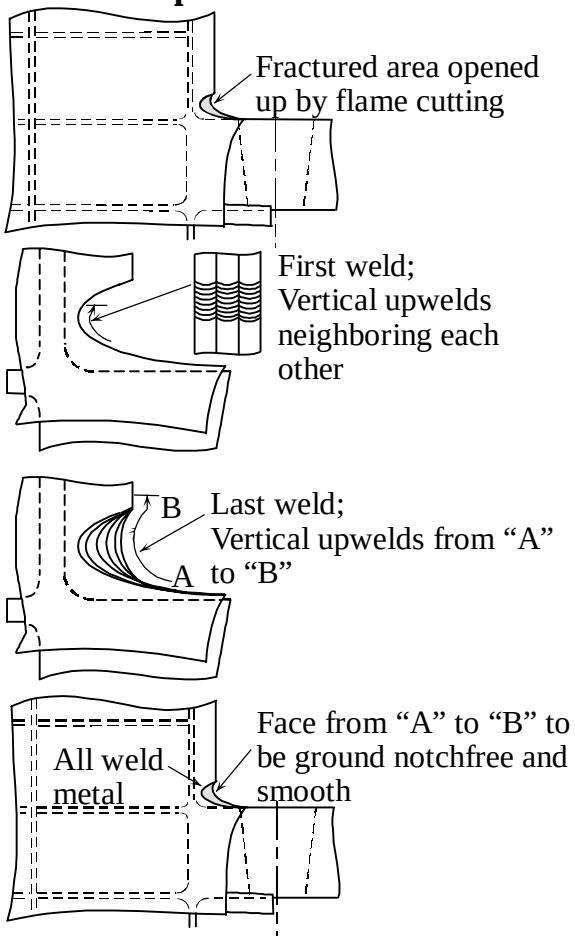
1. Modification of detail design of the connection by increasing the plate thickness and full penetration welding.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	4
Detail of damage	Fractures in rudder plating of semi-spade rudder (short fracture with end located forward of the vertical web)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

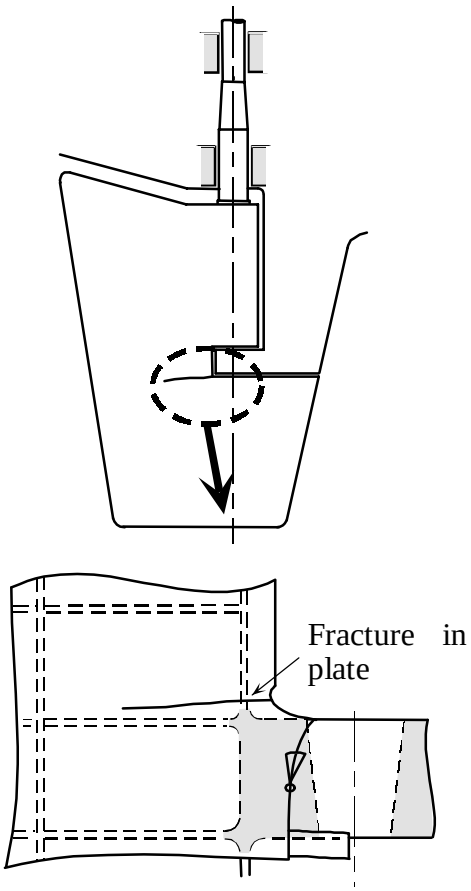
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

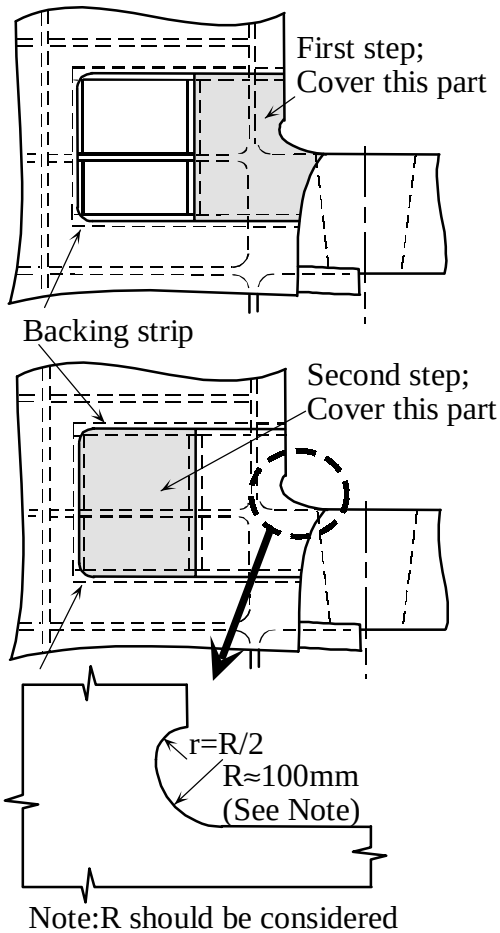
1. Grooving-out and welding of the fracture is not always adequate (metallurgical notch in way of a high stressed area).
2. In the proposed repair procedure the metallurgical notches are shifted into a zone exposed to lower stresses.
3. After welding a modification of the radius according to the proposal in **Example 5** is to be carried out.
4. In case of very small crack it can be ground off by increasing the radius.

GENERAL CARGO SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	5
Detail of damage	Fractures in rudder plating of semi-spade rudder extending beyond the vertical web	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

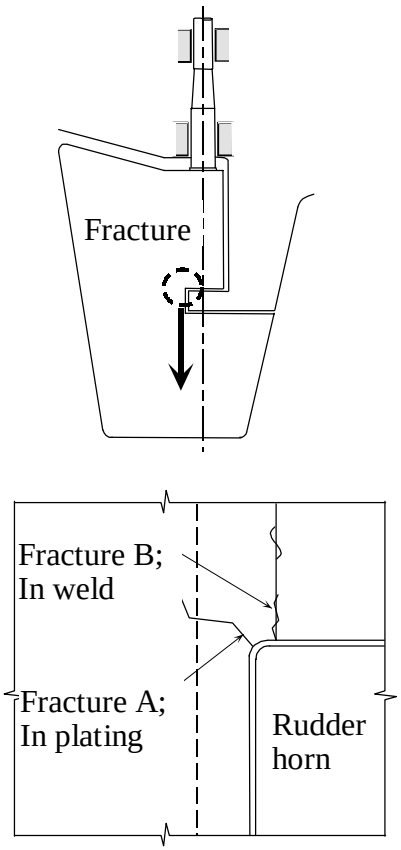
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

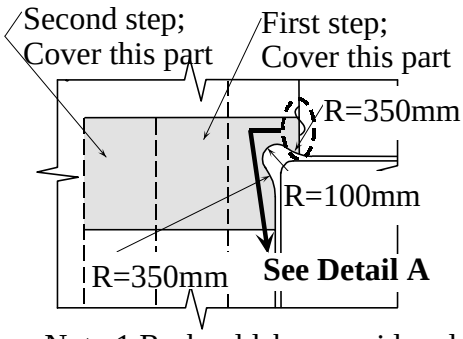
1. Fractured plating is to be cut-out.
2. Internal structures are to be checked.
3. Cut-out is to be closed by an insert plating according to the sketch (welding only from one side is demonstrated).
4. Modification of the radius.
5. In case of a new cast piece, connection with the plating is to be shifted outside the high stress area.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	6
Detail of damage	Fractures in rudder plating of semi-spade rudder in way of pintle cutout	

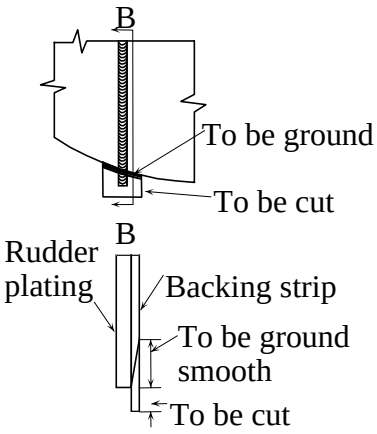
Sketch of damage



Sketch of repair



Note:1.R should be considered according to local detail
2.New contour should be ground smooth



View B - B

Notes on possible cause of damage

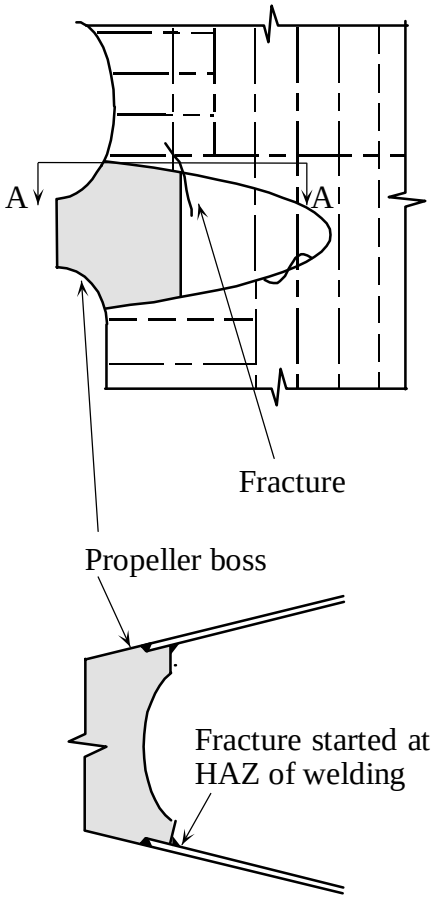
1. Inadequate design for stress concentration in way of pintle bearing (**Fracture A**).
2. Imperfection in welding seam (**Fracture B**).

Notes on repairs

1. Fractured part to be cropped off.
2. Repair by two insert plates of modified, stress releasing contour. For the vertical seam no backing strip is used 100mm off contour, welding from both sides, to be ground after welding.
3. Variant (See **Detail A**): Repair as mentioned under 2 with the use of backing strip for the compete vertical seam. After welding backing strip partly removed by grinding.

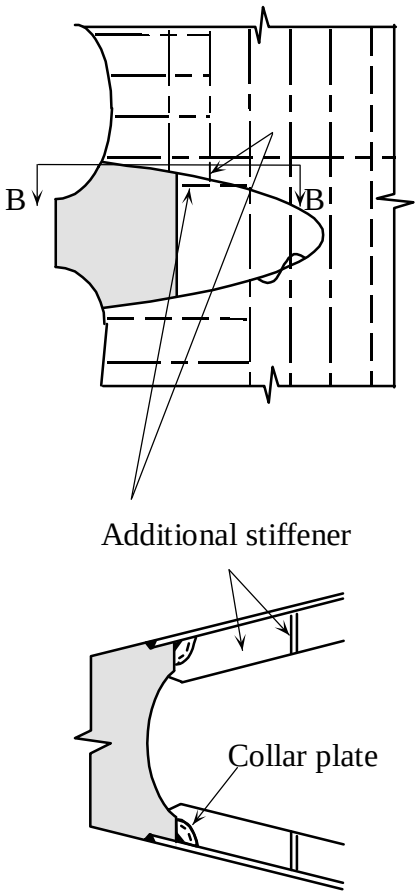
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	7
Detail of damage	Fractures in side shell plating at the connection to propeller boss	

Sketch of damage



View A - A

Sketch of repair



View B - B

Notes on possible cause of damage

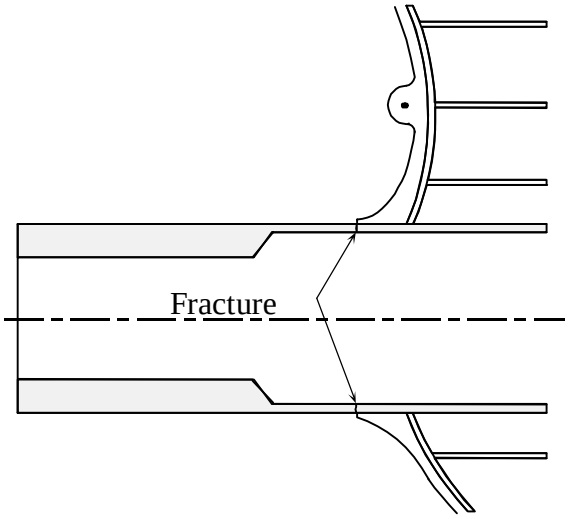
1. Fatigue fracture due to vibration.

Notes on repairs

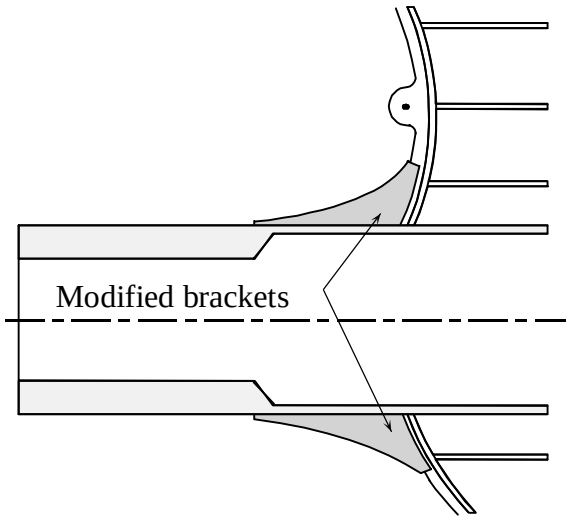
1. Fractured side shell plating is to be cropped and part renewed.
2. Additional stiffeners are to be provided.
3. Collar plate is to be provided.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	8
Detail of damage	Fractures in stern tube at the connection to stern frame	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Fatigue fracture due to vibration.

Notes on repairs

1. Fractured tube is to be veed-out and welded from both sides.
2. Brackets are to be replaced by modified brackets with soft transition.

Part 3 Machinery and accommodation spaces

Contents

Area 1 Engine room structure
Area 2 Accommodation structure

Area 1 Engine room structure

Contents

1 General

2 What to look for - Engine room inspection
2.1 Material wastage
2.2 Fractures

3 What to look for - Tank inspection
3.1 Material wastage
3.2 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Fractures

Examples of structural detail failures and repairs - Area 1	
Example No.	**Title**
1	Fractures in brackets at main engine foundation
2	Corrosion in bottom plating under sounding pipe in way of bilge storage tank
3	Corrosion in bottom plating under inlet/suction pipe in way of bilge storage tank

1 General

The engine room structure is categorized as follows:

- Boundary structure which consists of upper deck, bulkhead, inner bottom plating, funnel, etc.
- Deep tank structure
- Double bottom tank structure

The boundary structure can generally be inspected routinely and therefore any damages found can usually be easily rectified. Deep tank and double bottom structures, owing to access difficulties, generally cannot be inspected routinely. Damage of these structures is usually only found during dry docking or when a leakage is in evidence.

2 What to look for - Engine room inspection

2.1 Material wastage

2.1.1 Tank top plating, shell plating and bulkhead plating adjacent to the tank top plating may suffer severe corrosion caused by leakage or lack of maintenance of sea water lines.

2.1.2 Bilge well should be cleaned and inspected carefully for heavy pitting corrosion caused by sea water leakage at gland packing or maintenance operation of machinery.

2.1.3 Part of the funnel forming the boundary structure often suffer severe corrosion which may impair fire fighting in engine room and weathertightness.

3 What to look for - Tank inspection

3.1 Material wastage

3.1.1 The environment in bilge tanks, where mixture of oily residue and seawater is accumulated, is more corrosive when compared to other double bottom tanks. Severe corrosion may result in holes in the bottom plating, especially under sounding pipe. Pitting corrosion caused by seawater entered from air pipe is seldom found in cofferdam spaces.

3.2 Fractures

3.2.1 In general, deep tanks for fresh water or fuel oil are located in engine room. The structure in these tanks often sustains fractures due to vibration. Fracture of double bottom structure in engine room is seldom found due to its high structural rigidity.

4 General comments on repair

4.1 Material wastage

4.1.1 Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed.

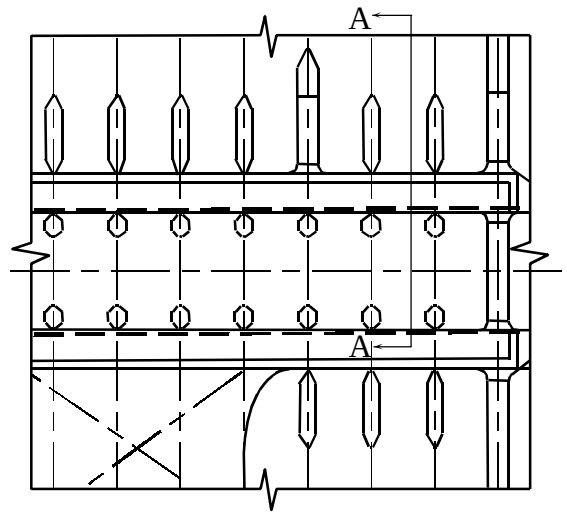
Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

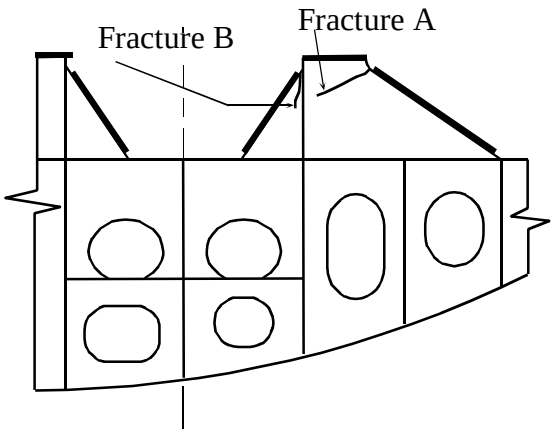
4.2 Fractures

4.2.1 For fatigue fractures caused by vibration, in additional to the normal repair of the fractures, consideration should be given to modification of the natural frequency of the structure to avoid resonance. This may be achieved by providing additional structural reinforcement, however, in many cases, a number of tentative tests may be required to reach the desired solution.

BILK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	1
Detail of damage	Fractures in brackets at main engine foundation	

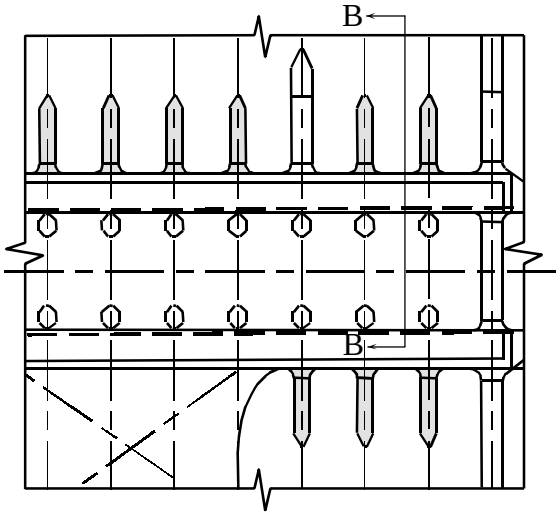
Sketch of damage

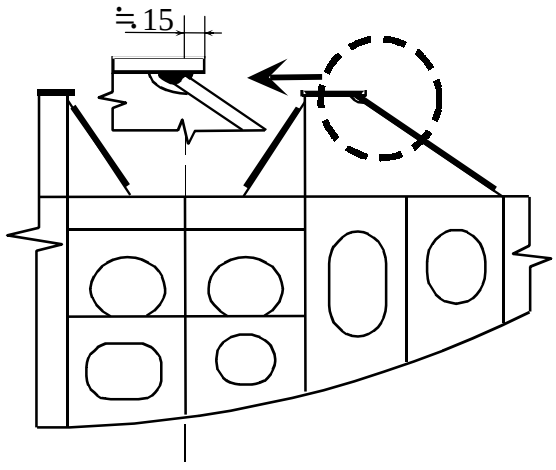




View A - A

Sketch of repair





View B - B

Notes on possible cause of damage

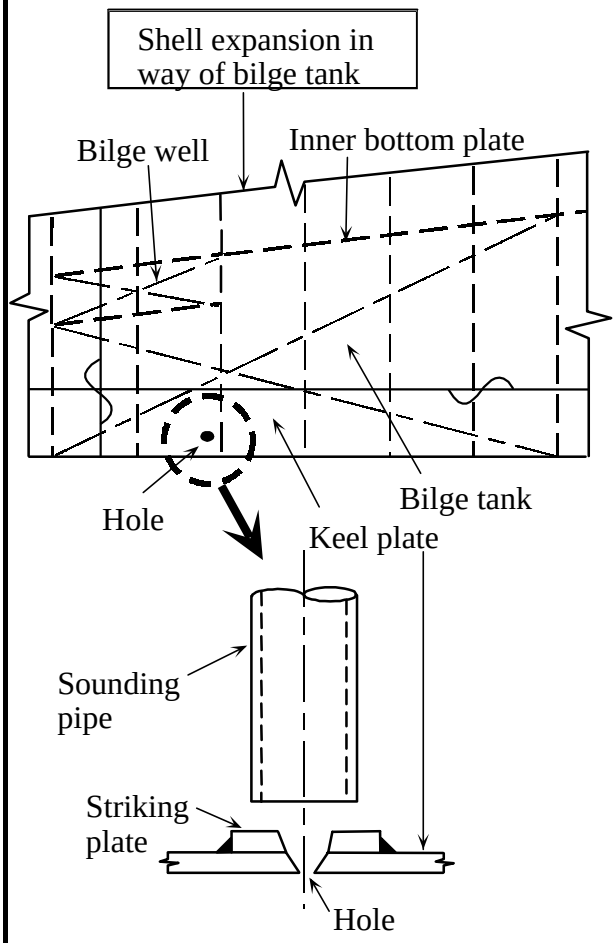
1. Vibration of main engine.
2. Insufficient strength of brackets at main engine foundation.
3. Insufficient pre-load bolts.

Notes on repairs

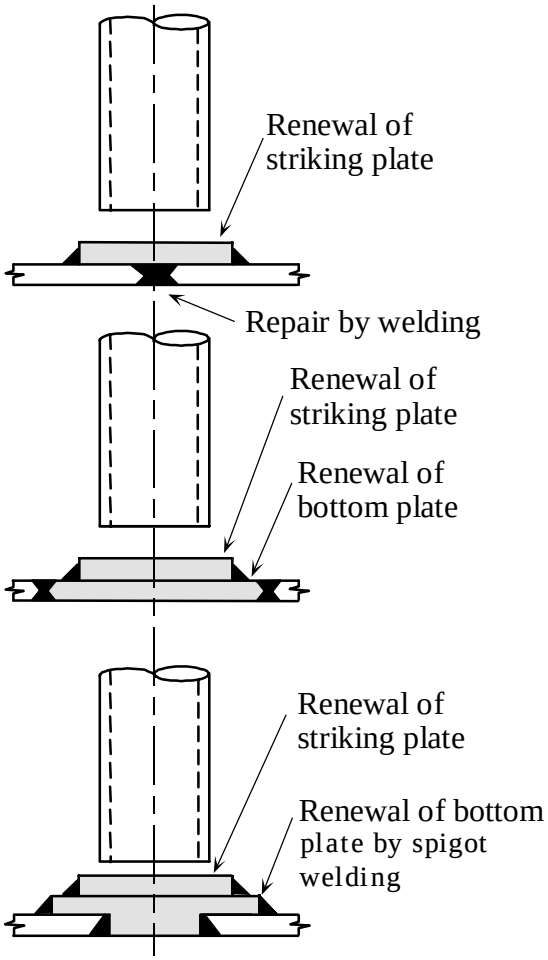
1. Fractures are to be veed-out and rewelded.
2. New modified brackets at main engine foundation.
3. Or insert pieces and additional flanges to increase section modulus of the brackets.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	2
Detail of damage	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion of bottom plating under sounding pipe.

Notes on repairs

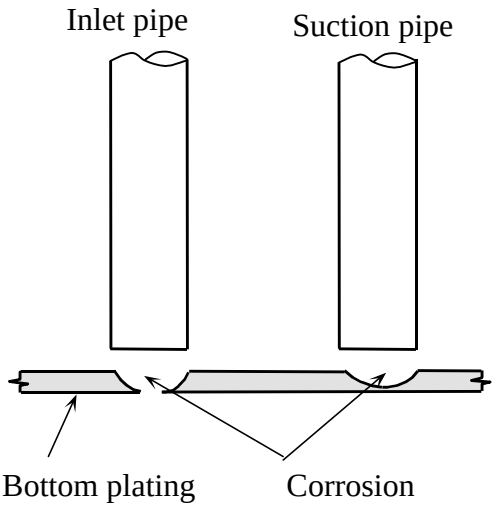
1. Corroded striking plating should be renewed.
2. Bottom plate should be repaired depending on the condition of corrosion.

   (Note)

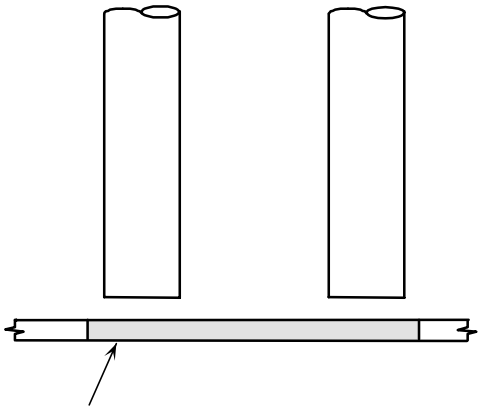
   Repair by spigot welding can be applied to the structure only when the stress level is considerably low. Generally this procedure cannot be applied to the repair of bottom plating of ballast tanks in cargo hold region.

BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	3
Detail of damage	Corrosion in bottom plating under inlet/suction/pipe in way of bilge tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion of bottom plating under the inlet/suction pipe.

Notes on repairs

1. Corroded bottom plating is to be cropped and part renewed. Thicker plate is preferable.
2. Replacement of pipe end by enlarged conical opening (similar to suction head in ballast tank) is preferable.

Area 2 Accommodation structure

Contents

1 General

Figures and/or Photographs - Area 1	
No.	**Title**
Photograph 1	Corroded accommodation house side structure

1 General

Corrosion is the main concern in accommodation structure and deck houses of aging ships. Owing to the lesser thickness of the structure plating, corrosion can propagate through the thickness of the plating resulting in holes in the structure.

Severe corrosion may be found in exposed deck plating and deck house side structure adjacent to the deck plating where water is liable to accumulate (See **Photograph 1**). Corrosion may also be found in accommodation bulkheads around cutout for fittings, such as doors, side scuttles, ventilators, etc., where proper maintenance of the area is relatively difficult. Deterioration of the bulkheads including fittings may impair the integrity of weathertightness.
Fatigue fractures caused by vibration may be found, in the structure itself and in various stays of the structure~~s~~, mast, antenna etc. For such fractures, consideration should be given to modify the natural frequency of the structure by providing additional reinforcement during repair.

Photograph 1 Corroded accommodation house side structure

BCS- G77 Guidelines for the Surveyor on how to Control the Thickness Measurement Process

ITL- PR 19 stipulates that:

> *"1. Thickness measurements required in the context of hull structural classification surveys, if not carried out by BCS itself shall be witnessed by a surveyor. The attendance of the surveyor shall be recorded.*
>
> *2. This requires the surveyor to be on board, while the gaugings are taken, to the extent necessary to control the process [See Note 1].*
>
> ***2.1 Survey meeting***
>
> *Prior to commencement of the Intermediate or Special survey, as required by BCS- R Z7 , R Z7.1, R Z7.2, R Z10s or R Z15, a meeting is to be held between the attending surveyor(s), the master of the ship or mobile offshore unit or an appropriately qualified representative appointed by the master or Company, the owner's representative(s) in attendance and the thickness measurement firm's representative(s) so as to ensure the safe and efficient execution of the surveys and thickness measurements to be carried out onboard."*

It is recommended that thickness measurements should be carried out in a single operation, by one thickness measurement firm. If, however, thickness measurements are carried out in several operations during the allowable period for the survey and/or by different thickness measurement firms, separate survey meetings should be held at each time.

Items that should be addressed and agreed in this meeting are among others:

1.1 schedule for thickness measurements;

1.2 provisions for thickness measurements (personal safety, means of access, cleaning and de-scaling as appropriate, illumination, ventilation);

1.3 planned scope of survey:

- mandatory extent of thickness measurements (according to classification rules)
- areas subject to close-up surveys and thickness measurements including areas previously identified with substantial corrosion, if applicable.

1.4 availability onboard of drawings with original scantlings;

1.5 allowable thickness diminution;

1.6 taking representative readings in general and where uneven corrosion / pitting is found;

1.7 procedure for additional readings of areas with substantial corrosion, if applicable (according to classification rules);

1.8 communication between surveyor(s), thickness measurement operator(s) and owner's representative(s):

- reporting of thickness measurements on regular basis;

- prompt notification of the surveyor in case of findings;
- excessive [See Note 2] and/or extensive [See Note 3] corrosion or pitting / grooving of any significance;
- structural defects like buckling, fractures and deformed structures;
- detached and/or holed structure;
- corrosion of welds;

1.9 the thickness measurement firm should provide information related to:

- equipment to be used;
- personnel records of operators scheduled for thickness measurements onboard.

1.10 documented record of the survey meeting.

2. MONITORING OF THE THICKNESS MEASUREMENT PROCESS ONBOARD

The surveyor should decide final extent and location of thickness measurements after overall survey of representative spaces onboard. In case the owner prefers to commence the thickness measurements prior to the overall survey then the surveyor shall advise that the planned extent and locations of thickness measurements are subject to confirmation during the overall survey. Based on findings, the surveyor may require that additional thickness measurements have to be taken.

2.1 Prior to commencing the thickness measurements, the surveyor should:

- check type of equipment and verify that equipment is calibrated according to recognized national / international standards and properly labelled;
- witness calibration appropriate for size and type of material;
- be satisfied with operator's skills and competence;
- ensure that the thickness measurement operator will be using instruments using pulsed echo technique (either with oscilloscope or digital instruments using multiple echo). Single echo instruments may be used on uncoated surfaces, which have been properly cleaned.

2.2 The surveyor should direct the gauging operation by selecting locations such that readings taken represent, on average, the condition of the structure for that area.

2.3 Thickness measurements mainly to evaluate the extent of corrosion, which may affect the hull girder strength, should be carried out in a systematic manner of all longitudinal structural members. The surveyor should be in attendance during this process.

2.4 Thickness measurements of structures in areas where close-up surveys are required shall be carried out simultaneously with the close-up surveys in order to facilitate a meaningful survey.

2.5 The surveyor may specially consider the extent of thickness measurements of structures within spaces where the protective coating is found to be in GOOD condition.

2.6 Where thickness measurements indicate substantial corrosion or excessive diminution the surveyor should direct locations for additional thickness measurements in order to delineate areas of substantial corrosion and to identify structural members for repairs / renewals.

3. REVIEW AND VERIFICATION

3.1 Upon completion of the thickness measurements, the surveyor should confirm that no further gaugings are needed, or specify additional gaugings.

3.2 If extent of thickness measurements have been reduced, the surveyor's special consideration should be reported.

3.3 In case thickness measurements are partly carried out, the extent of remaining thickness measurements should be reported for the use of the next surveyor.

3.4 Surveyor should confirm that the proper thickness measurement reporting forms were used if the ship is under the ESP programme.

3.5 Upon completion of the thickness measurements onboard, the surveyor should verify and keep a copy of the preliminary thickness measurement report signed by the operator.

3.6 Upon review that the final gauging report is consistent with the preliminary report, the Surveyor is to countersign the cover page of the final report. The Surveyor should keep the preliminary report, as a minimum, until the review is completed.

Note:

1) It is confirmed that this also applies to thickness measurements taken during voyages.

2) Excessive corrosion is an extent of corrosion that exceeds the allowable limit.

3) Extensive corrosion is an extent of corrosion consisting of hard and/or loose scale, including pitting, over 70% or more of the area under consideration, accompanied by evidence of thickness diminution.

BCS- G 78 Safe Use of Portable Ladders for Close-up Surveys

1. The Owner should ensure that equipment selected for temporary work affords adequate protection against the risks of falls from a height.

2. The manner is which portable ladders can most safely be used by workers should be specified.

3. Portable ladders should rest on a stable, strong, suitably sized, immobile footing so that the rungs remain horizontal. Suspended ladders should be attached in a manner so that they can not be displaced and so that swinging is prevented.

4. The feet of portable ladders should be prevented from slipping during use by securing the stiles at or near their upper and lower ends, by any anti-slip device or by other arrangements of equivalent effectiveness. Slip resistant feet should not be used as substitute for the care in placing, lashing or holding a ladder upon slippery surface.

5. Portable ladders should meet the following criteria:

- Not more than 5 m in length for freestanding portable ladders.
- Non-self supporting and self-supporting portable ladders should support at least four times the maximum intended load.
- The minimum clear distance between side rails for all portable ladders should be according to a recognized standard.
- The rungs and steps of portable ladders should be designed to minimise slipping, e.g. corrugated, knurled, dimpled, coated with skid resistance material.

6. Ladders should be maintained free of oil, grease and other slipping hazards.

Guidance on the ISPS Code for Maritime Security Auditors

Introduction

1. Scope and Application

This guidance is intended for use by BCS's auditors when performing certification audits under the ISPS Code, unless the relevant Administration has provided special instructions that indicate otherwise.

This document is also intended to facilitate audits' consistency and uniformity by providing examples, which, however are not to be interpreted as prescriptive solutions or checklists.

Reference is made to the following documents adopted by the International Maritime Organisation (IMO):

- SOLAS Chapter V
- SOLAS XI-1 and XI-2
- ISPS Code Parts A and B

The ISPS Code comprises Parts A and B. IMO has defined Part A as mandatory, Part B as Guidance to the Provisions of SOLAS Chapter XI-2 and Part A.of the ISPS Code. It is considered that it is not possible to implement the provisions of part A without application of the relevant sections of Part B. In this regard , part B is to be considered mandatory by BCS auditors.

The term "should" when used in the above documents shall be taken to mean the same as "shall" and be construed to be a mandatory requirement.

2. Application of the ISPS Code by Companies

By design, the ISPS Code supports and encourages the development of a security culture in shipping. The content of the Ship Security Assessment and Security Plan will therefore be affected by the Company commitment, values and beliefs that cannot be enforced through the regulatory process. In carrying out the Ship Security Assessment (SSA) and developing the Ship Security Plan (SSP) Companies will have used guidance from Administrations, Industry Groups, the Societies and armed forces.

As with the ISM Code, assessing detailed compliance from detailed prescriptive management system solutions is not practical and is inconsistent with the concept of risk based approach. Each Company will develop solutions for its ships, individually tailored to meet their unique needs and trading patterns, whilst meeting internationally agreed standards for maritime security.

As an auditor, it is important to recognise that each Company develops and maintains a security management system that is most appropriate for the Company and their particular ships.

3. Certification Process

The verification of compliance with the mandatory rules and regulations, required as part of the ISPS Code, neither duplicates nor replaces the surveys required by other statutory surveys. Compliance with the ISPS Code does not relieve the Company, the Master or any other entity or

person involved in the management or operation of the ship of their responsibilities.

The verification process of compliance with the ISPS Code is an audit process involves interviews of shipboard personnel and a review of security assessment and Plan documentation and associated records. Audit is a sampling process and is not exhaustive in nature. Issuance of certification is based upon verification that the sample taken demonstrates that the security system and any associated security equipment of the ship is in all respects satisfactory and that the ship complies with the applicable requirements of Chapter XI-2 of the Convention and Part A of the ISPS Code.

4. Editorial Principles

For convenience, this document incorporates the actual text of Part A and part B of the ISPS Code, followed by the relevant recommended guidance for BCS auditors. The document will be updated as necessary consistent with BCS' experience in the audit process.

CHAPTER XI-2
SPECIAL MEASURES TO ENHANCE MARITIME SECURITY

Regulation 1
Definitions

1 For the purpose of this chapter, unless expressly provided otherwise:

.1 *Bulk carrier* means a bulk carrier as defined in regulation IX/1.6.

.2 *Chemical tanker* means a chemical tanker as defined in regulation VII/8.2.

.3 *Gas carrier* means a gas carrier as defined in regulation VII/11.2.

.4 *High-speed craft* means a craft as defined in regulation X/1.2.

.5 *Mobile offshore drilling unit* means a mechanically propelled mobile offshore drilling unit, as defined in regulation IX/1, not on location.

.6 *Oil tanker* means an oil tanker as defined in regulation II-1/2.12.

.7 *Company* means a Company as defined in regulation IX/1.

.8 *Ship/port interface* means the interactions that occur when a ship is directly and immediately affected by actions involving the movement of persons, goods or the provisions of port services to or from the ship.

.9 *Port facility* is a location, as determined by the Contracting Government or by the Designated Authority, where the ship/port interface takes place. This includes areas such as anchorages, waiting berths and approaches from seaward, as appropriate.

.10 *Ship to ship activity* means any activity not related to a port facility that involves the transfer of goods or persons from one ship to another.

.11 *Designated Authority* means the organization(s) or the administration(s) identified, within the Contracting Government, as responsible for ensuring the implementation of the provisions of this chapter pertaining to port facility security and ship/port interface, from the point of view of the port facility.

.12 *International Ship and Port Facility Security (ISPS) Code* means the International Code for the Security of Ships and of Port Facilities consisting of Part A (the provisions of which shall be treated as mandatory) and part B (the provisions of which shall be treated as recommendatory), as adopted, on 12 December 2002, by resolution 2 of the Conference of Contracting Governments to the International Convention for the Safety of Life at Sea, 1974 as may be amended by the Organization, provided that:

.1 amendments to part A of the Code are adopted, brought into force and take effect in accordance with article VIII of the present Convention concerning the amendment procedures applicable to the Annex other than chapter I; and

.2 amendments to part B of the Code are adopted by the Maritime Safety Committee in accordance with its Rules of Procedure.

.13 *Security incident* means any suspicious act or circumstance threatening the security of a ship, including a mobile offshore drilling unit and a high speed craft, or of a port facility or of any ship/port interface or any ship to ship activity.

.14 *Security level* means the qualification of the degree of risk that a security incident will be attempted or will occur.

.15 *Declaration of security* means an agreement reached between a ship and either a port facility or another ship with which it interfaces specifying the security measures each will implement.

.16 *Recognized security organization* means an organization with appropriate expertise in security matters and with appropriate knowledge of ship and port operations authorized to carry out an assessment, or a verification, or an approval or a certification activity, required by this chapter or by part A of the ISPS Code.

2 The term "ship", when used in regulations 3 to 13, includes mobile offshore drilling units and high-speed craft.

3 The term “all ships”, when used in this chapter, means any ship to which this chapter applies.

4 The term “Contracting Government”, when used in regulations 3, 4, 7, 10, 11, 12 and 13 includes a reference to the “Designated Authority”.

Regulation 2
Application

1 This chapter applies to:

.1 the following types of ships engaged on international voyages:

.1.1 passenger ships, including high-speed passenger craft;

.1.2 cargo ships, including high-speed craft, of 500 gross tonnage and upwards; and

.1.3 mobile offshore drilling units; and

.2 port facilities serving such ships engaged on international voyages.

2 Notwithstanding the provisions of paragraph 1.2, Contracting Governments shall decide the extent of application of this chapter and of the relevant sections of part A of the ISPS Code to those port facilities within their territory which, although used primarily by ships not engaged on international voyages, are required, occasionally, to serve ships arriving or departing on an international voyage.

2.1 Contracting Governments shall base their decisions, under paragraph 2, on a port facility

security assessment carried out in accordance with the provisions of part A of the ISPS Code.

2.2 Any decision which a Contracting Government makes, under paragraph 2, shall not compromise the level of security intended to be achieved by this chapter or by part A of the ISPS Code.

3 This chapter does not apply to warships, naval auxiliaries or other ships owned or operated by a Contracting Government and used only on Government non-commercial service.

4 Nothing in this chapter shall prejudice the rights or obligations of States under international law.

Regulation 3
Obligations of Contracting Governments with respect to security

1 Administrations shall set security levels and ensure the provision of security level information to ships entitled to fly their flag. When changes in security level occur, security level information shall be updated as the circumstance dictates.

2 Contracting Governments shall set security levels and ensure the provision of security level information to port facilities within their territory, and to ships prior to entering a port or whilst in a port within their territory. When changes in security level occur, security level information shall be updated as the circumstance dictates.

B/Responsibilities of Contracting Governments

B/1.6 Contracting Governments have, under the provisions of chapter XI-2 and part A of this Code, various responsibilities, which, amongst others, include:

- setting the applicable security level;
- approving the Ship Security Plan and relevant amendments to a previously approved plan;
- verifying the compliance of ships with the provisions of chapter XI-2 and part A of this Code and issuing to ships the International Ship Security Certificate;
- determining which of the port facilities located within their territory are required to designate a Port Facility Security Officer who will be responsible for the preparation of the Port Facility Security Plan;
- ensuring completion and approval of the Port Facility Security Assessment and of any subsequent amendments to a previously approved assessment;
- approving the Port Facility Security Plan and any subsequent amendments to a previously approved plan; and
- exercising control and compliance measures**;**
- testing approved plans; and
- communicating information to the International Maritime Organization and to the shipping and port industries.

B/1.7 Contracting Governments can designate, or establish, Designated Authorities within Government to undertake, with respect to port facilities, their security duties under chapter XI-2 and Part A of this Code and allow Recognised Security Organisations to carry out certain work with respect to port facilities but the final decision on the acceptance and approval of this work should be given by the Contracting Government or the Designated Authority. Administrations may also delegate the undertaking of certain security duties**,** relating to ships, to Recognised Security Organizations. The following duties or activities cannot delegated to a Recognized Security Organization:

- setting of the applicable security level;
- determining which of the port facilities located within the territory of a Contracting Government

are required to designate a Port Facility Security Officer and to prepare a Port Facility Security Plan;
- approving a Port Facility Security Assessment or any subsequent amendments to a previously approved assessment;
- approving a Port Facility Security Plan or any subsequent amendments to a previously approved plan;
- exercising control and compliance measures; and
- establishing the requirements for a Declaration of Security.

B/Setting the Security Level

B/1.8 The setting of the security level applying at any particular time is the responsibility of Contracting Governments and can apply to ships and port facilities. Part A of this Code defines three security levels for international use. These are:

- Security Level 1, normal; the level at which ships and port facilities normally operate;
- Security Level 2, heightened; the level applying for as long as there is a heightened risk of a security incident; and
- Security Level 3, exceptional, the level applying for the period of time when there is the probable or imminent risk of a security incident.

Regulation 4
Requirements for Companies and ships

1 Companies shall comply with the relevant requirements of this chapter and of part A of the ISPS Code, taking into account the guidance given in part B of the ISPS Code.

B/The Company and the Ship

B/1.9 Any Company operating ships to which chapter XI-2 and part A of this Code apply has to designate a Company Security Officer for the Company and a Ship Security Officer for each of its ships. The duties, responsibilities and training requirements of these officers and requirements for drills, and exercises are defined in part A of this Code.

B/1.10 The Company Security Officer's responsibilities include, in brief amongst others, ensuring that a Ship Security Assessment is properly carried out, that a Ship Security Plan is prepared and submitted for approval by, or on behalf of, the Administration and thereafter is placed on board each ship to which part A of this Code applies and in respect of which that person has been appointed as the Company Security Officer.

2 Ships shall comply with the relevant requirements of this chapter and of part A of the ISPS Code, taking into account the guidance given in part B of the ISPS Code, and such compliance shall be verified and certified as provided for in part A of the ISPS Code.

3 Prior to entering a port or whilst in a port within the territory of a Contracting Government, a ship shall comply with the requirements for the security level set by that Contracting Government, if such security level is higher than the security level set by the Administration for that ship.

4 Ships shall respond without undue delay to any change to a higher security level.

5 Where a ship is not in compliance with the requirements of this chapter or of part A of the ISPS Code, or cannot comply with the requirements of the security level set by the Administration or by another Contracting Government and applicable to that ship, then the ship shall notify the appropriate competent authority prior to conducting any ship/port interface or prior to entry into port, whichever occurs earlier.

B/1.11 The Ship Security Plan should indicate the operational and physical security measures the ship itself should take to ensure it always operates at security level 1. The plan should also indicate the additional, or intensified, security measures the ship itself can take to move to and operate at security level 2 when instructed to do so. Furthermore, the plan should indicate the possible preparatory actions the ship could take to allow prompt response to the instructions that may be issued to the ship by those responding at security level 3 to a security incident or threat thereof.

B/1.12 The ships to which the requirements of chapter XI-2 and part A of this Code apply are required to have, and operated in accordance with, a Ship Security Plan approved by, or on behalf of, the Administration. The Company and Ship Security Officer should monitor the continuing relevance and effectiveness of the plan, including the undertaking of internal audits. Amendments to any of the elements of an approved plan**,** for which the Administration has determined that approval is required, have to be submitted for review and approval before their incorporation in the approved plan and their implementation by the ship.

B/1.13 The ship has to carry an International Ship Security Certificate indicating that it complies with the requirements of chapter XI-2 and part A of this Code. Part A of this Code includes provisions relating to the verification and certification of the ship's compliance with the requirements on an initial, renewal and intermediate verification basis.

B/1.14 When a ship is at a port or is proceeding to a port of a Contracting Government, the Contracting Government has the right, under the provisions of regulation XI-2/9, to exercise various control and compliance measures with respect to that ship. The ship is subject to port State control inspections but such inspections will not normally extend to examination of the Ship Security Plan itself except in specific circumstances. The ship may, also, be subject to additional control measures if the Contracting Government exercising the control and compliance measures has reason to believe that the security of the ship has, or the port facilities it has served have, been compromised.

B/1.15 The ship is also required to have onboard information, to be made available to Contracting Governments upon request, indicating who is responsible for deciding the employment of the ship's personnel and for deciding various aspects relating to the employment of the ship.

Regulation 5
Specific responsibility of Companies

The Company shall ensure that the master has available on board, at all times, information through which officers duly authorised by a Contracting Government can establish:

.1 who is responsible for appointing the members of the crew or other persons currently employed or engaged on board the ship in any capacity on the business of that ship;

.2 who is responsible for deciding the employment of the ship; and

.3 in cases where the ship is employed under the terms of charter party(ies), who are the parties to such charter party(ies).

B/6.1	Regulation XI-2/5 requires the company to provide the master of the ship with information to meet the requirements of the Company under the provisions of this regulation. This information should include items such as:
.1	parties responsible for appointing shipboard personnel, such as ship management companies, manning agents, contractors, concessionaries, for example, retail sales outlets, casinos etc;
.2	parties responsible for deciding the employment of the ship including, time or bareboat charterer(s) or any other entity acting in such capacity; and
.3	in cases when the ship is employed under the terms of a charter party, the contact details of those parties including time or voyage charterers
B/6.2	In accordance with regulation XI-2/5 the Company is obliged to update and keep this information current as and when changes occur.
B/6.3	This information should be in English, French or Spanish language.
B/6.4	With respect to ships constructed before [1 July 2004], this information should reflect the actual condition on that date.
B/6.5	With respect to ships constructed on or after [1 July 2004] and for ships constructed before [1 July 2004] which were out of service on [1 July 2004], the information should be provided as from the date of entry of the ship into service and should reflect the actual condition on that date.
B/6.6	After [1 July 2004] when a ship is withdrawn from service the information should be provided as from the date of re-entry of the ship into service and should reflect the actual condition on that date.
B/6.7	Previously provided information that does not relate to the actual condition on that date need not be retained on board.
B/6.8	When the responsibility for the operation of the ship is assumed by another Company, the information relating to the Company, which operated the ship, are not required to be left on board.

Regulation 6
Ship security alert system

1 All ships shall be provided with a ship security alert system, as follows:

.1 ships constructed on or after 1 July 2004;

.2 passenger ships, including high-speed passenger craft, constructed before 1 July 2004, not later than the first survey of the radio installation after 1 July 2004;

.3 oil tankers, chemical tankers, gas carriers, bulk carriers and cargo high speed craft, of 500 gross tonnage and upwards constructed before 1 July 2004, not later than the first

survey of the radio installation after 1 July 2004; and

.4 other cargo ships of 500 gross tonnage and upward and mobile offshore drilling units constructed before 1 July 2004, not later than the first survey of the radio installation after 1 July 2006.

2 The ship security alert system, when activated, shall:

.1 initiate and transmit a ship-to-shore security alert to a competent authority designated by the Administration**,** which in these circumstances may include the Company, identifying the ship, its location and indicating that the security of the ship is under threat or it has been compromised;

.2 not send the ship security alert to any other ships;

.3 not raise any alarm on-board the ship; and

.4 continue the ship security alert until deactivated and/or reset.

3 The ship security alert system shall:

.1 be capable of being activated from the navigation bridge and in at least one other location; and

.2 conform to performance standards not inferior to those adopted by the Organization.

4 The ship security alert system activation points shall be designed so as to prevent the inadvertent initiation of the ship security alert.

5 The requirement for a ship security alert system may be complied with by using the radio installation fitted for compliance with the requirements of chapter IV, provided all requirements of this regulation are complied with.

6 When an Administration receives notification of a ship security alert, that Administration shall immediately notify the State(s) in the vicinity of which the ship is presently operating.

7 When a Contracting Government receives notification of a ship security alert from a ship which is not entitled to fly its flag, that Contracting Government shall immediately notify the relevant Administration and, if appropriate, the State(s) in the vicinity of which the ship is presently operating.

Regulation 7
Threats to ships

1 Contracting Governments shall set security levels and ensure the provision of security level information to ships operating in their territorial sea or having communicated an intention to enter their territorial sea.

B/Threats to ships and other incidents at Sea
B/4.21 Contracting Governments should provide general guidance on the measures considered

appropriate to reduce the security risk to ships flying their flag when at sea. They should provide specific advice on the action to be taken in accordance with security levels 1 to 3, if:

.1 there is a change in the security level applying to the ship while it is at sea, e.g. because of the geographical area in which it is operating or relating to the ship itself; and

.2 there is a security incident or threat thereof involving the ship while at sea.

Contracting Governments should establish the best methods and procedures for these purposes. In the case of an imminent attack the ship should seek to establish direct communication with those responsible in the flag State for responding to security incidents.

2 Contracting Governments shall provide a point of contact through which such ships can request advice or assistance and to which such ships can report any security concerns about other ships, movements or communications.

B/4.22 Contracting Governments should also establish a point of contact for advice on security for any ship:

.1 entitled to fly their flag; or

.2 operating in their territorial sea or having communicated an intention to enter their territorial sea.

3 Where a risk of attack has been identified, the Contracting Government concerned shall advise the ships concerned and their Administrations of:

.1 the current security level;

.2 any security measures that should be put in place by the ships concerned to protect themselves from attack, in accordance with the provisions of part A of the ISPS Code; and

.3 security measures that the coastal State has decided to put in place, as appropriate.

B/4.23 Contracting Governments should offer advice to ships operating in their territorial sea or having communicated an intention to enter their territorial sea, which could include advice:

1 to alter or delay their intended passage;

2 to navigate on a particular course or proceed to a specific location;

3 on the availability of any personnel or equipment that could be placed on the ship;

4 to co-ordinate the passage, arrival into port or departure from port, to allow escort by patrol craft or aircraft (fixed-wing or helicopter).

Contracting Governments should remind ships operating in their territorial sea, or having communicated an intention to enter their territorial sea, of any temporary restricted areas that they have published.

B/4.24 Contracting Governments should recommend that ships operating in their territorial sea, or having communicated an intention to enter their territorial sea, implement expeditiously, for the ship's protection and for the protection of other ships in the vicinity, any security measure the Contracting Government may have advised.

B/4.25 The plans prepared by the Contracting Governments for the purposes given in paragraph 4.22

should include information on an appropriate point of contact, available on a 24-hour basis, within the Contracting Government including the Administration. These plans should also include information on the circumstances in which the Administration considers assistance should be sought from nearby coastal States, and a procedure for liaison between port facility security officers and ship security officers.

Regulation 8
Master's discretion for ship safety and security

1 The master shall not be constrained by the Company, the charterer or any other person from taking or executing any decision which, in the professional judgement of the master, is necessary to maintain the safety and security of the ship. This includes denial of access to persons (except those identified as duly authorized by a Contracting Government) or their effects and refusal to load cargo, including containers or other closed cargo transport units.

2 If, in the professional judgement of the master, a conflict between any safety and security requirements applicable to the ship arises during its operations, the master shall give effect to those requirements necessary to maintain the safety of the ship. In such cases, the master may implement temporary security measures and shall forthwith inform the Administration and, if appropriate, the Contracting Government in whose port the ship is operating or intends to enter. Any such temporary security measures under this regulation shall, to the highest possible degree, be commensurate with the prevailing security level. When such cases are identified, the Administration shall ensure that such conflicts are resolved and that the possibility of recurrence is minimised.

Regulation 9
Control and compliance measures

B/Control and Compliance Measures [4]

4 Refer to Further Work by the International Maritime Organisation pertaining to Enhancement of Maritime Security, adopted by the Conference on Maritime Security by resolution [3], inviting, amongst others, the Organisation to review Assembly Resolutions A.787(19) and A.882(21).

B/General

B/4.29 Regulation XI-2/9 describes the control and compliance measures applicable to ships under chapter XI-2. It is divided into three distinct sections; control of ships already in a port, control of ships intending to enter a port of another Contracting Government, and additional provisions applicable to both situations.

B/4.30 Regulation XI-2/9.1, control of ships in port, implements a system for the control of ships while in the port of a foreign country where duly authorised officers of the Contracting Government (duly authorized officers) have the right to go on board the ship to verify that the required certificates are in proper order. Then if there are clear grounds to believe the ship does not comply, control measures such as additional inspections or detention may be taken. This reflects current control systems [5].

Regulation XI-2/9.1 builds on such systems and allows for additional measures (including expulsion of a ship from a port to be taken as a control measure) when duly authorized officers have clear grounds for believing that a ship is in non-compliance with the requirements of chapter XI-2 or part A of this Code. Regulation XI-2/9.3 describes the safeguards that promote fair and proportionate implementation of these additional measures.

See regulation I/19 and regulation IX/6.2 of SOLAS 74 as amended, article 21 of LOADLINE 66 as modified by the 1988 LOADLINE Protocol, articles 5 and 6, regulation 8A of Annex I, regulation 15 of Annex II of MARPOL 73/78 as amended, article X of STCW 78 as amended and IMO Assembly Resolutions A.787(19) and A.882(21).

B/4.31 Regulation XI-2/9.2 applies control measures to ensure compliance to ships intending to enter a port of another Contracting Government and introduces an entirely different concept of control within chapter XI-2, applying to security only. Under this regulation measures may be implemented prior to the ship entering port, to better ensure security. Just as in regulation XI-2/9.1, this additional control system is based on the concept of clear grounds for believing the ship does not comply with chapter XI-2 or part A of this Code, and includes significant safeguards in regulations XI-2/9.2.2 and XI-2/9.2.5 as well as in regulation XI-2/9.3.

B/4.32 Clear grounds that the ship is not in compliance means evidence or reliable information that the ship does not correspond with the requirements of chapter XI-2 or part A of this Code, taking into account the guidance given in this part of the Code. Such evidence or reliable information may arise from the duly authorized officer's professional judgement or observations gained while verifying the ship's International Ship Security Certificate or Interim International Ship Security Certificate issued in accordance with part A of this Code (certificate) or from other sources. Even if a valid certificate is on board the ship, the duly authorized officers may still have clear grounds for believing that the ship is not in compliance based on their professional judgment.

B/4.33 Examples of possible clear grounds under regulations XI-2/9.1 and XI-2/9.2 may include, when relevant:

1 evidence from a review of the certificate that it is not valid or it has expired;

2 evidence or reliable information that serious deficiencies exist in the security equipment, documentation or arrangements required by chapter XI-2 and part A of this Code;

3 receipt of a report or complaint which, in the professional judgment of the duly authorized officer, contains reliable information clearly indicating that the ship does not comply with the requirements of chapter XI-2 or part A of this Code;

4 evidence or observation gained by a duly authorized officer using professional judgment that the master or ship's personnel is not familiar with essential shipboard security procedures or cannot carry out drills related to the security of the ship or that such procedures or drills have not been carried out;

5 evidence or observation gained by a duly authorized officer using professional judgment that key members ship's personnel are not able to establish proper communication with any other key members of ship's personnel with security responsibilities on board the ship;

6 evidence or reliable information that the ship has embarked persons, or loaded stores or goods at a port facility or from another ship where either the port facility or the other ship is in violation of chapter XI-2 or part A of this Code, and the ship in question has not completed a Declaration of Security, nor taken appropriate, special or additional security measures or has not maintained appropriate ship security procedures;

7 evidence or reliable information that the ship has embarked persons, or loaded stores or goods at a port facility or from another source (e.g., another ship or helicopter transfer) where either the port facility or the other source is not required to comply with chapter XI-2 or part A of this Code, and the ship has not taken appropriate, special or additional security measures or has not maintained appropriate security procedures; and

8. the ship holds a subsequent, consecutively issued Interim International Ship Security Certificate as described in section A/19.4, and if, in the professional judgment of an officer duly authorized, one of the purposes of the ship or a Company in requesting such certificate is to avoid full compliance with chapter XI-2 and part A of this Code beyond the period of the initial interim certificate as described in section A/19.4.4.

B/4.34 The international law implications of regulation XI-2/9 are particularly relevant, and the regulation should be implemented with regulation XI-2/2.4 in mind, as the potential exists for situations where either measures will be taken which fall outside the scope of chapter XI-2, or where rights of affected ships, outside chapter XI-2, should be considered. Thus, regulation XI-2/9 does not prejudice the Contracting Government from taking measures having a basis in, and consistent with, international law, to ensure the safety or security of people, ships, port facilities and other property in cases where the ship, although in compliance with chapter XI-2 and part A of this Code, is still considered to present a security risk.

B/4.35 When a Contracting Government imposes control measures on a ship, the Administration should, without delay, be contacted with sufficient information to enable the Administration to fully liaise with the Contracting Government.

1 Control of ships in port

1.1 For the purpose of this chapter, every ship to which this chapter applies is subject to control when in a port of another Contracting Government by officers duly authorised by that Government, who may be the same as those carrying out the functions of regulation I/19. Such control shall be limited to verifying that there is onboard a valid International Ship Security Certificate or a valid Interim International Ship's Security Certificate issued under the provisions of part A of the ISPS Code (Certificate), which if valid shall be accepted, unless there are clear grounds for believing that the ship is not in compliance with the requirements of this chapter or part A of the ISPS Code.

1.2 When there are such clear grounds, or where no valid Certificate is produced when required, the officers duly authorized by the Contracting Government shall impose any one or more control measures in relation to that ship as provided in paragraph 1.3. Any such measures imposed must be proportionate, taking into account the guidance given in part B of the ISPS Code.

1.3 Such control measures are as follows: inspection of the ship, delaying the ship, detention of the ship, restriction of operations including movement within the port, or expulsion of the ship from port. Such control measures may additionally or alternatively include other lesser administrative or corrective measures.

B/Control of ships in port

B/4.36 Where the non-compliance is either a defective item of equipment or faulty documentation leading to the ship's detention and the non-compliance cannot be remedied in the port of inspection, the Contracting Government may allow the ship to sail to another port provided that any conditions agreed between the port States and the Administration or master are met.

2 Ships intending to enter a port of another Contracting Government

2.1 For the purpose of this chapter, a Contracting Government may require that ships intending to enter its ports provide the following information to officers duly authorized by that Government to ensure compliance with this chapter prior to entry into port with the aim of avoiding the need to impose control measures or steps:

.1 that the ship possesses a valid Certificate and the name of its issuing authority;

.2 the security level at which the ship is currently operating;

.3 the security level at which the ship operated in any previous port where it has conducted a ship/port interface within the timeframe specified in paragraph 2.3;

.4 any special or additional security measures that were taken by the ship in any previous port where it has conducted a ship/port interface within the timeframe specified in paragraph 2.3;

.5 that the appropriate ship security procedures were maintained during any ship to ship activity within the timeframe specified in paragraph 2.3; or

.6 other practical security related information (but not details of the ship security plan), taking into account the guidance given in part B of the ISPS Code.

If requested by the Contracting Government, the ship or the Company shall provide confirmation, acceptable to that Contracting Government, of the information required above.

B/4.37 Regulation XI-2/9.2.1 lists the information Contracting Governments may require from a ship as a condition of entry into port. One item of information listed is confirmation of any special or additional measures taken by the ship during its last ten calls at a port facility.

Examples could include:
1 records of the measures taken while visiting a port facility located in the territory of a State which is not a Contracting Government especially those measures that would normally have been provided by port facilities located in the territories of Contracting Governments; and
2 any Declarations of Security that were entered into with port facilities or other ships.

B/4.38 Another item of information listed, that may be required as a condition of entry into port, is confirmation that appropriate ship security procedures were maintained during ship-to-ship activity conducted within the period of the last 10 calls at a port facility. It would not normally be required to include records of transfers of pilots, customs, immigration, security officials nor bunkering, lightering, loading of supplies and unloading of waste by ship within port facilities as these would normally fall within the auspices of the Port Facility Security Plan. Examples of information that might be given include:
1 records of the measures taken while engaged in a ship to ship activity with a ship flying the flag of a State which is not a Contracting Government especially those measures that would normally have been provided by ships flying the flag of Contracting Governments;
2 records of the measures taken while engaged in a ship to ship activity with a ship that is flying the flag of a Contracting Government but is not required to comply with the provisions

of chapter XI-2 and part A of this Code such as a copy of any security certificate issued to that ship under other provisions; and

3 in the event that persons or goods rescued at sea are on board, all known information about such persons or goods, including their identities when known and the results of any checks run on behalf of the ship to establish the security status of those rescued. It is not the intention of chapter XI-2 or part A of this Code to delay or prevent the delivery of those in distress at sea to a place of safety. It is the sole intention of chapter XI-2 and part A of this Code to provide States with enough appropriate information to maintain their security integrity.

B/4.39 Examples of other practical security related information that may be required as a condition of entry into port in order to assist with ensuring the safety and security of persons, port facilities, ships and other property include:

1 information contained in the Continuous Synopsis Record;
2 location of the ship at the time the report is made;
3 expected time of arrival of the ship in port;
4 crew list;
5 general description of cargo aboard the ship;
6 passenger list; and
7 information required to be carried under regulation XI-2/10.

2.2 Every ship to which this chapter applies intending to enter the port of another Contracting Government shall provide the information described in paragraph 2.1 on the request of the officers duly authorized by that Government. The master may decline to provide such information on the understanding that failure to do so may result in denial of entry into port.

2.3 The ship shall keep records of the information referred to in paragraph 2.1 for the last 10 calls at port facilities.

2.4 If, after receipt of the information described in paragraph 2.1, officers duly authorised by the Contracting Government of the port in which the ship intends to enter have clear grounds for believing that the ship is in non-compliance with the requirements of this chapter or part A of the ISPS Code, such officers shall attempt to establish communication with and between the ship and the Administration in order to rectify the non-compliance. If such communication does not result in rectification, or if such officers have clear grounds otherwise for believing that the ship is in non-compliance with the requirements of this chapter or part A of the ISPS Code, such officers may take steps in relation to that ship as provided in paragraph 2.5. Any such steps taken must be proportionate, taking into account the guidance given in part B of the ISPS Code.

2.5 Such steps are as follows:

.1 a requirement for the rectification of the non-compliance;

.2 a requirement that the ship proceed to a location specified in the territorial sea or internal waters of that Contracting Government;

.3 inspection of the ship, if the ship is in the territorial sea of the Contracting Government the port of which the ship intends to enter; or

.4 denial of entry into port.

Prior to initiating any such steps, the ship shall be informed by the Contracting Government of

its intentions. Upon this information the master may withdraw the intention to enter that port. In such cases, this regulation shall not apply.

B/4.40 Regulation XI-2/9.2.5 allows the master of a ship, upon being informed that the coastal or port State will implement control measures under regulation XI-2/9.2, to withdraw the intention for the ship to enter port. If the master withdraws that intention, regulation XI-2/9 no longer applies, and any other steps that are taken must be based on, and consistent with, international law.

3 Additional provisions

3.1 In the event:

.1 of the imposition of a control measure, other than a lesser administrative or corrective measure, referred to in paragraph 1.3; or

.2 any of the steps referred to in paragraph 2.5 are taken,

an officer duly authorized by the Contracting Government shall forthwith inform in writing the Administration specifying which control measures have been imposed or steps taken and the reasons thereof. The Contracting Government imposing the control measures or steps shall also notify the recognized security organization, which issued the Certificate relating to the ship concerned and the Organization when any such control measures have been imposed or steps taken.

3.2 When entry into port is denied or the ship is expelled from port, the authorities of the port State should communicate the appropriate facts to the authorities of the State of the next appropriate ports of call, when known, and any other appropriate coastal States, taking into account guidelines to be developed by the Organization. Confidentiality and security of such notification shall be ensured.

B/4.41 In all cases where a ship is denied entry or expelled from a port, all known facts should be communicated to the authorities of relevant States. This communication should consist of the following when known:

1 name of ship, its flag, the ship's identification number, call sign, ship type and cargo;
2 reason for denying entry or expulsion from port or port areas;
3 if relevant, the nature of any security non-compliance;
4 if relevant, details of any attempts made to rectify any non-compliance, including any conditions imposed on the ship for the voyage;
5 past port(s) of call and next declared port of call;
6 time of departure and likely estimated time of arrival at those ports;
7 any instructions given to ship, e.g., reporting on route;
8 available information on the security level at which the ship is currently operating;
9 information regarding any communications the port State has had with the Administration;
10 contact point within the port State making the report for the purpose of obtaining further information;
11 crew list; and
12 any other relevant information.

B/4.42 Relevant States to contact should include those along the ship's intended passage to its next

port, particularly if the ship intends to enter the territorial sea of that coastal State. Other relevant States could include previous ports of call, so that further information might be obtained and security issues relating to the previous ports resolved.

3.3 Denial of entry into port, pursuant to paragraphs 2.4 and 2.5, or expulsion from port, pursuant to paragraphs 1.1 to 1.3, shall only be imposed where the officers duly authorized by the Contracting Government have clear grounds to believe that the ship poses an immediate threat to the security or safety of persons, or of ships or other property and there are no other appropriate means for removing that threat.

3.4 The control measures referred to in paragraph 1.3 and the steps referred to in paragraph 2.5 shall only be imposed, pursuant to this regulation, until the non-compliance giving rise to the control measures or steps has been corrected to the satisfaction of the Contracting Government, taking into account actions proposed by the ship or the Administration, if any.

3.5 When Contracting Governments exercise control under paragraph 1 or take steps under paragraph 2:

.1 all possible efforts shall be made to avoid a ship being unduly detained or delayed. If a ship is thereby unduly detained, or delayed, it shall be entitled to compensation for any loss or damage suffered; and

.2 necessary access to the ship shall not be prevented for emergency or humanitarian reasons and for security purposes.

B/4.43 In exercising control and compliance measures, the duly authorized officers should ensure that any measures or steps imposed are proportionate. Such measures or steps should be reasonable and of the minimum severity and duration necessary to rectify or mitigate the non-compliance.

B/4.44 The word “delay” in regulation XI-2/9.3.3.1 also refers to situations where, pursuant to actions taken under this regulation, the ship is unduly denied entry into port or the ship is unduly expelled from port.

Regulation 10
Requirements for port facilities

1 Port facilities shall comply with the relevant requirements of this chapter and part A of the ISPS Code, taking into account the guidance given in part B of the ISPS Code.

2 Contracting Governments with a port facility or port facilities within their territory, to which this regulation applies, shall ensure that:

.1 port facility security assessments are carried out, reviewed and approved in accordance with the provisions of part A of the ISPS Code; and

.2 port facility security plans are developed, reviewed, approved and implemented in accordance with the provisions of part A of the ISPS Code.

3 Contracting Governments shall designate and communicate the measures required to be addressed in a port facility security plan for the various security levels, including when the

submission of a Declaration of Security will be required.

B/The Port Facility

B/1.16 Each Contracting Government has to ensure completion of a Port Facility Security Assessment for each of the port facilities**,** located within its territory, serving ships engaged on international voyages. The Contracting Government, a Designated Authority or a Recognized Security Organization may carry out this assessment. The completed Port Facility Security Assessment has to be approved by the Contracting Government or the Designated Authority concerned. This approval cannot be delegated. Port Facility Security Assessments should be periodically reviewed.

B/1.17 The Port Facility Security Assessment is fundamentally a risk analysis of all aspects of a port facility's operation in order to determine which part(s) of it are more susceptible, and/or more likely, to be the subject of attack. Security risk is a function of the threat of an attack coupled with the vulnerability of the target and the consequences of an attack.

The assessment must include the following components:

- the perceived threat to port installations and infrastructure must be determined;
- the potential vulnerabilities identified; and
- the consequences of incidents calculated.

On completion of the analysis, it will be possible to produce an overall assessment of the level of risk. The Port Facility Security Assessment will help determine which port facilities are required to appoint a Port Facility Security Officer and prepare a Port Facility Security Plan.

B/1.18 The port facilities which have to comply with the requirements of chapter XI-2 and part A of this Code are required to designate a Port Facility Security Officer. The duties, responsibilities and training requirements of these officers and requirements for drills and exercises are defined in part A of this Code.

B/1.19 The Port Facility Security Plan should indicate the operational and physical security measures the port facility should take to ensure that it always operates at security level 1. The plan should also indicate the additional, or intensified, security measures the port facility can take to move to and operate at security level 2 when instructed to do so. Furthermore, the plan should indicate the possible preparatory actions the port facility could take to allow prompt response to the instructions that may be issued by those responding at security level 3 to a security incident or threat thereof.

B/1.20 The port facilities which have to comply with the requirements of chapter XI-2 and part A of this Code are required to have**,** and operate in accordance with, a Port Facility Security Plan approved by the Contracting Government or by the Designated Authority concerned. The Port Facility Security Officer should implement its provisions and monitor the continuing effectiveness and relevance of the plan, including commissioning internal audits of the application of the plan. Amendments to any of the elements of an approved plan, for which the Contracting Government or the Designated Authority concerned has determined that approval is required, have to be submitted for review and approval before their incorporation in the approved plan and their implementation at the port facility. The Contracting Government or the Designated Authority concerned may test the effectiveness of the plan. The Port Facility Security Assessment covering the port facility or on which the development of the plan has been based should be regularly reviewed. All these activities may lead to amendment of the approved plan. Any amendments to specified elements of an approved plan will have to be submitted for

approval by the Contracting Government or by the Designated Authority concerned.

B/1.21 Ships using port facilities may be subject to the port State control inspections and additional control measures outlined in regulation XI-2/9. The relevant authorities may request the provision of information regarding the ship, its cargo, passengers and ship's personnel prior to the ship's entry into port. There may be circumstances in which entry into port could be denied.

Regulation 11
Alternative security agreements

1 Contracting Governments may, when implementing this chapter and part A of the ISPS Code, conclude in writing bilateral or multilateral agreements with other Contracting Governments on alternative security arrangements covering short international voyages on fixed routes between port facilities located within their territories.

2 Any such agreement shall not compromise the level of security of other ships or of port facilities not covered by the agreement.

3 No ship covered by such an agreement shall conduct any ship-to-ship activities with any ship not covered by the agreement.

4 Such agreements shall be reviewed periodically, taking into account the experience gained as well as any changes in the particular circumstances or the assessed threats to the security of the ships, the port facilities or the routes covered by the agreement.

B/Alternative Security Agreements

B/4.26 Contracting Governments, in considering how to implement chapter XI-2 and part A of this Code, may conclude one or more agreements with one or more Contracting Governments. The scope of an agreement is limited to short international voyages on fixed routes between port facilities in the territory of the parties to the agreement. When concluding an agreement, and thereafter, the Contracting Governments should consult other Contracting Governments and Administrations with an interest in the effects of the agreement. Ships flying the flag of a State that is not party to the agreement should only be allowed to operate on the fixed routes covered by the agreement if their Administration agrees that the ship should comply with the provisions of the agreement and requires the ship to do so. In no case can such an agreement compromise the level of security of other ships and port facilities not covered by it, and specifically, all ships covered by such an agreement may not conduct ship-to-ship activities with ships not so covered. Any operational interface undertaken by ships covered by the agreement should be covered by it. The operation of each agreement must be continually monitored and amended when the need arises and in any event should be reviewed every 5 years.

Regulation 12
Equivalent security arrangements

1 An Administration may allow a particular ship or a group of ships entitled to fly its flag to implement other security measures equivalent to those prescribed in this chapter or in part A of the ISPS Code, provided such security measures are at least as effective as those prescribed in this chapter or part A of the ISPS Code. The Administration, which allows such security measures, shall communicate to the Organization particulars thereof.

2 When implementing this chapter and part A of the ISPS Code, a Contracting Government may allow a particular port facility or a group of port facilities located within its territory, other than those covered by an agreement concluded under regulation 11, to implement security measures equivalent to those prescribed in this chapter or in Part A of the ISPS Code, provided such security measures are at least as effective as those prescribed in this chapter or part A of the ISPS Code. The Contracting Government, which allows such security measures, shall communicate to the Organization particulars thereof.

B/Equivalent arrangements for port facilities

B/4.27 For certain specific port facilities with limited or special operations but with more than occasional traffic, it may be appropriate to ensure compliance by security measures equivalent to those prescribed in chapter XI-2 and in part A of this Code. This can, in particular, be the case for terminals such as those attached to factories, or quaysides with no frequent operations..

Regulation 13
Communication of information

1 Contracting Governments shall, not later than 1 July 2004, communicate to the Organization and shall make available for the information of Companies and ships:

.1 the names and contact details of their national authority or authorities responsible for ship and port facility security;

.2 the locations within their territory covered by the approved port facility security plans.

.3 the names and contact details of those who have been designated to be available at all times to receive and act upon the ship-to-shore security alerts, referred to in regulation 6.2.1;

.4 the names and contact details of those who have been designated to be available at all times to receive and act upon any communications from Contracting Governments exercising control and compliance measures, referred to in regulation 9.3.1; and

.5 the names and contact details of those who have been designated to be available at all times to provide advice or assistance to ships and to whom ships can report any security concerns, referred to in regulation 7.2;

and thereafter update such information as and when changes relating thereto occur. The Organization shall circulate such particulars to other Contracting Governments for the information of their officers.

2 Contracting Governments shall, not later than 1 July 2004, communicate to the Organization the names and contact details of any recognized security organizations authorized to act on their behalf together with details of the specific responsibility and conditions of authority delegated to such organizations. Such information shall be updated as and when changes relating thereto occur. The Organization shall circulate such particulars to other Contracting Governments for the information of their officers.

3 Contracting Governments shall, not later than 1 July 2004 communicate to the Organization a

list showing the approved port facility security plans for the port facilities located within their territory together with the location or locations covered by each approved port facility security plan and the corresponding date of approval and thereafter shall further communicate when any of the following changes take place:

.1 changes in the location or locations covered by an approved port facility security plan are to be introduced or have been introduced. In such cases the information to be communicated shall indicate the changes in the location or locations covered by the plan and the date as of which such changes are to be introduced or were implemented;

.2 an approved port facility security plan, previously included in the list submitted to the Organization, is to be withdrawn or has been withdrawn. In such cases, the information to be communicated shall indicate the date on which the withdrawal will take effect or was implemented. In these cases, the communication shall be made to the Organization as soon as is practically possible; and

.3 additions are to be made to the list of approved port facility security plans.

In such cases, the information to be communicated shall indicate the location or locations covered by the plan and the date of approval.

B/4.14 Where a port facility has a PFSP that fact has to be communicated to the Organization and that information must also be made available to Company and Ship Security Officers. No further details of the PFSP have to be published other than that it is in place. Contracting Governments should consider establishing either central or regional points of contact, or other means of providing up to date information on the locations where PFSPs are in place, together with contact details for the relevant PFSO. The existence of such contact points should be publicised. They could also provide information on the recognized security organizations appointed to act on behalf of the Contracting Government, together with details of the specific responsibility and conditions of authority delegated to such recognised security organizations.

B/4.15 In the case of a port that does not have a PFSP (and therefore does not have a PFSO) the central or regional point of contact should be able to identify a suitably qualified person ashore who can arrange for appropriate security measures to be in place, if needed, for the duration of the ship's visit.

4 Contracting Governments shall, at five year intervals after 1 July 2004, communicate to the Organization a revised and updated list showing all the approved port facility security plans for the port facilities located within their territory together with the location or locations covered by each approved port facility security plan and the corresponding date of approval (and the date of approval of any amendments thereto) which will supersede and replace all information communicated to the Organization, pursuant to paragraph 3, during the preceding five years.

5 Contracting Governments shall communicate to the Organization information that an agreement under regulation 11 has been concluded. The information communicated shall include:

.1 the names of the Contracting Governments which have concluded the agreement;

.2 the port facilities and the fixed routes covered by the agreement;

.3 the periodicity of review of the agreement;

.4 the date of entry into force of the agreement; and

.5 information on any consultations which have taken place with other Contracting Governments;

and thereafter shall communicate, as soon as practically possible, to the Organization information when the agreement has been amended or has ended.

6 Any Contracting Government which allows, under the provisions of regulation 12, any equivalent security arrangements with respect to a ship entitled to fly its flag or with respect to a port facility located within its territory, shall communicate to the Organization particulars thereof.

7 The Organization shall make available the information communicated under paragraph 3 to other Contracting Governments upon request.

B/Information and Communication

B/1.22 Chapter XI-2 and part A of this Code require Contracting Governments to provide certain information to the International Maritime Organization and for information to be made available to allow effective communication between Contracting Governments and between Company/Ship Security Officers and the Port Facility Security Officers responsible for the port facility their ships visit.

B/4.17 Contracting Governments should also make the information indicated in paragraphs 4.14 to 4.16, available to other Contracting Governments on request.

Part A of
INTERNATIONAL CODE FOR THE SECURITY OF SHIPS
AND OF PORT FACILITIES

PREAMBLE

AP/1 The Diplomatic Conference on Maritime Security held in London in December 2002 adopted new provisions in the International Convention for the Safety of Life at Sea, 1974 and this Code to enhance maritime security. These new requirements form the international framework through which ships and port facilities can co-operate to detect and deter acts which threaten security in the maritime transport sector.

AP/2 Following the tragic events of 11th September 2001, the twenty-second session of the Assembly of the International Maritime Organization (the Organization), in November 2001**,** unanimously agreed to the development of new measures relating to the security of ships and of port facilities for adoption by a Conference of Contracting Governments to the International Convention for the Safety of Life at Sea**,** 1974 (known as the Diplomatic Conference on Maritime Security) in December 2002. Preparation for the Diplomatic Conference was entrusted to the Organization's Maritime Safety Committee (MSC) on the basis of submissions made by Member States, intergovernmental organizations and non-governmental organizations in consultative status with the Organization.

AP/3 The MSC, at its first extraordinary session, held also in November 2001, in order to accelerate the development and the adoption of the appropriate security measures established an MSC Intersessional Working Group on Maritime Security**.** The first meeting of the MSC Intersessional Working Group on Maritime Security was held in February 2002 and the outcome of its discussions was reported to, and considered by, the seventy-fifth session of the MSC in March 2002, when an *ad hoc* Working Group was established to further develop the proposals made. The seventy-fifth session of the MSC considered the report of that Working Group and recommended that work should be taken forward through a further MSC Intersessional Working Group, which was held in September 2002. The seventy-sixth session of the MSC considered the outcome of the September 2002 session of the MSC Intersessional Working Group and the further work undertaken by the MSC Working Group held in conjunction with the Committee's seventy-sixth session in December 2002, immediately prior to the Diplomatic Conference and agreed the final version of the proposed texts to be considered by the Diplomatic Conference.

AP/4 The Diplomatic Conference (9 to 13 December 2002) also adopted amendments to the existing provisions of the International Convention for the Safety of Life at Sea, 1974 (SOLAS 74) accelerating the implementation of the requirement to fit Automatic Identification Systems and adopted new Regulations in Chapter XI-1 of SOLAS 74 covering marking of the Ship's Identification Number and the carriage of a Continuous Synopsis Record. The Diplomatic Conference also adopted a number of Conference Resolutions including those covering implementation and revision of this Code, Technical Co-operation, and co-operative work with the International Labour Organization and World Customs Organization. It was recognised that review and amendment of certain of the new provisions regarding maritime security may be required on completion of the work of these two Organizations.

AP/5 The provision of Chapter XI-2 of SOLAS 74 and this Code apply to ships and to port facilities. The extension of SOLAS 74 to cover port facilities was agreed on the basis that SOLAS 74 offered the speediest means of ensuring the necessary security measures entered into force and

given effect quickly. However, it was further agreed that the provisions relating to port facilities should relate solely to the ship/port interface. The wider issue of the security of port areas will be the subject of further joint work between the International Maritime Organization and the International Labour Organization. It was also agreed that the provisions should not extend to the actual response to attacks or to any necessary clear-up activities after such an attack.

AP/6 In drafting the provision care has been taken to ensure compatibility with the provisions of the International Convention on Standards of Training, Certification and Watch-keeping and Certification for Seafarers, 1978, as amended, the International Safety Management (ISM) Code and the harmonised system of survey and certification.

AP/7 The provisions represent a significant change in the approach of the international maritime industries to the issue of security in the maritime transport sector. It is recognised that they may place a significant additional burden on certain Contracting Governments. The importance of Technical Co-operation to assist Contracting Governments implement the provisions is fully recognised.

AP/8 Implementation of the provisions will require continuing effective co-operation and understanding between all those involved with, or using, ships and port facilities including ship's personnel, port personnel, passengers, cargo interests, ship and port management and those in National and Local Authorities with security responsibilities. Existing practices and procedures will have to be reviewed and changed if they do not provide an adequate level of security. In the interests of enhanced maritime security additional responsibilities will have to be carried by the shipping and port industries and by National and Local Authorities.

AP/9 The guidance given in Part B of this Code should be taken into account when implementing the security provisions set out in Chapter XI-2 of SOLAS 74 and in Part A of this Code. However, it is recognised that the extent to which the guidance applies may vary depending on the nature of the port facility and of the ship, its trade and/or cargo.

AP/10 Nothing in this Code shall be interpreted or applied in a manner inconsistent with the proper respect of fundamental rights and freedoms as set out in international instruments, particularly those relating to maritime workers and refugees including the International Labour Organisation Declaration of Fundamental Principles and Rights at Work as well as international standards concerning maritime and port workers.

AP/11 Recognizing that the Convention on the Facilitation of Maritime Traffic, 1965, as amended, provides that foreign crew members shall be allowed ashore by the public authorities while the ship on which they arrive is in port, provided that the formalities on arrival of the ship have been fulfilled and the public authorities have no reason to refuse permission to come ashore for reasons of public health, public safety or public order, Contracting Governments when approving ship and port facility security plans should pay due cognisance to the fact that ship's personnel live and work on the vessel and need shore leave and access to shore based seafarer welfare facilities, including medical care.

No additional guidance

PART A

THE SAFETY OF LIFE AT SEA, 1974 AS AMENDED

MANDATORY REQUIREMENTS REGARDING THE PROVISIONS OF CHAPTER XI-2 OF THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AS AMENDED

1 GENERAL

A/1.1 Introduction

This part of the International Code for the Security of Ships and Port Facilities contains mandatory provisions to which reference is made in chapter XI-2 of the International Convention for the Safety of Life at Sea, 1974 as amended.

B/General

B/1.1 The preamble of this Code indicates that chapter XI-2 and part A of this Code establish the new international framework of measures to enhance maritime security and through which ships and port facilities can co-operate to detect and deter acts which threaten security in the maritime transport sector.

B/1.2 This introduction outlines, in a concise manner, the processes envisaged in establishing and implementing the measures and arrangements needed to achieve and maintain compliance with the provisions of chapter XI-2 and of part A of this Code and identifies the main elements on which guidance is offered. The guidance is provided in paragraphs 2 through to 19. It also sets down essential considerations, which should be taken into account when considering the application of the guidance relating to ships and port facilities.

B/1.3 If the reader's interest relates to ships alone, it is strongly recommended that this part of the Code is still read as a whole, particularly the sections relating to port facilities. The same applies to those whose primary interest are port facilities; they should also read the sections relating to ships.

B/1.4 The guidance provided in the following sections relates primarily to protection of the ship when it is at a port facility. There could, however, be situations when a ship may pose a threat to the port facility, e.g. because, once within the port facility, it could be used as a base from which to launch an attack. When considering the appropriate security measures to respond to ship-based security threats, those completing the Port Facility Security Assessment or preparing the Port Facility Security Plan should consider making appropriate adaptations to the guidance offered in the following sections.

B/1.5 The reader is advised that nothing in this Part of the Code should be read or interpreted in conflict with any of the provisions of either chapter XI-2 or part A of this Code and that the aforesaid provisions always prevail and override any unintended inconsistency which may have been inadvertently expressed in this Part of the Code. The guidance provided in this Part of the Code should always be read, interpreted and applied in a manner which is consistent with the aims, objectives and principles established in chapter XI-2 and part A of this Code.

No additional guidance

A/1.2 Objectives

The objectives of this Code are:

1 to establish an international framework involving co-operation between Contracting Governments, Government agencies, local administrations and the shipping and port industries to detect security threats and take preventive measures against security incidents affecting ships or port facilities used in international trade;

2 to establish the respective roles and responsibilities of the Contracting Governments, Government agencies, local administrations and the shipping and port industries, at the national and international level for ensuring maritime security;

3 to ensure the early and efficient collection and exchange of security-related information;

4 to provide a methodology for security assessments so as to have in place plans and procedures to react to changing security levels; and

5 to ensure confidence that adequate and proportionate maritime security measures are in place.

The objective of the ISPS Code is to ensure an internationally agreed response to the threats posed by maritime security. To do this, the responsibilities of both Governments and Industry are to be defined and acknowledged. In addition a mechanism for the exchange of information between the interested parties is required. It is agreed that a qualitative risk based approach is adopted, the Code providing a methodology for performing the necessary risk assessments.

A/1.3 Functional requirements

In order to achieve its objectives, this Code embodies a number of functional requirements. These include, but are not limited to:

.1 gathering and assessing information with respect to security threats and exchanging such information with appropriate Contracting Governments;

.2 requiring the maintenance of communication protocols for ships and port facilities;

.3 preventing unauthorized access to ships, port facilities and their restricted areas;

.4 preventing the introduction of unauthorized weapons, incendiary devices or explosives to ships or port facilities;

.5 providing means for raising the alarm in reaction to security threats or security incidents;

.6 requiring ship and port facility security plans based upon security assessments; and

.7 requiring training, drills and exercises to ensure familiarity with security plans and procedures.

These are some of the requirements that must be satisfied if the objectives of the Code are to be met.

A/2 DEFINITIONS

A/2.1 For the purpose of this part, unless expressly provided otherwise:

.1 *Convention* means the International Convention for the Safety of Life at Sea, 1974 as amended.

.2 *Regulation* means a regulation of the Convention.

.3 *Chapter* means a chapter of the Convention.

.4 *Ship security plan* means a plan developed to ensure the application of measures on board the ship designed to protect persons on board, cargo**,** cargo transport units, ship's stores or the ship from the risks of a security incident.

.5 *Port facility security plan* means a plan developed to ensure the application of measures designed to protect the port facility and ships, persons**,** cargo, cargo transport units and ship's stores within the port facility from the risks of a security incident.

.6 *Ship security officer* means the person on board the ship**,** accountable to the master**,** designated by the Company as responsible for the security of the ship, including implementation and maintenance of the ship security plan and for liaison with the company security officer and port facility security officers.

.7 *Company security officer* means the person designated by the Company for ensuring that a ship security assessment is carried out; that a ship security plan is developed, submitted for approval, and thereafter implemented and maintained and for liaison with port facility security officers and the ship security officer.

Although this definition is similar to that for the "Designated Person" in the ISM Code, the word "ashore" is not included. This will clarify the matter with regard to instances where the master is also the owner of the vessel and there is no company infrastructure ashore. In such cases the master may be the company security officer and the ship security officer.

.8 *Port facility security officer* means the person designated as responsible for the development, implementation, revision and maintenance of the port facility security plan and for liaison with the ship security officers and company security officers.

.9 *Security level 1* means the level for which minimum appropriate protective security measures shall be maintained at all times.

.10 *Security level 2* means the level for which appropriate additional protective security measures shall be maintained for a period of time as a result of heightened risk of a security incident.

.11 *Security level 3* means the level for which further specific protective security measures

shall be maintained for a limited period of time when a security incident is probable or imminent, although it may not be possible to identify the specific target.

The following additional definitions are used within BCS-PR 24 and this document:

The term *Non-compliance* means non fulfillment of a specified requirement or the subject is inappropriate for the ship

The term *Verification* means the audit of the SSP and associated procedures, checking the operational status of the Ship Security Alert System and checking a representative sample of associated security and surveillance equipment and systems mentioned in the SSP

2.2 The term “ship”, when used in this Code, includes mobile offshore drilling units and high-speed craft as defined in regulation XI-2/1.

2.3 The term “Contracting Government” in connection with any reference to a port facility, when used in sections 14 to 18, includes a reference to the Designated Authority..

2.4 Terms not otherwise defined in this part shall have the same meaning as the meaning attributed to them in chapters I and XI-2.

B/2.1 No guidance is provided with respect to the definitions set out in chapter XI-2 or part A of this Code.

B/2.2 For the purpose of this Part of the Code:

1 section. means a section of part A of the Code and is indicated as .section A/<followed by the number of the section>.;

2 paragraph. means a paragraph of this Part of the Code and is indicated as .paragraph <followed by the number of the paragraph>.; and

3 Contracting Government., when used in paragraphs 14 to 18, means the .Contracting Government within whose territory the port facility is located. and includes a reference to the Designated Authority..

Throughout the Code the term “Administration” is used to refer to that part of a Government with responsibilities for merchant shipping flying their Flag, “Designated Authority” refers to that part of a Government with responsibilities for Port Facility Security under their jurisdiction and “Contracting Government” is used to refer to any part of the Government, including the “Administration” or the “Designated Authority”.

A/3 APPLICATION

A/3.1 This Code applies to:

1 the following types of ships engaged on international voyages:

1 passenger ships, including high-speed passenger craft;

2 cargo ships, including high-speed craft, of 500 gross tonnage and upwards; and

3 mobile offshore drilling units; and

2 port facilities serving such ships engaged on international voyages.

B/3.4 The provisions of chapter XI-2 and part A of this Code are not intended to apply to port facilities designed and used primarily for military purposes.

A/3.2 Notwithstanding the provisions of section 3.1.2, Contracting Governments shall decide the extent of application of this part of the Code to those port facilities within their territory which, although used primarily by ships not engaged on international voyages, are required, occasionally, to serve ships arriving or departing on an international voyage.

A/3.2.1 Contracting Governments shall base their decisions, under section 3.2, on a port facility security assessment carried out in accordance with this part of the Code.

A/3.2.2 Any decision which a Contracting Government makes, under section 3.2, shall not compromise the level of security intended to be achieved by chapter XI-2 or by this part of the Code.

A/3.3 This Code does not apply to warships, naval auxiliaries or other ships owned or operated by a Contracting Government and used only on Government non-commercial service.

A/3.4 Sections 5 to 13 and 19 of this part apply to Companies and ships as specified in regulation XI-2/4.

A/3.5 Sections 5 and 14 to 18 of this part apply to port facilities as specified in regulation XI-2/10.

A/3.6 Nothing in this Code shall prejudice the rights or obligations of States under international law.

B/General

B/3.1 The guidance given in this Part of the Code should be taken into account when implementing the requirements of chapter XI-2 and part A of this Code.

B/3.2 However, it should be recognized that the extent to which the guidance on ships applies will depend on the type of ship, its cargoes and/or passengers, its trading pattern and the characteristics of the port facilities visited by the ship.

B/3.3 Similarly, in relation to the guidance on port facilities, the extent to which this guidance applies will depend on the port facilities, the types of ships using the port facility, the types of cargo and/or passengers and the trading patterns of visiting ships.

The Code is applicable to, but not restricted to, ships that are subject to the ISM Code

A/4 RESPONSIBILITIES OF CONTRACTING GOVERNMENTS

A/4.1 Subject to the provisions of regulation XI-2/3 and XI-2/7, Contracting Governments shall set security levels and provide guidance for protection from security incidents. Higher security levels indicate greater likelihood of occurrence of a security incident. Factors to be considered in setting the appropriate security level include:

.1 the degree that the threat information is credible;

.2 the degree that the threat information is corroborated;

.3 the degree that the threat information is specific or imminent; and

.4 the potential consequences of such a security incident.

A/4.2 Contracting Governments, when they set security level 3, shall issue, as necessary, appropriate instructions and shall provide security related information to the ships and port facilities that may be affected.

A/4.3 Contracting Governments may delegate to a recognized security organization certain of their security related duties under chapter XI-2 and this part of the Code with the exception of:

1 setting of the applicable security level;

2 approving a Port Facility Security Assessment and subsequent amendments to an approved assessment;

3 determining the port facilities which will be required to designate a Port Facility Security Officer;

4 approving a Port Facility Security Plan and subsequent amendments to an approved plan;

5 exercising control and compliance measures pursuant to regulation XI-2/9; and

6 establishing the requirements for a Declaration of Security.

A/4.4 Contracting Governments shall, to the extent they consider appropriate, test the effectiveness of the Ship or the Port Facility Security Plans, or of amendments to such plans, they have approved, or, in the case of ships, of plans which have been approved on their behalf.

B/Security of Assessments and Plans

B/4.1 Contracting Governments should ensure that appropriate measures are in place to avoid unauthorized disclosure of, or access to, security sensitive material relating to Ship Security Assessments, Ship Security Plans, Port Facility Security Assessments and Port Facility Security Plans, and to individual assessments or plans.

B/Designated Authorities

B/4.2 Contracting Governments may identify a Designated Authority within Government to undertake their security duties relating to port facilities as set out in chapter XI-2 or part A of this Code.

B/Recognized Security Organizations

B/4.3 Contracting Governments may authorize a Recognized Security Organization (RSO) to undertake certain security related activities, including:

1 approval of Ship Security Plans, or amendments thereto, on behalf of the Administration;

2 verification and certification of compliance of ships with the requirements of chapter

XI-2 and part A of this Code on behalf of the Administration; and

3 conducting Port Facility Security Assessments required by the Contracting Government.

B/4.4 An RSO may also advise or provide assistance to Companies or port facilities on security matters, including Ship Security Assessments, Ship Security Plans, Port Facility Security Assessments and Port Facility Security Plans. This can include completion of a Ship Security Assessment or Plan or Port Facility Security Assessment or Plan. If an RSO has done so in respect of a ship security assessment or plan that RSO should not be authorised to approve that ship security plan.

B/4.5 When authorizing an RSO, Contracting Governments should give consideration to the competency of such an organization. An RSO should be able to demonstrate:

1 expertise in relevant aspects of security;

2 appropriate knowledge of ship and port operations, including knowledge of ship design and construction if providing services in respect of ships and port design and construction if providing services in respect of port facilities;

3 their capability to assess the likely security risks that could occur during ship and port facility operations including the ship/port interface and how to minimise such risks;

4 their ability to maintain and improve the expertise of their personnel;

5 their ability to monitor the continuing trustworthiness of their personnel;

6 their ability to maintain appropriate measures to avoid unauthorised disclosure of, or access to, security sensitive material;

7 their knowledge of the requirements chapter XI-2 and Part A of this Code and relevant national and international legislation and security requirements; and

8 their knowledge of current security threats and patterns;

9 their knowledge on recognition and detection of weapons, dangerous substances and devices;

10 their knowledge on recognition, on a non-discriminatory basis, of characteristics and behavioral patterns of persons who are likely to threaten security;

11 their knowledge on techniques used to circumvent security measures; and

12 their knowledge of security and surveillance equipment and systems and their operational limitations.

When delegating specific duties to an RSO, Contracting Governments, including Administrations, should ensure that the RSO has the competencies needed to undertake the task.

B/4.6 A Recognized Organization, as defined in regulation I/6 and fulfilling the requirements of regulation XI-1/1, may be appointed as a RSO provided it has the appropriate security related expertise listed in paragraph 4.5.

B/4.7 A Port or Harbour Authority or Port Facility operator may be appointed as an RSO provided it has the appropriate security related expertise listed in paragraph 4.5.

B/Setting the Security Level

B/4.8 In setting the security level Contracting Governments should take account of general and specific threat information. Contracting Governments should set the security level applying to ships or port facilities at one of three levels:

- Security level 1: normal, the level at which the ship or port facility normally operates;
- Security level 2: heightened, the level applying for as long as there is a heightened risk of a

security incident; and

- Security level 3: exceptional, the level applying for the period of time when there is the probable or imminent risk of a security incident.

B/4.9 Setting security level 3 should be an exceptional measure applying only when there is credible information that a security incident is probable or imminent. Security level 3 should only be set for the duration of the identified security threat or actual security incident. While the security levels may change from security level 1, through security level 2 to security level 3, it is also possible that the security levels will change directly from security level 1 to security level 3.

B/4.10 At all times the Master of a ship has the ultimate responsibility for the safety of the ship. Even at security level 3 a Master may seek clarification or amendment of instructions issued by those responding to a security incident, or threat thereof, if there are reasons to believe that compliance with any instruction may imperil the safety of the ship.

B/4.11 The Company Security Officer (CSO) or the Ship Security Officer (SSO) should liase at the earliest opportunity with the Port Facility Security Officer (PFSO) of the port facility the ship is intended to visit to establish the security level applying for that ship at the port facility. Having established contact with a ship, the PFSO should advise the ship of any subsequent change in the port facility.s security level and should provide the ship with any relevant security information.

B/4.12 While there may be circumstances when an individual ship may be operating at a higher security level than the port facility it is visiting, there will be no circumstances when a ship can have a lower security level than the port facility it is visiting. If a ship has a higher security level than the port facility it intends to use, the CSO or SSO should advise the PFSO without delay. The PFSO should undertake an assessment of the particular situation in consultation with the CSO or SSO and agree on appropriate security measures with the ship, which may include completion and signing of a Declaration of Security.

B/4.13 Contracting Governments should consider how information on changes in security levels should be promulgated rapidly. Administrations may wish to use NAVTEX messages or Notices to Mariners as the method for notifying such changes in security levels to ship and CSO and SSO. Or, they may wish to consider other methods of communication that provide equivalent or better speed and coverage. Contracting Governments should establish means of notifying PFSOs of changes in security levels. Contracting Governments should compile and maintain the contact details for a list of those who need to be informed of changes in security levels. Whereas the security level need not be regarded as being particularly sensitive, the underlying threat information may be highly sensitive. Contracting Governments should give careful consideration to the type and detail of the information conveyed and the method by which it is conveyed, to SSOs, CSOs and PFSOs.

B/4.16 Contracting Governments should also provide the contact details of Government officers to whom an SSO, a CSO and a PFSO can report security concerns. These Government officers should assess such reports before taking appropriate action. Such reported concerns may have a bearing on the security measures falling under the jurisdiction of another Contracting Government. In that case, the Contracting Governments should consider contacting their counterpart in the other Contracting Government to discuss whether remedial action is appropriate. For this purpose, the contact details of the Government officers should be communicated to the International Maritime Organization.

B/Identification Documents

B/4.18 Contracting Governments are encouraged to issue appropriate identification documents to Government officials entitled to board ships or enter port facilities when performing their official duties and to establish procedures whereby the authenticity of such documents might be verified.

B/Fixed and Floating Platforms and Mobile Drilling Units on location

B/4.19 Contracting Governments should consider establishing appropriate security measures for fixed and floating platforms and mobile offshore drilling units on location to allow interaction with ships which are required to comply with the provisions of chapter XI-2 and part A of this Code[1].

[1] Refer to Establishment of Appropriate Measures to Enhance the Security of Ships, Port Facilities, Mobile Offshore Drilling Units on location and Fixed and Floating Platforms Not Covered by Chapter XI-2 of 1974 SOLAS Convention, adopted by the Conference on Maritime Security by resolution [7].

B/Ships which are not required to comply with part A of this Code

B/4.20 Contracting Governments should consider establishing appropriate security measures to enhance the security of ships to which this chapter XI-2 and part A of this Code does not apply and to ensure that any security provisions applying to such ships allow interaction with ships to which part A of this Code applies.

B/Manning Level

B/4.28 In establishing the minimum safe manning of a ship the Administration should take into account[2] that the minimum safe manning provisions established by regulation V/14[3] only address the safe navigation of the ship. The Administration should also take into account any additional workload which may result from the implementation of the ship's security plan and ensure that the ship is sufficiently and effectively manned. In doing so the Administration should verify that ships are able to implement the hours of rest and other measures to address fatigue which have been promulgated by national law, in the context of all shipboard duties assigned to the various shipboard personnel.

[2] Refer to Further Work by the International Maritime Organisation pertaining to Enhancement of Maritime Security, adopted by the Conference on Maritime Security by resolution [3], inviting, amongst others, the Organisation to review Assembly Resolution A.890(21) on Principles of Safe Manning. This review may also lead to amendments of regulation V/14.

[3] As was in force on the date of adoption of this Code.

B/Non-party ships and ships below convention size

B/4.45 With respect to ships flying the flag of a State which is not a Contracting Government to the Convention and not a Party to the 1988 SOLAS Protocol[6], Contracting Governments should not give more favourable treatment to such ships. Accordingly, the requirements of regulation XI-2/9 and the guidance provided in this Part of the Code should be applied to those ships.

[6] Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974.

B/4.46 Ships below Convention size are subject to measures by which States maintain security. Such measures should be taken with due regard to the requirements in chapter XI-2 and the guidance provided in this Part of the Code.

Contracting Governments may delegate authority to "Recognised Security Organisations" (RSOs) to undertake the following function on their behalf:

- **Approving "Ship Security Plans" (SSPs),**
- **Verifying implementation of the SSP onboard ships**
- **Issuing International Ship Security Certificates (ISSCs), including Interim ISSCs on their behalf.**

RSOs may also assist in the conducting of Ship Security Assessment (SSAs) and in the preparation of SSPs. In such circumstances the RSO must not approve the SSP, verify its implementation onboard or issue an ISSC to a ship in respect of the implementation.

A/5 DECLARATION OF SECURITY

A/5.1 Contracting Governments shall determine when a Declaration of Security is required by assessing the risk the ship/port interface or ship to ship activity poses to people, property or the environment.

B/5.1 A Declaration of Security (DoS) should be completed when the Contracting Government of the port facility deems it to be necessary or when a ship deems it necessary.

B/5.1.1 The need for a DoS may be indicated by the results of the Port Facility Security Assessment (PFSA) and the reasons and circumstances in which a DoS is required should be set out in the Port Facility Security Plan (PFSP).

B/5.1.2 The need for a DoS may be indicated by an Administration for ships entitled to fly its flag or as a result of a ship security assessment and should be set out in the ship security plan.

A/5.2 A ship can request completion of a Declaration of Security when:

.1 the ship is operating at a higher security level than the port facility or another ship it is interfacing with;

.2 there is an agreement on Declaration of Security between Contracting Governments covering certain international voyages or specific ships on those voyages;

.3 there has been a security threat or a security incident involving the ship or involving the port facility, as applicable;

.4 the ship is at a port which is not required to have and implement an approved port facility security plan; or

.5 the ship is conducting ship to ship activities with another ship not required to have and implement an approved ship security plan.

B/5.2 It is likely that a DoS will be requested at higher security levels, when a ship has a higher security level than the port facility, or another ship with which it interfaces, and for ship/port interface or ship to ship activities that pose a higher risk to persons, property or the environment for reasons specific to that ship, including its cargo or passengers or the circumstances at the port facility or a combination of these factors.

B/5.2.1 In the case that a ship or an Administration, on behalf of ships entitled to fly its flag, requests completion of a DoS, the Port Facility Security Officer (PFSO) or Ship Security Officer (SSO)

should acknowledge the request and discuss appropriate security measures.

A/5.3 Requests for the completion of a Declaration of Security, under this section, shall be acknowledged by the applicable port facility or ship.

B/5.3 A PFSO may also initiate a DoS prior to ship/port interfaces that are identified in the approved PFSA as being of particular concern. Examples may include the embarking or disembarking passengers, and the transfer, loading or unloading of dangerous goods or hazardous substances. The PFSA may also identify facilities at or near highly populated areas or economically significant operations that warrant a DoS.

A/5.4 The Declaration of Security shall be completed by:

.1 the master or the ship security officer on behalf of the ship(s); and, if appropriate,

.2 the port facility security officer or, if the Contracting Government determines otherwise, by any other body responsible for shore-side security, on behalf of the port facility.

B/5.4 The main purpose of a DoS is to ensure agreement is reached between the ship and the port facility or with other ships with which it interfaces as to the respective security measures each will undertake in accordance with the provisions of their respective approved security plans.

B/5.4.1 The agreed DoS should be signed and dated by both the port facility and the ship(s), as applicable, to indicate compliance with chapter XI-2 and part A of this Code and should include its duration, the relevant security level, or levels and the contact points.

B/5.4.2 A change in the security level may require that a new or revised DoS be completed.

A/5.5 The Declaration of Security shall address the security requirements that could be shared between a port facility and a ship (or between ships) and shall state the responsibility for each.

A/5.6 Contracting Governments shall specify, bearing in mind the provisions of regulation XI-2/9.2.3, the minimum period for which Declarations of Security shall be kept by the port facilities located within their territory.

A/5.7 Administrations shall specify, bearing in mind the provisions of regulation XI-2/9.2.3, the minimum period for which Declarations of Security shall be kept by ships entitled to fly their flag.

B/5.5 The DoS should be completed in English, French or Spanish or in a language common to both the port facility and the ship or the ships, as applicable.

B/5.6 A model DoS is included in Appendix 1 to this Part of the Code.

Appendix 1 of ISPS Part B contains a pro forma "Declaration of Security" (DOS) which contains details of security arrangements which will normally be shared between the ship and the Port Facility. Although Administrations will specify the length of time that a DOC must be retained on board, the DOS should be kept on board for at least 10 ship/port or ship/ship interfaces to meet the requirements of ISPS A/10 and SOLAS XI-2/9.2.3.

The DOS can be likened to a ship / shore checklist.

A/6 OBLIGATIONS OF THE COMPANY

A/6.1 The Company shall ensure that the ship security plan contains a clear statement emphasizing the master's authority. The Company shall establish in the ship security plan that the master has the overriding authority and responsibility to make decisions with respect to the security of the ship and to request the assistance of the Company or of any Contracting Government as may be necessary.

There should be no conflict between the statement of "overriding authority" and the requirement in SOLAS XI-2/8 "Master's Discretion" and the requirements to act on instructions given by Contracting Governments at Security Level 3. It should be clear that when a conflict between "security" and "safety", then the requirement for "safety" shall prevail (SOLAS XI-2/8.2).

A/6.2 The Company shall ensure that the company security officer, the master and the ship security officer are given the necessary support to fulfil their duties and responsibilities in accordance with chapter XI-2 and this part of the Code.

Manning the ship in accordance with the Safe Manning Document may not be sufficient to demonstrate that this requirements has been met. Auditors should ensure that security, and all other shipboard duties, are being effectively carried out and that requirements for work/rest times are being met.

A/7 SHIP SECURITY

A/7.1 A ship is required to act upon the security levels set by Contracting Governments as set out below.

A/7.2 At security level 1, the following activities shall be carried out, through appropriate measures, on all ships, taking into account the guidance given in part B of this Code, in order to identify and take preventive measures against security incidents:

.1 ensuring the performance of all ship security duties;

.2 controlling access to the ship;

.3 controlling the embarkation of persons and their effects;

.4 monitoring restricted areas to ensure that only authorized persons have access;

.5 monitoring of deck areas and areas surrounding the ship;

.6 supervising the handling of cargo and ship's stores; and

.7 ensuring that security communication is readily available.

A/7.3 At security level 2, the additional protective measures, specified in the ship security plan, shall be implemented for each activity detailed in section 7.2, taking into account the guidance given in part B of this Code.

A/7.4 At security level 3, further specific protective measures, specified in the ship security plan, shall be implemented for each activity detailed in section 7.2, taking into account the guidance given in part B of this Code.

It is not acceptable for a ship to claim that it operates at the highest state of security alertness regardless of the security level set by the Contracting Governments. There must be a progression from the measures employed at security level 1 through security level 2 to the measures employed at security level 3, or from level 1 direct to level 3.

A/7.5 Whenever security level 2 or 3 is set by the Administration, the ship shall acknowledge receipt of the instructions on change of the security level.

In order to verify that this requirement has been met, records of this acknowledgement should be kept on board. This will be in addition to the requirement in ISPS A/10.1.4 which requires records to be maintained of changing security levels. This record may be in the form of a logbook, or similar, entry.

A/7.6 Prior to entering a port, or whilst in a port within the territory of a Contracting Government that has set security level 2 or 3, the ship shall acknowledge receipt of this instruction and shall confirm to the port facility security officer the initiation of the implementation of the appropriate measures and procedures as detailed in the ship security plan, and in the case of security level 3 in instructions issued by the Contracting Government which has set security level 3. The ship shall report any difficulties in implementation. In such cases, the port facility security officer and ship security officer shall liase and co-ordinate the appropriate actions.

Records of this acknowledgement should be retained onboard.

A/7.7 If a ship is required by the Administration to set, or is already at, a higher security level than that set for the port it intends to enter or in which it is already located, then the ship shall advise, without delay, the competent authority of the Contracting Government within whose territory the port facility is located and the port facility security officer of the situation.

Records should be retained onboard.

A/7.7.1 In such cases, the ship security officer shall liase with the port facility security officer and co-ordinate appropriate actions, if necessary.

A/7.8 An Administration requiring ships entitled to fly its flag to set security level 2 or 3 in a port of another Contracting Government shall inform that Contracting Government without delay.

A/7.9 When Contracting Governments set security levels and ensure the provision of security level information to ships operating in their territorial sea, or having communicated an intention to enter their territorial sea, such ships shall be advised to maintain vigilance and report immediately to their Administration and any nearby coastal States any information that comes to their attention that might affect maritime security in the area.

A/7.9.1 When advising such ships of the applicable security level, a Contracting Government shall, taking into account the guidance given in the part B of this Code, also advise those ships of any security measure that they should take and, if appropriate, of measures that have been taken by the Contracting Government to provide protection against the threat.

Relevant guidance is provided under sections 8, 9 and 13.

A/8 SHIP SECURITY ASSESSMENT

A/8.1 The ship security assessment is an essential and integral part of the process of developing and updating the ship security plan.

Companies may wish to produce a generic Ship Security Assessment (SSA) that covers the assessment of security risks across a part of their fleet, or their entire fleet. Such an approach is acceptable provided an "on site security survey" has been carried out on each ship and the SSA reflects all relevant ship specific aspects.

A/8.2 The company security officer shall ensure that the ship security assessment is carried out by persons with appropriate skills to evaluate the security of a ship, in accordance with this section, taking into account the guidance given in part B of this Code.

B/8.1 The Company Security Officer (CSO) is responsible for ensuring that a Ship Security Assessment (SSA) is carried out for each of the ships in the Company's fleet which is required to comply with the provisions of chapter XI-2 and part A of this Code for which the CSO is responsible. While the CSO need not necessarily personally undertake all the duties associated with the post, the ultimate responsibility for ensuring that they are properly performed remains with the individual CSO.

B/8.2 Prior to commencing the SSA, the CSO should ensure that advantage is taken of information available on the assessment of threat for the ports at which the ship will call or at which passengers embark or disembark and about the port facilities and their protective measures. The CSO should study previous reports on similar security needs. Where feasible, the CSO should meet with appropriate persons on the ship and in the port facilities to discuss the purpose and methodology of the assessment. The CSO should follow any specific guidance offered by the Contracting Governments.

A/8.3 Subject to the provisions of section 9.2.1, a recognised security organisation may carry out the ship security assessment of a specific ship.

A RSO carrying out such a ship security assessment (SSA), whether in whole or in part, can not approve a SSP based on the SSA or certify a ship implementing the SSP.

A/8.4 The ship security assessment shall include an on-scene security survey and, at least, the following elements:

.1 identification of existing security measures, procedures and operations;

.2 identification and evaluation of key ship board operations that it is important to protect;

.3 identification of possible threats to the key ship board operations and the likelihood of their occurrence, in order to establish and prioritise security measures; and

.4 identification of weaknesses, including human factors in the infrastructure, policies and procedures.

B/8.3 A SSA should address the following elements on board or within the ship:

1 physical security;
2 structural integrity;
3 personnel protection systems;
4 procedural policies;
5 radio and telecommunication systems, including computer systems and networks;
6 other areas that may, if damaged or used for illicit observation, pose a risk to people, property, or operations on board the ship or within a port facility.

B/8.4 Those involved in a SSA should be able to draw upon expert assistance in relation to:

1 knowledge of current security threats and patterns;
2 recognition and detection of weapons, dangerous substances and devices;
3 recognition, on a non-discriminatory basis, of characteristics and behavioral patterns of persons who are likely to threaten security;
4 techniques used to circumvent security measures;
5 methods used to cause a security incident;
6 effects of explosives on ship's structures and equipment;
7 ship security;
8 ship/port interface business practices;
9 contingency planning, emergency preparedness and response;
10 physical security;
11 radio and telecommunications systems, including computer systems and networks;
12 marine engineering; and
13 ship and port operations.

B/8.5 The CSO should obtain and record the information required to conduct an assessment, including:

1 the general layout of the ship;
2 the location of areas which should have restricted access, such as navigation bridge, machinery spaces of category A and other control stations as defined in chapter II-2, etc.;
3 the location and function of each actual or potential access point to the ship;
4 changes in the tide which may have an impact on the vulnerability or security of the ship;
5 the cargo spaces and stowage arrangements;
6 the locations where the ship's stores and essential maintenance equipment is stored;
7 the locations where unaccompanied baggage is stored;
8 the emergency and stand-by equipment available to maintain essential services;
9 the number of ship's personnel, any existing security duties and any existing training requirement practices of the Company;
10 existing security and safety equipment for the protection of passengers and ship's personnel;
11 escape and evacuation routes and assembly stations which have to be maintained to ensure the orderly and safe emergency evacuation of the ship;
12 existing agreements with private security companies providing ship/waterside security

services; and

13 existing security measures and procedures in effect, including inspection and, control procedures, identification systems, surveillance and monitoring equipment, personnel identification documents and communication, alarms, lighting, access control and other appropriate systems.

B/8.6 The SSA should examine each identified point of access, including open weather decks, and evaluate its potential for use by individuals who might seek to breach security. This includes points of access available to individuals having legitimate access as well as those who seek to obtain unauthorized entry.

B/8.7 The SSA should consider the continuing relevance of the existing security measures and guidance, procedures and operations, under both routine and emergency conditions and should determine security guidance including:

1 the restricted areas;
2 the response procedures to fire or other emergency conditions;
3 the level of supervision of the ship's personnel, passengers, visitors, vendors, repair technicians, dock workers, etc.;
4 the frequency and effectiveness of security patrols;
5 the access control systems, including identification systems;
6 the security communications systems and procedures;
7 the security doors, barriers and lighting; and
8 the security and surveillance equipment and systems, if any.

B/8.8 The SSA should consider the persons, activities, services and operations that it is important to protect. This includes:

1 the ship's personnel;
2 passengers, visitors, vendors, repair technicians, port facility personnel, etc;
3 the capacity to maintain safe navigation and emergency response;
4 the cargo, particularly dangerous goods or hazardous substances;
5 the ship's stores;
6 the ship security communication equipment and systems, if any; and
7 the ship's security surveillance equipment and systems, if any.

B/8.9 The SSA should consider all possible threats, which may include the following types of security incidents:

1 damage to, or destruction of, the ship or of a port facility, e.g. by explosive devices, arson, sabotage or vandalism;
2 hijacking or seizure of the ship or of persons on board;
3 tampering with cargo, essential ship equipment or systems or ship's stores;
4 unauthorized access or use, including presence of stowaways;
5 smuggling weapons or equipment, including weapons of mass destruction;
6 use of the ship to carry those intending to cause a security incident and/or their equipment;
7 use of the ship itself as a weapon or as a means to cause damage or destruction**;**
8 attacks from seaward whilst at berth or at anchor; and
9 attacks whilst at sea.

B/8.10 The SSA should take into account all possible vulnerabilities, which may include:

1 conflicts between safety and security measures;
2 conflicts between shipboard duties and security assignments;

3 watch-keeping duties, number of ship's personnel, particularly with implications on crew fatigue, alertness and performance;
4 any identified security training deficiencies; and
5 any security equipment and systems, including communication systems.

B/8.11 The CSO and SSO should always have regard to the effect that security measures may have on ship's personnel who will remain on the ship for long periods. When developing security measures, particular consideration should be given to the convenience, comfort and personal privacy of the ship's personnel and their ability to maintain their effectiveness over long periods.

On-scene Security Survey

B/8.14 The on-scene security survey is an integral part of any SSA. The on-scene security survey should examine and evaluate existing shipboard protective measures, procedures and operations for:

1 ensuring the performance of all ship security duties;
2 monitoring restricted areas to ensure that only authorized persons have access;
3 controlling access to the ship, including any identification systems;
4 monitoring of deck areas and areas surrounding the ship;
5 controlling the embarkation of persons and their effects (accompanied and unaccompanied baggage and ship's personnel personal effects);
6 supervising the handling of cargo and the delivery of ship's stores; and
7 ensuring that ship security communication, information, and equipment are readily available.

There should be evidence that each individual ship has been subject to an "on site security survey

A/8.5 The ship security assessment shall be documented, reviewed, accepted and retained by the Company.

B/8.12 Upon completion of the SSA, a report shall be prepared, consisting of a summary of how the assessment was conducted, a description of each vulnerability found during the assessment and a description of counter measures that could be used to address each vulnerability. The report shall be protected from unauthorized access or disclosure.

B/8.13 If the SSA has not been carried out by the Company the report of the SSA should be reviewed and accepted by the CSO.

Although there is no formal requirement for the SSA to be approved, it must accompany the SSP when the SSP is submitted for approval. The approval process for the SSP should include an evaluation of the SSA to verify that it is appropriate for the ship and that all the mandatory requirements for the SSA have been fulfilled

The SSA should be reviewed at least once every 12 months. In addition should it be identified during training, drills, or following an incident that the SSA, and hence the SSP, are inappropriate they should be reviewed and amended accordingly. Records should be maintained of the review process.

A/9 SHIP SECURITY PLAN

A/9.1 Each ship shall carry on board a ship security plan approved by the Administration. The plan

shall make provisions for the three security levels as defined in this part of the Code.

B/9.1 The Company Security Officer (CSO) has the responsibility of ensuring that a Ship Security Plan (SSP) is prepared and submitted for approval. The content of each individual SSP should vary depending on the particular ship it covers. The Ship Security Assessment (SSA) will have identified the particular features of the ship and the potential threats and vulnerabilities. The preparation of the SSP will require these features to be addressed in detail. Administrations may prepare advice on the preparation and content of a SSP.

B/9.2 All SSPs should:

1 detail the organizational structure of security for the ship;

2 detail the ship's relationships with the Company, port facilities, other ships and relevant authorities with security responsibility;

3 detail the communication systems to allow effective continuous communication within the ship and between the ship and others, including port facilities;

4 detail the basic security measures for security level 1, both operational and physical, that will always be in place;

5 detail the additional security measures that will allow the ship to progress without delay to security level 2 and, when necessary, to security level 3;

6 provide for regular review, or audit, of the SSP and for its amendment in response to experience or changing circumstances; and

7 reporting procedures to the appropriate Contracting Governments contact points.

B/9.3 Preparation of an effective SSP should rest on a thorough assessment of all issues that relate to the security of the ship, including, in particular, a thorough appreciation of the physical and operational characteristics, including the voyage pattern, of the individual ship.

Companies may wish to produce a generic Ship Security Plan (SSP) that covers the management of security across a part of their fleet, or their entire fleet. Such an approach is acceptable provided an "on site security survey" has been carried out on each ship and both the SSP and the SSA on which it is based reflect all relevant ship specific aspects.

A/9.1.1 Subject to the provisions of section 9.2.1, a recognised security organisation may prepare the ship security plan for a specific ship.

If a RSO has been involved in the preparation of a SSP it can not approve such a SSP or issue an ISSC to a ship that has implemented the plan.

A/9.2 The Administration may entrust the review and approval of ship security plans, or of amendments to a previously approved plan, to recognised security organisations.

A/9.2.1 In such cases the recognised security organisation, undertaking the review and approval of a ship security plan, or its amendments, for a specific ship shall not have been involved in either the preparation of the ship security assessment or of the ship security plan, or of the amendments, under review.

B/9.4 All SSPs should be approved by, or on behalf of, the Administration. If an Administration uses a Recognised Security Organisation (RSO) to review or approve the SSP the RSO should not be associated with any other RSO that prepared, or assisted in the preparation of, the plan.

A/9.3 The submission of a ship security plan, or of amendments to a previously approved plan, for approval shall be accompanied by the security assessment on the basis of which the plan, or the amendments, have been developed.

A/9.4 Such a plan shall be developed**,** taking into account the guidance given in part B of this Code and shall be written in the working language or languages of the ship. If the language or languages used is not English, French or Spanish, a translation into one of these languages shall be included. The plan shall address, at least, the following:

.1 measures designed to prevent weapons, dangerous substances and devices intended for use against people, ships or ports and the carriage of which is not authorized from being taken on board the ship;

Measures may be procedural or otherwise.

.2 identification of the restricted areas and measures for the prevention of unauthorized access to them;

.3 measures for the prevention of unauthorized access to the ship;

.4 procedures for responding to security threats or breaches of security, including provisions for maintaining critical operations of the ship or ship/port interface;

.5 procedures for responding to any security instructions Contracting Governments may give at security level 3;

.6 procedures for evacuation in case of security threats or breaches of security;

.7 duties of shipboard personnel assigned security responsibilities and of other shipboard personnel on security aspects;

The auditor should verify by interview that persons onboard are familiar with their duties and_responsibilities, as specified in the SSP.

.8 procedures for auditing the security activities;

Internal audits should be conducted at least once every 12 months. Copies of internal audit reports should be retained onboard, for a minimum period of 5 years, treated as confidential information and protected against unauthorised disclosure.

.9 procedures for training, drills and exercises associated with the plan;

The schedule of drills and training should reflect the risks to security identified in the SSA.

.10 procedures for interfacing with port facility security activities;

.11 procedures for the periodic review of the plan and for updating;

The SSP should be reviewed at least once every 12 months in conjunction with the SSA. In addition should it be identified during training, drills or following an incident that the SSP, and hence the

SSA, are inappropriate, they should be reviewed and amended accordingly. Records should be maintained of the review process.

.12 procedures for reporting security incidents;

.13 identification of the ship security officer;

Identification of the SSO can be by name or position.

.14 identification of the company security officer including with 24-hour contact details;

Identification of the CSO can be by name or position. Auditors may, as part of the verification process test the 24hr contact details supplied for the CSO.

.15 procedures to ensure the inspection, testing, calibration, and maintenance of any security equipment provided on board, if any;

The objective of testing, calibration and maintenance should be to ensure that the equipment is "fit for purpose" and should be in accordance with manufacturers' recommendations.

.16 frequency for testing or calibration any security equipment provided on board, if any;

.17 identification of the locations where the ship security alert system activation points are provided;[1] and

.18 procedures, instructions and guidance on the use of the ship security alert system, including the testing, activation, deactivation and resetting and to limit false alerts.1

[1] *Administrations may allow, in order to avoid any compromising of the objective of providing on board the ship security alert system, this information to be kept elsewhere on board in a document known to the master, the ship security officer and other senior shipboard personnel as may be decided by the Company.*

B/9.5 CSOs and Ship Security Officers (SSOs) should develop procedures to:
1 assess the continuing effectiveness of the SSP; and
2 prepare amendments of the plan subsequent to its approval.

B/9.6 The security measures included in the SSP should be in place when the initial verification for compliance with the requirements of chapter XI-2 and Part A of this Code will be carried out. Otherwise the process of issue to the ship of the required International Ship Security Certificate cannot be carried out. If there is any subsequent failure of security equipment or systems, or suspension of a security measure for whatever reason, equivalent temporary security measures should be adopted, notified to, and agreed by, the Administration.

Organization and Performance of Ship Security Duties

B/9.7 In addition to the guidance given in section 9.2, the SSP should establish the following which relate to all security levels:
1 the duties and responsibilities of all shipboard personnel with a security role;
2 the procedures or safeguards necessary to allow such continuous communications to be maintained at all times;

3 the procedures needed to assess the continuing effectiveness of security procedures and any security and surveillance equipment and systems, including procedures for identifying and responding to equipment or systems failure or malfunction;
4 the procedures and practices to protect security sensitive information held in paper or electronic format;
5 the type and maintenance requirements, of security and surveillance equipment and systems, if any;
6 the procedures to ensure the timely submission, and assessment, of reports relating to possible breaches of security or security concerns; and
7 procedures to establish, maintain and up-date an inventory of any dangerous goods or hazardous substances carried on board, including their location.

B/9.8 The remainder of this section addresses specifically the security measures that could be taken at each security level covering:
1 Access to the Ship by ship's personnel, passengers, visitors, etc;
2 Restricted Areas on the Ship;
3 Handling of Cargo;
4 Delivery of Ship's Stores;
5 Handling Unaccompanied Baggage; and
6 Monitoring the Security of the Ship.

Access to the Ship

B/9.9 The SSP should establish the security measures covering all means of access to the ship identified in the SSA. This should include any:
1 access ladders;
2 access gangways;
3 access ramps;
4 access doors, side scuttles, windows and ports;
5 mooring lines and anchor chains; and
6 cranes and hoisting gear.

B/9.10 For each of these the SSP should identify the appropriate locations where access restrictions or prohibitions should be applied for each of the security levels. For each security level the SSP should establish the type of restriction or prohibition to be applied and the means of enforcing them.

B/9.11 The SSP should establish for each security level the means of identification required to allow access to the ship and for individuals to remain on the ship without challenge, this may involve developing an appropriate identification system allowing for permanent and temporary identifications, for ship's personnel and visitors respectively. Any ship identification system should, when it is practicable to do so, be co-ordinated with that applying to the port facility. Passengers should be able to prove their identity by boarding passes, tickets, etc., but should not be permitted access to restricted areas unless supervised. The SSP should establish provisions to ensure that the identification systems are regularly updated, and that abuse of procedures should be subject to disciplinary action.

B/9.12 Those unwilling or unable to establish their identity and/or to confirm the purpose of their visit when requested to do so should be denied access to the ship and their attempt to obtain access should be reported, as appropriate, to the SSOs, the CSOs, the Port Facility Security Officer (PFSO) and to the national or local authorities with security responsibilities.

B/9.13 The SSP should establish the frequency of application of any access controls particularly if they are to be applied on a random, or occasional, basis.

Security Level 1

B/9.14 At security level 1, the SSP should establish the security measures to control access to the ship, where the following may be applied:

1 checking the identity of all persons seeking to board the ship and confirming their reasons for doing so by checking, for example, joining instructions, passenger tickets, boarding passes, work orders etc;

2 in liaison with the port facility the ship should ensure that designated secure areas are established in which inspections and searching of people, baggage (including carry on items), personal effects, vehicles and their contents can take place;

3 in liaison with the port facility the ship should ensure that vehicles destined to be loaded on board car carriers, ro-ro and other passenger ships are subjected to search prior to loading, in accordance with the frequency required in the SSP;

4 segregating checked persons and their personal effects from unchecked persons and their personal effects;

5 segregating embarking from disembarking passengers;

6 identification of access points that should be secured or attended to prevent unauthorized access;

7 securing, by locking or other means, access to unattended spaces adjoining areas to which passengers and visitors have access; and .8 providing security briefings to all ship personnel on possible threats, the procedures for reporting suspicious persons, objects or activities and the need for vigilance.

B/9.15 At security level 1, all those seeking to board a ship should be liable to search. The frequency of such searches, including random searches, should be specified in the approved SSP and should be specifically approved by the Administration. Such searches may best be undertaken by the port facility in close co-operation with the ship and in close proximity to it. Unless there are clear security grounds for doing so, members of the ship's personnel should not be required to search their colleagues or their personal effects. Any such search shall be undertaken in a manner which fully takes into account the human rights of the individual and preserves their basic human dignity.

Security Level 2

B/9.16 At security level 2, the SSP should establish the security measures to be applied to protect against a heightened risk of a security incident to ensure higher vigilance and tighter control, which may include:

1 assigning additional personnel to patrol deck areas during silent hours to deter unauthorised access;

2 limiting the number of access points to the ship, identifying those to be closed and the means of adequately securing them;

3 deterring waterside access to the ship, including**,** for example, in liaison with the port facility, provision of boat patrols;

4 establishing a restricted area on the shore-side of the ship, in close co-operation with the port facility;

5 increasing the frequency and detail of searches of people, personal effects, and vehicles being embarked or loaded onto the ship;

6 escorting visitors on the ship;

7 providing additional specific security briefings to all ship personnel on any identified threats, re-emphasising the procedures for reporting suspicious persons, objects, or

activities and the stressing the need for increased vigilance; and

8 carrying out a full or partial search of the ship.

Security Level 3

B/9.17 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operation with those responding and the port facility, which may include:

1 limiting access to a single, controlled, access point;
2 granting access only to those responding to the security incident or threat thereof;
3 directions of persons on board;
4 suspension of embarkation or disembarkation;
5 suspension of cargo handling operations, deliveries etc;
6 evacuation of the ship;
7 movement of the ship; and
8 preparing for a full or partial search of the ship.

Restricted Areas on the Ship

B/9.18 The SSP should identify the restricted areas to be established on the ship, specify their extent, times of application, the security measures to be taken to control access to them and those to be taken to control activities within them. The purpose of restricted areas are to:

1 prevent unauthorised access;
2 protect passengers, ship's personnel, and personnel from port facilities or other agencies authorised to be on board the ship;
3 protect sensitive security areas within the ship; and
4 protect cargo and ship's stores from tampering.

B/9.19 The SSP should ensure that there are clearly established policies and practices to control access to all restricted areas them.

B/9.20 The SSP should provide that all restricted areas should be clearly marked indicating that access to the area is restricted and that unauthorised presence within the area constitutes a breach of security.

B/9.21 Restricted areas may include:

1 navigation bridge, machinery spaces of category A and other control stations as defined in chapter II-2;
2 spaces containing security and surveillance equipment and systems and their controls and lighting system controls;
3 ventilation and air-conditioning systems and other similar spaces;
4 spaces with access to potable water tanks, pumps, or manifolds;
5 spaces containing dangerous goods or hazardous substances;
6 spaces containing cargo pumps and their controls;
7 cargo spaces and spaces containing ship’s stores;
8 crew accommodation; and
9 any other areas as determined by the CSO, through the SSA to which access must be restricted to maintain the security of the ship.

Security Level 1

B/9.22 At security level 1, the SSP should establish the security measures to be applied to restricted areas, which may include:

1 locking or securing access points;
2 using surveillance equipment to monitor the areas;
3 using guards or patrols; and
4 using automatic intrusion detection devices to alert the ship's personnel of unauthorized access.

Security Level 2

B/9.23 At security level 2, the frequency and intensity of the monitoring of, and control of access to restricted areas should be increased to ensure that only authorized persons have access. The SSP should establish the additional security measures to be applied, which may include:
1 establishing restricted areas adjacent to access points;
2 continuously monitoring surveillance equipment; and
3 dedicating additional personnel to guard and patrol restricted areas.

Security Level 3

B/9.24 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operations with those responding and the port facility, which may include:
1 setting up of additional restricted areas on the ship in proximity to the security incident, or the believed location of the security threat, to which access is denied; and
2 searching of restricted areas as part of a search of the ship.

Handling of Cargo

B/9.25 The security measures relating to cargo handling should:
1 prevent tampering, and
2 prevent cargo that is not meant for carriage from being accepted and stored on board the ship.

B/9.26 The security measures, some of which may have to be applied in liaison with the port facility, should include inventory control procedures at access points to the ship. Once on board the ship, cargo should be capable of being identified as having been approved for loading onto the ship. In addition, security measures should be developed to ensure that cargo, once on board, is not tampered with.

Security Level 1

B/9.27 At security level 1, the SSP should establish the security measures to be applied during cargo handling, which may include:
1 routine checking of cargo, cargo transport units and cargo spaces prior to, and during, cargo handling operations;
2 checks to ensure that cargo being loaded matches the cargo documentation;
3 ensuring, in liaison with the port facility, that vehicles to be loaded on board car-carriers, ro-ro and passenger ships are subjected to search prior to loading, in accordance with the frequency required in the SSP; and
4 checking of seals or other methods used to prevent tampering.

B/9.28 Checking of cargo may be accomplished by the following means:
1 visual and physical examination; and
2 using scanning/detection equipment, mechanical devices, or dogs.

B/9.29 When there are regular, or repeated, cargo movement the CSO or SSO may, in consultation with

the port facility, agree arrangements with shippers or others responsible for such cargo covering off-site checking, sealing, scheduling, supporting documentation, etc. Such arrangements should be communicated to and agreed with the PFSO concerned.

Security Level 2

B/9.30 At security level 2, the SSP should establish the additional security measures to be applied during cargo handling, which may include:

1 detailed checking of cargo, cargo transport units and cargo spaces;
2 intensified checks to ensure that only the intended cargo is loaded;
3 intensified searching of vehicles to be loaded on car-carriers, ro-ro and passenger ships; and
4 increased frequency and detail in checking of seals or other methods used to prevent tampering.

B/9.31 Detailed checking of cargo may be accomplished by the following means:

1 increasing the frequency and detail of visual and physical examination;
2 increasing the frequency of the use of scanning/detection equipment, mechanical devices, or dogs; and
3 co-ordinating enhanced security measures with the shipper or other responsible party in accordance with an established agreement and procedures.

Security Level 3

B/9.32 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operation with those responding and the port facility, which may include:

1 suspension of the loading or unloading of cargo; and
2 verify the inventory of dangerous goods and hazardous substances carried on board, if any, and their location.

Delivery of Ship's Stores

B/9.33 The security measures relating to the delivery of ship's stores should:

1 ensure checking of ship's stores and package integrity;
2 prevent ship's stores from being accepted without inspection;
3 prevent tampering; and
4 prevent ship's stores from being accepted unless ordered.

B/9.34 For ships regularly using the port facility it may be appropriate to establish procedures involving the ship, its suppliers and the port facility covering notification and timing of deliveries and their documentation. There should always be some way of confirming that stores presented for delivery are accompanied by evidence that they have been ordered by the ship.

Security Level 1

B/9.35 At security level 1, the SSP should establish the security measures to be applied during delivery of ship's stores, which may include:

1 checking to ensure stores match the order prior to being loaded on board; and
2 ensuring immediate secure stowage of ship's stores.

Security Level 2

B/9.36 At security level 2, the SSP should establish the additional security measures to be applied

during delivery of ship's stores by exercising checks prior to receiving stores on board and intensifying inspections.

Security Level 3

B/9.37 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operation with those responding and the port facility, which may include:

1 subjecting ship's stores to more extensive checking;
2 preparation for restriction or suspension of handling of ship's stores; and
3 refusal to accept ship's stores on board the ship.

Handling Unaccompanied Baggage

B/9.38 The SSP should establish the security measures to be applied to ensure that unaccompanied baggage (i.e. any baggage, including personal effects, which is not with the passenger or member of ship's personnel at the point of inspection or search) is identified and subjected to appropriate screening, including searching, before it is accepted on board the ship. It is not envisaged that such baggage will be subjected to screening by both the ship and the port facility, and in cases where both are suitably equipped, the responsibility for screening should rest with the port facility. Close co-operation with the port facility is essential and steps should be taken to ensure that unaccompanied baggage is handled securely after screening.

Security Level 1

B/9.39 At security level 1, the SSP should establish the security measures to be applied when handling unaccompanied baggage to ensure that unaccompanied baggage is screened or searched up to and including 100 percent, which may include use of x-ray screening.

Security Level 2

B/9.40 At security level 2, the SSP should establish the additional security measures to be applied when handling unaccompanied baggage which should include 100 percent x-ray screening of all unaccompanied baggage.

Security Level 3

B/9.41 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operation with those responding and the port facility, which may include:

1 subjecting such baggage to more extensive screening, for example x-raying it from at least two different angles;
2 preparation for restriction or suspension of handling of unaccompanied baggage; and
3 refusal to accept unaccompanied baggage on board the ship.

Monitoring the Security of the Ship

B/9.42 The ship should have the capability to monitor the ship, the restricted areas on board and areas surrounding the ship. Such monitoring capabilities may include use of:

1 lighting;
2 watch-keepers, security guards and deck watches including patrols, and
3 automatic intrusion detection devices and surveillance equipment.

B/9.43 When used, automatic intrusion detection devices should activate an audible and/or visual alarm at a location that is continuously attended or monitored.

B/9.44 The SSP should establish the procedures and equipment needed at each security level and the means of ensuring that monitoring equipment will be able to perform continually, including consideration of the possible effects of weather conditions or of power disruptions.

Security Level 1

B/9.45 At security level 1, the SSP should establish the security measures to be applied which may be a combination of lighting, watch keepers, security guards or use of security and surveillance equipment to allow ship's security personnel to observe the ship in general, and barriers and restricted areas in particular.

B/9.46 The ship's deck and access points to the ship should be illuminated during hours of darkness and periods of low visibility while conducting ship/port interface activities or at a port facility or anchorage when necessary. While underway, when necessary, ships should use the maximum lighting available consistent with safe navigation, having regard to the provisions of the International Regulation for the Prevention of Collisions at Sea in force. The following should be considered when establishing the appropriate level and location of lighting:

1 the ship's personnel should be able to detect activities beyond the ship, on both the shore side and the waterside;
2 coverage should include the area on and around the ship;
3 coverage should facilitate personnel identification at access points; and
4 coverage may be provided through coordination with the port facility.

Security Level 2

B/9.47 At security level 2, the SSP should establish the additional security measures to be applied to enhance the monitoring and surveillance capabilities, which may include:

1 increasing the frequency and detail of security patrols;
2 increasing the coverage and intensity of lighting or the use of security and surveillance and equipment;
3 assigning additional personnel as security lookouts; and
4 ensuring coordination with waterside boat patrols, and foot or vehicle patrols on the shore-side, when provided.

B/9.48 Additional lighting may be necessary to protect against a heightened risk of a security incidents. When necessary, the additional lighting requirements may be accomplished by coordinating with the port facility to provide additional shore side lighting.

Security Level 3

B/9.49 At security level 3, the ship should comply with the instructions issued by those responding to the security incident or threat thereof. The SSP should detail the security measures which could be taken by the ship, in close co-operation with those responding and the port facility, which may include:

1 switching on of all lighting on, or illuminating the vicinity of, the ship;
2 switching on of all on board surveillance equipment capable of recording activities on, or in the vicinity of, the ship;
3 maximising the length of time such surveillance equipment can continue to record;
4 preparation for underwater inspection of the hull of the ship; and
5 initiation of measures, including the slow revolution of the ship's propellers, if practicable, to deter underwater access to the hull of the ship.

Declarations of Security

B/9.52 The SSP should detail how requests for DoS from a port facility will be handled and the circumstances under which the ship itself should request a DoS.

The contents of the SSP should be sufficiently detailed as to make clear how each of the above areas is to be addressed and procedures implemented onboard.
For example, the sentence "*Onboard measures shall prevent unauthorized access to the ship.*" is not sufficient to demonstrate compliance with the requirement of ISPS A/9.4.3.

A/9.4.1 Personnel conducting internal audits of the security activities specified in the plan or evaluating its implementation shall be independent of the activities being audited unless this is impracticable due to the size and the nature of the Company or of the ship.

Audit and Review

B/9.53 The SSP should establish how the CSO and the SSO intend to audit the continued effectiveness of the SSP and the procedure to be followed to review, update or amend the SSP.

A/9.5 The Administration shall determine which changes to an approved ship security plan or to any security equipment specified in an approved plan shall not be implemented unless the relevant amendments to the plan are approved by the Administration. Any such changes shall be at least as effective as those measures prescribed in chapter XI-2 and this part of the Code.

A/9.5.1 The nature of the changes to the ship security plan or the security equipment that have been specifically approved by the Administration, pursuant to section 9.5, shall be documented in a manner that clearly indicates such approval. This approval shall be available on board and shall be presented together with the International Ship Security Certificate (or the Interim International Ship Security Certificate). If these changes are temporary, once the original approved measures or equipment are reinstated, this documentation no longer needs to be retained by the ship.

The approval and implementation of amendments to the approved SSP should be verified at each verification audit. This verification should cover every amendment to the approved SSP that has been approved by the Administration since the previous verification audit, or since the SSP was originally approved. Additional verifications for the implementation of amendments will be at the instruction of the Administration.

A/9.6 The plan may be kept in an electronic format. In such a case, it shall be protected by procedures aimed at preventing its unauthorised deletion, destruction or amendment.

A/9.7 The plan shall be protected from unauthorized access or disclosure.

Arrangements should be in place so that all interested parties have sufficient access to the relevant sections of the SSP to allow them to effectively discharge their duties under the SSP. This includes arrangements to allow officers duly authorised by Contracting Governments, as stated in SOLAS XI-2/9 ("Port State Control"), access to the plan as allowed in ISPS A/9.8.1

A/9.8 Ship security plans are not subject to inspection by officers duly authorised by a Contracting Government to carry out control and compliance measures in accordance with regulation XI-2/9, save in circumstances specified in section 9.8.1.

A/9.8.1 If the officers duly authorised by a Contracting Government have clear grounds to believe that the ship is not in compliance with the requirements of chapter XI-2 or part A of this Code, and the only means to verify or rectify the non-compliance is to review the relevant requirements of the ship security plan, limited access to the specific sections of the plan relating to the non-compliance is exceptionally allowed, but only with the consent of the Contracting Government of, or the master of, the ship concerned. Nevertheless, the provisions in the plan relating to section 9.4 subsections .2, .4, .5, .7, .15, .17 and .18 of this part of the Code are considered as confidential information, and cannot be subject to inspection unless otherwise agreed by the Contracting Governments concerned.

Differing Security Levels

B/9.50 The SSP should establish details of the procedures and security measures the ship could adopt if the ship is at a higher security level than that applying to a port facility.

Activities not covered by the Code

B/9.51 The SSP should establish details of the procedures and security measures the ship should apply when:

1 it is at a port of a State which is not a Contracting Government;

2 it is interfacing with a ship to which this Code does not apply[7];

3 it is interfacing with fixed or floating platforms or a mobile drilling unit on location; or

4 it is interfacing with a port or port facility which is not required to comply with chapter XI-2 and part A of this Code.

[7] Refer to Further Work by the International Maritime Organisation pertaining to Enhancement of Maritime Security, adopted by the Conference on Maritime Security by resolution [3].

A/10 RECORDS

A/10.1 Records of the following activities addressed in the ship security plan shall be kept on board for at least the minimum period specified by the Administration, bearing in mind the provisions of regulation XI-2/9.2.3:

.1 training, drills and exercises;

.2 security threats and security incidents;

.3 breaches of security;

.4 changes in security level;

.5 communications relating to the direct security of the ship such as specific threats to the ship or to port facilities the ship is, or has been;

.6 internal audits and reviews of security activities;

.7 periodic review of the ship security assessment;

.8 periodic review of the ship security plan;

.9 implementation of any amendments to the plan; and

.10 maintenance, calibration and testing of security equipment, if any including testing of the ship security alert system.

A/10.2 The records shall be kept in the working language or languages of the ship. If the language or languages used are not English, French or Spanish, a translation into one of these languages shall be included.

A/10.3 The records may be kept in an electronic format. In such a case, they shall be protected by procedures aimed at preventing their unauthorised deletion, destruction or amendment.

A/10.4 The records shall be protected from unauthorized access or disclosure.

B/10.1 Records should be available to duly authorized officers of Contracting Governments to verify that the provisions of ship security plans are being implemented.

B/10.2 Records may be kept in any format but should be protect from unauthorized access or disclosure.

Section 10 details the minimum records that must be retained onboard. It is unlikely that full compliance with the ISPS Code can be verified by these records alone.

The company should have a procedure in place and implemented for the control of records. Auditors should ensure that sufficient records are available so that compliance, as required by ISPS 19.1.1.1, can be verified.

A/11 COMPANY SECURITY OFFICER

A/11.1 The Company shall designate a company security officer. A person designated as the company security officer may act as the company security officer for one or more ships, depending on the number or types of ships the Company operates provided it is clearly identified for which ships this person is responsible. A Company may, depending on the number or types of ships they operate designate several persons as company security officers provided it is clearly identified for which ships each person is responsible.

A/11.2 In addition to those specified elsewhere in this part of the Code, the duties and responsibilities of the company security officer shall include, but are not limited to:

.1 advising the level of threats likely to be encountered by the ship, using appropriate security assessments and other relevant information;

.2 ensuring that ship security assessments are carried out;

.3 ensuring the development, the submission for approval, and thereafter the implementation and maintenance of the ship security plan;

.4 ensuring that the ship security plan is modified, as appropriate, to correct deficiencies and satisfy the security requirements of the individual ship;

.5 arranging for internal audits and reviews of security activities;

.6 arranging for the initial and subsequent verifications of the ship by the Administration or the recognised security organisation;

.7 ensuring that deficiencies and non-conformities identified during internal audits, periodic reviews, security inspections and verifications of compliance are promptly addressed and dealt with;

.8 enhancing security awareness and vigilance;

.9 ensuring adequate training for personnel responsible for the security of the ship;

.10 ensuring effective communication and co-operation between the ship security officer and the relevant port facility security officers;

.11 ensuring consistency between security requirements and safety requirement;

.12 ensuring that, if sister-ship or fleet security plans are used, the plan for each ship reflects the ship-specific information accurately; and

.13 ensuring that any alternative or equivalent arrangements approved for a particular ship or group of ships are implemented and maintained.

B/Relevant guidance is provided under sections 8, 9 and 13.

A/12 SHIP SECURITY OFFICER

A/12.1 A ship security officer shall be designated on each ship.

The Ship Security Officer (SSO) shall have the authority onboard to enable the stated duties and responsibilities to be carried out effectively.

A/12.2 In addition to those specified elsewhere in this part of the Code, the duties and responsibilities of the ship security officer shall include, but are not limited to:

.1 undertaking regular security inspections of the ship to ensure that appropriate security measures are maintained;

.2 maintaining and supervising the implementation of the ship security plan, including any amendments to the plan;

.3 co-ordinating the security aspects of the handling of cargo and ship's stores with other shipboard personnel and with the relevant port facility security officers;

.4 proposing modifications to the ship security plan;

.5 reporting to the Company Security Officer any deficiencies and non-conformities

identified during internal audits, periodic reviews, security inspections and verifications of compliance and implementing any corrective actions;

.6 enhancing security awareness and vigilance on board;

.7 ensuring that adequate training has been provided to shipboard personnel, as appropriate;

.8 reporting all security incidents;

.9 co-ordinating implementation of the ship security plan with the company security officer and the relevant port facility security officer; and

.10 ensuring that security equipment is properly operated, tested, calibrated and maintained, if any.

B/Relevant guidance is provided under sections 8, 9 and 13.

The Auditor should confirm by interview with the SSO, and others, that these duties and responsibilities are understood both in general terms and how they are applied to this ship.

A/13 TRAINING, DRILLS AND EXERCISES ON SHIP SECURITY

A/13.1 The company security officer and appropriate shore-based personnel shall have knowledge and have received training, taking into account the guidance given in part B of this Code.

B/13.1 The Company Security Officer (CSO) and appropriate shore based Company personnel**,** and the Ship Security Officer (SSO), should have knowledge of, and receive training, in some or all of the following, as appropriate:

1 security administration;
2 relevant international conventions, codes and recommendations;
3 relevant Government legislation and regulations;
4 responsibilities and functions of other security organisations;
5 methodology of ship security assessment;
6 methods of ship security surveys and inspections;
7 ship and port operations and conditions;
8 ship and port facility security measures;
9 emergency preparedness and response and contingency planning;
10 instruction techniques for security training and education, including security measures and procedures;
11 handling sensitive security related information and security related communications;
12 knowledge of current security threats and patterns;
13 recognition and detection of weapons, dangerous substances and devices;
14 recognition, on a non discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security;
15 techniques used to circumvent security measures;
16 security equipment and systems and their operational limitations;
17 methods of conducting audits, inspection, control and monitoring;
18 methods of physical searches and non-intrusive inspections;

	19	security drills and exercises, including drills and exercises with port facilities; and
	20	assessment of security drills and exercises.

A/13.2 The ship security officer shall have knowledge and have received training, taking into account the guidance given in part B of this Code.

B/13.2	In addition the SSO should have adequate knowledge of, and receive training, in some or all of the following, as appropriate:	
	1	the layout of the ship;
	2	the ship security plan and related procedures (including scenario-based training on how to respond);
	3	crowd management and control techniques;
	4	operations of security equipment and systems; and
	5	testing, calibration and whilst at sea maintenance of security equipment and systems.

There should be evidence onboard that the SSO has received training in the areas identified in ISPS A/12.2. The effectiveness of this training should be ascertained by means that may include interview with the SSO.

A/13.3 Shipboard personnel having specific security duties and responsibilities shall understand their responsibilities for ship security as described in the ship security plan and shall have sufficient knowledge and ability to perform their assigned duties, taking into account the guidance given in Part B of this Code.

B/13.3	Shipboard personnel having specific security duties should have sufficient knowledge and ability to perform their assigned duties, including**,** as appropriate:	
	1	knowledge of current security threats and patterns;
	2	recognition and detection of weapons, dangerous substances and devices;
	3	recognition of characteristics and behavioural patterns of persons who are likely to threaten security;
	4	techniques used to circumvent security measures;
	5	crowd management and control techniques;
	6	security related communications;
	7	knowledge of the emergency procedures and contingency plans;
	8	operations of security equipment and systems;
	9	testing, calibration and whilst at sea maintenance of security equipment and systems,
	10	inspection, control, and monitoring techniques; and
	11	methods of physical searches of persons, personal effects, baggage, cargo, and ship's stores.
B/13.4	All other shipboard personnel should have sufficient knowledge of and be familiar with relevant provisions of the SSP, including:	
	1	the meaning and the consequential requirements of the different security levels;
	2	knowledge of the emergency procedures and contingency plans;
	3	recognition and detection of weapons, dangerous substances and devices;
	4	recognition, on a non discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security; and
	5	techniques used to circumvent security measures.

All crew onboard should have received security familiarization training appropriate to their

assigned security duties. The training should be documented to allow the auditor to verify that it has been carried out in a timely manner. Effectiveness of this training may be verified by interview.

A/13.4 To ensure the effective implementation of the ship security plan, drills shall be carried out at appropriate intervals taking into account the ship type, ship personnel changes, port facilities to be visited and other relevant circumstances, taking into account guidance given in part B of this Code.

B/13.5 The objective of drills and exercises is to ensure that shipboard personnel are proficient in all assigned security duties at all security levels and the identification of any security related deficiencies, which need to be addressed.

B/13.6 To ensure the effective implementation of the provisions of the ship security plan, drills should be conducted at least once every three months. In addition, in cases where more than 25 percent of the ship's personnel has been changed, at any one time, with personnel that has not previously participated in any drill on that ship, within the last 3 months, a drill should be conducted within one week of the change. These drills should test individual elements of the plan such as those security threats listed in paragraph 8.9.

Drills and exercises should be conducted at the frequencies stated in Part B of the Code.

A/13.5 The company security officer shall ensure the effective coordination and implementation of ship security plans by participating in exercises at appropriate intervals, taking into account the guidance given in part B of this Code.

B/13.7 Various types of exercises which may include participation of company security officers, port facility security officers, relevant authorities of Contracting Governments as well as ship security officers, if available, should be carried out at least once each calendar year with no more than 18 months between the exercises. These exercises should test communications, coordination, resource availability, and response. These exercises may be:

1 full scale or live;
2 tabletop simulation or seminar; or
3 combined with other exercises held such as search and rescue or emergency response exercises.

B/13.8 Company participation in an exercise with another Contracting Government should be recognised by the Administration.

Records should be available for all drills carried out on board the ship, including those which involved the company in compliance with ISPS A/13.5

14 PORT FACILITY SECURITY TO 18 "TRAINING FOR PORT FACILITIES"

There should be a process by which the ship can receive basic port security information prior to arrival.

A/19 VERIFICATION AND CERTIFICATION FOR SHIPS

A/19.1 Verifications

A/19.1.1 Each ship to which this part of the Code applies shall be subject to the verifications specified below:

.1 an initial verification before the ship is put in service or before the certificate required under section 19.2 is issued for the first time, which shall include a complete verification of its security system and any associated security equipment covered by the relevant provisions of chapter XI-2, this part of the Code and the approved ship security plan. This verification shall ensure that the security system and any associated security equipment of the ship fully complies with the applicable requirements of chapter XI-2 and this part of the Code, is in satisfactory condition and fit for the service for which the ship is intended;

.2 a renewal verification at intervals specified by the Administration, but not exceeding five years, except where section 19.3.1 or 19.3.4 is applicable. This verification shall ensure that the security system and any associated security equipment of the ship fully complies with the applicable requirements of chapter XI-2, this part of the Code and the approved Ship Security Plan, is in satisfactory condition and fit for the service for which the ship is intended;

The use of the term "fully complies" in Section 19.1.1.1 and 19.1.1.2 means that a certificate cannot be issued unless ALL the requirements of the approved SSP are fully implemented and any associated security equipment and systems are present and fit for purpose. If the auditor identifies through objective evidence non-compliance in the approved SSP, this shall be communicated to the company, the Administration and the organisation that approved the plan. In such cases an ISSC shall not be issued until it can be shown that the security system, and any associated security equipment of the ship, is in all respects satisfactory and that the ship complies with the applicable requirements of chapter XI-2 of the Convention and part A and B of the ISPS Code.

.3 at least one intermediate verification. If only one intermediate verification is carried out it shall take place between the second and third anniversary date of the certificate as defined in regulation I/2(n). The intermediate verification shall include inspection of the security system and any associated security equipment of the ship to ensure that it remains satisfactory for the service for which the ship is intended. Such intermediate verification shall be endorsed on the certificate;

.4 any additional verifications as determined by the Administration.

A/19.1.2 The verifications of ships shall be carried out by officers of the Administration. The Administration may, however, entrust the verifications to a recognized security organization referred to in regulation XI-2/1.

A/19.1.3 In every case, the Administration concerned shall fully guarantee the completeness and efficiency of the verification and shall undertake to ensure the necessary arrangements to satisfy this obligation.

A/19.1.4 The security system and any associated security equipment of the ship after verification shall be maintained to conform with the provisions of regulations XI-2/4.2 and XI-2/6, this part of the Code and the approved ship security plan. After any verification under section 19.1.1 has been completed, no changes shall be made in security system and in any associated security equipment or the approved ship security plan without the sanction of the Administration.

At the Initial, Intermediate, Renewal and any additional verification, the auditor shall verify through a representative sample that at all security equipment and systems has been maintained and calibrated in accordance with the provisions of the SSP and the manufacturers' instructions.

A/19.2 Issue or endorsement of certificate

A/19.2.1 An International Ship Security Certificate shall be issued after the initial or renewal verification in accordance with the provisions of section 19.1.

A/19.2.2 Such certificate shall be issued or endorsed either by the Administration or by the a recognized security organization acting on behalf of the Administration.

A/19.2.3 Another Contracting Government may, at the request of the Administration, cause the ship to be verified and, if satisfied that the provisions of section 19.1.1 are complied with, shall issue or authorize the issue of an International Ship Security Certificate to the ship and, where appropriate, endorse or authorize the endorsement of that certificate on the ship, in accordance with this Code.

A/19.2.3.1 A copy of the certificate and a copy of the verification report shall be transmitted as soon as possible to the requesting Administration.

A/19.2.3.2 A certificate so issued shall contain a statement to the effect that it has been issued at the request of the Administration and it shall have the same force and receive the same recognition as the certificate issued under section 19.2.2.

A/19.2.4 The International Ship Security Certificate shall be drawn up in a form corresponding to the model given in the appendix to this Code. If the language used is not English, French or Spanish, the text shall include a translation into one of these languages.

No additional guidance.

A/19.3 Duration and validity of certificate

A/19.3.1 An International Ship Security Certificate shall be issued for a period specified by the Administration which shall not exceed five years.

On completion of an audit, and to facilitate the review process by the audit organisation, a certificate with validity not exceeding five (5) months may be issued by the auditor.

A/19.3.2 When the renewal verification is completed within three months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal verification to a date not exceeding five years from the date of expiry of the existing certificate.

A/19.3.2.1 When the renewal verification is completed after the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal verification to a date not exceeding five years from the date of expiry of the existing certificate.

A/19.3.2.2 When the renewal verification is completed more than three months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the

renewal verification to a date not exceeding five years from the date of completion of the renewal verification.

A/19.3.3 If a certificate is issued for a period of less than five years, the Administration may extend the validity of the certificate beyond the expiry date to the maximum period specified in section 19.3.1, provided that the verifications referred to in section 19.1.1 applicable when a certificate is issued for a period of five years are carried out as appropriate.

A/19.3.4 If a renewal verification has been completed and a new certificate cannot be issued or placed on board the ship before the expiry date of the existing certificate, the Administration or recognized security organization acting on behalf of the Administration may endorse the existing certificate and such a certificate shall be accepted as valid for a further period which shall not exceed five months from the expiry date.

A/19.3.5 If a ship at the time when a certificate expires is not in a port in which it is to be verified, the Administration may extend the period of validity of the certificate but this extension shall be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is verified, and then only in cases where it appears proper and reasonable to do so. No certificate shall be extended for a period longer than three months, and the ship to which an extension is granted shall not, on its arrival in the port in which it is to be verified, be entitled by virtue of such extension to leave that port without having a new certificate. When the renewal verification is completed, the new certificate shall be valid to a date not exceeding five years from the expiry date of the existing certificate before the extension was granted.

A/19.3.6 A certificate issued to a ship engaged on short voyages which has not been extended under the foregoing provisions of this section may be extended by the Administration for a period of grace of up to one month from the date of expiry stated on it. When the renewal verification is completed, the new certificate shall be valid to a date not exceeding five years from the date of expiry of the existing certificate before the extension was granted.

A/19.3.7 If an intermediate verification is completed before the period specified in section 19.1.1, then:

.1 the expiry date shown on the certificate shall be amended by endorsement to a date which shall not be more than three years later than the date on which the intermediate verification was completed;

.2 the expiry date may remain unchanged provided one or more additional verifications are carried out so that the maximum intervals between the verifications prescribed by section 19.1.1 are not exceeded.

A/19.3.8 A certificate issued under section 19.2 shall cease to be valid in any of the following cases:

.1 if the relevant verifications are not completed within the periods specified under section 19.1.1;

.2 if the certificate is not endorsed in accordance with section 19.1.1.3 and 19.3.7.2 if applicable;

.3 when a Company assumes the responsibility for the operation of a ship not previously operated by that Company; and

.4 upon transfer of the ship to the flag of another State.

A/19.3.9 In the case of:

.1 a transfer of a ship to the flag of another Contracting Government, the Contracting Government whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the receiving Administration copies of, or all information relating to, the International Ship Security Certificate carried by the ship before the transfer and copies of available verification reports, or

.2 a Company that assumes responsibility for the operation of a ship not previously operated by that Company, the previous Company shall as soon as possible, transmit to the receiving Company copies of any information related to the International Ship Security Certificate or to facilitate the verifications described in section 19.4.2.

A/19.4 Interim certification

A/19.4.1 The certificates specified in section 19.2 shall be issued only when the Administration issuing the certificate is fully satisfied that the ship complies with the requirements of section 19.1. However, after [1 July 2004], for the purposes of:

.1 a ship without a certificate, on delivery or prior to its entry or re-entry into service;

.2 transfer of a ship from the flag of a Contracting Government to the flag of another Contracting Government;

.3 transfer of a ship to the flag of a Contracting Government from a State which is not a Contracting Government; or

.4 when a Company assumes the responsibility for the operation of a ship not previously operated by that Company;

If the ship re-enters the management of a company after a "reasonable" period of time under the management of others, conformation should be sought from the Administration as to whether it is appropriate to issue interim certification.

until the certificate referred to in section 19.2 is issued, the Administration may cause an Interim International Ship Security Certificate to be issued, in a form corresponding to the model given in the Appendix to this part of the Code.

A/19.4.2 An Interim International Ship Security Certificate shall only be issued when the Administration or recognized security organization, on behalf of the Administration, has verified that:

.1 the ship security assessment required by this part of the Code has been completed,

.2 a copy of the ship security plan meeting the requirements of chapter XI-2 and part A of this Code is provided on board, has been submitted for review and approval, and is being implemented on the ship;

.3 the ship is provided with a ship security alert system meeting the requirements of regulation XI-2/6, if required,

.4 the Company Security Officer:

.1 has ensured:

.1 the review of the ship security plan for compliance with this part of the Code,

.2 that the plan has been submitted for approval, and

.3 that the plan is being implemented on the ship, and

.2 has established the necessary arrangements, including arrangements for drills, exercises and internal audits, through which the Company Security Officer is satisfied that the ship will successfully complete the required verification in accordance with section 19.1.1.1, within 6 months;

.5 arrangements have been made for carrying out the required verifications under section 19.1.1.1;

There should be evidence onboard that the company intends to conduct an internal security audit on the ship within three months and that the ship is planned to be offered for full term certification within the validity of the Interim ISSC.

.6 the master, the ship's security officer and other ship's personnel with specific security duties are familiar with their duties and responsibilities as specified in this part of the Code; and with the relevant provisions of the ship security plan placed on board; and have been provided such information in the working language of the ship's personnel or languages understood by them; and

.7 the ship security officer meets the requirements of this part of the Code.

A/19.4.3 An Interim International Ship Security Certificate may be issued by the Administration or by a recognized security organization authorized to act on its behalf.

A/19.4.4 An Interim International Ship Security Certificate shall be valid for 6 months, or until the certificate required by section 19.2 is issued, whichever comes first, and may not be extended.

A/19.4.5 No Contracting Government shall cause a subsequent, consecutive Interim International Ship Security Certificate to be issued to a ship if, in the judgment of the Administration or the recognized security organization, one of the purposes of the ship or a Company in requesting such certificate is to avoid full compliance with chapter XI-2 and this part of the Code beyond the period of the initial interim certificate as specified in section 19.4.4.

A/19.4.6 For the purposes of regulation XI-2/9, Contracting Governments may, prior to accepting an Interim International Ship Security Certificate as a valid certificate, ensure that the requirements of sections 19.4.2.4 to 19.4.2.6 have been met.

APPENDIX TO PART A
APPENDIX 1

Form of the International Ship Security Certificate
INTERNATIONAL SHIP SECURITY CERTIFICATE

(official seal) *(State)*

Certificate No.

Issued under the provisions of the
INTERNATIONAL CODE FOR THE SECURITY OF SHIPS AND OF PORT FACILITIES (ISPS CODE)

Under the authority of the Government of _____
(name of State)

by _____
(persons or organization authorized)

Name of ship :……..……
Distinctive number or letters:…….……..…...
Port of registry :…….……
Type of ship :…….……
Gross tonnage :…….
IMO Number :……..……..
Name and address of the Company :……..……...

THIS IS TO CERTIFY:

1 that the security system and any associated security equipment of the ship has been verified in accordance with section 19.1 of part A of the ISPS Code;

2 that the verification showed that the security system and any associated security equipment of the ship is in all respects satisfactory and that the ship complies with the applicable requirements of chapter XI-2 of the Convention and part A of the ISPS Code;

3 that the ship is provided with an approved Ship Security Plan.

Date of initial / renewal verification on which this certificate is based ……..……..

This Certificate is valid until …….
subject to verifications in accordance with section 19.1.1 of part A of the ISPS Code.

Issued at ……..
(place of issue of the Certificate)

Date of issue ……..
(signature of the duly authorized official issuing the Certificate)

(Seal or stamp of issuing authority, as appropriate)

ENDORSEMENT FOR INTERMEDIATE VERIFICATION

THIS IS TO CERTIFY that at an intermediate verification required by section 19.1.1 of part A of the ISPS Code the ship was found to comply with the relevant provisions of chapter XI-2 of the Convention and part A of the ISPS Code.

Intermediate verification

Signed ……
(Signature of authorized official)
Place ……..

Date ……

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT FOR ADDITIONAL VERIFICATIONS*

Additional verification

Signed ……
(Signature of authorized official)
Place …….

Date ……

(Seal or stamp of the authority, as appropriate)

Additional verification

Signed ……..…
(Signature of authorized official)
Place ……..

Date ……

(Seal or stamp of the authority, as appropriate)

Additional verification

Signed ……
(Signature of authorized official)
Place …….

Date ……

(Seal or stamp of the authority, as appropriate)

* This part of the certificate shall be adapted by the Administration to indicate whether it has established additional verifications as provided for in section 19.1.1.4.

ADDITIONAL VERIFICATION IN ACCORDANCE WITH SECTION A/19.3.7.2 OF THE ISPS CODE

THIS IS TO CERTIFY that at an additional verification required by section 19.3.7.2 of part A of the ISPS Code the ship was found to comply with the relevant provisions of chapter XI-2 of the Convention and part A of the ISPS Code.

Signed ……
(Signature of authorized official)
Place …….

Date ……

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT TO EXTEND THE CERTIFICATE IF VALID FOR LESS THAN 5 YEARS WHERE SECTION A/19.3.3 OF THE ISPS CODE APPLIES

The ship complies with the relevant provisions of part A of the ISPS Code, and the Certificate shall, in accordance with section 19.3.3 of part A of the ISPS Code, be accepted as valid until …….

Signed ……
(Signature of authorized official)
Place ……

Date ……

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT WHERE THE RENEWAL VERIFICATION HAS BEEN COMPLETED AND SECTION A/*19.3.4* OF THE ISPS CODE APPLIES

The ship complies with the relevant provisions of part A of the ISPS Code, and the Certificate shall, in accordance with section 19.3.4 of part A of the ISPS Code, be accepted as valid until …….

Signed ……
(Signature of authorized official)
Place ……

Date ……

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT TO EXTEND THE VALIDITY OF THE CERTIFICATE UNTIL REACHING THE PORT OF VERIFICATION WHERE SECTION A/19.3.5 OF THE ISPS CODE APPLIES OR FOR A PERIOD OF GRACE WHERE SECTION A/19.3.6 OF THE ISPS CODE APPLIES

This Certificate shall, in accordance with section 19.3.5 / 19.3.6* of part A of the ISPS Code, be accepted as valid until …….

Signed ……
(Signature of authorized official)
Place …….

Date ……

(Seal or stamp of the authority, as appropriate)

ENDORSEMENT FOR ADVANCEMENT OF EXPIRY DATE WHERE SECTION A/19.3.7.1 OF THE ISPS CODE APPLIES

In accordance with section 19.3.7.1 of part A of the ISPS Code, the new expiry date** is ……..…

Signed ……
(Signature of authorized official)
Place …….

Date ……

(Seal or stamp of the authority, as appropriate)

***

Appendix 2

* Delete as appropriate.
** In case of completion of this part of the certificate the expiry date shown on the front of the certificate shall also be amended accordingly.

Form of the Interim International Ship Security Certificate

INTERIM INTERNATIONAL SHIP SECURITY CERTIFICATE

(official seal)

(State)

Certificate No.

Issued under the provisions of the

INTERNATIONAL CODE FOR THE SECURITY OF SHIPS AND OF PORT FACILITIES
(ISPS CODE)

Under the authority of the Government of _____
(name of State)

by _____
(persons or organization authorized)

Name of ship : ….....….….....
Distinctive number or letters : ….....
Port of registry : ….....….
Type of ship : ……….....
Gross tonnage : ….....
IMO Number : ….....….
Name and address of company : ….....…
Is this a subsequent, consecutive interim certificate? Yes/ No*
If Yes, date of issue of initial interim certificate….....

THIS IS TO CERTIFY THAT the requirements of section A/19.4.2 of the ISPS Code have been complied with.

This Certificate is issued pursuant to section A/19.4* of the ISPS Code.

This Certificate is valid until ….....

Issued at ….....
(*place of issue of the certificate)*

Date of issue …..... …..... ….....
(signature of the duly authorized official issuing the Certificate)

(Seal or stamp of issuing authority, as appropriate)

* Delete as appropriate.

Index for Questionnaire of Checklist of Plan Approval *Annex 1*

Requirements of			*Questionnaire*
Part A	*Part B*		
Section 5/	**DECLARATION OF SECURITY**		
	B/5.2		Is the need for a DoS set out in the ship security plan?
Section 6/ OBLIGATIONS OF THE COMPANY			
A/6.1			Has the Company ensured that the ship security plan contains a clear statement emphasizing the master's authority?
A/6.1			Has the Company established in the ship security plan that the master has the overriding authority and responsibility to make decisions with respect to the security of the ship and to request the assistance of the Company or of any Contracting Government
A/6.2			Has the Company ensured that the company security officer, the master and the ship security officer are given the necessary support to fulfil their duties and responsibilities in accordance with chapter XI-2 and this part of the Code?
	B/6.1		Has following information included?
		.1	parties responsible for appointing shipboard personnel, such as ship management companies, manning agents, contractors, concessionaries, for example, retail sales outlets, casinos etc
		.2	parties responsible for deciding the employment of the ship including, time or bareboat charterer(s) or any other entity acting in such capacity
		.3	in cases when the ship is employed under the terms of a charter party, the contact details of those parties including time or voyage charterers
Section 8/ SHIP SECURITY ASSESSMENT			
A/8.2			Has the Ship Security Assessment carried out for the ship by the person with appropriate skills to evaluate the ship's security?
A/8.4			Has the SSA included the followings?
A/8.4			on-scene security survey
A/8.4.1			identification of existing security measures, procedures and operations
A/8.4.2			identification and evaluation of key ship board operations that it is important to protect
A/8.4.3			identification of possible threats to the key ship board operations and the likelihood of their occurrence, in order to establish and prioritise security measures;
A/8.4.4			identification of weaknesses, including human factors in the infrastructure, policies and procedures
	B/8.2		Prior to commencing the SSA, has the CSO ensured that advantage is taken of information available on the assessment of threat for the ports at which the ship will call or at which passengers embark or disembark and about the port facilities and their protective measures?
	B/8.2		Has the CSO studied previous reports on similar security needs?
	B/8.2		Has the CSO met with appropriate persons on the ship and in the port facilities to discuss the purpose and methodology of the assessment, where feasible?
	B/8.2		Has the CSO should follow any specific guidance offered by the Contracting Governments?
	B/8.3		Has the SSA addressed the following elements on board or within the ship?
		.1	physical security
		.2	structural integrity
		.3	personnel protection systems
		.4	procedural policies
		.5	radio and telecommunication systems, including computer systems and networks;
		.6	other areas that may, if damaged or used for illicit observation, pose a risk to people, property, or operations on board the ship or within a port facility
	B/8.4		Have those involved in a SSA been able to draw upon expert assistance in relation to the followings?

Requirements of			*Questionnaire*
Part A	***Part B***		
		.1	knowledge of current security threats and patterns
		.2	recognition and detection of weapons, dangerous substances and devices
		.3	recognition, on a non-discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security
		.4	techniques used to circumvent security measures
		.5	methods used to cause a security incident
		.6	effects of explosives on ship's structures and equipment
		.7	ship security
		.8	ship/port interface business practices
		.9	contingency planning, emergency preparedness and response
		.10	physical security
		.11	radio and telecommunications systems, including computer systems and networks
		.12	marine engineering
		.13	ship and port operations
	B/8.5	Has the CSO obtained and recorded the information required to conduct an assessment for followings?	
		.1	the general layout of the ship
		.2	the location of areas which should have restricted access, such as navigation bridge, machinery spaces of category A and other control stations as defined in chapter II-2, etc.
		.3	the location and function of each actual or potential access point to the ship
		.4	changes in the tide which may have an impact on the vulnerability or security of the ship
		.5	the cargo spaces and stowage arrangements
		.6	the locations where the ship's stores and essential maintenance equipment is stored
		.7	the locations where unaccompanied baggage is stored
		.8	the emergency and stand-by equipment available to maintain essential services
		.9	the number of ship's personnel, any existing security duties and any existing training requirement practices of the Company;
		.10	existing security and safety equipment for the protection of passengers and ship's personnel;
		.11	escape and evacuation routes and assembly stations which have to be maintained to ensure the orderly and safe emergency evacuation of the ship
		.12	existing agreements with private security companies providing ship/waterside security services
		.13	existing security measures and procedures in effect, including inspection and, control procedures, identification systems, surveillance and monitoring equipment, personnel identification documents and communication, alarms, lighting, access control and other appropriate systems.
	B/8.6	Has the SSA examineed each identified point of access, including open weather decks, and evaluate its potential for use by individuals who might seek to breach security? This includes points of access available to individuals having legitimate access as well as those who seek to obtain unauthorized entry.	
	B/8.7	Has the SSA considered the continuing relevance of the existing security measures and guidance, procedures and operations, under both routine and emergency conditions and should determine security guidance for Followings?	
		.1	the restricted areas
		.2	the response procedures to fire or other emergency conditions
		.3	the level of supervision of the ship's personnel, passengers, visitors, vendors, repair technicians, dock workers, etc.

Requirements of			*Questionnaire*
Part A	*Part B*		
		.4	the frequency and effectiveness of security patrols
		.5	the access control systems, including identification systems
		.6	the security communications systems and procedures
		.7	the security doors, barriers and lighting
		.8	the security and surveillance equipment and systems, if any
	B/8.8	Has the SSA considered the following persons, activities, services and operations that it is important to protect?	
		.1	the ship's personnel
		.2	passengers, visitors, vendors, repair technicians, port facility personnel, etc;
		.3	the capacity to maintain safe navigation and emergency response
		.4	the cargo, particularly dangerous goods or hazardous substances
		.5	the ship's stores
		.6	the ship security communication equipment and systems, if any
		.7	the ship's security surveillance equipment and systems, if any
	B/8.9	Has the SSA considered all possible threats, which may include the following types of security incidents?	
		.1	damage to, or destruction of, the ship or of a port facility, e.g. by explosive devices, arson, sabotage or vandalism
		.2	hijacking or seizure of the ship or of persons on board
		.3	tampering with cargo, essential ship equipment or systems or ship's stores
		.4	unauthorized access or use, including presence of stowaways
		.5	smuggling weapons or equipment, including weapons of mass destruction
		.6	use of the ship to carry those intending to cause a security incident and/or their equipment
		.7	use of the ship itself as a weapon or as a means to cause damage or destruction
		.8	attacks from seaward whilst at berth or at anchor
		.9	attacks whilst at sea
	B/8.10	Has the SSA taken into account all possible vulnerabilities for followings?	
		.1	conflicts between safety and security measures
		.2	conflicts between shipboard duties and security assignments;
		.3	watch-keeping duties, number of ship's personnel, particularly with implications on crew fatigue, alertness and performance
		.4	any identified security training deficiencies
		.5	any security equipment and systems, including communication systems
	B/8.11	Has the particular consideration been given to the convenience, comfort and personal privacy of the ship's personnel and their ability to maintain their effectiveness over long periods?	
	B/8.12	Upon completion of the SSA, has the report been prepared, consisting of a summary of how the assessment was conducted, a description of each vulnerability found during the assessment and a description of counter measures that could be used to address each vulnerability?	
	B/8.13	If the SSA has not been carried out by the Company, has the report of the SSA been reviewed and accepted by the CSO?	
	B/8.14	Has the on-scene security survey been examined and evaluated existing shipboard protective measures, procedures and operations for followings?	
		.1	ensuring the performance of all ship security duties
		.2	monitoring restricted areas to ensure that only authorized persons have access;

Requirements of			*Questionnaire*
Part A	***Part B***		
		.3	controlling access to the ship, including any identification systems
		.4	monitoring of deck areas and areas surrounding the ship
		.5	controlling the embarkation of persons and their effects (accompanied and unaccompanied baggage and ship's personnel personal effects);
		.6	supervising the handling of cargo and the delivery of ship's stores;
		.7	ensuring that ship security communication, information, and equipment are readily available
Section 9/ SHIP SECURITY PLAN			
A/9.3	Does the result of Ship Security Assessment attach to the Ship Security Plan?		
A/9.4	Does the Plan address the following?		
		.1	measures designed to prevent weapons, dangerous substances and devices intended for use against people, ships or ports and the carriage of which is not authorized from being taken on board the ship
		.2	identification of the restricted areas and measures for the prevention of unauthorized access
		.3	measures for the prevention of unauthorized access to the ship
		.4	procedures for responding to security threats or breaches of security, including provisions for maintaining critical operations of the ship or ship/port interface
		.5	procedures for responding to any security instructions Contracting Governments may give at security level 3
		.6	procedures for evacuation in case of security threats or breaches of security
		.7	duties of shipboard personnel assigned security responsibilities and of other shipboard personnel on security aspects
		.8	procedures for auditing the security activities
		.9	procedures for training, drills and exercises associated with the plan
		.10	procedures for interfacing with port facility security activities
		.11	procedures for the periodic review of the plan and for updating
		.12	procedures for reporting security incidents
		.13	identification of the ship security officer
		.14	identification of the company security officer including with 24-hour contact details
		.15	procedures to ensure the inspection, testing, calibration, and maintenance of any security equipment provided on board, if any
		.16	frequency for testing or calibration any security equipment provided on board, if any
		.17	identification of the locations where the ship security alert system activation points are provided
		.18	procedures, instructions and guidance on the use of the ship security alert system, including the testing, activation, deactivation and resetting and to limit false alerts
A/9.4.1	Is the personnel conducting internal audits of the security activities specified in the plan or evaluating its implementation independent of the activities being audited unless this is impracticable due to the size and the nature of the Company or of the ship?		
A/9.6	In the case that the Plan is to be kept in an electronic format, is it to be protected by procedures aimed at preventing its unauthorised deletion, destruction or amendment?		
	B/9.2	Does the SSP contain following contents?	
		.1	detail of the organizational structure of security for the ship

Requirements of			*Questionnaire*
Part A	***Part B***		
		.2	detail of the ship's relationships with the Company, port facilities, other ships and relevant authorities with security responsibility
		.3	detail of the communication systems to allow effective continuous communication within the ship and between the ship and others, including port facilities;
		.4	detail of the basic security measures for security level 1, both operational and physical, that will always be in place
		.5	detail of the additional security measures that will allow the ship to progress without delay to security level 2 and, when necessary, to security level 3
		.6	details of the regular review, or audit, of the SSP and for its amendment in response to experience or changing circumstances
		.7	reporting procedures to the appropriate Contracting Governments contact points
	B/9.3		Has the preparation of an effective SSP rested on a thorough assessment of all issues that relate to the security of the ship, including, in particular, a thorough appreciation of the physical and operational characteristics, including the voyage pattern, of the individual ship?
	B/9.4		Has this Society not prepared, or assisted in the preparation of, the plan?
	B/9.5		Have the following procedures been developed by CSO and SSO?
		.1	assess the continuing effectiveness of the SSP
		.2	prepare amendments of the plan subsequent to its approval
	B/9.7		Has the SSP established the following which relate to all security levels?
		.1	the duties and responsibilities of all shipboard personnel with a security role
		.2	the procedures or safeguards necessary to allow such continuous communications to be maintained at all times
		.3	the procedures needed to assess the continuing effectiveness of security procedures and any security and surveillance equipment and systems, including procedures for identifying and responding to equipment or systems failure or malfunction
		.4	the procedures and practices to protect security sensitive information held in paper or electronic format
		.5	the type and maintenance requirements, of security and surveillance equipment and systems, if any
		.6	the procedures to ensure the timely submission, and assessment, of reports relating to possible breaches of security or security concerns
		.7	procedures to establish, maintain and up-date an inventory of any dangerous goods or hazardous substances carried on board, including their location
(Access to the Ship)			
	B/9.9		Has the SSP established the security measures covering all means of access to the ship identified in the SSA?
		.1	access ladders
		.2	access gangways
		.3	access ramps
		.4	access doors, side scuttles, windows and ports
		.5	mooring lines and anchor chains
		.6	cranes and hoisting gear
	B/9.10		Has the SSP identified the appropriate locations where access restrictions or prohibitions should be applied for each of the security levels for each level?
	B/9.10		Has the SSP established the type of restriction or prohibition to be applied and the means of enforcing them for each security level?

Requirements of		*Questionnaire*	
Part A	***Part B***		
	B/9.11	Has the SSP established for each security level the means of identification required to allow access to the ship and for individuals to remain on the ship without challenge?	
	B/9.11	Has any ship identification system been co-ordinated with that applying to the port facility?	
	B/9.11	Has the SSP established provisions to ensure that the identification systems are regularly updated, and that abuse of procedures should be subject to disciplinary action?	
	B/9.13	Has the SSP established the frequency of application of any access controls particularly if they are to be applied on a random, or occasional, basis?	
	(Security Level 1)		
	B/9.14	Has the SSP established the following security measures to control access to the ship?	
		.1	checking the identity of all persons seeking to board the ship and confirming their reasons for doing so by checking, for example, joining instructions, passenger tickets, boarding passes, work orders etc
		.2	in liaison with the port facility the ship should ensure that designated secure areas are established in which inspections and searching of people, baggage (including carry on items), personal effects, vehicles and their contents can take place
		.3	in liaison with the port facility the ship should ensure that vehicles destined to be loaded on board car carriers, ro-ro and other passenger ships are subjected to search prior to loading, in accordance with the frequency required in the SSP
		.4	segregating checked persons and their personal effects from unchecked persons and their personal effects
		.5	segregating embarking from disembarking passengers
		.6	identification of access points that should be secured or attended to prevent unauthorized access
		.7	securing, by locking or other means, access to unattended spaces adjoining areas to which passengers and visitors have access
		.8	providing security briefings to all ship personnel on possible threats, the procedures for reporting suspicious persons, objects or activities and the need for vigilance
	B/9.15	Has the SSP specified that all those seeking to board a ship should be liable to search, and has the frequency of such searches, including random searches, been specified in the SSP?	
	(Security Level 2)		
	B/9.16	Has the SSP established the following security measures?	
		.1	assigning additional personnel to patrol deck areas during silent hours to deter unauthorised access
		.2	limiting the number of access points to the ship, identifying those to be closed and the means of adequately securing them
		.3	deterring waterside access to the ship, including, for example, in liaison with the port facility, provision of boat patrols
		.4	establishing a restricted area on the shore-side of the ship, in close co-operation with the port facility
		.5	increasing the frequency and detail of searches of people, personal effects, and vehicles being embarked or loaded onto the ship;
		.6	escorting visitors on the ship
		.7	providing additional specific security briefings to all ship personnel on any identified threats, re- emphasising the procedures for reporting suspicious persons, objects, or activities and the stressing the need for increased vigilance
		.8	carrying out a full or partial search of the ship
	(Security Level 3)		
	B/9.17	Has the SSP detailed the following security measures?	

Requirements of			*Questionnaire*
Part A	***Part B***		
		.1	limiting access to a single, controlled, access point
		.2	granting access only to those responding to the security incident or threat thereof;
		.3	directions of persons on board
		.4	suspension of embarkation or disembarkation
		.5	suspension of cargo handling operations, deliveries etc
		.6	evacuation of the ship
		.7	movement of the ship
		.8	preparing for a full or partial search of the s
(Restricted Areas on the Ship)			
	B/9.18		Has the SSP identified the restricted areas to be established on the ship, specified their extent, times of application, the security measures to be taken to control access to them and those to be taken to control activities within them?
	B/9.19		Does the SSP ensure that there are clearly established policies and practices to control access to all restricted areas them?
	B/9.20		Does the SSP provide that all restricted areas should be clearly marked indicating that access to the area is restricted and that unauthorised presence within the area constitutes a breach of security?
	B/9.21		Does the restricted areas include the followings?
		.1	navigation bridge, machinery spaces of category A and other control stations as defined in chapter II-2
		.2	spaces containing security and surveillance equipment and systems and their controls and lighting system controls
		.3	ventilation and air-conditioning systems and other similar spaces
		.4	spaces with access to potable water tanks, pumps, or manifolds
		.5	spaces containing dangerous goods or hazardous substances
		.6	spaces containing cargo pumps and their controls
		.7	cargo spaces and spaces containing ship’s stores
		.8	crew accommodation
		.9	any other areas as determined by the CSO, through the SSA to which access must be restricted to maintain the security of the ship
	(Security Level 1)		
	B/9.22		Has the SSP established the following security measures to be applied to restricted areas?
		.1	locking or securing access points
		.2	using surveillance equipment to monitor the areas
		.3	using guards or patrols
		.4	using automatic intrusion detection devices to alert the ship’s personnel of unauthorized access
	(Security Level 2)		
	B/9.23		Has the frequency and intensity of the monitoring of, and control of access to restricted areas been increased to ensure that only authorized persons have access?

Requirements of			*Questionnaire*
Part A	***Part B***		
	B/9.23	Has the SSP established the following additional security measures?	
		.1	establishing restricted areas adjacent to access points
		.2	continuously monitoring surveillance equipment
		.3	dedicating additional personnel to guard and patrol restricted areas
	(Security Level 3)		
	B/9.24	Has the SSP detailed the following security measures which could be taken by the ship, in close co-operations with those responding and the port facility?	
		.1	setting up of additional restricted areas on the ship in proximity to the security incident, or the believed location of the security threat, to which access is denied
		.2	searching of restricted areas as part of a search of the ship
(Handling of Cargo)			
	(Security Level 1)		
	B/9.27	Has the SSP established the following security measures to be applied during cargo handling?	
		.1	routine checking of cargo, cargo transport units and cargo spaces prior to, and during, cargo handling operations;
		.2	checks to ensure that cargo being loaded matches the cargo documentation
		.3	ensuring, in liaison with the port facility, that vehicles to be loaded on board car-carriers, ro-ro and passenger ships are subjected to search prior to loading, in accordance with the frequency required in the SSP
		.4	checking of seals or other methods used to prevent tampering
	(Security Level 2)		
	B/9.30	Has the SSP established the following additional security measures to be applied during cargo handling>	
		.1	detailed checking of cargo, cargo transport units and cargo spaces
		.2	intensified checks to ensure that only the intended cargo is loaded
		.3	intensified searching of vehicles to be loaded on car-carriers, ro-ro and passenger ships
		.4	increased frequency and detail in checking of seals or other methods used to prevent tampering
	(Security Level 3)		
	B/9.32	Has the SSP detailed the following security measures which could be taken by the ship, in close co-operation with those responding and the port facility?	
		.1	suspension of the loading or unloading of cargo
		.2	verify the inventory of dangerous goods and hazardous substances carried on board, if any, and their location
(Delivery of Ship's Store)			
	(Security Level 1)		
	B/9.35	Has the SSP established the following security measures to be applied during delivery of ship’s stores?	
		.1	checking to ensure stores match the order prior to being loaded on board
		.2	ensuring immediate secure stowage of ship’s stores
	(Security Level 2)		

Requirements of			*Questionnaire*
Part A	***Part B***		
	B/9.36		Has the SSP established the additional security measures to be applied during delivery of ship's stores by exercising checks prior to receiving stores on board and intensifying inspections?
	(Security Level 3)		
	B/9.37		Has the SSP detailed the following security measures which could be taken by the ship, in close co-operation with those responding and the port facility?
		.1	subjecting ship's stores to more extensive checking
		.2	preparation for restriction or suspension of handling of ship's stores
		.3	refusal to accept ship's stores on board the ship
(Handling Unaccompanied Baggage)			
	(Security Level 1)		
	B/9.39		Has the SSP established the security measures to be applied when handling unaccompanied baggage to ensure that unaccompanied baggage is screened or searched up to and including 100 percent, which may include use of x-ray screening?
	(Security Level 2)		
	B/9.40		Has the SSP established the additional security measures to be applied when handling unaccompanied baggage which should include 100 percent x-ray screening of all unaccompanied baggage?
	(Security Level 3)		
	B/9.41		Has the SSP detailed the following security measures which could be taken by the ship, in close co-operation with those responding and the port facility?
		.1	subjecting such baggage to more extensive screening, for example x-raying it from at least two different angles
		.2	preparation for restriction or suspension of handling of unaccompanied baggage
		.3	refusal to accept unaccompanied baggage on board the ship.
(Monitoring the Security of the Ship)			
	B/9.44		Has the SSP established the procedures and equipment needed at each security level and the means of ensuring that monitoring equipment will be able to perform continually, including consideration of the possible effects of weather conditions or of power disruptions?
	(Security Level 1)		
	B/9.45		Has the SSP established the security measures to be applied which may be a combination of lighting, watch keepers, security guards or use of security and surveillance equipment to allow ship's security personnel to observe the ship in general, and barriers and restricted areas in particular?
	B/9.46		Has the following been considered when establishing the appropriate level and location of lighting?
		.1	the ship's personnel should be able to detect activities beyond the ship, on both the shore side and the waterside
		.2	coverage should include the area on and around the ship
		.3	coverage should facilitate personnel identification at access points
		.4	coverage may be provided through coordination with the port facility
	(Security Level 2)		

Requirements of		*Questionnaire*	
Part A	***Part B***		
	B/9.47	Has the SSP established the following additional security measures to be applied to enhance the monitoring and surveillance capabilities?	
		.1	increasing the frequency and detail of security patrols
		.2	increasing the coverage and intensity of lighting or the use of security and surveillance and equipment
		.3	assigning additional personnel as security lookouts
		.4	ensuring coordination with waterside boat patrols, and foot or vehicle patrols on the shore-side, when provided
	(Security Level 3)		
	B/9.49	Has the SSP detailed the following security measures which could be taken by the ship, in close co-operation with those responding and the port facility?	
		.1	switching on of all lighting on, or illuminating the vicinity of, the ship
		.2	switching on of all on board surveillance equipment capable of recording activities on, or in the vicinity of, the ship
		.3	maximising the length of time such surveillance equipment can continue to record
		.4	preparation for underwater inspection of the hull of the ship
		.5	initiation of measures, including the slow revolution of the ship's propellers, if practicable, to deter underwater access to the hull of the ship
(Differing Security Levels)			
	B/9.50	Has the SSP established details of the procedures and security measures the ship could adopt if the ship is at a higher security level than that applying to a port facility?	
(Activities not covered by the Code)			
	B/9.51	Has the SSP established details of the procedures and security measures the ship should apply when the following cases?	
		.1	it is at a port of a State which is not a Contracting Government
		.2	it is interfacing with a ship to which this Code does not apply
		.3	it is interfacing with fixed or floating platforms or a mobile drilling unit on location
		.4	it is interfacing with a port or port facility which is not required to comply with chapter XI-2 and part A of this Code
(Declaration of Security)			
	B/9.52	Has the SSP detailed how requests for DoS from a port facility will be handled and the circumstances under which the ship itself should request a DoS?	
(Audit and Review)			
	B/9.53	Has the SSP should establish how the CSO and the SSO intend to audit the continued effectiveness of the SSP and the procedure to be followed to review, update or amend the SSP?	
Section 10/ RECORDS			
A/10.3	In the case that the records are to be kept in an electronic format, is it to be protected by procedures aimed at preventing its unauthorised deletion, destruction or amendment?		
Section 11/ COMPANY SECURITY OFFICER			
A/11.1	Does the Company Security Officer designated for the ship?		

Requirements of		***Questionnaire***
Part A	***Part B***	
A/11.2	Are following duties and responsibilities of the company security officer included in the Plan?	
	.1	advising the level of threats likely to be encountered by the ship, using appropriate security assessments and other relevant information
	.2	ensuring that ship security assessments are carried out
	.3	ensuring the development, the submission for approval, and thereafter the implementation and maintenance of the ship security plan
	.4	ensuring that the ship security plan is modified, as appropriate, to correct deficiencies and satisfy the security requirements of the individual ship
	.5	arranging for internal audits and reviews of security activities
	.6	arranging for the initial and subsequent verifications of the ship by the Administration or the recognised security organisation
	.7	ensuring that deficiencies and non-conformities identified during internal audits, periodic reviews, security inspections and verifications of compliance are promptly addressed and dealt with
	.8	enhancing security awareness and vigilance
	.9	ensuring adequate training for personnel responsible for the security of the ship
	.10	ensuring effective communication and co-operation between the ship security officer and the relevant port facility security officers
	.11	ensuring consistency between security requirements and safety requirement
	.12	ensuring that, if sister-ship or fleet security plans are used, the plan for each ship reflects the ship-specific information accurately
	.13	ensuring that any alternative or equivalent arrangements approved for a particular ship or group of ships are implemented and maintained
Section 12/ SHIP SECURITY OFFICER		
A/12.1	Does the Ship Security Officer designated on the ship?	
A/12.2	Are following duties and responsibilities of the ship security officer included in the Plan?	
	.1	undertaking regular security inspections of the ship to ensure that appropriate security measures are maintained
	.2	maintaining and supervising the implementation of the ship security plan, including any amendments to the plan
	.3	co-ordinating the security aspects of the handling of cargo and ship’s stores with other shipboard personnel and with the relevant port facility security officers;
	.4	proposing modifications to the ship security plan
	.5	reporting to the Company Security Officer any deficiencies and non-conformities identified during internal audits, periodic reviews, security inspections and verifications of compliance and implementing any corrective actions
	.6	enhancing security awareness and vigilance on board
	.7	ensuring that adequate training has been provided to shipboard personnel, as appropriate
	.8	reporting all security incidents
	.9	co-ordinating implementation of the ship security plan with the company security officer and the relevant port facility security officer
	.10	ensuring that security equipment is properly operated, tested, calibrated and maintained, if any.

Index for Questionnaire of Checklist for On-site Verification *Annex 2*

Requirements of SOLAS XI-2		*Questionnaire*
Regulation 5/ Specific responsibility of Companies		
	Has the Company ensured that the master has available on board, at all times, the following information?	
	.1	who is responsible for appointing the members of the crew or other persons currently employed or engaged on board the ship in any capacity on the business of that ship
	.2	who is responsible for deciding the employment of the ship
	.3	in cases where the ship is employed under the terms of charter party(ies), who are the parties to such charter party(ies)
Regulation 6/ Ship security alert system		
1	Has the ship been provided with a ship security alert system? (Ship's type =)(required*/not required*)	
3	.1	Has the ship security alert system been capable of being activated from the navigation bridge and in at least one other location?
	.2	Has the ship security alert system been conformed to performance standards not inferior to those adopted by the Organization?
4	Has the ship security alert system activation points been designed so as to prevent the inadvertent initiation of the ship security alert?	
Regulation 8/ Master's discretion for ship safety and security		
1	Has the master not been constrained by the Company, the charterer or any other person from taking or executing any decision which, in the professional judgement of the master, is necessary to maintain the safety and security of the ship?	
2	When a conflict between any safety and security requirements applicable to the ship arised during its operations, has the master given effect to those requirements necessary to maintain the safety of the ship?	
Regulation 9/ Control and compliance measures		
2.3	Does the ship shall keep records of the information referred to in paragraph 2.1 for the last 10 calls at port facilities?	

Requirements of		*Index for Questionnaire*
Part A	***Part B***	
Section 5/DECLARATION OF SECURITY		
A/5.7	Have DoSs been kept onboard the ship within the period specified by the Administration?	
	B/5.4.1	Is the agreed DoS signed and dated by both the port facility and the ship?
	B/5.5	Is the agreed DoS completed in English, French or Spanish or in a language common to both the port facility and the ship or the ships?
Section 6/OBLIGATIONS OF THE COMPANY		
A/6.1	Has the Company ensured that the ship security plan contains a clear statement emphasizing the master's authority?	
A/6.1	Has the Company established in the ship security plan that the master has the overriding authority and responsibility to make decisions with respect to the security of the ship and to request the assistance of the Company or of any Contracting Government as may be necessary?	
A/6.2	Has the Company ensured that the company security officer, the master and the ship security officer are given the necessary support to fulfil their duties and responsibilities in accordance with chapter XI-2 and this part of the Code?	
	B/6.1	Has following information included?
	B/6.1.1	parties responsible for appointing shipboard personnel, such as ship management companies, manning agents, contractors, concessionaries, for example, retail sales outlets, casinos etc
	B/6.1.2	parties responsible for deciding the employment of the ship including, time or bareboat charterer(s) or any other entity acting in such capacity
	B/6.1.3	in cases when the ship is employed under the terms of a charter party, the contact details of those parties including time or voyage charterers
Section 7/SHIP SECURITY		
A/7.1	Does the ship act upon the security levels set by Contracting Governments as set out in A/7.2?	
A/7.2	At security level 1, have the following activities being carried out, through appropriate measures?	
A/7.2.1	ensuring the performance of all ship security duties	
A/7.2.2	controlling access to the ship	
A/7.2.3	controlling the embarkation of persons and their effects	
A/7.2.4	monitoring restricted areas to ensure that only authorized persons have access	
A/7.2.5	monitoring of deck areas and areas surrounding the ship	
A/7.2.6	supervising the handling of cargo and ship's stores	
A/7.2.7	ensuring that security communication is readily available	
A/7.3	At security level 2, have the additional protective measures, specified in the ship security plan, being implemented for each activity detailed in section 7.2?	
A/7.4	At security level 3, have further specific protective measures, specified in the ship security plan, being implemented for each activity detailed in section 7.2?	
Section 9/SHIP SECURITY PLAN		
A/9.1	Does the ship carry on board the approved Ship Security Plan?	
A/9.7	Does the plan being protected from unauthorized access or disclosure?	

Requirements of		*Index for Questionnaire*
Part A	***Part B***	
Section 10/RECORDS		
A/10.1		Does the records of the following activities addressed in the ship security plan being kept on board for at least the minimum period specified by the Administration?
A/10.1.1		training, drills and exercises
A/10.1.2		security threats and security incidents
A/10.1.3		breaches of security
A/10.1.4		changes in security level
A/10.1.5		communications relating to the direct security of the ship such as specific threats to the ship or to port facilities the ship is, or has been
A/10.1.6		internal audits and reviews of security activities
A/10.1.7		periodic review of the ship security assessment
A/10.1.8		periodic review of the ship security plan
A/10.1.9		implementation of any amendments to the plan
A/10.1.10		maintenance, calibration and testing of security equipment, if any including testing of the ship security alert system
A/10.2		Does the records being kept in the working language or languages of the ship? If the language or languages used are not English, French or Spanish, does a translation into one of these languages being included?
A/10.4		Does the records being protected from unauthorized access or disclosure?
Section 11/COMPANY SECURITY OFFICER		
A/11.1		Does the Company Security Officer designated for the ship?
Section 12/SHIP SECURITY OFFICER		
A/12.1		Does the Ship Security Officer designated on the ship?
Section 13/TRAINING, DRILLS AND EXERCISES ON SHIP SECURITY		
A/13.2		Does the ship security officer have knowledge and have received training?
	B/13.1	Does the Ship Security Officer (SSO) have knowledge of, and receive training, in the following?
	B/13.1.1	security administration
	B/13.1.2	relevant international conventions, codes and recommendations
	B/13.1.3	relevant Government legislation and regulations
	B/13.1.4	responsibilities and functions of other security organisations
	B/13.1.5	methodology of ship security assessment
	B/13.1.6	methods of ship security surveys and inspections
	B/13.1.7	ship and port operations and conditions
	B/13.1.8	ship and port facility security measures
	B/13.1.9	emergency preparedness and response and contingency planning

Requirements of		*Index for Questionnaire*
Part A	***Part B***	
	B/13.1.10	instruction techniques for security training and education, including security measures and procedures
	B/13.1.11	handling sensitive security related information and security related communications
	B/13.1.12	knowledge of current security threats and patterns
	B/13.1.13	recognition and detection of weapons, dangerous substances and devices
	B/13.1.14	recognition, on a non discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security
	B/13.1.15	techniques used to circumvent security measures
	B/13.1.16	security equipment and systems and their operational limitations
	B/13.1.17	methods of conducting audits, inspection, control and monitoring;
	B/13.1.18	methods of physical searches and non-intrusive inspections
	B/13.1.19	security drills and exercises, including drills and exercises with port facilities
	B/13.1.20	assessment of security drills and exercises
	B/13.2.1	the layout of the ship
	B/13.2.2	the ship security plan and related procedures (including scenario-based training on how to respond)
	B/13.2.3	crowd management and control techniques
	B/13.2.4	operations of security equipment and systems
	B/13.2.5	testing, calibration and whilst at sea maintenance of security equipment and systems
A/13.3	Does shipboard personnel having specific security duties and responsibilities understand their responsibilities for ship security as described in the ship security plan, and have sufficient knowledge and ability to perform their assigned duties?	
	B/13.3	Have shipboard personnel having specific security duties have sufficient knowledge and ability to perform their assigned duties, for following matters?
	B/13.3.1	knowledge of current security threats and patterns
	B/13.3.2	recognition and detection of weapons, dangerous substances and devices
	B/13.3.3	recognition of characteristics and behavioural patterns of persons who are likely to threaten security
	B/13.3.4	techniques used to circumvent security measures
	B/13.3.5	crowd management and control techniques
	B/13.3.6	security related communications
	B/13.3.7	knowledge of the emergency procedures and contingency plans
	B/13.3.8	operations of security equipment and systems
	B/13.3.9	testing, calibration and whilst at sea maintenance of security equipment and systems
	B/13.3.10	inspection, control, and monitoring techniques
	B/13.3.11	methods of physical searches of persons, personal effects, baggage, cargo, and ship's stores
	B/13.4	Does All other shipboard personnel have sufficient knowledge of the following items and is familiar with relevant provisions of the SSP, if any?
	B/13.4.1	the meaning and the consequential requirements of the different security levels

Requirements of		*Index for Questionnaire*
Part A	***Part B***	
	B/13.4.2	knowledge of the emergency procedures and contingency plans
	B/13.4.3	recognition and detection of weapons, dangerous substances and devices
	B/13.4.4	recognition, on a non discriminatory basis, of characteristics and behavioural patterns of persons who are likely to threaten security
	B/13.4.5	techniques used to circumvent security measures
A/13.4	Does the drills being carried out at appropriate intervals?	
	B/13.6	Does the drills being conducted at least once every three months?
	B/13.6	In cases where more than 25 percent of the ship's personnel has been changed, at any one time, with personnel that has not previously participated in any drill on that ship, within the last 3 months, does the drill being conducted within one week of the change?
	B/13.6	Have the drills tested individual elements of the plan such as those security threats listed in paragraph 8.9?
A/13.5	Has the company security officer ensured the effective coordination and implementation of ship security plans by participating in exercises at appropriate intervals?	
	B/13.7	Have the exercises which include participation of company security officers, port facility security officers, relevant authorities of Contracting Governments as well as ship security officers, been carried out at least once each calendar year with no more than 18 months between the exercises?
	B/13.7	Have the exercises tested communications, coordination, resource availability, and response?
	B/13.8	Has the company participation in an exercise with another Contracting Government been recognised by the Administration?

BCS- G84 CONTAINER SHIPS

Guidelines for Surveys, Assessment and Repair of Hull Structures

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1 Introduction

The International Association of Classification Societies (IACS) is introducing a series of Guidelines with the intention of assisting the surveyors of IACS Member Societies and other interested parties involved in the survey, assessment and repair of hull structures of certain ship types.

The present Guidelines are intended for a container ship which is constructed with a single deck, double side skin tanks, passageways and double bottom in the cargo space area, and is intended exclusively to carry cargo in containers in the cargo holds, on deck and on hatch covers. **Figure 1** shows the general view of a typical container ship.

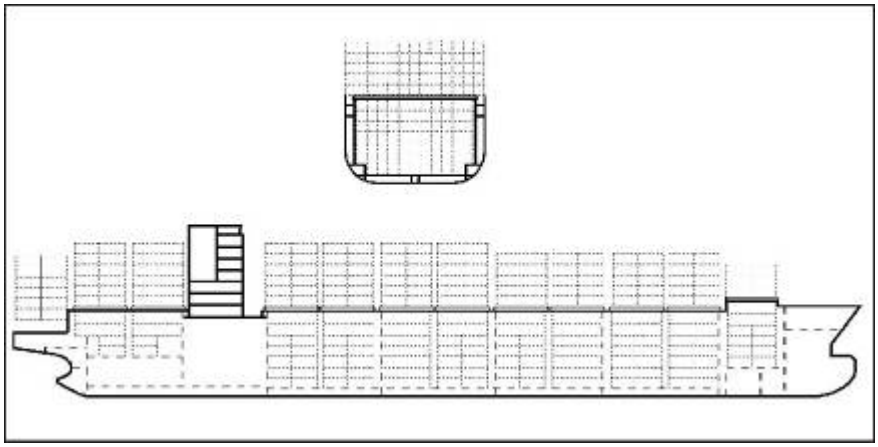


Figure 1 General view of a typical container ship

The Guidelines focus on the IACS Member Societies' survey procedures but may also be useful in connection with the inspection/examination schemes of other regulatory bodies, owners and operators.

The Guidelines include a review of survey preparation criteria, which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the other preparation necessary before the surveys can be carried out.

The Guidelines encompass the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

An important feature of the Guidelines is the inclusion of the section which illustrates examples of structural deterioration and damages related to each structural area and gives what to look for, possible cause, and recommended repair methods, when considered appropriate.

The Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents - "Early Warning Scheme - EWS, with the emphasis on the proper reporting of significant hull damages by the respective Classification Societies, will enable the analysis of problems as they arise, including revisions of these Guidelines.

The Guidelines have been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of surveyors, and is to be used at the surveyors' discretion. It is recognized that alternative and satisfactory methods are already applied by surveyors. Should there be any doubt with regard to interpretation or

validity in connection with particular applications, clarification should be obtained from the Classification Society concerned.

Figure 2 shows a typical cargo hold structural arrangement.

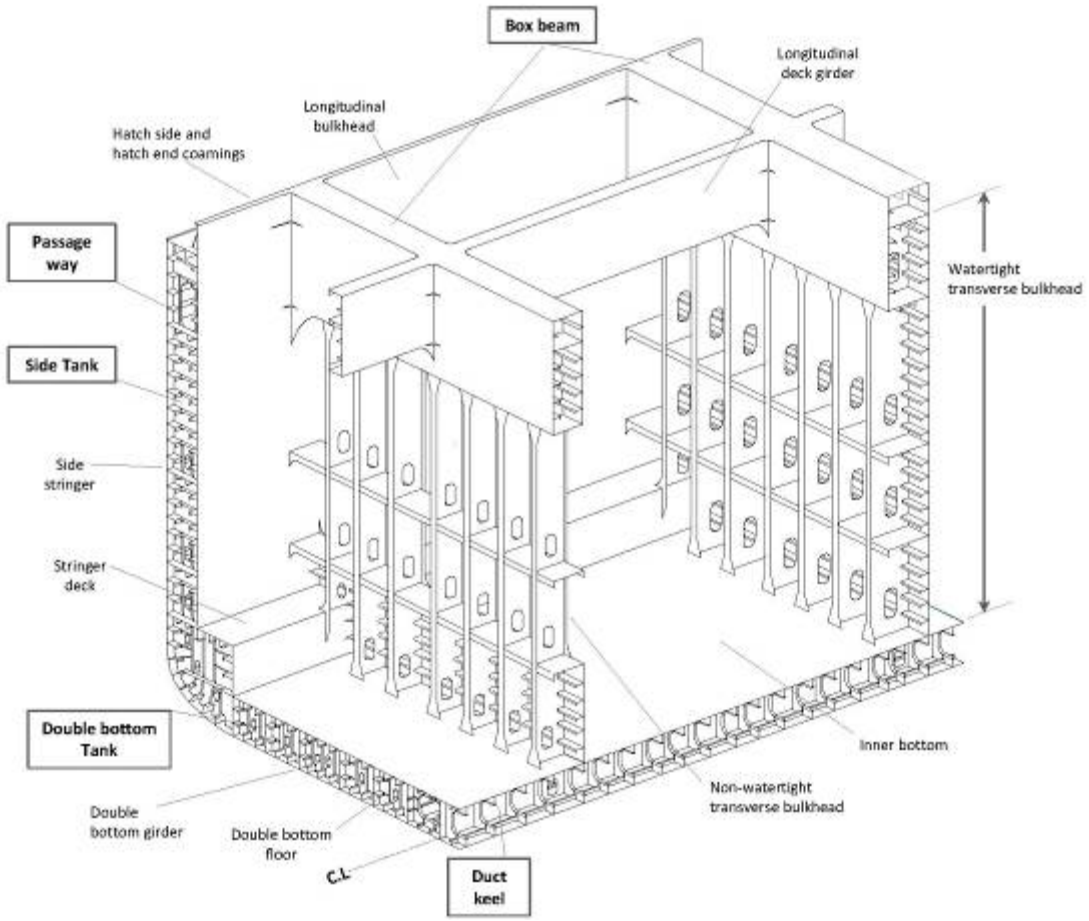


Figure 2 Typical cargo hold configuration for a container ship

2 Class survey requirements

2.1 Periodical Classification Surveys

2.1.1 General

For Class the programme of periodical hull surveys is of prime importance as far as structural assessment of the cargo holds and the adjacent tanks is concerned. The programme of periodical hull surveys consists of Annual, Intermediate and Special/Renewal Surveys. The purpose of the Annual and Intermediate Surveys is to confirm that the general condition of the vessel is maintained at a satisfactory level. The Special/Renewal Surveys of the hull structure are carried out at five year intervals with the purpose of establishing the condition of the structure to confirm that the structural integrity is satisfactory in accordance with the Classification Requirements, and will remain fit for its intended purpose until the next Special/Renewal Survey, subject to proper maintenance and operation. The Special/Renewal Surveys are also aimed at detecting possible damage and to establish the extent of any deterioration.

The Annual, Intermediate and Special/Renewal Surveys are briefly introduced in the following 2.1.2 - 2.1.4. The surveys are carried out taking into account the requirements specified in BCS- R Z7 , alongside the Rules and Regulations of BCS.

2.1.2 Special/Renewal Survey

The Special/Renewal Survey concentrates on examination in association with thickness determination. The report of the thickness measurement is recommended to be retained on board. Protective coating condition will be recorded for particular attention during the survey cycle. From 1991 it is a requirement for new ships to apply a protective coating to the structure in water ballast tanks which form part of the hull boundary, and, since 2008, all dedicated seawater ballast tanks are to be coated during construction in accordance with the PSPC (Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers), adopted by the Maritime Safety Committee by resolution MSC.215(82).

2.1.3 Annual Survey

At Annual Surveys, overall survey is required. For saltwater ballast tanks, examination may be required as a consequence of the Intermediate or Special Surveys.

2.1.4 Intermediate Survey

At Intermediate Surveys, in addition to the surveys required for Annual Surveys, examination of cargo holds and ballast tanks is required depending on the ship’s age.

2.1.5 Bottom Survey

Bottom Surveys are requested twice during the Special Survey interval and they should be generally carried out in dry dock. In some cases it may be possible to replace one Bottom Survey in dry dock with an In-Water Survey. This survey is carried out taking into account the requirements specified in BCS- R Z3 , alongside the Rules and Regulations of BCS.

It is worth to note that the Container ships may be admitted to the Pilot Scheme of Extended Interval between Surveys in Dry-Dock, which allows to schedule the bottom survey in dry dock with a time frame of 7,5 years by permitting that the bottom inspections (two at least) in between are carried out with the ship afloat. The scheme is applicable to ships having age not more than 10 years under the consent of the Flag Administration, The details for the admission to this scheme are set in BCS- G 133.

2.2 Damage and Repair Surveys

Damage surveys are occasional surveys which are, in general, outside the programme of periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or owner's representative to inform the Classification Society concerned when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages should be inspected and assessed by the Society's surveyors and the relevant repairs, if needed, are to be performed. In certain cases, depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the ~~planned~~ scheduled periodical survey.

2.3 Voyage Repairs and Maintenance

Where repairs to hull, machinery or equipment, which affect or may affect classification, are to be carried out by a riding crew during a voyage they are to be planned in advance. A complete repair procedure including the extent of proposed repair and the need for surveyor's attendance during the voyage is to be submitted to and agreed upon by the Surveyor reasonably in advance. Failure to notify BCS in advance of the repairs, may result in suspension of the vessel's class.

The above is not intended to include maintenance and overhaul to hull, machinery and equipment in accordance with manufacturers' recommended procedures and established marine practice and which does not require BCS's approval; however, any repair as a result of such maintenance and overhauls which affects or may affect classification is to be noted in the ship's log and submitted to the attending Surveyor for use in determining further survey requirements.

See BCS- R Z13.

3 Technical background for surveys

3.1 General

3.1.1 The purpose of carrying out periodical hull surveys is to detect possible structural defects and damages and to establish the extent of any deterioration. To help achieve this and to identify key locations on the hull structure that might warrant special attention, knowledge of any historical problems of the particular ship or other ships of a similar class is to be considered if available. In addition to the periodical surveys, occasional surveys of damages and repairs are carried out. Records of typical occurrences and chosen solutions should be available in the ship's history file.

3.2 Definitions

3.2.1 For clarity of definition and reporting of survey data, it is recommended that standard nomenclature for structural elements be adopted. Typical sections in way of cargo holds are illustrated in **Figures 3 (a)** and **(b)**. These figures show the generally accepted nomenclature.

The terms used in these guidelines are defined as follows:

(a) **Ballast Tank** is a tank which is used primarily for salt water ballast.

(b) **Spaces** are separate compartments including holds and tanks.

(c) **Close-up Survey** is a survey where the details of structural components are within the close visual inspection range of the surveyors, i.e. normally within reach of hand.

(d) **Transverse Section** includes all longitudinal members such as plating, longitudinals and girders at the deck, sides, longitudinal bulkheads, bottom and inner bottom. For transversely framed vessels, a transverse section includes adjacent frames and their end connections in way of transverse sections.

(e) **Representative Spaces** are those which are expected to reflect the condition of other spaces of similar type and service and with similar corrosion protection systems. When selecting representative spaces, account should be taken of the service and repair history on board.

(f) **Suspect Areas** are locations showing substantial corrosion and/or are considered by the surveyor to be prone to rapid material wastage.

(g) **Substantial Corrosion** is an extent of corrosion such that assessment of corrosion pattern indicates a material wastage in excess of 75 per cent of allowable margins, but within acceptable limits.

(h) **Coating Condition** is defined as follows:

Good — condition with only minor spot rusting.

Fair — condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20 per cent or more of areas under consideration, but less than as defined for Poor condition.

Poor — condition with general breakdown of coating over 20 per cent or more of areas or hard scale at 10 per cent or more of areas under consideration.

(i) **Transition Region** is a region where discontinuity in longitudinal structure occurs, e.g. at forward bulkhead of engine room, collision bulkhead and bulkheads of deep tanks in cargo hold region.

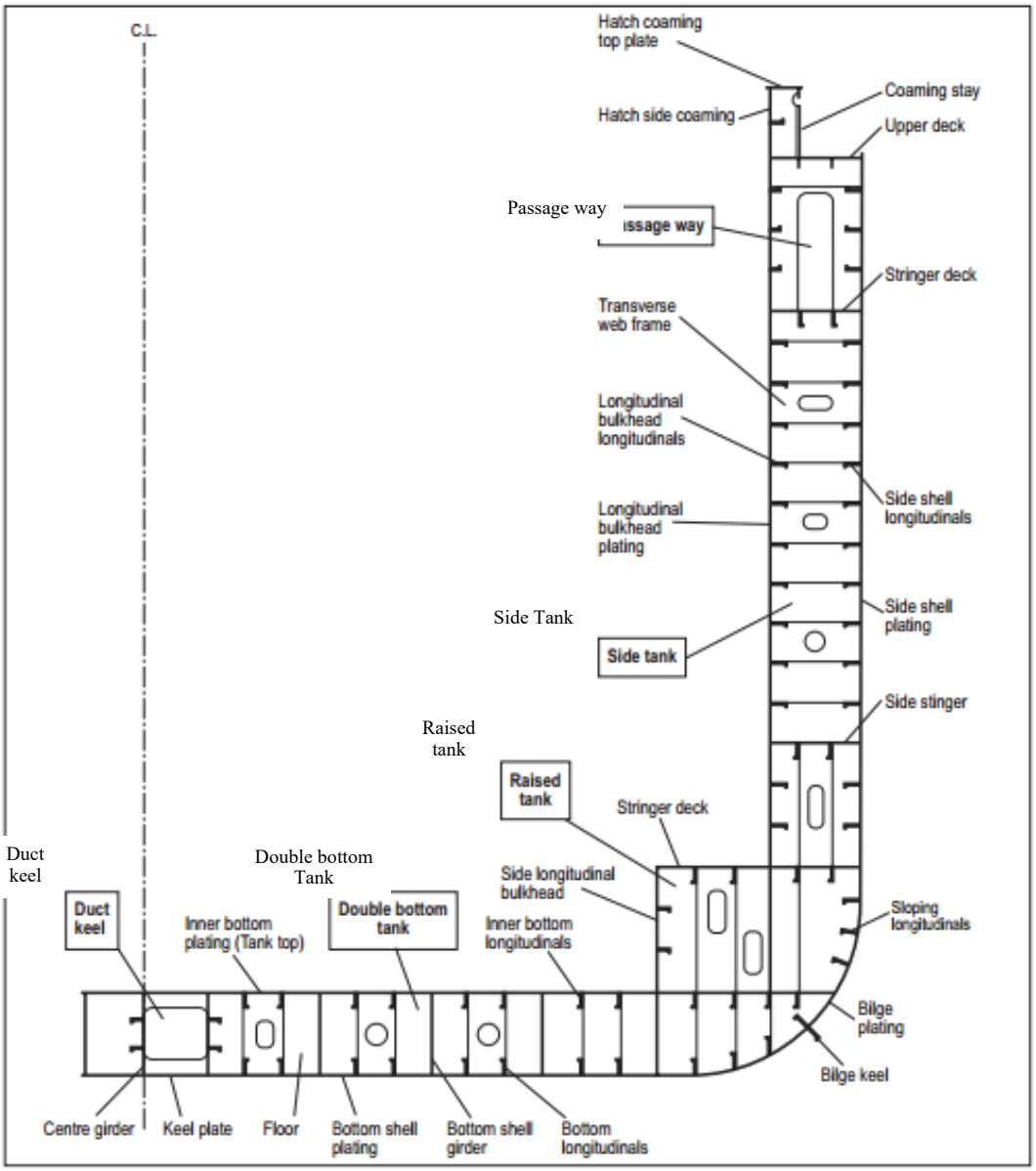


Figure 3 (a) Nomenclature for typical transverse section in way of cargo hold

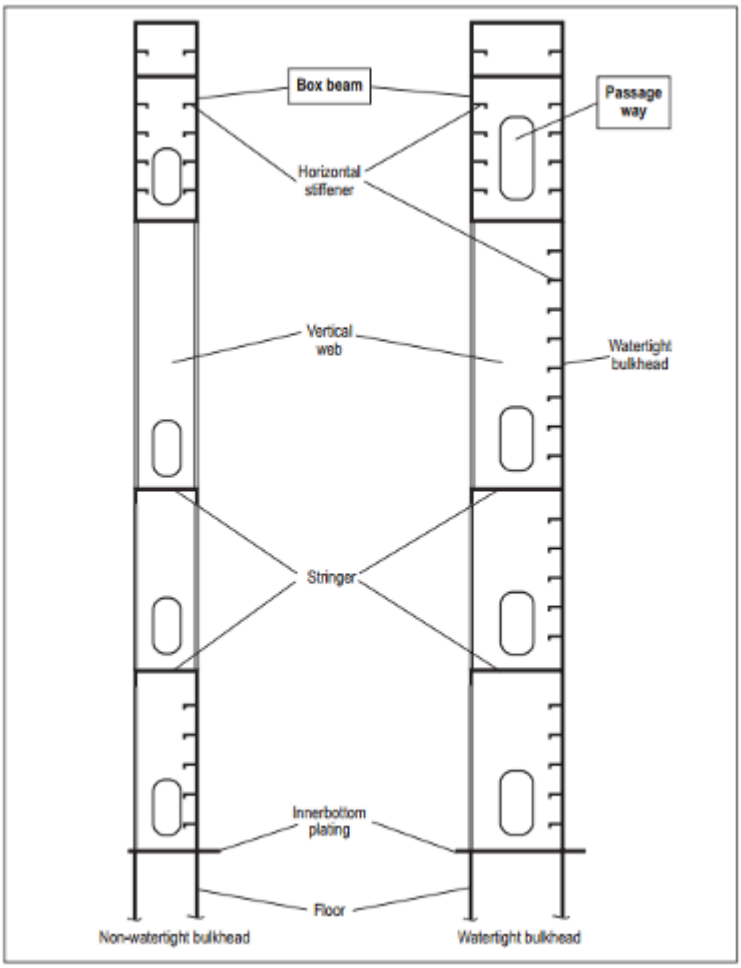


Figure 3 (b) Nomenclature for typical transverse bulkheads

3.3 Structural Damages and Deterioration

3.3.1 General

In the context of these Guidelines, structural damages and deterioration imply deficiencies caused by:

- excessive corrosion
- design faults
- material defects or bad workmanship
- navigation in extreme weather conditions
- loading and unloading operations, water ballast exchange at sea
- wear and tear
- contact (with quay side, ice, touching underwater objects, etc, but not as a direct consequence of accidents such as collisions, groundings and fire/explosions.)
- Deficiencies are normally recognized as:
- material wastage
- fractures
- deformations

The various types of deficiencies and where they may occur are discussed in more detail as follows:

3.3.2 Material wastage

In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible location of corrosion that may occur to the decks, holds, tanks and other structural elements.

General corrosion appears as a non-protective, friable rust which can occur uniformly on hold or tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred. Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals.

Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

Pitting corrosion is often found in the bottom plating or in horizontal surfaces, such as face plates, in ballast tanks and is normally initiated due to local breakdown of coating.

Erosion which is caused by the wearing effect of flowing liquid and abrasion, which is caused by mechanical actions, may also be responsible for material wastage.

3.3.3 Fractures

In most cases fractures are found at locations where stress concentrations occur. Weld defects, flaws, and where lifting fittings used during the construction of the ship are not properly removed are often recognized as areas of stress concentration when fractures are found. If fractures occurred under repeated stresses which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses caused by wave forces, fatigue fractures are also caused by vibration forces derived from main engine(s) or propeller(s), especially in the afterward part of the hull. If the initiation points of the fractures are not apparent, the structure on the other side of the plating should be examined.

Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify, clean, and closely inspect potential problem areas.

A fracture initiating at latent defects in welds more commonly appears at the beginning or end of a run of welds, at rounding corners at the end of a stiffener, or at an intersection. Special attention should be paid to welds at toes of brackets, at cut-outs and at intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations at the end of each length of weld.

It should be noted that fractures, particularly fatigue fractures due to repeated stresses, may lead to serious damage, e.g. a fatigue fracture in a frame may propagate into shell plating and affect the watertight integrity of the hull. In extreme weather conditions the shell fracture could extend further resulting in the loss of part of the shell plating and consequent flooding of side tank.

When a ship are built with extremely thick steel plates (with thickness of over 50mm) to longitudinal structural members in the upper deck and hatch coaming structural region (i.e. upper deck plating, hatch side coaming and hatch coaming top), when NDT is required by rules of BCS, NDT should be carried out in accordance with the requirements of BCS- R S 33

During the in tank inspections, careful inspections for latent fractures should be made to the structures where the hard coating is found broken down alongside (transverse) the block-joint butt welds in tanks with coating in a general good condition. These might be caused by stress concentrations.

3.3.4 Deformations

Deformation of structure is caused by in-plane load, out-of-plane load or combined loads. Such deformation is often identified as local deformation, i.e. deformation of a panel or stiffener, or global deformation, i.e. deformation of a beam, frame, girder or floor, including associated plating.

If a small increase of the in-plane loads cause large deformations, this process is called buckling.

Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to bottom slamming and wave impact forces are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the after part of the hull.

In the case of damage due to contact with other objects, special attention should be drawn to the fact that although damage to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic buckling will not normally be directly obvious but may be detected by evidence of coating damage, stress lines or shedding of scale.

Buckling damage may often be found in webs of web frames or floors. In many cases, this may be attributed to corrosion of webs/floors, wide stiffener spacing or wrongly positioned lightening holes, man-holes or slots in webs/floors.
Finally, it should be noted that inadvertent overloading may cause significant damage. In general, however, major damage is associated with excessive corrosion and contact damage.

3.4 Handling of Defects

3.4.1 Surveyors and inspectors should be familiar with the examples of structural defects and the repairs which are outlined in Section 5 of these Guidelines before undertaking a survey.

3.4.2 Any damage to ships structures that is considered to affect the ship’s Classification is to be repaired.

3.4.3 Before carrying out major repairs involving design modification, drawings are to be

submitted to the Classification Society for approval.

3.4.4 In general, where part of the structure has deteriorated to the permissible minimum thickness, the affected area is to be cropped and renewed. Doubler plates must not be used for the compensation of wasted plate. Repair work in tanks requires careful planning in terms of accessibility.

3.4.5 For structures subject to net scantling approach as per BCS-R S11A and BCS-R S21A or BCS rules, steel renewal is required where the gauged thickness is less than $t_{renewal}$ (t_{net} or t_{net} + 0.5 mm, depending on the corrosion addition assigned to the structures). Where the gauged thickness is within the range $t_{renewal}$ + 0.5 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal, and the coating is to be maintained in GOOD condition.

3.4.6 If replacement of defective parts may be allowed to be postponed, the following temporary measures may be acceptable at the surveyor's discretion (notwithstanding that carrying out a permanent repair straightaway is the preferable option):

(a) the affected area may be sandblasted and painted in order to reduce corrosion rate.
(b) doubler plates may be applied over the affected area. Special consideration should be given to areas buckled under compression.
(c) stronger members may support weakened stiffeners by applying temporarily connecting elements.
(d) cement box may be applied over the affected area.

A suitable condition of class is imposed by the class surveyor when temporary measures are accepted.

3.4.7 When the repair is performed afloat, the ship loading condition is to be adjusted to have a longitudinal stress at deck less than 50 MPa.

3.4.8 For controlling the quality of repair of hull structures, the standard of part B of BCS-G 47 "Shipbuilding and Repair Quality Standard" or equivalent standards recognized by the classification society, should be followed.

4 Survey planning, preparation and execution

4.1 General

4.1.1 The Owner should be aware of the scope of the coming survey and instruct those who are responsible, such as the Master or the Superintendent, to prepare the necessary arrangements. If there is any doubt, BCS should be consulted.

4.1.2 Survey execution will naturally be heavily influenced by the type and scope of the survey to be carried out. The scope of survey is normally determined prior to its execution

4.1.3 When deemed prudent and/or required by virtue of the periodic classification survey conducted, the Surveyor should study the ship's structural arrangements and review the ship's operating and survey history and those of sister ships, where possible, to determine any known potential problem areas particular to the class of the ship. Sketches of typical structural elements should be prepared in advance so that any defects and/or ultrasonic thickness measurements can be recorded rapidly and accurately.

4.2 Conditions for Survey

4.2.1 The owner is to provide the necessary facilities for a safe execution of the survey.

4.2.2 Tanks and spaces are to be safe for access, i.e. gas freed (marine chemist certificate), ventilated, etc. Reference could be made to BCSR 37 dealing with the safe entry into confined spaces.

4.2.3 Tanks and spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. and sufficient illumination is to be provided, to reveal corrosion, deformation, fractures, damages or other structural deterioration. In particular this applies to areas which are subject to thickness measurement.

4.3 Access Arrangement and Safety

4.3.1 In accordance with the intended survey, measures are to be provided to enable the hull structure to be examined and the thickness measurements to be carried out in a safe and practical way.

4.3.2 For surveys in cargo holds and salt water ballast tanks one or more of the following means of access, acceptable to the Surveyor, are to be provided:

(a) permanent staging and passages through structures
(b) temporary staging, e.g. ladders and passages through structures
(c) lifts and movable platforms; and
(d) other equivalent means.

4.3.3 In addition, particular attention should be given to the following guidance:

1. Prior to entering tanks and other closed spaces, e.g. chain lockers, void spaces, it is necessary to ensure that the oxygen content is tested and confirmed as safe. A responsible member of the crew should remain at the entrance to the space and if possible communication links should be established with both the bridge and engine room. Adequate lighting should be provided in addition to a hand held torch (flashlight).

2. In tanks where the structure has been coated and recently deballasted, a thin slippery film may often remain on surfaces. Care should be taken when inspecting such spaces.

3. The removal of scale can be extremely difficult. The removal of scale by hammering may cause sheet scale to fall, and in cargo holds this may result in residues of cargo falling from above. When using a chipping or scaling hammer care should be taken to protect eyes, and where possible safety glasses should be worn. If the structure is heavily scaled then it may be necessary to request de-scaling before conducting a satisfactory visual examination.

4. Owners or their representatives have been known to request that a survey be carried out from the top of the cargo during loading and unloading operations. For safety reasons, loading and unloading operations must be stopped in the hold being surveyed.

5. When entering a cargo hold or tank the bulkhead vertical ladders should be examined prior to descending to ensure that they are in good condition and rungs are not missing or loose. If holds are being entered when the hatch covers are in the closed position, then adequate lighting should be arranged in the holds. One person at a time should descend or ascend the ladder.

6. If a portable ladder is used for survey purposes, the ladder should be in good condition and fitted with adjustable feet, to prevent it from slipping. Two crew members should be in attendance in order that the base of the ladder is adequately supported during use.

7. If an extending/articulated ladder (frame walk) is used to enable the examination of upper portions of cargo hold structure, the ladder should incorporate a hydraulic locking system and a built-in safety harness. Regular maintenance and inspection of the ladder should be confirmed prior to its use.

8. If a hydraulic arm vehicle (“Cherry Picker”) is used to enable the examination of the upper parts of the cargo hold structure, the vehicle should be operated by qualified personnel and there should be evidence that the vehicle has been properly maintained. The standing platform should be fitted with a safety harness. For those vehicles equipped with a self-leveling platform, care should be taken that the locking device is engaged after completion of manoeuvring to ensure that the platform is fixed.

9. Staging is the most common means of access provided especially where repairs or renewals are being carried out. It should always be properly supported and fitted with handrails. Planks should be free from splits and lashed down. Staging erected hastily by inexperienced personnel should be avoided.

10. In double bottom tanks there will often be an accumulation of mud on the bottom of the tank and this should be removed, in particular in way of tank boundaries, and suction and sounding pipes, to enable a clear assessment of the structural condition.

4.4 Personal Equipment[1]

4.4.1 The following protective clothing and equipment to be worn as applicable during the surveys:

(a) **Working clothes**: Working clothes should be of a low flammability type and easily visible.

(b) **Head protection**: Hard hat (metal hats are not allowed) shall always be worn outside office building/unit accommodation.

(c) **Hand and arm protection**: Various types of gloves are available for use, and these should be used during all types of surveys. Rubber/plastic gloves may be necessary when working in cargo holds.

(d) **Foot protection**: Safety shoes or boots with steel toe caps and non-slip soles shall always be worn outside office buildings/unit accommodation. Special footwear may be necessary on slippery surfaces or in areas with chemical residues.

(e) **Ear protection**: Ear muffs or ear plugs are available and should be used when working in noisy areas. As a general rule, you need ear protection if you have to shout to make yourself understood by someone standing close to you.

(f) **Eye protection**: Goggles should always be used when there is danger of getting solid particles or dust into the eyes. Protection against welding arc flashes and ultraviolet light should also be considered.

(g) **Breathing protection**: Dust masks shall be used for protection against the breathing of harmful dust, paint spraying and sand blasting. Gas masks and filters should be used by personnel working for short periods in an atmosphere polluted by gases or vapour. (Self-contained breathing apparatus: Surveyors shall not enter spaces where such equipment is necessary due to the unsafe atmosphere. Only those who are specially trained and familiar with such equipment should use it and only in case of emergency).

(h) **Lifejacket**: Recommended to wear when embarking/disembarking ships offshore, from/to pilot boat.

4.4.2 The following survey equipment is to be used as applicable during the surveys:

(a) **Torches**: Torches (Flashlights) approved by a competent authority for use in a flammable atmosphere shall be used in gas-dangerous areas. A high intensity beam type is recommended for in-tank inspections. Torches are recommended to be fitted with suitable straps so that both hands may be free.

(b) **Hammer**: In addition to its normal purposes the hammer is recommended for use during surveys inside units, tanks etc. as it may be most useful for the purpose of giving a distress signal in the case of an emergency.

(c) **Oxygen analyser/Multigas detector**: For verification of an acceptable atmosphere prior to tank entry, pocket size instruments which give an audible alarm when unacceptable limits are reached, are recommended. Such equipment shall have been approved by national authorities.

[1] Reference should also be made to BCS- PR37 and BCS- G 72.

(d) **Safety belts and lines**: Safety belts and lines should be worn where there is a high risk of falling from more than 3 meters.

4.5 Thickness Measurement and Fracture Detection

4.5.1 Thickness measurement is to comply with the requirements of BCS. Thickness measurement should be carried out at points that adequately represent the nature and extent of any corrosion or wastage of the respective structure (plate, web, etc.)

4.5.2 Thickness measurement is normally carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven as required.

4.5.3 The required thickness measurements, if not carried out by BCS itself, are to be carried out by a qualified company certified by BCS, and are to be witnessed by a surveyor on board to the extent necessary to control the process. The report is to be verified by the surveyor in charge.

4.5.4 One or more of the following fracture detection procedures may be required if deemed necessary and should be operated by experienced qualified technicians:

(a) radiographic equipment
(b) ultrasonic equipment
(c) magnetic particle equipment
(d) dye penetrant

4.6 Survey at Sea or at Anchorage[2]

4.6.1 Voyage surveys may be accepted provided the survey party is given the necessary assistance from the shipboard personnel. The necessary precautions and procedures for carrying out the survey are to be in accordance with previous paragraphs. The ballasting system must be secured at all times during tank surveys.

4.6.2 A communication system is to be arranged between the survey party in the spaces under examination and the responsible officer on deck.

4.7 Documentation on Board

4.7.1 The following documentation is recommended to be placed on board and maintained and updated by the owner for the life of the ship in order to be readily available for the survey party.

4.7.2 Survey Report File: This file includes Reports of Structural Surveys and Thickness Measurement Reports.

4.7.3 Supporting Documents: The following additional documentation is recommended to be placed on board, including any other information that will assist in identifying Suspect Areas requiring examination.

(a) main structural plans of cargo holds and ballast tanks
(b) previous repair history
(c) cargo and ballast history
(d) inspection and action taken by ship’s personnel with reference to:

[2] Reference could be made to BCS- PR 37 dealing with the safe entry into confined spaces

- structural deterioration in general
- leakages in bulkheads and piping
- condition of coating or corrosion protection, if any

4.7.4 Prior to inspection, it is recommended that the documents on board the vessel be reviewed, as a basis for the current survey.

5 Structural detail failures and repairs

5.1 General

5.1.1 The listing of structural detail failures and repairs contained in this section of the Guidelines collates data supplied by BCS and is intended to provide guidance when considering similar cases of damage and failure. The proposed repairs reflect the experience of the surveyors of BCS, but it is realized that other satisfactory alternative methods of repair may be available. However, in each case the repairs are to be completed to the satisfaction of BCS surveyor concerned.

5.2 Catalogue of Structural Detail Failures and Repairs

5.2.1 The listing has been sub-divided into parts and areas to be given particular attention during surveys:

Part 1 Cargo hold region

Area 1 – Upper deck structure including passageways
Area 2 – Side structure including side tanks
Area 3 – Transverse bulkheads
Area 4 – Double bottom structure

Part 2 Fore and aft end regions

Area 1 – Fore end structure
Area 2 – Aft end structure
Area 3 – Stern frame, rudder arrangement and propeller shaft support

Part 3 Machinery and accommodation spaces

Area 1 – Engine room structure
Area 2 – Accommodation structure

Part 1 Cargo hold region

Contents

Area 1 – Upper deck structure including passageways

Area 2 – Side structure including side tanks

Area 3 – Transverse bulkheads

Area 4 – Double bottom

Area 1 Upper deck structure including passageways

Contents

1 General

2 What to look for – On-deck inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for – Under-deck inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Deformations
4.3 Fractures
4.4 Miscellaneous

Figures – Area 1

No.	Title
Figure 1	Simulation – bending of the ship in a seaway

Examples of structural detail failures and repairs – Area 1

Example No.	Title
1	Buckling of deck plating of transverse framing system
2-a	Fractures at main cargo hatch corner
2-b	Fractures at main cargo hatch corner initiated from welded joint of cell guide
2-c	Fractures at main cargo hatch corner initiated sniped end of stiffener
3-a	Fracture of welded seam between thick plate and thin plate at cross deck
3-b	Plate buckling in thin plate near thick plate at cross deck
3-c	Overall buckling of cross deck plating
3-d	Deformed and fractured deck plating around tug bitt
4	Fracture in deck girder initiated at bracket toe
5	Fractures in continuous longitudinal hatch coaming extension bracket
6	Fractures in hatch side coaming
7	Fracture in access hole of longitudinal hatch coaming
8-a	Fractures in hatch coaming top plate at the termination of rail for hatch cover
8-b	Fractures in hatch coaming top plate at the termination of rail for hatch cover
9	Fractures in hach coaming top plate initiated from butt weld of compression bar
10	Fracture in hatch coaming top plate i.w.o. quick acting cleat
11	Fractures in hatch coaming top plate around resting pad
12-a	Fractures in web of transverse hatch coaming stay
12-b	Fractures in web of transverse hatch coaming stay
13	Fractures in the connection of the web of transverse hatch coaming stay
14	Fracture in deck longitudinal
15	Fractures in longitudinal hatch cover girder
16	Fractures in deck girder
17	Fractures in the connections between hatch coaming and bulkhead of deck house
18	Fracture in deck plating at the pilot ladder access of bulwarks

1 General

1.1 Due to the large hatch openings for loading and unloading of containers the hull structure is very flexible showing considerable elastic deformations in a seaway as well as high longitudinal stresses. Normally containerships meet only hogging still water bending moment conditions of the hull causing high tensile stresses in the continuous longitudinal deck structures such as longitudinal hatch coamings, upper deck plating and longitudinals. The range of these higher bending stresses is extended over the complete cargo hold area. Particular areas of the deck may also be subjected to additional compressive stresses in heavy weather, caused by slamming or bow flare effect at the fore part of the ship. Longitudinal deck girders, even though in general not completely effective for the longitudinal hull girder strength, are also subject to high longitudinal stresses. In particular in case of the use of higher tensile steel in such high stressed areas special attention is to be paid to the detail design of the structure.

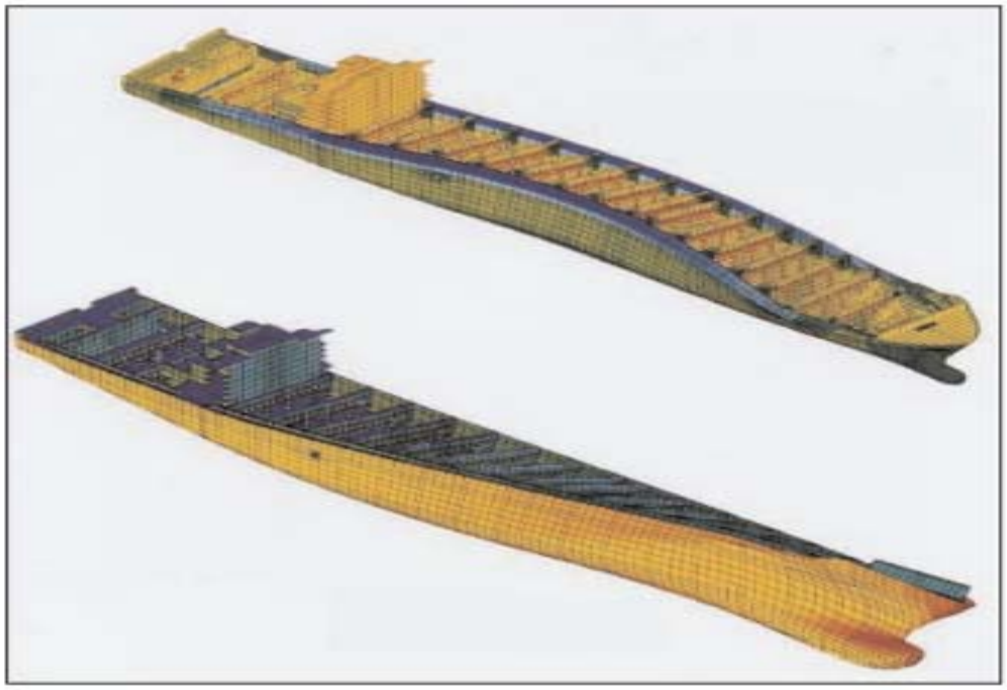


Figure 1 Simulation – bending of the ship in a seaway

1.2 The cross deck structure between cargo hatches is subjected to transverse compression from the sea pressure on the ship sides and in-plane bending due to torsional distortion of the hull girder under wave action. In association with this, the area around the corners of a main cargo hatch is subjected to high cyclical stresses due to the combined effect of hull girder bending moments, transverse and torsional loads.

1.3 Cargo hatch side coamings can be subjected to stress concentrations at their ends.

1.4 Considerable horizontal frictional forces in way of the hatch cover resting pads can result from the elastic deformation of the deck structure in combination with the hatch covers which are extremely rigid against horizontal in-plane loads. The magnitude of these frictional forces depends on the material combination in way of the bearing.

1.5 Hatch cover operations, combining with poor maintenance, can result in damage to cleats and gaskets leading to the loss of weathertight integrity of the hold spaces. Damage to hatch covers can also be sustained by mishandling and overloading of deck cargoes.

1.6 The marine environment, and the high temperature on deck and hatch cover plating due to heat from the sun may result in accelerated corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above.

1.7 The deterioration of fittings on deck, such as ventilators, air pipes and sounding pipes, may result in serious problems regarding weather/watertightness and/or firefighting.

2 What to look for – On-deck inspection

2.1 Material wastage

2.1.1 The general corrosion condition of the deck structure, cargo hatch covers and coamings may be observed by visual inspection. Special attention should be paid to areas where pipes, e.g. fire main pipes, hydraulic pipes and pipes for compressed air, are fitted close to the plating, making proper maintenance of the protective coating difficult to carry out. Severe corrosion of the hatch coaming plating inside cargo holds may occur due to difficult access for the maintenance of the protective coating. This may lead to fractures in the structure.

2.1.2 Grooving corrosion may occur at the transition between the thicker deck plating outside the line of cargo hatches and the thinner cross deck plating, especially when the difference in plate thickness is large. The difference in plate thickness causes water to gather in this area resulting in a corrosive environment which may subsequently lead to grooving.

2.1.3 Pitting corrosion may occur throughout the cross deck strip plating and on hatch covers. Water accumulation may create additional corrosion.

2.1.4 Wastage/corrosion may affect the integrity of steel hatch covers and the associated moving parts, e.g. cleats, pot-lifts, roller wheels, etc. For a ship provided with partially weathertight hatchway covers (referring to the IMO circular MSC/Circ.1087, Guidelines for Partially Weathertight Hatchway Covers onboard Container Ships), particular attention should be paid during inspection to the wastage/corrosions of the related fittings on the top plates of hatchway in way of the non-weathertight connections of hatch covers.

2.2 Deformations

2.2.1 Plate buckling (between stiffeners) may occur in areas subjected to in-plane compressive stresses, in particular if affected by corrosion. Special attention should be paid to areas where the compressive stresses are perpendicular to the direction of the stiffening system. Such areas may be found in the fore part of the ship where deck longitudinals are terminated and replaced by transverse beams (See **Example 1**) as well as in the cross deck strips between hatches when longitudinal stiffening is applied (See **Examples 3-b** and **3-c**).

2.2.2 Deformed structure may be observed in areas of the deck, hatch coamings, hatch covers and lashing equipment where cargo has been handled/loaded or mechanical equipment, e.g. hatch covers, has been operated. In exposed deck areas, in particular the forward deck, deformation of structure may be as a result of green seas loads on the deck.

2.2.3 Deformation/twisting of exposed structure above deck, such as side-coaming brackets, may result from impact due to improper handling of cargo and cargo handling machinery. Such damage may also be caused by shipping green sea water on deck in heavy weather.

2.2.4 Hatch cover deformation may be caused by wave loads acting on containers loaded on hatch covers and by dynamic mass forces.

2.2.5 Deck plate deformation may be detected in way of the connections between tug bitt and deck plating (See **Examples 3-d**).

2.3 Fractures

2.3.1 Fractures in areas of structural discontinuity and stress concentration will normally be detected by inspection. Special attention should be given to the structures at cargo hatches in general and to corners of deck openings in particular.

2.3.2 Fractures initiated in the deck plating outside the line of the hatch (See **Example 2-a, 2-b** and **2-c**) may propagate across the deck resulting in serious damage to hull structural integrity. Fractures initiated in the deck plating of the cross deck strip, in particular at the transition between the thicker deck plating and the thinner cross deck plating (see **Example 3-a**), may cause serious consequences if not repaired immediately.

2.3.3 Deck plate fractures may be detected in way of the connections between tug bitt and deck plating (See **Examples 3-d**).

2.3.4 Other fractures that may occur in the deck plating at hatches and in connected coamings can result/originate from:

(a) the geometry of the corners of the hatch openings.

(b) welded attachment on the free edge of the hatch corner plating. (See **Example 2-b**).

(c) fillet weld connection of the coaming to deck.

(d) attachments, cut-outs and notches for securing devices, and operating mechanisms for opening/closing hatch covers at the top of the coaming and/or coaming top bar (See **Examples 8-a, 8-b and 9**).

(e) hatch coaming stays supporting the hatch cover resting pads and the connection of resting pads to the top of the coaming as well as the supporting structures. (See **Example 11**).

(f) the termination of the side coaming extension brackets (See **Examples 5**).

(g) in way of lashing equipment connections.

2.3.5 Fractures in deck plating often occur at the termination of bulwarks, such as pilot ladder recess, due to stress concentration. The fractures may propagate resulting in a serious hull failure when the deck is subject to high longitudinal bending stress.

3 What to look for – Under-deck inspection (in passageways)

3.1 Material wastage

3.1.1 The level of wastage of under-deck stiffeners and structures in cross deck structures may have to be established by means of thickness measurements. As mentioned previously the combination of the effects from the marine environment and the local atmosphere will give rise to high corrosion rates.

3.2 Deformations

3.2.1 Deformation of the side shell transverse web frames and/or distortions of side shell longitudinals may occur due to external loads imposed on the structure in way of the tug pushing area, or in way of side shell fenders.

3.2.2 Improper ventilation during ballasting/deballasting of ballast tanks may cause deformation in deck structures. If such deformation is observed, an internal inspection of the ballast tank should be carried out in order to confirm the nature and the extent of damage.

3.3 Fractures

3.3.1 Fractures may be found in way of the connection between deck longitudinals and transverse bulkheads in particular at the end of supporting brackets.

4 General comments on repair

4.1 Material wastage

4.1.1 In the case of grooving corrosion at the transition between the thicker deck plating outside the line of cargo hatches and the thinner cross deck plating, consideration should be given to renewal of part of, or the entire width of, the adjacent cross deck plating.

4.1.2 In the case of pitting corrosion throughout the cross deck strip plating, consideration should be given to renewal of part of or the entire cross deck plating.

4.1.3 When heavy wastage is found on deck structure, the whole or part of the structure may be cropped and renewed depending on the permissible diminution levels allowed by the Classification Society concerned.

4.1.4 For wastage of cargo hatch covers a satisfactory thickness determination is to be carried out and the plating and stiffeners are to be cropped and renewed as appropriate depending on the extent of the wastage.

4.2 Deformations

4.2.1 When buckling of the deck plating has occurred, appropriate reinforcement is necessary in addition to cropping and renewal, regardless of the corrosion condition of the plating.

4.2.2 Cross deck structure, buckled due to loss in strength caused by wastage, is to be cropped and renewed as necessary. If the cross deck is stiffened longitudinally and the buckling results from inadequate transverse strength, additional transverse stiffeners should be fitted (See **Example 3-b** and **3-c**).

4.2.3 Deformations of cargo hatch covers should be cropped and part renewed, or renewed in full, depending on the extent of the damage.

4.3 Fractures

4.3.1 Fractures in way of cargo hatch corners should be carefully examined in conjunction with the design details (See Example 2-a, 2-b and **2-c**). Re-welding of such fractures is normally not considered to be a permanent solution. Where the difference in thickness between an insert plate and the adjacent deck plating is greater than 3 mm, the edge of the insert plate should be suitably beveled. In order to reduce the residual stress arising from this repair situation, the welding sequence and procedure is to be carefully monitored and low hydrogen electrodes should be used for welding the insert plate to the adjoining structure.

4.3.2 Where structures such as cell guides which are welded to the corners of the hatch openings are considered to be the cause of the fractures, the connection should be modified. (See **Example 2-b**).

4.3.3 In the case of fractures at the transition between the thicker deck plating outside the line of cargo hatches and the thinner cross deck plating, as well as in the hatch side coaming, consideration should be given to renew part of or the entire width of the adjacent cross deck plating, possibly with increased thickness (See **Example 3-a**).

4.3.4 When fractures have occurred in deck girders or connection of deck girders to the transverse bulkhead without significant corrosion, appropriate reinforcement should be considered in addition to cropping and renewal.

4.3.5 To reduce the possibility of future fractures in cargo hatch coamings the following details should be observed:

(a) cut-outs and other discontinuities at top of the coaming should have rounded corners (preferably elliptical or circular in shape) (See **Example 8-b**). Any local reinforcement should be given a tapered transition in the longitudinal direction and the rate of taper should not exceed 1 in 3 (See **Example 6**).

(b) cut-outs and drain holes are to be avoided in the hatch side coaming extension brackets. For fractured brackets, see **Examples 5**.

4.3.6 For cargo hatch covers, fractures of a minor nature may be veed-out and welded. For more extensive fractures, the structure should be cropped and part renewed.

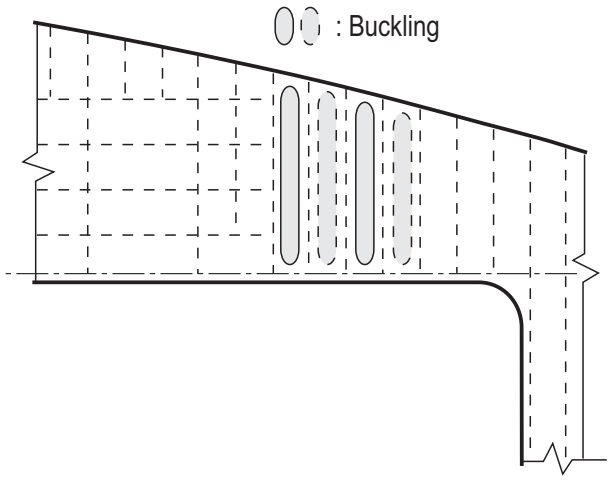
4.3.7 For fractures at the end of bulwarks an attempt should be made to modify the design in order to reduce the stress concentration in connection with general cropping and renewal (See Example 18).

4.4 Miscellaneous

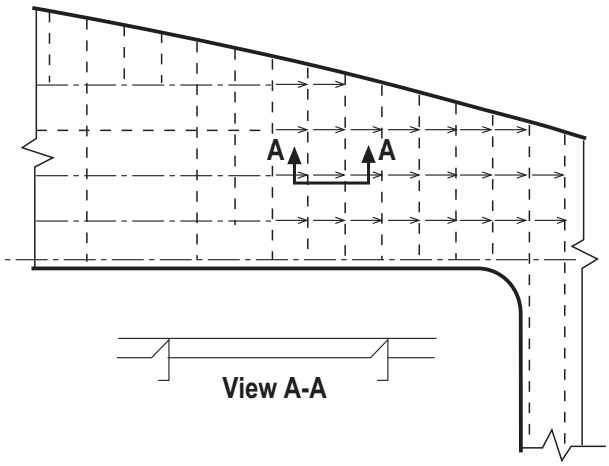
4.4.1 Ancillary equipment such as cleats, rollers etc. on cargo hatch covers are to be renewed as necessary when damaged or corroded.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 1**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Buckling of deck plating of transverse framing system	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Excessive compressive stress due to slamming or bow flare effect.

2. Insufficient longitudinal stiffening of deck plating.

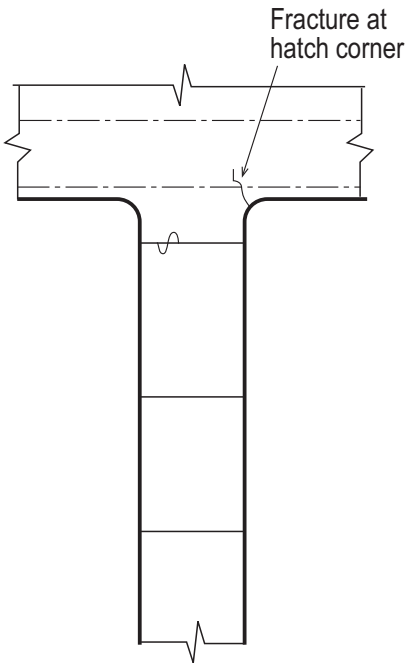
Notes on repairs

1. Buckled plating should be cropped and renewed. Longitudinal internal stiffeners should be provided.
   (Instead of longitudinal stiffeners, renewal by thicker deck plating can be accepted.)

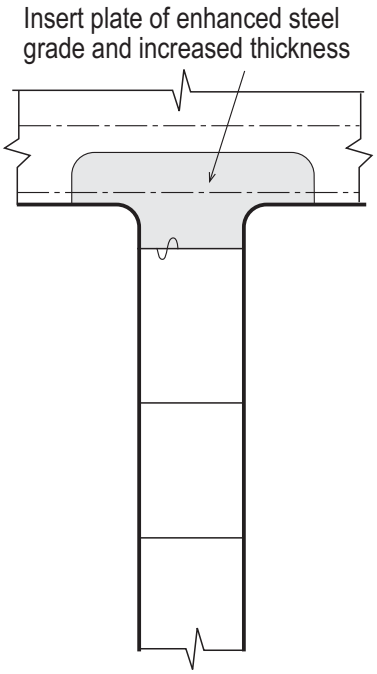
2. Stress concentration may occur at the end of sniped stiffener resulting in fatigue fracture. For locations where high cyclic stress may occur, appropriate connection such as lug-connection should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**2-a**
Detail of damage	Fractures at main cargo hatch corner	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at hatch corners, i.e. radius of corner.

Notes on repairs

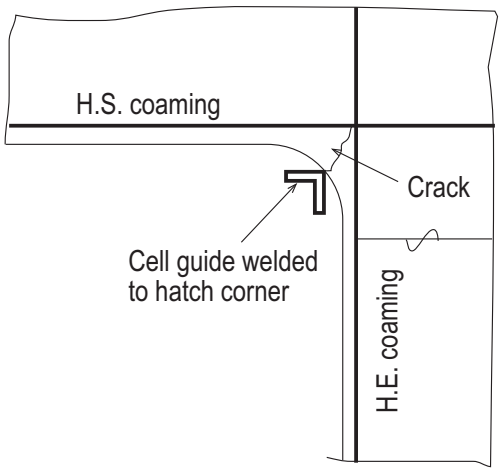
1. The corner plating in way of the fracture is to be cropped and renewed. If stress concentration is primary cause, insert plate should be increased thickness, enhanced steel grade and/or improved geometry.

   Insert plate should be continued beyond the longitudinal and transverse extent of the hatch corner radius ellipse or parabola, and the butt welds to the adjacent deck plating should be located well clear of the butts in the hatch coaming.

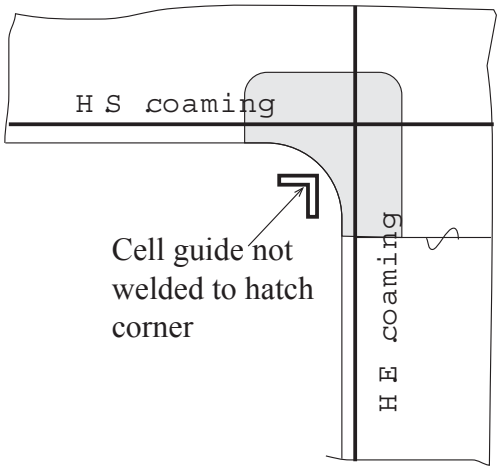
   It is recommended that the edges of the insert plate and the butt welds connecting the insert plates to the surrounding deck plating be made smooth by grinding. In this respect caution should be taken to ensure that the micro grooves of the grinding are parallel to the plate edge.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Upper deck structure including passageways	2-b
Detail of damage	Fractures at main cargo hatch corner initiated from welded joint of cell guide	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

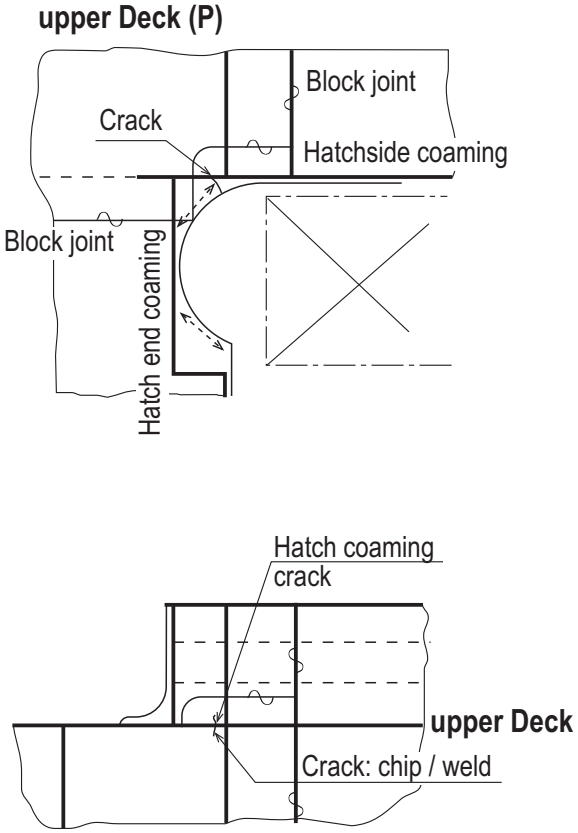
1. In addition to high stress of hatch corner welded connection of cell guide caused stress concentration.

Notes on repairs

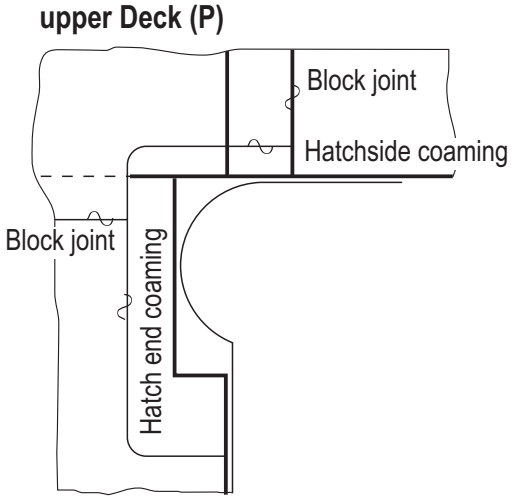
1. Fractured deck plating is to be cropped and renewed.
2. Welding of cell guides to deck plating at hatch corner is to be avoided.
3. Cell guide should be connected to ship structure below deck level.
4. Alternatively an integration of the cell guide into the hatch corner could be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**2-c**
Detail of damage	Fractures at main cargo hatch corner initiated at sniped end of stiffener	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

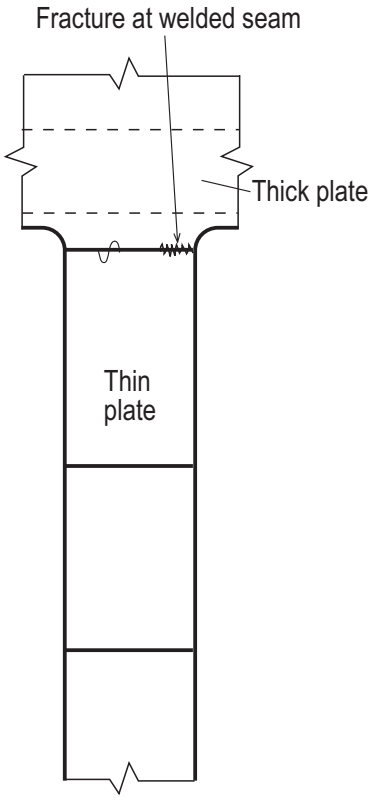
1. In addition to high stress at hatch corner sniped end of stiffener (for buckling) caused stress.

Notes on repairs

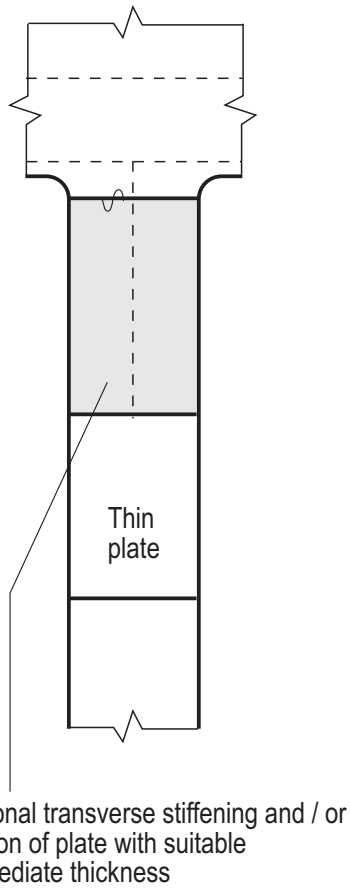
1. Fractured deck plating is to be cropped and renewed.
2. Stiffener is to be removed. If necessary, thicker deck plating is to be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**3-a**
Detail of damage	Fracture of welded seam between thick plate and thin plate at cross deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

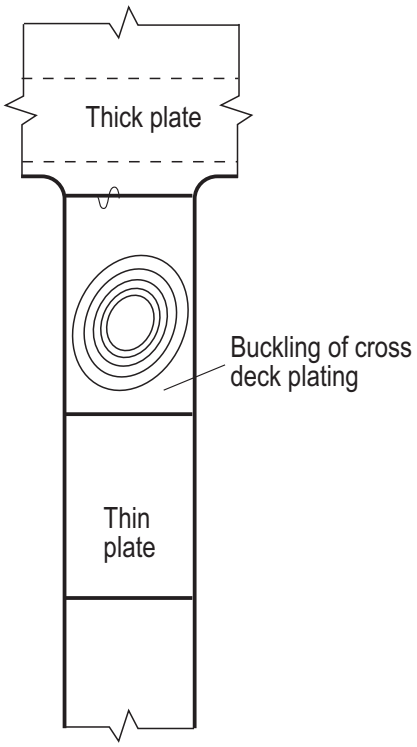
1. Stress concentration created by abrupt change in deck plating thickness.
2. In-plane bending in cross deck strip due to torsional (longitudinal) movements of ship sides.
3. Welded seam not clear of tangent point of hatch corner.

Notes on repairs

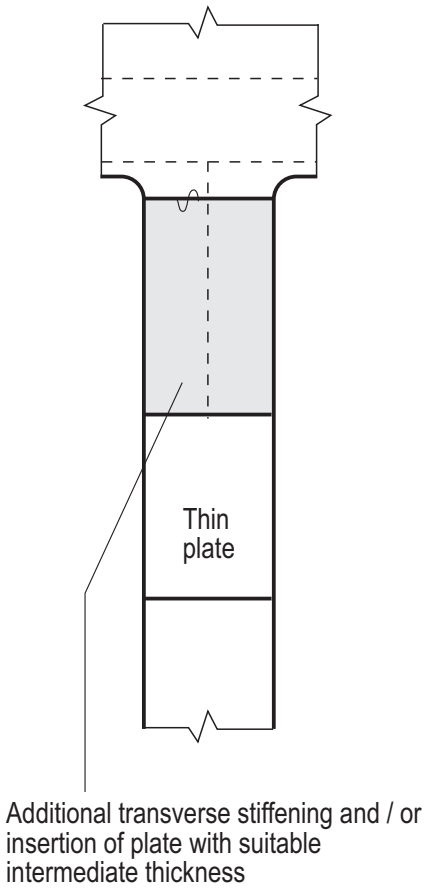
1. Insert plate of intermediate thickness is recommended.
2. Smooth transition between plates (beveling) should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 3-b**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Plate buckling in thin plate near thick plate at cross deck	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. In-plane shear of cross deck strip due to torsional (longitudinal) deflection of ship sides, often in combination with corrosion.

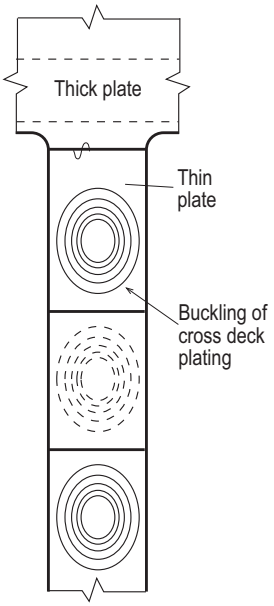
2. Insufficient transverse stiffening.

Notes on repairs

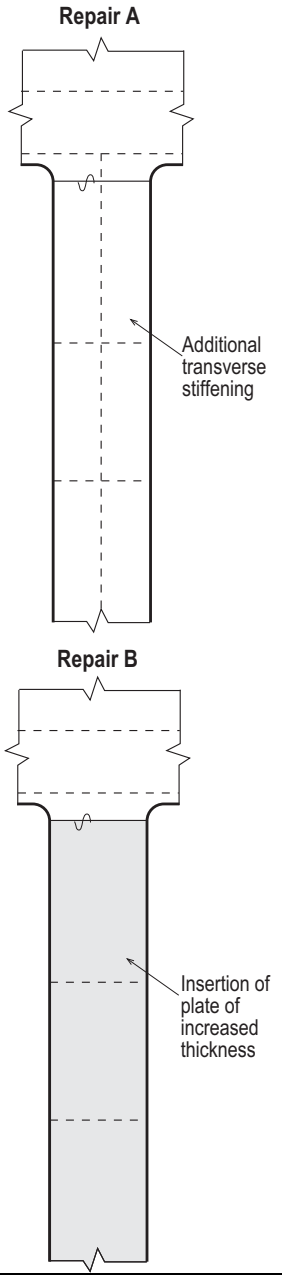
1. Transverse stiffeners extending from hatch sides towards centerline at least 10% of breadth of hatch, and/or increased plate thickness in the same area.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**3-c**
Detail of damage	Overall buckling of cross deck plating	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Transverse compression of deck due to sea load.

2. Insufficient transverse stiffening.

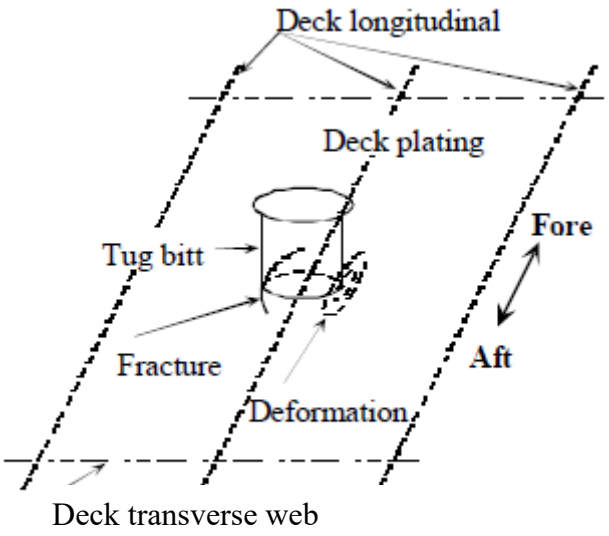
Notes on repairs

1. **Repair A**
   Plating of original thickness in combination with additional transverse stiffening.

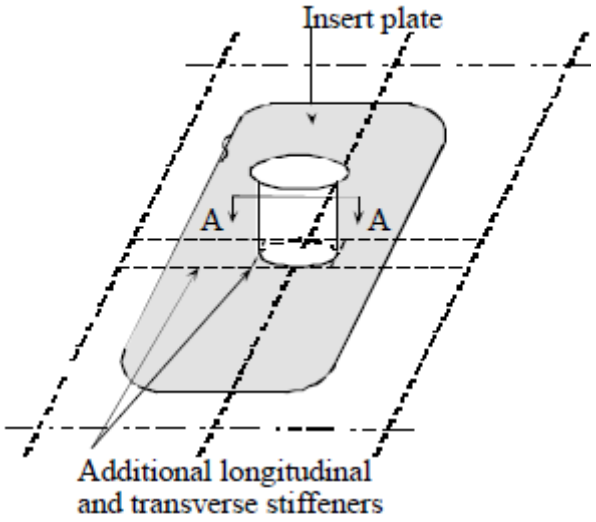
2. **Repair B**
   Insertion of plating of increased thickness.

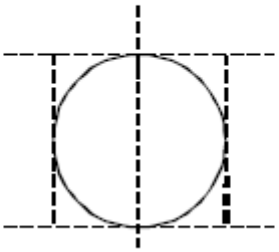
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 3-d
Area 1	Upper deck structure including passageways	
Detail of damage	Deformed and fractured deck plating around tug bitt	

Sketch of damage



Sketch of repair





View A-A

Notes on possible cause of damage

1. Insufficient strength

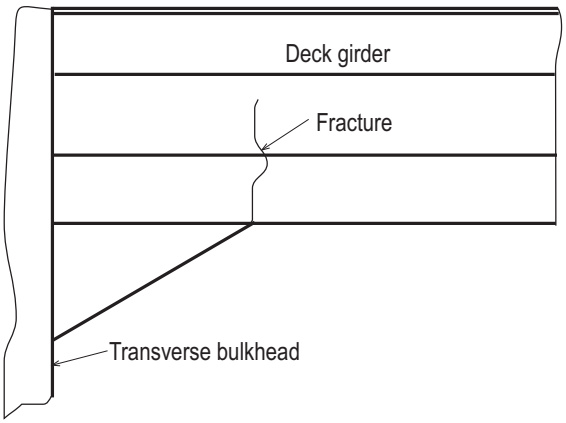
Notes on repairs

1. Fractured/deformed deck plating should be cropped and part renewed.

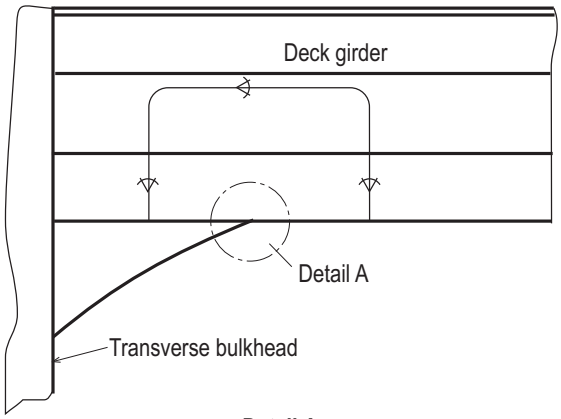
2. Reinforcement by stiffeners should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 4**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Fracture in longitudinal deck girder initiated at bracket toe	

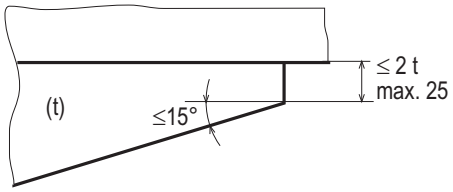
Sketch of damage



Sketch of repair



Detail A



Notes on possible cause of damage

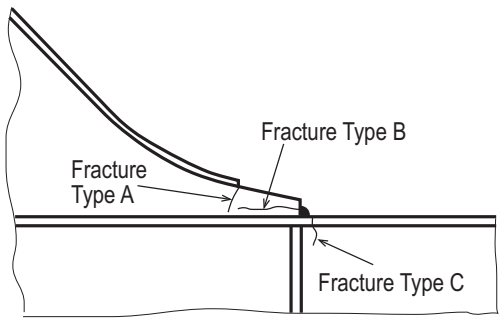
1. Stress concentration at the toe of deck girder bracket

Notes on repairs

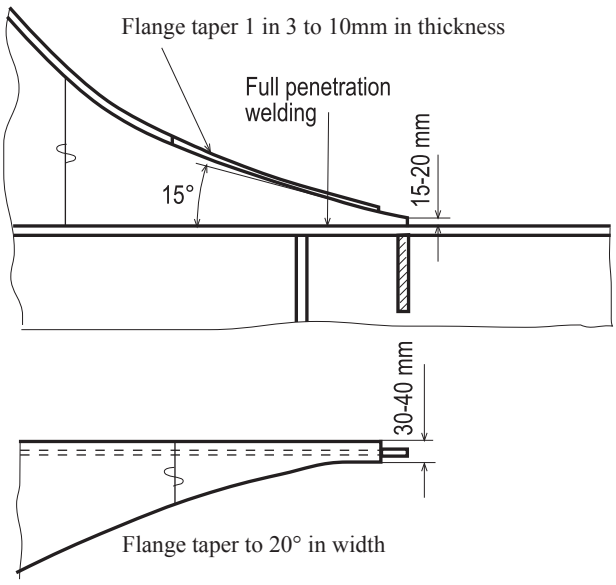
1. Fractured plating should be cropped and part renewed.
2. Modified soft bracket should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**5**
Detail of damage	Fractures in continuous longitudinal hatch coaming extension bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Flange force at the end of the flange too high due to insufficient tapering (**Fracture Type A**, propagating in the web).

2. Shear force in the web plate too high due to insufficient reduction of the web height at the end (**Fracture Type B**, propagating in the web at the undercut or HAZ of the fillet weld).

3. Insufficient support of the extension bracket below the deck (**Fracture Type C**, starting from undercut or HAZ of the fillet weld and propagating in the deck plating).

Notes on repairs

1. Extend the extension bracket as long as possible to arrange a gradual transition.

2. Reduce the web height at the end of the bracket; in case of high stress areas grind smooth the transition to the deck plating welding.

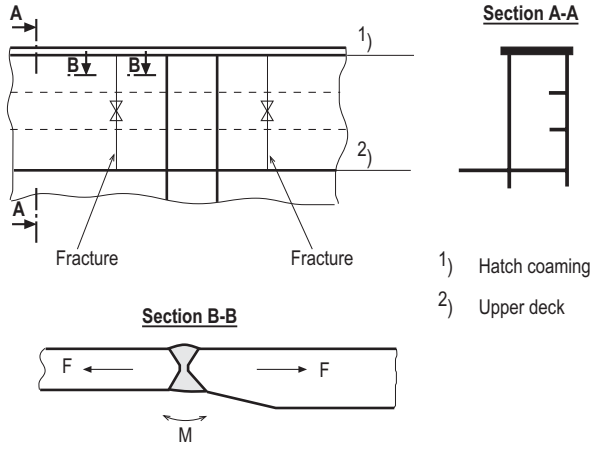
3. Reduce the cross sectional area of the flange at the end as far as possible. Such as flange taper 1 in 3 to 10mm in thickness and taper 20°in width.

4 Provide longitudinal structure in way of the web of the extension bracket to the next transverse structure or provide a new transverse structure.

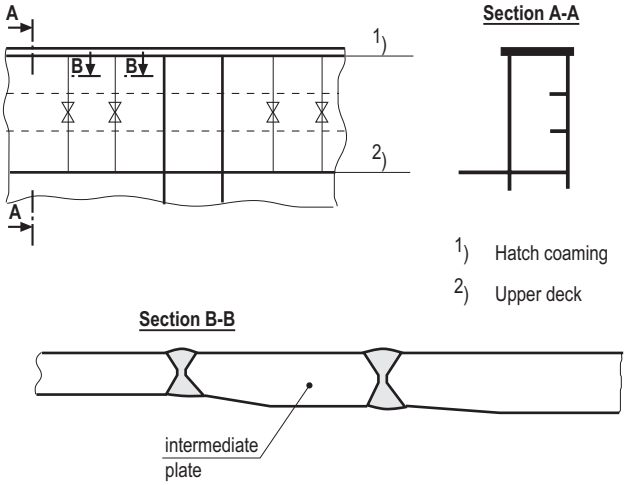
5. The web plate to be cropped and renewed with new plate which increase in thickness of 30-50%, if it does not become excessive

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**6**
Detail of damage	Fractures in hatch side coaming	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

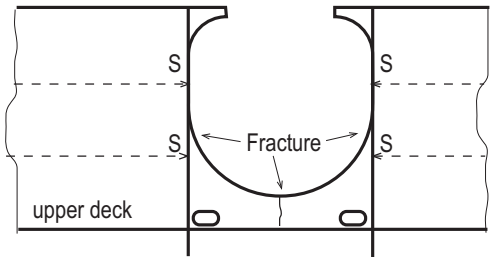
1. Additional stress caused by bending moment due to the difference of thickness.

Notes on repairs

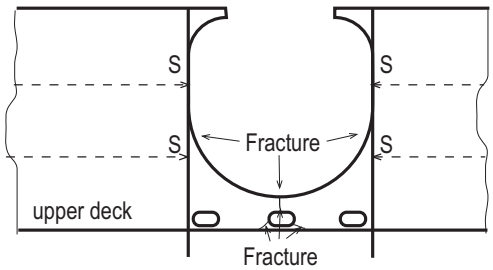
1. Fractured plating is to be cropped and renewed.
2. Insert of plate of intermediate thickness is to be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**7**
Detail of damage	Fracture in access hole of longitudinal hatch coaming	

Sketch of damage

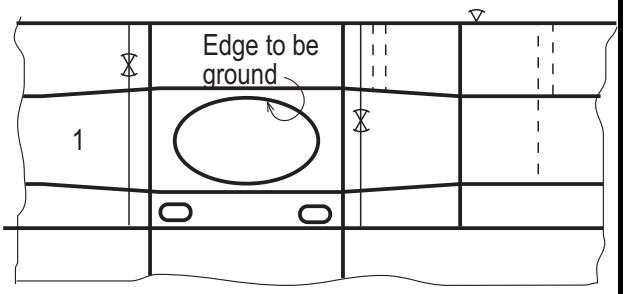


Sketch No. 1 a



Sketch No. 1 b

Sketch of repair



Notes on possible cause of damage

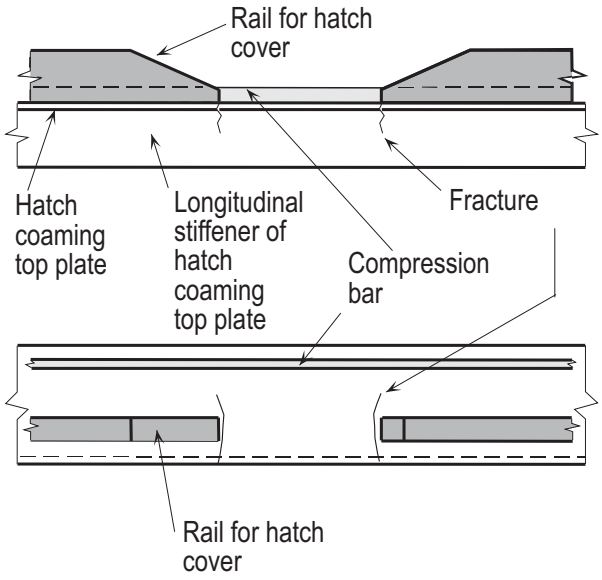
1. Coincidence of maximum of increased stress due to the reduction of the hatch coaming with the metallurgical notches due to the welding seams in web and flat bar located at the same position.

Notes on repairs

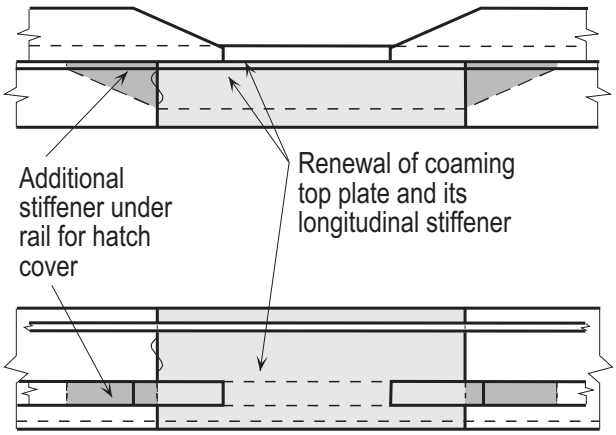
1. Hatch coaming to be continuous.
2. Access opening to be provided.
3. Drain holes to be elliptical and located above fillet weld to deck.
4. Hatch coaming stiffeners of same material as coaming

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**8-a**
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the termination of the rail for hatch cover due to poor design.

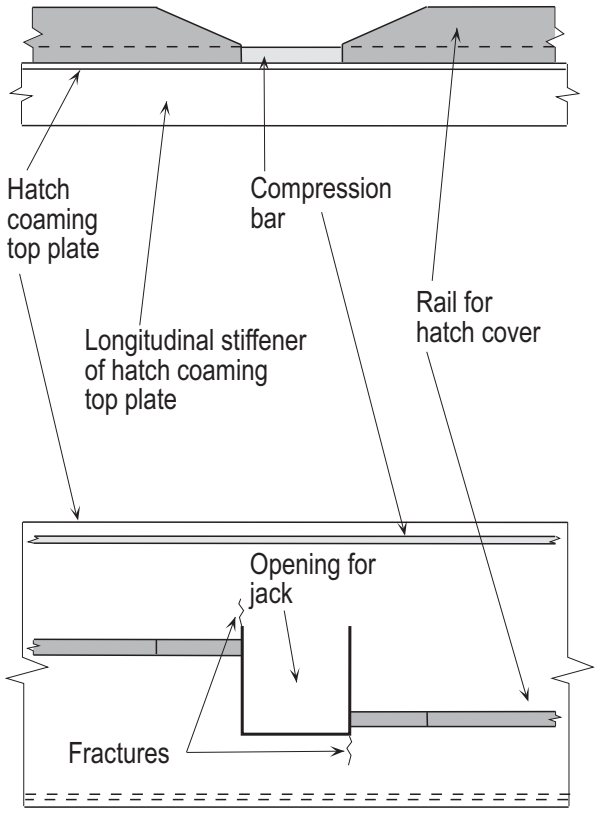
Notes on repairs

1. Fractured plate is to be cropped and part renewed.

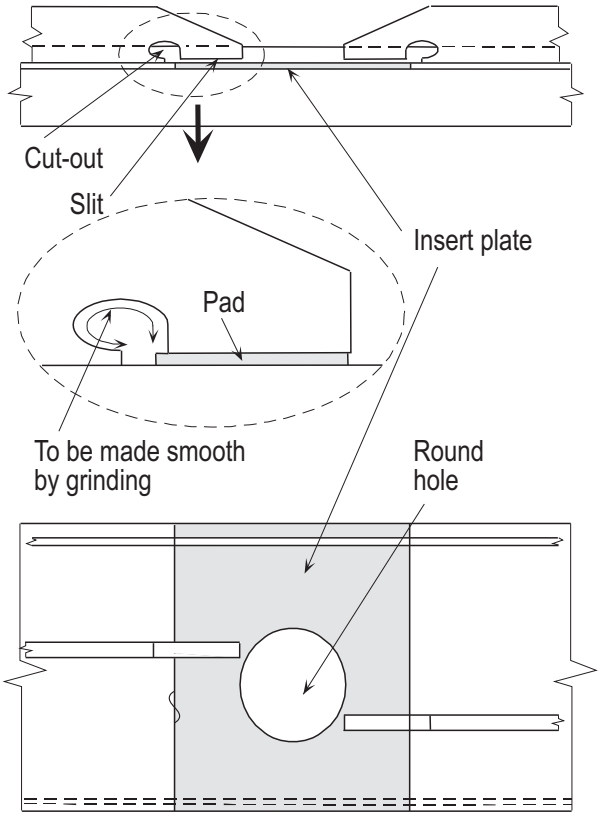
2. Thicker insert plate and/or reinforcement by additional stiffener under the top plate should be considered. Also refer to **Example 9-b**.

CONTAINER SHIP	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.8-b
Area 1	Upper deck structure including passageways	8-b
Detail of damage	Fractures in hatch coaming top plate at the termination of rail for hatch cover	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the termination of the rail for hatch cover due to poor design of opening.

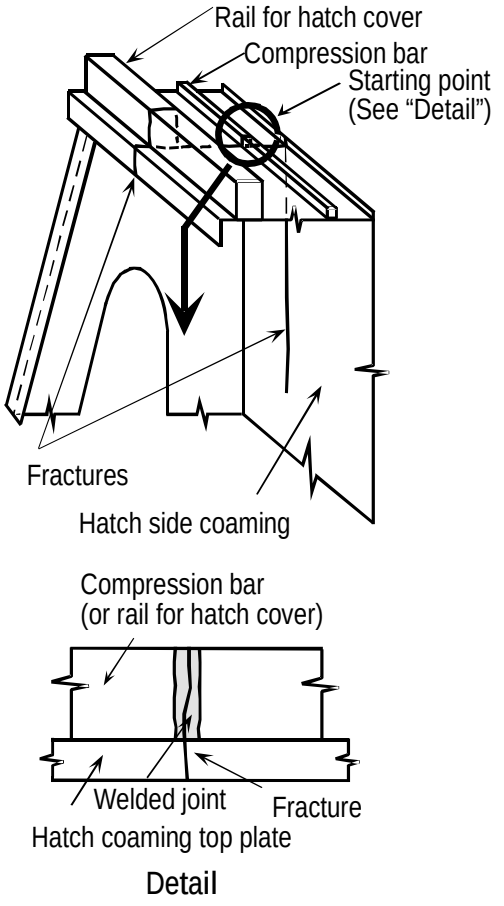
Notes on repairs

1. Fractured plate is to be cropped and part renewed.

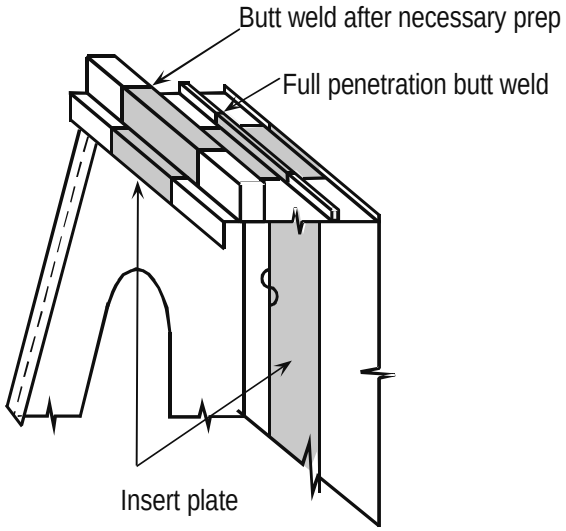
2. Thicker insert plate and/or reduction of stress concentration adopting large radius should be considered. Or cut-out in the rail and detachment of the welds as shown in the above drawing should be considered in order to reduce the stress of the corner of the opening.

CONTAINER SHIP	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**9**
Detail of damage	Fractures in hatch coaming top plate initiated from butt weld of compression bar	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy weather

2. Insufficient preparation of weld of compression bar and/or rail (Although the compression bar and rail are not longitudinal strength members, they are subject to the same longitudinal stress as longitudinal members)

3. Fracture may initiate from insufficient penetration of weld of rail for hatch cover.

Notes on repairs

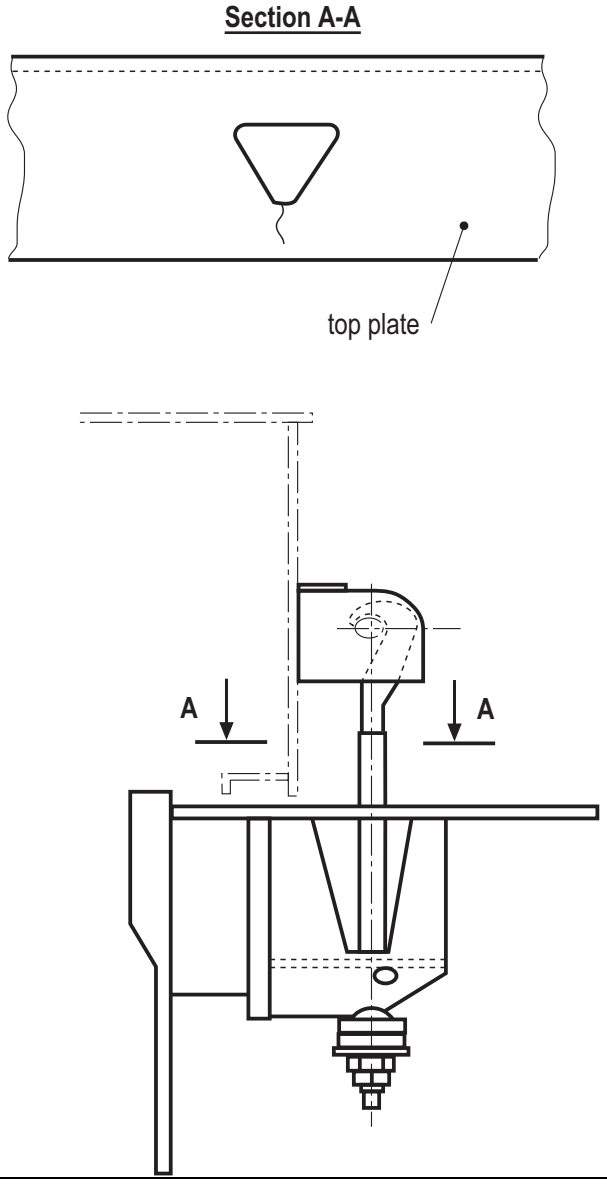
1. Loading condition of the ship and proper welding procedure should be carefully considered.

2. Fractured structure is to be cropped and renewed if considered necessary. (Small fracture may be veed-out and rewelded.)

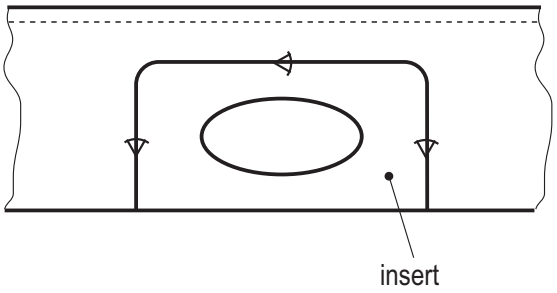
3. Full penetration welding should be applied to the butt weld of compression bar and rail.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**10**
Detail of damage	Fracture in hatch coaming top plate in way of i.w.o. quick acting cleat	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

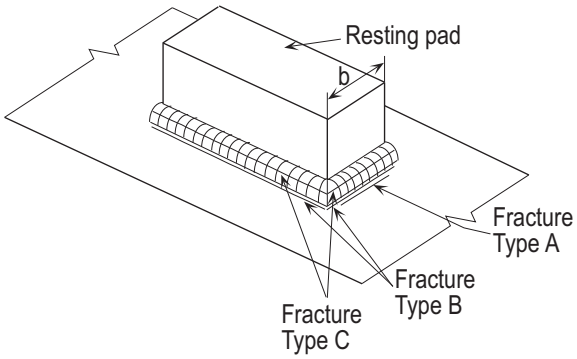
1. Stress concentration at hole
2. Inadequate design
3. Poor workmanship

Notes on repairs

1. Damaged area to be cropped and renewed. .
2. Elliptical hole to be provided for the quick acting cleat

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**11**
Detail of damage	Fractures in hatch coaming top plate around resting pad	

Sketch of damage

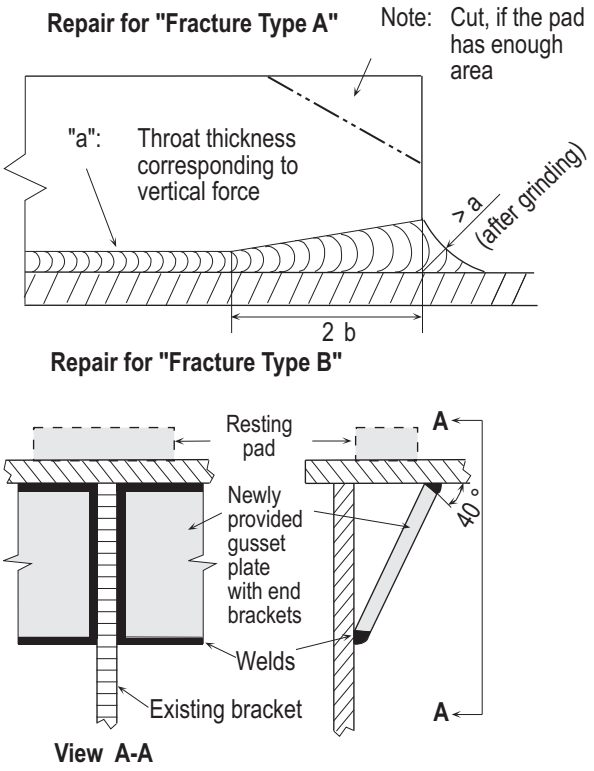


Fracture Type A:
Starting in way of the undercut or HAZ of the transverse fillet weld and propagating in the top plating.

Fracture Type B:
Starting in way of the undercut or HAZ of the longitudinal fillet weld and propagating in the top plating.

Fracture Type C:
Starting and propagating in fillet weld

Sketch of repair



Notes on possible cause of damage

1. **Fracture Type A**:
   Inappropriate transition from the hatch coaming top plating to the resting pad in respect to longitudinal stresses.

2. **Fracture Type B**:
   Insufficient support of the resting pad below the top plating.

3. **Fracture Type C**:
   Insufficient throat thickness of the fillet weld in relation to the vertical forces.

Notes on repairs

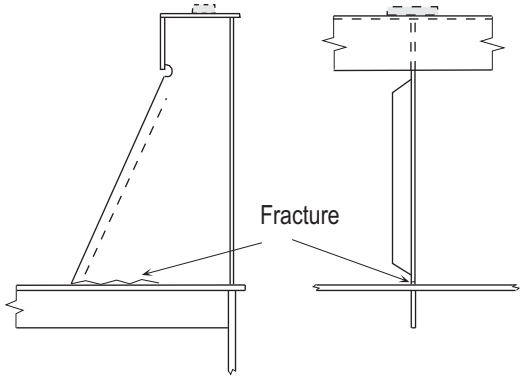
1. **Fracture Type A**:
   Modification of the transverse fillet weld according to the sketch; in some cases smoothing of the transition by grinding is acceptable.

2. **Fracture Type B**:
   Strengthening of the structures below the top plating according to the sketch.

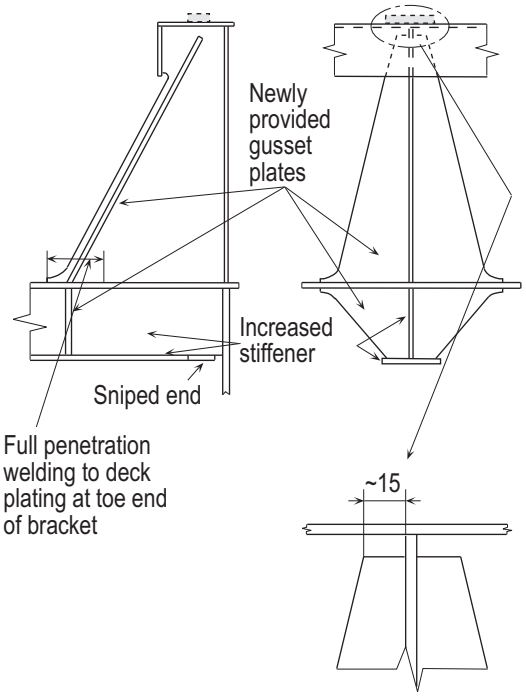
3. **Fracture Type C**:
   Increasing the throat thickness corresponding to the acting vertical forces.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**12-a**
Detail of damage	Fractures in web of transverse hatch coaming stay	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

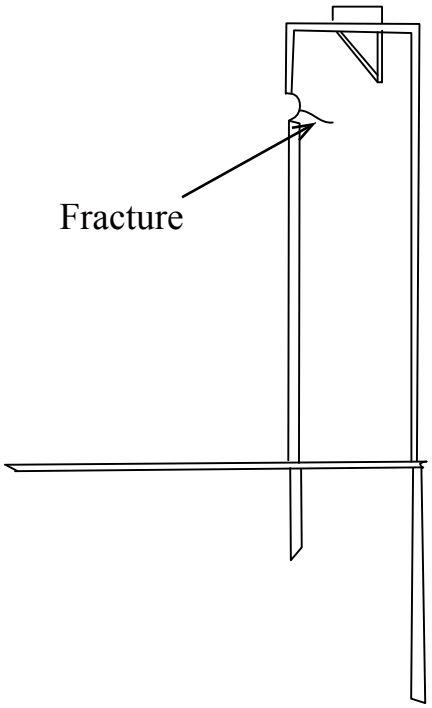
1. Insufficient consideration of the horizontal friction forces in way of the resting pads for hatch cover.

Notes on repairs

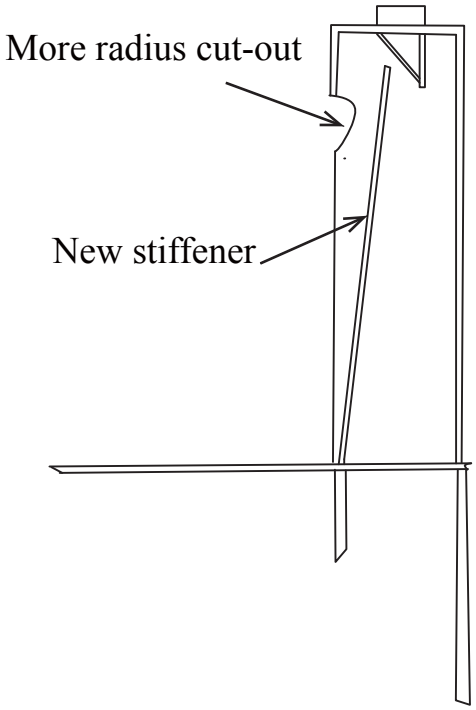
1. Modification of the design of the hatch coaming stay.
2. Full penetration welding between gusset plates and deck plating.
3. Strengthening and continuation of the structure below the deck.
4. Use pads with smaller coefficient of friction.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**12-b**
Detail of damage	Fractures in web of transverse hatch coaming stay	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient consideration of the horizontal friction forces in way of the resting pads for hatch cover.

Notes on repairs

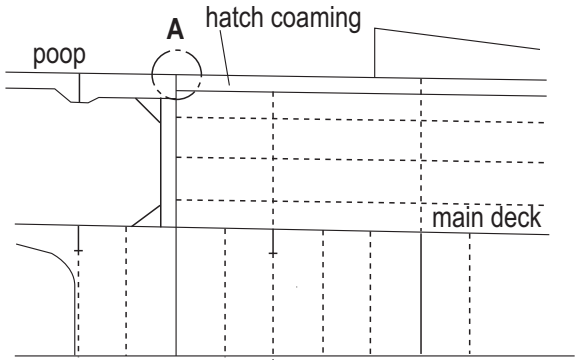
1. Expanded radius of the cut-out of the upper part of stay.

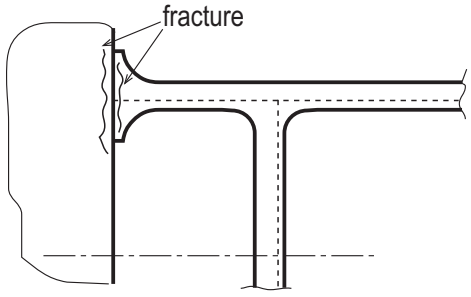
2. Fixing a vertical stiffener as long as possible.

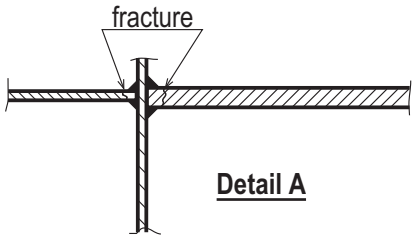
3. Grinding of the radius cut-out.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**13**
Detail of damage	Fractures in the connection of the web of transverse hatch coaming stay	

Sketch of damage



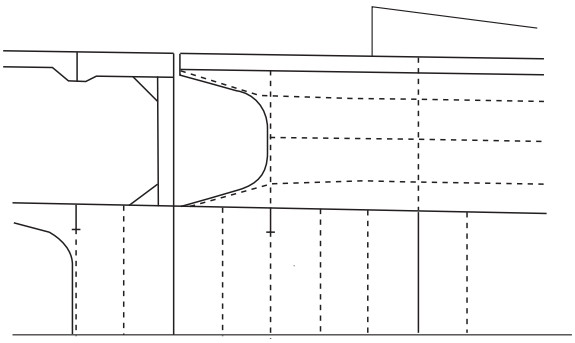


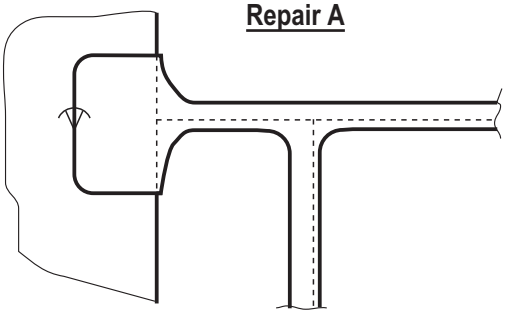


Detail A

Sketch of repair

Repair B





Repair A

Notes on possible cause of damage

1. Insufficient transfer of forces from hatch coaming top plate into poop deck plating by cruciform connection.

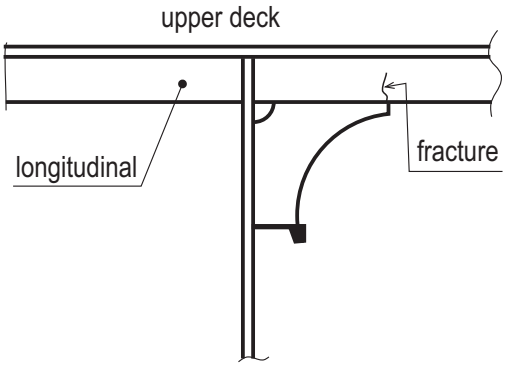
Notes on repairs

1. Continuation of hatch coaming top plate by inserting thick plate into the thin poop deck plating (chamfer 1:5) see Repair A.

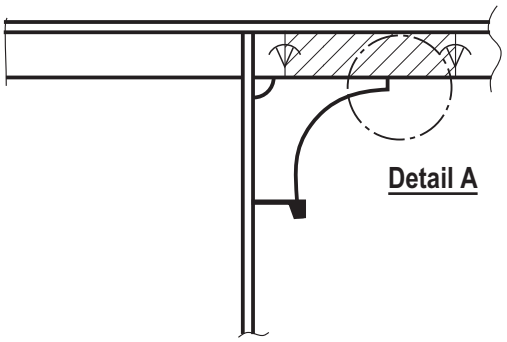
2. Cutting of the connection between longitudinal hatch coaming and poop in the case that the strength requirements are satisfactory (see Repair B).

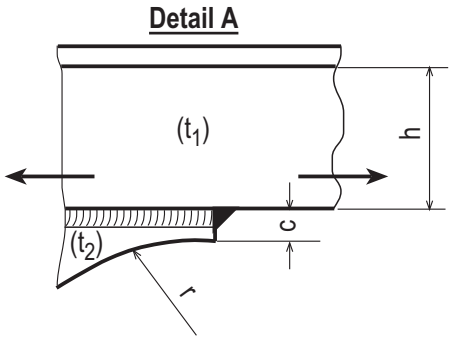
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**14**
Detail of damage	Fracture in Deck Longitudinal	

Sketch of damage



Sketch of repair





$c \leq 2\, t_2$ max. 25 mm

$r \geq 0{,}5\, h$

Notes on possible cause of damage

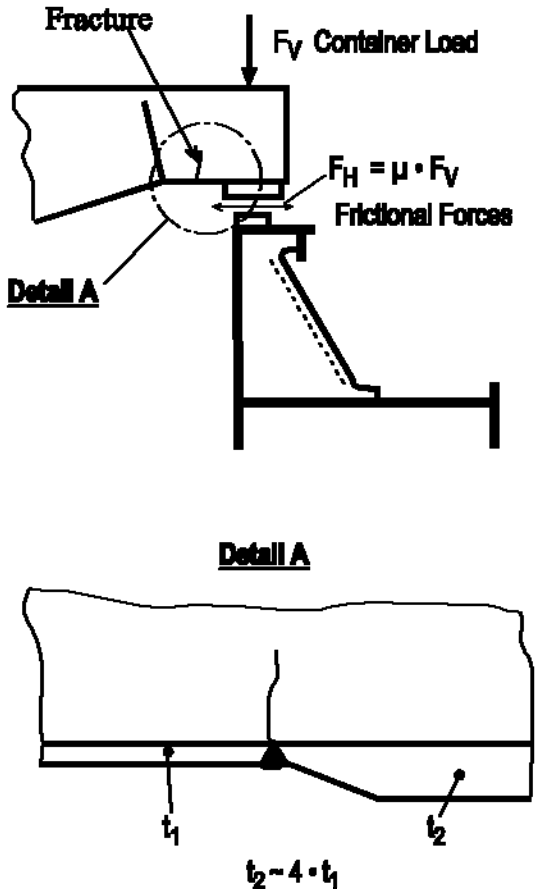
1. Stress concentration at bracket toe
2. Bracket toe too high
3. Poor workmanship

Notes on repairs

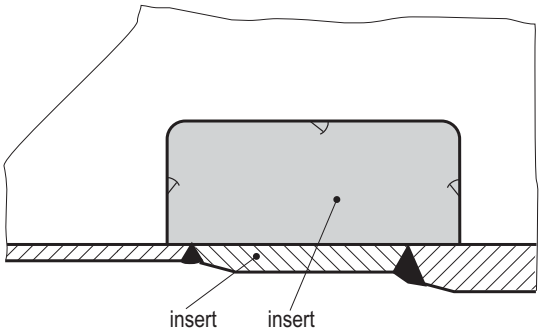
1. Damaged area to be cropped and renewed
2. New bracket with soft toe to be added.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 15**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Fractures in a hatch cover girder	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

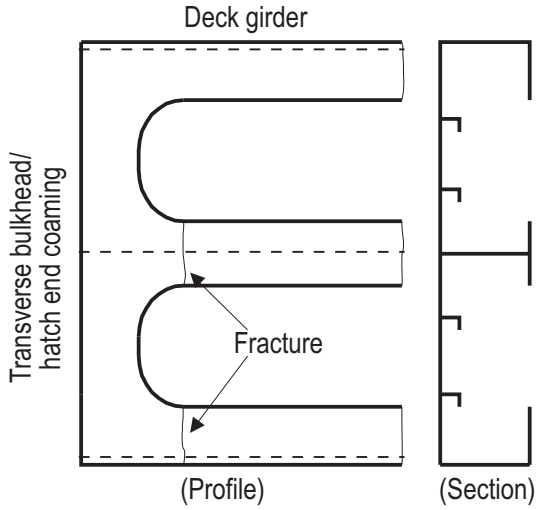
1. Stress concentration
2. Incorrect tapering leads to additional flange bending
3. Poor workmanship

Notes on repairs

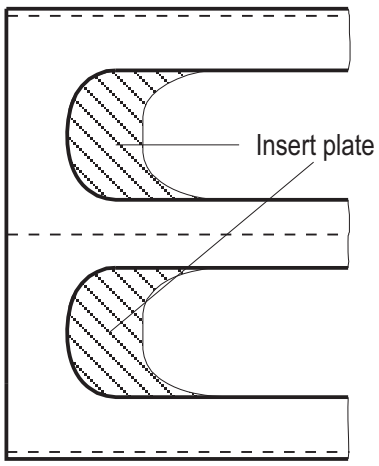
1. Damaged area to be cropped off and renewed
2. Flange with intermediate thickness to be fitted.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 16**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Fractures in deck girder	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

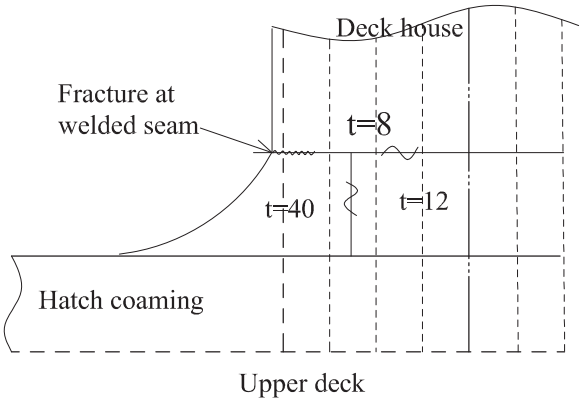
1. Insufficient rigidity at the end of deck girder against bending and torsion

Notes on repairs

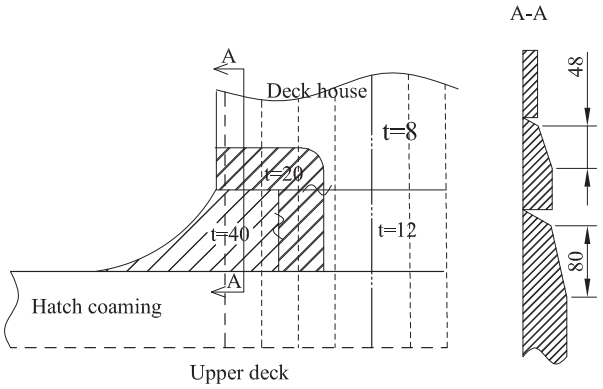
1. Fractured parts are to be cropped and partially renewed.
2. Insert plate at the end of deck girder as shown in sketch of repair.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 17**
Area 1	**Upper deck structure including passageways**	
Detail of damage	Fractures in the cconnections between hatch coaming and bulkhead of deck house	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the welding seam between plates with great differences of thickness.

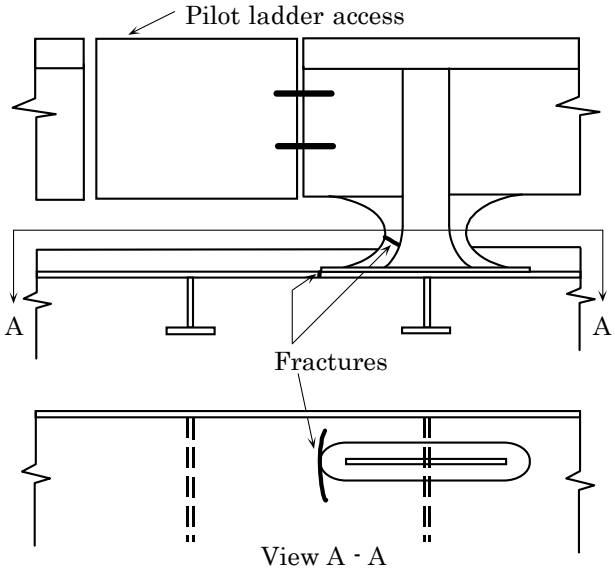
Notes on repairs

1. Inserting plates with medium thickness between the plates with great differences of thickness.

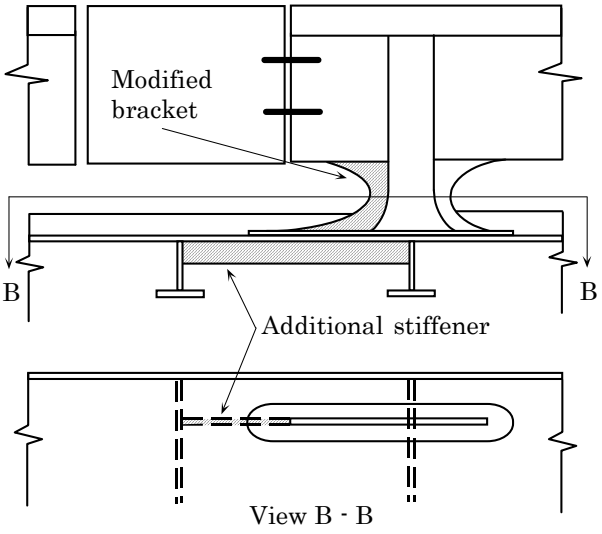
2 The plate to be tapered from thick plate to thin one

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 1	**Upper deck structure including passageways**	**18**
Detail of damage	Fracture in deck plating at the pilot ladder access of bulwarks	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the termination of bulwarks.

Notes on repairs

1. Fractured deck plating should be cropped and part renewed.

2. Reduction of stress concentration should be considered. When repairing the fracture in the gusset plate consider replacing the existing gusset plate with a softer one and extend the pad plate as appropriate. Additional under deck stiffening should be considered to address the fracture in the deck plating.

Area 2 Side structure including side tanks

Contents

1 General

2 What to look for – Cargo hold inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for Side tank inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 What to look for – External inspection
4.1 Material wastage
4.2 Deformations
4.3 Fractures

5 General comments on repair
5.1 Material wastage
5.2 Deformations
5.3 Fractures

Examples of structural detail failures and repairs – Area 2

Example No.	Title
1	Fractures in side shell frame at lower bracket
2-a	Fractures in side shell frame/lower bracket and side shell plating near tank top
2-b	Adverse effect of corrosion on the frame of forward hold
3-a	Buckling of side structure in way of side tank / passage way
3-b	Buckling of side structure in way of fender
4-a	Fracture and buckling in way of a cut-out for the passage of a longitudinal through a transverse web
4-b	Fracture at the connection of side shell longitudinal to transverse web
4-c	Fracture at the connection of side shell longitudinal to transverse web
4-d	Fracture at the connection of side shell longitudinal to transverse bulkhead
5	Fractures in side shell plating / longitudinal bulkhead plating at the corner of drain hole in longitudinal
6	Fractures in side wall of stringer deck (raised tank) at the connection of longitudinals to web of transverses
7	Fractures at the termination of stringer deck (raised tank)
8	Fracture in stringer deck in way of container sockets
9	Fracture in side longitudinal in way of side tank

1 General

1.1 In general, container ships have double hull side structure in the cargo hold area. The double hull is used as deep tanks, i.e. ballast tanks, heeling tanks or fuel oil tanks. In most cases, the upper part of the double hull is used as a passageway. Smaller container ships (and the foremost cargo hold in the case of larger container ships) may have a single side structure, at least in the upper part. Stringer decks (raised tanks) may be arranged in the foremost and aft cargo holds to provide additional space for container stacks.

1.2 In addition to contributing to the shear strength of the hull girder, the side structure forms the external boundary of a cargo hold and is naturally the first line of defence against ingress or leakage of sea water when the ship's hull is subjected to wave and other dynamic loading in heavy weather. The integrity of the side structure is of prime importance to the safety of the ship and this warrants very careful attention during survey and inspection.

1.3 The ship side structure is prone to damage caused by contact with the quay during berthing and impacts of cargo and cargo handling equipment during loading and unloading operations.

In longitudinally stiffened areas the side shell is more prone to damage due to action of fenders and tugs. A careful positioning of reinforced parts of the side shell structure in these areas, using the service experience of the owner, can reduce any damage.

1.4 In some cases cell guides are fitted at the longitudinal bulkheads in order to guide containers during loading and unloading as well as to support the containers during the voyage.

1.5 The structure in the transition regions at the fore and aft ends of the ship are subject to stress concentrations due to structural discontinuities. The side shell plating in the transition regions is also subject to panting. The lack of continuity of the longitudinal structure, and the increased slenderness and flexibility of the side structure, makes the structure at the transition regions more prone to fracture damage.

2 What to look for – Cargo hold inspection

2.1 Material wastage

2.1.1 Material wastage is not a typical problem of the side structure of container vessels. However the side shell frames of the single side skin area, which can be found in the foremost cargo hold, may be weakened by loss of thickness although diminution and deformations may not be apparent. Inspection should be made after the removal of any scale or rust deposit. Thickness measurements may be necessary, in case the corrosion is smooth and uniform, to determine the condition of the structure.

2.1.2 Wastage and possible grooving of the framing in the forward/aft hold, where side shell plating is oblique to frames, may result in fracture and buckling of the shell plating as shown in **Example 2-a/b**.

2.2 Deformations

2.2.1 The side shell plating in the foremost part of the cargo hold region is subject to panting, particularly in the case of a large bow flare.
2.2.2 Both the side shell plating and the internal structure can be found distorted forward and aft of tug push points, especially on ships with a longitudinal framing system.

2.2.3 Cell guides and their connections to the side structure can be found deformed or distorted due to mishandling during container stowage.

2.3 Fractures

2.3.1 Fractures can be found in way of cutouts for passage of longitudinals through transverse web frames. In smaller vessels with a transverse framing system, fractures are more evident at the toes of the upper and lower bracket(s) or at the connections between brackets and frames. In both cases the fractures may be attributed to stress concentrations and stress variations created, in the main, by loads from the seaway. The stress concentrations can also be a result of poor detail design and/or bad workmanship. Localized fatigue fracturing, possibly in association with localized corrosion, may be difficult to detect and those areas should receive close attention during periodical surveys.

2.3.2 The transition regions e.g. the ends of raised stringer decks or continuation brackets at collision bulkhead and engine room forward bulkhead are subject to stress concentrations due to structural discontinuities. The lack of continuity of the longitudinal structure can result in damage.

3 What to look for – Side tank inspection

3.1 Material wastage

3.1.1 Tanks are susceptible to corrosion and wastage of the internal structure, particularly in ageing ships. Coatings, if applied and properly maintained, serve as an indication as to whether the structure remains in satisfactory condition and highlights any structural defects.

3.1.2 The rate and extent of corrosion depends on the environmental conditions and protective measures employed, such as coating. The following structures are generally susceptible to corrosion.

a) Structure in corrosive environment:
- Transverse bulkhead adjacent to heated fuel oil tank
- Lowest part of tank plating

(b) Structure subject to high stress:
- Connection of side longitudinal to transverse web frame

(c) Areas susceptible to coating breakdown:
- Back side of longitudinal face plate
- Welded joint
- Edge of access opening

(d) Areas subjected to poor drainage:
- Web of sloping longitudinals
- Web of T-bar longitudinals
- Stringer Deck

3.2 Deformations

3.2.1 Deformation of structure may be caused by contact (with the quay side, fenders, tugs, ice, touching underwater objects, etc.), collision, mishandling of cargo and high stress. Attention should be paid to any structure subjected to high stress.

3.3 Fractures

3.3.1 Attention should be paid to the following areas during inspection for fracture damage: Areas subjected to stress concentration and dynamic wave loading:

- Connection of the longitudinals to transverse web frames.
- Connection of side longitudinal to watertight bulkhead.
- Connection of side longitudinal to transverse web frame.

3.3.2 The termination of the following structural member at the collision bulkhead or engine room forward bulkhead is prone to fracture damage due to discontinuity of the structure:

- Longitudinal bulkhead
- Stringer decks

4 What to look for – External inspection

4.1 Material wastage

4.1.1 The general condition with regard to wastage of the ship's sides may be observed by visual inspection from the quayside of the area above the waterline. Special attention should be paid to areas where the painting has deteriorated.

4.2 Deformations

4.2.1 The side shell should be carefully inspected with respect to possible deformations. The side shell below the water-line can usually only be inspected when the ship is dry docked. Therefore special attention with respect to possible deformations should be paid during dry-docking. When deformation of the shell plating is found, the area should also be inspected internally since even a small deformation may indicate serious damage to the internal structure.

4.2.2 Side shell plating in the foremost cargo hold maybe indented since the shell plating in the fore body has a large bow flare.

4.3 Fractures

4.3.1 Fractures in the shell plating above and below the water line in way of ballast tanks may be detected during dry-docking, as wet areas, in contrast to otherwise dry shell plating.

5 General comments on repair

5.1 Material wastage

5.1.1 If the corrosion is caused by high stress concentrations, renewal of original thicknesses is not sufficient to avoid re-occurrence. Renewal with increased thickness and / or appropriate corrosion protection measures is to be considered in this case.

5.2 Deformations

5.2.1 The cause of damage should always be identified. If the damage is due to negligence in operation, the ship's representative should be notified. If the deformation is caused by inadequate structural strength, appropriate reinforcement should be considered. Where the deformation is related to corrosion, appropriate corrosion protection measures should be considered.

5.3 Fractures

5.3.1 If the cause of the fracture is fatigue under the action of cyclic wave loading, consideration should be given to the improvement of structural detail design, such as provision of a soft toe bracket, to reduce stress concentration. If the fatigue fracture is vibration related, the damage is usually associated with moderate stress levels at a high cycle rate, improvement of structural detail may not be effective. In this case, measures for increasing structural damping and avoidance of resonance, such as providing additional stiffening, may be considered.

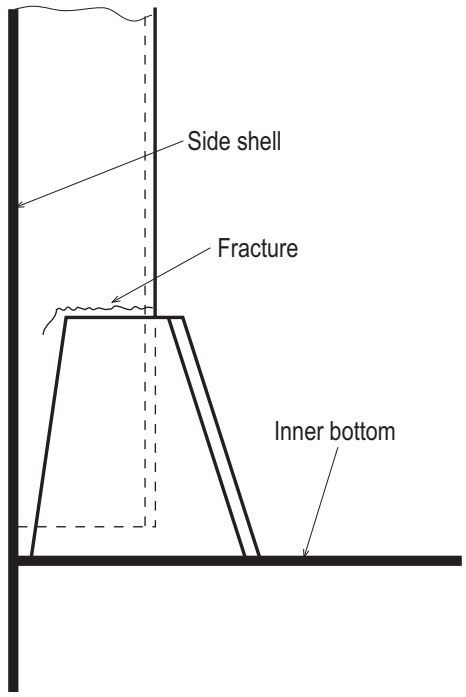
Where fractures occur due to material under excessive stress, indicating inadequate structural strength, renewal with thicker plate and / or provision of appropriate reinforcement should be considered.

Where fractures are found in the transition region, measures for reducing the stress concentration due to structural discontinuity should be considered.

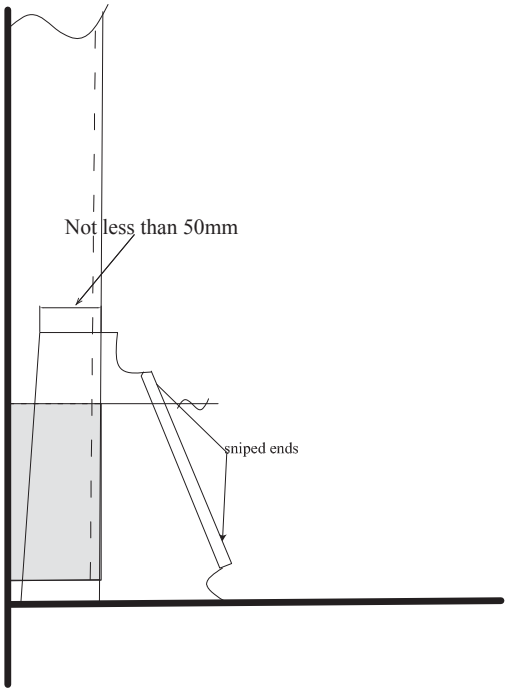
5.3.2 In order to reduce stress concentration due to discontinuity appropriate transition structures are to be provided in the contiguous space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 1**
Area 2	**Side structure including tanks**	
Detail of damage	Fracture in side shell frame at lower bracket	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

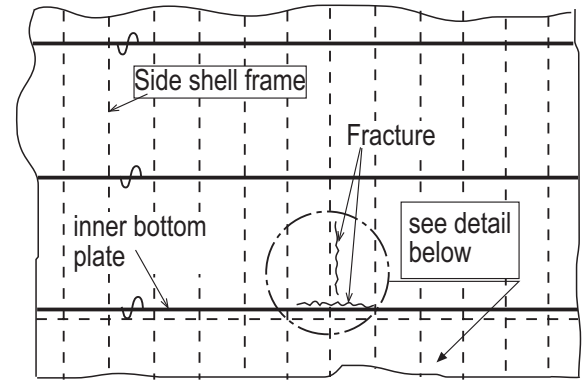
1. This type of damage is caused due to stress concentration.

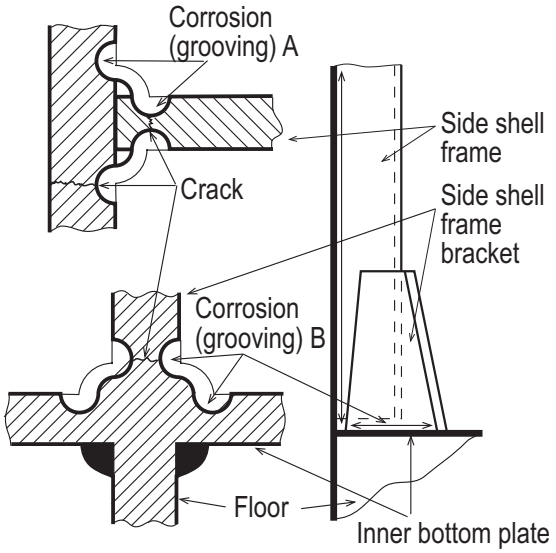
Notes on repairs

1. For small fractures, e.g. hairline fractures, the fracture can be veed-out, welded up, ground, examined by NDT for fractures, and rewelded.
2. For larger / significant fractures consideration is to be given to cropping and partly renewing / renewing the frame brackets with longer arms. If renewing the brackets, end of frames can be sniped to soften them.
3. If considered necessary soft toes may be incorporated at the end of bracket.

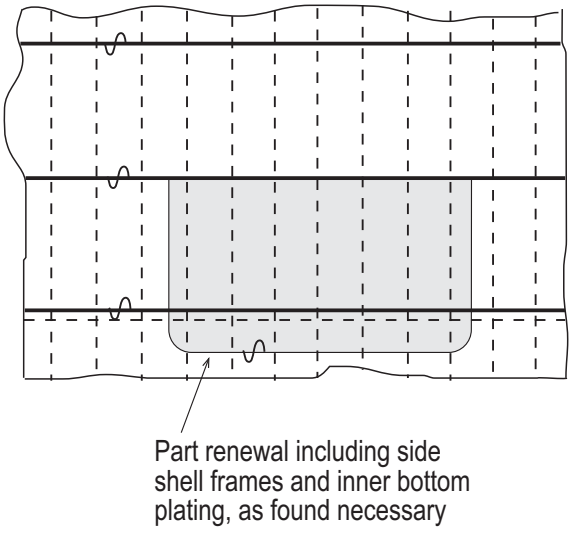
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**2-a**
Detail of damage	Fractures in side shell frame / lower bracket and side shell plating near tank top	

Sketch of damage





Sketch of repair



Notes on possible cause of damage

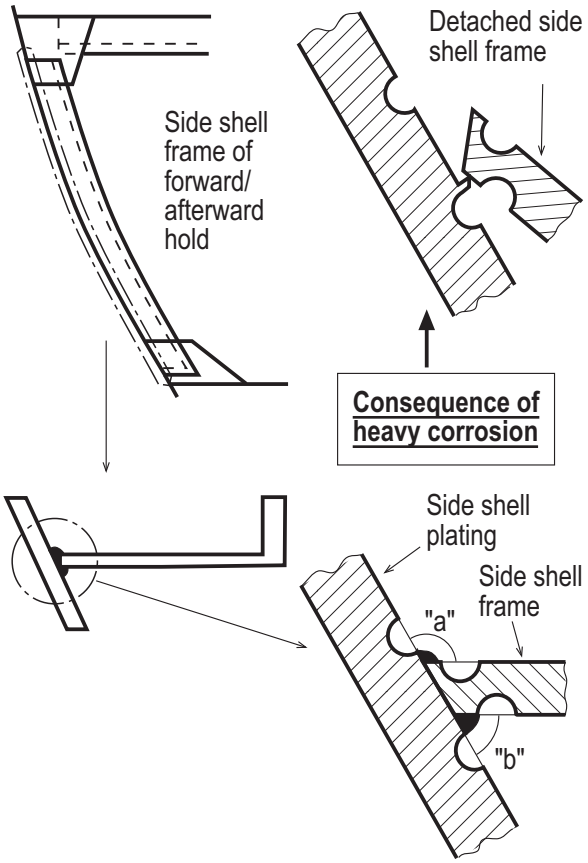
1. Fracture in side shell plating along side shell frame: Heavy corrosion (grooving) along side shell frame (See A)
2. Fracture in side shell plating along tank top: Heavy corrosion (grooving) along tank top (See B) resulting in detachment of side shell frame bracket from inner bottom plating.

Notes on repairs

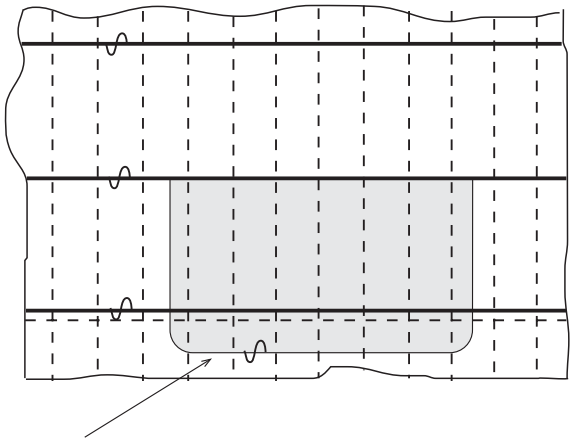
1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**2-b**
Detail of damage	Adverse effect of corrosion on the frame of forward / afterward hold	

Sketch of damage



Sketch of repair



1. Part renewal including side shell frames and inner bottom plating, as found necessary.
2. Deep penetration welding at the connections of side shell frame to side shell plating

Notes on possible cause of damage

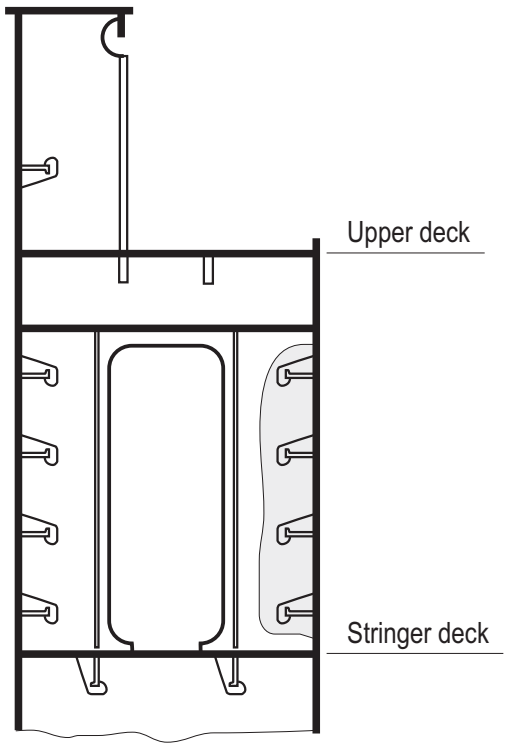
1. Heavy corrosion (grooving) of side shell frame along side shell plating and difference of throat thickness "a" from "b".
   (Since original throat thickness of "a" is usually smaller than that of "b", if same welding procedure is applied, the same corrosion has a more severe effect on "a", and may cause collapse and / or detachment of side shell frame.)

Notes on repairs

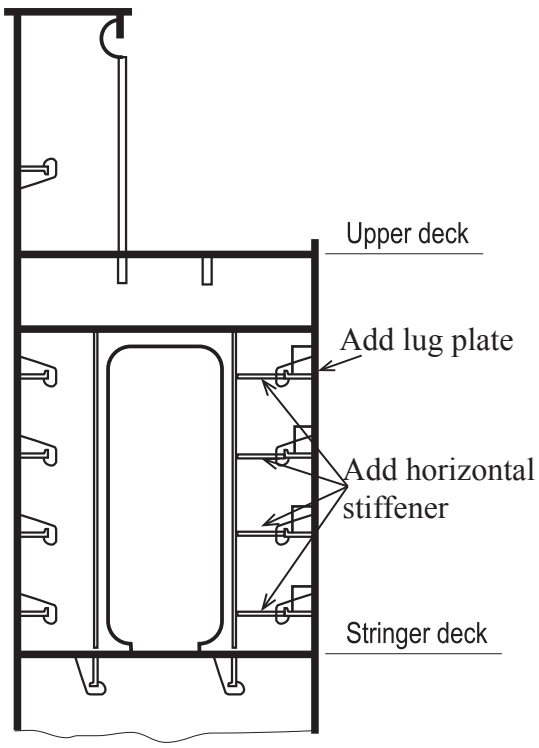
1. Sketch of repair applies when damage extends over several frames.
2. Isolated fractures may be repaired by veeing-out and rewelding.
3. Isolated cases of grooving may be repaired by build up of welding.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**3-a**
Detail of damage	Buckling of side structure in way of side tank / passage way	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Deformation of web of transverse web frame and / or distortion of side longitudinals due to insufficient buckling strength.

2. Insufficient strengthening of side structure in way of tug and / or fender area or misplacing of strengthened area, respectively.

Notes on repairs

1. Straightening or renewal (if necessary) of buckled web plate and distorted side longitudinals.

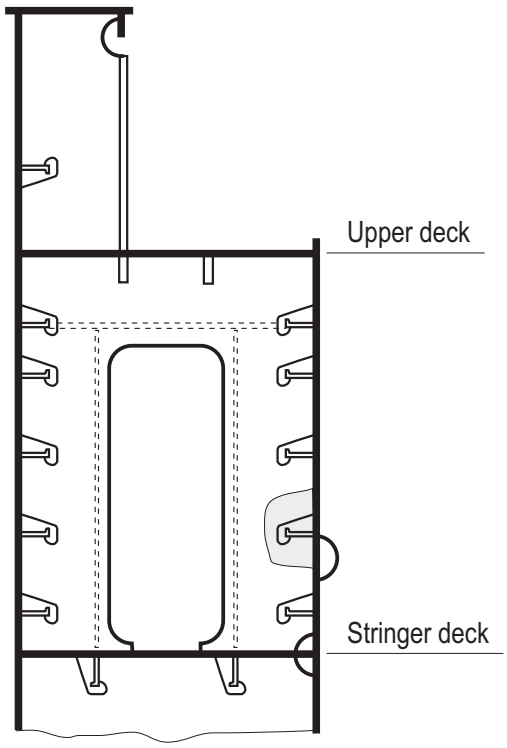
2. Fitting of additional horizontal stiffeners on web plate in way of side longitudinals.

3. Strengthening of tug or fender area or shifting of affected area to right position should be considered.

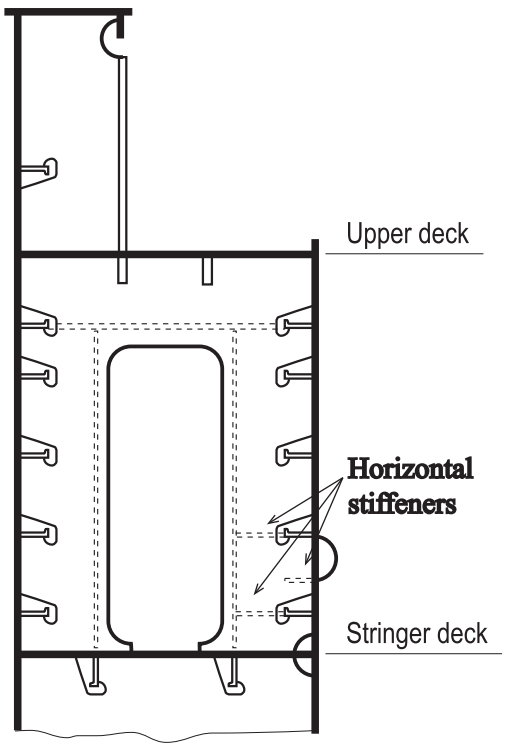
4 Horizontal stiffeners may be connected to the vertical stiffeners or sniped in way of the vertical stiffener

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**3-b**
Detail of damage	Buckling of side structure in way of fender	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Buckling of web of transverse web frame due to insufficient buckling strength in way of fender.

Notes on repairs

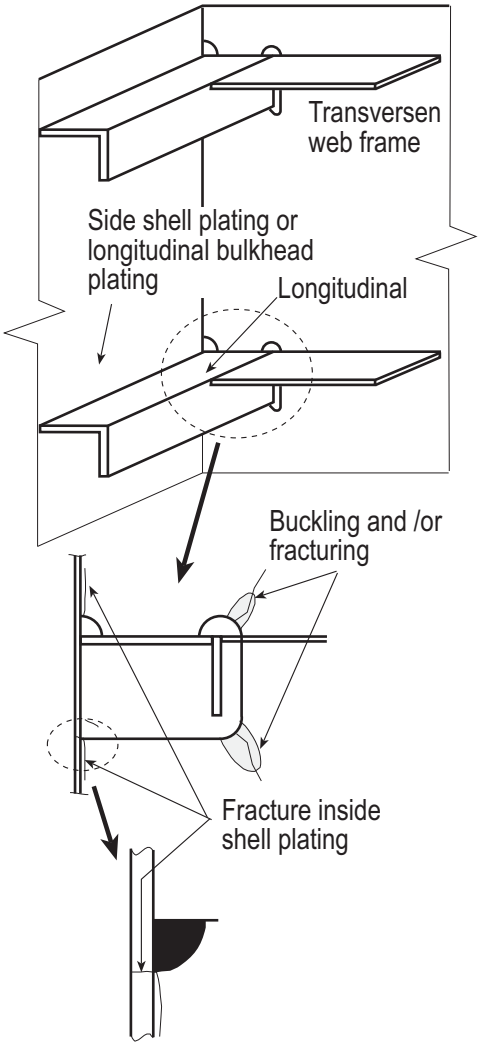
1. Straightening or renewal (if necessary) of buckled web plate and closing of cut-out for side longitudinal.

2. Fitting of additional horizontal stiffeners on web plate in way of fender.

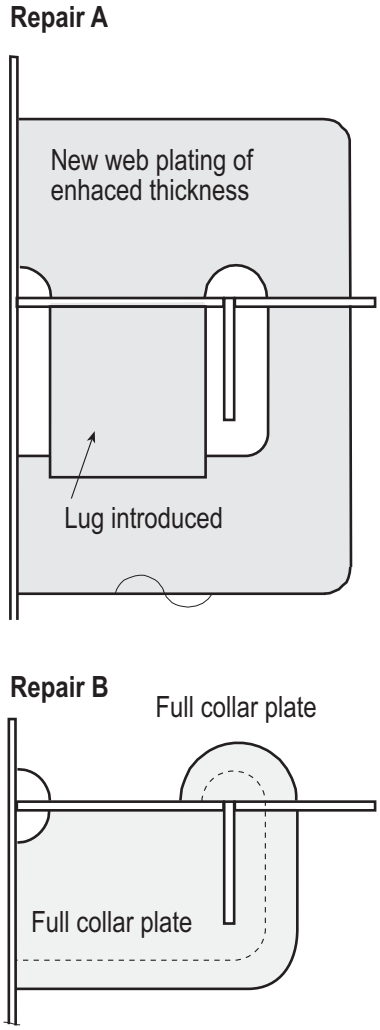
   Where the horizontal stiffeners extend to the vertical stiffener, they may be connected to the vertical stiffeners or sniped.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**4-a**
Detail of damage	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse web	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.

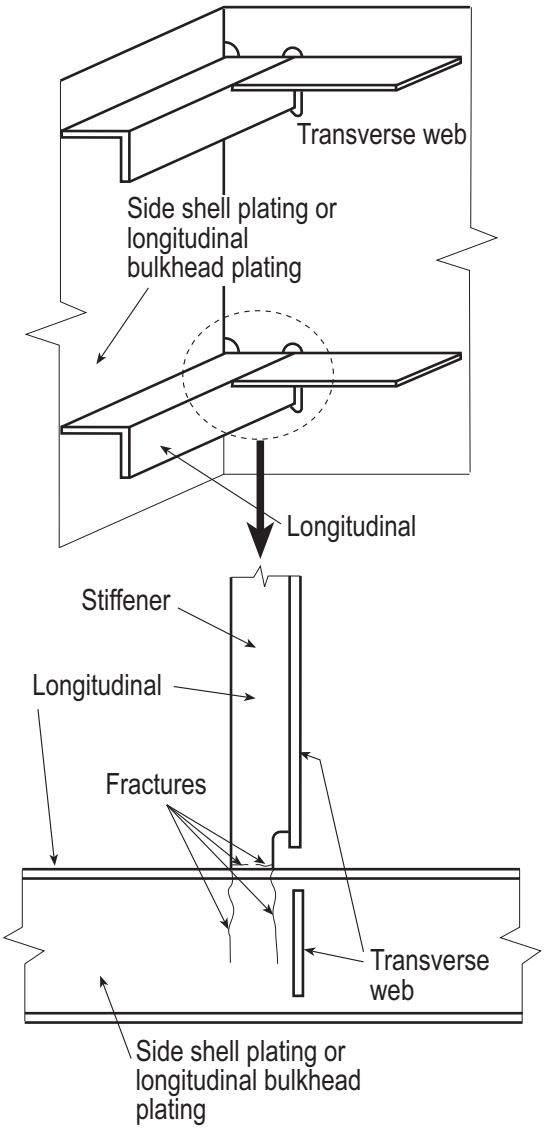
Notes on repairs

1. If fractures are significant then crop and part renew the web plating otherwise the fracture can be veed-out and welded provided the plating is not generally corroded.

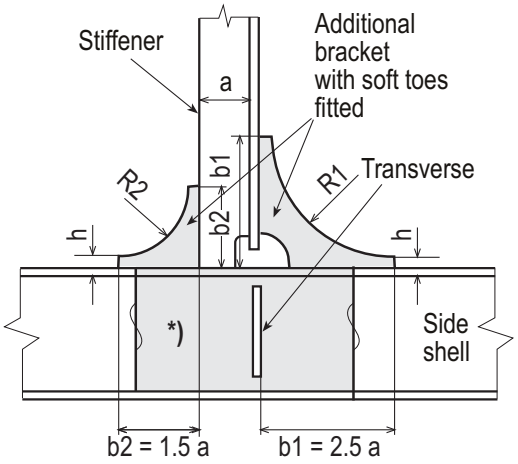
2. **Repair B** is to be incorporated if the lug proves to be ineffective.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**4-b**
Detail of damage	Fractures at the connection of side shell longitudinal to transverse web	

Sketch of damage



Sketch of repair



*) Where required, the longitudinal to be cropped and part renewed

1. For a slope at toes max. 1:3, R1 = (b1 - h) x 1.6 and R2 = (b2 - h) x 1.6
2. Soft toe bracket to be welded first to longitudinal
3. Scallop in bracket to be as small as possible recommended max. 35 mm
4. If toes of brackets are ground smooth, full penetration welds in way to be provided
5. Maximum length to thickness ratio = 50:1 for unstiffened bracket edge
6. Toe height, h, bo be as small as possible (10-15 mm)

Notes on possible cause of damage

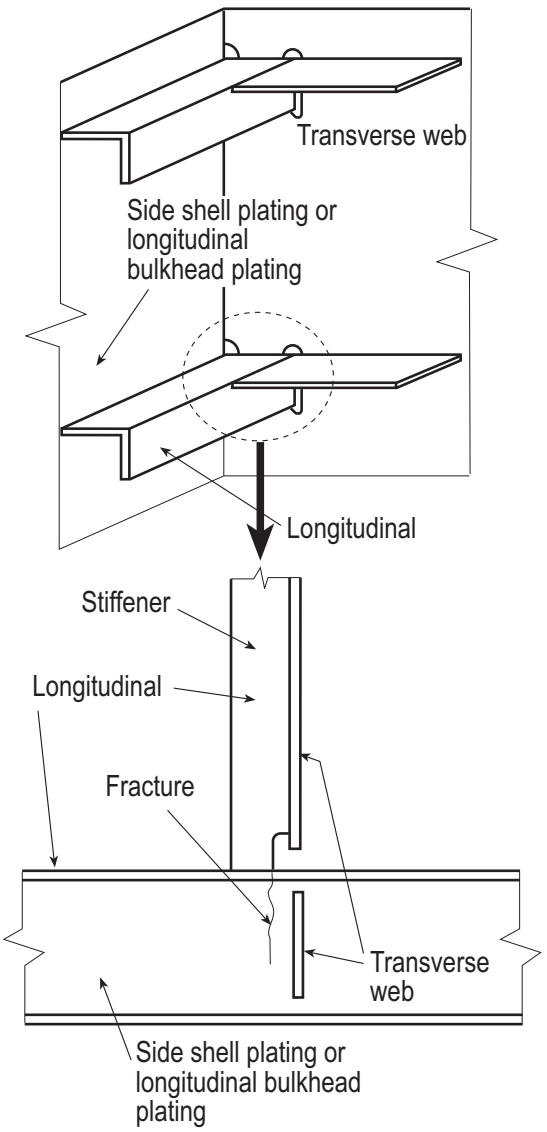
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

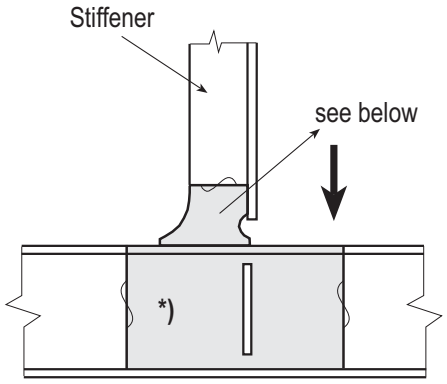
1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**4-c**
Detail of damage	Fractures at the connection of side shell longitudinal to transverse web	

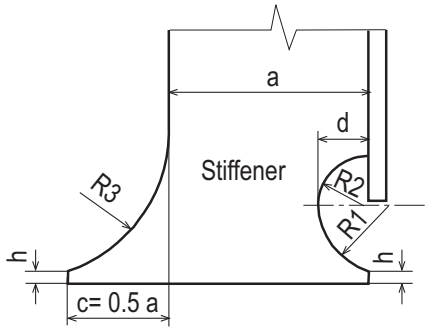
Sketch of damage



Sketch of repair



*) Where required, the longitudinal to be or opped and part renewed



Various cut-out shapes have been developed.

The following is one example:

1. Toe height as small as possible (h= 10-15 mm)
2. Depth "d" of key hole notch as samall a possible, max. 30 mm
3. For a slope at toe max. 1:3
4. R1 = 1.5 d; R2 = d and R3 = 1.5 c

Notes on possible cause of damage

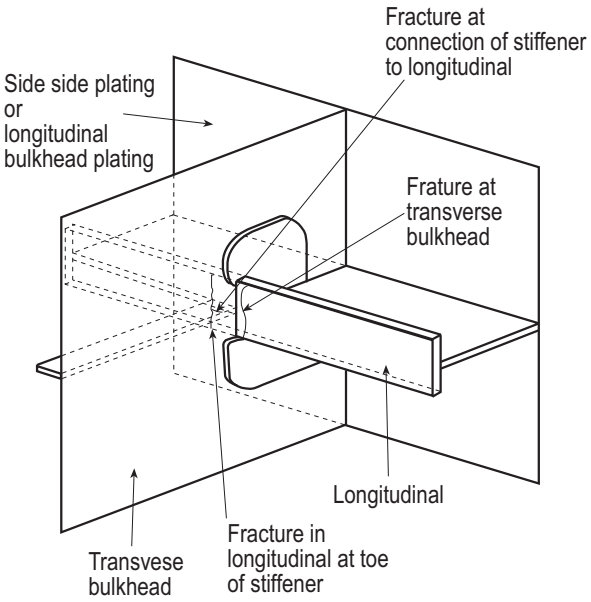
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

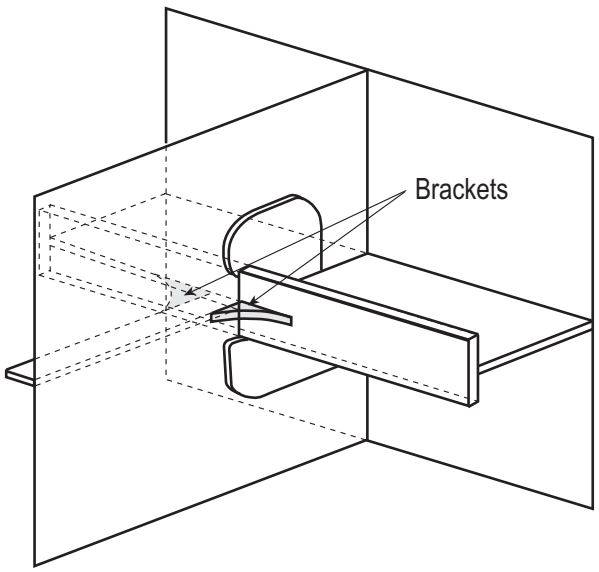
1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**4-d**
Detail of damage	Fractures at the connection of side shell longitudinal to transverse bulkhead	

Sketch of damage



Sketch of repair



Note: Regarding detail of brackets see 4-b

Notes on possible cause of damage

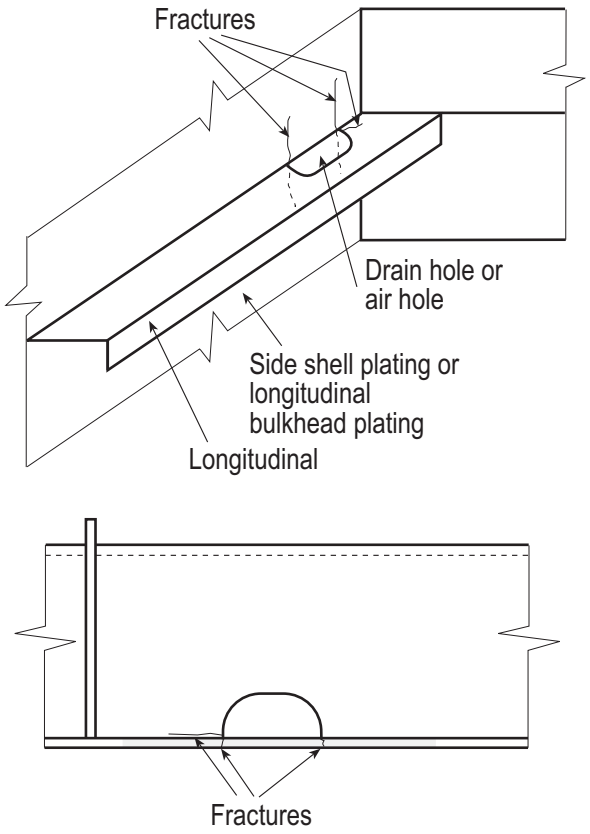
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

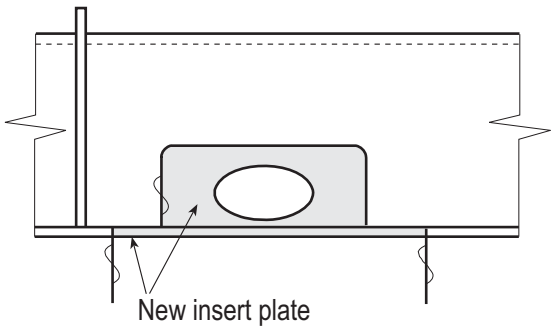
1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**5**
Detail of damage	Fractures in side shell plating/longitudinal bulkhead plating at the corner of drain hole in longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration and/or corrosion due to stress concentration at the corner of drain hole/air hole.

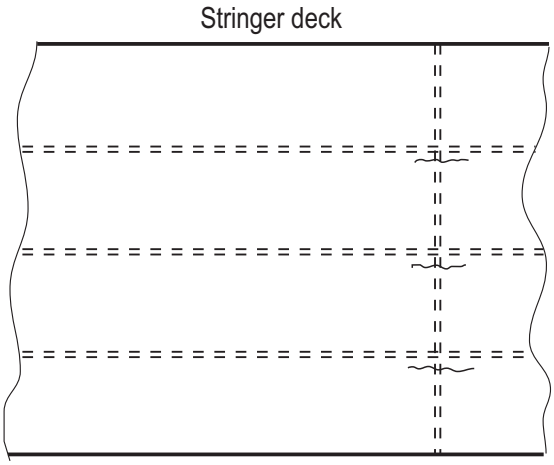
Notes on repairs

1. Fractured plating should be cropped and part renewed.

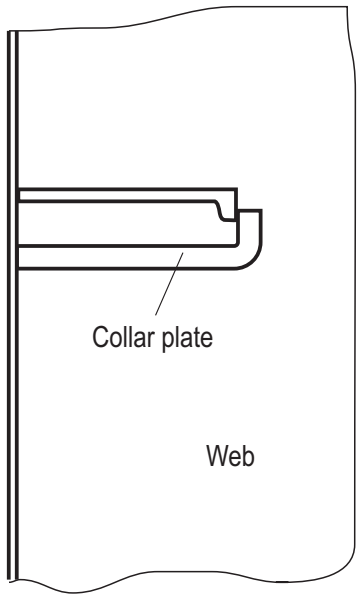
   If fatigue life is to be improved, change of drain hole/air hole shape is to be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**6**
Detail of damage	Fractures in side wall (raised tank) at the connection of longitudinals to web of transverses	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

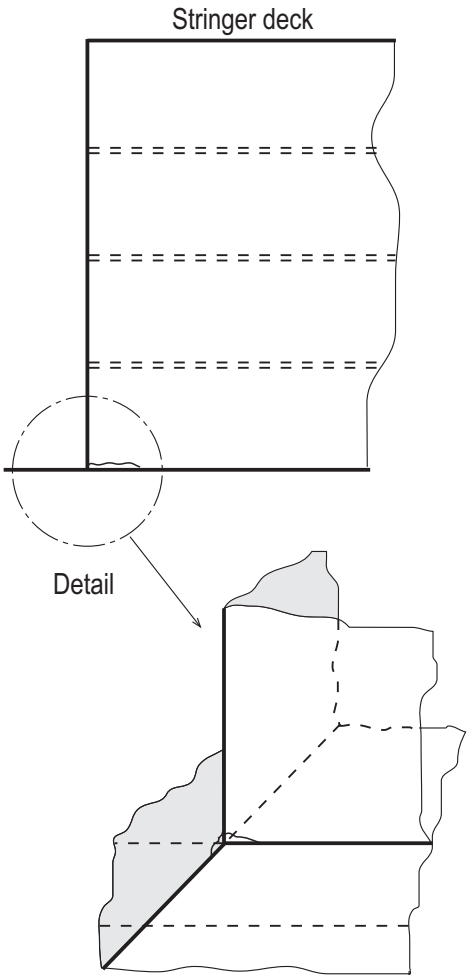
1. Damage can be caused by stress concentration leading to accelerated fatigue in this region.

Notes on repairs

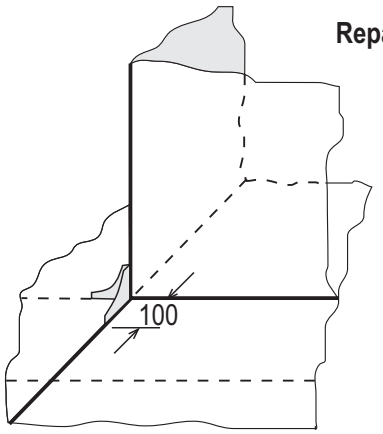
1. Fractured side wall plating to be cropped and renewed by insert plate.
2. Cut-outs for longitudinals to be closed by collar plates.

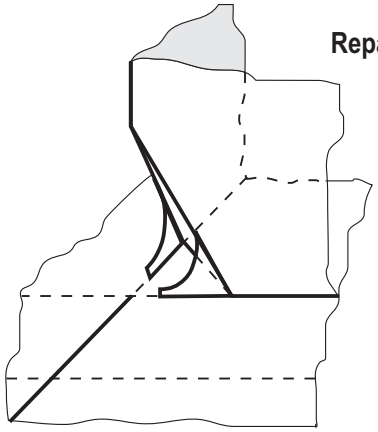
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**7**
Detail of damage	Fractures at the termination of stringer deck (raised tank)	

Sketch of damage



Sketch of repair





Notes on possible cause of damage

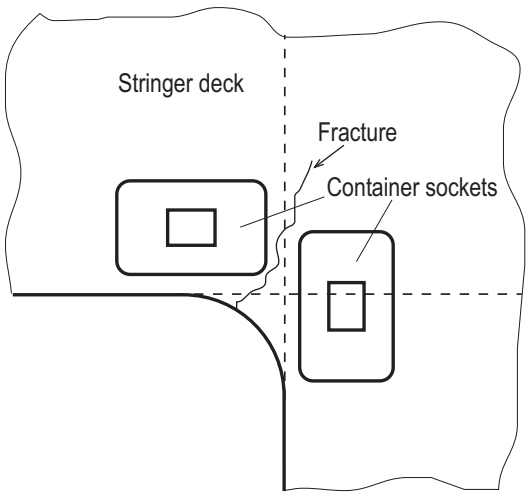
1. Damage can be caused by stress concentration leading to fatigue in this region.

Notes on repairs

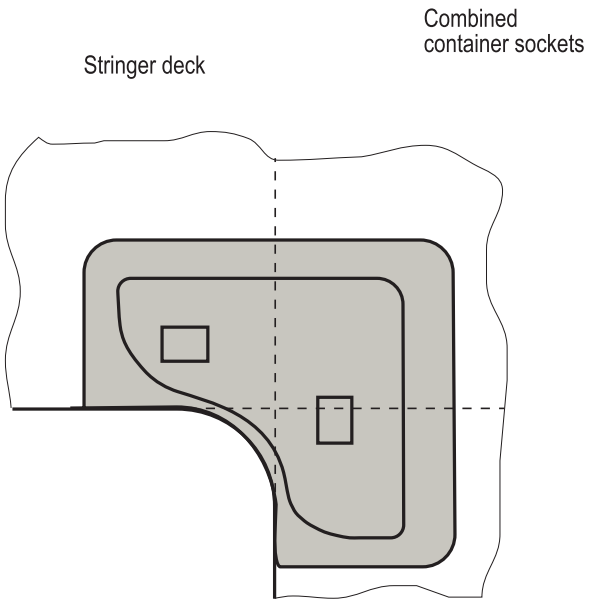
1. Fracture in tank top plating to be cropped and renewed by insert.
2. Repair A: Small brackets should be provided at the termination in longitudinal and / or transverse direction (proposed length about 100 mm)
3. Repair B: Modification of the design with soft nose transition should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**8**
Detail of damage	Fracture in stringer deck in way of container sockets	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration in the radiused corner in combination with stress concentration due to the arrangement of two separate container sockets.

2. Missing or insufficient support by internal structure in way of the container sockets.

Notes on repairs

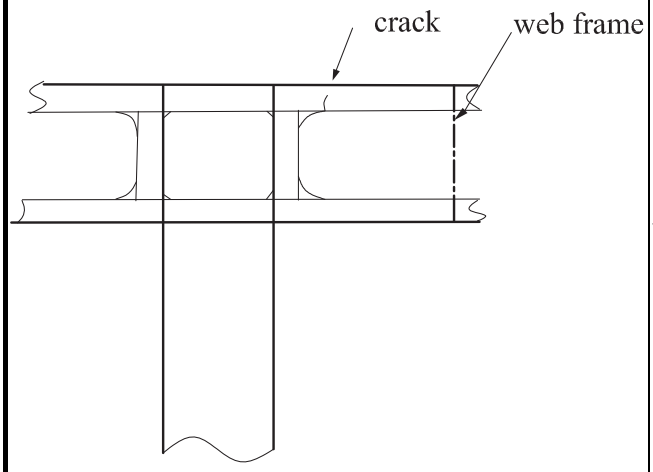
1. Fractured plating of stringer deck to be cropped and renewed by insert.

2. Use of a combined container socket instead of two separate sockets.

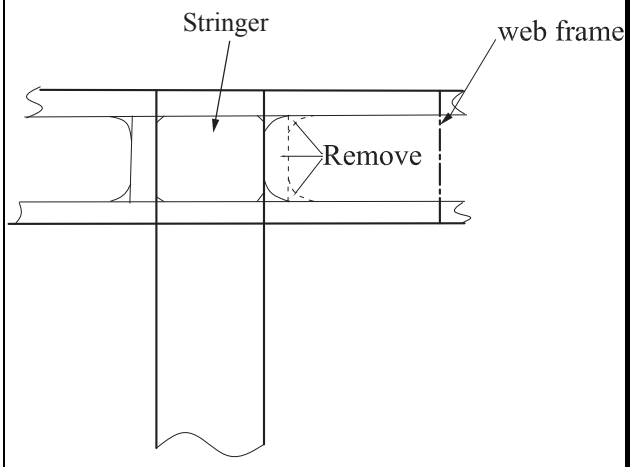
3. Additional supporting structures should be considered, if necessary.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 2	**Side structure including tanks**	**9**
Detail of damage	Fracture in side longitudinal in way of side tank	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Stress concentration at the connection between bulkhead stringer and side longitudinal.

Notes on repairs

1. Damaged side longitudinal is to be cropped off and renewed

2. Consideration is to be given to removal of the horizontal stiffener and brackets on the bulkhead and replacing them with new (similar) brackets. Technical staff of BCS should be consulted prior to removal structure.

Area 3 Transverse bulkhead structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Examples of structural detail failures and repairs – Area 3

Example No.	Title
1	Corrosion along inner bottom plating
2	Buckling in transverse bulkhead
3	Fractures in cut-outs for vertical stiffeners
4	Fractures at the corner of access cut-outs
5	Fractures around staircase hole in security platform

1 General

1.1 Two different types of transverse bulkheads are found in the cargo holds of container ships: watertight bulkheads and non-watertight bulkheads. The transverse bulkheads are located at the end of each cargo hold and are commonly constructed as plane double plated bulkheads with internal stiffening. In general every second transverse bulkhead is watertight i.e. with watertight plating on one side and with large cut-outs on the opposite side. The non-watertight bulkhead is constructed as plane double plated bulkhead with large cut-outs in the plating on both sides. Normally cell guides are fitted at the bulkheads in order to guide the containers during loading and unloading as well as to support the containers during the voyage. The bulkheads serve as main transverse strength elements in the structural design of the ship. Additionally the watertight bulkhead serves as a subdivision to prevent progressive flooding in an emergency situation.

1.2 The structure may sometimes appear to be in good condition when it is in fact excessively corroded. Heavy corrosion may lead to collapse of the structure under an extreme load, if it is not rectified properly.

1.3 Deformation of the plating may lead to the failure and collapse of the bulkhead under water pressure in an emergency situation. As a secondary consideration, deformations could interfere in ships loading and unloading operations in blocking container boxes inside cell guides.

2 What to look for

2.1 Material wastage

2.1.1 If coatings have broken down and there is evidence of corrosion, it is recommended that random thickness measurements be taken to establish the level of diminution.

2.1.2 Where the terms and requirements of the periodical survey dictate thickness measurement, or when the surveyor deems necessary, it is important that the extent of the gauging be sufficient to determine the general condition of the structure.

2.1.3 Particular attention is to be paid to the lower part of the bulkhead in cargo holds which can be subject to heavy corrosion due to water remaining.

2.2 Deformations

2.2.1 Deformation due to mechanical damage is often found in bulkhead structures due to rough cargo handling operations.

2.2.2 When the bulkhead has sustained serious uniform corrosion, the bulkhead may suffer shear buckling. Evidence of buckling may be indicated by the peeling of paint or rust. However, where deformation resulting from bending or shear stresses has occurred on a bulkhead with a small diminution in thickness, this could be due to poor design or the stack load has been exceeded and this aspect should be investigated before proceeding with repairs.

2.2.3 Frequently cell guides and their connections to the bulkhead structure have been deformed or distorted.

2.3 Fractures

2.3.1 Fractures usually occur in the stringer in way of the cut-outs for vertical stiffeners and in way of the access cut-outs.

2.3.2 In the case of heavily deformed and distorted cell guides fractures in the cell guide and/or in the connection to the bulkhead structure can be observed.

3 General comments on repair

3.1 Material wastage

3.1.1 When the reduction in thickness of plating and stiffeners has reached the diminution levels permitted by BCS, the wasted plating and stiffeners are to be cropped and renewed.

3.2 Deformations

3.2.1 If the deformation is local and of a limited extent, it could generally be faired out. Deformed plating in association with a generalized reduction in thickness should be partly or completely renewed.

3.2.2 Buckling of the bulkhead plating can also occur in way of the side shell resulting from contact damage and this is usually quite obvious. In such cases the damaged area is to be cropped and partly renewed. If the deformation is extensive, replacement of the plating, partly or completely, may be necessary. If the deformation is not in association with generalized reduction in thickness or due to excessive loading, additional strengthening should be considered.

3.2.3 Deformed and distorted cell guides and their connections to bulkhead structure are to be faired or cropped and renewed.

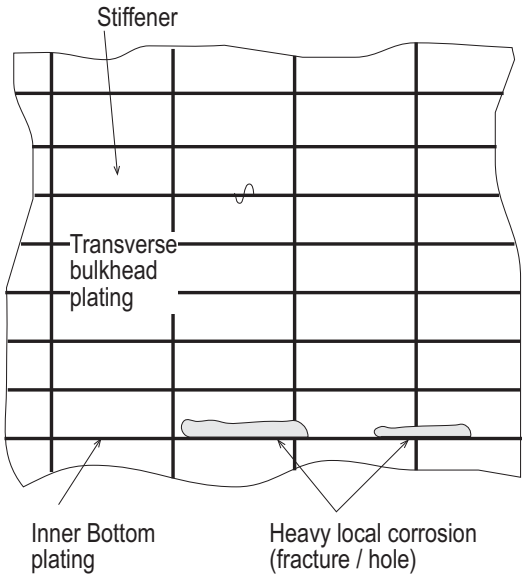
3.3 Fractures

3.3.1 Fractures that occur at the boundary weld connections as a result of latent weld defects should be veed-out, appropriately prepared and re-welded preferably using low hydrogen electrodes or equivalent.

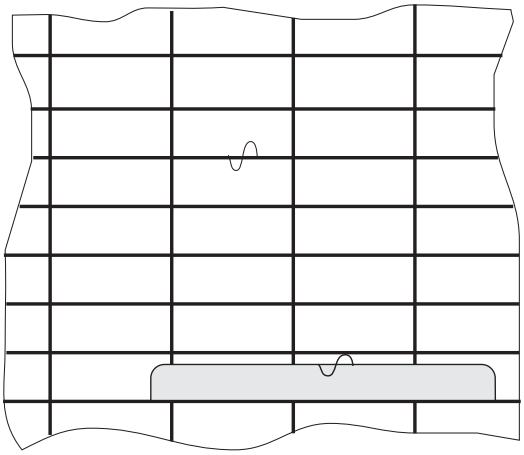
3.3.2 For fractures other than those described above, re-welding may not be a permanent solution and an attempt should be made to improve the design and construction in order to obviate a recurrence.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 1**
Area 3	**Transverse bulkhead structure**	
Detail of damage	Corrosion along inner bottom plating	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion including grooving along inner bottom.

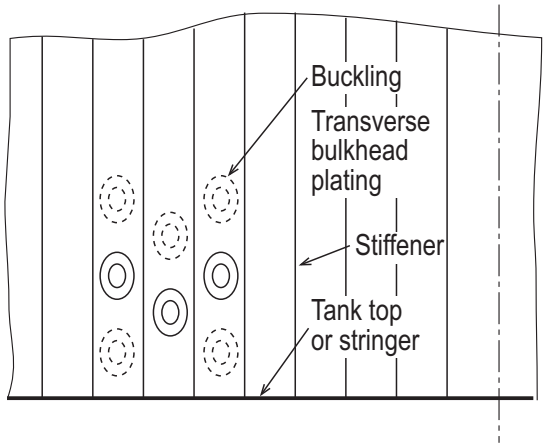
Notes on repairs

1. The extent of the renewal should be determined carefully. If the renewal plate (original thickness) is welded to thin plate (corroded plate), it may cause stress concentration and cause fracture.

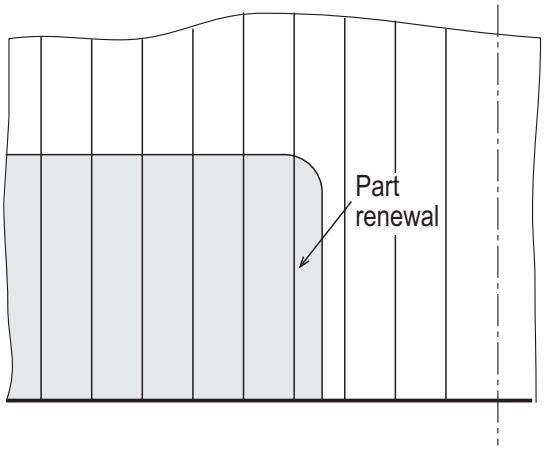
2. Protective coating should be applied.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 3	Transverse bulkhead structure	2
Detail of damage	Buckling in transverse bulkhead	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy general corrosion.

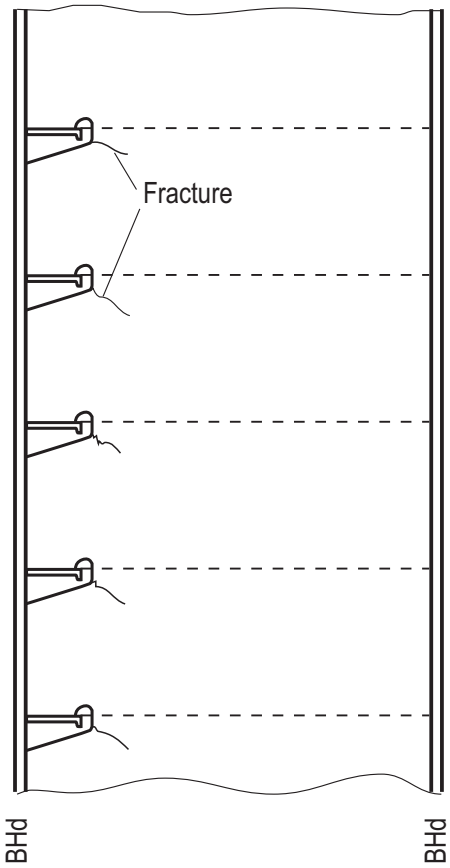
Notes on repairs

1. The extent of the renewal should be determined carefully. If the renewal plating (original thickness) is welded to thin plating (corroded plating), it may cause stress concentration and fracture.

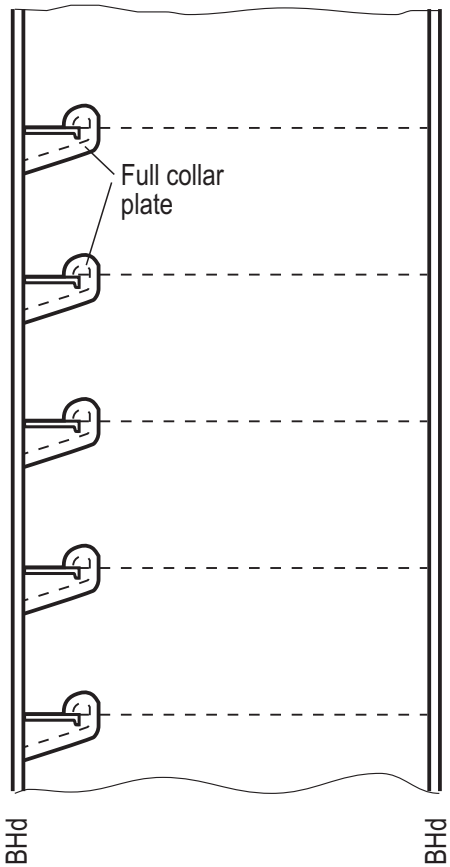
2. Protective coating should be applied.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Transverse bulkhead structure**	**3**
Detail of damage	Fractures in cut-outs for vertical stiffeners	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage caused by stress concentration leading to fatigue fractures.

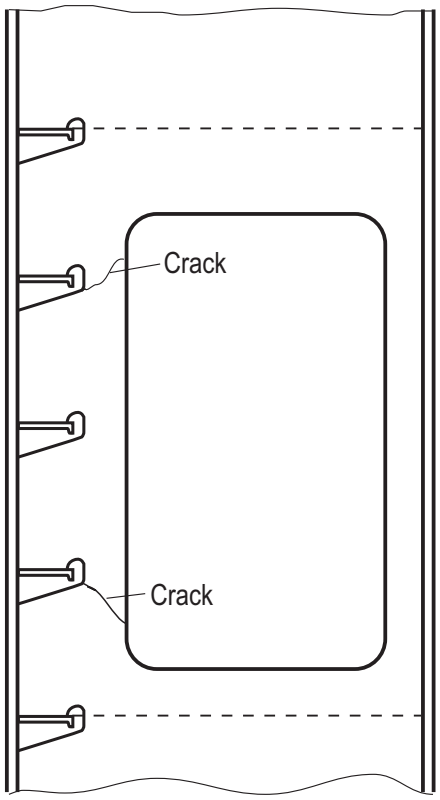
Notes on repairs

1. The fractured plating is to be cropped and part renewed as necessary.

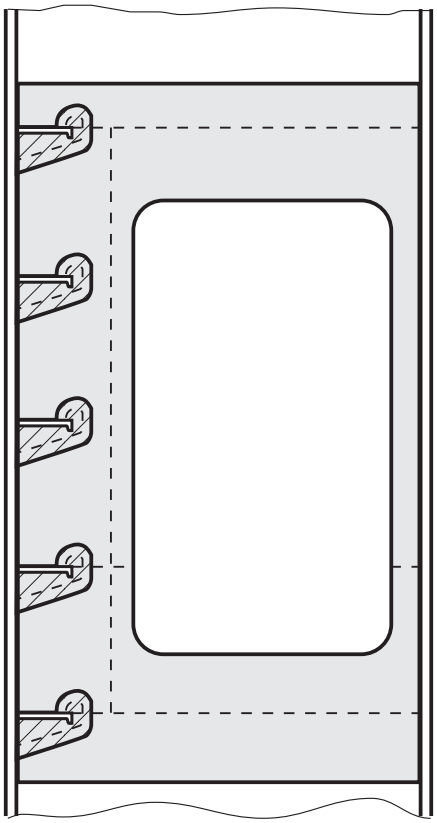
2. Collar plates to cut-outs are to be installed.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 3	**Transverse bulkhead structure**	**4**
Detail of damage	Fractures at the corners of access cut-outs	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

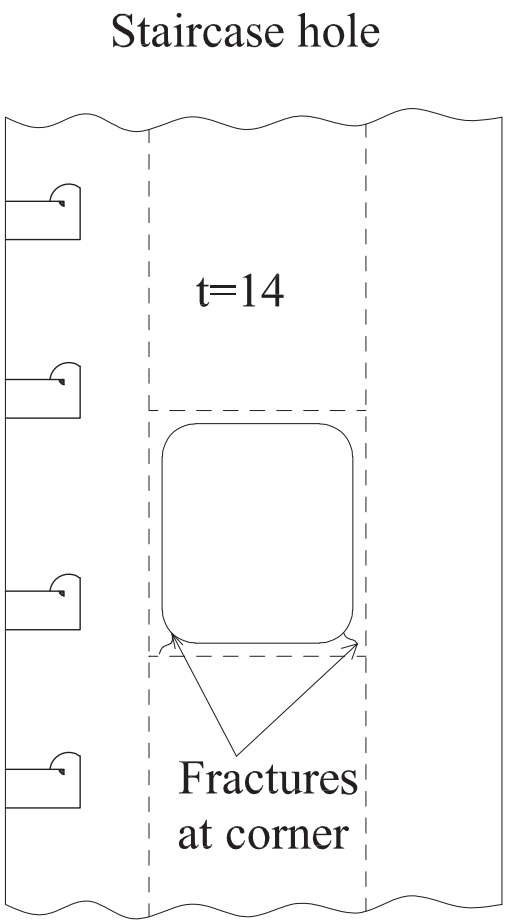
1. Damages caused by stress concentration leading to fatigue fractures.

Notes on repairs

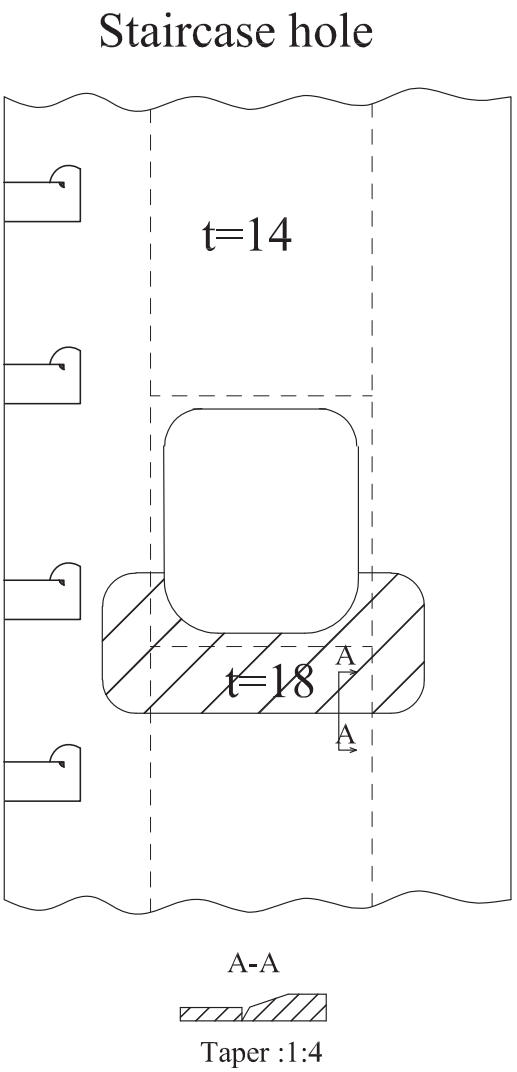
1. Insertion of plating of increased thickness (chamfer 1:3 to 1:5).
2. Collar plates to cut-outs for vertical stiffeners are to be installed.
3. Additional stiffener adjacent to access opening to be fitted
4. Reduction in size of access hole to be considered

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 5**
Area 3	**Transverse bulkhead structure**	
Detail of damage	Fractures around staircase hole in security platform	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1 Too small corner radius and/or insufficient local plate thickness.

Notes on repairs

1. Damaged plates are to be cropped and inserted with thicker plates.

2. A larger corner radius is to be considered.

Area 4 Double bottom structure

Contents

1 General

2 What to look for – Tank top inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for – Double bottom tank inspection
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 What to look for – External bottom inspection
2.1 Material wastage
2.2 Deformations
2.3 Fractures

5 General comments on repair
5.1 Material wastage
5.2 Deformations
5.3 Fractures

Figures and/or Photographs – Area 4

No.	Title
Figure 1	Example of buckling deformation observed in the bottom shell plating under cargo hold amidships
Figure 2	Grooving corrosion of weld of bottom plating
Figure 3	Section of the grooving shown in Figure 1

Examples of structural detail failures and repairs – Area 4

Example No.	Title
1	Fractures in inner bottom plating around container bottom pocket
2	Fractures, corrosion and/or buckling of floor/girder around lightening hole
3	Fractures in longitudinal at floor or bulkhead
4	Fractures in longitudinal girders in way of container support
5	Fractures in longitudinal in way of bilge well
6	Fractures in bottom shell inner bottom plating at the corner of drain hole/air hole in longitudinal
7	Fractures in bottom shell plating alongside girder and/or bottom longitudinal
8	Corrosion in bottom shell plating below suction head
9	Corrosion in bottom shell plating below sounding pipe
10	Deformation of forward bottom shell plating due to slamming
11	Fractures in bottom shell plating at the termination of bilge keel
12	Fracture in the tank top plate in way of the height transition of inner bottom

1 General

1.1 In addition to contributing to the longitudinal bending strength of the hull girder, the double bottom structure provides support for the cargo in the holds. The tank top structure is subjected to impact forces of containers during loading and unloading operations. The bottom shell at the forward part of the ship may sustain increased dynamic forces caused by slamming in heavy weather

1.2 Normally, on container ships, a strict observance of a maintenance programme in the cargo holds could be difficult due to the fact that cargo holds are very seldom completely empty. Therefore, the tank top and the adjacent areas of bulkheads are prone to increased corrosion and need particular attention during inspections

2 What to look for – Tank top inspection

2.1 Material wastage

2.1.1 The general corrosion condition of the tank top structure may be observed by visual inspection. The level of wastage of tank top plating may have to be established by means of thickness measurement. Special attention should be given to the intersection of the tank top with transverse bulkheads and side shell or longitudinal side tank bulkheads, respectively, where water may have accumulated and consequently accelerated the rate of corrosion.

2.1.2 The bilge wells should be cleaned and inspected closely since heavy pitting corrosion may have occurred due to accumulated water or corrosive solutions in the wells. Special attention should be paid to the plating in way of the bilge suction and sounding pipes.

2.1.3 Special attention should also be paid to areas where pipes penetrate the tank top.

2.2 Deformations

2.2.1 Buckling of the tank top plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses. Buckling of tank top plating in way of and/or nearby heated fuel oil tanks can be found in particular in case of a combination with pre-deformations due to the production process.

2.2.2 Deformed structures may be observed in areas of the tank top due to overloading or the impact of containers during loading/unloading operations, in particular in the case of insufficient, missing or misplaced sub-structures in way of container sockets.

2.2.3 Whenever deformations are observed on the tank top, further inspection in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coatings within the double bottom, which in turn may lead to an accelerated corrosion rate in these unprotected areas.

2.3 Fractures

2.3.1 Fractures will normally be found by close-up survey. Fractures that extend through the thickness of the plating or through the welds may be observed during pressure testing of the double bottom tanks.

3 What to look for – Double bottom tank inspection

3.1 Material wastage

3.1.1 The level of wastage of double bottom internal structure (longitudinals, transverses, floors, girders, etc.) may have to be established by means of thickness measurements. The rate and extent of corrosion depends on the corrosive environment, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (also see **3.1.2 - 3.1.4**).

a) Structure in corrosive environment:
Back side of inner bottom plating and inner bottom longitudinals Transverse watertight floors and girders adjacent to a heated fuel oil tank

(b) Structure subject to high stress:
Connection of longitudinals to transverse floors

(c) Areas susceptible to coating breakdown:
Back side of longitudinal face plates
Welded joints
Edges of access openings

(d) Areas subjected to poor drainage:
Web of bilge side longitudinals
Stringer deck

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer severe localised corrosion. In general, structure at the upper part of the double bottom tank usually has more severe corrosion than that at the lower part.

3.1.3 The high temperature due to heated fuel oil may accelerate corrosion of ballast tank structure near heated fuel tanks. The rate of corrosion depends on several factors such as:

- temperature and heat input to the ballast tank.
- condition of original coating and its maintenance.

(It is preferable for application and maintenance of ballast tank coatings that stiffeners on contiguous boundaries be fitted inside the – uncoated – fuel tank.)

- ballasting frequency and operations.
- age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.1.4 Shell plating below the suction head often suffers localized wear caused by erosion and cavitation because of the fluid flowing through the suction head. In addition, the suction head will be positioned in the lowest part of the tank and water/mud will cover the area even when the tank is empty. The condition of the shell plating may be established by hand by feeling beneath the suction head. When in doubt, the lower part of the suction head should be removed and thickness measurements taken. If the vessel is docked, the thickness can be measured from below. If the distance between the suction head and the underlying shell plating is too small to permit access, the suction head should be dismantled. The shell plating below the sounding pipe should also be carefully examined. When a striking plate has not been fitted or is worn out, heavy corrosion can be caused by the striking of the weight of the sounding tape (See **Example 2** in **Part 3**).

3.2 Deformations

3.2.1 Where deformations are identified during tank top inspection (See **2.2**) and external bottom inspection (See **4.2**), the deformed areas should be subjected to in tank inspection to determine the extent of the damage to the coating and internal structure.

3.2.2 For large container ships (8,000 TEU or over), even if no obvious deformations are identified during external bottom inspection, if small concave and convex deformations of bottom plates are detected during the in tank inspection, the adjacent areas of bottom plates should be carefully inspected for the similar deformations, which might be caused by the effect of the lateral loads which induce bi-axial stress of bottom shell plates. In such cases a strength assessment of the hull girder should be undertaken by BCS.

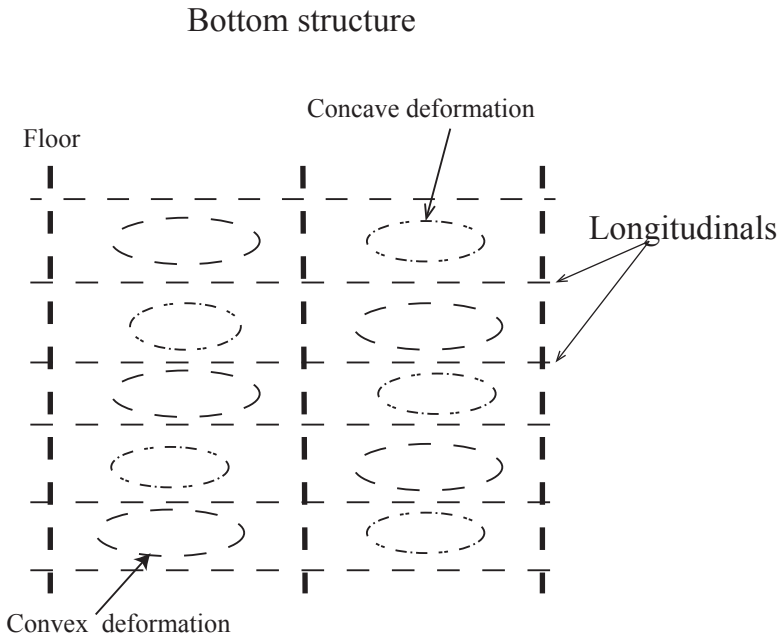


Figure 1 – Buckling deformation observed in the bottom shell plating in way of cargo hold amidships

Deformations in the structure not only reduce the structural strength but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3 Fractures

3.3.1 Fractures are more likely to be found by close-up survey.

3.3.2 Fractures may be caused by the cyclic deflection of the inner bottom induced by repeated loading from the sea or due to poor ‘through thickness’ properties of the inner bottom plating. Scallops in the underlying girders can create stress concentrations which further increase the risk of fractures.

These can be categorised as follows.

(a) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with the watertight floors below the transverse bulkhead, especially in way of suction wells.

(b) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets on the floors, as well as at the corners of the duct keel.

3.3.3 Transition region

In general, the termination of the following structural members at the collision bulkhead and engine room forward bulkhead is prone to fractures:

- side tank structure
- panting stringer in fore peak tank
- inner bottom plating in engine room

4 What to look for – External bottom inspection

4.1 Material wastage

4.1.1 Hull structure below the water line can usually be inspected only when the ship is dry-docked. The opportunity should be taken to inspect the external plating thoroughly. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See Figure ~~1~~ 2 and ~~2~~3). This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or “docking” plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating.

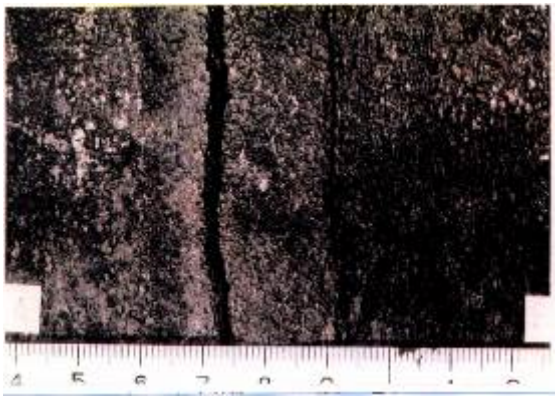


Figure 2
Grooving corrosion of welding of bottom plating

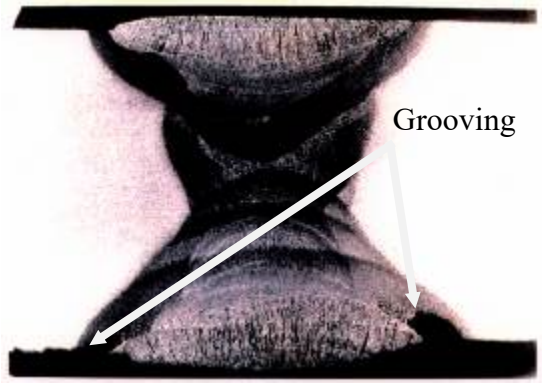


Figure 3
Section of the grooving shown in Figure 2

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations of bottom plating may also be attributed to dynamic force caused by wave slamming action at the forward part of the vessel, or contact with underwater objects. When deformation of the shell plating is found, the affected area should be inspected internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be inspected when the hull has dried since fractures in shell plating can easily be detected by observing leakage of water from the fractures in clear contrast to the dry shell plating. Therefore if the ship has been inspected while wet, it is recommended that the ship be inspected again when dry.

4.3.2 Fractures in butt welds and fillet welds, particularly at the wrap around at scallops and ends of bilge keel, are sometimes observed and may propagate into the bottom plating. The cause of fractures in butt welds is usually related to a weld defect or grooving. If the bilge keels are divided at the block joints of the hull, all ends of the bilge keels should be inspected.

5 General comments on repair

5.1 Material wastage

5.1.1 In general, where the tank top, double bottom internal structure, and bottom shell plating have wasted to the allowable level, the normal practice is to crop and renew the affected area. Where possible, plate renewals should be for the full width of the plate but in no case should they be less than the minimum set in paragraph 6.2 of Part B of BCS- G 47, to avoid build-up of residual stresses due to welding. Repair work on a double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit (See **Examples 8** and **9**). When scattered deep pitting is found, it may be repaired by welding, when performed in accordance with procedures agreed with BCS.

5.2 Deformations

5.2.1 Extensively deformed tank top and bottom plating should be replaced together with the deformed portion of girders, floors or transverse web frames. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, BCS should be contacted.

5.3 Fractures

5.3.1 Repair should be carried out in consideration of nature and extent of the fractures.

(a) Fractures of a minor nature may be veed-out and rewelded. Where fracturing is more extensive, the structure is to be cropped and renewed.

(b) For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.

(c) For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

5.3.2 The fractures in the internal structures of the double bottom should be repaired as follows.

(a) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with watertight floors are to be cropped and partly renewed. In addition, brackets with soft toes are to be fitted in order to reduce the stress concentrations at the floors or stiffeners.

(b) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets are to be cropped and the longitudinal part renewed if the fractures extend to over one third of the depth of the longitudinal. If fractures are not extensive they can be veed out and welded. In addition, reinforcement should be provided in the form of modification to existing bracket toes or the fitting of additional brackets with soft toes in order to reduce the stress concentration.

(c) Fractures at the corners of the transverse diaphragm/stiffeners in the duct keel are to be cropped and renewed. In addition, scallops are to be closed by overlapping collar plates.

(d) Fractures at the corners of the transverse web frame in the raised stringer decks are to be cropped and renewed. In addition, scallops are to be closed by overlapping collar plates.

5.3.3 The bilge keel should be repaired as follows.

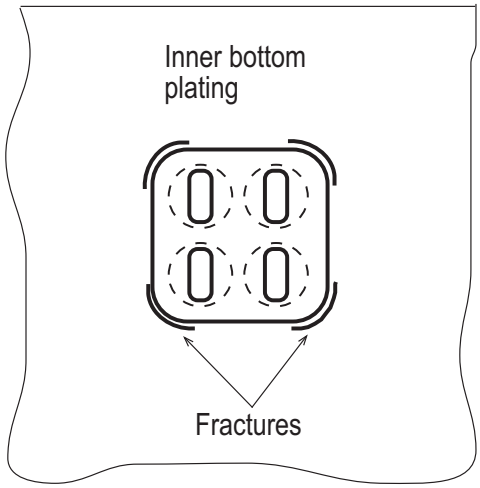
(a) Fractures or distortion in bilge keels must be promptly repaired. Fractured butt welds should be repaired using full penetration welds and proper welding procedures. The bilge keel is subjected to the same level of longitudinal hull girder stress as the bilge plating and fractures in the bilge keel can propagate into the shell plating.

(b) Termination of the bilge keel requires proper support by internal structure. This aspect should be taken into account when cropping and renewing damaged parts of a bilge keel (See **Example 11**).

5.3.4 In the transition region, in order to reduce stress concentration due to discontinuity, the appropriate structure is to be provided in the contiguous space. If such a structure is not provided, or is deficient due to corrosion or misalignment, fractures may occur at the terminations.

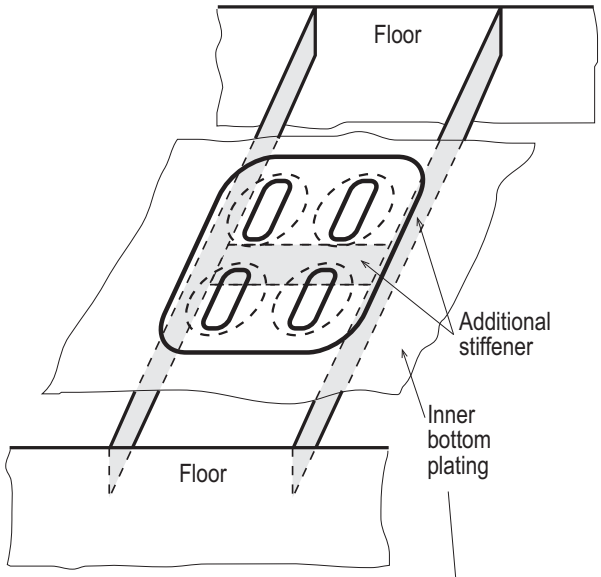
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**1**
Detail of damage	Fractures in inner bottom plating around container bottom pocket	

Sketch of damage

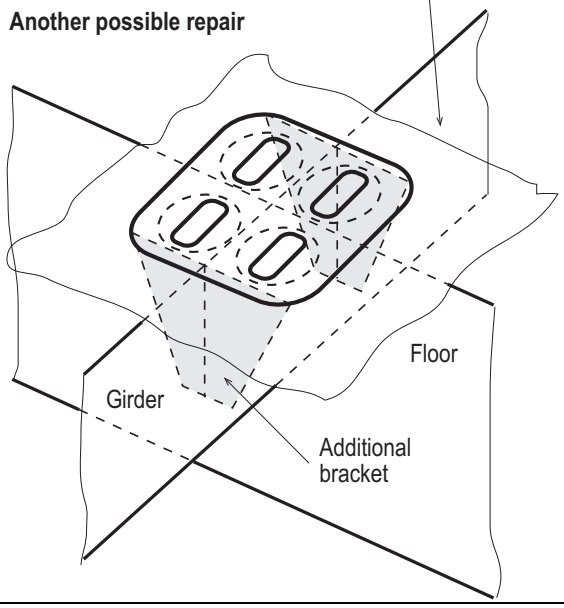


Sketch of repair

Most common repair



Another possible repair



Notes on possible cause of damage

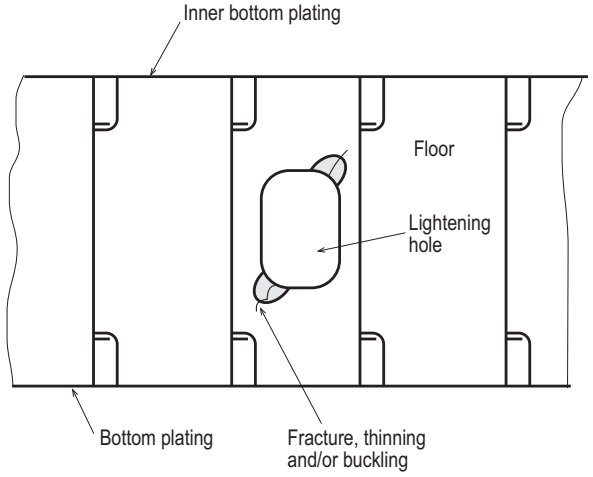
1. Pocket is not supported correctly by floor, longitudinal and/or stiffener.

Notes on repairs

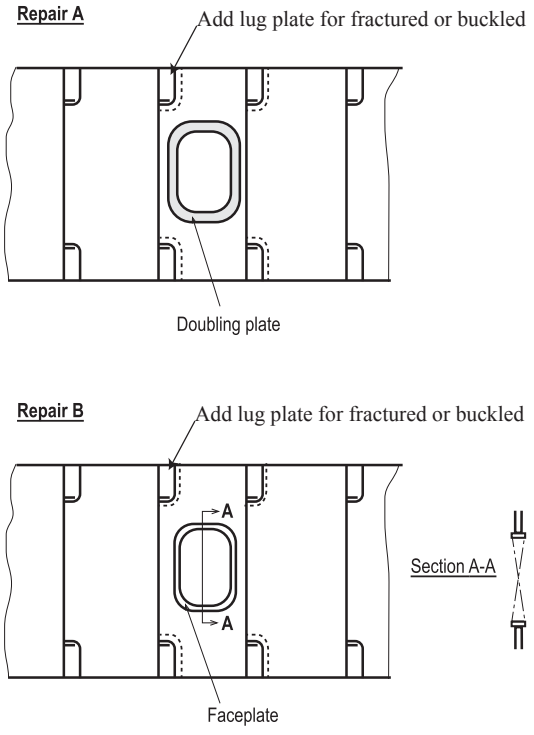
1. Fractured plating should be cropped and part renewed.
2. Adequate reinforcement should be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 2**
Area 4	**Double bottom structure**	
Detail of damage	Fractures, corrosion and/or buckling of floor/girder around lightening hole	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1 Insufficient strength due to lightening hole.

2 Fracture, corrosion and/or buckling around lightening hole due to high stress.

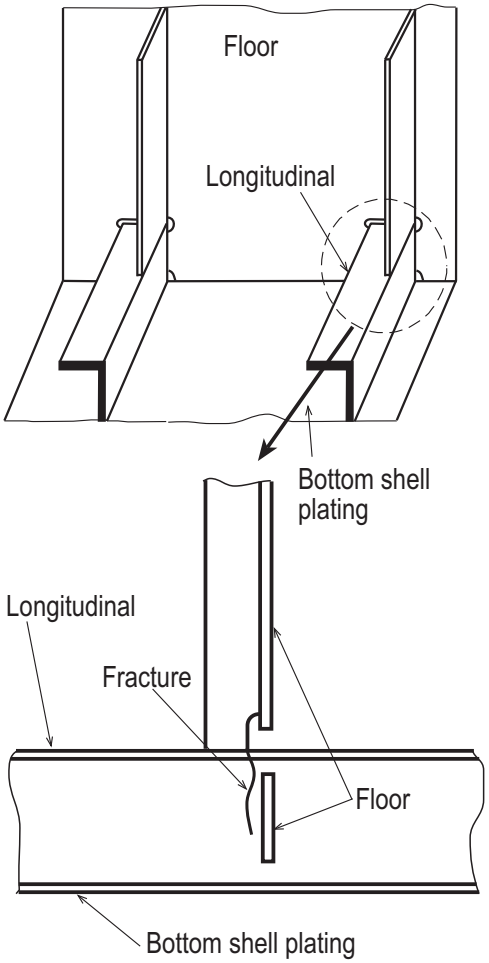
Notes on repairs

1. Fractured, corroded and/or buckled plating should be cropped and renewed if considered necessary.

2. Appropriate reinforcement should be considered.

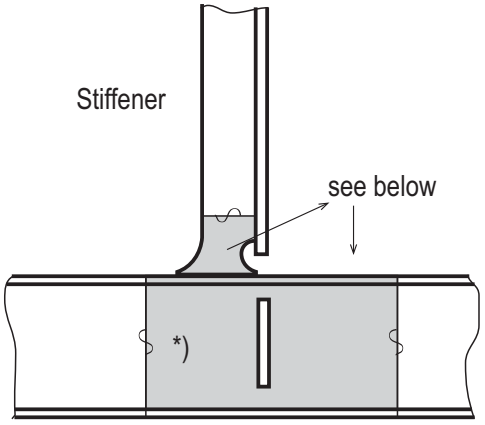
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**3**
Detail of damage	Fractures in longitudinal at floor or bulkhead	

Sketch of damage

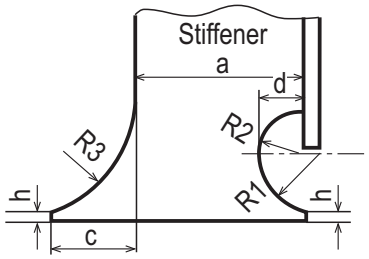


Note: same damage max occur at similar connection to inner bottom plating

Sketch of repair



*) Where required, the longitudinal to be cropped and part renewed



Various cut/out shapes have been developed. The following ist one example.

1. Toe height as small as possible (h = 10 - 15 mm)
2. Depth "d" of key hole notch as small a possible, max. 30 mm
3. For a slope at toe max. 1 : 3
4. R1 = 1.5 d
   R2 = d and
   R3 = 1.5 c

Notes on possible cause of damage

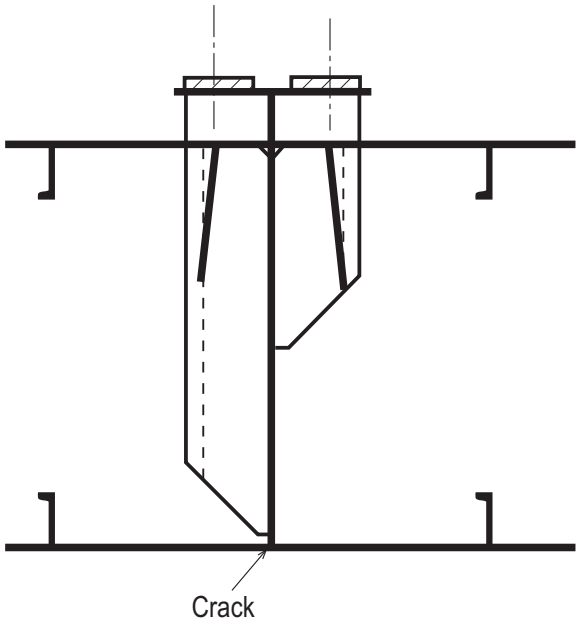
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

Notes on repairs

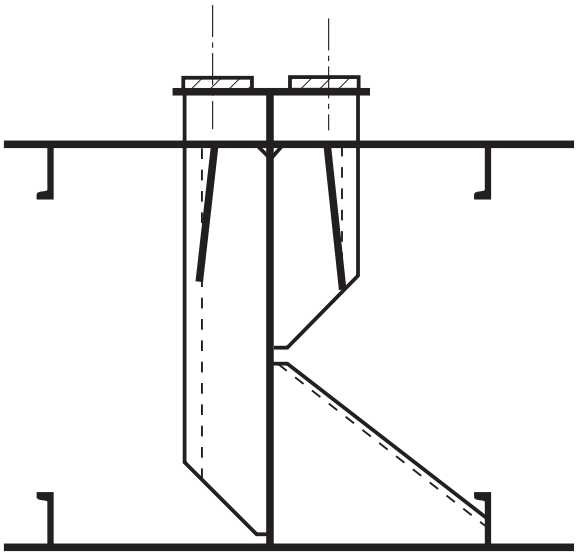
1. If fractures extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**4**
Detail of damage	Fractures in longitudinal girders in way of container support	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Damage can be caused by an insufficient strength of the longitudinal girder at the termination of the vertical stiffeners.

   The effect of a simultaneous occurrence of the tank pressure from one side and an asymmetrical load from the container sockets has not been taken into account.

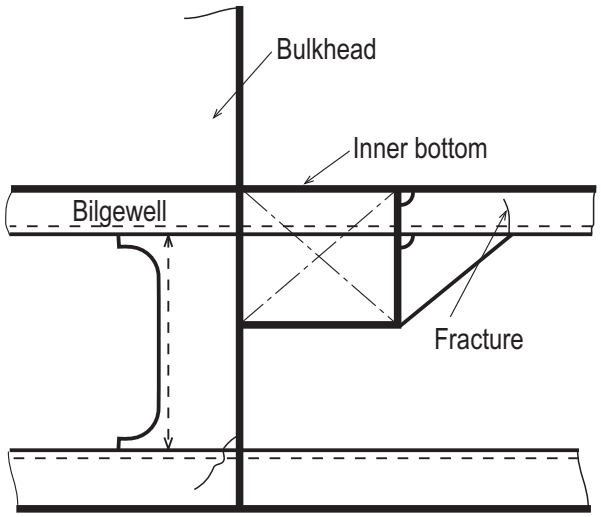
Notes on repairs

1. Fractured part of the longitudinal girder has to be cropped and renewed by an insert.

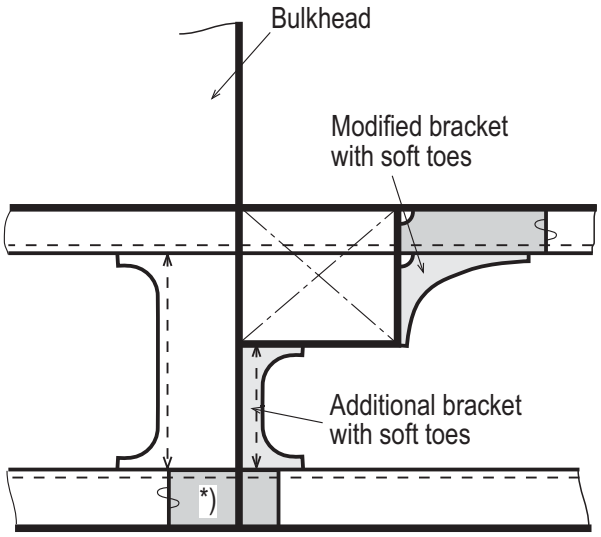
2. The lower part of the girder has to be supported by an additional transverse stiffener on the bottom shell plating.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**5**
Detail of damage	Fractures in longitudinal in way of bilge well	

Sketch of damage



Sketch of repair



*) : Where required the longitudinals to be cropped and part renewed

Notes on possible cause of damage

1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.

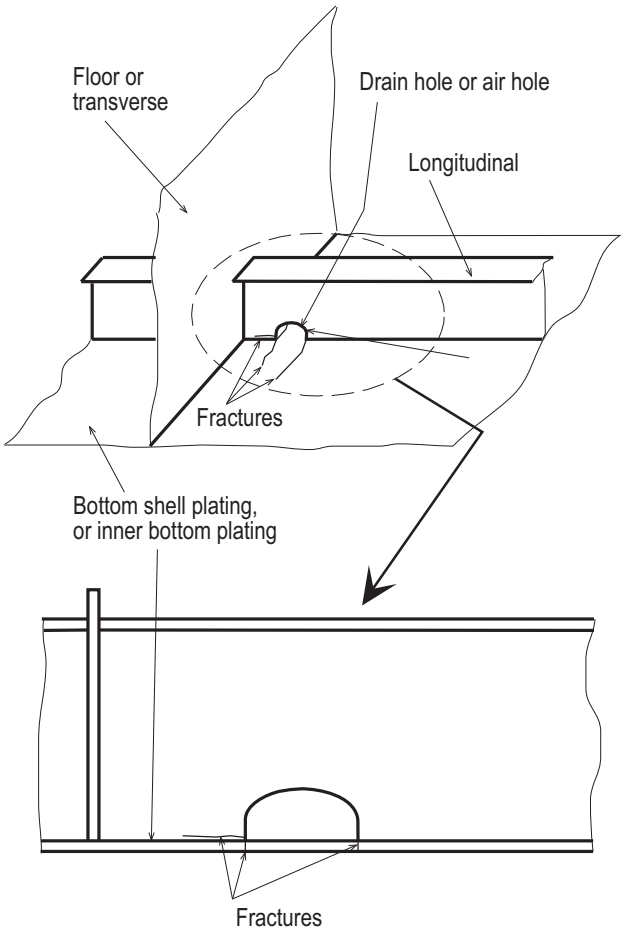
Notes on repairs

1. If fractures are not extensive e.g. hairline fractures then these can be veed-out and welded.

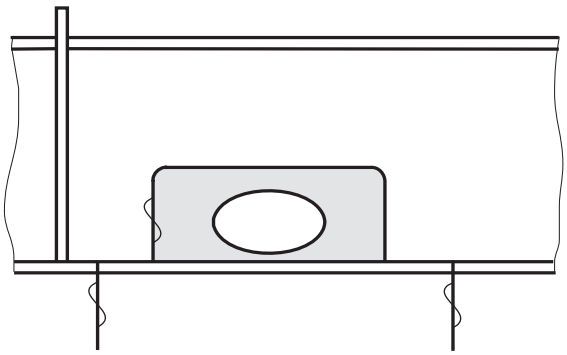
2. If the fracture extended to over one third of the depth of the longitudinal then crop and part renew.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**6**
Detail of damage	Fractures in bottom shell or inner bottom plating at the corner drain hole/air hole in longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

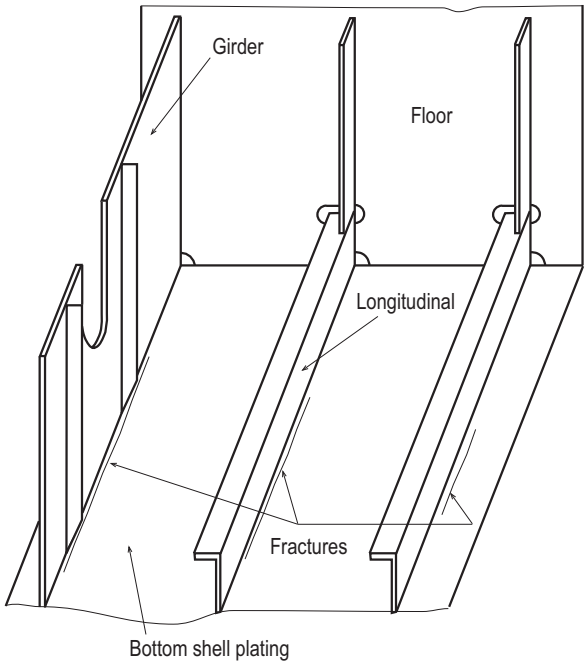
1. Stress concentration and/or corrosion due to stress concentration at the corner of drain hole/air hole.

Notes on repairs

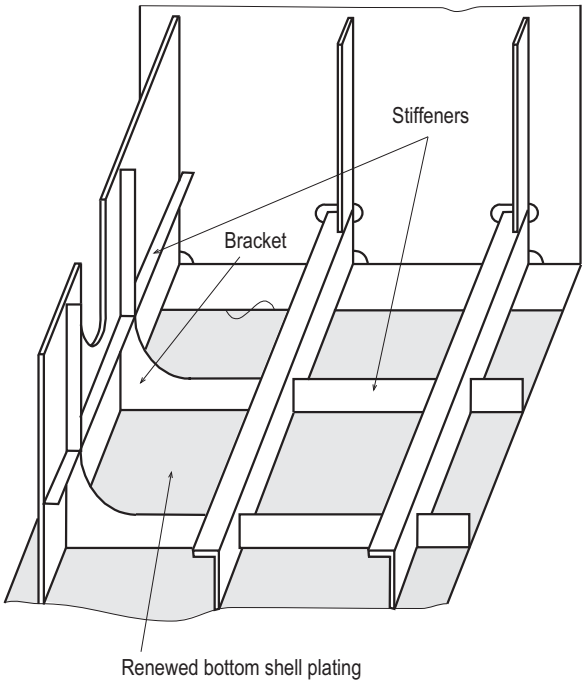
1. Fractured plating should be cropped and part renewed.
2. If fatigue life is to be improved, change of drain hole/air hole shape is to be considered.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structure**	**7**
Detail of damage	Fractures in bottom plating alongside girder and/or bottom longitudinal	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

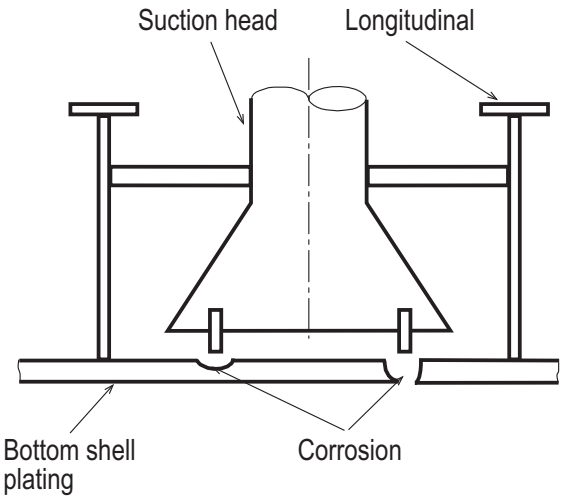
1. Vibration.

Notes on repairs

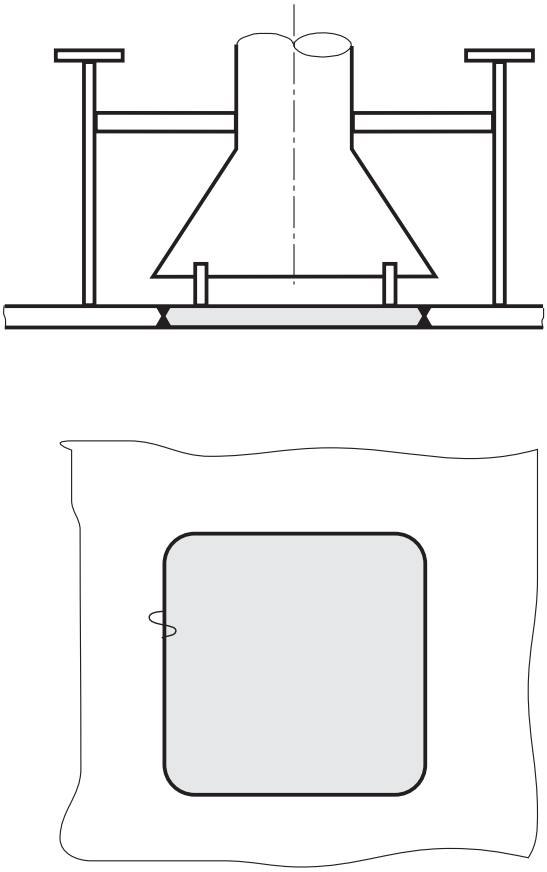
1. Fractured bottom shell plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional stiffener/bracket.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 8**
Area 4	**Double bottom tank structure**	
Detail of damage	Corrosion in bottom plating below suction head	

Sketch of damage



Sketch of repair



1. Insert to have round corners
2. Non-destructive examination to be applied after welding based on the Classification Society's rules

Notes on possible cause of damage

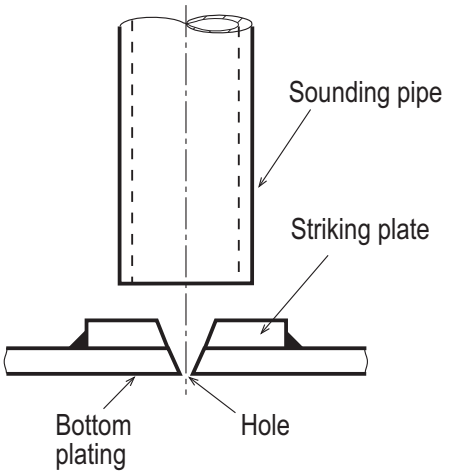
1. High flow rate associated with insufficient corrosion prevention system.
2. Galvanic action between dissimilar metals.

Notes on repairs

1. Affected plating should be cropped and part renewed. Thicker plate and suitable beveling should be considered.
2. If the corrosion is limited to a small area, i. e. pitting corrosion, repair by welding is acceptable.

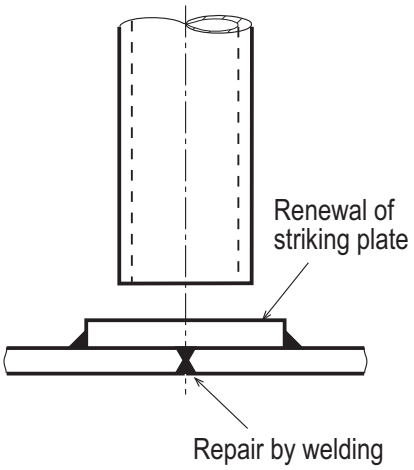
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No. 9**
Area 4	**Double bottom tank structure**	
Detail of damage	Corrosion in bottom plating below sounding pipe	

Sketch of damage

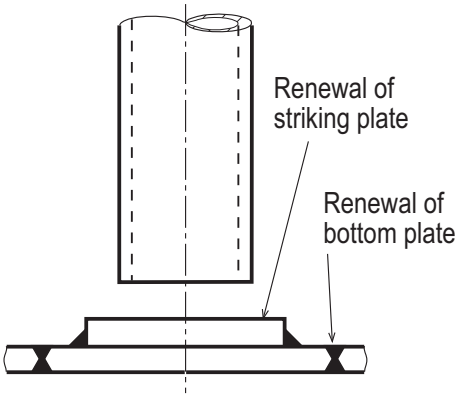


Sketch of repair

Reapair A



Reapair B



Notes on possible cause of damage

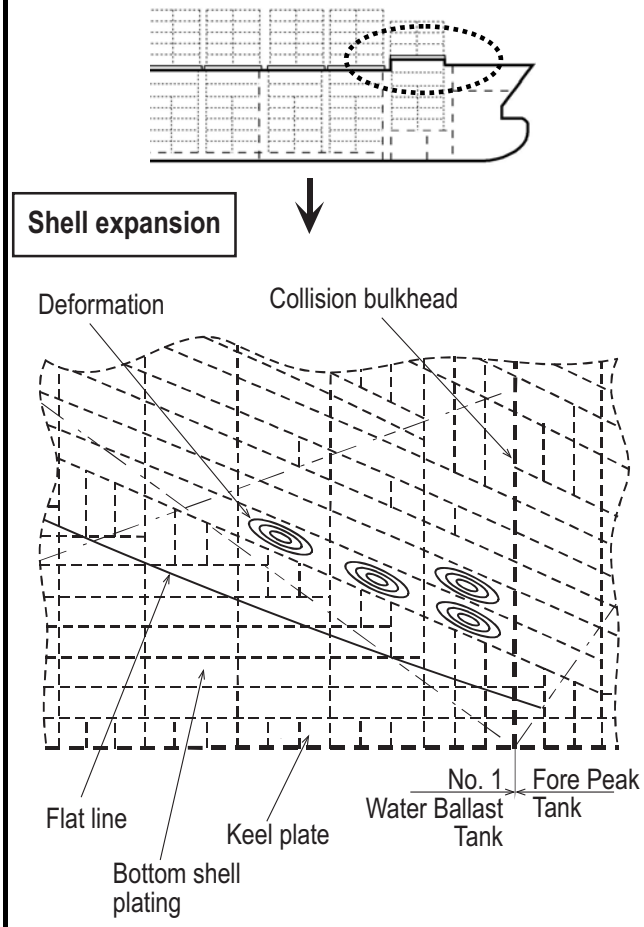
1. Accelerated corrosion of striking plate by the striking of the weight of the sounding tape.

Notes on repairs

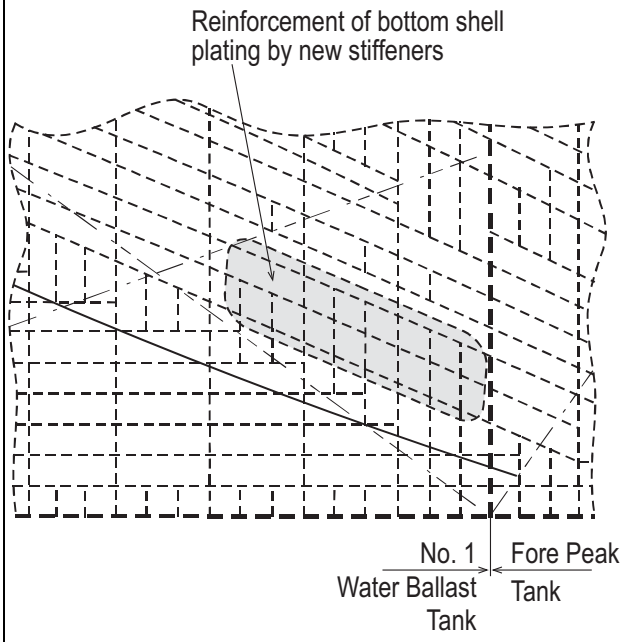
1. Corroded bottom plating should be welded or partly cropped and renewed if considered necessary.
2. Corroded striking plate should be renewed.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom tank structures**	**10**
Detail of damage	Deformation of forward bottom shell plate due to slamming	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

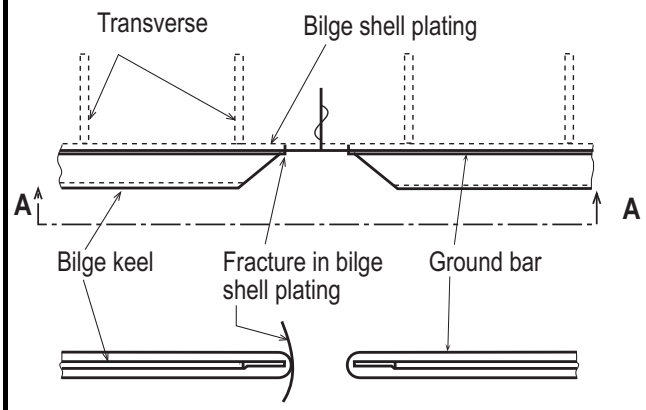
1. Heavy weather.
2. Poor design for slamming.
3. Poor operation, i.e. negligence of heavy ballast.

Notes on repairs

1. Deformed bottom shell plating should be faired in place, or partly cropped and renewed if considered necessary.
2. Bottom shell plating should be reinforced by stiffeners.

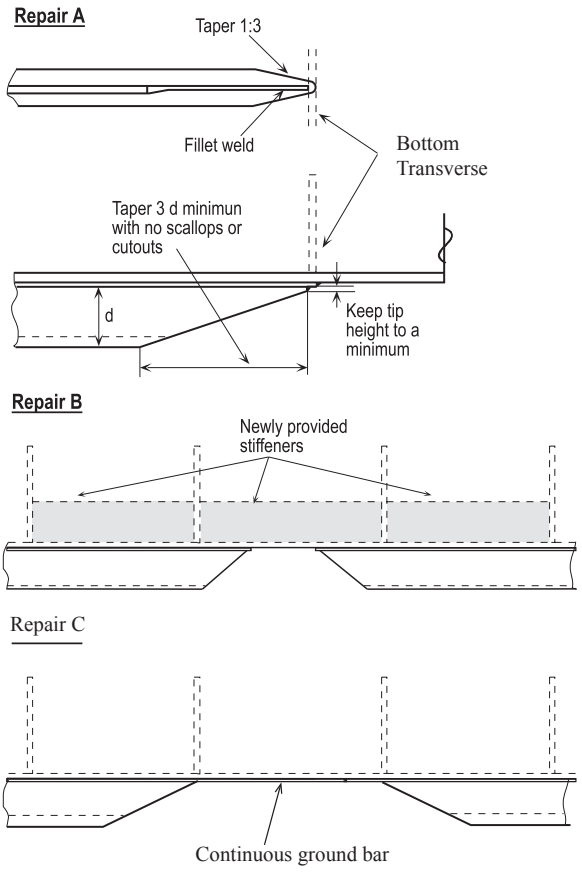
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom structure**	**11**
Detail of damage	Fractures in shell plating at the termination of bilge keel	

Sketch of damage



View A - A

Sketch of repair



Notes on possible cause of damage

1. Poor design causing stress concentration.

Notes on repairs

1. Fractured plating is to be cropped and renewed.

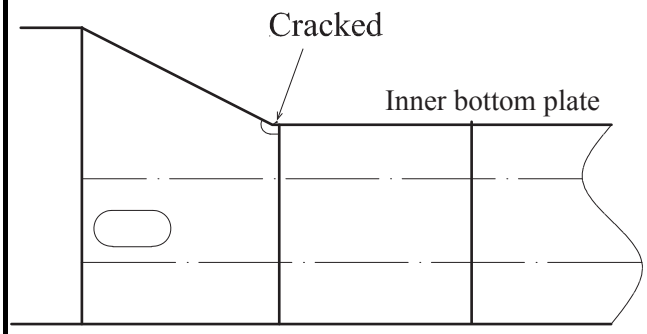
2. Reduction of stress concentration of the bilge keel end should be considered.

   Repair A: Modification of the detail of end
   Repair B: New internal stiffeners
   Repair C: Continuous ground bar (in connection with **Repair A**)

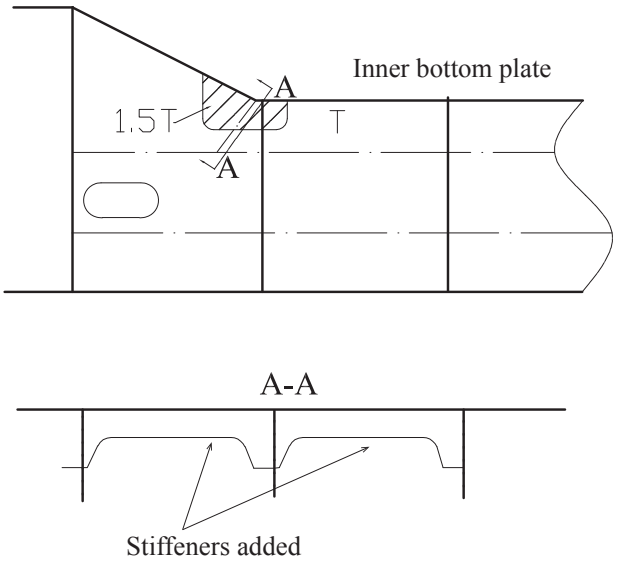
3. Instead of **Repair A** or **B** continuous ground bar should be considered, also the bilge keel should be terminated at transverses or brackets.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	**Cargo hold region**	**Example No.**
Area 4	**Double bottom structure**	**12**
Detail of damage	Fracture in the tank top plate in way of the height transition of inner bottom	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient strength of the sloping inner bottom plating in way of the knuckle;
2. Stress concentration in way of the cut-out of the longitudinal girder.

Notes on repairs

1. Damaged tank top plate is to be cropped and renewed.
2. Additional stiffeners are to be fitted near the knuckle of the slope inner bottom plates.
3. The cut-out is to be closed with a thicker collar plate.

Part 2 Fore and aft end regions

Contents

Area 1 – Fore end structure

Area 2 – Aft end structure

Area 3 – Stern frame, rudder arrangement and propeller shaft supports

Area 1 Fore end structures

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair

4.1 Material wastage
4.2 Deformations
4.3 Fractures

Figures and/or Photographs – Area 1

No.	Title
Figure 1	Fore end structure – Potential problem areas

Examples of structural detail failures and repairs – Area 1

Example No.	Title
1a	Deformation of forecastle deck (longitudinal stiffening system)
1b	Deformation of forecastle deck (transverse stiffening system)
2	Fractures in forecastle deck plating at the bulwark
3	Fractures in side bulkhead plating in way of chain locker
4	Deformation of side shell plating in way of forecastle space
5	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals
6	Fractures at toe of web frame bracket connection to stringer platform

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the fore peak ballast tank can be a major problem for many, and in particular ageing ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structures and the tank boundaries.

1.2 In general container ships have a high power main engine and are operated to a tight schedule. Therefore, ships can proceed in comparatively heavy weather at a relatively high speed. In particular in the case of larger bow flare high local pressure due to bow flare slamming as well as increased global bending moments and shear forces in the fore end of the ship can cause hull damage such as deformations and fractures.

1.3 Deformation can be caused by contact which can result in damage to the internal structure leading to fractures in the shell plating.

1.4 Fractures of internal structure in the fore peak tank and spaces also result from wave impact load due to slamming and panting.

1.5 The forecastle structure is exposed to green water and can suffer damage such as deformation of deck structures, deformation and fracture of bulwarks and collapse of masts, etc. Bulwarks are provided for the protection of the crew and of the anchor and mooring equipment. Due to the bow flare effect bulwarks are subject to impact forces which result in alternating tension and compression stresses which can cause fractures and corrosion at the bulwark bracket connections to the deck. These fractures may propagate to the deck plating and cause serious damage.

1.6 The shell plating around the anchor and hawse pipe may suffer corrosion, deformation and possible fracture due to the movement of an improperly stowed and secured anchor, especially in the case of an unsheltered position as the same high hydrodynamic impact forces act on the anchor as on the hull structure, influencing the motion of the anchor in the hawse pipe.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at the locations as indicated in **Figure 1** and particular attention should be given to these areas. A close-up survey should be carried out with selection of representative thickness measurements to determine the extent of corrosion.

2.1.2 Structure in the chain locker is liable to heavy corrosion due to mechanical damage of the protective coating caused by the action of anchor chains. In some ships, especially smaller ships, the side shell plating may form boundaries of the chain locker and heavy corrosion may consequently result in holes in the side shell plating.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. An examination of the damaged area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in the fore peak tank are normally found by inspection of the internal structure.

2.3.2 Fractures are often found in the transition region and reference should be made to **Part 1, Area 2.**

2.3.3 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of tanks.

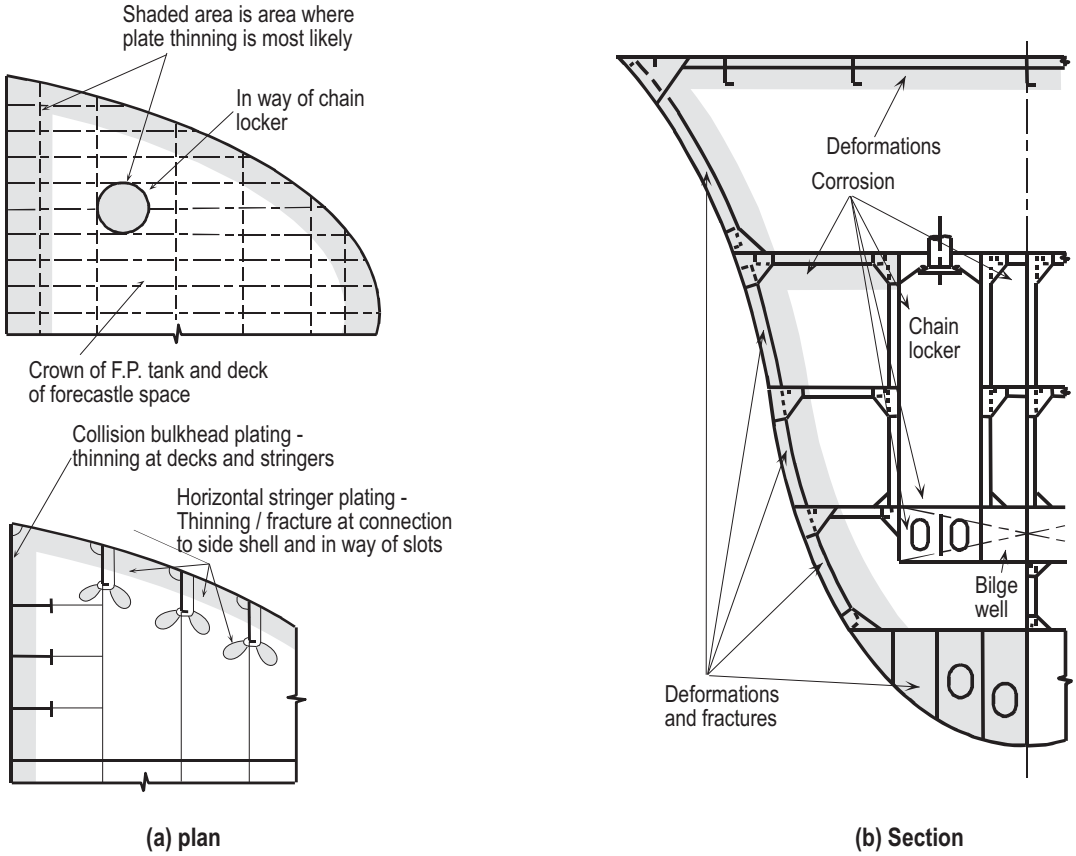


Fig 1 Fore end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

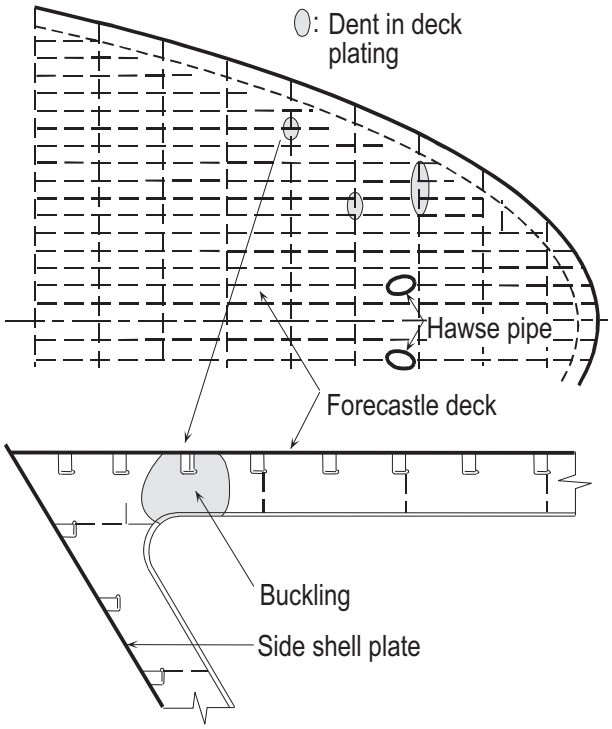
3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the nature and extent of damage.

3.3 Fractures

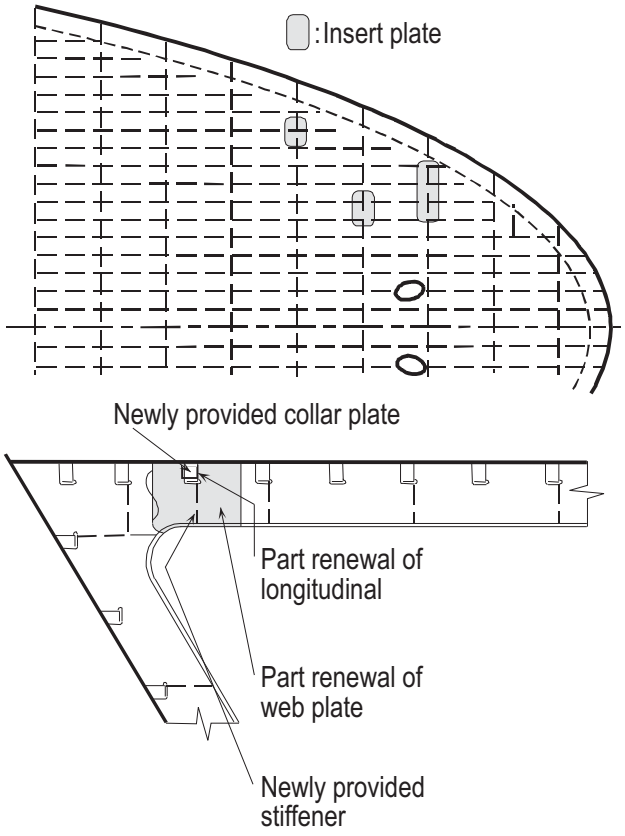
3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed. In the case of fractures caused by sea loads, increased thickness of plating and/or design modification to reduce stress concentrations should be considered (See **Examples 1a, 1b, 2** and **6**).

CONTAINER SHIPS	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**1a**
Detail of damage	Deformation of forecastle deck (longitudinal stiffening system)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

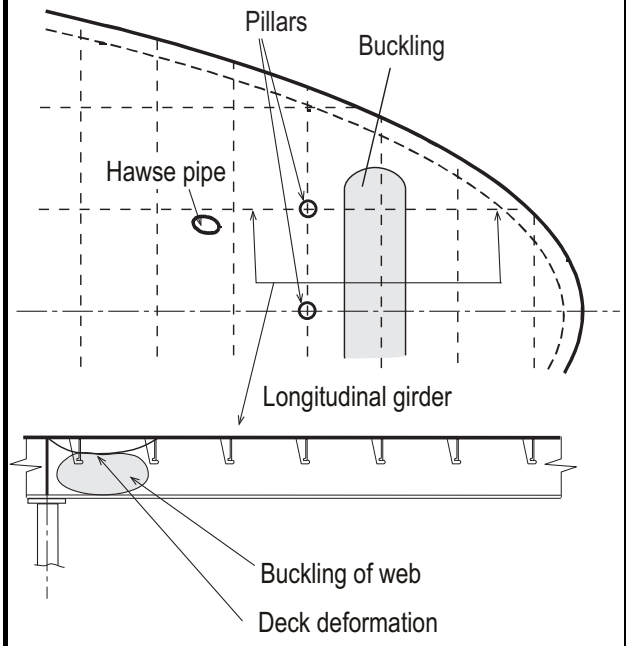
1. Green sea on deck.
2. Insufficient strength.

Notes on repairs

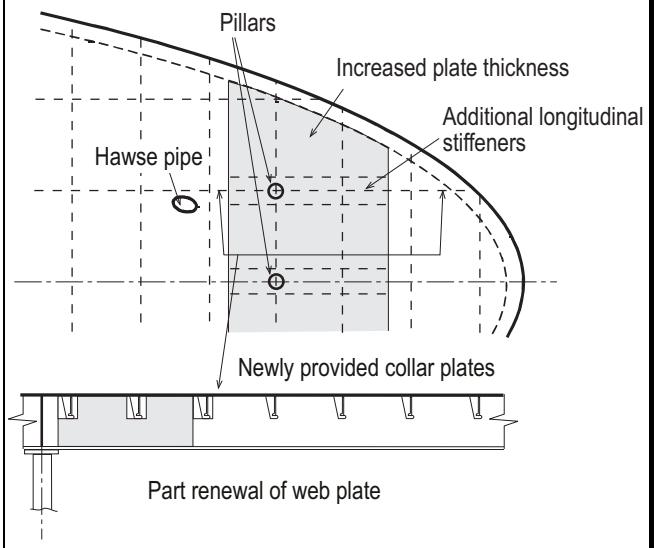
1. Deformed structure should be cropped and renewed.
2. Additional stiffeners on web of beam should be considered for reinforcement.

CONTAINERSHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**1-b**
Detail of damage	Deformation of forecastle deck (transverse stiffening system)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Green sea on deck and bow flare impact pressure.

2. Insufficient strength.

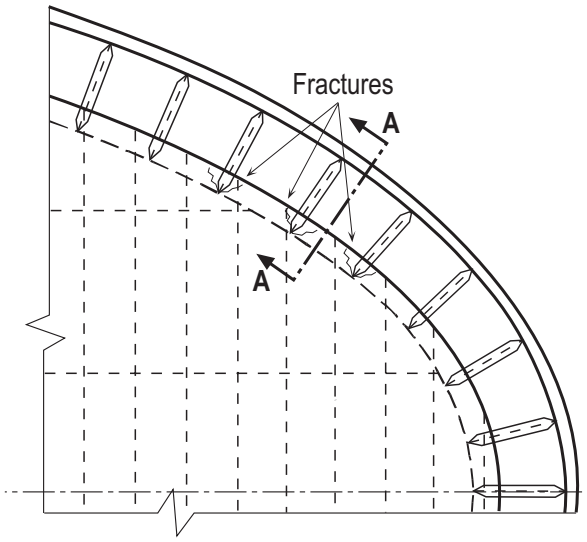
Notes on repairs

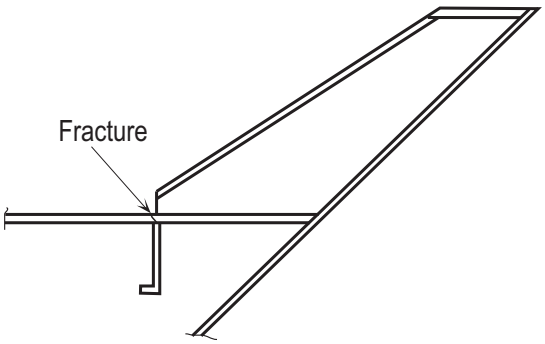
1. Deformed structure should be cropped and renewed. Plate thickness of the deck plating should be increased.

2. Additional longitudinal stiffeners parallel to the longitudinal girders. Openings in the web should be closed by collar plates.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	2
Detail of damage	Fractures in forecastle deck plating at bulwark	

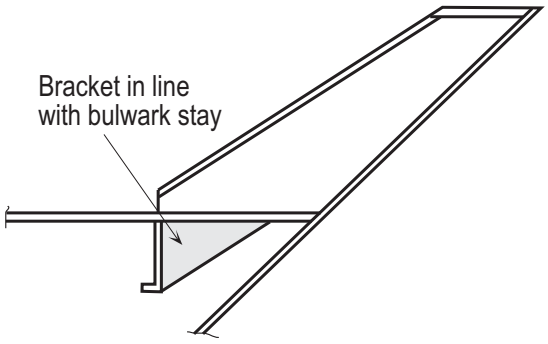
Sketch of damage





View A - A

Sketch of repair



View A - A

Notes on possible cause of damage

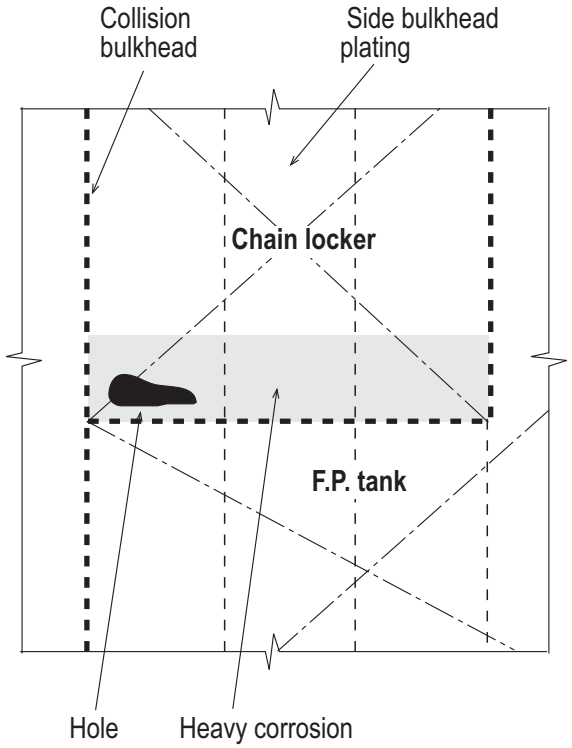
1. Bow flare effect in heavy weather.
2. Stress concentration due to poor design.

Notes on repairs

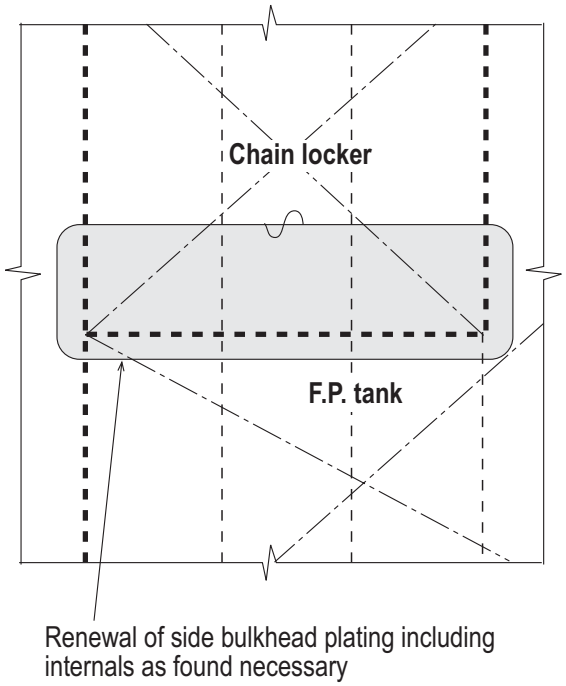
1. Fractured deck plating should be cropped and renewed.
2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	3
Detail of damage	Fractures in side in bulkhead plating way of chain locker	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion in region where mud is accumulated.

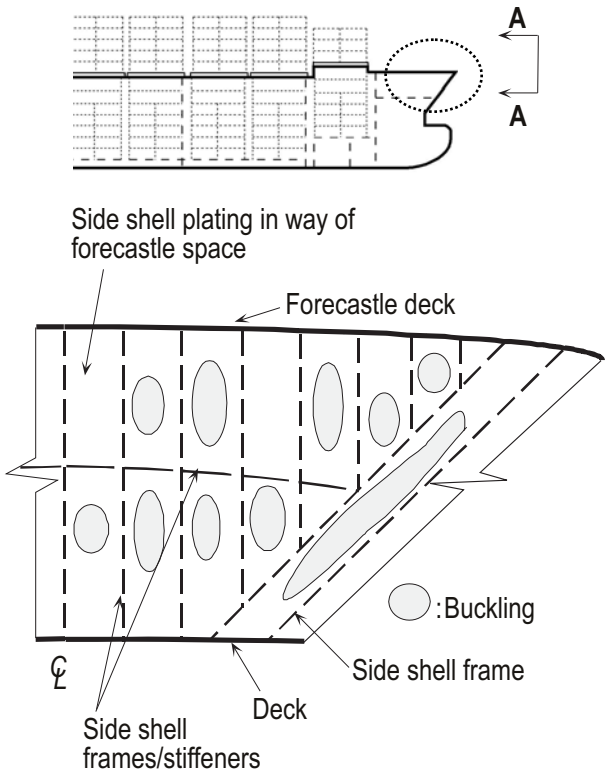
Notes on repairs

1. Corroded plating should be cropped and renewed.

2. Protective coating should be applied.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No. 4**
Area 1	**Fore end structure**	
Detail of damage	Deformation of side shell plating in way of forecastle space	

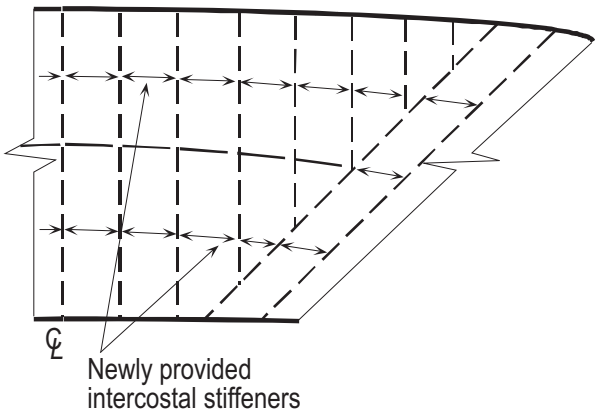
Sketch of damage



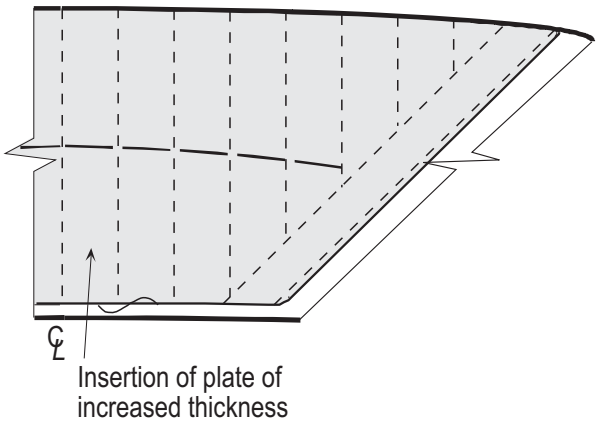
View A - A

Sketch of repair

Repair A



Repair B



Notes on possible cause of damage

1. Heavy weather.

2. Insufficient strength.

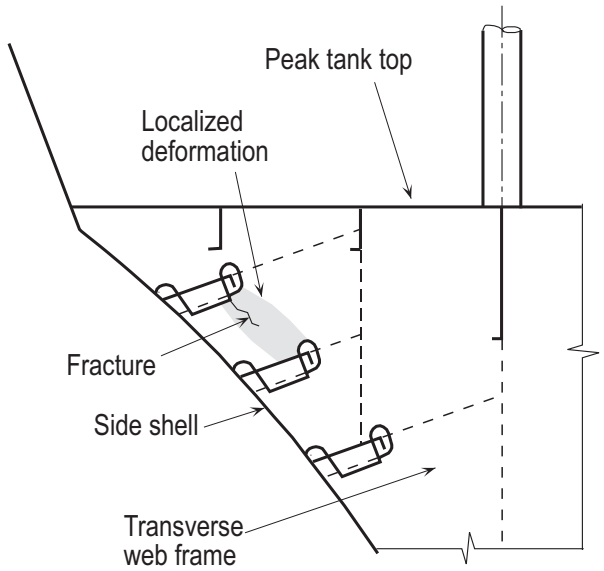
Notes on repairs

1. Deformed part should be cropped and part renewed.

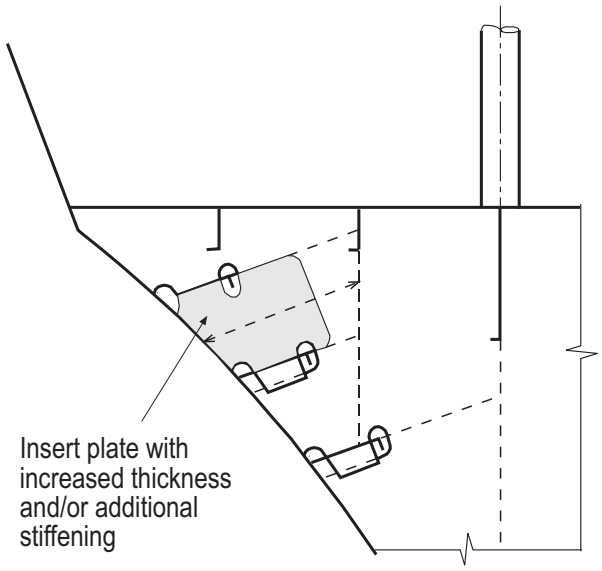
2. **Repair A**
Additional stiffeners between existing stiffeners should be considered.
Repair B
Insertion of plate of increased thickness without additional stiffeners.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 1	Fore end structure	5
Detail of damage	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Localized material wastage in way of coating failure at cut-outs and sharp edges due to working of the structure.

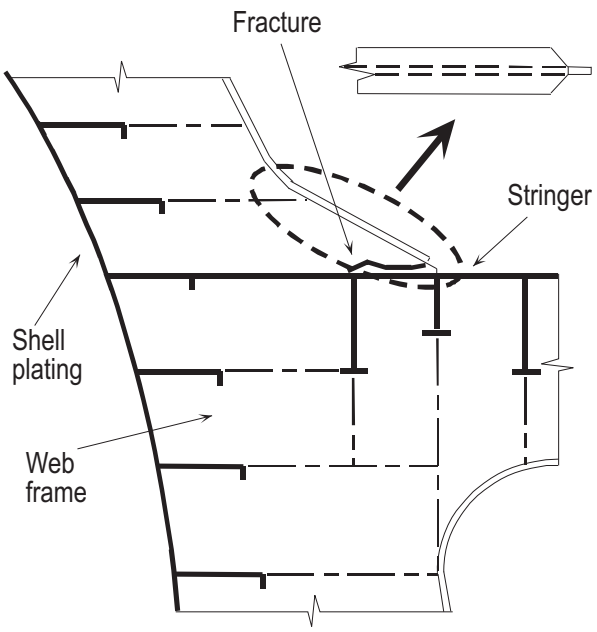
2. Dynamic seaway loading in way of bow flare.

Notes on repairs

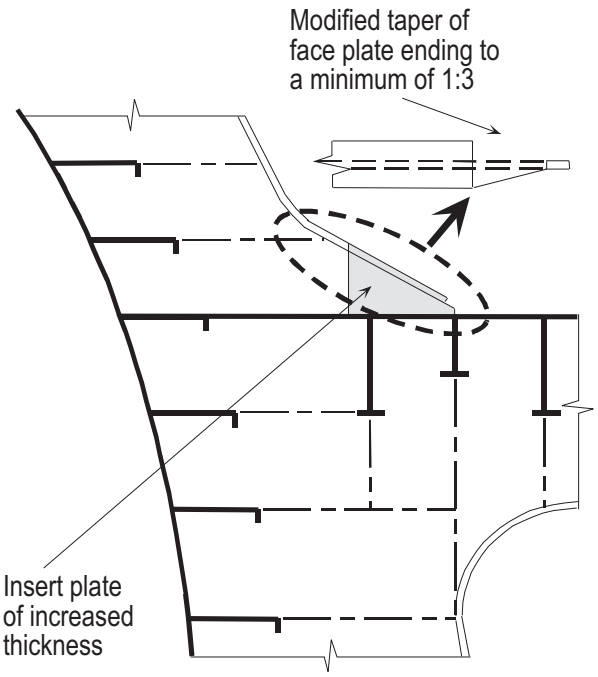
1. Sufficient panel strength to be provided to absorb the dynamic loads enhanced by bow flare shape.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 1	**Fore end structure**	**6**
Detail of damage	Fractures at toe of web frame bracket connection to stringer platform	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Inadequate bracket forming the web frame connection to the stringer.

2. Localized material wastage in way of coating failure at bracket due to flexing of the structure.

3. Dynamic seaway loading in way of bow flare.

Notes on repairs

1. Adequate soft nose bracket endings with a face plate taper of at least 1:3 to be provided.

Area 2 Aft end structures

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Figures and/or Photographs – Area 2

No.	Title
Figure 1	Aft end structure – Potential problem areas

Examples of structural detail failures and repairs – Area 2

Example No.	Title
1	Fractures in bulkhead in way of rudder trunk
2	Fractures at the connection of floors and girder/side brackets
3-a	Fractures in the steering gear flat by the rudder carrier
3-b	Fractures in steering gear foundation brackets and deformed deck plate

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the aft peak ballast tank can be a major problem for many, and in particular ageing, ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.

1.2 Deformation can be caused by contact or wave impact action from astern (which can result in damage to the internal structure leading to fractures in the shell plating).

1.3 Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at the locations as indicated in **Figure 1**. An inspection should be carried out with a selection of representative thickness measurements to determine the extent of corrosion. Particular attention should be given to bunker tank boundaries and spaces adjacent to the hot engine room.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and bulkheads. An examination of the deformed area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in welds at floor connections and other locations in the aft peak tank and rudder tank space can normally only be found by inspection.

2.3.2 The structure supporting the rudder carrier may fracture and/or deform due to excessive loads on the rudder. Bolts connecting the rudder carrier to the steering gear flat may also suffer damage under such loads.

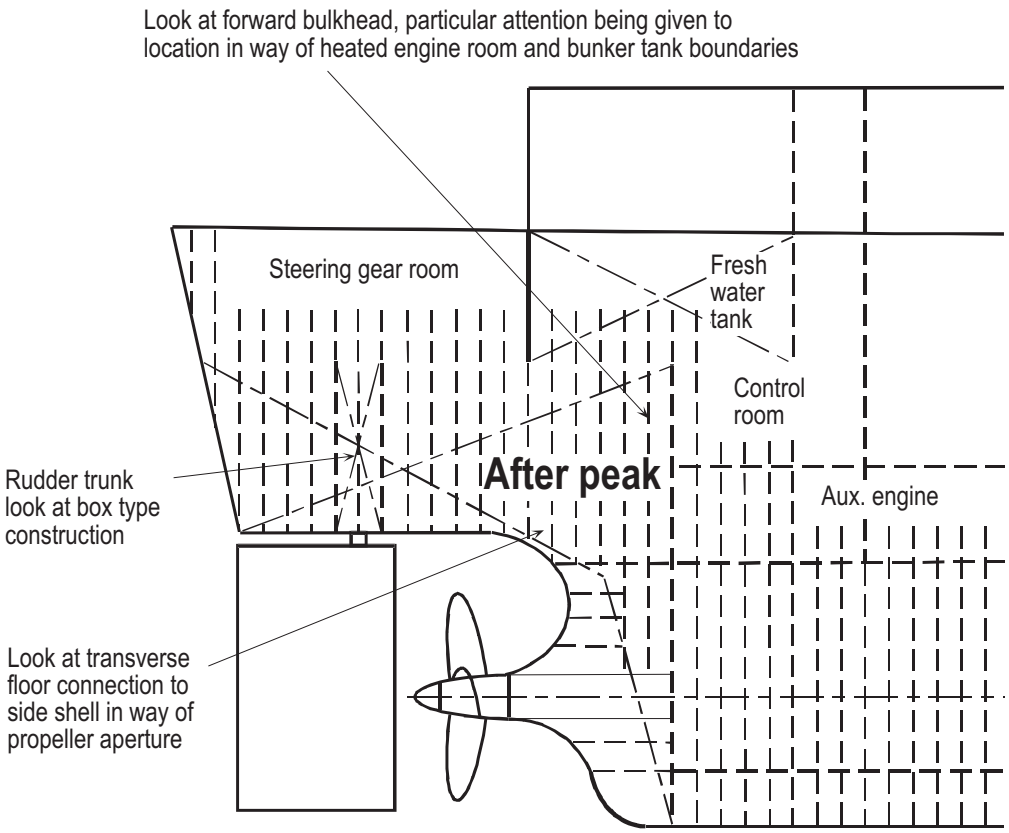


Figure 1 Aft end structure – Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissiable minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place, depending on the extent of damage.

3.3 Fractures

3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

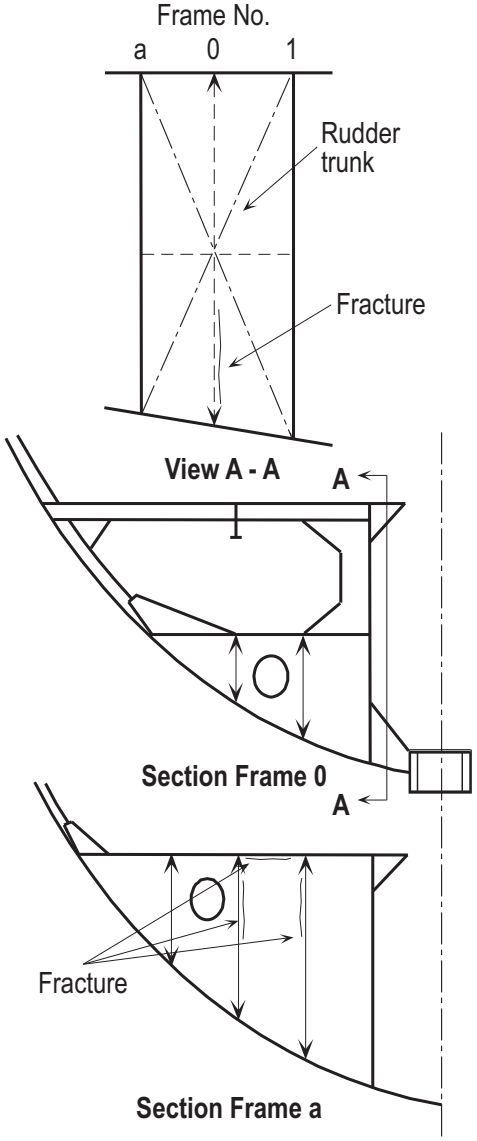
3.3.2 In order to prevent recurrence of damages suspected to be caused by main engine or propeller excited vibration, the cause of the vibration should be ascertained and additional reinforcements should be provided as found necessary (See **Examples 1** and **2**).

3.3.3 In the case of fractures caused by sea loads, increased thickness of plating and/or design modificaitons to reduce stress concentrations should be considered.

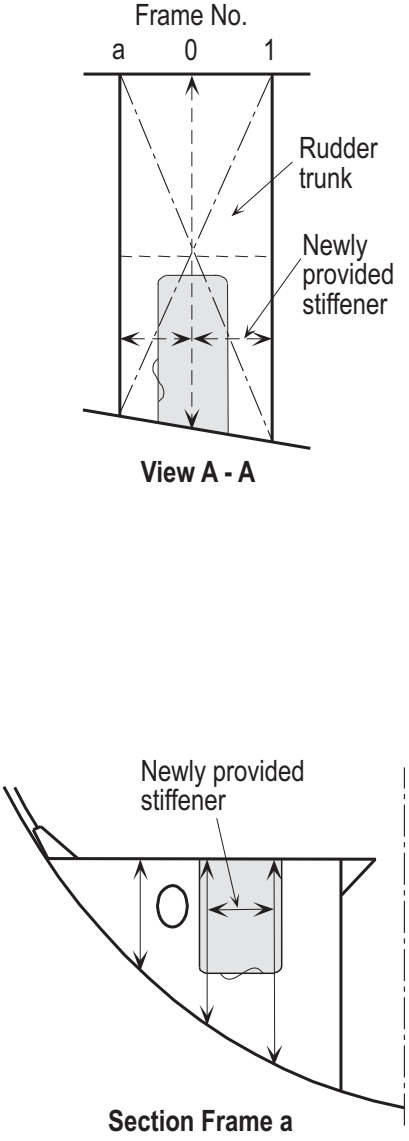
3.3.4 Fractured structure which supports the rudder carrier is to be cropped, and renewed, and may have to be reinforced (See E**xamples 3-a** and **3-b**).

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**1**
Detail of damage	Fractures in bulkhead in way of rudder trunk	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Vibration.

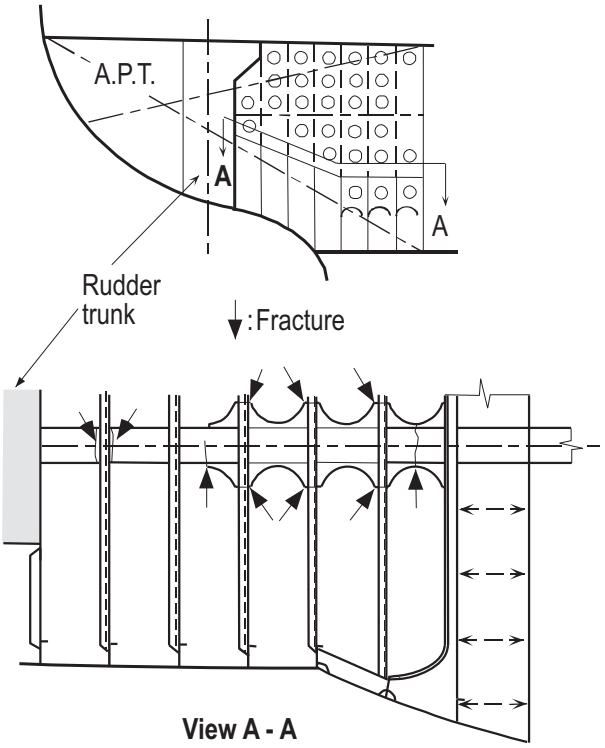
Notes on repairs

1. The fractured plating should be cropped and renewed.

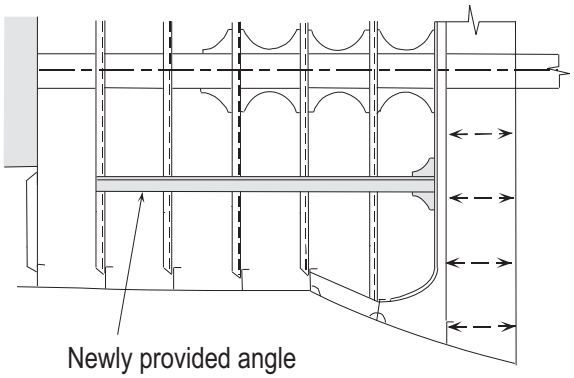
2. Natural frequency of the plate between stiffeners should be changed, e.g. reinforcement by additional stiffeners.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No. 2**
Area 2	**Aft end structure**	
Detail of damage	Fractures at the connection of floors and girders/side brackets	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Vibration.

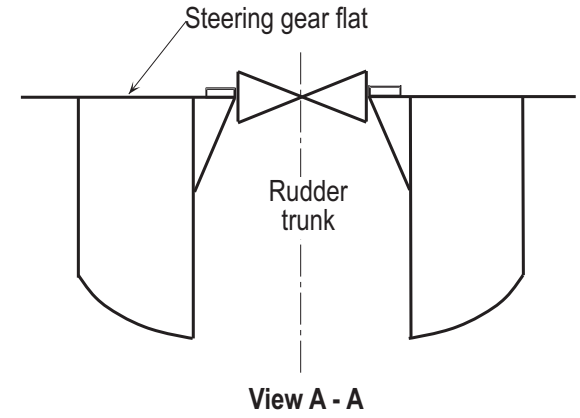
Notes on repairs

1. The fractured plating should be cropped and renewed.

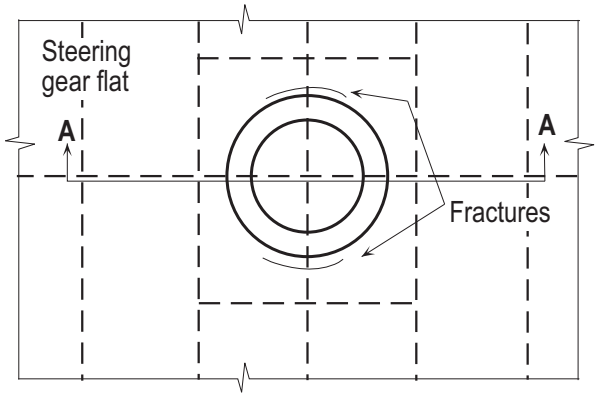
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional strut.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**3-a**
Detail of damage	Fractures in flat where rudder carrier is installed in steering gear room	

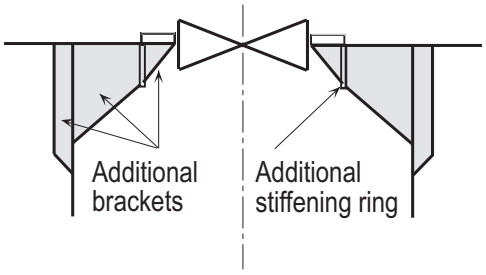
Sketch of damage



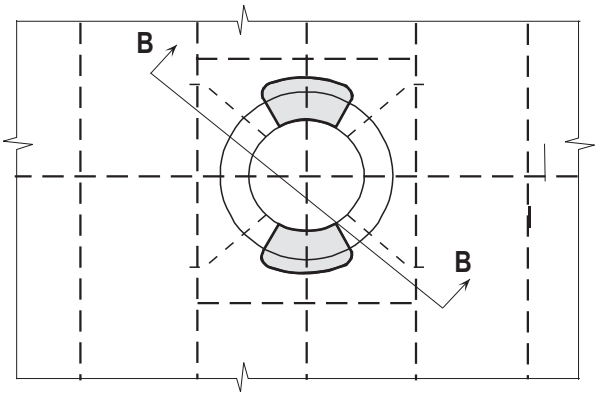
View A - A



Sketch of repair



View B - B



Notes on possible cause of damage

1. Inadequate design.

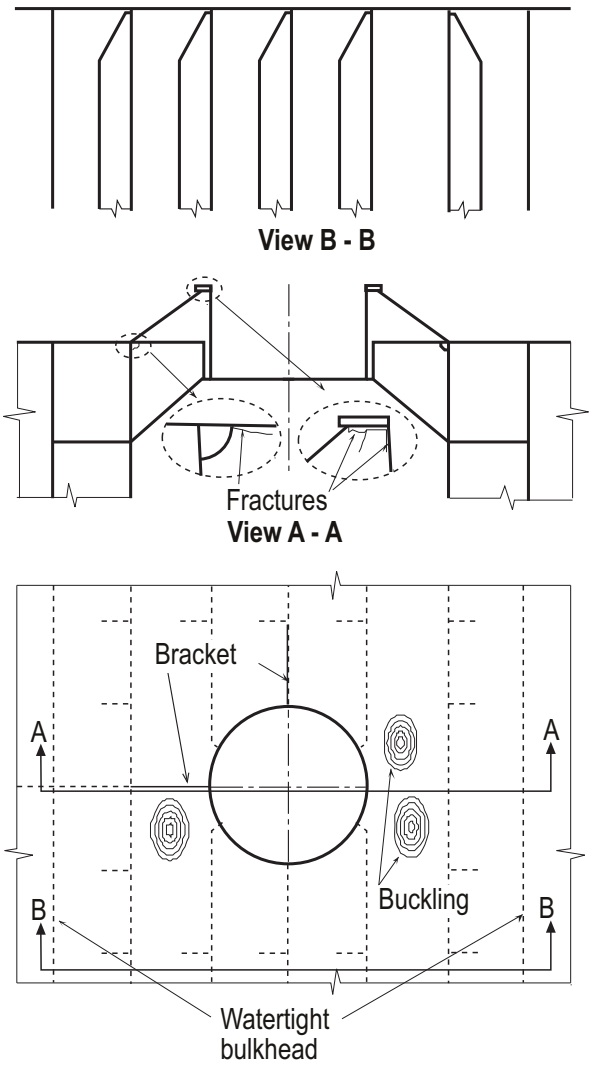
Notes on repairs

1. Fractured plating should be cropped and renewed.

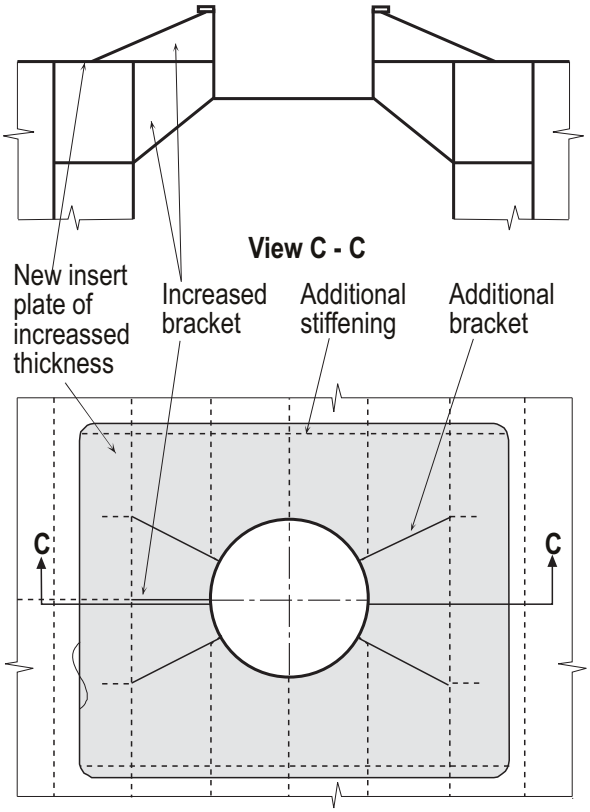
2. Additional brackets and stiffening ring should be fitted for reinforcement.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No.**
Area 2	**Aft end structure**	**3-b**
Detail of damage	Fractures in steering gear foundation brackets and deformed deck plate	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient deck strengthening (missing base plate).

2. Insufficient strengthening of steering gear foundation.

3. Bolts of steering gear were not sufficiently pre-loaded.

Notes on repairs

1. New insert base plate of increased plate thickness.

2. Additional longitudinal stiffening at base plate edges.

3. Additional foundation brackets above and under deck (star configuration).

Area 3 Stern frame, rudder arrangement and propeller shaft support

Contents

1 General

2 What to look for
2.1 Deformations
2.2 Fractures
2.3 Corrosion/Erosion/Abrasion

3 General comments on repair
3.1 Rudder stock and pintles
3.2 Plate structure
3.3 Abrasion of bush and sleeve
3.4 Assembling of rudders
3.5 Repair of propeller boss and stern tube

Figures and/or Photographs – Area 3

No.	Title
Figure 1	Nomenclature for stern frame, rudder arrangement and propeller shaft support
Figure 2	Potential problem areas
Photograph 1	Fractured rudder
Figure 3	Rudder stock repair by welding
Diagram 1	Preheating temperature

Examples of structural detail failures and repairs – Area 3

Example No.	Title
1	Fractures in rudder horn along bottom shell plating
2	Fractures in rudder stock
3	Fractures in connection of palm plate to rudder blade
4	Fractures in rudder plating of semi-spade rudder (short fractures with end located forward of the vertical web)
5	Fractures in rudder plating of semi-spade rudder extending beyond the vertical web
6	Fractures in rudder plating of semi-spade rudder in way of pintle cutout
7	Fractures in side shell plating at the connection to propeller boss
8	Fractures in stern tube at the connection to stern frame

1 General

1.1 The stern frame, strut bearing arrangement (if fitted) and connecting structures are exposed to propeller induced vibrations, which may lead to fatigue cracking in areas where stress concentrations occur.

1.2 The rudder and rudder horn are exposed to an accelerated and fluctuating stream from the propeller, which may also lead to fatigue cracking in areas where stress concentrations occur.

1.3 In extreme weather conditions the rudder may suffer wave slamming forces causing deformations of rudder stock and rudder horn as well as of the rudder itself.

1.4 The rudder and rudder horn as well as struts (on a shafting arrangement with strut bearings) may also come into contact with floating objects such as logs of timber or ice causing damages similar to those described in **1.3**.

1.5 Since different materials are used in adjacent compartments and structures, accelerated (galvanic) corrosion may occur if protective coatings and/or sacrificial anodes are not maintained properly.

1.6 Pre-existing manufacturing internal defects in cast pieces may lead to fatigue cracking.

1.7 A summary of potential problem areas is shown in **Figure 2**.

1.8 The mounting process of the rudder after dismantling and repair needs special attention in order to prevent deficiencies that might occur in the future

1.9 A complete survey of the rudder arrangement is only possible in drydock. However, in some cases a survey including a damage survey can be carried out afloat by divers or with a trimmed ship.

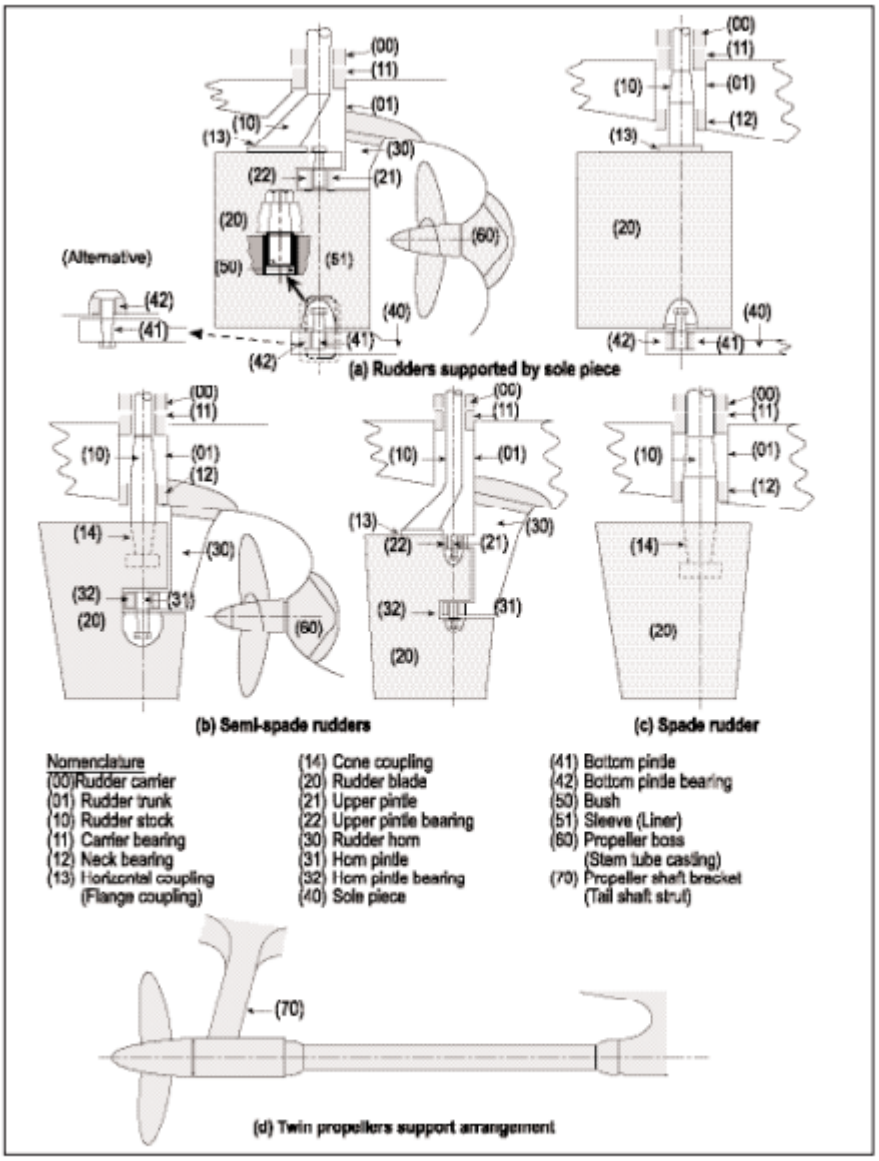


Figure 1 Nomenclature for stern frame, rudder arrangement and propeller shaft support

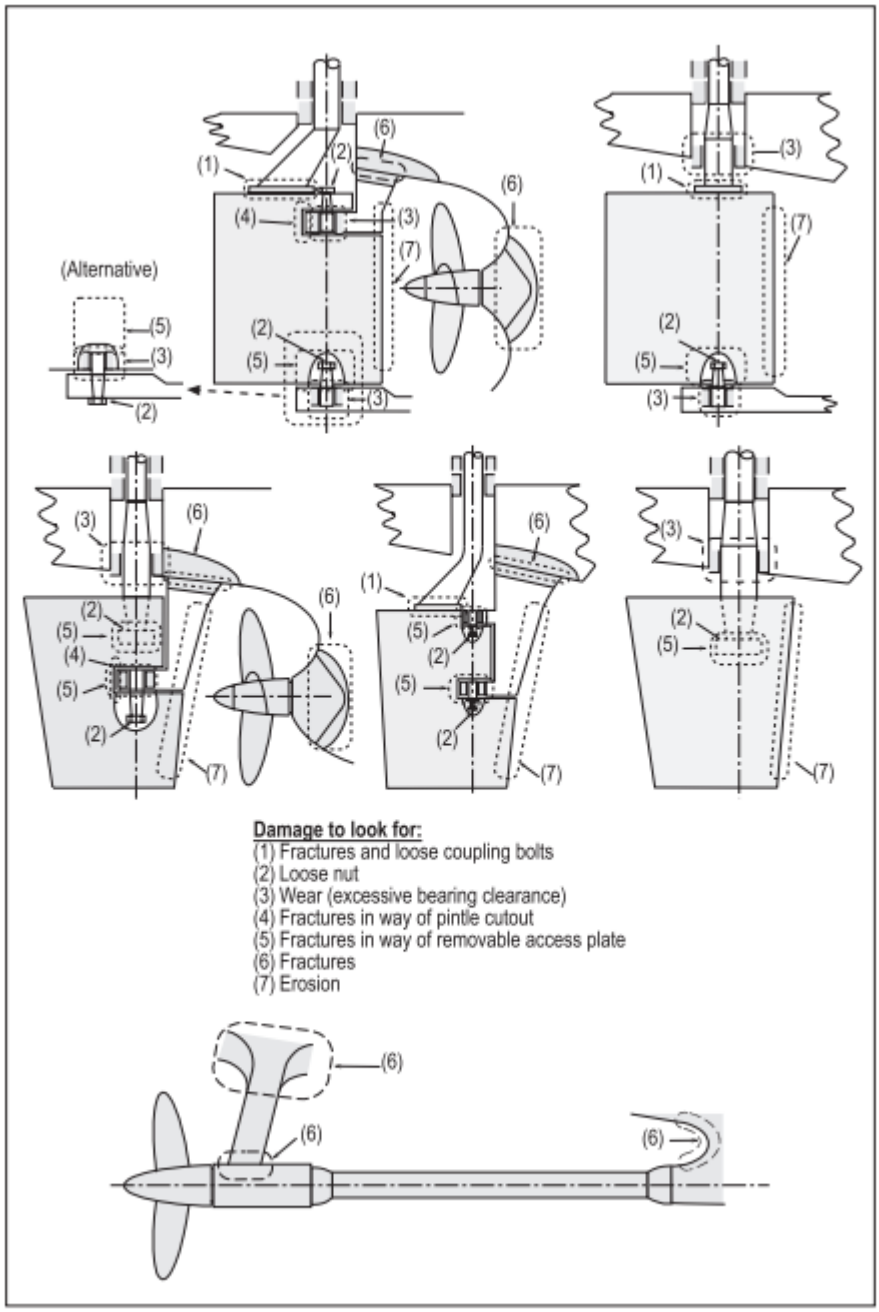


Figure 2 Potential problem areas

2 What to look for – Drydock inspection

2.1 Deformations

2.1.1 Rudder blade, rudder stock, rudder horn, sole piece and propeller boss/brackets have to be checked for deformations.

2.1.2 Excessive clearance could be an indication of deformation of rudder stock/rudder horn.

2.1.3 Possible twisting, deformation or slipping of the cone connection can be observed by the difference in angle between rudder and tiller.

2.1.4 If bending or twisting deformation is found, the rudder has to be dismounted for further inspection.

2.2 Fractures

2.2.1 Fractures in rudder plating should be looked for at slot welds and welds of the access plate of the vertical cone coupling between the rudder blade and rudder stock and/or pintle. Such welds may have latent defects due to the limited applicable welding procedure. Serious fractures in rudder plating may cause the loss of the rudder.

2.2.2 Fractures should be looked for at weld connections between the rudder horn, propeller boss and propeller shaft brackets, and stern frame.

2.2.3 Fractures should be looked for at the upper and lower corners in way of the pintle recess in case of semi-spade rudders. Typical fractures are shown in **Examples 4** and **5**.

2.2.4 Fractures should be looked for at the transition radius between the rudder stock and horizontal coupling (palm) plate, and the connection between the horizontal coupling plate and rudder blade in the case of horizontal coupling. Typical fractures are shown in **Examples 2** and **3**. Fatigue fractures should be looked for at the palm plate itself in case of loosened or lost coupling bolts.

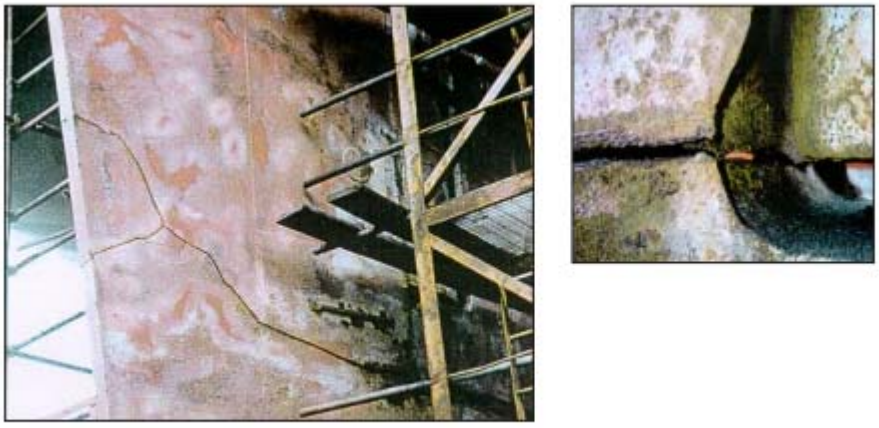
2.2.5 Fractures should be looked for in the rudder plating in way of the internal stiffening structures since (resonant) vibrations of the plating may have occurred.

2.2.6 If the rudder stock is deformed, fractures should be looked for in the rudder stock by nondestructive examinations before commencing repair measures, in particular in and around the keyway, if any.

2.3 Corrosion/Erosion/Abrasion

2.3.1 Corrosion/erosion (such as deep pitting corrosion) should be looked for in rudder/rudder horn plating, especially in welds. In extreme cases the corrosion /erosion may cause a large fracture as shown in

Photograph 1.



Photograph 1 Fractured rudder

2.3.2 The following should be looked for on rudder stock and pintle:

- excessive clearance between the sleeve and bush of the rudder stock/pintle beyond the allowable limit specified by BCS.
- condition of sleeve. If the sleeve is loose, ingress of water may have caused corrosion.
- deep pitting corrosion in the rudder stock and pintle adjacent to the stainless steel sleeve.
- slipping of rudder stock cone coupling. For a vertical cone coupling with hydraulic pressure connection, sliding of the rudder stock cone in the cast piece may cause severe surface damage.
- where a stainless steel liner/sleeve/cladding for the pintle/rudder stock is fitted into a stainless steel bush, an additional check should be made for crevice corrosion.

3 General comments on repair

3.1 Rudder stock and pintles

3.1.1 If the rudder stock is twisted due to excessive forces such as contact or grounding and has no additional damage (fractures etc.) or other significant deformation, the stock usually can be used. The need for repair or heat treatment of the stock will depend on the amount of twist in the stock according to the requirements of BCS. The keyway, if any, has to be milled in a new position.

3.1.2 Rudder stocks with bending deformations, not having any fractures, may be repaired, depending on the size of the deformation, either by warm or by cold straightening in an approved workshop according to a procedure approved by tTL. In case of warm straightening, as a guideline, the temperature should usually not exceed the heat treatment temperature of 530-580ºC.

3.1.3 In the case of fractures to a rudder stock with deformations, the stock may be used again depending on the nature and extent of the fractures. If a welding repair is considered acceptable, the fractures are to be removed by machining/grinding and the welding is to be based on an approved welding procedure together with post weld heat treatment as required by BCS.

3.1.4 Rudder stocks and/or pintles may be repaired by welding replacing wasted material by similar weld material provided its chemical composition is suitable for welding, i.e. the carbon content must usually not exceed 0.25%. The welding procedures are to be identified as a function of the carbon equivalent (Ceq). After removal of the wasted area (corrosion, scratches, etc.) by machining and/or grinding the build-up welding has to be carried out by an automatic spiral welding according to an approved welding procedure. The welding has to be extended over the area of large bending moments (rudder stocks). In special cases post weld heat treatment has to be carried out according to the requirements of BCS. After final machining, a sufficient number of layers of welding material have to remain on the rudder stock/pintle. A summary of the most important steps and conditions of this repair is shown in the **Figure 3**.

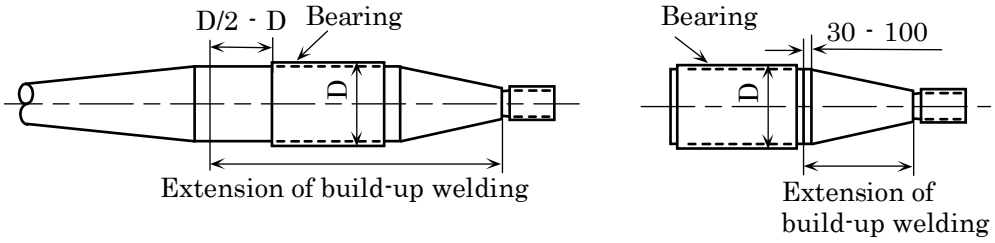
3.1.5 In the case of rudder stocks with bending loads, fatigue fractures in way of the transition radius between the rudder stock and the horizontal coupling plate cannot be repaired by local welding. A new rudder stock with a modified transition geometry has to be manufactured, as a rule (See **Example 2**). In exceptional cases a welding repair can be carried out based on an approved welding procedure. Measures have to be taken to avoid a coincidence of the metallurgical notch of the heat affected zone with the stress concentration in the radius area. Additional surveys of the repair (including non-destructive fracture examination) have to be carried out in reduced intervals.

Replacing wasted material by similar ordinary weld material

- Removal of the wasted area by machining and/or grinding, non-destructive examination for fractures (magnetic particle inspection preferred)

- Build-up welding by automatic spiral welding (turning device) according to an approved welding procedure (weld process, preheating, welding consumables, etc.)

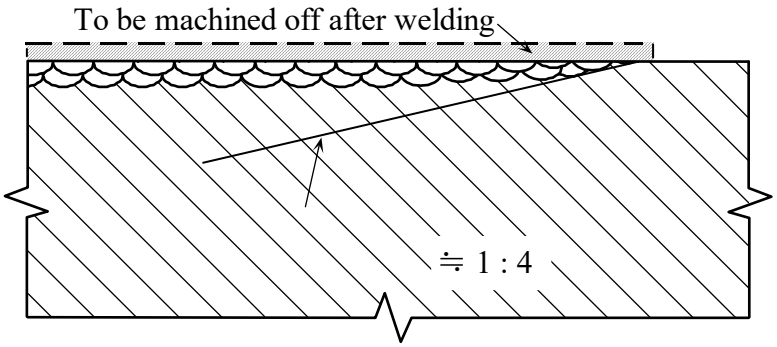
- Extension of build-up welding over the area of **large bending moments** (**shafts**) according to the sketch



Rudder stock Pintle

- Sufficient number of weld layers to compensate removed material, at least one layer in excess (heat treatment of the remaining layer)

- Transition at the end of the build-up welding according to the following sketch



- Post weld heat treatment if required in special cases (never for stainless steel cladding on ordinary steel)

- Final machining, at least two layers of welding material have to remain on the rudder stock (See the above sketch)

- Non-destructive fracture examination

Figure 3 Rudder stock repair by welding

3.2 Plate Structure

3.2.1 Fatigue fractures in welding seams (butt welds) caused by welding failures (lack of fusion) can be gouged out and rewelded with proper root penetration.

3.2.2 In the case of fractures probably caused by (resonant) vibration, vibration analysis of the rudder plating has to be performed, and design modifications have to be carried out in order to change the natural frequency of the plate field.

3.2.3 Short fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that do not propagate into vertical or horizontal stiffening structures may be repaired by gouging out and welding. The procedure according to **Example 4** should be preferred.

In the case of longer fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that propagate over a longer distance into the plating, a thorough check of the internal structures has to be carried out. The fractured parts of the plating and of the internal structures, if necessary, have to be replaced by insert plates. A proper welding connection between the insert plate and the internal stiffening structure is very important (See **Examples 5** and **6**).

The area of the pintle recess corners has to be ground smooth after the repair. In many cases a modification of the radius, an increased thickness of plating and an enhanced steel quality may be necessary.

3.2.4 For the fractures at the connection between plating and cast pieces an adequate preheating is necessary. The preheating temperature is to be determined taking into account the following parameters:

a) chemical composition (carbon equivalent Ceq)
b) thickness of the structure
c) hydrogen content in the welding consumables
d) heat input

3.2.5 As a guide, the preheating temperature can be obtained from **Diagram 1** using the plate thickness and carbon equivalent of the thicker structure.

3.2.6 All welding repairs are to be carried out using qualified/approved welding procedures.

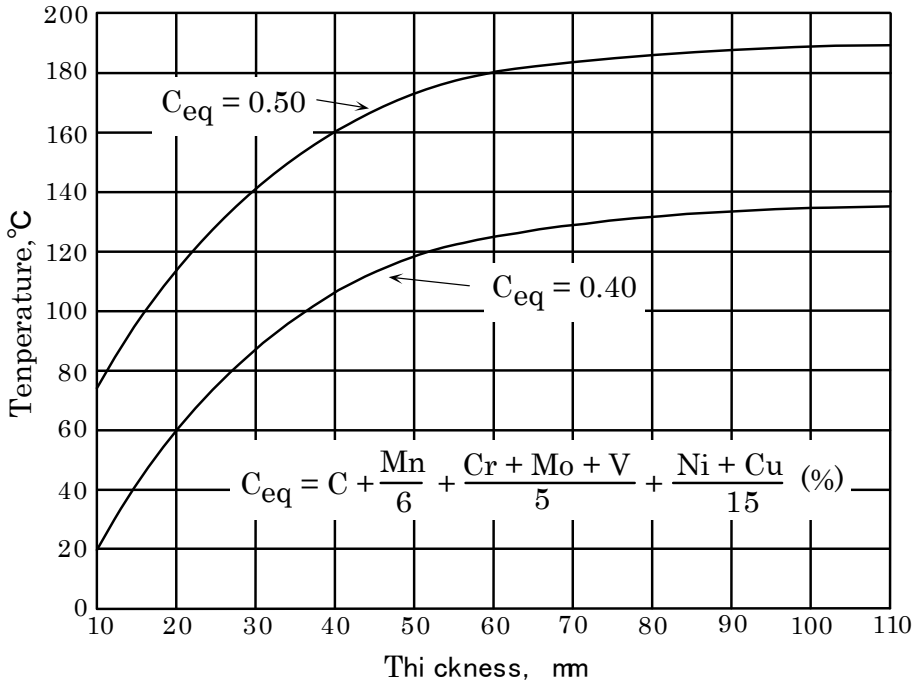


Diagram 1 Preheating temperature

3.3 Abrasion of bush and sleeve

The abrasion (wear down) rate depends on the features of the ship such as frequency of manoeuvring. However, if excessive clearance is found within a short period, e.g. 5 years, alignment of the rudder arrangement and the matching of the materials for sleeve and bush should be examined together with the replacement of the bush.

3.4 Assembling of rudders

During the assembling of the rudder after repair particular attention is to be paid to the alignment of the bearings concerned. For vertical cone couplings the contact surface between rudder stock/pintle and cast piece is to be re-checked after the repair.

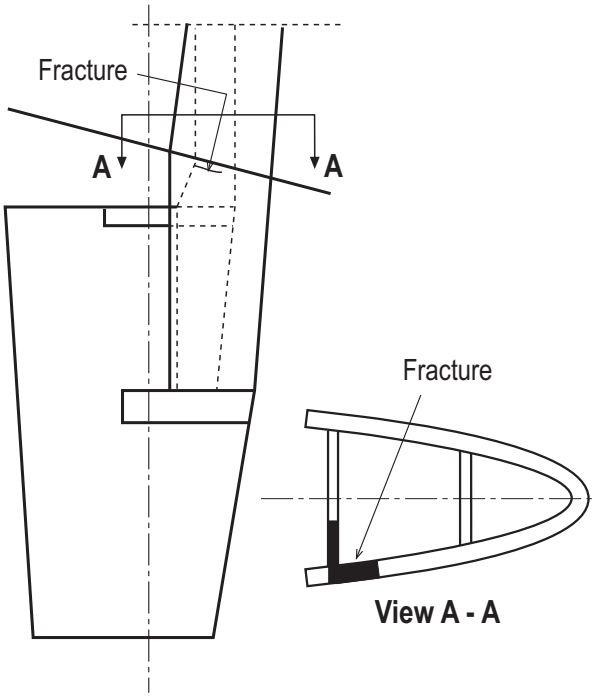
After mounting of all parts of the rudder, rudder stocks nuts with a vertical cone coupling and nuts of pintles are to be effectively secured. In the case of horizontal couplings, bolts and their nuts are to be secured either against each other or both against the coupling plates.

3.5 Propeller boss and stern tube

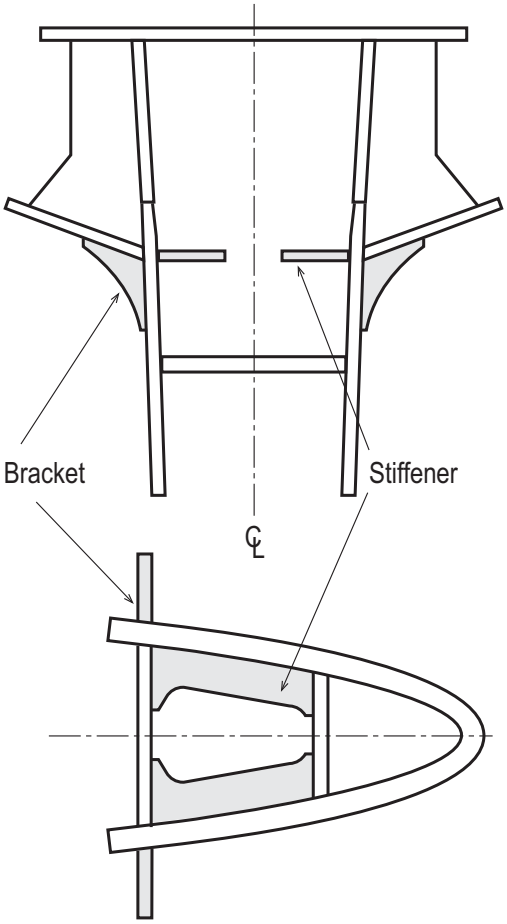
Repair examples for the propeller boss and stern tube are shown in Examples 7 and 8. Regarding the welding reference is made to 3.1.4, 3.2.4 and 3.2.5.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	1
Detail of damage	Fractures in rudder horn along bottom shell plating	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Insufficient strength due to poor design.

Notes on repairs

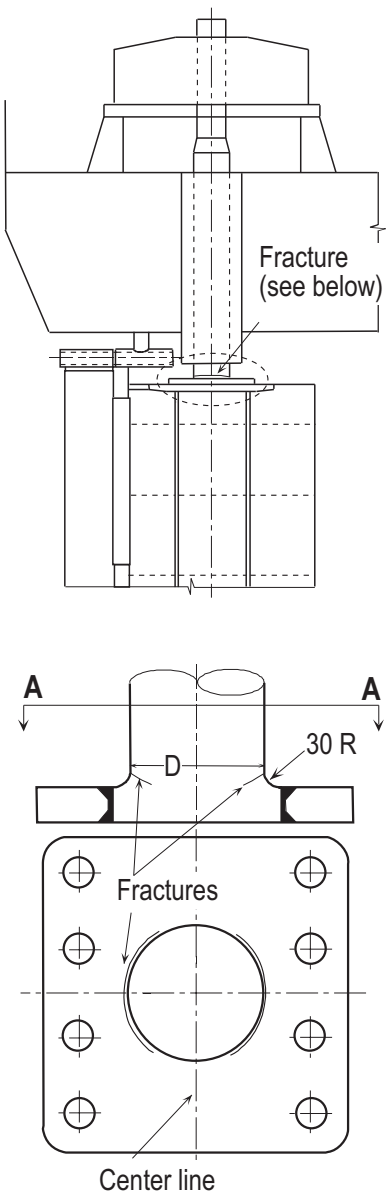
1. Fractured plating to be veed-out and rewelded.

2. Fractured plating to be cropped and renewed if considered necessary.

3. Reinforcement should be considered if considered necessary.

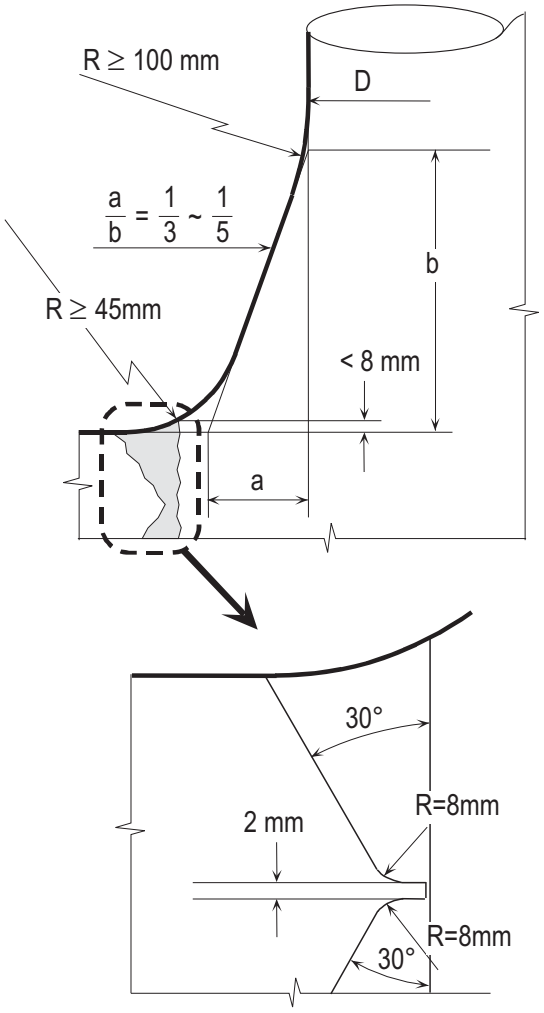
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No. 2
Area 3	Stern frame, rudder arrangement and propeller shaft support	
Detail of damage	Fractures in rudder stock	

Sketch of damage



View A - A

Sketch of repair



Notes on possible cause of damage

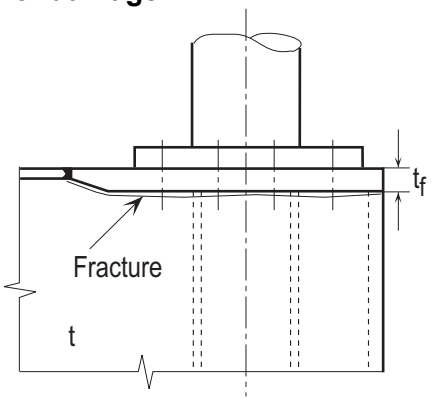
1. Inadequate design for stress concentration in rudder stock.

Notes on repairs

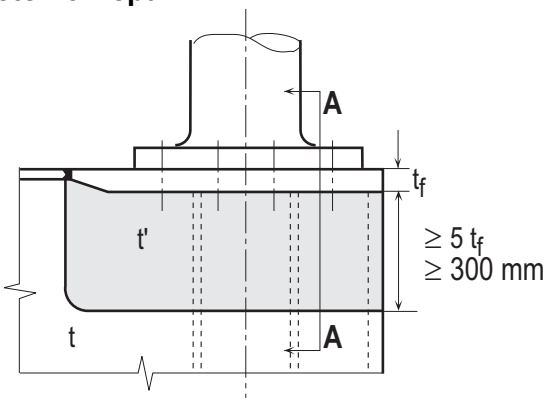
1. Modification of detail design of rudder stock to reduce the stress concentration.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	3
Detail of damage	Fractures in connection of palm plate to rudder blade	

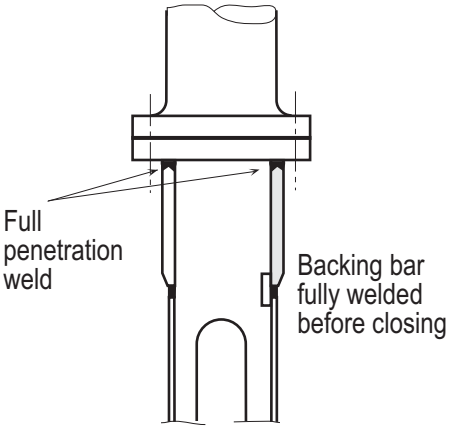
Sketch of damage



Sketch of repair



View A - A



t = plate thickness [mm]

t_f = actual flange thcikness [mm]

$t = \frac{t_f}{3} + 5\ [mm]$, where $t_f \leq 50$ mm

$t = \sqrt[3]{t_f}\ [mm]$, where $t_f \leq 50$ mm

Notes on possible cause of damage

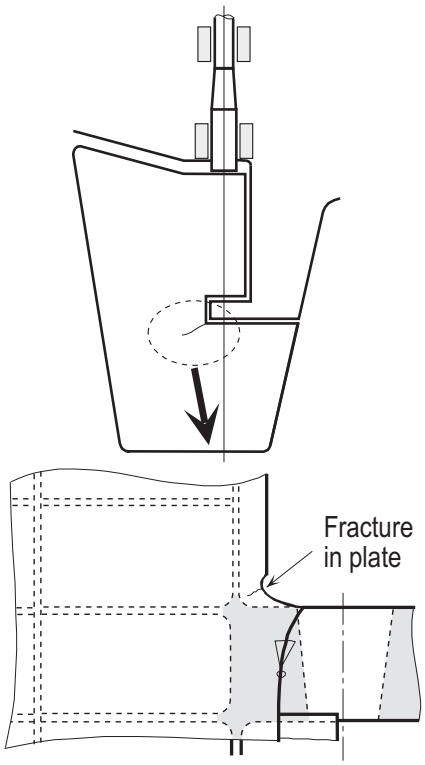
1. Inadequate connection between horizontal coupling plate and rudder blade plating (insufficient plating thickness and/or insufficient fillet weld).

Notes on repairs

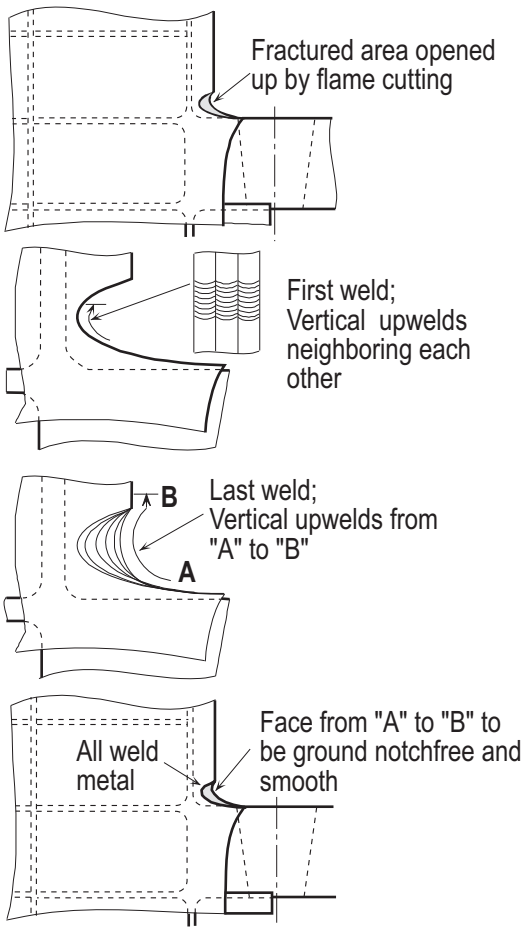
1. Modification of detail design of the connection by increasing the plate thickness and full penetration welding.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	**Fore and aft end regions**	**Example No. 4**
Area 3	**Stern frame, rudder arrangement and propeller shaft support**	
Detail of damage	Fractures in rudder plating of semi-spade rudder (short fracture with end located forward of the vertical web)	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

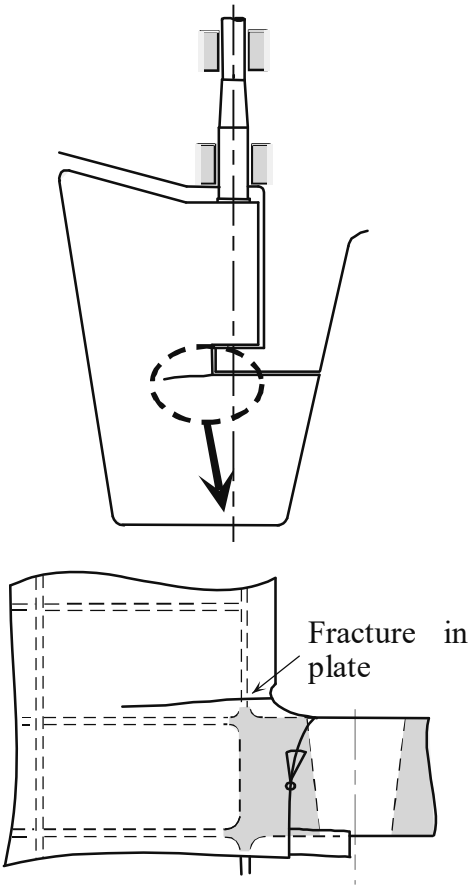
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

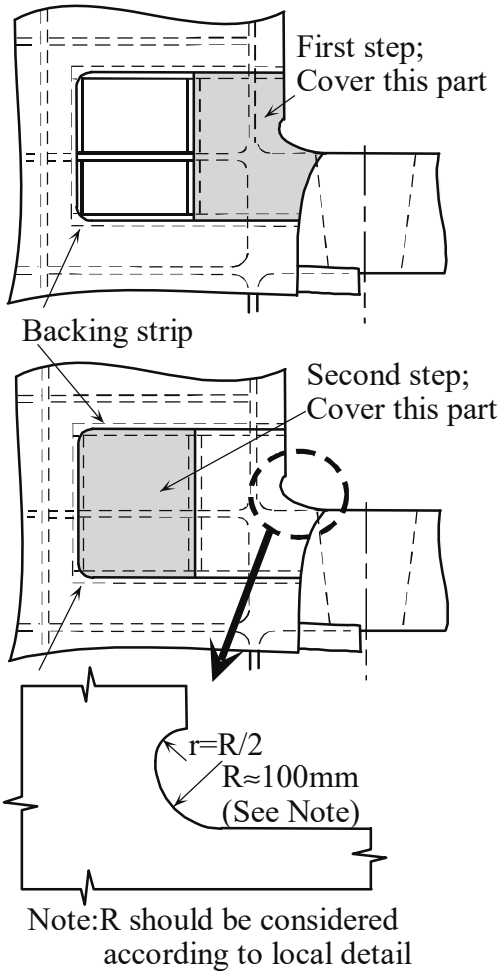
1. Grooving-out and welding of the fracture is not always adequate (metallurgical notch in way of a high stressed area).
2. In the proposed repair procedure the metallurgical notches are shifted into a zone exposed to lower stresses.
3. After welding a modification of the radius according to the proposal in **Example 5** is to be carried out.
4. In case of very small crack it can be ground off by increasing the radius.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	5
Detail of damage	Fractures in rudder plating of semi-spade rudder extending beyond the vertical web	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

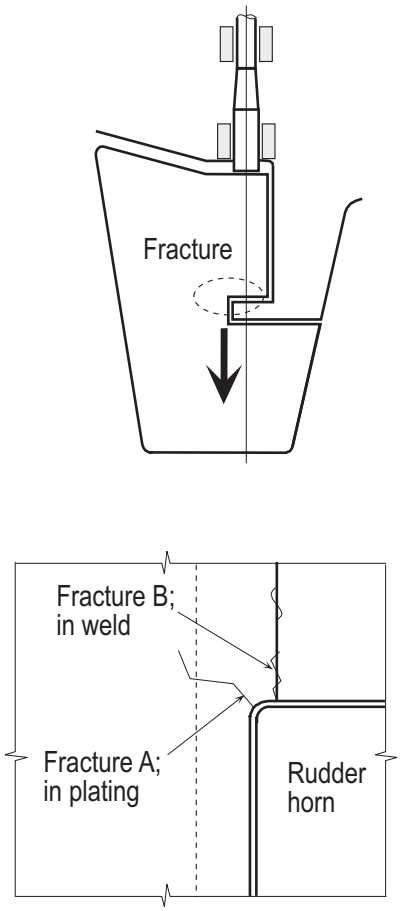
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.

Notes on repairs

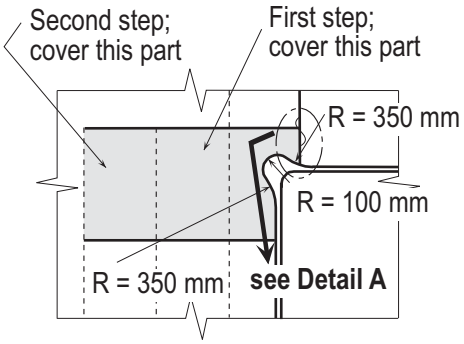
1. Fractured plating is to be cut-out.
2. Internal structures are to be checked.
3. Cut-out is to be closed by an insert plating according to the sketch (welding only from one side is demonstrated).
4. Modification of the radius.
5. In case of a new cast piece, connection with the plating is to be shifted outside the high stress area.

CONTAINER SHIP	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	6
Detail of damage	Fractures in rudder plating of semi-spade rudder in way of pintle cutout	

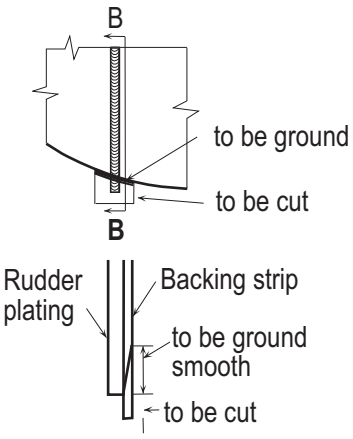
Sketch of damage



Sketch of repair



Note: 1. R should be considered according to local detail
2. New contour should be ground smooth



View B - B

Notes on possible cause of damage

1. Inadequate design for stress concentration in way of pintle bearing (**Fracture A**).

2. Imperfection in welding seam (**Fracture B**).

Notes on repairs

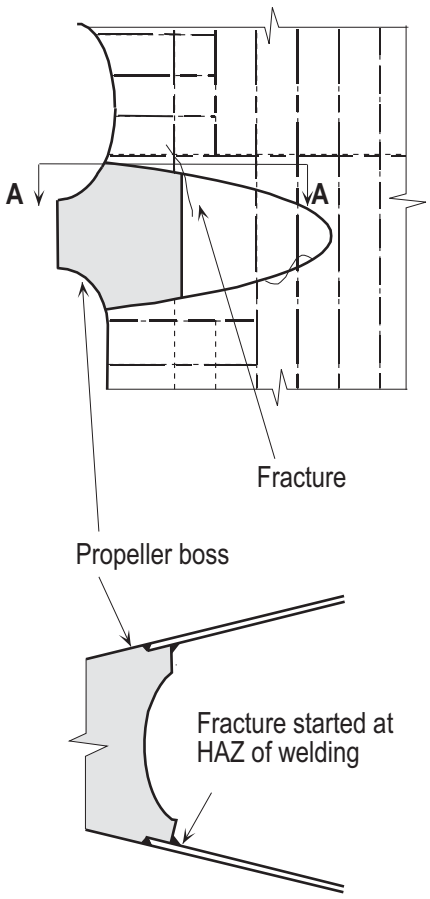
1. Fractured part to be cropped off.

2. Repair by two insert plates of modified, stress releasing contour. For the vertical seam no backing strip is used 100mm off contour, welding from both sides, to be ground after welding.

3. Variant (See **Detail A**): Repair as mentioned under 2 with the use of backing strip for the compete vertical seam. After welding backing strip partly removed by grinding.

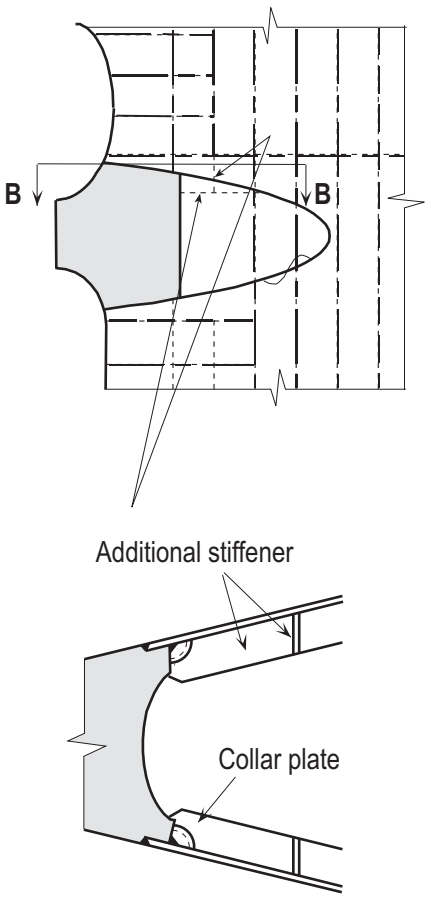
CONTAINER SHIP	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	7
Detail of damage	Fractures in side shell plating at the connection with propeller boss	

Sketch of damage



View A - A

Sketch of repair



View B - B

Notes on possible cause of damage

1. Fatigue fracture due to vibration.

Notes on repairs

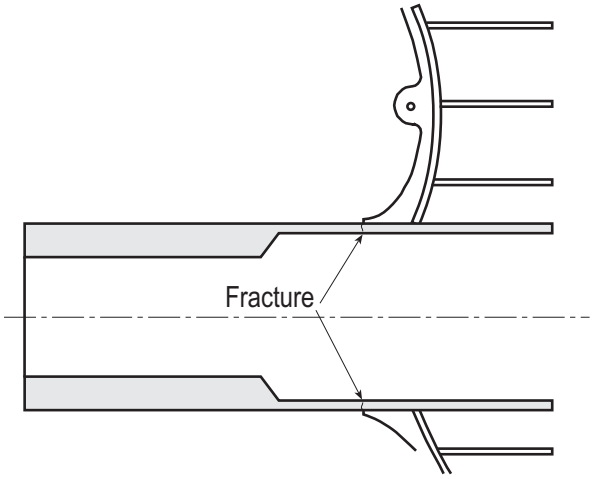
1. Fractured side shell plating is to be cropped and part renewed.

2. Additional stiffeners are to be provided.

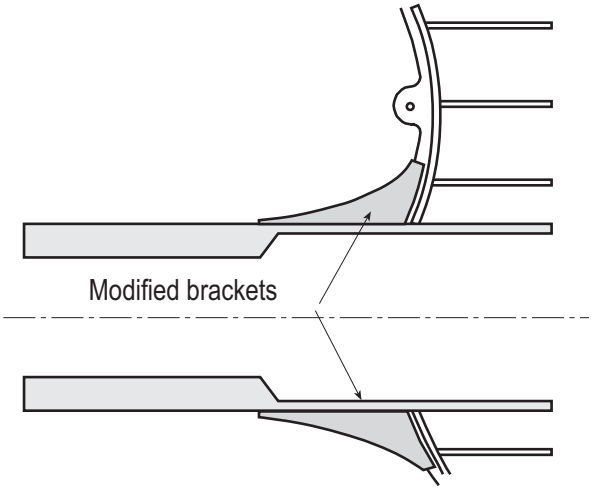
3. Collar plate is to be provided.

CONTAINER SHIP	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support	8
Detail of damage	Fractures in stern tube at the connection with stern frame	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Fatigue fracture due to vibration.

Notes on repairs

1. Fractured tube is to be veed-out and welded from both sides.

2. Brackets are to be replaced by modified brackets with soft transition.

Part 3 Machinery and accommodation spaces

Contents

Area 1 – Engine room structures

Area 2 – Accommodation structures

Area 1 Engine room structures

Contents

1 General

2 What to look for – Engine room inspection
2.1 Material wastage
2.2 Fractures

3 What to look for – Tank inspection
3.1 Material wastage
3.2 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Fractures

Examples of structural detail failures and repairs – Area 1

Example No.	Title
1	Fractures in brackets at main engine foundation
2	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in the engine room
3	Corrosion in bottom plating under inlet/suction pipe in way of bilge storage tank in the engine room

1 General

The engine room structure is categorized as follows:

- Boundary structure which consists of upper deck, bulkhead, inner bottom plating, funnel, etc.
- Deep tank structure
- Double bottom tank structure

The boundary structure can generally be inspected routinely and therefore any damages found can usually be easily rectified. Deep tank and double bottom structures, owing to access difficulties, generally cannot be inspected routinely. Damage of these structures is usually only found during dry docking or when a leakage is in evidence.

2 What to look for – Engine room inspection

2.1 Material wastage

2.1.1 Tank top plating, shell plating and bulkhead plating adjacent to the tank top plating may suffer severe corrosion caused by leakage or lack of maintenance of sea water lines.

2.1.2 The bilge well should be cleaned and inspected carefully for heavy pitting corrosion caused by sea water leakage at gland packing or maintenance operation of machinery.

2.1.3 Parts of the funnel forming the boundary structure often suffer severe corrosion which may impair weathertightness and fire fighting in the engine room.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. An examination of the damaged area should be carried out to determine the extent of the damage.

3 What to look for – Tank inspection

3.1 Material wastage

3.1.1 The environment in bilge tanks, where a mixture of oily residue and seawater is accumulated, is more corrosive when compared to other double bottom tanks. Severe corrosion may result in holes in the bottom plating, especially under sounding pipes. Pitting corrosion caused by seawater entering via an air pipe is occasionally found in cofferdam spaces.

3.2 Fractures

3.2.1 In general, deep tanks for fresh water or fuel oil are located in the engine room. The structure in these tanks often sustains fractures due to vibration. Fracture of double bottom structure in the engine room is seldom found due to its high structural rigidity.

4 General comments on repair

4.1 Material wastage

4.1.1 Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed.

Repair work in a double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

4.2 Deformations

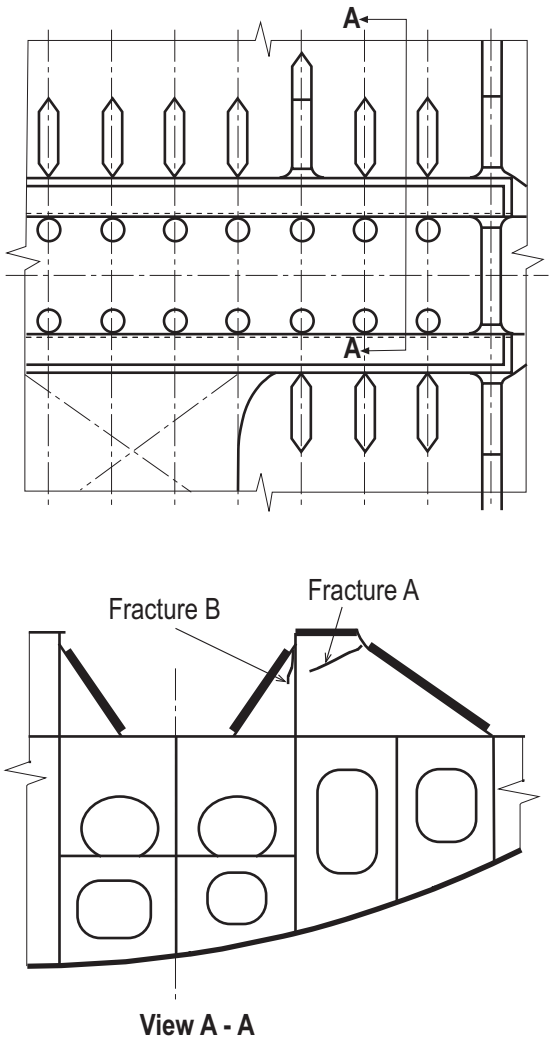
4.2.1 When buckling of the tank top plating has occurred, appropriate reinforcement is necessary in addition to cropping and renewal, regardless of the corrosion condition of the plating.

4.3 Fractures

4.3.1 For fatigue fractures caused by vibration, in addition to the normal repair of the fractures, consideration should be given to modification of the natural frequency of the structure to avoid resonance. This may be achieved by providing additional structural reinforcement, however, in many cases, a number of tentative tests may be required to reach the desired solution.

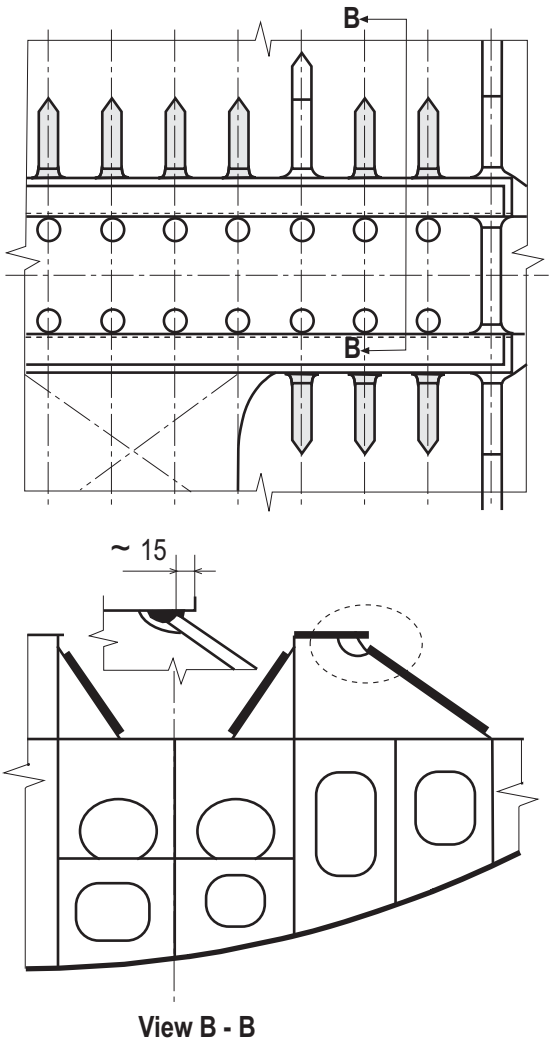
CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	1
Detail of damage	Fractures in brackets at main engine foundation	

Sketch of damage



View A - A

Sketch of repair



View B - B

Notes on possible cause of damage

1. Vibration of main engine.

2. Insufficient strength of brackets at main engine foundation.

3. Insufficient pre-load bolts.

Notes on repairs

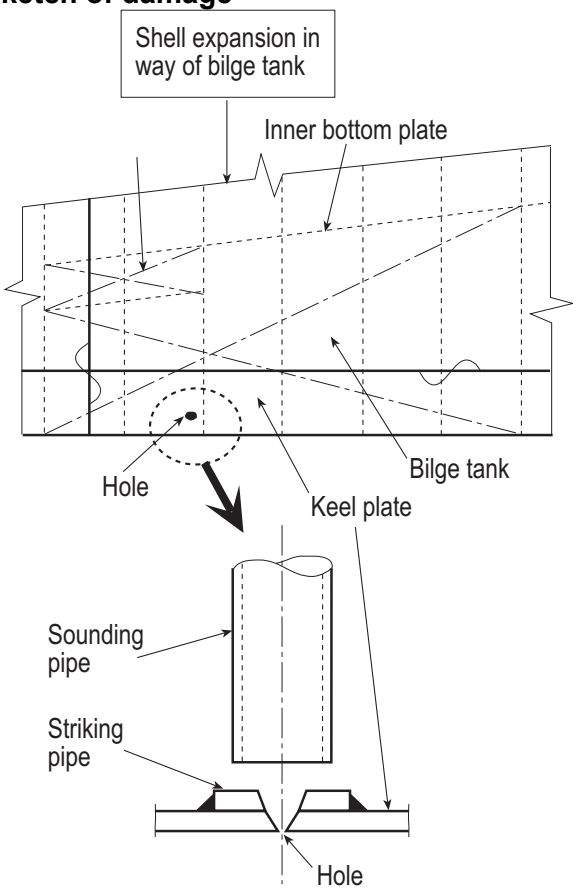
1. Fractures are to be veed-out and rewelded.

2. New modified brackets at main engine foundation.

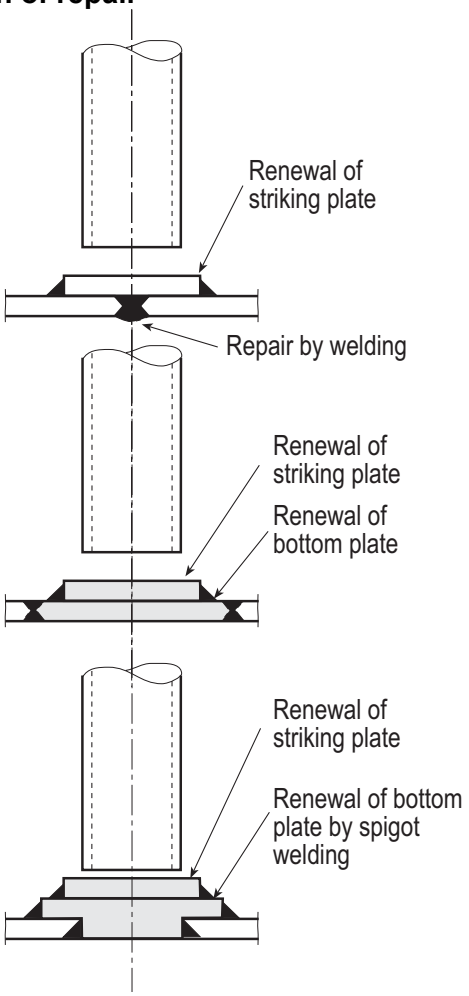
3. Or insert pieces and additional flanges to increase section modulus of the brackets.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	2
Detail of damage	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion of bottom plating under sounding pipe.

Notes on repairs

1. Corroded striking plating should be renewed.

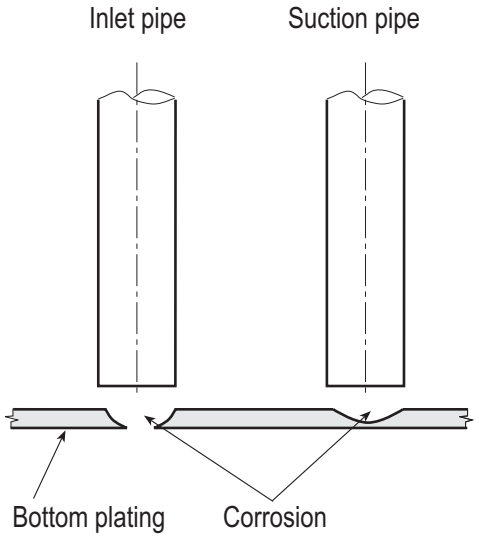
2. Bottom plate should be repaired depending on the condition of corrosion.

(Note)

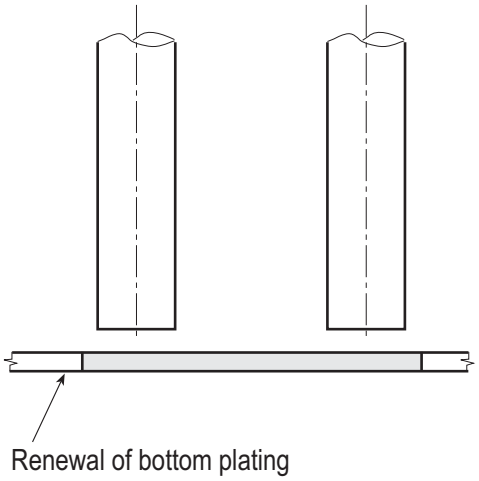
Repair by spigot welding can be applied to the structure only when the stress level is considerably low. Generally this procedure cannot be applied to the repair of bottom plating of ballast tanks in cargo hold region.

CONTAINER SHIPS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	**Machinery and accommodation spaces**	**Example No.**
Area 1	**Engine room structure**	**3**
Detail of damage	Corrosion in bottom plating under inlet/suction/pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Notes on possible cause of damage

1. Heavy corrosion of bottom plating under the inlet/suction pipe.

Notes on repairs

1. Corroded bottom plating is to be cropped and part renewed. Thicker plate is preferable.

2. Replacement of pipe end by enlarged conical opening (similar to suction head in ballast tank) is preferable.

Area 2 Accommodation structure

Contents

1 General

Figures and/or Photographs – Area 2

No.	Title
Photograph 1	Corroded accommodation house side structure

1 General

Corrosion is the main concern in accommodation structures and deck houses of ageing ships. Owing to the lesser thickness of the structure plating, corrosion can propagate through the thickness of the plating resulting in holes in the structure.

Severe corrosion may be found in exposed deck plating and the deck house side structure adjacent to the deck plating where water is liable to accumulate (See **Photograph 1**). Corrosion may also be found in accommodation bulkheads around the cutout for fittings, such as doors, side scuttles, ventilators, etc., where proper maintenance of the area is relatively difficult. Deterioration of the bulkheads including fittings may impair the integrity of weathertightness.

Fatigue fractures caused by vibration may be found in the structure itself and in various stays of the structures, mast, antenna etc. For such fractures, consideration should be given to modify the natural frequency of the structure by providing additional reinforcement during repair.

Photograph 1 Corroded accommodation house side structure

BCS-G 85 Recommendations on Voyage Data Recorder

These Recommendations are applicable to Voyage Data Recorders (VDR) required by SOLAS Chapter V, Reg. 20.

These Recommendations may be used by IACS Member Societies in conjunction with their requirements and procedures when approving VDR installation for ships.

The recommendations are based on the understanding that the applicable regulations and guidelines issued by the International Maritime Organization are complied with and, in particular IMO Res. A.694(17) and Res. MSC.333(90).

These Recommendations refer to VDRs installed on or after 1 July 2014. For VDRs installed before 1 July 2014 refer to Res. A.861(20), as amended by resolution MSC.214(81).

1. Type Approval

The VDR should be type approved (ref. SOLAS reg.V/18.1) and installed according to IMO Res. MSC.333(90). The VDR should be type tested according to IEC 61996.

2. Approval of documents

The following documents should be submitted for plan approval prior for the VDR installation onboard ship:

- General description of the installation
- Cable plan/block diagram identifying all sensors and cable types
- List of data items to be recorded by VDR
- All sensor’s interface specification
- Location of all VDR components (e.g. main unit, fixed recording medium in its protective capsule, float-free recording medium in its float-free capsule, long-term recording medium, dedicated reserve power source, microphones)
- Information about power supply to the VDR
- Type Approval Certificate for the VDR issued by or on behalf of the Administration.

BCS-G 86 Applicable Standards for BCS-R P4.7 “Requirements for Type Approval of Plastic Pipes”

Table 1: Typical requirements for all systems

	Test	Typical Standard	Notes
1	Internal pressure (1)	P4.3.1.3(i), ASTM D1599, ASTM D2992, ISO 15493 or equivalent	Top, Middle, Bottom (of range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections.
2	External pressure (1)	P4.3.1.3(ii), ISO 15493 or equivalent	As above, for straight pipes only.
3	Axial strength	P4.3.2	As above
4	Load deformation	ASTM D2412 or equivalent	Top, Middle, Bottom (of each pressure range)
5	Temperature limitations	ISO 75 Method A GRP piping system: HDT test on each type of resin acc. to ISO 75 method A Thermoplastic piping systems: ISO 75 Method A ISO 306 Plastics - Thermoplastic materials - Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80^0 C should not be used.	Each type of resin
6	Impact resistance	ISO 9854, ISO 9653, ISO 15493 ASTM D2444, or equivalent	Representative sample of each type of construction
7	Ageing	Manufacturer's standard ISO 9142	Each type of construction
8	Fatigue	Manufacturer's standard or service experience.	Each type of construction
9	Fluid absorption	ISO 8361	
10	Material compatibility (2)	ASTM C581 Manufacturer 's standard	

Table 2: Typical additional requirements depending on service and/or locations of piping

	Test	Typical Standard	Notes
1	Fire endurance (1)(2)	IMO Res. A.753(18), as amended, Appendix 1, 2	Representative samples of each type of construction and type of pipe connection
2	Flame spread (1)(2)	IMO Res. A.753(18), as amended, Appendix 3	Representative samples of each type of construction.
3	Smoke generation (2)	IMO Res. A.753(18), as amended, Appendix 3	Representative samples of each type of construction.
4	Toxicity (2)	IMO Res. A.753(18), as amended, Appendix 3	Representative samples of each type of construction.
5	Electrical conductivity (1)(2)	ASTM F1173-95 or ASTM D257, NS 6126 para. 11.2 or equivalent	Representative samples of each type of construction

Footnotes:

(1) Test to be witnessed by **BCS**'s Surveyor.

(2) If applicable.

Note: Tests of Table 2 are optional however, if not carried out, the range of approved applications for the pipes will be limited accordingly (see BCS-R P4. 4).

3. Survey

3.1 Testing of a new installation.

The final installation should be tested according to the manufacturer's instructions. Testing of the installation normally requires attendance from the manufacturer representative and use of special playback equipment (ref. IMO Res. MSC.333(90), Annex, 5.1.3).

Before the surveyor attends the test, the VDR should record for a period of at least 12 hours with all sensor inputs active (in operation) before the recorded data is presented for the surveyor item by item according to paragraph 7 in this document.

The survey is to verify that the installation complies with paragraphs 4, 5 and 7 of this document. In addition to verifying that the required sensor data of paragraph 7 are recorded as applicable, it should be verified that the configuration file includes proper identification of the data received on the various input channels.

The procedures required for data retrieval should be included in the ship's safety management system[1] and to be verified by or on behalf of the Administration.

3.2 Annual testing of VDR.

The voyage data recorder system, including all sensors, should be subjected to an annual performance test. The test should be conducted by an approved service supplier to verify the accuracy, duration and recoverability of the recorded data. In addition, tests and inspections should be conducted to determine the serviceability of all protective enclosures and devices fitted to aid location (Ref. SOLAS Ch. V Reg.18.8 and HSC Reg.13.16.2).

The service supplier should be approved by the Society or approvals done by the Flag Administration itself or duly authorised organisations acting on behalf of the Flag Administration. Service supplier approvals granted on behalf of the Flag Administration are to be conducted in accordance with the procedures detailed in BCS-R Z17, with reference to Annex 1, paragraph 9 therein.

The Surveyor should check that the vessel has a copy of a valid Certificate of Compliance (COC) which should contain following information:

- name and IMO number of the ship
- date and place of successfully passed testing
- manufacturer, type and serial number of the VDR
- name and address of service supplier
- name and signature of the technician carrying out the annual performance test
- Society service supplier approval certificate number and the date of expire of the service supplier certificate.

If the ship is not able to present a Certificate Of Compliance to document the annual test, only a conditional short term Passenger Ship Safety Certificate/Cargo Ship Safety Equipment Certificate/Cargo Ship Safety Certificate should be issued.

[1] see section 10 of the ISM Code

4. Location of the VDR components

All VDR components should be installed according the VDR manufacturer's installation guidelines and any special requirements stated in the Type Approval Certificate.

4.1 Fixed and float-free recording medium

The protective capsule should be located in open deck area close to the bridge and as near to the centerline of the ship as practically possible. Considerations should be made to ensure both the accessibility for routine maintenance and the accessibility for both ROVs and divers in case of underwater removal after an accident. The location of the float-free capsule should minimise the interference by radar beam and the risk of obstruction after release.

4.2 Microphones

Microphones should be so positioned on the bridge covering all work stations as described in MSC/Circ.982 so that conversation is recorded. The recording should be such that, on playback, a normal speaking voice should provide adequate intelligibility while the ship is performing its normal operations. This performance should be maintained at all work stations while there is a single audio alarm anywhere on the bridge or any noise, including noise from faulty equipment or mounting, or wind. This should be achieved through the use of at least two channels of audio recording. Microphones positioned outside on bridge wings, should be recorded on at least one additional separate channel.

4.3 Alarm unit

The VDR alarm unit (audible alarm device and visual indicator) should be located in the navigation bridge.

4.4 Other components

All other VDR components can be located as found appropriate allowing for easy maintenance (ref. IMO Res. MSC.333(90), Annex, 5.1.3).

5. Power supply

The VDR should be connected to the ship's main and emergency source of power and backed-up by the dedicated reserve source of electrical power for a period of 2 hours.

Recording should be continuous unless automatically terminated at the end of the 2 hour period of the supply by the dedicated reserve source of electrical power.

6. Sensor interfacing

Loss of one sensor should not cause loss of other data items that do not depend upon the particular sensor (e.g. failure of the radar should not cause loss of other data items than the radar picture).

The signal information may be derived from discrete sensors wired directly to the VDR or may also be derived from a suitable data network connection. Where the information is derived from a data network the interfacing should be implemented in such a manner that the network will continue to operate as intended in the event of any VDR system or interface component fault. The data transfer should be conducted in accordance with a relevant international interface standard (ref. IMO Res. MSC.333(90), Annex, 8).

7. Sensor input

7.1 Date and time

Date and time, referenced to UTC, should be obtained from a source external to the ship and an internal clock should be synchronized with valid date and time data. During times of a loss of the external source, the internal clock should be used. The recording should indicate which source is in use. The recording method should be such that the timing of all other recorded data items can be derived on playback with a resolution and continuity sufficient to reconstruct the history of the incident in detail (ref. IMO Res. MSC.333(90), Annex, 5.5.1).

7.2 Ship's position

From a global navigation satellite system receiver or alternatively, a terrestrial radionavigation system. The ships position should be recorded, as available on the ship, up to a resolution of 0.0001 min of arc.

7.3 Speed

Speed through water and speed over ground, including an indication which it is, derived from the speed and distance measuring equipment (speed log) should be recorded, as available on the ship, up to a resolution of 0.1 knots. The interval between recordings is not exceed 1 second. Speed over ground input from an Electronic Position Fixing System (EPFS) will require that EPFS is approved as speed log.

7.4 Heading

Heading from the main heading source in use should be recorded, as available on the ship, up to a resolution of 0.1. The interval between recordings is not exceed 1 second.

7.5 Bridge audio

The bridge audio signals should be recorded in accordance with paragraph 4.6.5 of IEC 61996.

7.6 Communication audio

From the VHF installed nearest to the conning position (see SOLAS Ch. V Reg. 22) or alternatively, nearest to the main radar display.

7.7 Radar data

The radar picture from the main radar (normally X-band at main conning position). Updating period less than every 15 second.

For ships where the statutory instrument requires two radar installations to be fitted and where inter switching facilities are provided between each installation the information from the radar installation that is in use by the navigator at the time of recording is the information that should be held in the voyage data recorder final recording medium.

7.8 ECDIS

Where a vessel is fitted with an ECDIS installation, the VDR should record the ECDIS display in use at the time as the primary means of navigation.

NOTE: In the case of a ship fitted with an INS, ‘ECDIS display’ signifies ‘route monitoring task and functions display’.

Where multiple ECDIS are installed and when it is not possible to determine which ECDIS image is used as the primary means of navigation, all images should be recorded in sequence such that at least one image is recorded at an interval not exceeding 15 s, with the most recent image from each location stored in turn. E.g. when 3 ECDIS displays are in use then each ECDIS image should be recorded at least every 45 s.

7.9 Echo sounder

Depth below the keel up to a resolution of 0.1m as available on the ship. The depth scale currently being displayed and other status information should be recovered where available. Updating frequency better than 1 Hz.

7.10 Main alarms

This should include the status of all mandatory alarms on the bridge, as listed in Resolution A.1021(26), Code on Alerts and Indicators, table 10.1.1.

Where the alarm functions described in table 10.1.1 include more than one alarm, the items should be recorded such that the status of each individual alarm can be identified within the final recording medium.

Where the statutory instruments permits the installation of override arrangements of shutdown or alarm functions, the activation of the override should be identified in the final recording medium.

7.11 Rudder order and response

The status of all steering gear power units installed in the ship and the status and settings of the control mode should be identified within the final recording medium.

Where arrangements are made for the remote control of the steering gear from more than one location, such as bridge wings or from automatic control systems such as autopilots and track controllers the individual order and response for the steering gear from the control location in operation and settings of the control mode in operation should be identified within the final recording medium.

Rudder order and response angles should be recorded up to a resolution of 1 degree as available and permitted on the ship. The interval between recordings is not exceed 1 second.

7.12 Engine and thruster order and response

This should include the positions of engine telegraph or direct engine/propeller pitch controls in operation, including shaft(s) r.p.m (or equivalent), and feedback indications, if fitted, including ahead/astern indicators. This should also include status of all propulsion thrusters (i.e. r.p.m., pitch and thrust direction).

RPM should be recorded up to resolution of 1 r.p.m. Where the controllable pitch propeller is used, the pitch should be recorded up to a resolution of 1 degree. The interval between recordings is not exceed 1 second.

7.13 Hull openings status

This should include all mandatory status information required to be displayed on the bridge.

Reference	Alarm	Applicability	Comments
SOLAS II-1			
15-1.2	Position of watertight external openings, except for cargo hatch covers	Cargo ships	

7.14 Watertight and fire door status

This should include all mandatory status information required to be displayed on the bridge.

Reference	Alarm	Applicability	Comments
SOLAS II-1			
13.6 and 14.2	Power-operated watertight doors indication	Passenger ships constructed on or after 1 February 1992 or passenger ships carrying goods vehicles and accompanying personnel regardless of the date of construction (ref. SOLAS II- 1/16.1/2)	*
13-1.2	Position of internal watertight doors used while at sea	Cargo ships	*
13-1.3	Position of internal watertight door and access hatch covers normally closed at sea	Cargo ships	*
SOLAS II-2			
7.9.3	Fire door indication	Passenger ships carrying more than 36 passengers	* If located on the bridge
9.4.1.1.5.6	Fire door indication	Passenger ships	* If located on the bridge
9.4.1.1.5.13	Special category space fire door indication	Passenger ships	* Except if power operated and automatically closed

* The status of each individual door should be identified within the final recording medium.

7.15 Accelerations and hull stresses

Where a ship is fitted with IMO mandated hull stress and response-monitoring equipment, all the data items that have been pre-selected within the equipment should be identified within the final recording medium. The interval between the recordings is not to exceed 1 second.

7.16 Wind speed and direction

This should be applicable where a ship is fitted with a sensor having a suitable output in accordance with IEC 61162. Either relative or true wind speed and direction should be identified within the final recording medium together with the information which of relative or true wind speed is recorded. The interval between the recordings is not to exceed 15 seconds.

7.17 AIS

All AIS data should be recorded.

7.18 Rolling Motion

The VDR should be connected to an electronic inclinometer if installed. The recording method should be such that the rolling motion can be reconstructed during playback.

7.19 Electronic Logbook

Where a ship is fitted with an electronic logbook in accordance with the standards of the IMO the information from this should be recorded.

NOTE: At the time of writing the IMO has not published any standards for this purpose.

7.20 Additional information

All other information recorded by the VDR should not degrade the performance of the VDR (e.g. reduce the capacity of the Protective Memory Capsule).

Recommendation 87

GUIDELINES FOR COATING MAINTENANCE & REPAIRS FOR BALLAST TANKS AND COMBINED CARGO/BALLAST TANKS ON OIL TANKERS

TANKS AND COMBINED CARGO/BALLAST TANKS ON OIL TANKERS
June 2004/Rev.1 June 2006/Rev.2 May 2015

BCS- G 87

Guidelines for Coating Maintenance & Repairs for Ballast tanks and Combined Cargo/Ballast tanks on Tankers

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Foreword

The principal objective of BCS is to set the technological standard for ships, in order to secure safety of life, property and environment at sea. With these Guidelines, BCS aims at assisting the Surveyors, Owners, Yards, Flag Administrations and other interested parties involved in the survey, assessment and repair of coatings in ballast tanks and combined cargo/ballast tanks herein referred to as “ballast tanks” on tankers.

Considerable space is dedicated, in these Guidelines, to definitions and description of terms (Appendix E) aiming at:

- describing every term which is used in these Guidelines and other commonly used terms, and
- providing, through a common language, the basis for a common understanding.

It is therefore suggested that Class Surveyors and Inspectors of Owners, Yards, Administrations and Manufacturers use, as far as possible, these definitions.

The motivation for developing these Guidelines is the revision of the BCS-R Z10.1, Z10.3 and Z10.4, which imply that coating found in less than GOOD condition is repaired or maintained in order to avoid annual survey. These Guidelines address a clear definition of GOOD coating condition and how to restore from FAIR and/or POOR conditions to GOOD respectively.

The basis for developing these Guidelines has been several Tanker Structure Co-operative Forum (TSCF) publications (see Reference), accordingly some text and illustrations have been reproduced directly in these Guidelines. TSCF assistance in the development of these Guidelines and permission to use such material is gratefully acknowledged.

1. Introduction

a) Application

These Guidelines focus on survey, maintenance and repair procedures of coatings.

Chapter 2 is primarily intended for Class surveyors in assessing the coating condition. Chapter 3 is primarily intended for Owners, Yards and Flag Administrations in connection with inspection, maintenance and/or repair schemes.

These Guidelines deal with ballast tanks and combined cargo/ballast tanks herein referred to as “ballast tanks” on tankers in service. They only cover maintenance and repair of coatings. Corrosion prevention systems other than coating are not covered, nor is the design, installation and maintenance of anodes, for such topics, clarification should be obtained by BCS. Steel repair is further described in other relevant BCS- G 47 “Shipbuilding and Repair Quality Standard”.

The intention with maintenance and repair in this context is to either:

- maintain GOOD coating condition, or
- restore GOOD coating condition if the coating is found in FAIR or POOR condition.

These Guidelines have been developed using the best information currently available, and considering that maintenance and repair may take place:

- In dry dock
- Afloat at yard
- On voyage (Riding crew)

They are intended only as guidance in support of the sound judgement of surveyors. Should there be any doubt with regard to interpretation or validity in connection with the use of these Guidelines, clarification should be obtained from BCS.

b) Class survey requirements

The coating system in ballast tanks is to be examined in connection with:

- Intermediate Surveys for tankers exceeding 5 years of age,
- Special Surveys for all tankers

The condition of the coating in ballast tanks is assigned and categorised as GOOD, FAIR or POOR based on visual inspection and estimated percentage of areas with coating failure and rusty surfaces. (see Table II in Chapter 2).

The ballast tank will be subject to Annual Survey when, during an Intermediate or Special Survey, as applicable, it is found with:

- no protective coating from the time of construction, or
- a soft coating, or
- ***Substantial Corrosion*** or
- protective coating in less than GOOD condition and the protective coating is not repaired to the satisfaction of the Surveyor, or
- a common plane boundary with a cargo tank with any means of heating, regardless of whether the heating system is in use and regardless of the condition of the

coating. (Only single hull oil tanker as defined in UR Z10.1)

Thickness measurements to the same extent as the previous Special Survey are mandatory requirements of Intermediate Surveys for tankers exceeding 10 years of age. However, the surveyor may request thickness measurements as a result of his examination of the ballast tanks, if he considers it necessary, on a tanker of any age. If the results of these thickness measurements indicate that ***Substantial Corrosion*** is present, the extent of thickness measurements is to be increased.

Areas of ***Substantial Corrosion*** identified at previous Special, Intermediate or Annual Surveys are to have thickness measurements taken at Annual Surveys regardless of the coating condition. ***Substantial Corrosion*** is an extent of corrosion such that assessment of corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits. When wastage exceeds acceptable limit, repair such as renewal of the hull structural members is to be carried out.

Further details on the scope and extent of annual surveys are provided in:

- BCS- R Z10.1, Z10.3 and Z10.4
- the instruction to surveyor of individual Classification Societies.

A record of ***Substantial Corrosion*** should still be made even if the owner elects to coat the area and arrest further corrosion.

For areas in ballast tanks where coatings are found to be in a GOOD condition, the extent of thickness measurements may be specially considered by BCS.

Special Surveys are to be carried out at 5 years intervals to renew the Class Certificate. Intermediate Survey is to be held at or between either the 2nd or 3rd Annual Survey. Annual Surveys are to be held within 3 months before or after anniversary date.

Table I shows the sample difference in frequency of internal inspections for ballast tanks in GOOD and less than GOOD condition.

Table I Sample difference in frequency of inspections for ballast tanks

Coating Condition	**Surveys (Internal Inspection)**															
Good	S			I		S			I		S			I		S
Fair or Poor	S	A	A	I	A	S	A	A	I	A	S	A	A	I	A	S
Years	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Note S: Special Survey I: Intermediate Survey A: Annual Survey																

Table I indicates also that the interval between a survey at which the coating is found in GOOD condition and the next following survey is 2 or 3 years, i.e. an average value of 30 months.

2. Coating Conditions

a) GOOD, FAIR, POOR

The ***present definitions*** of coating conditions "GOOD", "FAIR" and "POOR" in IMO Resolution A.1049(27)-ESP Code and BCS- R Z10.1, Z10.3 and Z10.4 are as follows:

GOOD: condition with only minor spot rusting
FAIR: condition with local breakdown of coating at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition
POOR: condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration

In ***these Guidelines***, it is found necessary to offer a clarification of these definitions in order to achieve unified assessment of coating conditions as follows, see also Table II below:

GOOD: Condition with spot rusting on less than 3% of the area under consideration without visible failure of the coating. Rusting at edges or welds, must be on less than 20 % of edges or weld lines in the area under consideration.
FAIR: Condition with breakdown of coating or rust penetration on less than 20 % of the area under consideration. Hard rust scale must be less than 10 % of the area under consideration. Rusting at edges or welds must be on less than 50 % of edges or weld lines in the area under consideration.
POOR: Condition with breakdown of coating or rust penetration on more than 20% or hard rust scale on more than 10% of the area under consideration or local breakdown concentrated at edges or welds on more than 50 % of edges or weld lines in the area under consideration.

Table II BCS clarification of "GOOD", "FAIR" and "POOR" coating conditions

	GOOD (3)	**FAIR**	**POOR**
Breakdown of coating or area rusted (1)	< 3%	3 – 20 %	> 20 %
Area of hard rust scale (1)	-	< 10 %	≥ 10 %
Local breakdown of coating or rust on edges or weld lines (2)	< 20 %	20 – 50 %	> 50 %
Notes **(1)** % is the percentage of the area under consideration or of the "critical structural area" **(2)** % is the percentage of edges or weld lines in the area under consideration or of the "critical structural area" **(3)** spot rusting i.e. rusting in spot without visible failure of coating			

These clarifications are further exemplified via photos along with narrative descriptions of the condition, uniform and localised assessment scales, in the enclosed Appendix H1 while a "Library of pictures" is provided in Appendix H2.

b) Areas under consideration

The term “areas under consideration” found in the definitions of coating condition “FAIR” and “POOR” in IMO Resolution A.1049(27)-ESP Code and in BCS- R Z10.1, Z10.3 and Z10.4 is clarified in the following.

Recognizing that different areas in the tank experience different coating breakdown and corrosion patterns, the intent is to subdivide the planar boundaries of the tank for evaluation of coating, into areas small enough to be readily examined and evaluated by the Surveyor, but not so small as to be structurally insignificant or too numerous to practically report on. Coating condition in each area should be reported using current practice and terminology (frame nos., longitudinal nos. and/or strakes nos. etc.). Each area is then rated (GOOD, FAIR or POOR) and the tank rating is then to be not higher than the rating of its “area under consideration” having the lowest rating. Examples of how to report coating conditions with respect to areas under consideration are given in Appendix I.

Special attention should be given to coating in Critical Structural Areas which are defined (see Appendix E) as “locations which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships (if available) to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship”. Each Critical Structural Area is rated (GOOD, FAIR or POOR) applying Table II and the rating of each “area under consideration” is then to be not higher than the rating of its Critical Structural Area (if present) having the lowest rating.

The “area under consideration” with the poorest coating condition will determine whether examination of ballast tanks is required at subsequent Annual Surveys. Hence, it is not intended to “average” the coating condition for all “areas under consideration” within a tank, to determine an “average” coating condition for the entire tank.

Definitions of “areas under consideration” are as follows (also illustrated for a Wing ballast tank, a fore peak ballast and aft peak tank in Figure I, Figure II, Figure III below, respectively):

SINGLE HULL TANKER - WING BALLAST TANKS

Deck and bottom

Areas of deck and bottom plating with attached structure (one (1) area to consider for deck and one (1) area to consider for bottom).

Side shell and longitudinal bulkheads

Areas of side shell and longitudinal bulkheads with attached structure, in lower, middle and upper third (three (3) areas to consider for side shell and three (3) areas to consider for longitudinal bulkhead).

Transverse bulkheads (forward and aft)

Areas of transverse bulkhead and attached stiffeners, in lower, middle and upper third (three (3) areas to consider for forward transverse bulkhead and three (3) areas to consider for aft transverse bulkhead).

DOUBLE HULL TANKER

Double bottom ballast tank

Areas of tank boundaries and attached structure, in lower and upper half of tank (two (2) areas to consider).

Double hull side tank

Deck and bottom

Areas of deck and bottom plating with attached structure (one (1) area to consider for deck and one (1) area to consider for bottom).

Side shell and longitudinal bulkheads

Areas of side shell and longitudinal bulkheads with attached structure, in lower, middle and upper third (three (3) areas to consider for side shell and three (3) areas to consider for longitudinal bulkhead).

Transverse bulkheads (forward and aft)

Areas of transverse bulkhead and attached stiffeners, in lower, middle and upper third (three (3) areas to consider for forward transverse bulkhead and three (3) areas to consider for aft transverse bulkhead).

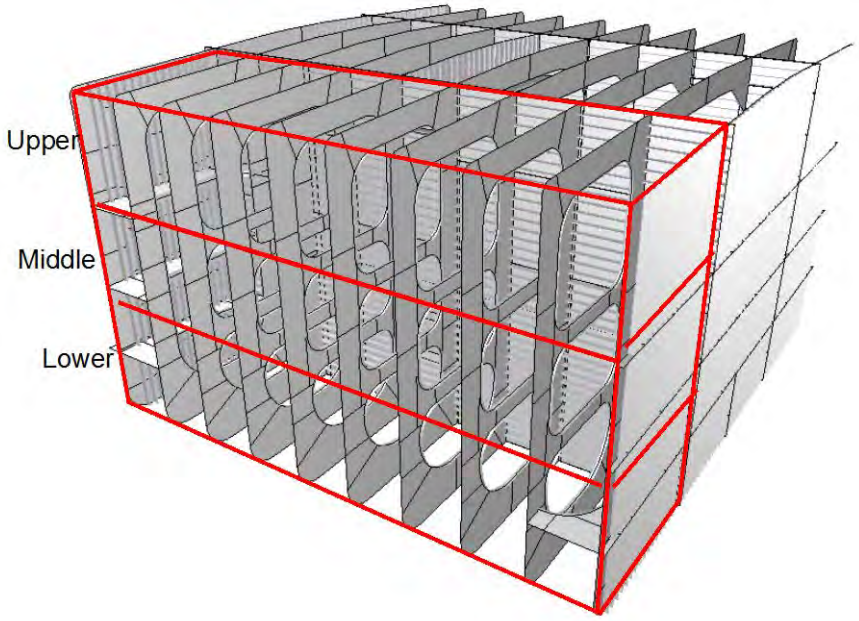


Figure I "areas under consideration" indicated for a Wing Ballast Tank, from one side, i.e., deck, side shell and transverse bulkheads forward.

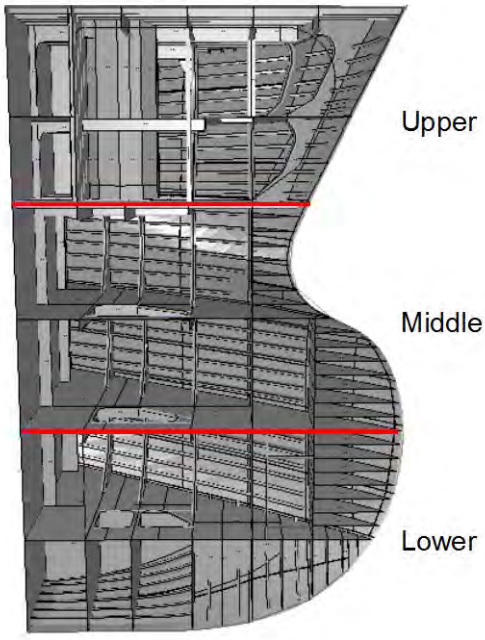


Figure II “areas under consideration” indicated for a Fore Peak Ballast Tank

FORE PEAK TANKS

Areas of tank boundaries and attached structure, in upper, middle and lower third of tank (three (3) areas to consider).

AFTER PEAK TANKS

Areas of tank boundaries and attached structure, in lower and upper half of tank (two (2) areas to consider).

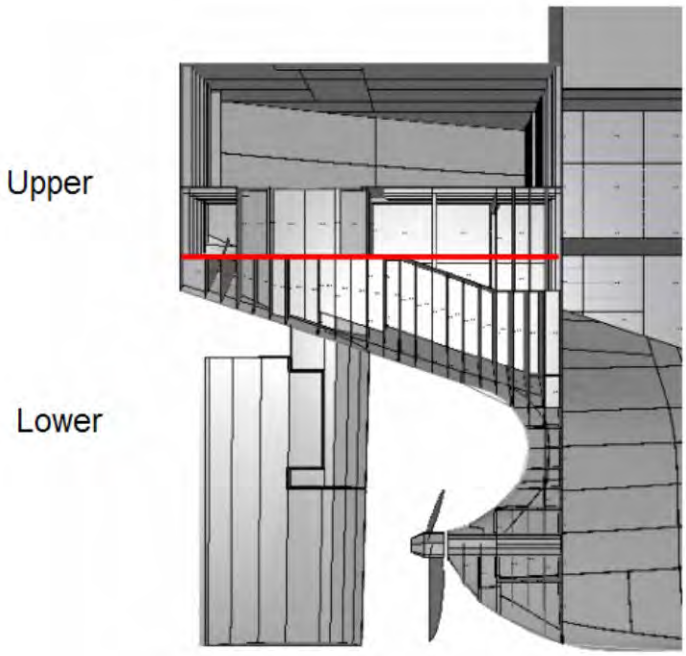


Figure III “areas under consideration” indicated for an Aft Peak Tank

3. Coating maintenance and repairs

a) Process Considerations

Major considerations are:

1. Safety
2. Salt contamination
3. Rust scale
4. Pitting corrosion
5. Temperature
6. Ventilation
7. Condensation
8. Dehumidification
9. Compatibility of coating systems
10. Design/Surface area

1. **Safety**. Ref. IMO Resolution A.1050(27) – “Revised recommendations for entering enclosed spaces aboard ships”, BCS - PR 37 – “Procedural Requirement for Confined Space Safe Entry” and BCS - G 72 “Confined Space Safe Practice”. It is an absolute requirement that all of the ship's safety and tank entry procedures and policies are adhered to. In addition, it is strongly recommended that all travel coating squad members

are trained in safe usage of all the equipment and tools to be used for the project on board, before being sent to the ship.

2. **Salt contamination** is an ever present problem onboard ships and will cause severe problems if not removed prior to coating application. A recommended procedure to reduce salt contamination is to remove loose rust scale followed by good fresh water rinsing, at elevated temperatures and high pressure, if possible. Test the salt content after washing and before coating using ISO 8502-9 and re-wash if necessary until the salt level is less than 30 mg/m^2. This should be the starting point in any surface preparation process in ballast tanks onboard ships. Coatings described as "salt tolerant" are available, however, the user is advised to determine from the manufacturer details of the required preparations, limitations of use and guarantees of performance and, regardless of that, it is recommended to reduce the salt level to not more than 30mg/m^2 prior to coating application.

3. **Rust scale** that is not removed prior to coating application will cause early failure. The loose top-scale is easy to remove, however the inner (black) hard scale is much more adherent. When over-coated it will soon detach between the steel and the scale and come off, typically with the coating adhering very well to the outside of it. If the hard scale cannot be removed the service life expectancy of the treatment is 1 to 2 years regardless of the coating used.

4. **Pitting corrosion** is a major problem onboard ships on plates that have been exposed to seawater for some time. If it has been accepted that the pits need not be welded up, in order to prevent further accelerated damage, a coating should be applied. Chloride salts will be present within the pits and it is essential that these are removed otherwise corrosion will soon start inside over-coated pits, affecting the service life. Various methods of salt removal from pits have been proposed e.g. water-jetting followed by blastcleaning possibly also exposure to high humidity and repeating of water-jetting. Whichever methods are chosen any residues from the washing processes must be removed otherwise the chlorides will precipitate out of the water on drying.

When Microbiologically Influenced Corrosion (MIC) is involved the pits are of a much wider nature, typically "shiny" clean inside with sharp edges to unaffected surrounding steel and often with a foul smell, like rotten egg, being evident when breaking up the scale cap. A MIC attack can proceed very deep, very fast.

5. **Temperature** is a critical parameter to consider. If it is too cold in the water it will be hard to keep the inside tank surfaces free from condensation and to cure the coating in a timely manner. Plan, if possible, the maintenance operation for periods, or locations, of warmer water. Areas above the water level can be heated, although it is a fairly difficult task.

6. **Ventilation** is a vital factor. This is one item that clearly supports both the quality of the application and the safety of the operation. Arrange the ventilation that it extracts from the lowest and furthest corners to ensure the fast and efficient removal of dangerous solvents. The use of so called "solvent free" coating systems does not mean that ventilation is not required!

7. **Condensation** is always a risk onboard ships. It is an absolute necessity that the travel coating squad have a good understanding about relative humidity and it's relation to

substrate temperature and dew point. To paint over a surface that is at, or below, the dew point, or that will be at or below the dew point while the coating is wet, will not perform.

8. **Dehumidification** is the best insurance for good productivity and performance that money can buy. There are two different types i.e. desiccant and refrigeration. Both work well, the desiccant-type being ideal in moderate and cold climates, and the refrigeration type in warmer climates. The use of dehumidifiers prevents condensation and dew point problems, ensures proper cure of the coating, reduces flash-back rusting, prevents grit blasting from "turning" and assists productivity.

9. **Compatibility of coating systems** is of utmost importance for good end result. To ensure compatibility of coating systems, using the same coating system as was originally employed is recommended and, if this is not possible, the paint manufacturer recommendations have to be followed.

10. **Design/Surface areas** should be differentiated with respect to coating application as degree of access varies. Edges, corners, weld seams and other areas that are difficult to coat needs special treatment. "Stripe coating" is used to produce a satisfactory coating and to obtain specified DFT on such areas. It is recommended applying a stripe coat in advance of every coat of the main coating system and preferably using a round (cylindrical) brush. This should be done using a colour that contrasts with the following main coat, as this makes it easier to see that the stripe coat is satisfactory. Stripe coats should be used after pre-treatment in order to obtain the best possible result.

b) Principles for Maintenance and Repairs

i. Ballast Tanks

Maintenance and repair process:

- mud out ("slurry up" and pump out all mud)
- de-scaling (hand scrape off loose scale - the use of magnesium descaling can be considered)
- phosphating of pitted parts (safety hazards to be controlled)
- fresh (potable) water rinsing
- drying
- surface preparation*
- anode protection
- coating

*Surface preparation method chosen depends on the amount of failure and the service life intent.

ii.Contractors

There are many contractors offering voyage repairs onboard ships recommending various tools and processes.

It is imperative that the process, specification, coating application parameters, standards and time schedule are discussed and agreed upon by the parties involved.

It is essential that the Contractor providing the service can prove that all personnel are fully qualified to carry out the required work. It is also necessary that whilst on-board the

team are also fully conversant with appropriate ship operation, safety and evacuation requirements.

iii.In-service Condition Monitoring

A successful maintenance and repair procedure starts with good information.

It is therefore a pre-requisite that the owner initiate, as a minimum, an annual inspection of all tanks and spaces by the ship's crew, sometimes assisted by additional inspectors.

Standardised reports should be used and submitted to the responsible superintendent that answers the following questions:

- ship's name
- tank number
- inspection date
- inspection by whom
- year coated
- coating name/type
- last repaired
- surface area
- amount of blistering ISO 4628-2 (see Appendix D. Pictorial ISO standards)
- amount of rusting ISO 4628-3 (see Appendix D. Pictorial ISO standards)
- amount of cracking ISO 4628-4 (see Appendix D. Pictorial ISO standards)
- amount of flaking ISO 4628-5 (see Appendix D. Pictorial ISO standards)
- amount of pitting corrosion
- amount of light rust scale
- amount of heavy rust scale
- extensive steel loss - if relevant, location
- rating (GOOD/FAIR/POOR, ref. Ch. 2. Coating Conditions, a))
- welds rusty - amount
- edges rusty - amount
- sounding pipe condition
- vent pipe condition
- ballast pipes condition
- surfaces under ballast suction piece
- amount of mud
- any structural damage
- other comments
- crew maintenance (see below)
- mechanical damage, location and extent

The rating used is to give the Owner's technical staff an objective report of the condition so that the urgency of the repairs can be established and the most cost effective solution found. The suitable rating system for this purpose is GOOD/FAIR/POOR, ref. Ch.2. Coating Conditions, a).

With this information available the owner's technical staff can plan ahead and find the most cost effective solution(s).

It should be realised that more control over the coating process can be achieved in dock and hence the overall cost effectiveness of voyage maintenance and repair must establish whether the required service life will be achievable.

"Crew maintenance"- Valuable information can be gained from well trained and informed crew members (most paint companies can provide on-board maintenance training) undertaking the tank condition inspections. It is recommended that the crew should identify the course of action necessary when defects have been detected. This exercise if carried out in a consistent manner will provide shore based staff with a good opportunity to judge the extent and urgency of any necessary repairs and respond accordingly.

iv.Recommended maintenance

The below Table III and Table IV describes the recommended short, medium and long term maintenance (e.g. 5, 10 and 15 years target lifetime respectively) to either maintain or to restore GOOD coating conditions.

Table III Recommended short term maintenance

Target Lifetime	Areas under consideration evaluated to	Pre-treatment[1], [2]	Coating system	Dry Film Thickness (DFT)
Short term maintenance (5 years)	GOOD	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Drying • Power tool cleaning/ wire brushing • Climatic control	"Hard coating" compatible with original coating or equivalent. Recommended "hard coatings" are • Pure or modified epoxy • Solvent less epoxy • Solvent free epoxy[3] • Epoxy mastic or surface tolerant	• 1 diluted touch-up/stripe coat • 1 x 100 µm 1st coat
	FAIR	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Surface treatment of damaged area by blast cleaning to grade Sa 2[4] or equivalent[5] • Drying • Climatic control		• 1 diluted touch-up/stripe coat • 1 x 100 µm diluted 1st coat[6] • 1 x 100 µm 2nd coat • DFT correction
	POOR	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Surface treatment of **all** areas under consideration to grade Sa 2[4] or equivalent[5] • Drying • Climatic control		

[1] For up to 5 years target lifetime, different pre-treatment methods using water may be employed.
[2] Small areas of coating damage may be treated individually without disturbing intact coating
[3] Solvent free epoxy (100% volume solid)
[4] ISO 8501-1
[5] equivalent grade e.g. by water-jetting (with or without abrasive)
[6] is depending on coating system, & volume solids content, etc.

Table IV Recommended medium and long term maintenance

Target Lifetime	Areas under consideration evaluated to	Pre-treatment[7]	Coating system	Dry Film Thickness (DFT)
Medium term maintenance (10 years) & Long term maintenance (15 years)	GOOD	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Drying • Power tool cleaning/ wire brushing • Climatic control	"Hard coating" compatible with original coating or equivalent, Recommended "hard coatings" are • Pure or modified epoxy • Solvent less epoxy • Solvent free epoxy[8] • Epoxy mastic or surface tolerant	• 1 diluted touch-up/stripe coat • 1 x 100 µm 1st coat
	FAIR	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Surface treatment of damaged area by blast cleaning to grade Sa 2½[9] • Drying • Climatic control		**Medium term maintenance:** • 1 diluted touch-up/stripe coat • 1 x 150 µm diluted 1st coat[10] • 1 diluted 2nd stripe coat • 1 x 150 µm 2nd coat • Dry Film Thickness (DFT) correction **Long term maintenance:** • 1 diluted touch-up/stripe coat • 1 x 150 µm diluted 1st coat[10] • 1 diluted 2nd stripe coat • 1 x 100 µm 2nd coat • 1 diluted 3rd stripe coat • 1 x 100 µm 3rd coat • DFT correction
	POOR	• Removal of mud, oil, grease, etc. • Fresh-water hosing • Blast cleaning of **all** areas under consideration to grade Sa 2½[9] • Drying • Climatic control		

[7] High-pressure water-jetting is not recommended for target lifetime beyond 5 years
[8] Solvent free epoxy (100% volume solid)
[9] ISO 8501-1
[10] is depending on coating system, % volume solids content, etc

References

1. Guidelines for ballast tanks coating systems and surface preparation, TSCF, 2002
2. Condition evaluation and maintenance of tanker structures, TSCF, 1992
3. Guidance manual for tanker structures, TSCF, 1997
4. Guidelines for the Inspection and Maintenance of Double Hull Tanker Structures, TSCF, 1995
5. BCS- Rs Z10.1 (Rev.12), Z10.3 (Rev.7) and Z10.4 (Rev.2)
6. Guidelines for corrosion protection of sea water ballast tanks and hold spaces, BV, 1995
7. Guidelines for Oil Tankers, BV, 2002
8. Guidelines for the selection, application and maintenance of corrosion systems of ships ballast tanks, RINA Guidelines, 2000
9. Corrosion Protection of Tanks and Cargo Holds, DNV Technical Report No. BGN-R3600197, 29th May 2000
10. Guidelines for the structural design of oil tankers, RINA, 2003

Appendix

A. Failures

i. Coating failures

The coating failures considered in these Guidelines is the coating degradations within the intended coating service life. The main types are identified in the following items.

Cracking

This is a break-down in which the cracks penetrate at least one layer and which may be expected to result ultimately in complete failure. Such cracks may result from:

- over thicknesses of paint,
- plastic structural deformations exceeding the elongation properties of the paint film
- localised fatigue stress, due to non appropriate design

Coating cracking

Flaking (loss of adhesion)

It consists in the lifting of the paint from the underlying surface in the form of flakes or scales. The causes of a loss of adhesion may be the following ones:

- unsatisfactory surface preparation,
- incompatibility with underlayer,
- contamination between layers,
- excessive curing time between layers

Coating flaking

Blistering

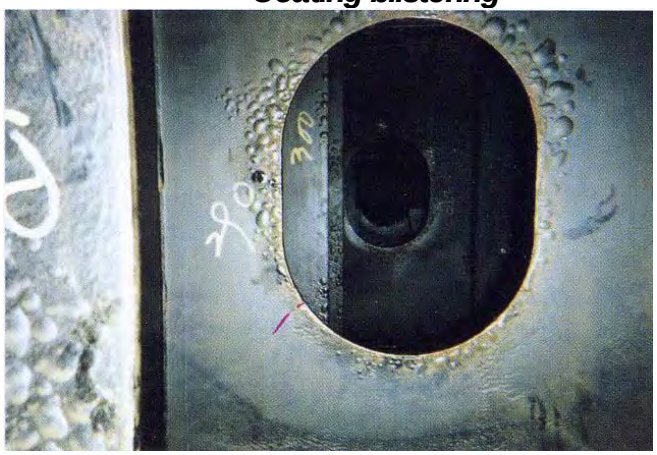
It appears as a bubble formation scattered on the surface of a paint film, with a

diameter ranging from 3-4 mm to 20-30 mm. Blisters contain liquid, vapour or gas. Blistering is a localised loss of adhesion and lifting of the film, coming generally from osmosis due to one of the following causes:

- Solvent retention,
- Improper coating application,
- Soluble salt contamination under the paint film, due to an insufficient cleaning of the surface.

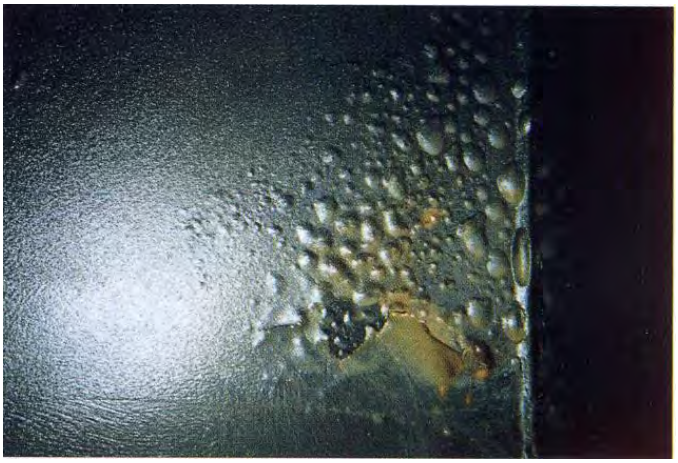
It is to be noted that in most cases there is no corrosion in an unbroken blister and many years of protection can be obtained if these blisters are left untouched.

Coating blistering



Blister around opening (8 years)

Due to a heavy overlap coating and poor workmanship, blisters have often been observed.



Blister on flat part (5 years)

Blisters have sometimes been observed on flat part and often been observed on areas which have difficulties to work on such as back of face plate of extrusions.

ii. Corrosion

There are many forms of corrosion. The typical corrosion pattern which may be observed in a sea water ballast tank are described in the following items.

General corrosion (uniform corrosion)

General corrosion appears as non-protective, friable rust which can uniformly occur on tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. The anodic and cathodic areas on the

same piece of steel change with time, so those areas that were once anodes become cathodes and vice versa. This process allows the formation of a relatively uniform corrosion of steel.

General corrosion

Pitting corrosion (localised corrosion)

Pitting corrosion is one of the most common forms that can be noted in ballast tanks. It is a localised corrosion that occurs on bottom plating, other horizontal surfaces and at structural details that trap water, particularly the aft bays of tank bottoms. For coated surfaces the attack produces deep and relatively small diameter pits that can lead to hull penetration. Pitting of uncoated tanks, as it progresses, forms shallow but very wide scabby patches (e.g. 300m mm diameter); the appearance resembles a condition of general corrosion. It is caused by the action of a localised corrosion cell on a steel surface due to the breaking of the coating (if present), to the presence of contaminants or impurities on the steel (e.g. mill scale) or to impurities present in the steel.

Pitting corrosion

Crevice corrosion

Crevice corrosion is also localised corrosion that appears as pitting. The most common case occurs in cracks and generally on steel surfaces covered by scales and deposits. Typical examples are ship welding seams, pipe supports and bolts. The phenomenon is due to the fact that a small area of steel (i.e. the crevice, the crack or the area covered by debris) lacks oxygen and becomes the anode of a corrosion cell, while the remaining free surface, abundantly oxygenated, becomes the cathode. Since the anodic area is very small compared to the cathodic one, the corrosion process is extremely fast.

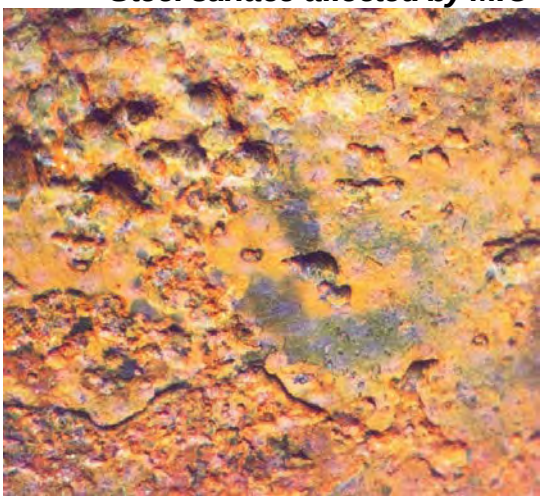
Erosion corrosion

Corrosion due to erosion occurs when abrasives (i.e. sand or mud) held in the sea water impinges, with a certain velocity, an existing corrosion cell. The abrasives remove the accumulation of corrosion products keeping the metal clean and the corrosion active. Crude oil washing or hot and cold seawater washing can be considered as a particular erosion corrosion form. The greasy or waxy layer that, covers the steel surfaces, act as a corrosion inhibitor is removed, together with corrosion product, by the washing process keeping the steel clean and the corrosion active.

Bacterial corrosion

Bacterial corrosion, called Microbiologically Influenced Corrosion (MIC) appears as scattered and/or localised pitting.

Steel surface affected by MIC



MIC is a form of corrosion originated by the presence of microscopic one-celled living organism including bacteria, fungi and algae. The corrosive bacteria live in water layer on the bottom of cargo oil tanks as well as in the sediment of water ballast tank bottom. Sulphate Reducing Bacteria (SRB) and Acid Producing Bacteria (APB) are the two most important and well known groups of micro-organisms, which cause corrosion. SRB and APB live together with other species of bacteria in colonies on the steel surfaces helping each other to grow.

SRB's are anaerobic in nature and obtain their needs of sulphur by a complex chemical reaction. During this reaction, the organism assimilates a small amount of sulphur, while the majority is released into the immediate environment as sulphide ions, which are hydrolysed as free H2S. In this way, SRB give rise to a corrosive process that supports the anodic dissolution of the steel. When bacteria have started to produce sulphide, the environmental condition becomes more favourable for growth, resulting in a population explosion.

APB's use the small quantity of oxygen of the water to metabolise hydrocarbons and produce organic acids such as propionic acid, acetic acid and other higher molecular acids. Since the APB's "consume" the residual oxygen present in the sediment, they produce, under the colonies, a suitable and ideal environment for the SRB's.

When active, the corrosion process originated by these bacteria can be extremely fast and can cause corrosion pits with a rate up to 1,5 – 3 mm per year, which is about five times higher than normally expected.

Colonies of bacteria may appear like slimy black deposits on the steel surfaces.

Stress corrosion

Steel subject to stress or fatigue can be affected by fractures, even small. These areas act as a crevice and, due to low aeration, will corrode as already described. Furthermore, a fracture can also cause micro cracking on the protective coating, giving rise to a very active corrosion cell.

B. Corrosion prevention

There are several methods to control the corrosion process. Each method has its advantages and limitations. In these Guidelines those concerning ballast tanks will be considered, specifying that although each method will be briefly described, the best solution in a total corrosion program is a suitable combination of all methods.

i. Protective coating (paints)

Coatings can protect metals from corrosion by providing a barrier between the metal and the electrolyte, preventing or inhibiting the corrosion process or in some cases by a particular form of cathodic protection.

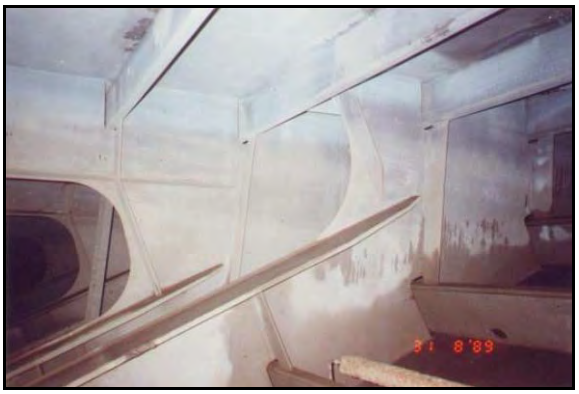
The selection of the coating system, as well as the selection of its application procedure is extremely important since it affects the performance of the coating itself and consequently the life of the steel structure.

The following photos show the ballast tanks of two ships with the same age of 13 years. During the construction, both ships were coated with an epoxy system, but the application procedure of the ship of the first photo was correctly done, while that one of the ship shown in the second photo was clearly poor. The photos are a clear example of the importance of the implementation of correct application procedure (surface preparation and paint system application) and coating selection.

Correct application, condition after 13 years	***Poor application, condition after 13 years***

If the protective coating is properly applied and a suitable maintenance program is performed, it can control the corrosion process of ballast tank surfaces for the

complete life of the ship (see the following photos).

Ballast tank after 16 years	*Ballast tank after 28 years*
	

Paint systems

A paint system is formed by one or more coats of paint, each of which is applied at a specified film thickness. This sequence of coats, called paint system, provides corrosion control by means of one or more of the following mechanisms:

- barrier protection (namely providing an insulating barrier between electrolyte and metal)
- chemical inhibition of corrosion reaction
- cathodic protection when a coat of zinc rich primer, acting as sacrificial anode, is applied

Paint system is the logic and organic sequence of successive coats. It can be represented in a schematic generic form as**: Primer - Undercoats – Finishing**

- **Primer** is the first coat of the paint system. It has very important function such as, for example, to assure the adhesion of the whole system and to provide the required anticorrosive protection. It must be applied after a proper surface preparation, before which its quality could decay. Primer has to be overcoated according to the overcoating time and instructions recommended by the paint manufacturer.
- **Undercoats** are used to connect the primer with the finishing coat and to increase the total thickness of the system, as requested by the material to be protected and the location (e.g. bottom, topside etc.).
- **Finishing** provides specific characteristics to the area where it is applied: aesthetic appearance for topside and other exposed areas, anti-fouling protection for the underwater etc.

On ballast tanks in order to optimise corrosion prevention, the same paint is generally applied in more coats, providing more properties at the same time.

It is useful, first of all, to clarify some terms of recent use:

- **Hard coatings:** Annex to IMO Resolution A.798(19) at item 2.6 defines Hard Coatings as "...***a coating which chemically converts during its curing process, normally used for new constructions or non-convertible air drying coating which may be used for the maintenance purposes. Hard coating can be either inorganic or organic.***" All conventional paints are included in this definition, e.g. epoxy, polyurethane, zinc silicate, vinyl, etc.
- **Semi-hard coatings:** are coatings that, after drying, remain flexible and hard enough to be touched and walked upon without damaging them and that are not affected by water erosion during de-ballasting operations.

- **Soft coatings:** are coatings that do not dry, but remain permanently soft. Soft coatings are not recommended. Where Soft Coatings have been applied, safe access is to be provided for the surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft coating is to be removed.

Paint systems for ballast tanks

There are a lot of paint systems available for the protection of ballast tank surfaces. Each paint system proposed by the paint manufacturer has its number of coats and its specific film thickness. A schematic description of the various paint systems would be too vague and generic. For information only, the following table gives the basic characteristics of the paint systems until now more widely used for ballast tanks

Table A Paint systems for ballast tanks

PAINT SYSTEM	CHARACTERISTICS
PURE or MODIFIED EPOXY	Two-components Light colour
SOLVENT LESS EPOXY	Two-components Light colour
SOLVENT FREE EPOXY (100% volume solids)	Two-components Light colour
EPOXY MASTIC and SURFACE TOLERANT	Two-components Light colour

Classification of hard coatings

Hard coatings for ballast tanks may be classified according to a recognized standard such as for example, B1 as described in TSCF publication “Guidelines for ballast tanks coating systems and surface preparation”, 2002, Appendix (3)

ii. Cathodic protection

Cathodic protection is a system of corrosion control by means of which a sufficient amount of direct current passing onto a metallic surface, converts the entire anodic surface to a cathodic area. Cathodic protection is effective only when the metallic surface is immersed. A cathodic protection system can be carried out by means of impressed current equipment or by sacrificial anodes. In ballast tanks the impressed current system is not permitted, due to the large amount of hydrogen gas produced by the process. Therefore only a system of sacrificial anodes (zinc or aluminium) is used. Anodes generate the necessary direct current so that they are corroded by their natural potential difference, protecting the surrounding steel.
Pitguard anodes are suitable for arresting Sulphate Reducing Bacterial (SRB) attack.

iii. Design

Corrosion prevention already starts during the design stage of the ship. A suitable structural design may control the corrosion by eliminating one or more components necessary for the corrosion reaction or by permitting an easier application of other methods of corrosion control and prevention. A good design must avoid:

- contact of dissimilar metals

- stagnation and water traps
- crevices (e.g. skip/chain/intermittent welds or irregular welding seams), that apart from the already described reasons, are difficult to protect with coating
- irregular and sharp surfaces, because they are difficult to coat with the correct film thickness
- difficult-to-reach-areas, since they can prevent the correct application of the coating

In connection with repair, it is recommended to pay close attention to obtain a design favourable from a corrosion prevention point of view.

C. Surface preparation methods

The main methods of surface preparation options are:

1. Hand chipping
2. Power tool cleaning; needle-gun, chipping-gun, rotary grinders, wire brushes, etc.
3. Water-jetting
4. Ultra-high-pressure water-jetting
5. Slurry blasting
6. Water-jetting with grit injection
7. Ultra-high-pressure water-jetting with grit injection
8. Dry ice blasting
9. Sodium-bicarbonate (Baking Soda) blasting
10. Blast cleaning
11. Magnesium de-scaling
12. Sponge-jet blasting

1. **Hand chipping** is a fairly slow and labour intensive method that does not require much technical ability of the operator. It does not yield a clean substrate and coatings in seawater ballast spaces applied over hand chipped surfaces normally fail within 2 years. The so called "surface tolerant" primers will perform better, typically up to two years, whereas conventional primers will fail much earlier.

2. **Power tool cleaning** is a surface preparation method that can yield a very clean substrate. It is much more labour intensive than blast cleaning. Many tools such as rotary disc grinders and wire brushes, etc., will not clean inside crevices or shallow pits. Care is to be taken when using these tools e.g.:

- wire brushes which does not give a high surface profile
- needle gun cleaning peens the surface and is not ideal.

The typical service period that a good coating will provide on power tool cleaned surfaces ranges from 2 to 5 years. The cleaner, and higher the surface profile (roughness) the greater the expected performance. As for the hand chipped surfaces a coating that is designed for a more compromised substrate will typically perform better than one that is less tolerant. Typically a well suited method for small spot repairs.

3. **Water-jetting (WJ)** is defined as having a water pressure in excess of 1000 bars (15,000 psi) is a relatively new process. The energy output and with it the cleaning ratio and success is highly dependent on the nozzle pressure, water volume and the design of nozzle. In general however, water-jetting will only remove loose rust, loose scale and loose paint at an acceptable production rate. It will not remove mill-scale or "black rust" (magnetite-scale). Painting over such scale will bring the performance expectation down to that of hand chipping. The process does not provide a surface profile to promote coating

adhesion and relies on the original abrasive blasted or corroded surface condition. Where there is no scale and a clean substrate is produced, although there will always be some re-rusting, the service life expectancy can be in excess of 5 years. Surface tolerant coatings are the best option for these surfaces. Warning is given here regarding so called "moisture tolerant" coatings.

As the industry has not yet advanced to a point where it can accurately define or measure moisture content on a substrate, Owners could be subject to high risk if reliant on "moisture tolerant coatings".

It is also to be noted that the use of water miscible components in the coating to assist with the dissolution (displacement) of the surface water is common in so called moisture tolerant coatings. Such species will however act as solutes in an osmotic couple with water and can be the direct cause of blisters.

Moisture curing coating types e.g. polyurethanes etc., can use some or all of the surface water in its curing reaction. The same problem applies however since the amount of surface water cannot be measured and the stoichiometry of the reaction will not be ideal, any excess water may therefore cause exactly the same problems as for a non-moisture cured system.

Water treatments below 68 bar (1000 psi) are not surface preparation methods but cleaning methods. NACE defined them as **Low-pressure Washing**, having water pressure below 68 bar while **High-pressure Water Cleaning (HPWC)** are termed the treatments having pressures from 68 to 680 bar (1000 to 10000 psi).

4. **Ultra-high-pressure water-jetting (UHP-WJ)** is defined by NACE as having a pressure in excess of 1500 bars (22,000 psi). Normally, such tools operate at 2000 bars (30,000 psi) or more. UHP-WJ produce better and faster cleaning than the water-jetting method does. The service life expectancy span for UHP-WJ can be 2 to 10 years depending on the cleanliness achieved, the amount of re-rusting and moisture control during painting. The same comments about coatings apply as for water-jetting.

5. **Slurry blasting** is using a modified dry grit blasting system with water as the propellant instead of air. There are no advantages (apart from a reduced dust and salt level) with this system compared to normal blast cleaning, but it has quite a few draw-backs, which is why it has not been used onboard ships to any significant degree. The service life expectancy will depend on the amount of re-rusting which is usually significant and varies from 3 to 5 years. This method does remove scale. The same comments about coatings apply as for water-jetting.

6. **Water-jetting with grit injection** has been used with success on some projects at sea. It produces a surface cleanliness about the same as slurry blasting but leaves much less wet grit to be removed. Re-rusting is a major problem and coating performance is dependent on how that matter is dealt with. Service life expectancy and coating comments will be the same as for the slurry blasting.

7. **Ultra-high-pressure water-jetting with grit injection** is interesting in that the production rate is reported to be very high, the grit consumption quite low and the re-rusting easily removed with water only using the same pump. It removes scale but is difficult to use in hard to reach areas. Properly operated this method could yield the same

performance expectation as grit blasting; e.g. in excess of 10 years. Coating comments, same as for water-jetting.

8. **Dry-ice blasting** is suggested from time to time. It clean at a similar rate as sodium bicarbonate blasting does. The equipment is expensive and produces cold surfaces that are subject to condensation onboard ships. Dry-ice blasting does not remove millscale or hard rust scale. This method has not been used to any significant degree onboard ships. If used, adequate ventilation must be arranged to offset any carbon dioxide build-up during melting of the dry ice.

9. **Sodium-bicarbonate blasting** ("baking-soda blasting") is another method that is proposed from time to time. It is interesting as the residue is water miscible and can be pumped out. The process must be followed by water rinsing as residual "baking-soda" will otherwise act as a solute to water in an osmotic couple that may cause blisters. Flash-back rusting will always be a problem and the service life expectancy is therefore in the water-jetting region. Sodium-bicarbonate blasting does not remove mill-scale or hard rust scale.

10. **Blast cleaning** - the work horse for corrosion prevention systems for a great many years is still the most cost effective method to yield a good substrate for the coating. The service life expectancy is in excess of 10 years. It is noted that there are several different types of grit, e.g. copper slag, garnet, sand, etc.: not all of them are suitable for use in all cases and care is therefore to be taken in selecting the most appropriate type for the case under consideration.

When used as a repair process, great care is needed to minimise the amount of damage to the sound coating close to the areas being repaired. Invariably there will be some damage to the sound coatings, resulting in rust spots appearing.

It is to be noted that there are a number of different grit blasting units i.e. open air, vacuum, etc. There is also a large selection of unit sizes available e.g. back-pack, minipot, 200 litre pot, "hopper" size, etc. The type used would depend on the project to be undertaken.

11. **Magnesium de-scaling** is sometimes used for ballast tank de-scaling and coating. Hydrogen gas formation is a major risk factor when using this method. It is also vital to wash the tank down immediately after the seawater used for the de-scaling has been pumped out or a detrimental white powder (calcium/magnesium carbonate) is formed on the surface of the steel. This method has had varying success and the service life expectancy will be regarded as in the water-jetting region of 2 to 5 years.

12. **Sponge-jet blasting** is a method that uses grit abrasives with a "sponged" surface. The method requires recycling which will involve an abrasive washing system. The interest is that adjacent areas may not be damaged by ricochets from blasting, hence it may be a useful means of preparing block joint surfaces within painted ballast spaces.

D. Pictorial ISO standards

ISO 4628: Paint and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect.

Part 1: General principles and rating schemes.
Part 2: Designation of degree of blistering.
Part 3: Designation of degree of rusting.
Part 4: Designation of degree of cracking
Part 5: Designation of degree of flaking

ISO 4628/1: General principles and rating schemes.

Table B Intensity of deterioration

Rating	Intensity of change
0	unchanged, i.e. no perceptible change
1	very slight, i.e. just perceptible change
2	slight, i.e. clearly perceptible change
3	moderate, i.e. very clearly perceptible change
4	considerable, i.e. pronounced change
5	sever, i.e. intense change

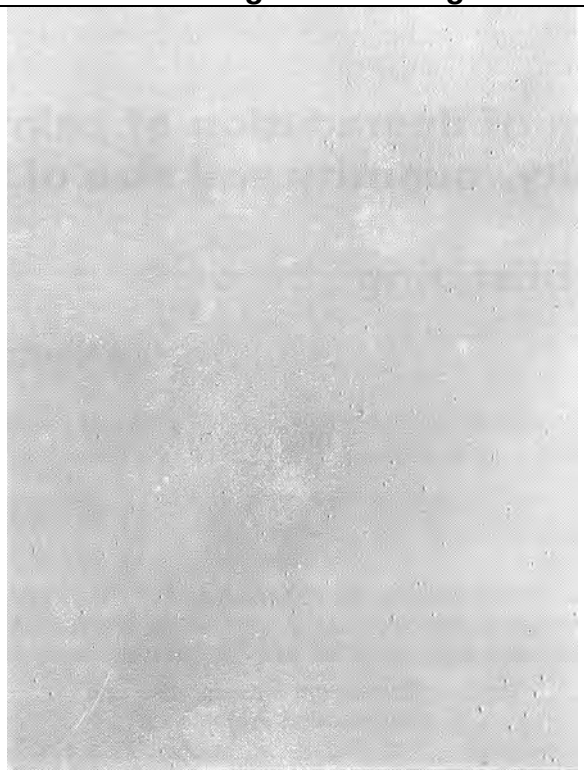
Table C Quantity of defects

Rating	Quantity of defects (relative to a test area of 1 to 2 dm^2)
0	none, i.e. no detectable defect
1	very few, i.e. some just significant defects
2	few, i.e. small but significant amounts of defects
3	moderate, i.e. medium amount of defects
4	considerable, i.e. serious amount of defects
5	dense, i.e. dense pattern of defects

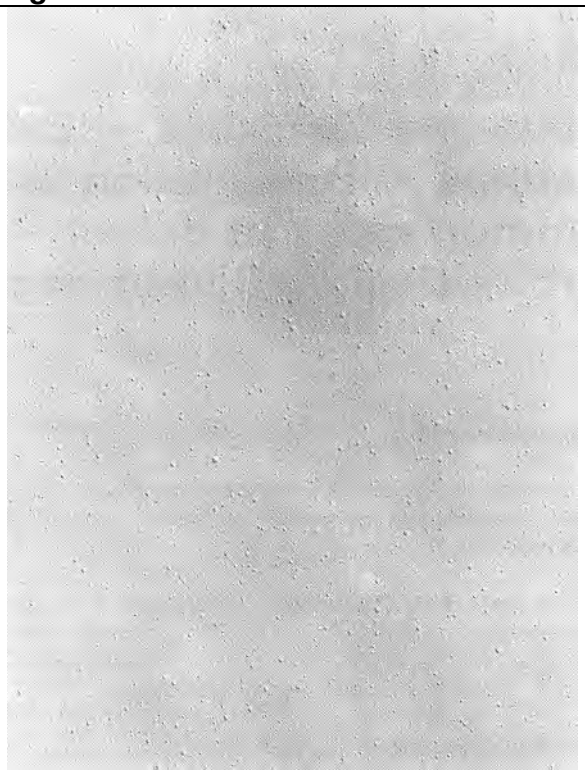
Table D Size of defects

Rating	Size of defects
0	not visible under x 10 magnification
1	only visible under magnification up to x 10
2	just visible with normal corrected vision
3	clearly visible with normal corrected vision (up to 0,5 mm)
4	range 0,5 to 5 mm
5	larger than 5 mm

ISO 4628/2: Designation of degree of blistering.



Density 2



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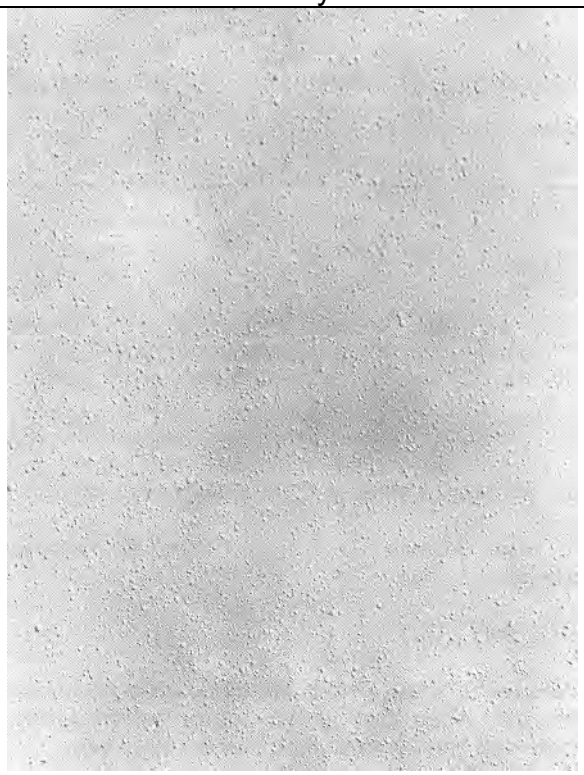

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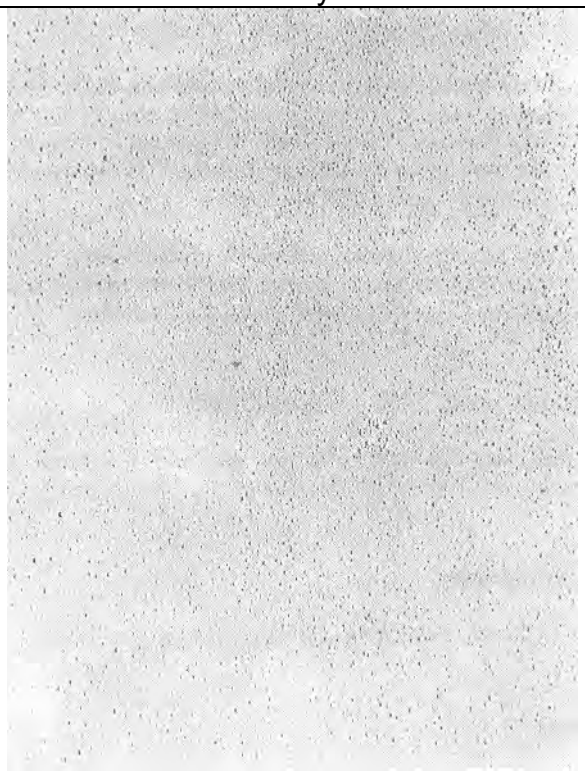
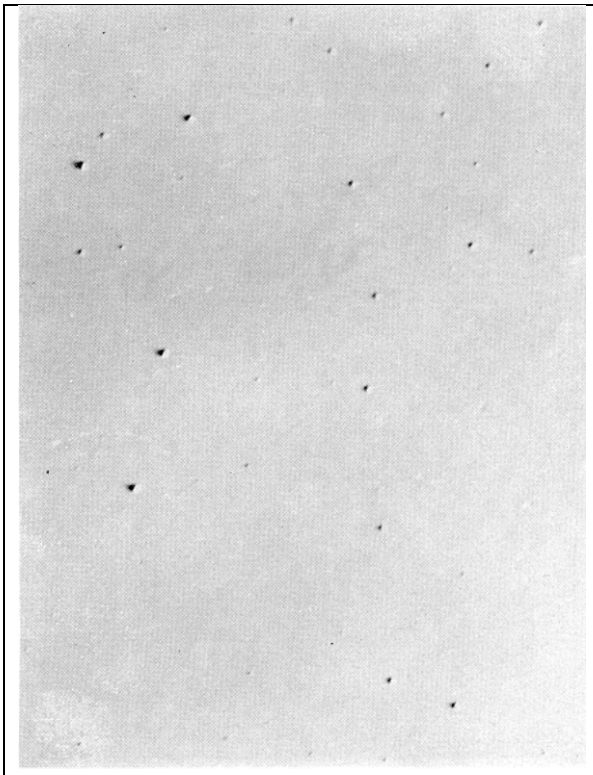


Density 5

Figure A - Degree of blistering. Blisters of size 2



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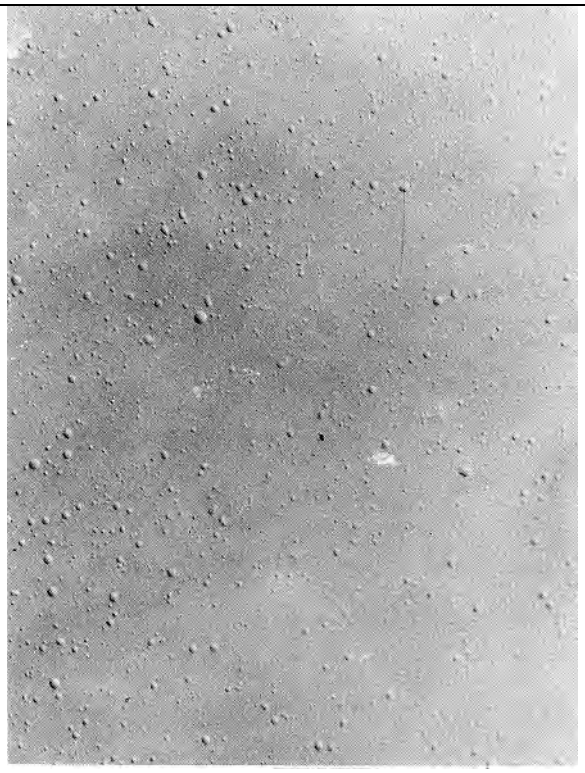

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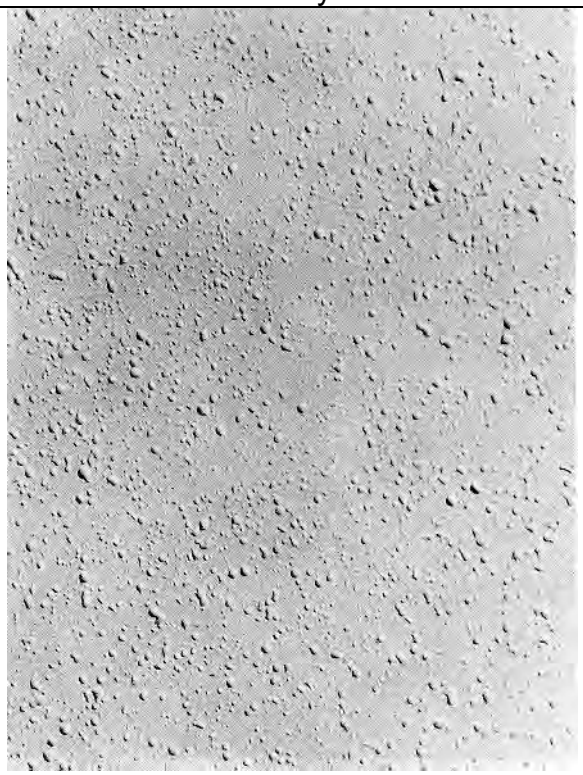
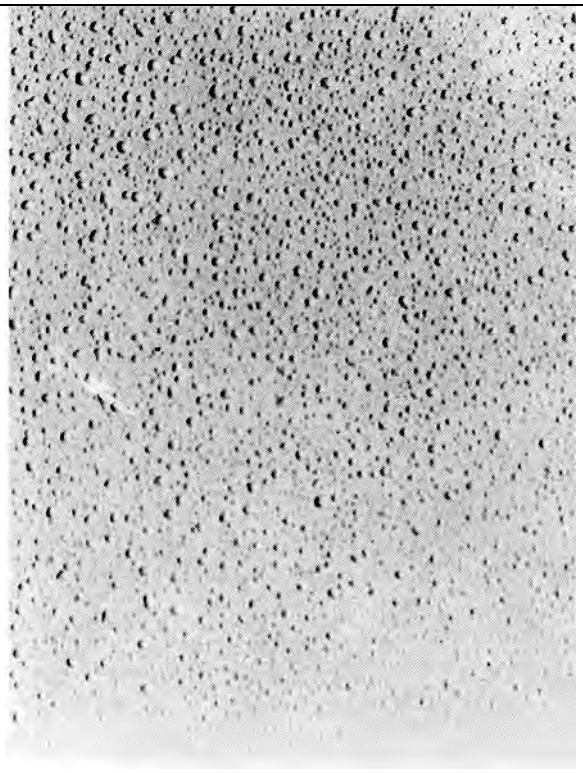


Density 4

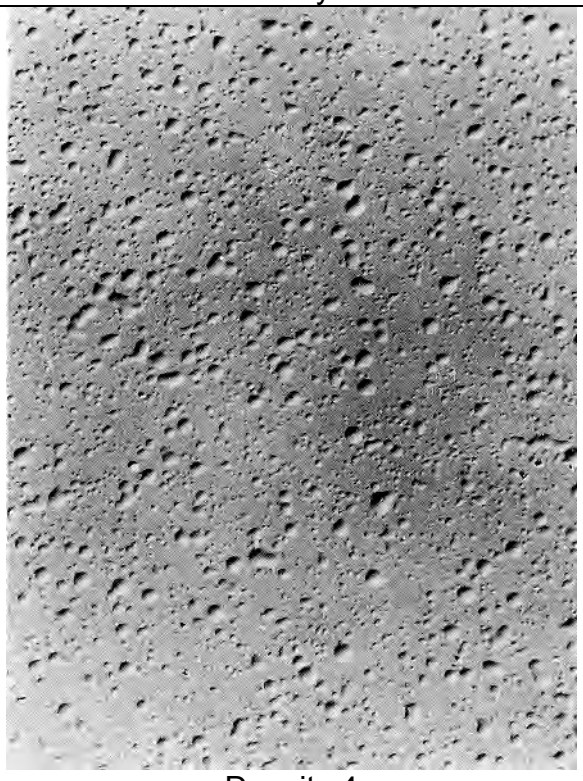


Density 5

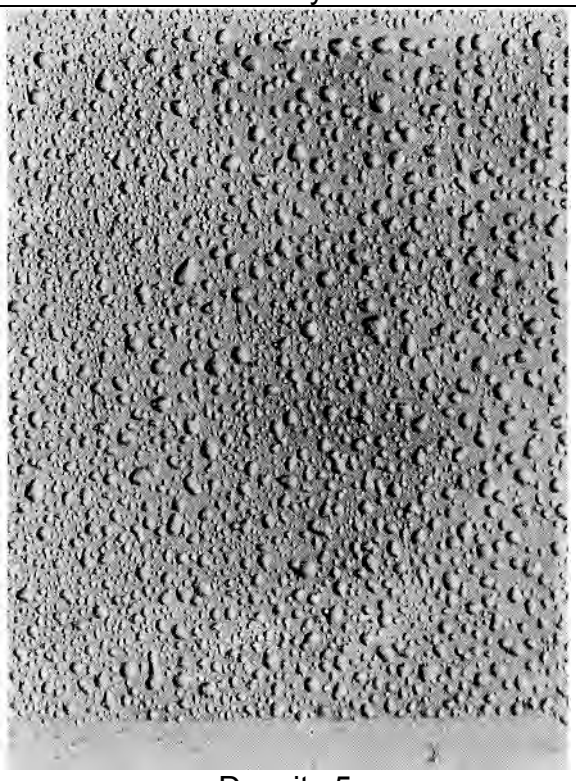
Figure B - Degree of blistering. Blisters of size 3

Density 2

Density 3



Density 4

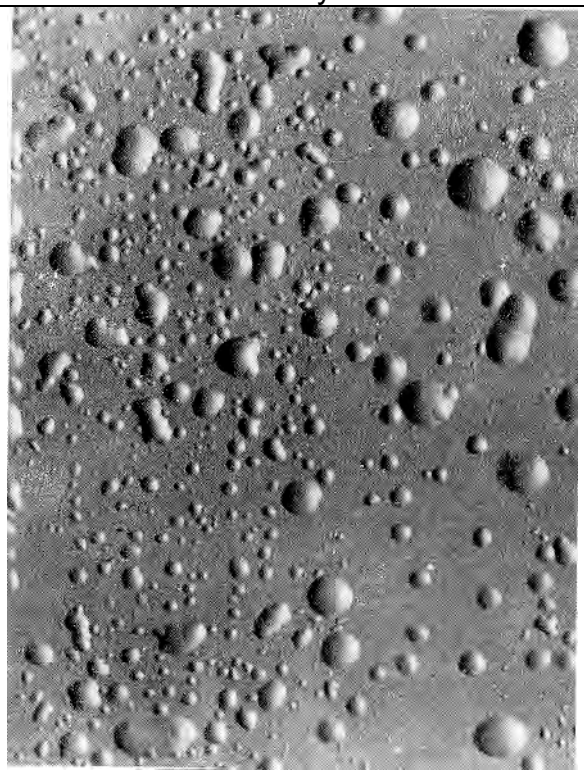


Density 5

Figure C - Degree of blistering. Blisters of size 4

Density 2

Density 3



Density 4

Density 5

Figure D - Degree of blistering. Blisters of size 5

ISO 4628/3: Designation of degree of rusting

Table E Degree of rusting and area

Degree	Area rusted %
Ri 0	0
Ri 1	0.05
Ri 2	0.5
Ri 3	1
Ri 4	8
Ri 5	40/50

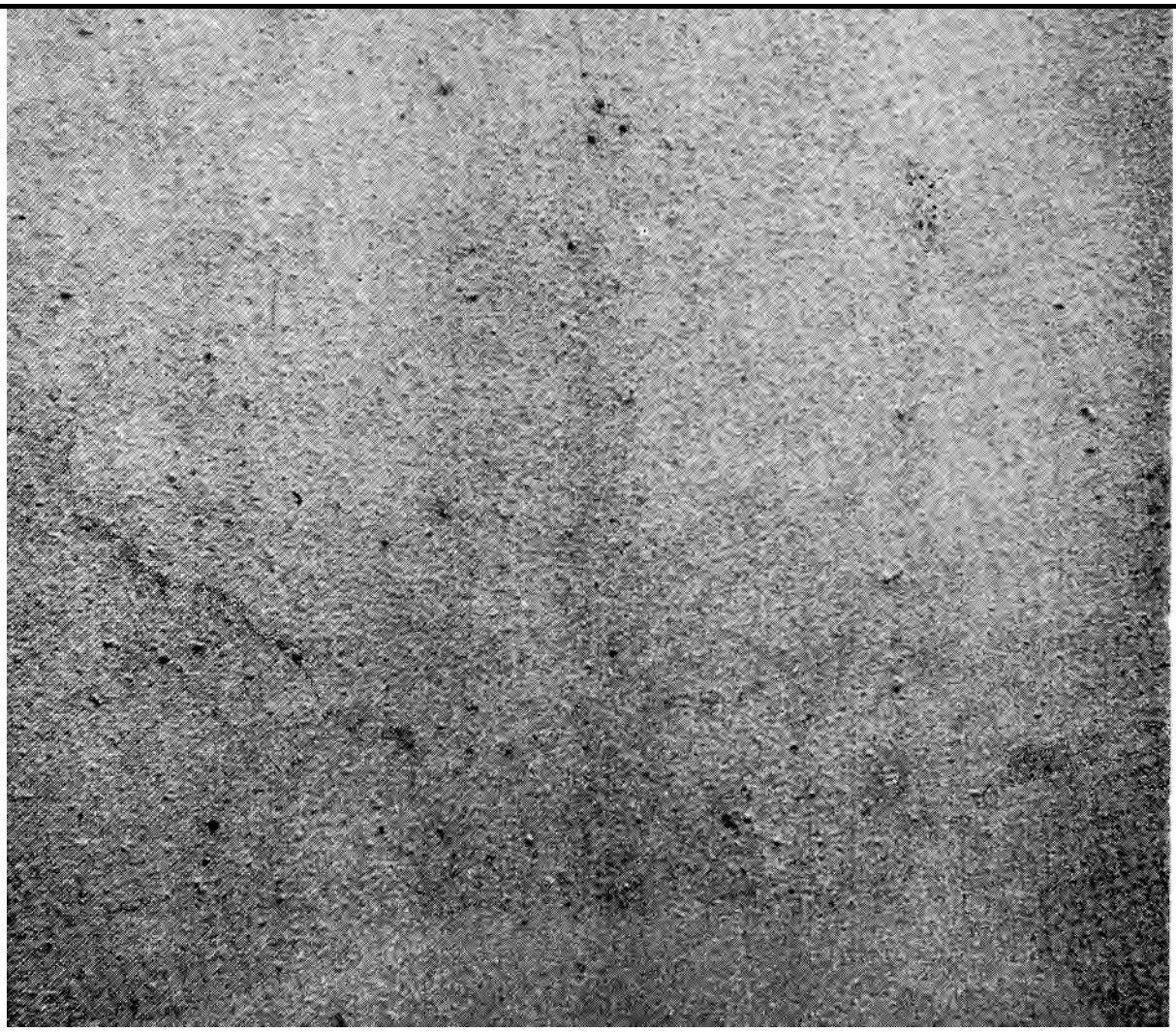


Figure E - Degree of rusting. Ri 1

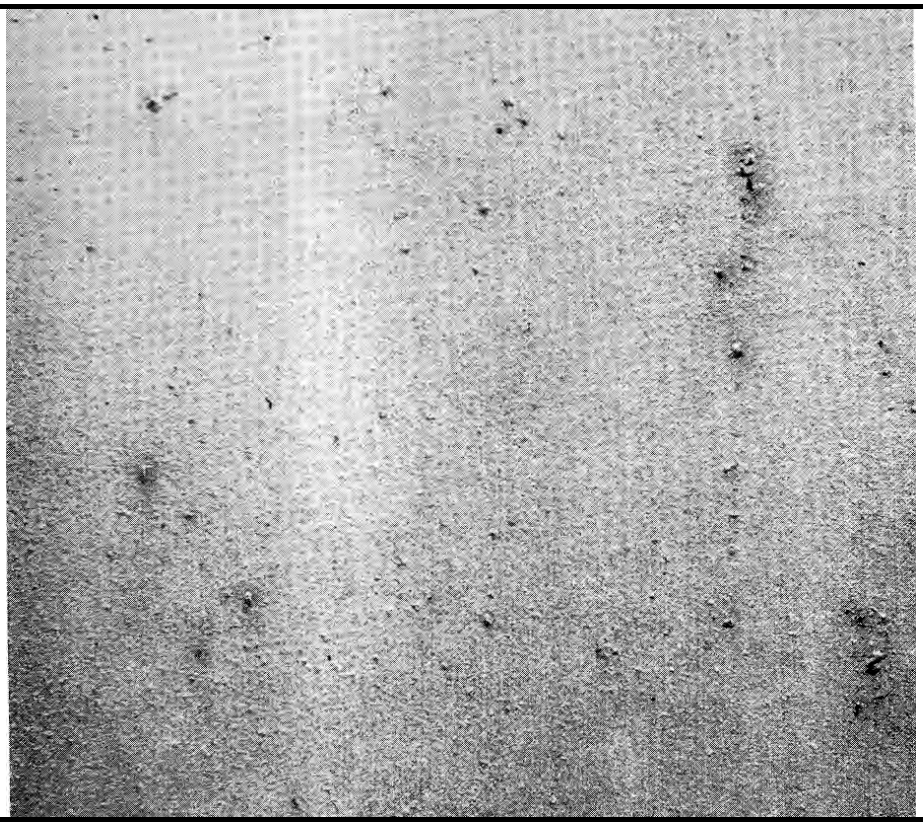


Figure F - Degree of rusting. Ri 2

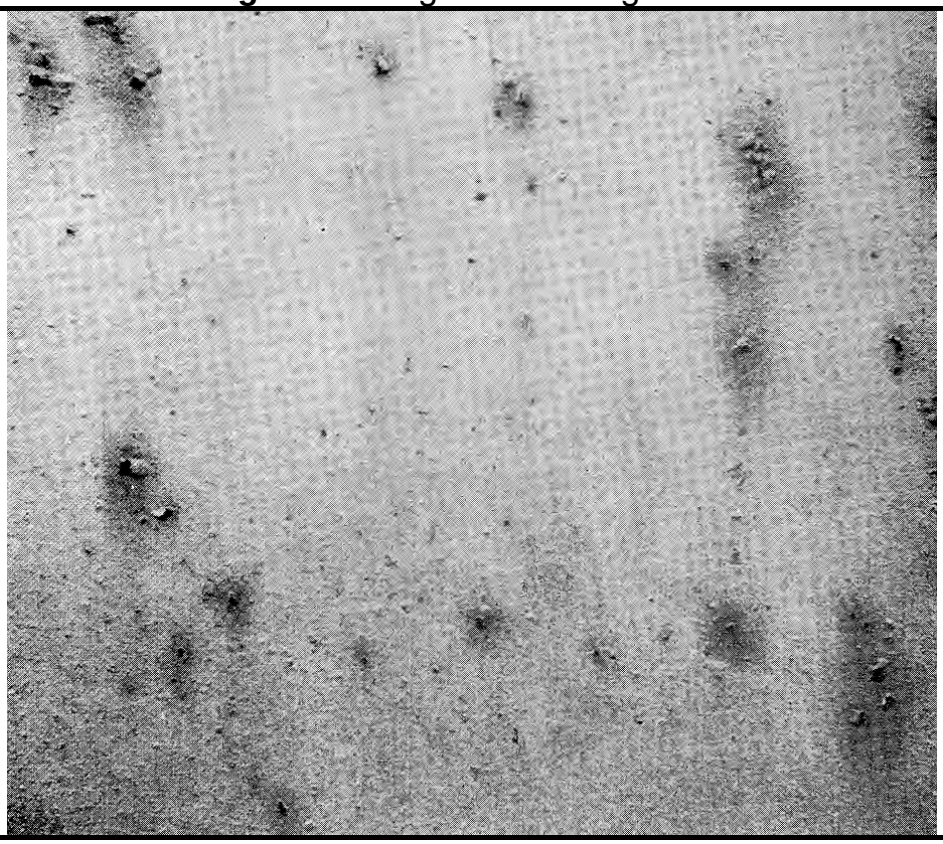


Figure G - Degree of rusting. Ri 3

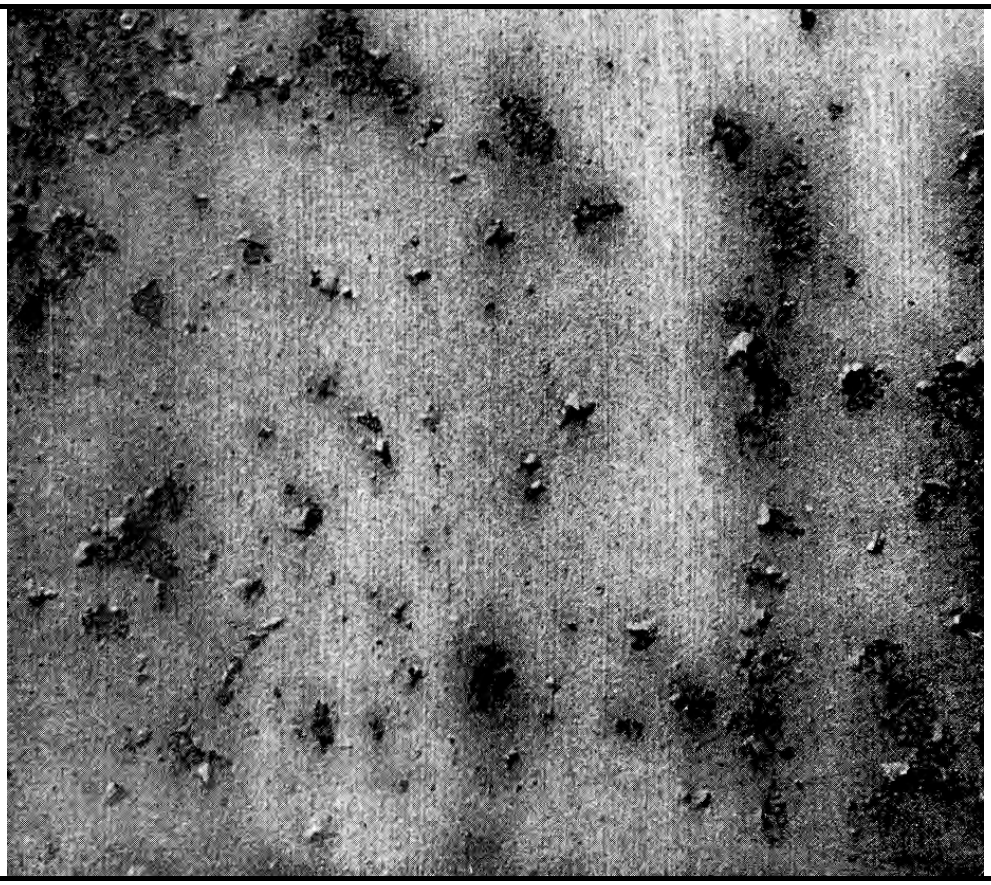


Figure H- Degree of rusting. Ri 4

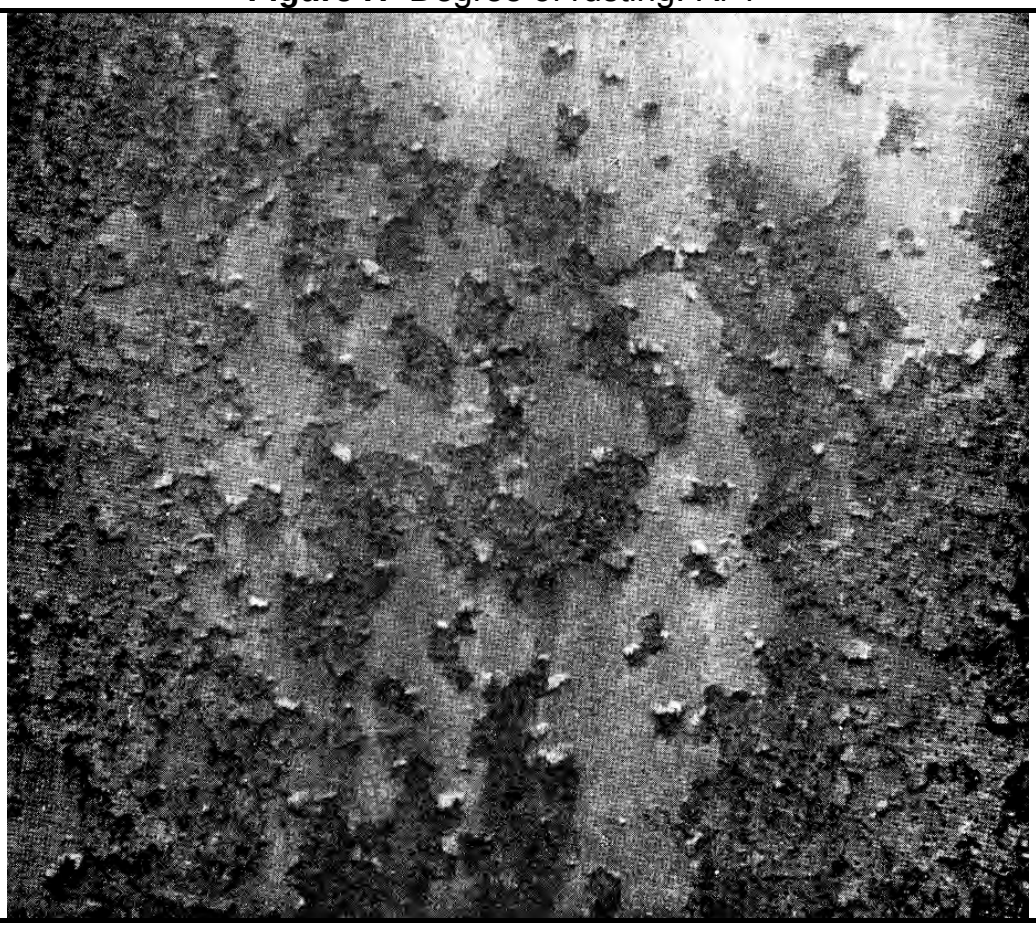


Figure I - Degree of rusting. Ri 5

ISO 4628/4: Designation of degree of cracking

Table F Rating scheme for the designation of the size of cracks

Rating	Size of cracks
0	not visible under x 10 magnification
1	only visible under magnification up to x 10
2	just visible with normal corrected vision
3	clearly visible with normal corrected vision
4	large cracks generally up to 1 mm wide
5	very large cracks generally more than 1 mm wide

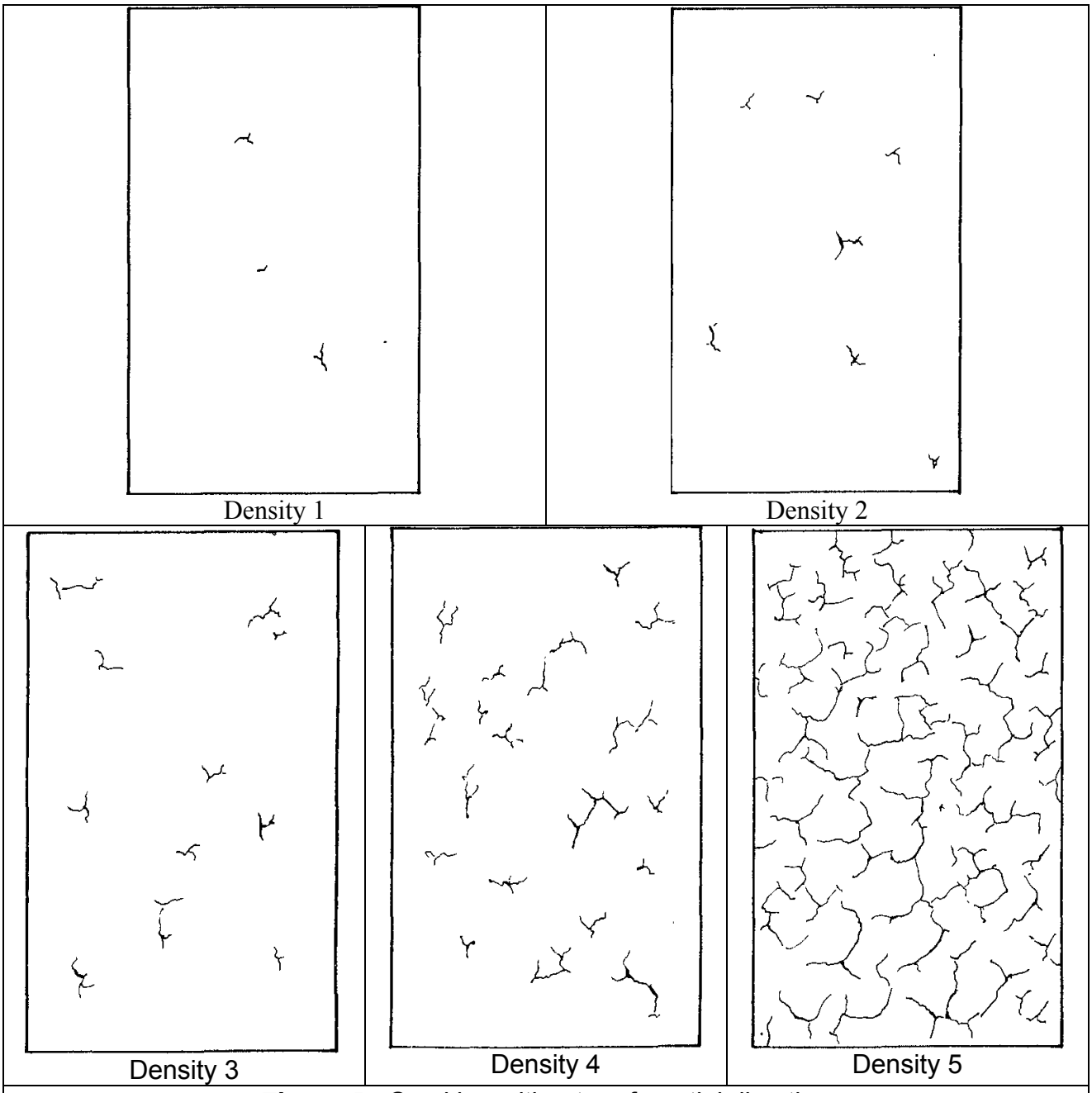
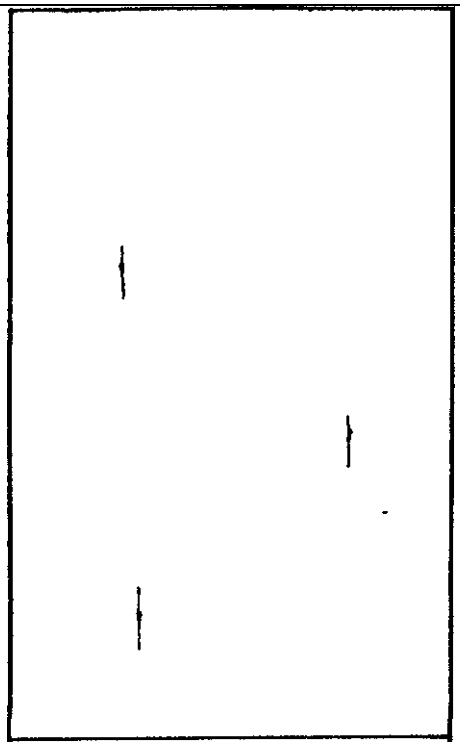
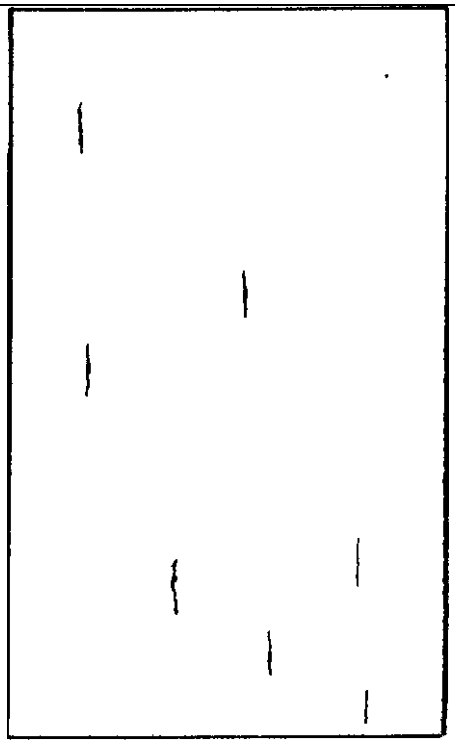


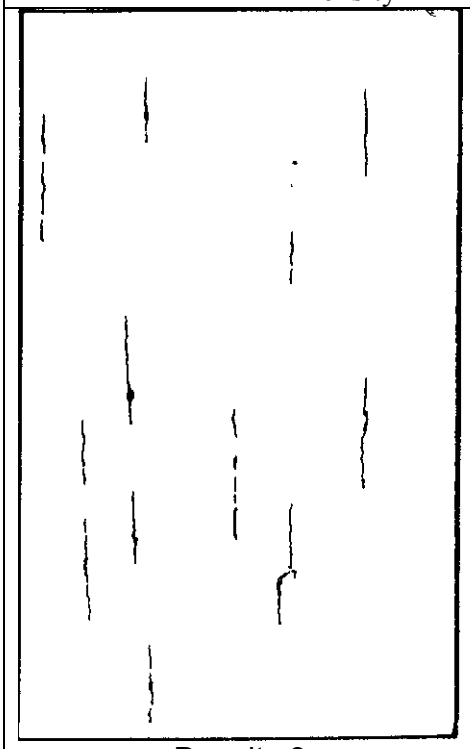
Figure J - Cracking without preferential direction



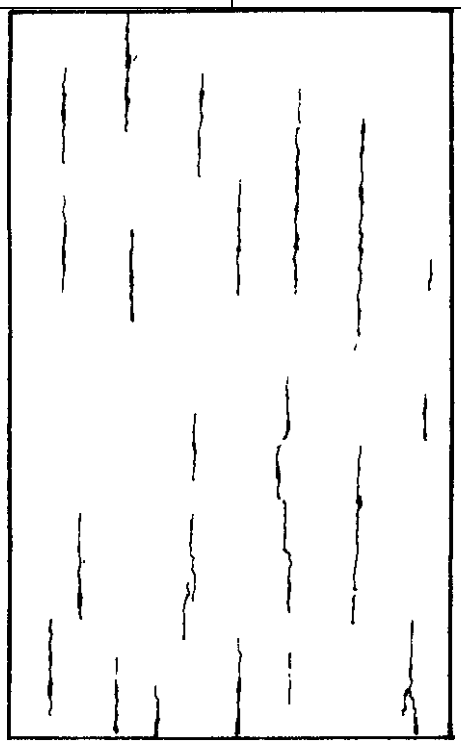
Density 1



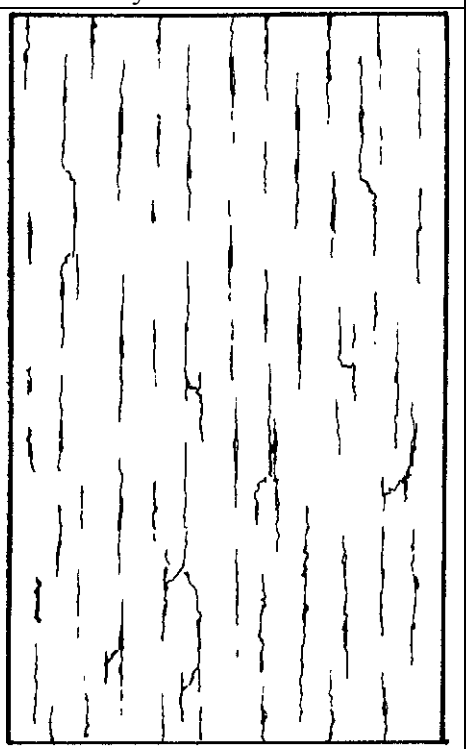
Density 2



Density 3



Density 4



Density 5

Figure K - Cracking with one preferential direction (e.g. due to brush marks or wood grain)

ISO 4628/5: Designation of degree of flaking

Table G Scale for the designation of the quantity of flaking

Class	**Flaked area** **%**
0	0
1	0.1
2	0.3
3	1
4	3
5	15

Table H Scale for the designation of the approximate size of areas exposed by flaking

Rating	**Size of flaking** (largest dimension)
0	not visible under x 10 magnification
1	up to 1 mm
2	up to 3 mm
3	up to 10 mm
4	up to 30 mm
5	larger than 30 mm

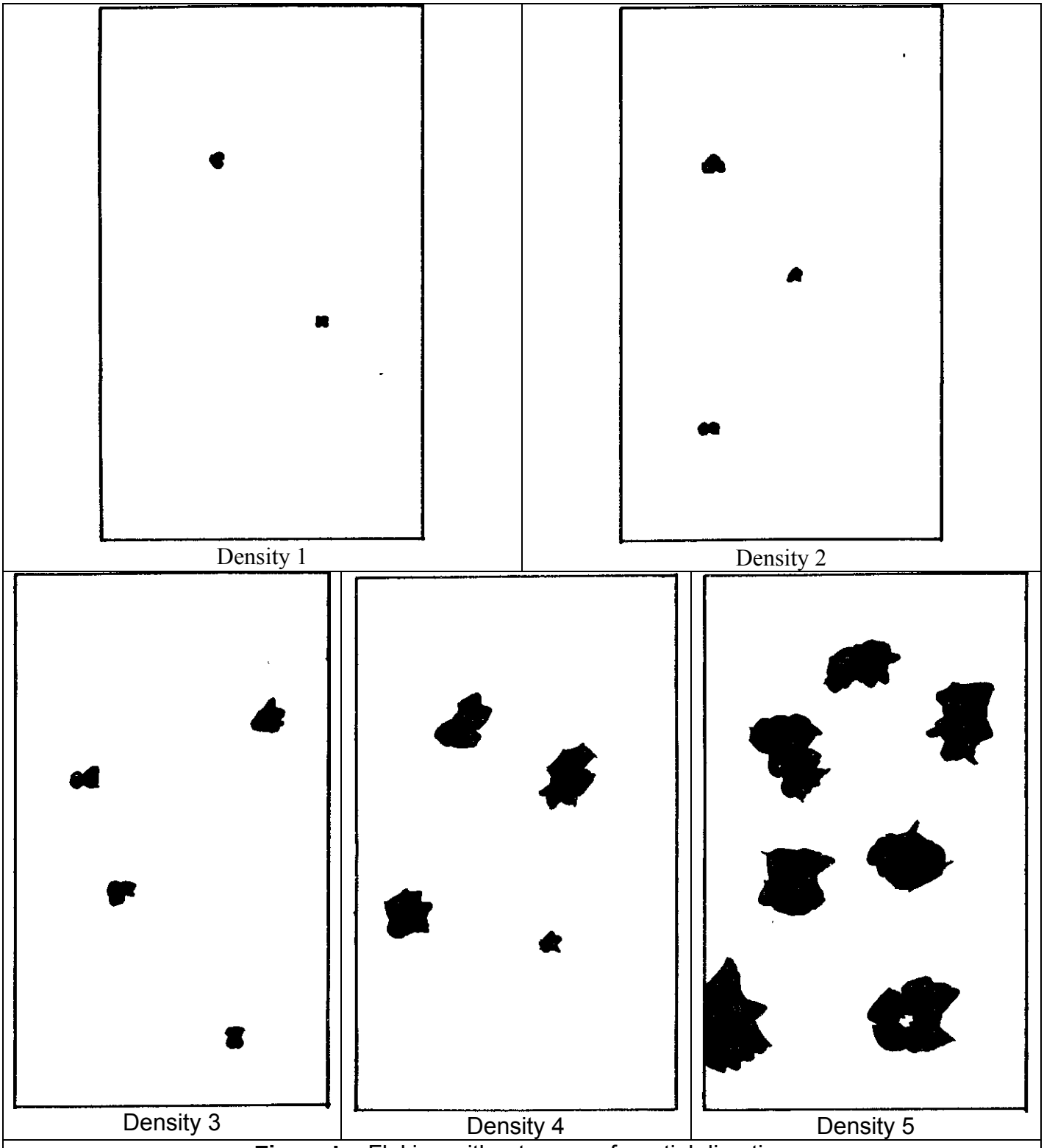
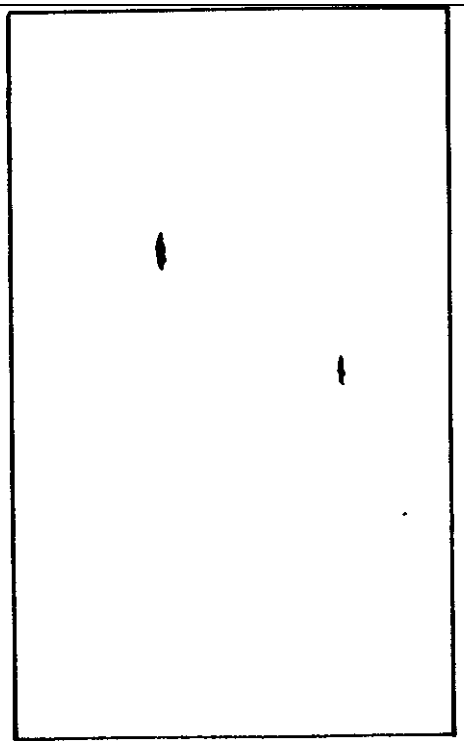
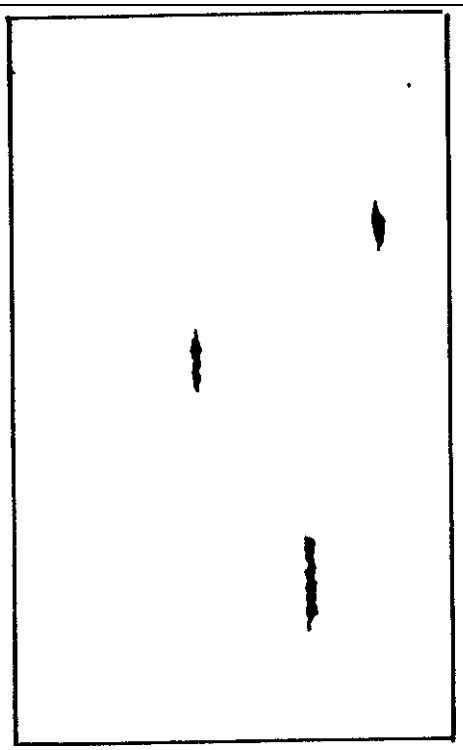


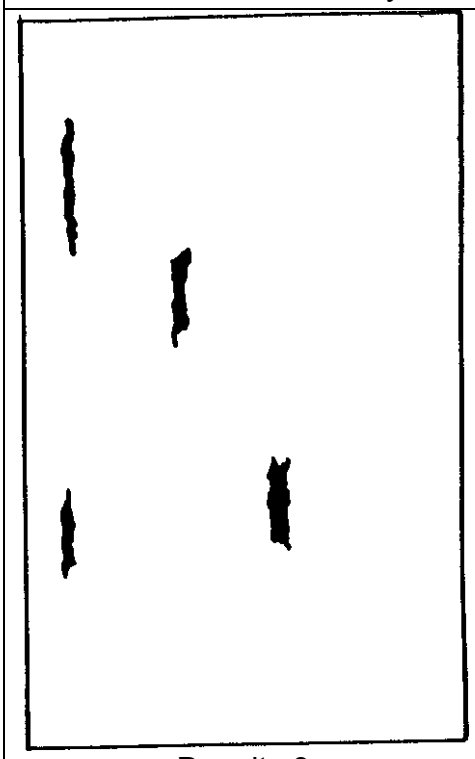
Figure L - Flaking without any preferential direction



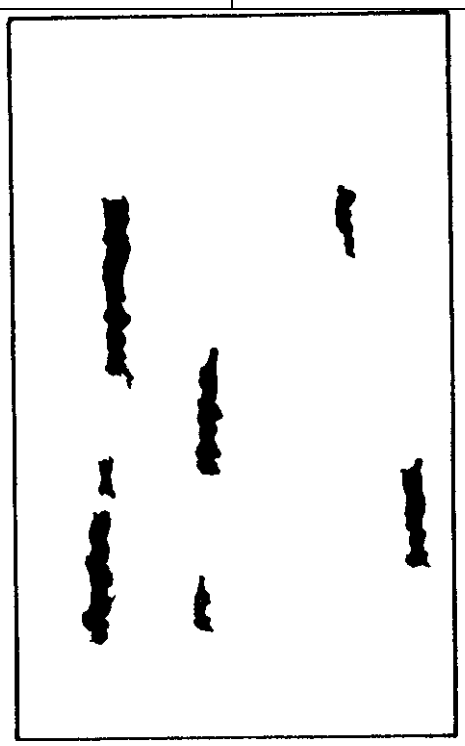
Density 1



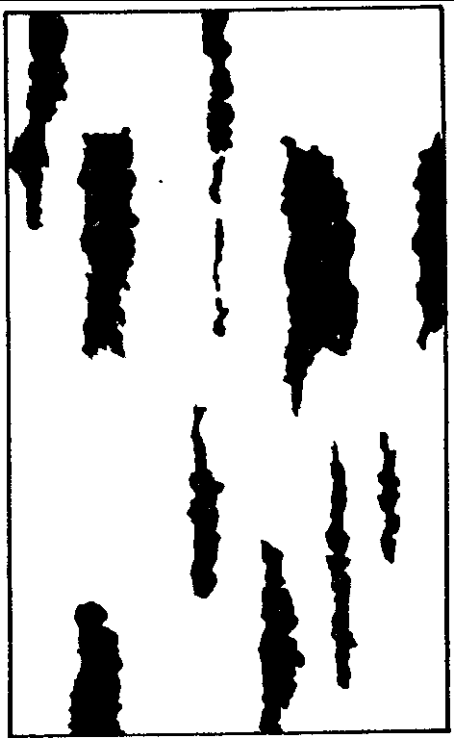
Density 2



Density 3



Density 4



Density 5

Figure M - Flaking with one preferential direction

E. Definitions and description of terms

Abrasive: The agent used for abrasive blast cleaning; for example, garnet, grit, shot etc.

Absorption: The process of soaking up, or assimilation of one substance by another.

Adhesion: The bonding strength; the attraction of a coating to the substrate.

Administration/Flag Administrations: Government of the state whose flag the ship is entitled to fly.

Adsorption: The process of attraction to a surface; attachment; the retention of foreign molecules on the surface of a substance.

Ageing: Progressive degradation of a coating in the long run.

Air Entrapment: The inclusion of air bubbles in liquid paint or a paint film.

Air Spraying: An application method by which paint is atomised by compressed air and transported to the surface.

Airless Spraying: An application method by which the paint is forced to a great pressure (up to 350 kg/sq. cm.) and is atomised by forcing it through a tiny nozzle.

Ambient temperature: The room temperature or temperature of surroundings.

Amphoteric: Capable of reacting chemically either as/with an acid or as/with a base.
and/or Suspect Areas.

Anode: The corroding part of an electrochemical corrosion cell such as sacrificial anode or impressed current anode. The electrode at which corrosion occurs.

Anticorrosive: Generic term defining paint used to protect metals from corrosion.

Ballast Tank: A tank which is being used solely for water ballast or a tank which is used for both cargo and ballast will be treated as a Ballast Tank when substantial corrosion has been found in that tank.

Batch: The amount of paint produced in a single production process and identified by a number assigned by manufacturer.

Binder: The component of a coating that holds the paint together and fixed to the substrate. Common such binders are; epoxies, vinyl, urethane, etc.

Blast cleaning: Cleaning with propelled abrasive.

Bleeding: The appearance of a coloured substance on a newly painted surface from a previously painted substrate. The soluble substances causing this defect are for example: bituminous paint, specific organic pigments, etc.

Blistering: Bubbling in coating films normally caused by osmosis.

Block Holding Primer (BHP): Primer applied at block stage to reduce the amount of ***in-situ*** secondary surface preparation. Not a pre-construction primer.

Blushing: Development of a milky appearance on a coating surface during drying process caused by humidity and/or from the precipitation of one or more solid components of the paint.

Body: Improper term to indicate the high percentage of volume solid of a paint.

Breakdown of coating: Defects in the coatings like rust penetration, blistering, flaking and cracking.

Brittle failure: Cracking and/or other failure normally encountered with hard, low ductility glassy objects and films.

Brittleness: Degree of resistance to cracking or breaking by bending. Lack of resistance to cracking or breaking when bent.

Bubbling: Coating defect, temporary or permanent, in which small bubbles of air or solvent or both are present in the applied film.

Cargo Area: That part of the ship that contains cargo tanks, slop tanks and cargo/ballast pump rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

Cathode: The electrode at which corrosion does not usually occur.

Cathodic Protection: Corrosion prevention by sacrificial anodes or impressed current.

Chalking: Formation of powder on a coated surface as a result of weathering.
Checking

Chipping: Cleanliness method of steel by removing paint, rust and mill scale, or other material by mechanical tools.

Clean surface: One free of contamination (including non-visible contamination such as soluble salts).

Close-up Inspection: An inspection where details of structural components are within the close visual inspection range of the surveyors, i.e. normally within reach of hand.

Close-up Survey: A survey where the details of structural components are within the close visual inspection range of the surveyor, i.e. normally within reach of hand.

Clotted: Irreversible gelatinisation of a paint that becomes unusable.

Coat of paint: One layer of dry paint, resulting from a single wet application.

Coating Material: Compound generally liquid, mastic or powder, forming a solid, filling protective and/or decorative coating.

Coating system: A number of coats separately applied, in a predetermined order, at suitable intervals to allow for drying and curing, resulting in a completed job.

Coating, Lining: Term used to define various products that are applied on steel to protect it from corrosion and/or to decorate it.

Coatings: Surface coverings; paints; barriers.

Cohesion: Property of holding together of a single material.

Compatibility: Attitude of a paint to be applied on another already dry coating.

Conductivity: The inverse of the resistance (Ohm cm). In these guidelines: conductivity, i.e. specific electrical conductance, of an electrolyte, as salt and water mixtures (seawater).

Corrosion prevention/protection system: A system designed for protecting the metal substrate from corrosion. For the purpose of these Guidelines, a corrosion prevention/protection system is

1) a hard coating, or

2) a hard coating supplemented by anodes

Corrosion rate: The rate usually in mm/year, at which the corrosion process proceeds. The corrosion rate is always to be calculated from metal loss on the surface, even when occurring on both sides of a steel plate. Corrosion rate shall not be confused with "steel thickness reduction rate".

Corrosion: Decay; oxidation; deterioration due to interaction with environment.
Cracking

Cracking of coating: Defect with fracture in the coating in at least one coat, often down to the substrate. Related expression is checking, which is surface cracking and crocodilling.

Critical Structural Areas: Are locations which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships (if available) to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

Cross Application: System of application by airless spraying and by brush consisting of crossing the various coats at right angles.

Cross Hatch Test: A method for testing adhesion of a coating, performed by a parallel series of crosshatch cuts near each other.

Cross-spray: Spraying first in one direction and second at right angles.

Curing agent: Hardener; promoter.

Curing Time: Time required by a coating to reach its complete properties and mechanical characteristic.

Curing: Setting up; hardening.

Curtaining: Special form of sagging by which the film appears locally with high thickness and with flakes similar to drape curtains.

Dew point: Temperature at which moisture condenses.

DFT: Dry film thickness.

Diluent: A liquid which lowers viscosity and increases the bulk but is not necessarily a solvent for the solid ingredients; a thinner.

Discing: Surface preparation method carried out with an abrasive disc assembled on a pneumatic or electric tool.

Discoloration: Colour change of a coating after application, normally caused by exposure to sunlight or chemical atmospheres.

Double Hull Oil Tanker: For the purpose of these Guidelines a Double Hull Oil Tanker is a ship which is constructed primarily for the carriage of oil in bulk, which has the cargo tanks protected by a double hull which extends for the entire length of the cargo area, consisting of double sides and double bottom spaces for the carriage of water ballast or void spaces. For other classification purposes, the definition provided in BCS- Rs and/or in Classification Societies Rules is to be used.

Dry Film Thickness (DFT): The thickness of the paint film, after drying and curing.

Dry spray: Over spray or bounce back; sand finish due to spray particles being partially dried before reaching the surface.

Dry to handle: Time interval between application and ability to pick up without damage.

Dry to recoat: Time interval between application and ability to receive next coat satisfactorily.

Dry to touch: Time interval between application and tack-free time.

Dryers: Substances that incorporated in relatively small percentages in the paint accelerate the drying process.

Drying time: Time interval between application and final cure.

Drying: Process by which coatings change from a liquid to solid state due to evaporation of the solvent, physical/chemical reactions of the binder or a combination of these factors.

Dulling or Tarnishing: Loss of gloss of a coating.

Edging: Striping.

Elasticity: Term improperly used to indicate the flexibility of the coating, corresponding to a permanent plastic deformation.

Electrochemical cell: See electrolytic corrosion.

Electrolytic corrosion: Corrosion occurring in an electrolyte, i.e. an electrically conductive liquid such as salt water. Anodes and cathodes formed on the steel surface, together with an electrolyte and the metallic pathway through the metal, constitute electrochemical cells.

Enamel: A finish coat of paint that shows a smooth, gloss surface after drying.

Epoxy amine: Amine cured epoxy resin.

Epoxy resins: Film formers (binders) usually made from bisphenol-A and epichlorohydrin, resins containing the oxyrane ring.

Erosion: Gradual and irregular destruction of coating surface caused by a mechanical or also by a chemical-physical action.

Explosion limits: A range of the ratio of solvent vapour to air in which the mixture will explode if ignited. Below the lower explosion limit (LEL) or above the higher explosion limit (HEL) the mixture is too lean or too rich to explode. The critical ratio runs from about one to 7 percent of solvent vapour by volume at atmospheric pressure.

Extender: Inert substance, for certain characteristics similar to pigments, but without or of low hiding power, used as a paint component for technical needs or for economic reasons (filling) (see “Pigments”).

Feather edge: Tapered edge.

Ferrous: Iron containing.

Film integrity: Degree of continuity of film.

Film thickness: The thickness of a coating layer or a multilayer coating system. Minimum and maximum values are the only relevant numbers when dealing with corrosion protection.

Film: A layer of coating material applied on a surface. The film just applied, before evaporation of the solvents is called “wet film”; the dry paint film, after solvent evaporation, “dry film”.

Fingers (airless): Broken spray pattern, finger like.

Finish: Term used to define indifferently the final coat in a paint system or the general aspect of a painted surface after drying.

Flaking: Detachment of a coating from the surface, in the form of flakes.

Flash off: Starting stage of drying process, during which most of the solvents evaporate from the coating.

Flash Point: The lowest temperature at which a liquid gives off sufficient vapour to form an ignitable mixture with the air near the surface of the liquid.

Flexibility: The degree at which a coating is able to conform to movement or deformation of it's supporting surface without cracking or flaking.

Flooding-Floating: Differentiated separation of pigments on a coating surface

Flow: Degree to which a wet paint film can level out after application so as to eliminate brush marks and produce a smooth uniform finish.

Forced drying: Acceleration of drying by increasing the temperature above ambient temperature accommodated by forced air circulation.

Galvanic corrosion: Corrosion of dissimilar metals in electrical contact.

Galvanising: Anticorrosive system which consists in dipping a steel structure, into melted zinc at a temperature of approximately 450°C.

Galvanized steel: Zinc plated steel applied in a molten bath of zinc.

Gelling: Partial or complete transformation of a paint into a mass similar to a gelatine.

General corrosion: Evenly distributed corrosion attack on steel surface.

Generic: Belonging to a particular family.

Glazing: Coat intentionally applied with a small thickness.

Gloss: Aptitude of a surface to reflect the light in certain conditions.

Grit: An abrasive obtained from slag and various other materials.

Guide: Guides are publications which give information and advice on technical and formal matters related to the design, building, operation, maintenance and repair of ships (and other objects) to yield a specific goal.

Guidelines: See Guide.

Hard coating: A coating which chemically converts during its curing process, normally used for new constructions or non-convertible air drying coating which may be used for the maintenance purposes. Hard coating can be either inorganic or organic. All conventional paints are included in this definition, e.g. epoxy, polyurethane, zinc silicate, vinyl, etc.

Hard rust scale: Sever general corrosion accumulated in layers adhering tightly to the steel surface.

Hardener, Curing agent, Catalyst: Component of a two-pack paint that mixed with a binder creates a chemical reaction forming a harder and resistant film.

Hardness: Resistance of a dry coating to scratching or to superficial deformation due to pressure.

Hiding Power: The ability of a coating material to hide, after drying, the colour of surface underneath.

Hold point: A stage in the production process where the work is stopped for an inspection to take place.

Holiday: Pinhole; skip; discontinuity; voids.

Hot Spraying: Spray application of a coating that has been heated to reduce its viscosity in special equipment.

Humidity: Measure of moisture content; relative humidity is the ratio of the quantity of water vapour in the air to the greatest amount possible at the given temperature. Saturated air is said to have a humidity of 100%.

Hydroxyl: Chemical radical; OH; basic nature.

Hygroscopic: Having a tendency to absorb water.

Immersion: Referring to an environment which is continually submerged in a liquid, often water.

Impressed current: Cathodic protection system in which the current is supplied at the anode from an external source.

Induction time: The period of time between mixing of two component products and the moment they can be used .

Inert: Not reactive.

Inhibitive pigment: One which retards a corrosion process.

Inhibitor: An agent added to retard corrosion.

Inorganic coating: Those employing inorganic binders or vehicles.

Inorganic: Material containing primarily ionic bonds and elements other than C and H.

In-situ: In these guidelines meaning work at the final hull stage; Plate stage - to - Panel stage - to - Block stage - to - Super-block stage - to ***-In-situ*** stage.

Inspection Hold point: Point in the production process where work will stop to enable inspection to take place.

Inter-coat contamination: Presence of foreign matter between successive coats.

Job-specification: Detailed working procedure outlining each step in the surface preparation and coating processes; including inspection hold points, thickness ranges, etc.

Lead free: Contains by weight less than 0.5% lead for industrial products and less than 0.06% lead in consumer products.

Light colour: Light colour in these guidelines means a colour that reflects light to an extent that a simple flash light (hand torch) will make inspection easy and fast. Normally light grey, buff, off-white, swimming pool blue/green, etc. easily distinguishable from rust.

Linings: Internal barriers; linings may be coated or sheet type.

Local breakdown of coating: Various kinds of more or less concentrated or spot-wise defects in the coatings like rust penetration, blistering, flaking and cracking.

Maintenance painting: (1) repair painting; any painting after the initial paint job; in a broader sense it includes painting of items installed on maintenance; (2) all painting except that done solely for aesthetics.

Masking: Covering areas not painted.

Mastic: A heavy bodied coating of high build.:

Material Safety Data Sheet: Document published by paint manufacturer in which components of the paints and all the safety requirements are given.

Mechanical cleaning: Power tool cleaning, by means of grinding disc, wire brush or similar.

Mill scale: Oxide layer formed on steel by hot rolling.

Miscible: Capable of mixing or blending uniformly.

Mist coat: Thin tack coat; thin adhesive coat. Common practice to wet an inorganic zinc layer, and permit air escape, before full build when top coating.

Moisture vapour transmission (MVT): Moisture vapour transmission rate through a membrane.

MSDS: Material Safety Data Sheet

Non-ferrous: A term used to designate metals or alloys that do not contain iron; example; brass, aluminium, magnesium, copper, etc.

NSF: National Sanitation Foundation; Organization in US certificating coatings for potable water tanks.

Oil Tanker: for the purpose of these Guidelines an Oil Tanker is a ship which is constructed primarily to carry oil in bulk and includes ship types such as combination

carriers (Ore/Oil ships etc.). For other classification purposes, the definition provided in BCS Rs and/or in Classification Societies Rules is to be used.

Orange peel: Appearance similar to orange peel, that can be seen on a film applied by airless spraying due to incomplete levelling.

Organic: Containing carbon.

Osmosis: Transfer of liquid through a paint film or other membrane as the result of a solute/solvent couple.

Osmotic blistering: Formation of blisters containing liquid through osmosis.

Overall Inspection: An inspection intended to report on the overall condition of the hull structure and determine the extent of additional close-up inspections.

Overall Survey: A survey intended to report on the overall condition of the hull structure and determine the extent of additional Close-up Surveys.

Owner: Owner or Owners representative.

Paint system: The complete number and type of coats comprising a paint job. In a broader sense, surface preparation, pre-treatments, dry film thickness, and manner of application are included in the definition of a paint system.

Peeling: Disbonding of particles of a coating from substrate in the form of strips, due to loss of adhesion.

Peen: To draw, bend or flatten by or as if by hammering with a peen (wedge-shaped end of the head of a hammer).

Peened: As if hammered by a rounded tool or shot.

Permeability: Quality or state of being permeable.

pH value: Measure of acidity or alkalinity; pH 7 is neutral; the pH value of acids ranges from 1 to 7, and of alkalis (bases) from 7 to 14 in water solution.

Pigments: Insoluble coloured particles dispersed in a coating material in order to define appearance, structure and functionality of the final film.

Pinholes: Presence of small holes in a coating that are formed during application or drying.

Pitting: Cavity in a metallic surface, due to localised corrosion.

Plasticizer: A paint ingredient which imparts flexibility.

Polymerization: Formation of large molecules from small ones.

Pot-life: Time interval after mixing during which liquid material is usable with no difficulty.

Power Tool Preparation: Surface preparation method carried out by mechanical tools, pneumatic or electric such as abrasive discs, wire brush, sandpaper etc.

Preventive maintenance painting: Spot repair painting; touch-up or full coats of paint before rusting starts.

Prime coat: First coat.

Primer: General term used to define the first coat of a paint system applied to provide adhesion and/or corrosion protection.

Product Data Sheet: Document published by paint manufacturer in which the characteristic of the product, the method to use, the instructions for application and storage are indicated.

Profile depth: Average distance between tops of peaks and bottom of valleys on the surface.

Profile-surface: Surface contour as viewed from edge.

Prompt and Thorough Repair: A permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of classification.

Protective Coating: Usually epoxy coating or equivalent. Other coating systems may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's specification.

Protective life: (also called Useful life) Interval of time during which a paint system protects substrate from deterioration.

Recoat time: Time interval required between application of successive coats.

Repainting: Repetition of a complete painting operation including surface preparation.

Representative Tanks: Those tanks which are expected to reflect the condition of other tanks of similar type and service and with similar corrosion protection systems. When selecting Representative Tanks account is to be taken of the service and repair history onboard and identifiable Critical Areas

Resin: The film former; binder.

Roller Application: Hand application of a coat of paint using an absorbing roller on a surface.

Rugotest: Profile comparator from RUPERT & CO. LTD, UK; by BS2634 and ISO2632.

Sacrificial anode: Anode made from less noble metal than steel in the galvanic series, (usually zinc or aluminium). When immersed, the anode protects the steel by coming into solution.

Sags: Runs

Salt fog test: A cabinet designed to accelerate the corrosion process in evaluating coatings; combines 100% humidity with a 5% salt concentration at 100°F in an enclosed cabinet, as in ASTM - B 117.

Sandblast: Blast cleaning using sand as an abrasive.

Sandpapering: Generic term identifying various methods used to smooth or in some cases to roughen a coating surface. In particular, sandpapering is a smoothing carried out with abrasive paper.

Saponification: The alkaline hydrolysis of fats/oils whereby a soap is formed; typical reaction between alkyds and galvanized metals resulting in peeling or from cathodic protection.

Scattered breakdown of coating: Various kinds of evenly distributed defects in the coatings like rust penetration, blistering, flaking and cracking.

Semi-hard coating: Coating that, after drying, remain flexible and hard enough to be touched and walked upon without damaging them and that are not affected by water erosion during de-ballasting operations.

Service life: See Protective life.

Settling: Accumulation of pigments and fillers in the bottom of a paint container.

Shop primer: An inexpensive, rust inhibiting primer designed to protect steel from general weathering immediately after plate fabrication and before final coating processes.

Shot blasting: Blast cleaning using steel shot as the abrasive.

Shrinkage: Decrease in volume on drying.

Skinning: Solidification process of the superficial part of paint in the can due to oxidation, evaporation, coagulation etc.

Soft coating: Defined as coatings that does not dry, but remain permanently soft.

Solid Content: Non-volatile part of a paint, see also solids by volume.

Solids volume: Formulated percent of total paint volume occupied by non-volatile parts of the coating.

Solubility: Degree to which a substance may be dissolved.

Solution: A liquid in which a substance is dissolved.

Solvent entrapment: The encapsulation of solvent within a cured paint film.

Solvent: A liquid in which another substance may be dissolved.

Solvent-Free: Paint without volatile binder (also called 100% volume solid).

Solvent-Less: Paint containing a small percentage (generally 10/15%) of volatile binder.

Spaces: Separate compartments including holds and tanks.

Specification: A set of instructions detailing the plan for coating of a project; a list of criteria for a coating.

Spontaneous degradation: Coating degradation that is controlled and directed internally: self-acting: developing without apparent external influence, force, cause, or treatment.

Spot repair: Preventative maintenance; repainting of small areas.

Spot rusting: Rusting in spot without visible failure of coating.

Spreading Rate: Surface in square metres covered by one litre of paint at a specified thickness.

Stripe Coating: Painting method used before a general coat on positions (weld, back, edge, corner etc.) where it is not easy to achieve the final thickness with the simple airless spray application.

Striping: Edge, weld, scallop painting prior to priming.

Substantial Corrosion: An extent of corrosion such that assessment of corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits.

Substrate: Surface to be painted; in this context carbon steel, stainless steel, galvanized steel and all surfaces that can affect the corrosion rate or can corrode.

Surface tension: Cohesive force on liquid surface.

Suspect Areas: Locations showing Substantial Corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

Sweat-in time: Time for a two component material to start the reaction that allows the two components to become soluble in each other; Induction time.

Sweating: Condensing moisture on a substrate.

Swelling: Increasing in volume.

Tg: Glass transition temperature - the temperature at which a coating is transformed from the rubbery to the glassy state.; e.g. becomes a brittle hard film. Or, the temperature under which the coating becomes rubbery and able to deform.

Thermo-Hygrometric Condition: The environmental conditions that are present during surface preparation and paint application.

Thermosetting: Becomes rigid under heat due to chemical cross linking and cannot be remelted.

Thinners: Volatile organic liquids for reducing viscosity; diluents.

Thinning Ratio: Percentage of solvents to add to a paint, to make it suitable for a defined application system.

Thixotropic: False-bodied; a gel which liquefies with agitation but gels again on standing.

Thixotropy: Characteristic of a coating material to reach a viscosity reduction when shaken, stirred or other mechanical operations and that readily recovers its original viscosity when allowed to stand.

Touch drying: Drying is the stage of film formation in which, when exercising a light pressure with the finger, no sign remains and it is not sticky.

Touch-up painting: Spot repair painting usually conducted a few months after initial painting. Also, manual painting to correct thickness deficiencies.

Touch-up: Operation of repair of spot damage coated surface.

Transverse Section: Includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, inner bottom and longitudinal bulkheads.

TSCF: Tanker Structure Co-operative Forum

Turn: To oxidize.

Two-Pack Paints: Paints stored in two separate containers and that have to be mixed in the correct proportion before application.

Useful life: See Protective life.

Varnish, Lacquer: Non-pigmented coating material.

Vehicle: The liquid portion of paint in which the pigment is dispersed. It is made up of resin and solvent.

Viscosity: A measure of fluidity of a liquid.

Volume Solids: Non-volatile part of a coating compound, which after drying forms the coating.

Walk-on-time: Time at which a coating is dried/cured enough so that it can be walked upon without being damaged.

Weld joints: Beads of weld joining two members.

Weld slag: Amorphous deposit formed during welding.

Weld spatter: Beads of metal left adjoining a weld.

Weld splatter: See weld spatter.

Wet Film Thickness: The thickness of paint film just applied and before evaporation of the volatile part.

Wet-on-Wet: Paint technique consisting of the application of a coat on a previous one not yet dry. The result is of one film that dries as a whole. The process requires specific paints.

Wetting strength: The maximum distance or penetration the vehicle is capable of delivering the paint or coating assembly in a vertical or horizontal direction on a specific substrate.

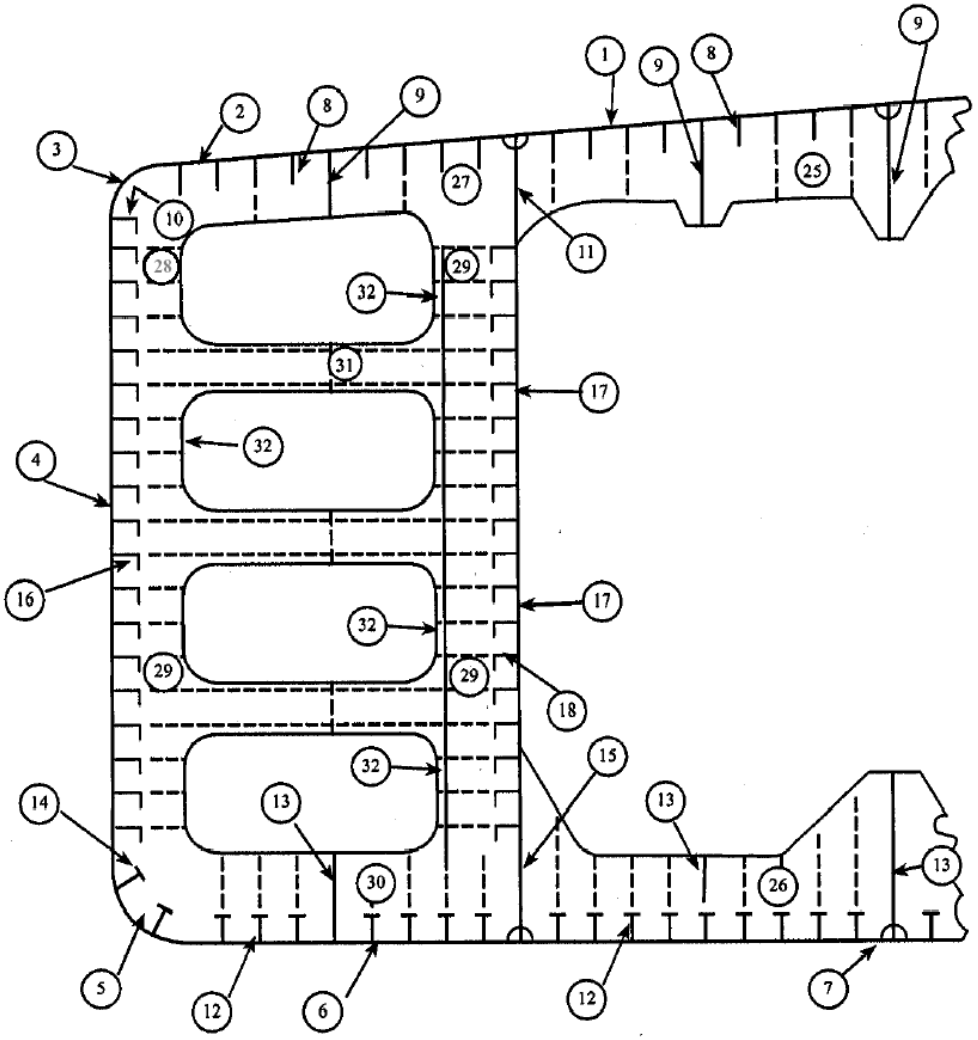
Wetting time: The time required for a vehicle to reach the end point of a distance and penetration on a metal.

Wrinkling: Coating defect due to a non-homogeneous solidification of the paint film with wrinkling of the surface coat.

Zinc rich coating: Products containing > 86% (by weight) metallic zinc in the dry film.

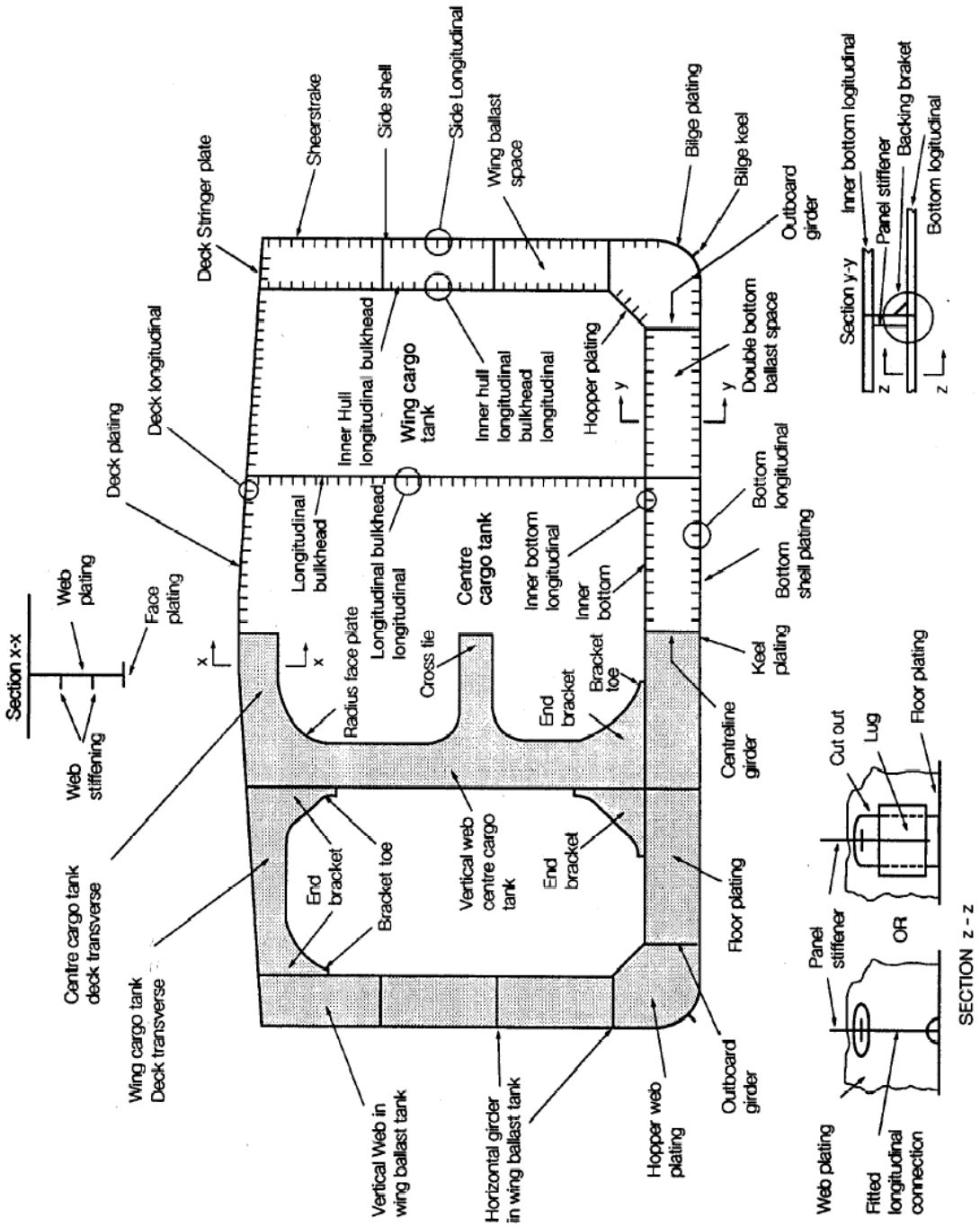
Zinc silicate: Inorganic zinc coating.

Typical nomenclature for single hull: Typical transverse section of single hull tanker



1	Strength deck plating	14	Bilge longitudinals
2	Stringer plate	15	Longitudinal bulkhead lower strake
3	Sheer strake	16	Side shell longitudinals
4	Side shell plating	17	Longitudinal bulkhead plating
5	Bilge plating	18	Longitudinal bulkhead longitudinals
6	Bottom shell plating	25	Deck transverse centre tank
7	Keel plate	26	Bottom transverse centre tank
8	Deck longitudinals	27	Deck transverse wing tank
9	Deck girders	28	Side shell vertical web
10	Sheer strake longitudinal	29	Longitudinal bulkhead vertical web
11	Longitudinal bulkhead top strake	30	Bottom transverse wing tank
12	Bottom longitudinals	31	Cross ties
13	Bottom girders	32	Transverse web face plate

Typical nomenclature for double hull: Typical transverse section of double hull tanker



F. Pertinent Standard

STANDARD	SUBJECT
ASTM 56	flash-point
ASTM 711	drying times of coatings
ASTM 1005	thickness measurements
ASTM 1259	binder/pigment/ volatile/solids content
ASTM 1310	flash-point
ASTM 1640	drying times of coatings
ASTM 1953	drying times of coatings
ASTM 2240	hardness
ASTM 262	binder/pigment/ volatile/solids content
ASTM 2832	binder/pigment/ volatile/solids content
ASTM 3278	fiash-point
ASTM D93	fiash-point
ASTM D522	elongation, bending over mandrel
ASTM D610	degree rusting
ASTM D658	abrasion resistance
ASTM D659	degree chalking
ASTM D660	degree checking
ASTM D661	degree cracking
ASTM D662	degree erosion
ASTM D714	degree blistering
ASTM D772	degree flaking
ASTM D821	abrasion resistance
ASTM D968	abrasion resistance
ASTM D1141	synthetic seawater
ASTM D1186	dry thickness, ferrous
ASTM D1200	viscosity
ASTM D1212	wet thickness reading
ASTM D1397	abrasion resistance
ASTM D1400	dry thickness, non-ferrous
ASTM D1653	water vapor transmission
ASTM D1737	elongation, bending over mandrel
ASTM D2134	hardness
ASTM D2197	adhesion, scrape test
ASTM D2370	tensile elongation, free film
ASTM D2485	heat resistance testing
ASTM D2485	resistance to high temperature
ASTM D2697	binder/pigment/ volatile/solids content
ASTM D2794	impact resistance
ASTM D3732	drying times of coatings
ASTM G8	cathodic disbondment
ASTM G14	impact resistance
ASTM G53	cyclic test
ASTM MD570	water absorption of plastics and free coating films
ASTM MD3258	porosity of films
ASTM MD3276	guidance for inspectors
ASTM MD3359	adhesion by tape test
ASTM MD3363	hardness by pencil test
ASTM ME376	eddy current gauge
BS 2634	surface roughness comparator
BS 2691	thickness measurements
BS 3900 part C5	thickness measurements
BS 3900 part C5	wet film thickness
BS 3900 Part E4	elongation, cupping of coated plates (Erichsen test)
BS 3900 Part E1	elongation, bending over mandrel
BS 3900 Part E3	impact resistance
BS 3900 Part E7	impact resistance
BS 3900 PART G7	heat resistance testing
BS 4164	hardness

BS 4164	heat resistance testing
BS 4232	degrees of surface preparation
BS 4692	heat resistance testing
BS 5493	wet film thickness
BS 6374	holiday / pinhole detection
DIN 1342	viscosity
DIN 2691	thickness measurements
DIN 51550	viscosity
DIN 51755	flash-point
DIN 51758	flash-point
DIN 53156	elongation, cupping of coated plates (Erichsen test)
DIN 53177	viscosity
DIN 53213	flash-point
DIN 55928	degrees of surface preparation
ISO 1517	drying times of coatings
ISO 2808	thickness measurements
ISO 2812-2	immersion/freeze/ dry test
ISO 3233	binder/pigment/ volatile/solids content
ISO 4828-4	paint and varnishes- evaluation of degradation of paint coatings
ISO 6270	condense chamber test
ISO 7253	salt spray testing
ISO 8501-1	surface preparation
ISO 8501-3	steel surface imperfections
ISO 8502-1	soluble iron
ISO 8501-3	steel preparation
ISO 8502-2	labtest- chlorides
ISO 8502-3	dust assessment
ISO 8502-4	condensation probability
ISO 8502-6	field extraction – chlorides
ISO 8502-9	field conductimetric determination of water soluble salts
ISO 8503-1	surface roughness spec.
ISO 8503-2	surface roughness comparator
ISO 8503-3	surface roughness microsc.
ISO 8503-4	surface profile, Stylus instrument
ISO 8504-1	surface preparation methods
ISO 8504-2	abrasive blast cleaning
ISO 8504-3	power & hand tool cleaning
ISO 8502-10	titrimetric determination of water soluble salts
ISO 8503-1	roughness definition
ISO 8503-2	roughness comparator
ISO 8503-3	roughness, Fucus microscope
ISO 8503-4	roughness, Stylus instrument
NACE No.7	water jetting/blasting standards
NACE TM 170-70	degrees of surface preparation
NACE RP0178	weld and steel standards
NACE RP0274	holiday/pinhole detection
SIS 055900	degrees of surface preparation
SIS 162201	hardness
SIS 184153	drying times of coatings
SIS 184160	thickness measurements
SSPC PA2	thickness gauge calibration
SSPC SP 1	substrate degreasing
SSPC VIS 1	degrees of surface preparation, blasted steel

SSPC VIS 3	degrees of surface preparation, power tooled steel	SSPC-VIS4(1)	water jetting/blasting standards

G. Tables comparing commonly used standards

Table I Comparison of blasting standards

Standard	Highest degree = White metal	Good degree = near white
ISO 8501-1	Sa 3	Sa2 ½
SIS 055900	Sa 3	Sa2 ½
DIN 55928	SA 3	Sa2 ½
BS 4232	First Quality	Second Quality
NACE TM170-70	No.1	No.2
SSPC	SP 5	SP 10

Table J Comparison of power tool standards

Standard	Highest degree	High degree	Lower degree
ISO 8501-1	NA	St 3	St 2 ½
SIS 055900	NA	St 3	St 2 1/2
DIN 55928	NA	St 3	Sa 2 1/2
SSPC	SP 11	SP 3	SP 2

Table K Correlation between ISO and ASTM rating systems for blisters

Denisity		**Size**	
ASTM	**ISO**	**ASTM**	**ISO**
None	0		
(less than few)	1	(smaller than 8)	1
Few	2	8	2
Medium	3	6	3
Medium – Dense	4	4	4
Dense	5	2	5

Table L Correlation between ISO and European rust scales

ISO rust scale	**European rust scale**
Ri 0	Re 0
Ri 1	Re 1
Ri 2	Re 2
Ri 3	Re 3
Ri 4	Re 5
Ri 5	Re 7

Table M Approximate correlation between ISO and ASTM rust scales

ISO rust scale	**ASTM D 610**
Ri 0	10
Ri 1	9
Ri 2	7
Ri 3	6
Ri 4	4
Ri 5	1 to 2

H1. Examples of assessment of coating conditions

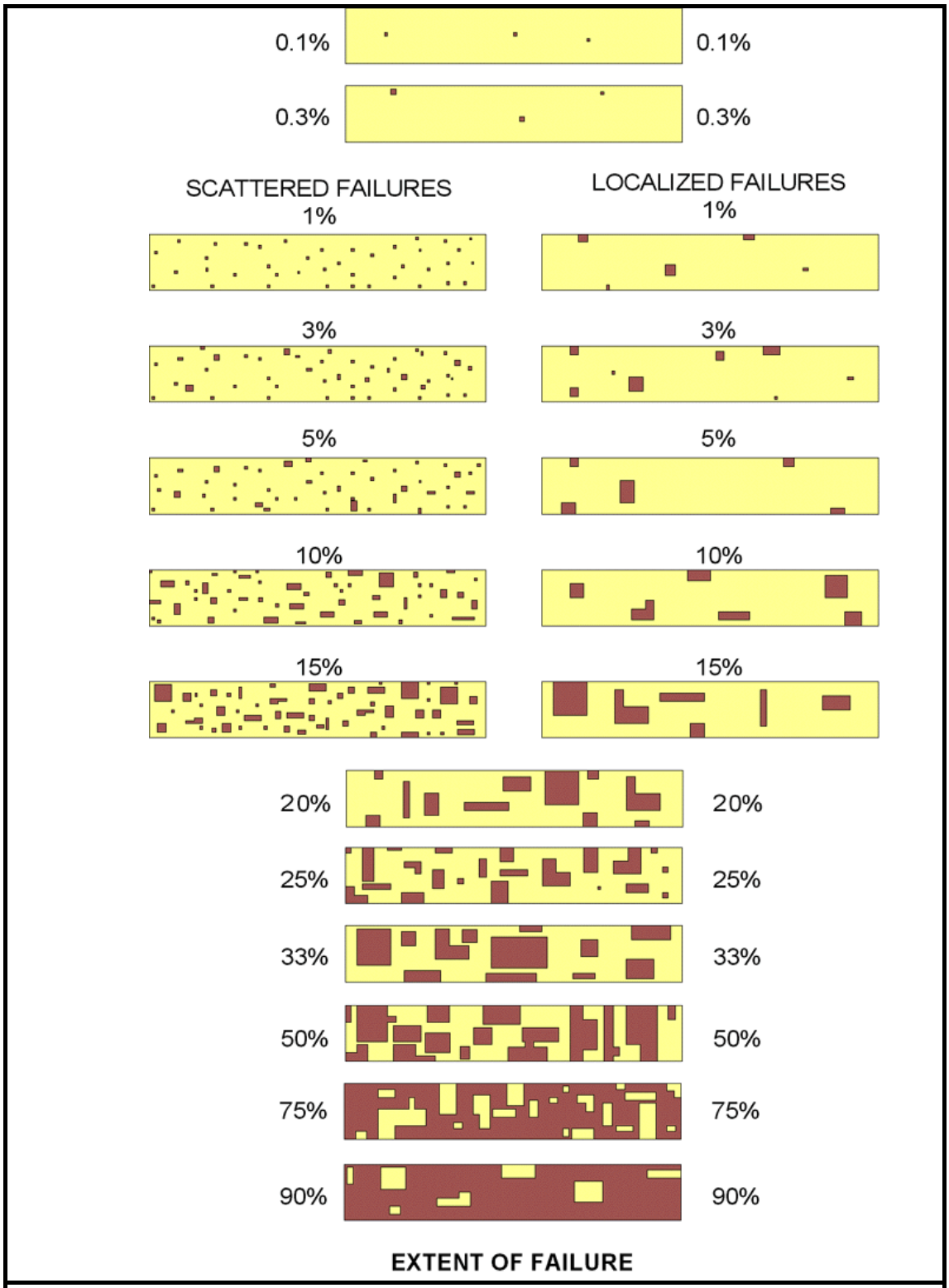


Figure N - Assessment scale for breakdown

Notes: Condition: **GOOD**
spot rusting: scattered 1%
spot rusting on edges or weld lines: localised less than 5%

Assessment scale:

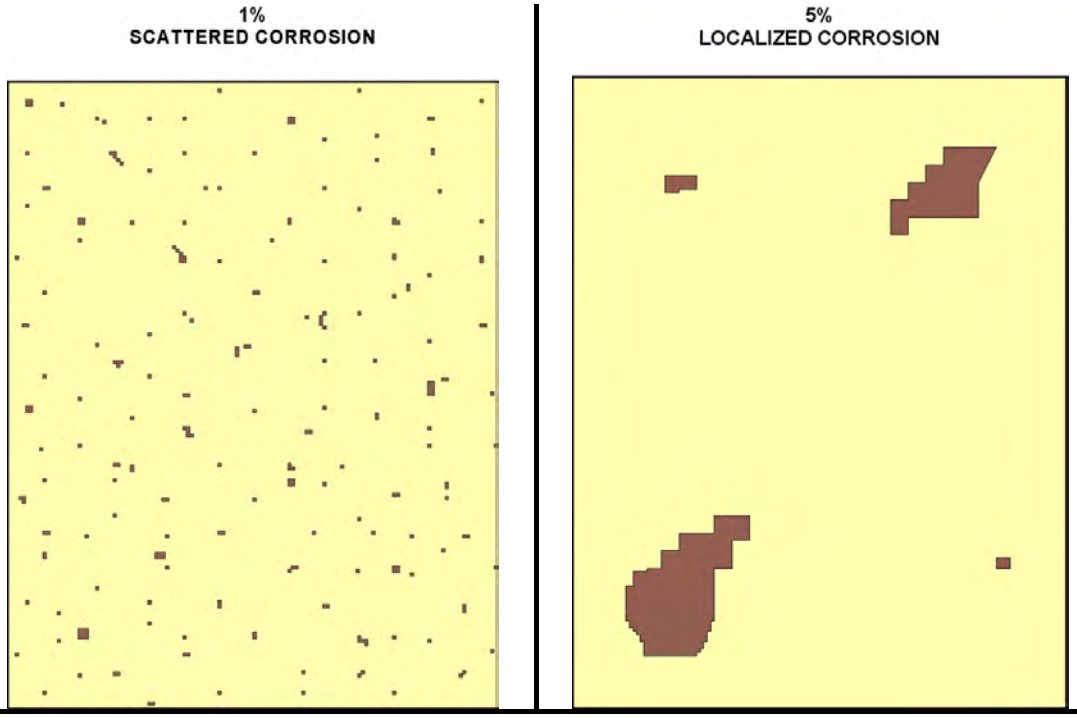


Figure O - Coating Condition Evaluation

Notes: Condition: **FAIR**
Breakdown of coating/area rusted: localised 15-20%
Area of hard rust scale: Less than 10% of the area rusted
Local breakdown of coating or rust on edges or weld lines: 30-40%
Remarks: FAIR for longitudinal close to bottom, remaining surface; **GOOD**

Assessment scale:

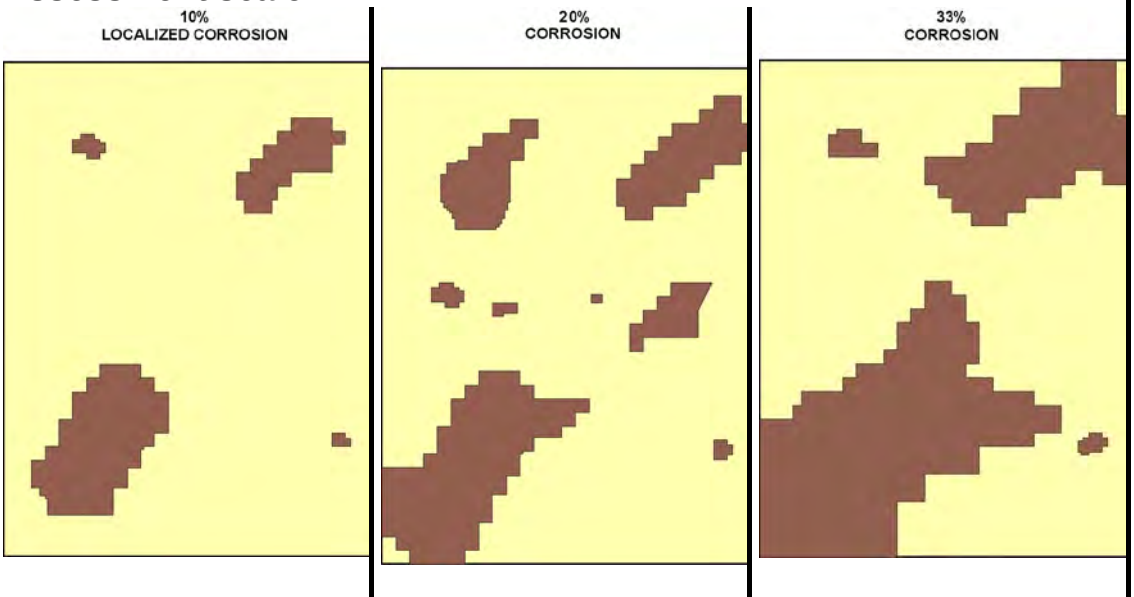


Figure P - Coating Condition Evaluation

Notes: Condition: **POOR**
Breakdown of coating/area rusted: approx. 30%
Area of hard rust scale: More than 10% of the area rusted
Local breakdown of coating or rust on edges or weld lines: 30-40%

Assessment scale:

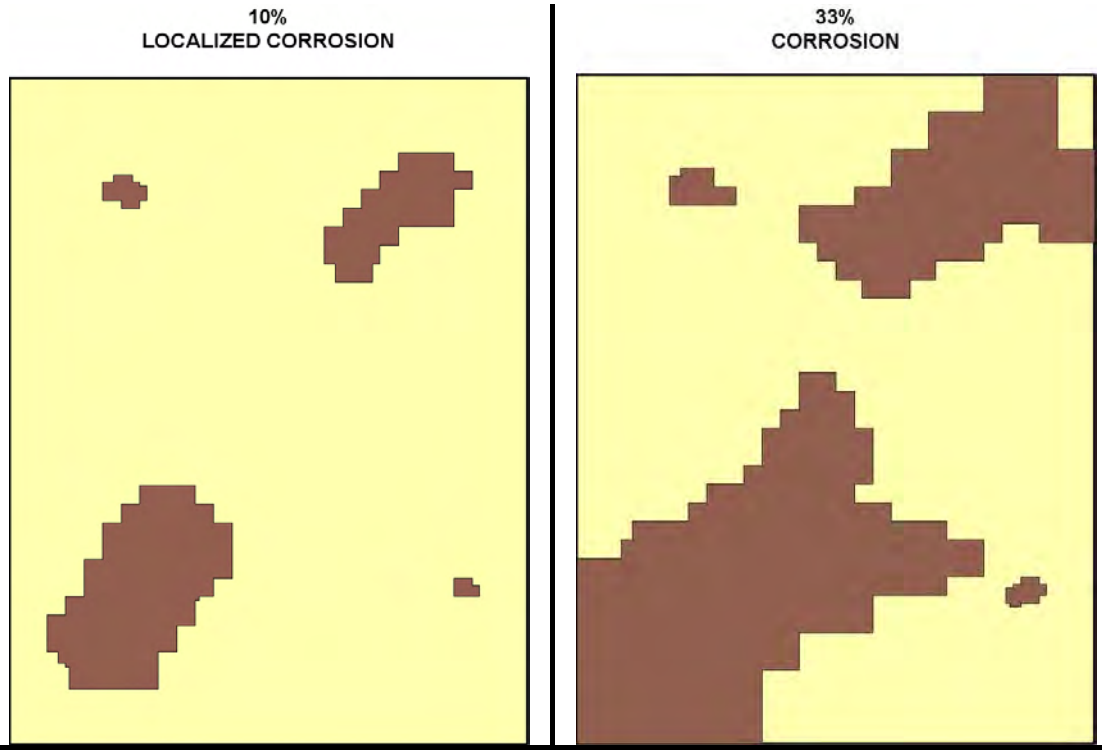


Figure Q - Coating Condition Evaluation

H2. Library of pictures

GOOD COATING CONDITION

GOOD COATING CONDITION

GOOD COATING CONDITION

GOOD COATING CONDITION

GOOD COATING CONDITION

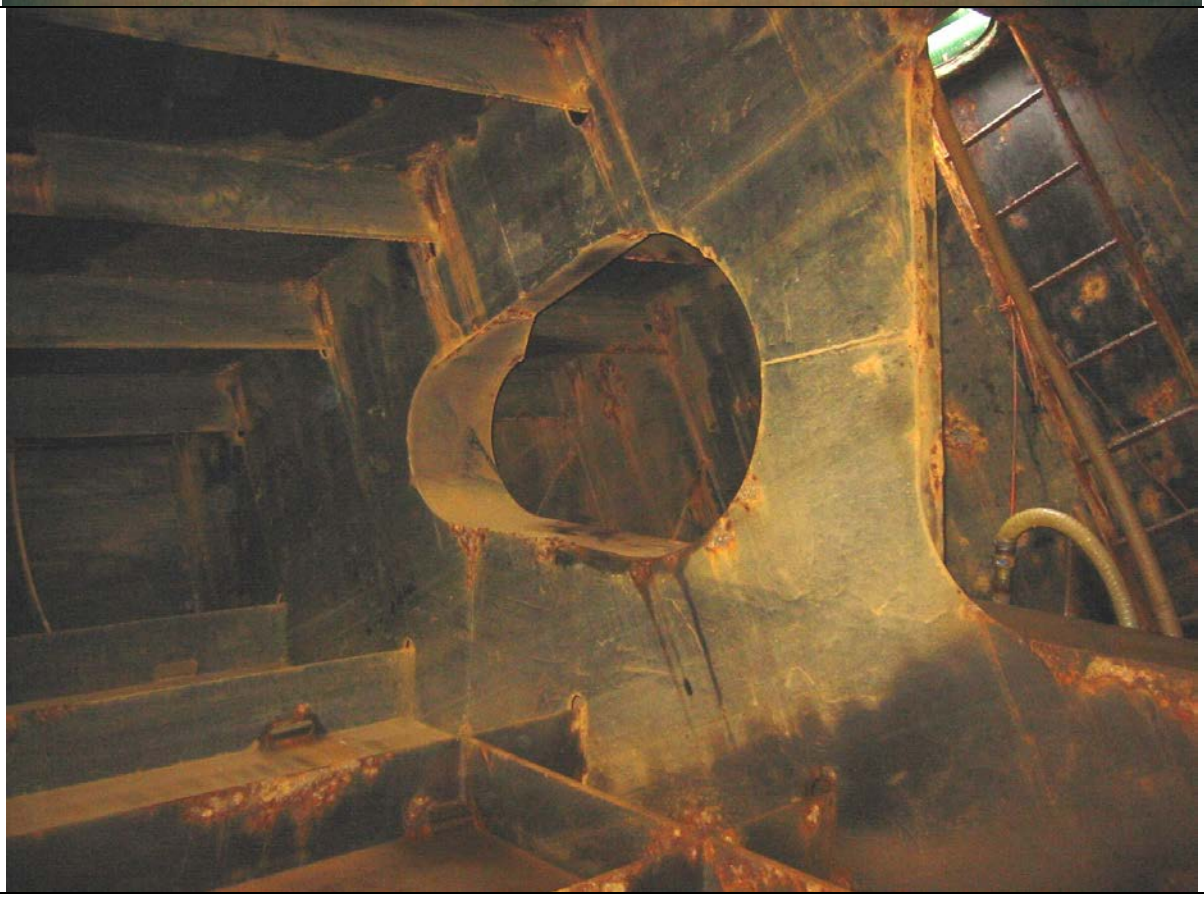
TRANSITION GOOD TO FAIR COATING CONDITION:
THIS IS A GOOD CONDITION

FAIR COATING CONDITION

FAIR COATING CONDITION

FAIR COATING CONDITION

FAIR COATING CONDITION



FAIR COATING CONDITION

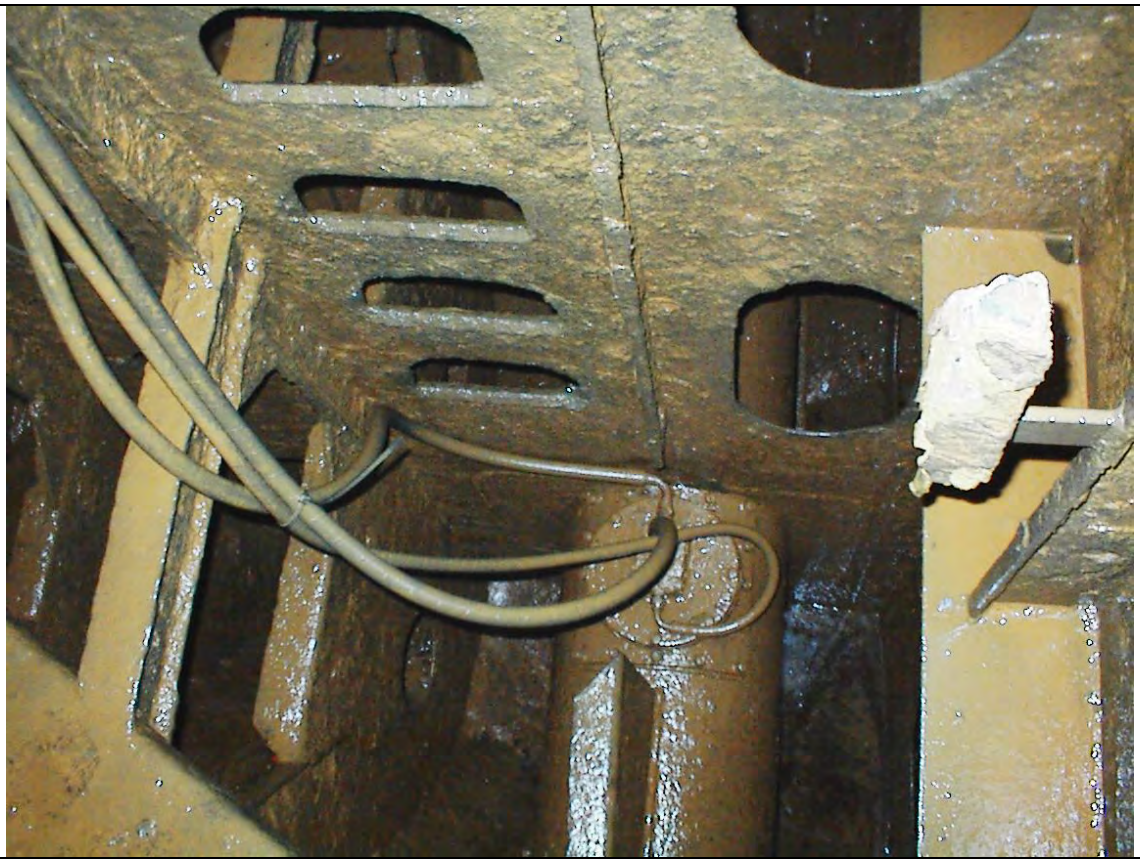
TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A FAIR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A FAIR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A FAIR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A FAIR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A POOR CONDITION



TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A POOR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A POOR CONDITION

TRANSITION FAIR TO POOR COATING CONDITION:
THIS IS A POOR CONDITION

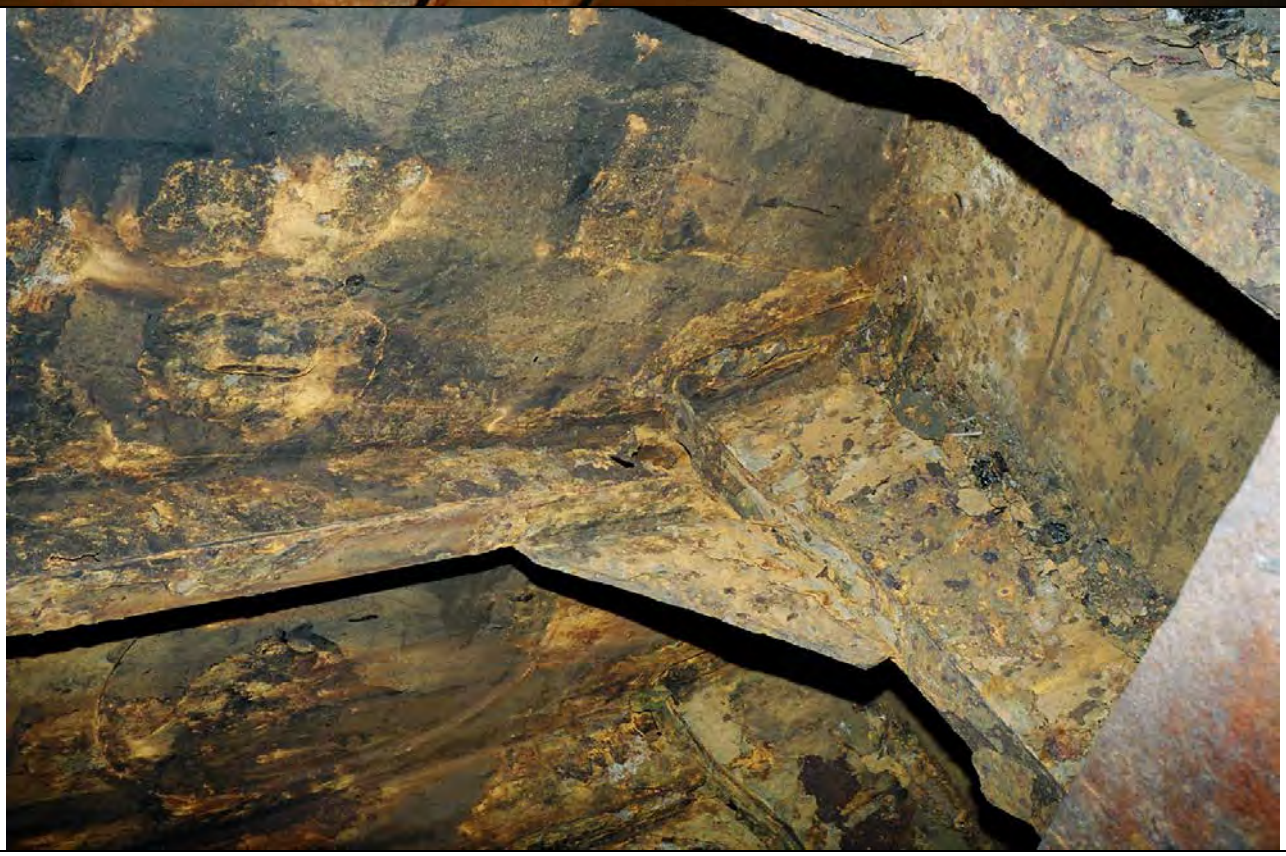
POOR COATING CONDITION

POOR COATING CONDITION

POOR COATING CONDITION

POOR COATING CONDITION

POOR COATING CONDITION



I. Examples of how to report coating conditions with respect to areas under consideration

The figure below illustrates how the surveyors may report coating condition in the Executive Hull Summary, Table IX (iv).

EXAMPLE 1: Single Hull Tanker

No. 3Wing Ballast Tank (P)				Tank Protection [1]	**C**
Structure [2]	**Coating Condition**[3]			**Remarks** [4]	
	Areas under consideration				
	Upper	Middle	Lower		
Fore Transverse Bulkhead	**F**	**G**	**G**		
Aft Transverse Bulkhead	**F**	**G**	**G**		
Side Shell	**F**	**F**	**F**		
Longitudinal Bulkhead	**F**	**G**	**G**		
Deck	**F**				
Bottom	**F**				
OVERALL TANK RATING	**FAIR**			To be examined at next annual survey	

Notes:

1) **C:** Coating, **A**: Anodes, **NP**: No protection

2) The structure includes plating and attached structural members

3) **G**: Good, **F**: Fair and **P**: Poor in accordance with Table II, reproduced herein below

4) Other than "Good" condition, locations and structure members are to be reported. For instance, a case of "Fair" condition. "Fair coating member: upper deck plating Fr No 45 to Fr No 85"

Table II BCS clarification of "GOOD", "FAIR" and "POOR" coating conditions

	GOOD (3)	**FAIR**	**POOR**
Breakdown of coating or area rusted (1)	< 3%	3 – 20 %	> 20 %
Area of hard rust scale (1)	-	< 10 %	≥ 10 %
Local breakdown of coating or rust on edges or weld lines (2)	< 20 %	20 – 50 %	> 50 %
Notes **(1)** % is the percentage of the area under consideration or of the "critical structural area" **(2)** % is the percentage of edges or weld lines in the area under consideration or of the "critical structural area" **(3)** spot rusting i.e. rusting in spot without visible failure of coating			

Example 2: Double Hull Tanker

No. 1 Double Bottom Tank				Tank Protection [1]	**C, A**
Structure [2]	**Coating Condition** [3]			**Remarks** [4]	
	Areas under consideration				
	Lower	Upper			
Double Bottom Tank	**P**	**F**			
OVERALL TANK RATING	**POOR**			To be examined at next annual survey	
No. 1 Double Hull Side Tank Port				Tank Protection [1]	**C, A**
Double Hull Side Tank	Areas under consideration				
	Upper	Middle	Lower		
Fore Transverse Bulkhead	**F**	**G**	**G**		
Aft Transverse Bulkhead	**F**	**G**	**G**		
Side Shell	**F**	**F**	**F**		
Longitudinal Bulkhead	**G**	**G**	**G**		
Deck	**G**				
Bottom	**G**				
OVERALL TANK RATING	**FAIR**			To be examined at next annual survey	

Notes:

1) **C:** Coating, **A**: Anodes, **NP**: No protection

2) The structure includes plating and attached structural members

3) **G**: Good, **F**: Fair and **P**: Poor in accordance with Table II, reproduced herein below

4) Other than "Good" condition, locations and structure members are to be reported. For instance, a case of "Fair" condition. "Fair coating member: upper deck plating Fr No 45 to Fr No 85"

Table II BCSclarification of "GOOD", "FAIR" and "POOR" coating conditions

	GOOD (3)	**FAIR**	**POOR**
Breakdown of coating or area rusted (1)	< 3%	3 – 20 %	> 20 %
Area of hard rust scale (1)	-	< 10 %	≥ 10 %
Local breakdown of coating or rust on edges or weld lines (2)	< 20 %	20 – 50 %	> 50 %
Notes **(1)** % is the percentage of the area under consideration or of the "critical structural area" **(2)** % is the percentage of edges or weld lines in the area under consideration or of the "critical structural area" **(3)** spot rusting i.e. rusting in spot without visible failure of coating			

Example 3: Fore Peak Tank

Fore Peak				Tank Protection [1]	**C**
Structure [2]	**Coating Condition** [3]			**Remarks** [4]	
	Areas under consideration				
	Upper	Middle	Lower		
Fore Peak Tank	**G**	**G**	**P**		
OVERALL TANK RATING		**POOR**		To be examined at next annual survey	

Notes:

1) **C:** Coating, **A**: Anodes, **NP**: No protection
2) The structure includes plating and attached structural members
3) **G**: Good, **F**: Fair and **P**: Poor in accordance with Table II, reproduced herein below
4) Other than "Good" condition, locations and structure members are to be reported. For instance, a case of "Fair" condition. "Fair coating member: upper deck plating Fr No 45 to Fr No 85"

Table II BCS clarification of "GOOD", "FAIR" and "POOR" coating conditions

	GOOD (3)	**FAIR**	**POOR**
Breakdown of coating or area rusted (1)	< 3%	3 – 20 %	> 20 %
Area of hard rust scale (1)	-	< 10 %	≥ 10 %
Local breakdown of coating or rust on edges or weld lines (2)	< 20 %	20 – 50 %	> 50 %
Notes **(1)** % is the percentage of the area under consideration or of the "critical structural area" **(2)** % is the percentage of edges or weld lines in the area under consideration or of the "critical structural area" **(3)** spot rusting i.e. rusting in spot without visible failure of coating			

BCS-G 88 Periodical hydrostatic tests of air cylinders of safety equipment

SCBA for fireman outfits	5 years *
SCBA for safety equipment of chemical tankers or gas carriers	5 years
EEBDs	Manufacturer's instruction
Lifeboat air cylinders	5 years

* Based on MSC.1/Circ.1432

BCS-G 89 Firms engaged in testing of navigational equipment and systems

General Comments

Firms engaged in the testing of navigational equipment and systems are not required to be approved as service suppliers under BCS Requirement Z17. However, it is recommended that the classification society/recognized organization concerned be guided by the following when seeking or approving assistance for the surveyor during initial, annual, periodical or renewal surveys of navigational systems and equipment covered by IMO Records of Equipment for the SOLAS Safety Certificates (Forms P, C and E), i.e. navigational equipment required by SOLAS Reg. V/19.

Firms should be approved for the ‘functional level’ and not for the ‘manufacturer level’. Approval of firms by classification societies does not include the ability to service the equipment down to the ‘manufacturer level’.

If a firm is not able to cover all groups of navigational equipment the groups of equipment for which the firm is approved should be listed on any certificate issued.

Process

Item 1: Extent of engagement:

Performing inspection and testing of navigational equipment and systems on board ships for compliance with SOLAS requirements.

The service supplier engagements are divided into 5 groups of services as listed under item 5. Preferably, the service supplier should seek approval for all of these groups in order to be approved as service supplier for navigational equipment and systems. Approval of service suppliers according to a limited number of groups may be considered on a case by case basis.

Item 2: Reference documents:

The service supplier should have access to SOLAS Ch. V and all IMO Performance Standards relevant for each group of services as well as all IEC cross product standards (IEC 60945 and IEC 61162 series). The Ship Safety Equipment is listed in Section 2.1 of BCS-G 128 and its Performance Standards are listed under item 5.

Where different flag states have their own interpretations or requirements regarding particular equipment or systems, these need to be part of the instructions / procedures, and arrangements for updating the validity of such interpretations / requirements should be in place.

Item 3: Personnel:

The service supplier should provide evidence that the person carrying out the inspection has education from a technical school (a minimum two years’ programme of engineering or physical science) or from a nautical institution with relevant seagoing experience as a certified ship’s officer. Personnel should be trained in testing navigational equipment and systems, preferably by the manufacturer of the equipment. Personnel should also have

passed training concerning initial, annual, periodical and renewal surveys and have proficiency in the English language commensurate with the work.

Personnel testing colour calibration on ECDIS should, in addition, have a documented Ishihara colour vision deficiency test or equivalent and have colour vision not worse than would be required for seagoing service as an officer.

Item 4: Procedures and instructions:

The supplier should have documented procedures and instructions for carrying out the testing and examination of navigational equipment and systems. Such procedures and instructions should ensure that the level of performance tests is in compliance with the relevant technical standards.

The procedures should cover all types of equipment within the relevant group for which approval is sought. Dedicated checklists with appropriate pass criteria for each test / inspection should be available.

Item 5: Equipment / publications

The service supplier should, as a minimum, have the applicable publications for the different groups of services.

The supplier should have the major and auxiliary equipment (e.g. multi meter, earth fault finder, NMEA logger, AIS test set, sound generator, sound level meter, etc.) required for correctly performing the testing. A record of the test equipment used should be kept. The record should contain information on manufacturer and type of equipment, and a log of maintenance and calibrations.

	Systems	Publications (As of 2019)
Group 1.	Heading information systems incl. bearing devices	IMO A.382(X) - Magnetic compass IMO A.424(XI) - Gyro compass IMO A.821(19) - Gyro compass for HSC IMO MSC.86(70), Annex 2 - TMHD (fitted before 1 July 2002) IMO MSC.116(73) – THD IMO MSC.166(78) - TMHD
	Rate-of-turn indicators	IMO A.526(13) - R.O.T.I.
Group 2.	Speed and distance measuring equipment (SDME)	IMO A.478(XII) - SDME (fitted before 1 January 1997) IMO A.824(19) - SDME (fitted before 1 July 2002) IMO MSC.96(72) - SDME IMO MSC.334(90) - SDME
	Echo sounding equipment	IMO A.224(VII) - Echo sounder (fitted before 1 January 2001) IMO MSC.74(69), Annex 4 - Echo sounder

Group 3.	Positioning systems	IMO A.815(19) - World-wide Radio navigation System IMO A.529(13) - Accuracy Standards for Navigation IMO A.818(19) - Loran-C / Chayka IMO A.819(19) - GPS (fitted before 1 July 2003) IMO MSC.112(73) - GPS IMO MSC.53(66) - GLONASS (fitted before 1 July 2003) IMO MSC.113(73) - GLONASS IMO MSC.74(69), Annex 1 - GPS / GLONASS (fitted before 1 July 2003) IMO MSC.115(73) - GPS / GLONASS IMO MSC.114(73) - DGPS / DGLONASS IMO MSC.233(82)-GALILEO IMO MSC.379(93)-BDS IMO MSC.401(95) and IMO MSC.432(98)-Multi-system IMO MSC.449(99) and IMO MSC.452(99)-IRNSS
	Radar systems incl. plotting aids	IMOA.222(VII) - Radar (fitted before 1 September 1984) IMO A.477(XII) - Radar (fitted before 1 July 1999) IMO MSC 64(67), Annex 4 - Radar IMO A.278(VIII) - Symbols for Radar IMO A.422(XI) - ARPA (fitted before 1 January 1997) IMO A.823(19) - ARPA IMO A.820(19) - Radar HSC IMO MSC.192(79)-Radar
	ECDIS, charts and nautical publications	Updated list of available charts and ENC (http://catalogue.ukho.gov.uk/home.asp; http://www.hidrografico.pt/website/ic_enc/viewer.htm) Relevant IMO SLS.14 Circulars related Nautical charts and publications. IMO A.817(19) - ECDIS IMO MSC.64(67), Annex 5 - ECDIS back-up IMO MSC.86(70), Annex 4 - ECDIS RCDS mode IMO MSC.232(82)-ECDIS(fitted after 1 January 2009)
	AIS	IMO MSC.74(69), Annex 3 - AIS IMO SN Circ.217 - Presentation of AIS
Group 4.	Alarm systems	IMO MSC.128(75) - BNWAS IACS BDEAP (SC181) IMO MSC.282(86) – BNWAS
	Indicators	(IMO requirements for rudder, propeller, thrust, pitch and operational mode indicators requirements not yet available)
	Sound reception systems	IMO MSC.86(70), Annex 1

Group 5.	Heading / Track control systems (HCS / TCS) Integrated Bridge Systems (IBS) Integrated Navigational System (INS)	IMO A.342(IX) - HCS (fitted before 1 January 1999) IMO MSC.64(67), Annex 3 - HCS IMO A.822(19) - HCS for HSC IMO MSC.74(69), Annex 2 – TCS IMO MSC.64(67), Annex 1 – IBS IMO MSC.86(70), Annex 3 - INS

Item 6: Reporting:

The service supplier should confirm by means of a documented report that the equipment has been tested satisfactorily.

Item 7: Review and Verification:

The surveyor should be on board to the extent necessary to control the process.

The surveyor should confirm that no further testing is needed or specify additional testing.

The surveyor should verify the report of the service supplier.

BCS- G 90

SHIP STRUCTURE ACCESS MANUAL

Oct 2005

Foreword

This access manual provides for safe conduct of overall and close-up inspections and thickness measurements on a regular basis throughout ship's operational life, and gives necessary information and instructions for that purpose, under the provisions of ***SOLAS*** regulation II-1/3-6 adopted by resolution ***MSC***.134(76) as amended by resolution ***MSC***.151(78) and the Technical provisions for means of access for inspections adopted by resolution ***MSC***.133(76) as amended by resolution ***MSC***.158(78).

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6 Inventory of Portable Mean of Access

Appendix 1 **[*Prepared for each ship appropriately*, *e.g.*, Plans for Access to the under deck structures within No.x Cargo Tanks (P/S)]**

Appendix **[*Prepared for each ship appropriately*]**

Appendix **[*Prepared for each ship appropriately*]**

Appendix **[*Prepared for each ship appropriately*]**

Appendix **[*Prepared for each ship appropriately*]**

Appendix **Inventory of Portable Means of Access**

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7 Records of Inspections and Maintenance

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Ship Structure Access Manual

Preamble

It has long been recognized that the only way of ensuring that the condition of a ship's structure is maintained to conform to the applicable requirements is for all its components to be surveyed on a regular basis throughout their operational life. This will ensure that they are free from damage such as cracks, buckling or deformation due to corrosion, overloading, or contact damage and that thickness diminution is within established limits. The provision of suitable means of access to the hull structure for the purpose of carrying out overall and close-up surveys and inspections is essential and such means should be considered and provided for at the ship design stage.

Ships should be designed and built with due consideration as to how they will be surveyed by flag State inspectors and BCS surveyors during their in-service life and how the crew will be able to monitor the condition of the ship. Without adequate access, the structural condition of the ship can deteriorate undetected and major structural failure can arise. A comprehensive approach to design and maintenance is required to cover the whole projected life of the ship.

Part I Manual for Safe Access

1 General Information

1.1 Ship Particular

[***Prepared for each ship appropriately***]

1.2 Tank Arrangement

[***Prepared for each ship appropriately***]

2 Scope of Access Manual

2.1 General

2.1.1 Permanent means of access provided for the ship do not give access to all areas required to be surveyed and measured. It is necessary that all areas outside of reach (i.e., normally beyond hand's reach) of the permanent means of access can be accessed by alternative means in combination with the permanent means of access, including those specified by resolution A.744(18), as amended. Critical structural areas, if necessary, also can be accessed by appropriate means of access.

2.1.2 Such means of access are described as shown in section 4. However other access arrangements including innovative means may be accepted in lieu of the arrangement described in the manual, based on case-by-case acceptance with BCS prior to the survey.

2.1.3 Where movable means of access are supplied by a shore-based provider, it should be noted that the confirmation of suitability for the purpose and its safe and adequate use should be made by the Owner based on recorded maintenance and inspection regime by the provider of the equipment. It should be also noted that the surveyor has the right to reject movable means of access if not satisfied with the documentation or condition of the equipment.

2.1.4 Where the Ship Safety Management System specifies handling/operation of means of access, reference to these documents should be made in the access manual.

2.2 Critical Structural Areas

2.2.1 Critical structural areas are locations which have been identified from calculations to require monitoring or from the service history of similar or sister ships to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship, and, for this ship, are listed as follows:

[***Prepared for each ship appropriately***]

2.2.2 Where monitoring other locations are deemed as necessary from the service history of this ship, or similar or sister ships, such locations should be added to the above list.

2.3 Relevant Rules and Regulations

Reference is to be made to the following publications:

(a) ***SOLAS*** regulation II-1/3-6 adopted by resolution ***MSC***.134(76), as amended;
(b) Technical Provisions adopted by resolution ***MSC***.133(76), as amended;
(c) Guidelines on the Enhanced Programme of Inspection During Surveys of Bulk Carriers and Oil Tankers adopted by resolution ***A***.744(18), as amended;
(d) BCS- Rs Z10.1, Z10.2, Z10.4 and Z10.5, as appropriate;
(e) BCS- I SC191, as amended;
(f) The relevant Class Rules for Vessels of BCS;
(g) BCS- G 39 “Safe use of rafts or boats for Survey”;
(h) BCS- G 78 “Safe use of Portable Ladders for Close-Up Surveys”; and
(i) BCS- G 91, “Guidelines for Approval/Acceptance of Alternative Means of Access”.

2.4 Approval / Re-approval

2.4.1 Any changes of the permanent, portable, movable or alternative means of access within the scope of this manual are subject to review and approval / re-approval by the Administration or by the organization recognized by the Administration. An updated copy of the approved manual is to be kept on board. For the approval / re-approval, it should be demonstrated that such means of access provides the required access.

2.4.2 Notwithstanding the provisions of 2.4.1, replacing portable means of access with similar portable means which would give an equivalent safety and accessibility, might not require the approval / re-approval, subject to being recorded in the access manual and review by the Administration or by the organization recognized by the Administration at a periodical survey after such change.

3 Definitions

3.1 Portable means of access are means that generally may be hand carried by the crew ***e.g.*** ladders, small platforms and staging. Portable means specified as part of the Ship Structure Access Manual should be carried onboard the ship throughout the duration of the validity of the relevant access manual.

3.2 Movable means of access may include devices like a cherry picker, wire lift platforms, rafts or other means. Unless otherwise specified in the Technical Provisions (TP) or UI SC191, as amended, such means need not necessarily be kept on board or capable of being operated by the ship’s crew. However arrangements for the provision of such means should be addressed during survey planning. Movable means of access should be included in the Ship Structure Access Manual to designate the extent of access to the structural members to be surveyed and measured.

3.3 Alternative means of access is a term within SOLAS II-1/3-6 and TP for portable or movable means of access provided for the survey and thickness measurements of hull

structure in areas otherwise not accessible by permanent means of access. For the purpose of this manual, alternative means of access include supplementary or additional means to provide necessary access for surveys and thickness measurements in accordance with SOLAS II-1/3-6.

3.4 ***Approved*** means that the construction and materials of the means of access and any attachment to the ship's structure should be to the satisfaction of the Administration . Compliance with the procedures in BCS- G 91 should be used in the absence of any specific instructions from a specific administration

3.5 ***Acceptance:*** it should be demonstrated to the satisfaction of the Owner that the equipment provided has been maintained and is, where applicable, provided with operators who are trained to use such equipment. This should be demonstrated to the surveyors by the production of documents, prior to the equipment being used, which demonstrate that the equipment has been maintained and which indicate any limitations of the equipment.

3.6 ***Authorized person*** is a specified Company person using the means of access that should assume the role of inspector and check for obvious damage prior to using the access arrangements. Whilst using the means of access the inspector should verify the condition of the sections used by close up examination of those sections and note any deterioration in the provisions. Should any damage or deterioration be found, the effect of such deterioration should be assessed as to whether the damage or deterioration affects the safety for continued use of the means of access. Deterioration found that is considered to affect safe use should be determined and measures should be put in place to ensure that the affected section(s) should not be further used prior effective repair.

3.7 Rung means the step of a vertical ladder or step on the vertical surface.

3.8 Tread means the step of an inclined ladder or step for the vertical access opening.

3.9 Spaces are separate compartments including holds and tanks.

3.10 Ballast tank is a tank which is used for water ballast and includes side ballast tanks, ballast double bottom spaces, topside tanks, hopper side tanks and peak tanks.

3.11 An overall survey is a survey intended to report on the overall condition of the hull structure and determine the extent of close-up surveys.

3.12 A close-up survey is a survey where the details of structural components are within the close visual inspection range of the surveyor, ***i.e.***, normally within reach of hand.

3.13 Transverse section includes all longitudinal members such as plating, longitudinals and girders at the deck, side and bottom, inner bottom and hopper side plating, longitudinal bulkheads, and bottom plating in top wing tanks.

3.14 Representative spaces are those, which are expected to reflect the condition of other spaces of similar type and service and with similar corrosion prevention systems. When selecting representative spaces account should be taken of the service and repair history on board and identifiable critical and/or suspect areas.

3.15 Suspect areas are locations showing substantial corrosion and/or are considered by the

surveyor to be prone to rapid wastage.

3.16 Substantial corrosion is an extent of corrosion such that assessment of corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits.

3.17 A corrosion prevention system is normally considered a full hard coating.
Hard protective coating should be epoxy coating or equivalent. Other coating systems may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's specifications.

3.18 Coating condition is defined as follows:

GOOD condition with only minor spot rusting;

FAIR condition with local breakdown of coating at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition;

POOR condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

3.19 Critical structural areas are locations, which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships to be sensitive to cracking, buckling or corrosion, which would impair the structural integrity of the ship.

4 Access Plans

[***Prepared appropriately***]

4.1 Plans showing the means of access to the space (including openings for introducing portable means), with appropriate technical specifications and dimensions are as shown in appendixes X.

4.2 Plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions are as shown in appendixes X.

4.3 Plans showing the means of access within the space to enable close-up inspections to be carried out and necessary alternative means to be deployed. For any alternative means carried on board, appropriate technical specifications and dimensions are as shown in appendixes X.

5 Instructions

5.1 Instructions for Use of Means of Access

5.1.1 All persons using the means of access arrangements should study the instructions for safety in the access manual so as to gain adequate knowledge of the arrangements for the space(s) to be inspected prior to the use. Appropriate personal protective equipment must be available, if required.

5.1.2 Any recorded deficiencies to the means of access for the space(s) to be inspected should be considered. Any section with significant damage is not to be used.

5.1.3 It is recognized that climbing may be used by surveyors during surveys but is not accepted as an alternative means of access. When climbing the structures within tanks is necessary during surveys, the surface of the structures should be free of oil, sludge and mud and relatively dry to the satisfaction of the surveyor so that a good firm, non-slip footing maybe obtained.

5.2 Instructions for Inspection and Maintenance of Means of Access

5.2.1 Verification of means of access including portable equipment and their attachment is part of periodical surveys for continued effectiveness of the means of access in that space which is subject to the survey. After a space has been ventilated, cleaned and illuminated for the survey, an inspection of means of access should be carried out by the crew and/or an authorized person.

5.2.2 Periodical inspections of means of access should be carried out by the crew and/or an authorized person as a part of regular inspection and maintenance, at intervals, which are determined taking into account any corrosive atmosphere that may be within the space.

5.2.3 Any authorized person using the means of access should assume the role of inspector and check for obvious damage prior to using the access arrangements. Whilst using the means of access the inspector should verify the condition of the sections used by close up examination of those sections and note any deterioration in the provisions. Should any damage or deterioration be found, the effect of such deterioration should be assessed as to whether the damage or deterioration affects the safety for continued use of the access. Deterioration found that is considered to affect safe use should be determined as “substantial damage” and measures should be put in place to ensure that the affected section(s) are not to be further used prior to completing effective repair.

5.2.4 Periodical surveys of any space that contains means of access should include verification of the continued effectiveness of the means of access in that space. Usually, survey of the means of access is not expected to exceed the scope and extent of the survey being undertaken. If the means of access is found deficient the scope of survey should be extended if this is considered appropriate.

5.2.5 Records of all inspections should be established based on the requirements detailed in the ships Safety Management System. The records should be readily available to persons using the means of access and a copy attached to the access manual. The latest record for the portion of the means of access inspected should include as a minimum the date of the inspection, the name and title of the inspector, a confirmation signature, the sections of means of access inspected, verification of continued serviceable condition or details of any deterioration or substantial damage found. A file of permits issued should be maintained for verification.

5.2.6 Where movable means of access are supplied by a shore-based provider, the confirmation of its safe and adequate use should be made based on recorded maintenance and inspection regime by the provider of the equipment. Cognizance should be taken of the complexity of the equipment when making the judgment on the periodicity of inspections and thoroughness of maintenance by the provider of equipment.

5.2.7 The maintenance of all means of access should be in accordance with the Ships Safety Management System.

5.3 Instructions for the Rigging and Use of Portable Means of Access

5.3.1 Portable ladders should rest on a stable, strong, suitably sized, immobile footing so that the rungs remain horizontal. Suspended ladders should be attached in a manner so that they cannot be displaced and so that swinging is prevented. Step ladders, hanging ladders and ladders more than 5 ***m*** long may only been utilized if fitted with a mechanical device to secure the upper end of the ladder. Portable ladders should be maintained free of oil, grease and other slipping hazards.

5.3.2 The feet of portable ladders should be prevented from slipping during use by securing the stiles at or near their upper and lower ends, by any anti-slip device or by other arrangements of equivalent effectiveness. Unless otherwise stated in its specification or unless provided with appropriate securing means, the ladder should be raised at an angle of approximately 70 ***degrees***.

5.3.3 When portable ladders are used on top of inner bottom or on deep stringers, the falling height should generally not exceed 6 ***m***. Suitable attachment points for securing safety harnesses should be provided. If it is necessary to exceed this height:

- there should be at least 3 ***m*** of water above the highest structural element in the bottom to provide a "cushion";
- a suitable safety harnesses or safety rafting should be considered; and
- and personal floating devices (***PFD***) should be used.

The free falling height above the water surface should not exceed 6 ***m***.

5.3.4 Portable ladders should be arranged and rigged to support at least four ***times*** the maximum intended load.

5.3.5 When climbing ladders in tanks containing water, personnel should wear flotation aids. A floatation aid is a simple form of lifejacket, which does not impede climbing, or a self-inflatable lifejacket.

5.3.6 Aluminum ladders may be used in cargo tanks, but should not be stored in the cargo area or other gas dangerous spaces.

5.3.7 The securing of the equipment, its operation and training in use should be in accordance with the Ships Safety Management System.

5.4 Instructions for Safety Rafting (if, applicable)

5.4.1 Surveys of tanks or spaces by means of rafts or boats may only be undertaken with the agreement of the attending surveyor(s), who is to take into account the safety arrangements provided, including weather forecasting and ship response in reasonable sea conditions. Appropriate safety measures, including the following, should be taken by the authorized person prior to survey to the satisfaction of the attending surveyor(s).

5.4.2 When rafts or boats will be used for close-up survey the following conditions should be observed:

(1) Only rough duty, inflatable rafts or boats, having satisfactory residual buoyancy and stability even if one chamber is ruptured, should be used;

(2) The boat or raft should be tethered to the access ladder and an additional person should be stationed down the access ladder with a clear view of the boat or raft;

(3) Appropriate lifejackets should be available for all participants;
(4) The surface of water in the tank should be calm (under all foreseeable conditions the expected rise of water within the tank should not exceed 0.25 ***m***) and the water level either stationary or falling. On no account should the level of the water be rising while the boat or raft is in use;
(5) The tank or space must contain clean ballast water only. When a thin sheen of oil on the water is observed, further testing of the atmosphere should be done to ensure that the tank or space is safe for entering;
(6) For rafting of cargo tanks, at no time should the upside of the boat or raft be allowed to be within 1 ***m*** of the deepest under deck web face flat so that the survey team is not isolated from a direct escape route to the tank hatch. Filling to levels above the deck transverses should only be contemplated if a permanent means of access, as per paragraph 5.4.3.2, below, is provided. For bulk cargo holds designed for filling of water (e.g. ballast holds) and where filling up to a height not less than 2 ***m*** below top of side frames is permitted (e.g. air draft holds), rafting may be utilized in lieu of permanent means of access to side frames (ref. TP Table 2 - 1.8) provided the structural capacity of the hold is sufficient to withstand static loads at all levels of water needed to survey the side shell frames; and
(7) If the tanks (or spaces) are connected by a common venting system, or inert gas system, the tank in which the boat or raft is to be used should be isolated to prevent a transfer of gas from other tanks (or spaces).

5.4.3 In addition to the above, rafts or boats alone may be allowed for close-up survey of the under deck areas for tanks or spaces if the depth of the webs are 1.5 ***m*** or less. If the depth of the webs is more than 1.5 ***m***, rafts or boats alone may be allowed only:
(1) when the coating of the under deck structure, as evaluated from a safe distance (see 5.4.2(6), is in GOOD condition and there is no evidence of wastage; or
(2) if a permanent means of access is provided in each bay to allow safe entry and exit. This means:
(a) access direct from the deck via a vertical ladder and a small platform about 2 ***m*** below the deck; or
(b) access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform should, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water level should be assumed to be not more than 3 ***m*** from the deck plate measured at the midspan of deck transverses and in the middle length of the tank.

5.4.4 Safety Meetings should be held prior to entering the tank or space and regularly during the survey on board for ensuring the following:
(1) the establishment of proper preparation and the close co-operation between the attending surveyor(s) and the company's representatives onboard prior to and during the survey are an essential part in the safe and efficient conduct of the survey; and
(2) applicable safety procedures and responsibilities should be discussed and agreed to ensure that the survey is carried out under controlled conditions.

5.4.5 Adequate communication arrangements and equipment should be prepared for ensuring the following:
(1) the attending surveyor(s) is always accompanied by at least one responsible person assigned by the company experienced in tank and enclosed spaces inspection. In addition a backup team of at least two experienced persons should be stationed at the hatch opening of the tank or space that is being surveyed. The

back-up team should continuously observe the work in the tank or space and should keep lifesaving and evacuation equipment ready for use;

(2) a communication system should be arranged between the survey party in the tank or space being examined and the responsible officer on deck, the navigation bridge and the personnel in charge of handling the ballast pump(s) in the pump control room. These communication arrangements should be maintained throughout the survey;

(3) adequate and safe lighting should be provided for the safe and efficient conduct of the survey; and

(4) adequate protective clothing should be made available and used (***e.g.*** safety helmet, gloves, safety shoes, etc) during the survey.

5.4.6 The organization for the surveys by the means of rafting, its operation and training in use should be in accordance with the Ships Safety Management System.

5.5 Instructions for Use of Portable Platforms (if, applicable)

5.5.1 Portable platforms should not be more than 3 ***m*** in length.

5.5.2 Safety measures, including ensuring that portable platforms are safely secured and supported prior to use, should be taken by the authorized person prior to survey to the satisfaction of the attending surveyor(s).

5.5.3 The rigging of the equipment, its operation and training in use should be in accordance with the Ships Safety Management System.

5.6 Instructions for Use of Staging (if, applicable)

5.6.1 Appropriate safety measures should be taken by the authorized person prior to survey to the satisfaction of the attending surveyor(s).

5.6.2 Before working on or near any staging it should be ensured:

(1) A minimum of 6 evenly spaced suspension points – steel wire ropes or chains evenly spaced and as near vertical as possible;

(2) Scaffold tubes are linked by rigid-angle couplers;

(3) An adequate working platform, fully boarded with toe boards and guardrails. Platform transforms (at 1.2 ***m*** intervals) resting on ledgers (at 2.5 ***m*** interval) and double transforms at platform board overlaps;

(4) The staging is level and provided with safe access (such as ladders);

(5) The staging is adequately decked (for example have a work surface and platform), and provided with guardrails; and

(6) The staging is adequate for the work performed taking into account that falls are a significant hazard in site.

5.6.3 Where specifically designed staging is carried on board as a part of the means of access listed in Ship Structure Access Manual, the rigging of the equipment, its operation and training in use should be in accordance with the Ships Safety Management System.

5.7 Instructions for Use of Wire Lift Platform (if, applicable)

5.7.1 Safety measures, including the following, should be taken by an authorized person prior to survey to the satisfaction of the attending surveyor(s):

(1) Rigging of wires should be in accordance with manufacturer's recommendations and conducted by suitably qualified riggers;

(2) Fix points to which the wires will be connected should be examined before each use and verified as in good condition (free of wastage, fractures, etc.); and

(3) Means should be provided for using fall protection with a lifeline that can be tended from above the platform.

5.7.2 The rigging of the equipment, its operation and training in use should be in accordance with the Ships Safety Management System.

5.8 Instructions for Use of Hydraulic Arm Vehicles (if, applicable)

5.8.1 The vehicle should be operated by qualified personnel and evidence should be provided that the vehicle has been properly maintained by a shore-based provider. The standing platform should be fitted with anchor points for attaching fall arrest systems. For those vehicles provided with a self-leveling platform, care should be taken that the locking device is engaged after completion of maneuvering to ensure that the platform is fixed.

5.8.2 Safety measures, including the following, should be taken by an authorized person prior to survey to the satisfaction of the attending surveyor(s):

(1) Lift controls, including safety devices should be serviceable and should be operated throughout the range prior to use;

(2) Operators should be trained;

(3) The equipment range of use should be agreed with the operator before using the equipment;

(4) Operators should work within the basket;

(5) Body belts (such as harnesses) with lanyards should be used;

(6) Permissible load and reach limitations should not be exceeded;

(7) Brakes should be set; outriggers used, if so equipped; and wheels chocked; if on incline;

(8) Unless designed otherwise, aerial lift trucks should not be moved when the boom is elevated in a working position with workers in the basket;

(9) Upper and lower controls should be required and should be plainly marked. Lower controls should be capable of overriding the upper controls;

(10) Special precautions should be made to ensure the vessel and the lifting device are stable when aerial lifts are used on vessels (for example barges, floats);

(11) Personal flotation devices (***PFD***) should be used when working over water; and

(12) Caution should be taken for potential crushing hazards (for example booming into the overhead, pinch point).

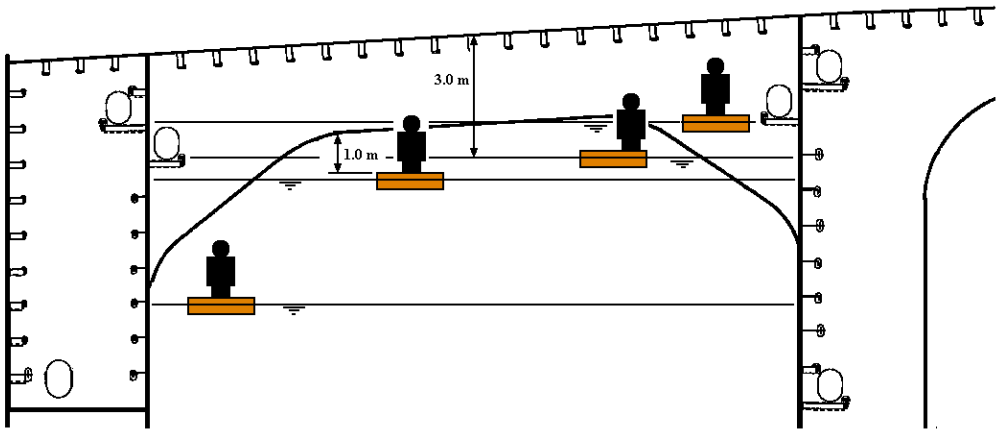
5.8.3 The operation and training in the use of this type of equipment should be in accordance with the Ships Safety Management System.

6 Inventory of Portable Means of Access

All portable means of access are listed as shown in appendix zz.

Appendix 1

Plans for Access to the under deck structures within No.x Cargo Tanks (P/S) (*example*)

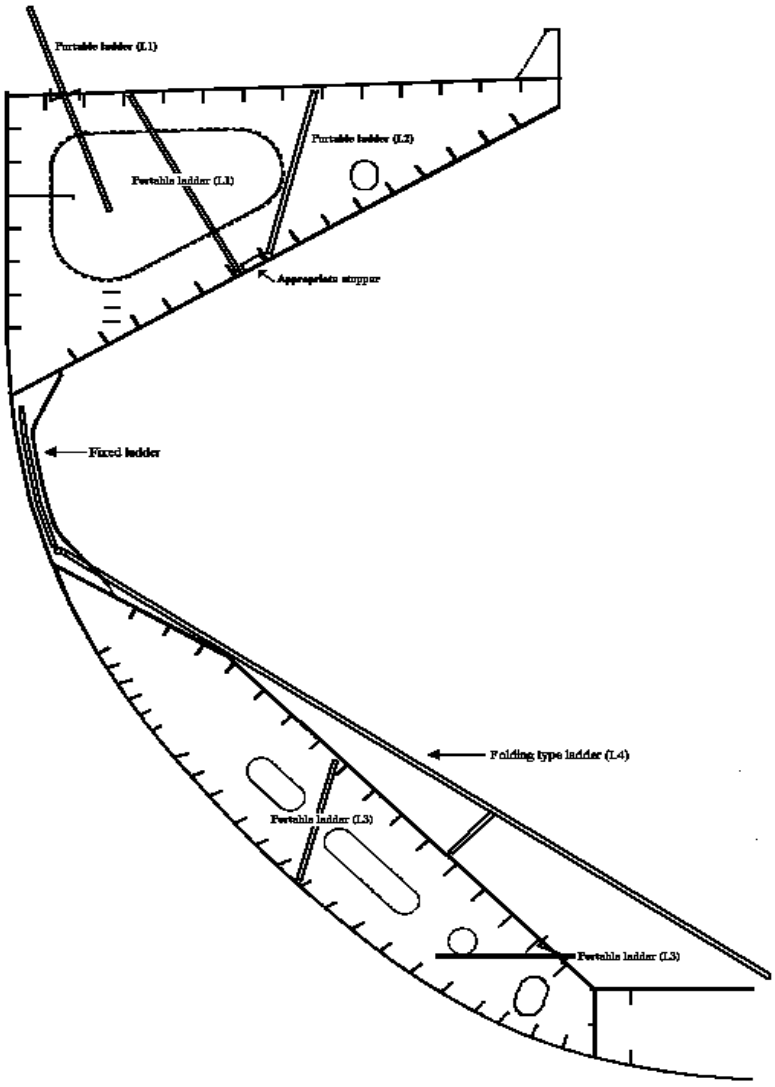


Appendix

Top Side Tank, Bilge Hopper Tank and Cargo Hold (Hold Frames)
(*example*)

Notes:

1. Before use, the top of the ladder located in the top wing tank should be secured to ensure sufficient support of the ladder towards the deck longitudinals.
2. Where ladders used at relatively small angle (***e.g.***, less than 45 ***degrees***) such as those prepared for the use on the hopper tank sloping plate (see the folding type ladder in the following figure), steps of such ladders are assumed designed in such a way that a safe walkway is provided. For such ladders of more than 5 ***m*** in length, handrail should be provided.



Appendix Inventory of Portable Means of Access

[***Prepared appropriately***]

ID	Type	Dimensions	Applicable spaces	Number/Storage	Note
L1	Portable ladder	5 ***m***	All spaces	2 sets / No.1 Deck Store	See the attached maker's specification.
L2	Portable ladder	4 ***m***	All spaces	1 set / No.1 Deck Store	SG mark by Consumer Product Safety Association, Japan See the attached maker's specification.
L3	Portable ladder	3 ***m***	All spaces	1 set / No.1 Deck Store 1 set / Boatswain Store	SG mark by Consumer Product Safety Association, Japan See the attached maker's specification.
L4	Folding type ladder	18 ***m***	Cargo holds	3 sets / No.2 Deck Store	See the attached maker's specification.

Part 2 Records for Means of Access

(***This part is approved for its form only at new building.***)

7 Records of Inspections and Maintenance

[***Prepared appropriately***]

Note: The record for the portion of the means of access inspected should include as a minimum the date of the inspection, the name and title of the inspector, a confirmation signature, the sections of means of access inspected, verification of continued serviceable condition or details of any deterioration or substantial damage found.

8 Records of Change of Portable Means of Access

[***Prepared appropriately***]

BCS- G 91 Guidelines for Approval / Acceptance of Alternative Means of Access

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1. REFERENCES

SOLAS II-1/3-6, as amended by Resolution MSC.151(78)
Amendments to the Technical Provisions for Means of Access for Inspections MSC.158(78

) BCS- I SC191
BCS- R Z10.1, 10.2, 10.4 and 10.5
BCS- Gs:
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TSCF Guidelines for the inspection and maintenance of double hull tanker structure

2. INTRODUCTION

This annex describes guidance for the approval or acceptance, as appropriate, of alternative means of access to be provided for compliance with SOLAS II-1/3-6. The Ship Structure Access Manual approved in accordance with SOLAS II-1/3-6 should identify the access arrangements including permanent and alternative means of access as necessary to carry out overall and close up examination and thickness measurements of any structural member. This annex also covers means of access used independently or in combination with the provided permanent means of access to areas to be surveyed and measured in accordance with SOLAS II-1/3-6.

3. DEFINITIONS

Approved means that the construction and materials of the means of access and any attachment to the ship's structure should be to the satisfaction of the Administration. Compliance with the procedures in this annex will satisfy the requirements of an administration in the absence of any specific instructions from a specific administration.

Acceptance: it should be demonstrated to the satisfaction of the Owner that the equipment provided has been maintained and is, where applicable, provided with operators who are trained to use such equipment. This should be demonstrated to the surveyors by the production of documents, prior to the equipment being used, which demonstrate that the equipment has been maintained and which indicate any limitations of the equipment.

Initial survey: the means of access should be subject to an initial survey prior to the delivery of the ship, in accordance with regulation I/10 and it should be demonstrated that the means of access specified in plans required by SOLAS II-1/3-6 paragraphs 4.1.1, 4.1.2 and 4.1.3 are obtainable.

Alternative means of access is a term within SOLAS II-1/3-6 and the Technical Provisions (TP) for *portable or movable means* of access provided for the survey and thickness measurements of hull structure in areas otherwise not accessible by permanent means of access. For the purpose of this annex, alternative means of access include supplementary or additional means to provide necessary access for surveys and thickness measurements in accordance with SOLAS II-1/3-6.

Portable means of access are means that generally may be hand carried or arranged by the crew, e.g. ladders, small platforms and staging. Portable means specified as part of the Ship Structure Access Manual should be carried onboard the ship throughout the duration of the validity of the relevant access manual.

Movable means of access may include devices like a 'cherry picker', wire lift platforms, rafts or other means. Unless otherwise specified in the TP or this UI, such means need not necessarily be kept on board or capable of being operated by the ship's crew. However arrangements for the provision of such means should be addressed during survey planning. Movable means of access should be included in the Ship Structure Access Manual to designate the extent of access to the structural members to be surveyed and measured.

Authorised person is a specified Company person using the means of access who should assume the role of inspector and check for obvious damage prior to using the access arrangements. Whilst using the means of access the inspector should verify the condition of the sections used by close up examination of those sections and note any deterioration in the provisions. Should any damage or deterioration be found, the effect of such deterioration should be assessed as to whether the damage or deterioration affects the safety for continued use of the means of access. Deterioration found that is considered to affect safe use should be determined and measures should be put in place to ensure that the affected section(s) should not be further used prior effective repair.

4. GENERAL

It is recognised that permanent means of access specified in the TP will not give access to all areas required to be surveyed and measured. Therefore, it is necessary that all areas outside of reach (i.e., normally beyond hand's reach) of the permanent means of access should be accessed by alternative means in combination with the permanent means of access, including those specified by resolution A.744(18), as amended.

Means of access, including alternative means of access, specified in the TP together with the Ship Structure Access Manual should be approved (where appropriate) and where authorised, on behalf of the Administration. In lieu of the alternative means of access required by the regulations and TP, innovative means of access may be allowed, based on case by case acceptance, see section 5.7.

When an alternative means of access is supplied by the builder for compliance with SOLAS regulation II-1/3-6 and TP, it can be approved (where appropriate) and where authorised, on behalf of the Administration, by the Classification Society, to a recognised National or International Standard. Any limitations to the use of the equipment at sea or in port should be described in the approved Ship Structure Access Manual.

Where movable means of access are supplied by a shore-based provider, then the confirmation of its safe and adequate use should be made by the Owner based on recorded maintenance and inspection regime by the provider of the equipment. Cognisance should be taken of the complexity of the equipment when making the judgement on the periodicity of inspections and thoroughness of maintenance by the provider of equipment. The surveyor has the right to reject moveable means of access if not satisfied with the documentation or condition of the equipment.

It should be demonstrated as part of the initial survey, that the means of access identified in the Ship Structure Access Manual provides the required access, prior to delivery for the first ship in the series, or prior to initial use of a Ship Structure Access Manual where an existing means of access is amended, or a new means of access is added.

It should be demonstrated by the Owner that the equipment provided has been maintained and a person operating the equipment is trained in the safe use of such equipment. These should be demonstrated to the surveyors by the production of documents, prior to the equipment being used, which demonstrate that the equipment has been maintained and which indicate any limitations of the equipment.

The records of training, inspections and maintenance should be established in accordance with requirements of the Ships Safety Management System.

All classification surveyors should apply their own classification safe method of working requirements. See also the relevant BCS- R Z10 requirements for Access to Structures.

5. ALTERNATIVE MEANS OF ACCESS

The Owners are responsible for ensuring that alternative means of access are suitable for the purpose of the appropriate use. The equipment where applicable should be operated by qualified personnel and evidence should be provided that the equipment has been properly maintained by a shore-based provider.
The standing platform should be fitted with anchor points for attaching fall arrest systems. For equipment provided with a self levelling platform, care should be taken that the locking device is engaged after completion of manoeuvring to ensure that the platform is fixed.

5.1 Hydraulic arm vehicles (“Cherry Picker”)

5.1.1 Application

Hydraulic arm vehicles or aerial lifts (‘‘Cherry Picker’’) may be used to enable the examination of the cargo hold structure on bulk carriers not accessible by permanent ladders fitted in accordance with Table 2 paragraph 1.6. In the Ship Structural Access Manual the Cherry Pickers may be accepted as movable means, for use up to 17 m above the tank top.

5.1.2 Safety routines

Safety measures, including the following, should be taken by an authorised person prior to survey to the satisfaction of the attending surveyor(s):

- Lift controls, including safety devices should be serviceable and should be operated throughout the range prior to use. Operators should be trained;
- The equipment range of use should be agreed with the operator before using the equipment;
- Operators should work within the basket;
- Body belts (such as harnesses) with lanyards should be used;
- Permissible load and reach limitations should not be exceeded;
- Brakes should be set; outriggers used, if so equipped; and wheels chocked; if on an incline;
- Unless designed otherwise, aerial lift trucks should not be moved when the boom is elevated in a working position with workers in the basket;
- Upper and lower controls should be required and should be plainly marked. Lower controls should be capable of overriding the upper controls;
- Special precautions should be made to ensure the vessel and the lifting device are stable when aerial lifts are used on other vessels (for example barges, floats);
- Personal flotation devices (PFD) should be used when working over water;
- Caution should be taken for potential crushing hazards (for example booming into the overhead, pinch point).

The operation and training in the use of this type of equipment should be addressed by the Ships Safety Management System.

5.2 Wire lift platform

5.2.1 Application

Wire lift platforms may be used for inspection of structural members of ballast tanks, cargo oil tanks and cargo holds. Such equipment should be rated for more than one person and be operated by suitably authorised personnel. If carried on board and included in the Ship Structure Access Manual, the designer will have to take into consideration safety aspects associated with deployment and use of such means of access. The platform and equipment, including fixed points to the ships structure should be approved on behalf of the Administration being based on a recognised International or National Standard.

The following should be addressed for approval of the wire lift platform:

- accidental loss of balance;
- permissible weight;
- protection against overload;
- secondary means of escape;
- guard rails;
- permissible loads;
- permanent markings of the loads;
- recovery in the event of power loss.

5.2.2 Safety routines

Safety measures, including the following, should be taken by an authorised person prior to survey to the satisfaction of the attending surveyor(s):

- Lift controls, including safety devices and brakes should be serviceable and should be operated throughout the range prior to use. Operators should be trained.
- Rigging of wires should be in accordance with manufacturer’s recommendations and conducted by qualified personnel.
- Fix points to which the wires will be connected should be examined before each use and verified in good condition (free of wastage, fractures).
- Permissible load limitations should not be exceeded.
- Personnel should work from within the lift basket.
- Body belts (such as harnesses) with lanyards should be used.
- Means should be provided for using fall protection with a lifeline that can be tended from above the platform.
- The maintenance of all equipment, the rigging of the equipment, its operation and training in use should be addressed by the Ships Safety Management System.

5.3 Portable platforms

5.3.1 Application

Portable platforms not more than 3m length may be used for access between longitudinal permanent means of access and the structural member to be accessed. (see Figure 1.) Handrails should be provided, unless a safety harness is used in conjunction with the prearranged handgrips in way of the structure being accessed.

Portable platforms may be used as a portable means of access, provided that the platform and equipment, including fixed points to the ship's structure are specifically designed for the task and approved on behalf of the Administration based on a recognised International or National Standard.

Where portable platforms are included in the approved Ship Structure Access Manual, then the following should be considered prior to approval:

- permissible loads;
- permanent markings of the loads;
- fixing arrangements;
- guard rails;
- non skid construction.

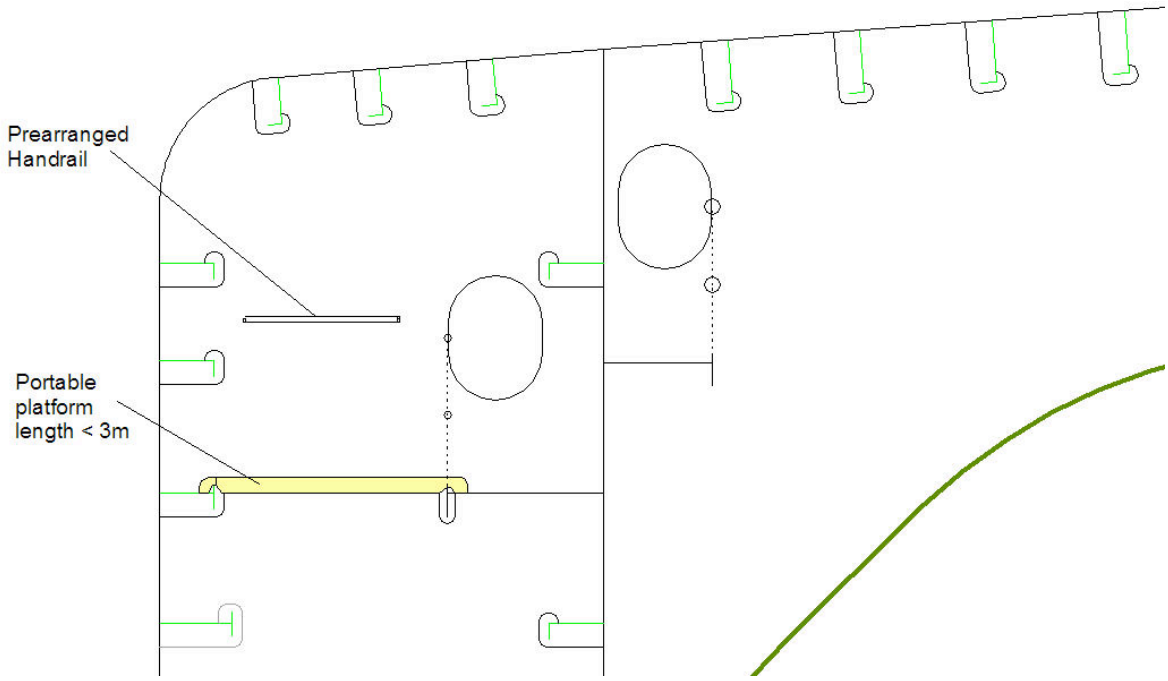


Fig.1 Portable Platform

5.3.2 Safety routines

Safety measures, including the following, should be taken by the authorised person prior to survey to the satisfaction of the attending surveyor(s):

It should be ensured that portable platforms are safety secured and supported prior to use.

The maintenance of all equipment, the fixing of the equipment, its operation and training in its use should be addressed by the Ships Safety Management System.

5.4 Staging

5.4.1 Application

Staging is the most common means of access provided especially where repairs or renewals are being carried out. Staging is generally an option for access to any structural members to be surveyed and measured in tanks, holds and spaces but is NOT considered as an alternative to permanent means of access under TP Table 1 - 1.1.4 and Table 2 - 1.8. Staging not carried on board is not subject to approval as part of SOLAS II-1/3-6. In this case, Owner and/or provider of equipment are responsible for ensuring safety use.

Where staging and the associated equipment including its attachments to the ship's structure are specifically designed for survey and thickness measurement in accordance with SOLAS II-1/3-6, such staging should be approved on behalf of the Administration based on a recognised International or National Standard and necessary consideration is taken for the safety in the use.

5.4.2 Safety routines

Safety measures, including the following, should be taken by an authorised person prior to survey to the satisfaction of the attending surveyor(s):

Before working on or near any staging it should be ensured:

- a minimum of 6 evenly spaced suspension points - SWR or chains evenly spaced and as near vertical as possible;
- scaffold tubes are linked by right-angle couplers;
- an adequate working platform, fully boarded with toe boards and guard rails. Platform transforms (at 1.2m intervals) resting on ledgers (at 2.5m interval) and double transforms at platform board overlaps;
- the staging is level and provided with safe access (such as ladders);
- the staging is adequately decked (for example have a work surface and platform), and provided with guardrails;
- the staging is adequate for the work performed taking into account that falls are a significant hazard in site.

Where staging is approved as a part of the Ship Structure Access Manual and carried on board, the maintenance of all equipment, the rigging of the equipment, its operation and training in its use should be addressed by the Ships Safety Management System.

5.5 Rafting

5.5.1 Application

Rafting is generally used as term for surveys carried out by means of boats or rafts. Rafting may be an option for use in tanks, holds and spaces which may be filled with water provided the arrangement of internal structure is as described in this section. BCS- G 39 “Safe use of rafts or boats for survey” should be followed when rafting is specified for use in the Ship Structure Safe Access Manual as moveable means of access.

The structure arrangement should allow easy escape to deck from any position being rafted. At least 1.0m clearance above and 0.5m clearance beyond the breadth of the raft should be allowed for the safe passage passed any internal obstructions.

Bulk cargo holds
For bulk cargo holds designed for filling of water (e.g. ballast holds) and where filling up to a height not less than 2m below top of side frames is permitted (e.g. air draft holds), rafting may be utilized in lieu of permanent means of access to side frames (ref. TP Table 2 - 1.8) provided the structural capacity of the hold is sufficient to withstand static loads at all levels of water needed to survey the side shell frames. Refer to BCS- R Z10.2 and Z10.5 for limitations on rafting of cargo holds.

Oil cargo tanks
Rafting of cargo tanks is subject to restrictions on discharging of water in harbour and weather conditions at voyage. Rafting as alternative means of access should therefore not be considered as “readily accessible” in oil cargo tank and do not provide an alternative to fitting of longitudinal permanent means of access as required by TP Table 1 - 1.1.4. Refer to BCS- R Z10.1 and Z10.4 for limitations on rafting of cargo tanks.

5.5.2 Safety routines

Safety measures, including the following, should be taken by an authorised person prior to survey to the satisfaction of the attending surveyor(s):

It is the responsibility of the Owners to provide a raft that meets the requirements of BCS- G 39.

The organisation for the surveys by the means of rafting, its operation and training in use should be addressed by the Ships Safety Management System.

5.6 Portable Ladders

5.6.1 Application

Portable ladders may be used for access to any structural members as supplementary and/or additional to permanent means of access in accordance with SOLAS II-1/3-6 and should be included in the Ship Structure Access Manual.

The requirements of BCS- G 78 “Safe Use of Portable Ladders for Close-up Surveys” should be used when specified for use in the Ship Structure Safe Access Manual as a portable means of access.

Portable ladders should be designed based on a recognised International or National Standard. The rungs and steps of portable ladders should be designed to minimise slipping, e.g. corrugated, knurled, dimpled or coated with skid resistance material.

Step ladders, hanging ladders and ladders more than 5m long may only been utilized if fitted with a mechanical device to secure the upper end of the ladder.

In accordance with BCS- R Z10.2, paragraph 5.3, the use of a portable ladder fitted with a mechanical device to secure the upper end of the ladder is acceptable for the “close up survey of sufficient extent, minimum 25% of frames, to establish the condition of the lower region of the shell frames including approx. lower one third length of the side frame at side shell and side frame end attachment and the adjacent shell plating of the forward cargo hold” at annual Survey, required in 3.2.4.1.b, and the “one other selected cargo hold” required in 3 .2.4.2.b.

5.6.2 Safety routines

Safety measures, including the following, should be taken by an authorised person prior to survey to the satisfaction of the attending surveyor(s):

See BCS- G 78 “Safe Use of Portable Ladders for Close-up Surveys”

The feet of portable ladders should be prevented from slipping during use by securing the stiles at or near their upper and lower ends, by any anti-slip device or by other arrangements of equivalent effectiveness. Unless otherwise specified in a specification of each portable ladder or relevant safety standards, the ladder should be in general raised at an angle of around 70 degrees to the horizontal.

Portable ladders should be used on top of bottom or deep stringer platform so that the free falling height does not exceed 6m. If it is necessary to exceed this height, there should be at least 3m of water above the highest structural element in the bottom to provide a "cushion" or a safety harnesses to be used. The free falling height above the water surface should not exceed 6 metres.

When climbing ladders in tanks containing water, the surveying personnel should wear "flotation" aids. A flotation aid is a simple form of lifejacket which does not impede climbing or a self-inflatable lifejacket.

Aluminium ladders may be used in cargo tanks, but can not be stored in the cargo area or other gas dangerous spaces.

The maintenance of all equipment, the securing of the equipment, its operation and training in use should be addressed by the Ships Safety Management System.

BCS-G 95 Recommendation for the Application of SOLAS Regulation V/15 Bridge Design, Equipment Arrangement and Procedures (BDEAP)

Foreword

This Recommendation sets forth a set of guidelines for determining compliance with the principles and aims of SOLAS regulation V/15 relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures when applying the requirements of SOLAS regulations V/19, 22, 24, 25, 27 and 28 at the time of delivery of the newbuilding.

The development of this Recommendation has been based on the international regulatory regime and IMO instruments and standards already accepted and referred to by IMO. The platform for the Recommendation is:

- the aims specified in SOLAS regulation V/15 for application of SOLAS regulations V/19, 22, 24, 25, 27 and 28
- the content of SOLAS regulations V/19, 22, 24, 25, 27, 28
- applicable parts of MSC/Circ.982, “Guidelines on ergonomic criteria for bridge equipment and layout”
- applicable parts of IMO resolutions and performance standards referred to in SOLAS
- applicable parts of ISO and IEC standards referred to for information in MSC/Circ.982
- STCW Code
- ISM Code

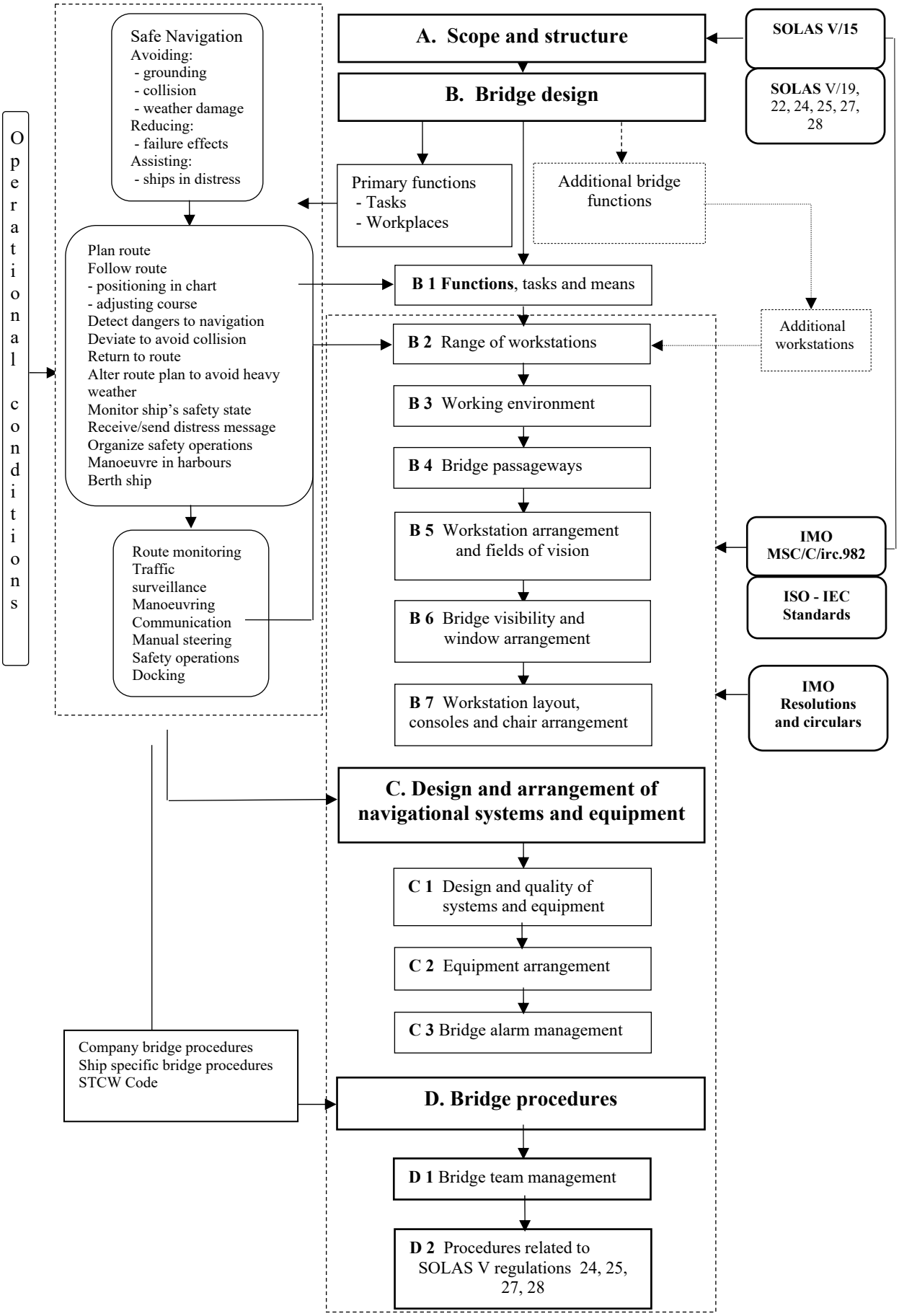
This Recommendation is developed to serve as a self-contained document for the understanding and application of the requirements, supported by:

- Annex A giving guidance and examples on how the requirements set forth may be met by acceptable technical solutions. The guidance is not regarded mandatory in relation to the requirements and does not in any way exclude alternative solutions that may fulfil the purpose of the requirements.
    - Appendix 1 to Annex A, “Tasks and related means – Examples of location of main equipment”

- Annex B “Facts and principles – Related to SOLAS V/15 and the BCS Recommendation” that should assist in achieving a common understanding of the content of SOLAS regulation 15 and the approach and framework of the Recommendation.
    - Appendix 1 to Annex B clarifying the content of each aim of SOLAS regulation V/15.

Chapter C 2 “Bridge alarm management” is established by compilation of relevant IMO and classification requirements and guidelines. The chapter is recommended for compliance until superseded by an IMO performance standard.

The diagram following this foreword gives an overview of approach and content.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- collision
- weather damage
Reducing:
- failure effects
Assisting:
- ships in distress
Plan route
Follow route
- positioning in chart
- adjusting course
Detect dangers to navigation
Deviate to avoid collision
Return to route
Alter route plan to avoid heavy weather
Monitor ship's safety state
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Annex A Guidance and examples relating to requirements of the Recommendation

Appendix 1 of Annex A Tasks and related means – Examples of location of main equipment

Annex B Facts and principles related to BCS Recommendation

Appendix 1 of Annex B Clarification of the content of each aim specified in SOLAS regulation V/15

A. GENERAL

A 1 Scope and approach

This Recommendation for bridge design, equipment arrangement and procedures (BDEAP) related to newbuildings is compiled and developed to cover the principles and aims of SOLAS V regulation 15, when applying the requirements of SOLAS regulations:

V/19 "Carriage requirements for shipborne navigational systems and equipment"
V/22 "Navigation bridge visibility"
V/24 "Use of heading and/or track control systems"
V/25 "Operation of steering gear"
V/27 "Nautical charts and nautical publications"
V/28 "Records of navigational activities"

taking SOLAS regulations V/18 and 20 into consideration.

The requirements of these SOLAS regulations affecting bridge design, design and arrangement of navigational systems and equipment on the bridge and bridge procedures, are harmonized with related guidelines of MSC/Circ.982 and relevant ISO and IEC standards for application of the SOLAS regulations in accordance with the aim of:

.1 facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions;

.2 promoting effective and safe bridge resource management;

.3 enabling the bridge team and the pilot to have convenient and continuous access to essential information which is presented in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays;

.4 indicating the operational status of automated functions and integrated components, systems and/or sub-systems;

.5 allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot;

.6 preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot;

.7 minimizing the risk of human error and detecting such error if it occurs through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action.

Note:
See Appendix 1 of Annex B, "Facts and principles – Related to SOLAS V/15 and the BCS Recommendation"

A 2 Structure and application

A 2.1 BCS Recommendation BDEAP is structured to reflect the areas and aims addressed by SOLAS regulation V/15.

A 2.1.1 Requirements
The requirements set forth cover SOLAS regulations and applicable parts of MSC/Circ.982, enabling the standard to be used as a stand-alone document for the purpose of approval work

during the building process, and are organized within the areas addressed by SOLAS regulation V/15:

- Bridge design
- Design and arrangement of navigational systems and equipment
- Bridge procedures

A 2.1.2 Guidance note
Guidance notes and examples as to how various requirements may be met by acceptable technical solutions or other remedies are given in the Annex A to the Recommendation. A guidance note given does not in any way exclude alternative solutions that may fulfil the purpose and intention of the requirement provided other requirements and the overall bridge functionality are not adversely affected.

A 2.1.3 Note
Notes are used to give useful information which does not necessarily affect the approval in relation to SOLAS regulation V/15, but may affect the choice of compliant solutions when relevant.

A 2.1.4 Annexes
Annex A of the Recommendation gives guidance and examples related to requirements, supported by Appendix 1
Annex B informs about facts and principles related to the understanding of SOLAS regulation V15 and the framework of the Recommendation, supported by Appendix 1

A 2.2 The content of the main document is through chapters B, C and D and is structured to reflect the main areas addressed by SOLAS regulation V/15 with the aim of enabling it to serve as a rational check list throughout an approval process for newbuildings.

A 2.3 Approval in accordance with the Recommendation gives evidence for compliance with SOLAS regulation V/15 when applying SOLAS regulations V/19, 22, 24, 25, 27 and 28 at the time of delivery of the newbuilding. See Annex B.

A 2.3.1 SOLAS regulation 19 and 22
Verification of compliance with SOLAS regulations V/19 and 22 includes verification of the ability of the bridge design, layout and equipment arrangement to promote effective and safe bridge resource management (see A 5.4) by ensuring that navigation bridge resources (see A 5.4.1), including information provided by visibility through bridge windows, are arranged to be made readily available for the bridge watch resources (see A 5.4.2), enabling safe performance of navigation functions and effective bridge team management (see A 5.5).

A 2.3.2 SOLAS regulation V/24, 25, 27 and 28
Procedures established for bridge resource management and for purposes specified in SOLAS regulations V/24, 25, 27 and 28 should become part of the ship's safety management system and included in the ISM certification.

A 3 Normative references

- Applicable parts of MSC/Circ.982 - Guidelines on ergonomic criteria for bridge equipment and layout
- MSC/Circ.603 - Guidelines on display sizes and techniques for navigational purposes
- IMO A.694(17) - General requirements for shipborne radio equipment forming part of the global maritime distress and safety system and for electronic navigational aids
- IMO A.1021(26) Code on Alerts and Indicators, 2009

A 4 Informative references

A. 4.1 IEC standards referred to in MSC/Circ.982 for relevant additional information:

- IEC 60945 ed.4 2008, Maritime navigation and radio communication equipment and systems - General requirements - Methods of testing and required test results
- IEC 61174 2015, Electronic Chart Display and Information System (ECDIS) - Operational and performance requirements, methods of testing and required test results

A.4.2 ISM Code

A.4.3 Company and Ship Specific Bridge Procedures Manual

A 4.4 STCW 1978, as amended

A 4.5 Maritime Regulations for the Operation of the Panama Canal, NOTICE TO SHIPPING No.N-1, Navigation Bridge Features Required of Transiting Vessels

A 5 Definitions

For the purpose of this document:

A 5.1 Alarm: An alarm or alarm system which announces by audible and visual means a condition requiring attention.

A 5.1.1 *Accept*: Manual silencing of an audible alarm from remote position

A 5.1.2 *Acknowledge*: Manual silencing of audible alarm at the location of the equipment, bringing visual alarm to steady state

A 5.1.3 *Cancel:* Manual stopping of a visual alarm after the cause has been eliminated.

A 5.2 Bridge: The area from which the navigation and control of the ship is exercised, including the wheelhouse and bridge wings.

A 5.2.1 *Bridge wings*: Those parts of the bridge on both sides of the ship's wheelhouse which, in general, extend to the ship's side.

A 5.2.2 *Navigation bridge*: Area of a wheelhouse or enclosed bridge allocated navigating functions and control of the ship, and which includes any additional bridge workstation to be used by the officer of the watch.

A 5.2.3 *Totally enclosed bridge:* A bridge without open bridge wings, meaning that bridge wings form an integral part of an enclosed wheelhouse.

A 5.2.4 *Wheelhouse:* Enclosed area of the bridge.

A 5.3 Bridge function: A group of tasks, duties and responsibilities necessary for operation of the ship and carried out on the bridge.

A 5.3.1 *Primary bridge functions:* Functions related to determination, execution and maintenance of safe course, speed and position of the ship in relation to the waters, traffic and weather conditions.

Such functions are:

- route planning …….. see A 5.16 and A 5.17.7
- navigating …… see A 5.13 and 5.17.2
  - route monitoring ……see A 5.13.1
    - grounding avoidance see A 5.13.1.1
  - traffic surveillance …….see A 5.13.2
    - collision avoidance see A 5.13.2.1

- monitoring safety …… see A 5.12.1
- manoeuvring ……see A 5.11 and A 5.17.2
  - alter course/heading ……..see A 5.13
  - change speed …….see A 5.13
- monitoring …… see A 5.12 and A 5.17.1
- conning ……. see A 5.9
- docking ……. see A 5.10 and A 5.17.5
- external and internal communication …….. see A 5.17.3
- manual steering ……. see A 5.17.6

A 5.3.2 *Additional bridge functions:* Functions related to ship operations which should be carried out on the bridge in addition to primary functions, but not necessarily by the watch officer. Examples of such functions are:

- extended communication functions
- monitoring and control of ballasting and cargo operations
- monitoring and control of machinery
- monitoring and control of domestic systems

A 5.4 Bridge resource management: Safeguarding that the bridge team comprises a sufficient number of specific individuals, appropriately qualified and fit for the duties and responsibilities assigned, and that information, instruments and equipment are readily available for efficient and safe performance of the dedicated functions at allocated locations.

A 5.4.1 *Navigation bridge resources*: Information, instruments and equipment arranged to be made readily available for individual members of the bridge team at specific locations, enabling safe performance of duties and responsibilities, effective co-operation and easy communication between bridge team members.

A 5.4.2 *Bridge-watch resources*: Qualified and fit individuals that may be assigned duties and responsibilities relevant for performance of navigational functions and bridge team operations.

A 5.5 Bridge team management: Safeguarding that the composition of the bridge team is continuously appropriate in relation to operational conditions by manning dedicated workstations outfitted, arranged and located for performance of specific functions and effective and safe bridge team operations by properly trained and fit individuals; familiar with instruments and equipment to be used and with their individual duties and responsibility as member of the current bridge team and with the function(s) to be performed at the individual workstations of the bridge team.

A 5.6 Close to: Within active reach (inside the wheelhouse).

A 5.7 Commanding view: View without obstructions which could interfere with the ability of the officer of the watch and the pilot to perform their main tasks, providing at least the field of vision required for safe performance of collision avoidance functions, requiring that the view of the sea surface forward of the bow to 10° on either side is not obscured by more than two ship lengths (2 x LOA), or 500m, whichever is less, and that a horizontal field of vision extends over an arc of not less than 225° - that is from right ahead to not less than 22.5° abaft the beam on either side of the ship.
Ref. SOLAS regulation V/22, 1.1, 1.2 and 1.3.

A 5.8 Close view of the sea surface: The view of the sea surface close to both sides of the ship's bow.

A 5.9 Conning station or position: Place in the wheelhouse arranged and located for monitoring and directing the ship's movements in narrow waters and buoy lanes by visual observations, providing a commanding view (A 5.7), close view of the sea surface (A 5.8) and the required information for conning (SOLAS regulation V/19).

A 5.9.1 *Additional conning station:* Workstation used for navigation, including conning, providing a commanding view with access to radar and navigational chart in addition to information required for conning by Reg.V/19, which may serve as alternative conning station for the pilot when required.

Note:
Both the conning station/position (A 5.9) and a workstation that may serve as additional conning station (A 5.9.1) need to provide a commanding view. The difference is that the commanding view in the first occurrence is provided at a position which also allows a close view of the sea surface, while the additional conning station provides additional information from instruments (radar/chart) and the commanding view from the working position at the radar, without necessarily providing a close view of the sea surface.

A 5.10 Docking: Manoeuvring the ship alongside a berth while controlling mooring operations.

A 5.11 Manoeuvring: Operation of steering systems and propulsion machinery as required to move the ship into predetermined directions, positions or tracks.

A 5.12 Monitoring: Observation of bridge operations and surrounding environment. See A 5.17.1.

A 5.12.1 *Monitoring safety state of the ship:* Act of constantly checking relevant information from instruments and monitoring systems related to the condition of the ship, its machinery and equipment in order to detect any irregularities. See A 5.17.4.

A 5.13 Navigating: Performance of route monitoring and traffic surveillance, execution of course alterations and speed changes as required to follow the pre-planned route and avoiding danger of grounding and collision.

A 5.13.1 *Route monitoring:* Monitoring the ship's position in relation to the planned route and the waters by deriving the ship's position from a continuous positioning system and a second independent positioning method of a different type, determining course adjustments required to follow the route within acceptable track-errors and alteration of the course at severe off-track-errors as required to avoid the danger of grounding.

A 15.13.1.1 *Grounding avoidance:* Executing appropriate course adjustments for the ship to follow the route and alteration of the course to avoid the danger of grounding at excessive off-track-errors, taking into consideration the safe route, waters, traffic and dangers of collision.

A 5.13.2 *Traffic surveillance*: Observing the traffic visually and by means of instruments, revealing other ships' course and speed relative to own ship and determining dangers of collision.

A 5.13.2.1 *Collision avoidance:* Determining and executing adequate course and speed changes to avoid the danger of collision, taking into consideration the traffic pattern, the route back-to-track, dangers to navigation and the risk of grounding.

A 5.14 Operational conditions:

A 5.14.1 *Normal operational conditions*: When all shipboard systems and equipment related to primary bridge functions operate within design limits, and weather conditions or traffic do not cause excessive operator workloads.

A 5.14.2 *Irregular operational conditions*: When external conditions cause excessive operator workloads.

A 5.14.3 *Abnormal operational conditions*: When malfunction of technical system requires operation of backup systems on the bridge, or when it occurs during an irregular operating

condition, or when the officer of the watch becomes unfit to perform his duties and has not yet been replaced by another qualified officer.

A 5.14.4 *Emergency situations*: When incidents seriously affect internal operating conditions of the ship and the ability to maintain safe course and speed (fire, ship system technical failure, structural damage).

A 5.14.5 *Distress situations*: Loss of propulsion and/or steering, or when the ship is not seaworthy due to other reasons (situation prior to abandon ship situation).

A 5.15 Waters:

A 5.15.1 *Ocean area:* Waters that encompass navigation beyond the outer limits of coastal waters. Ocean areas do not restrict the freedom of course setting in any direction for a distance equivalent to 30 minutes of sailing with the relevant ship speed.

A 5.15.2 *Coastal waters:* Waters that encompass navigation along a coast at a distance less than the equivalence of 30 minutes of sailing with the relevant ship speed. The other side of the course line allows freedom of course setting in any direction for a distance equivalent to at least 30 minutes of sailing with the relevant ship speed.

A 5.15.3 *Narrow waters*: Waters that do not allow the freedom of course setting to any side of the course line for a distance equivalent to 30 minutes of sailing with the relevant ship speed.

A 5.16 Route planning: Pre-determination of course lines, radius turns and ship speed in relation to the waters to be navigated.

A 5.17 Workstation: A workplace at which one or several tasks constituting a particular activity are carried out, designed, arranged and located as required to provide the information, systems and equipment required for safe and efficient performance of dedicated tasks and bridge team co-operations.

A 5.17.1 *Workstation for monitoring*: A workstation facilitating equipment and a commanding view for observation of the ship's heading and speed, the waters and traffic, incorporating means as required for route monitoring, used by the watch officer, assistant navigator or pilot as required for efficient bridge team operations.

Note:
The workstation is considered part of the workstation for navigating and manoeuvring (see A 5.17.2) for the purpose of route monitoring by the use of paper charts or ECDIS electronic back-up, and may serve as additional conning station (A 5.9.1 and B 5.6).

A 5.17.2 *Workstation for navigating and manoeuvring*: A workstation with commanding view used by navigators when carrying out route monitoring, traffic surveillance, course alterations and speed changes, and which enables monitoring of the safety state of the ship.

A 5.17.3 *Workstation for communication*: A workplace for operation and control of equipment for Global Maritime Distress and Safety System (GMDSS), and shipboard communication for ship operations under normal conditions and emergency situations.

A 5.17.4 *Workstation for safety operations*: A workplace dedicated for organisation and control of internal emergency and distress operations providing easy access to external and internal communication and information related to the safety state of the ship.

A 5.17.5 *Workstation for docking*: Workplace on bridge wings providing the field of vision and information required for controlling the manoeuvring of a ship alongside a berth, tug operations and mooring operations.

A 5.17.6 *Workstation for manual steering*: A workplace providing the field of vision, indicators and equipment required for steering the ship manually by a helmsman in accordance with orders received from the navigator responsible for bridge operations.

A 5.17.7 *Workstation for planning and documentation*: A workplace equipped for planning the route(s) of the complete voyage from departure to destination and documenting bridge operations during the voyage.

A 6 Documentation to be submitted by the ship builder for approval

A 6.1 Fields of vision drawings showing:

a) The overall horizontal field of vision from inside the wheelhouse (see B 5.4) and workstations for navigating and manoeuvring, monitoring, docking, manual steering and conning and any other workstation to be used by navigators. The drawings should include the arc of individual blind sectors and the sum of blind sectors forward of the beam and similar for the arc of 22.5° abaft the beam on either side of the ship.

b) The vertical field of vision over the bow under most unfavourable conditions of draught, trim and deck cargo seen from the conning station and workstations for monitoring and for navigating and manoeuvring. The drawing(s) should include the line of sight under the upper edge of the window from standing working position at the workstation and over the lower edge of the front window from sitting position if applicable.

c) Window arrangement, including inclination, dimensions, framing and height of lower and upper edge above bridge deck surface and the height of the deckhead.

A 6.2 Bridge layout drawings showing:

a) The bridge layout, including the configuration and location of all bridge workstations, including workstations for additional bridge functions.

b) Configuration and dimensions of workstation consoles including console foundations.

A 6.2.1 Drawing of the chair with indication of min. and max. seat heights above the bridge deck surface should be submitted if chairs are to be installed for use at workstation consoles. See B 7.3.1.

A 6.3 Equipment location drawings showing:

a) Location of instruments and equipment in all workstation consoles.
b) Location of equipment located elsewhere on the bridge.
c) The distance between deckhead mounted equipment and bridge deck surface.

A 6.4 List of equipment showing:

All relevant bridge equipment with specification of type, model, manufacturer, supplier and type approval reference with extension date or copy of valid certificates, when applicable.
See also the Note to C 1.1.

A 6.5 If an integrated navigation system, not type approved, is to be installed, the following documentation should be submitted:

a) the system configuration
b) functional description
c) factory acceptance test if applicable

d) failure mode and effect analysis (FMEA) for the system

A 6.6 If an integrated bridge system as defined in the IBS performance standard is installed, a failure mode and effect analysis (FMEA) for the system should be submitted.

A 6.7 Program for on board tests of equipment and systems

a) A program for the on board testing of the bridge equipment and systems required to be carried, as well as additional navigation equipment installed, should be submitted for approval at the earliest possible stage before sea trials.

b) The program to be submitted should include tests required to ascertain that all controls, indicators, displays and alarm functions operate in accordance with equipment and system specifications.

c) If an integrated navigation system is installed, a test program based on the failure mode and effect analysis (FMEA) for the system should be submitted. If the integrated system incorporates automatic route keeping, the test program should include tests of the track-keeping abilities.

d) If an integrated bridge system (IBS) is installed, a test program based on the failure mode and effect analysis (FMEA) for the system should be submitted.

A 6.8 Ships of special construction or purpose
Whenever the Society concerned determines that a ship of special construction or purpose cannot comply fully with these provisions without interfering with performance of special bridge functions, the bridge should comply with solutions determined by the Society to be the closest possible compliance with the relevant requirements in respect of that ship, based on a justification commonly agreed to by the shipbuilder and the owners and submitted by the shipbuilder.

A 6.9 If the bridge layout, provision of view, outfitting and location of workstations supporting safe and effective bridge team management do not conform to the principles and requirements set forth in this Recommendation, information describing the bridge functions and bridge team management during different operational conditions (see D 1.1), provided by the owner or operator, should be regarded an inclusive part of the documentation required in A 6.2 and A 6.3 to be submitted for approval by the shipbuilder. (See also A 8.2).

Note:
When deemed necessary for consideration of bridge arrangement or for submitting additional documentation to justify arrangement solutions, it is regarded the responsibility of the builder to ensure that the owner provides such information in the context of the building specification, disregarding the type of arrangement. Any such information should be submitted for information.

A 7 Documentation to be submitted by the ship builder for information

A 7.1 Manuals or instructions for equipment installed for the use of bridge personnel should be submitted for information upon request.

A 7.2 If a type approved integrated navigation system is to be installed, the following documentation should be submitted for information:

a) the system configuration;
b) functional description;
c) type approval certificate;
d) failure mode and effect analysis (FMEA) for the system, if applicable.

A 8 Documentation to be submitted by the ship owners

A 8.1 Ship specific bridge procedures should be included in the ship's management plan, available on the bridge for ISM certification, covering:

- distribution of bridge functions and tasks (see B 1);
- manning and training requirements on the bridge at identified operating conditions, taking into account the requirements in B 1 and D 1;
- familiarization schemes applicable for bridge personnel as required by STCW I/14, para 1.4 and 1.5;
- the use of the heading and/or track control system, operation of steering gear, updating of nautical charts and recording of navigational activities proving compliance with SOLAS regulations V/24, 25, 27 and 28.

A 8.2 If outfitting and location of workstations and bridge team management do not conform to the principles and requirements set forth in this Recommendation, the ship owner or operator should provide the builder with information describing bridge functions and operational procedures, including bridge team management during different operational conditions (see D 1.1), which is to be included in the documentation required in A 6.2 and A 6.3 (See also A 6.9).

Note:
When required, the owner or operator should ensure that this information is provided in the context of the building specification. See Note to A 6.9.

A 8.3 Description of functions to be performed at workstations which are additional to workstations for primary bridge functions should be submitted.

A 8.4 If operational procedures are required to compensate for accepted technical solutions interfering with the functionality of the bridge, such procedures should be included in the ship's specific procedures for bridge operations.
(See A 6.6).

B. BRIDGE DESIGN

The bridge shall be designed and arranged with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *promoting effective and safe bridge resource management*
- *allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot*
- *preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot*

Ref. SOLAS V/15.1, 15.2, 15.5, 15.6

The design of bridges is governed by:

- the functions and related tasks to be carried out on the bridge, systems used and methods of task performance
- the range, layout and location of workstations required for performance of bridge functions
- the fields of vision required for visual observations from each of the workstations
- composition of the bridge team and the procedures required for safe operations under all identified conditions
- the type and range of equipment to be provided for performance of the tasks at the individual workstations and elsewhere on the bridge

Design requirements are related to application of SOLAS regulations V/19 and 22.

B 1 Functions, tasks and means

The bridge shall be designed with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and navigating the ship safely under all operational conditions*

Ref. SOLAS regulation V/15.1

The table below shows the main bridge functions and tasks to be carried out on the bridge and relevant location of equipment, if installed. The table may serve as a general reference for outfitting of workstations. Mandatory equipment to be installed for different ship sizes (SOLAS regulation V/19) is indicated in Table C 3.1.

The type of equipment installed on the individual bridge, the system configurations and automation level may affect the method of navigation, operational procedures and qualification levels. It is regarded to be the responsibility of the owners and users that procedures, knowledge and training of the bridge personnel are related to the individual ship's bridge system. Such issues should be documented in the Company and Ship specific bridge procedures manual and documented in the ISM Code procedures manual for the vessel. (See A 8.1, A 8.2)

Tasks and means			
Tasks to be performed	**Equipment** to be operated	**Information** to be viewed	**Remarks**
Navigation – Grounding avoidance			
Planning			
Plan route prior to departure	Paper chart/table Nautical publications GNSS (GPS)		
Alter route while under way	ECDIS* ECDIS backup**		* Optional installation ** If replacing paper
In Transit			
Monitor route-keeping: - Determine position by bearings - Read position on display - Plot position	Pelorus/gyro repeater* Radar GNSS (GPS) Paper chart/table		* Analogue Bearings 360˚ around the horizon, (one on each bridge wing) Additional pelorus at nav. workstation is recommended if feasible.
- Determine and plot position automatic	ECDIS		Optional installation
Maintain route/alter course by - manual steering - using autopilot - automatic route-keeping	Manual steering control Heading control system Track control system* (ECDIS)		* Alternative to heading control Interfaced to ECDIS, gyro, speed, radar when part of INS
Give sound signals	Whistle control		Fog – traffic
Receive sound signals	Sound reception system	Loudspeakers	Totally enclosed bridge
Monitor/Take action: - operational warnings - system failure alarms	Alarm panel		If installed
- ship's safety state	Alarm systems		
Monitor heading, turn, rudder angle, speed, propulsion		Gyro repeater Indicators: - rudder angle - rate-of-turn* - RPM, Pitch - speed log	* > 50 000 grt
Adjust lighting	Dimmer buttons		
Monitor shallow water areas	Echo Sounder system	Water depth	(Anchoring)
Monitor performance automatic route-keeping system		Conning info display	Optional Organizing indicator info providing situation awareness when in automatic route-keeping mode
Effect internal communication	Intercom (auto telephone)		
Effect external communication	VHF		Related to navigation

Tasks and means			
Tasks to be performed	**Equipment** to be operated	**Information** to be viewed	**Remarks**
Receive/send distress message	GMDSS equipment or remote control		If applicable
Traffic surveillance – Collision avoidance			
Detect floating targets Analyse traffic situations Observe visually Decide on collision avoidance measures	Radar with ETP* (may incl. AIS) Binoculars Window wiper - cleaning - heating control Clear-view screen* AIS (automatic ident. system)	Targets' relative position, course, speed. Expected passing distance Time Target true pos., course, speed	* Electronic target plotting ("historical" data) * If installed
Manoeuvring			(For route-keeping)
Change steering mode	Steering mode switch		
Alter heading	Heading control	Heading (Gyro)	
Observe rudder angle		Rudder angle	
Override steering	Override control		If applicable
Manual steering control			
Change speed	Propulsion control	RPM/Pitch	
Give sound signals	Whistle control		
Receive sound signals	Sound reception system	Loudspeaker	Totally enclosed bridges
Navigate back to route Maintain track of traffic	Paper chart/table GNSS (GPS)		
	Radar with route and navigable waters		
	ECDIS*		* May replace paper if w/backup
Harbour manoeuvring	Thruster		Optional
Anchoring			
Manoeuvre Monitor the depth Positioning (Identify anchor position)	Manual steering control Propulsion control (Thruster control.)* Echo sounder Radar Chart GNSS (GPS)	Heading Rudder angle RPM/Pitch Water depth Targets Ship's position	Performed at front workstations or in combination with docking station Information to be provided for pilots * Optional
Observe ship's safety state			
Monitor alarm conditions: - Navigation Equip. & system failures Operational warnings	Main alarm panel w/indicators and acceptance button*	Alarm list	* If applicable See chapter C 2
- Machinery condition		Machinery alarms	Installations related to the ship's specification
- Cargo condition		Cargo alarms	

Tasks and means			
Tasks to be performed	**Equipment** to be operated	**Information** to be viewed	**Remarks**
- Fire interior machinery cargo		Fire alarms	Installations related to the ship's specification
Manual steering			*(Rating)*
Maintain, adjust, alter heading according to order	Steering control Intercom (Command)	Gyro repeater Magnetic comp. Rudder angle Rate-of-turn*	* > 50 000 grt
Conning functions			
Determine & direct course and speed in relation to waters and traffic			
Monitor:			
- heading		Gyro repeater	May be digital
- rudder angle		Rudder angle	
- rate-of-turn		RoT indicator	> 50 000 grt
- propulsion		RPM/Pitch	
- speed		Speed log	
- water depth		Echo sounder display	Anchoring
Give sound signals	Whistle control button		
Effect communication	VHF		Available
Documentation	Log-book or equivalent		Manual or Electronic – Legal !
Safety operations			
Take action on alarm condition: - analyse situation - consult plans and drawings	Manuals – Drawings – (PC)		May be computer based info
- observe ship's external operational situation			Cooperation with navigating officer
- organize and execute measures by communication - check status of ventilation system	Intercom (UHF) Emergency stop		
Monitor development of alarm conditions	Alarm panel/screen		If applicable
- Cargo alarms	Alarm panel		If installed
- Fire detection & alarms	Fire detection + alarm panel		
- Gas & smoke detection			

Tasks and means			
Tasks to be performed	**Equipment** to be operated	**Information** to be viewed	**Remarks**
External communication			
Distress - weather - safety	GMDSS equipment		As required (Area)
Determine weather conditions Consider navigation warnings	Navtex receiver		
Public correspondence	Additional equipment		Specified by owners
Docking operations (bridge wings)			
Directing steering	Intercom (command)	Heading Rudder angle	
Directing speed	Intercom (command)	RPM/Pitch	
Giving sound signals	Whistle control button		
Receiving sound signals	Sound reception system	Loudspeaker	Totally enclosed bridge
Perform manoeuvring	Steering Propulsion control Thruster control*		* Optional
Additional functions			See Chapter B 2

B 2 Type and range of workstations

The ship's navigation bridge should not be used for purposes other than navigation, communications and other functions essential to the safe operation of the ship, its engines and cargo, and workplaces should be arranged with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *promoting effective and safe bridge resource management*

Ref. SOLAS V/15.1, 15.2

B 2.1 Individual workstations for performance of primary bridge functions including pilotage should be provided for:

- navigating and manoeuvring.... see A 5.17.2
- monitoring ……... see A 5.17.1
- manual steering …… see A 5.17.6
- docking on bridge wings …….. see A 5.17.5
- planning ……see A 5.17.7
- safety operations ……... see A 5.17.4
- communication ……. see A 5.17.3
- conning ……see A 5.9

(See A 6.2 and A 6.3)

B 2.2 Additional workstations may be arranged for performance of other functions than those related to primary bridge functions when relevant.
(See A 5.3.2)

B 2.3 Functions to be performed at any workstation for additional functions should be identified at the planning stage of the newbuilding. The category of functions (workstations) needs to be known to enable consideration and approval of the location of such workstations on the bridge in relation to the use of the regular workstations and bridge team management. See A 8.3 and D 1.1.

Note:
The main types of additional bridge workstations may be divided into three distinct categories based on purpose and functions and whether they are to be operated by the watch officer or not:

A. Workstations for functions regarded related to operation of the ship, its engines and cargo:

   a) to be monitored and controlled by the officer of the watch
   b) to be used by other personnel than the officer of the watch

B. Workstations for functions not regarded essential to safe operation of the ship and to be used by other personnel than the watch officer, but located on the bridge for practical reasons.

Disregarding the type of additional functions to be carried out, when such functions are included as part of the responsibility of the officer of the watch, it must be taken into consideration that additional functions will always have a lower priority than performance of primary functions.
See B 5.14 – B 5.16.
See Guidance note, Annex A.

B 3 Working environment

The bridge shall be designed and arranged with the aim of:

- *preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot*

Ref. SOLAS V/15.6

Internal environmental conditions on the bridge that may affect human performance are:

- temperature
- humidity
- ventilation
- noise
- vibration
- illumination and type of lighting
- glare and reflection
- interior colours
- occupational safety

B 3.1 The enclosed bridge or wheelhouse should be provided with air conditioning or a ventilation system for regulation of temperature and humidity helping to avoid that the thermal response of the body affects efficient task performance under various operating conditions.

Note:
Temperatures which are not less than 18˚C in cold climates and do not exceed 27˚C in tropical climates are regarded feasible for normal bridge watch conditions. These temperatures are

based on relatively still air and normal air humidity (40% – 60%). Higher temperatures are acceptable if airflow is increased and humidity is lowered.

B 3.2 Ventilation system with suitable air flow velocity and rate of air circulation should be provided. Direction of air flow from air conditioning and heating systems towards workplaces should be avoided.

B 3.3 Excessive levels of noise interfering with voice communication, causing fatigue and degrading overall system reliability, should be avoided.
See Guidance note, Annex A.

B 3.4 Vibrations when the ship is at normal transit speeds should not affect the reading of indicators or the performance of bridge equipment.

B 3.5 Lighting arranged for adjustment of illumination and direction of light should be provided at all workplaces and lighting should always be arranged at entrances and exits of enclosed workplace areas. Light controls should be visible in darkness. The illumination brightness should be sufficient for safe performance of the tasks and possible to dim down to zero. White ceiling lights do not require dimming facilities.

B 3.6 Lighting that may be required for continuous operations during darkness and in entrances to the bridge should be of a type that provides the least impact on night vision, with adjustable brightness to suit the operations and ease visual adaptation to darkness.
See Guidance note, Annex A.

B 3.7 It should be possible to dim equipment displays and indicators providing information to individual workstations and the lighting covering the workstation area, at the workstation in use.

B 3.8 Light sources should be arranged and located in a way that prevents glare, stray image and mirror effects in bridge windows and deckhead areas above workstations.
See Guidance note, Annex A.

B 3.9 To reduce the risk of personnel injury during bridge operations,

- the wheelhouse floor, bridge wings and upper bridge decks should have non-slip surfaces;
- hand- or grab-rails should be installed as required at workstations, passageways and entrances, enabling personnel to move and stand safely when the ship is rolling and pitching in heavy weather;
- chair deck rails installed at workstations should be provided with anti-trip skirting board or be flush mounted;
- stairway openings should be protected if not sufficiently lit or otherwise indicated during darkness;
- sharp edges or protuberances which could cause injury to personnel should be avoided;
- deck mounted hatches and manhole covers set into the wheelhouse, bridge wings and upper bridge decks should be flush fitting to remove trip hazards.

B 3.10 Personnel safety equipment to be stored on the bridge should be clearly marked and easily accessible.

B 3.11 All portable items, including safety equipment, tools, lights and pencils should be stored at dedicated places.

B 4 Bridge passageways

The bridge should be designed and arranged with the aim of:

- *promoting effective and safe bridge resource management*

Ref. SOLAS V/15.2

Bridge passageways should facilitate the expected movement of the bridge team between individual workstations, bridge entrances, exits and windows in carrying out the bridge tasks safely and effectively including the maintenance of equipment.

B 4.1 A clear route across the wheelhouse, from bridge wing to bridge wing for two persons to pass each other, should be provided. The width of the passageway should preferably be 1200 mm and not less than 700 mm at any single point of obstruction and allow easy access to side doors.

B 4.2 The distance between separate workstation areas should be sufficient to allow unobstructed passage for persons not working at the stations. The width of such passageways should not be less than 700 mm, allowing for a persons sitting or standing at their workstations.

B 4.3 The distance from the bridge front bulkhead, or from any console and installation placed against the front bulkhead to any console or installation placed away from the bridge front, should be sufficient for one person to pass a stationary person. The width should preferably be 1000 mm and not less than 800 mm.

B 4.4 The distance between bridge wing consoles, if installed and bulkheads should be as little as possible for easy operation of controls from both a position behind and beside the console giving optimum view of the ship's side and the mooring operations, but wide enough for one person to pass the console. The width of the passageway should preferably be 600 mm.

Note:
The Panama Canal Commission (PCC) requires that a minimum of 1 metre clearance from consoles or obstructions shall be provided from the forward to aft portions of the bridge wing ends. Special requests for relaxation of this requirement may be considered on a case-by-case basis.

B 4.5 The clear deckhead height in the wheelhouse should take into account the installation of deckhead panels and instruments as well as the height of door openings required for easy entrance to the wheelhouse. The following clear heights for unobstructed passage should be provided:

a) The clear height between the bridge deck surface covering and the underside of the deck head covering should be at least 2250 mm.

b) The lower edge of deck head-mounted equipment in open areas and passageways, as well as the upper edge of door openings to bridge wings and other open deck areas should be at least 2100 mm above the deck.

c) The height of entrances and doors to the wheelhouse from adjacent passageways should not be less than 2000 mm.

B 4.6 All wheelhouse doors should be operable with one hand. Bridge wing doors should not be self closing and means should be provided to hold the doors open.

B 5 Workstation arrangements and required fields of vision

The bridge should be designed and arranged with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *promoting effective and safe bridge resource management*
- *allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot*
- *preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot*

Ref. SOLAS regulations V/15.1, 15.2, 15.3, 15.5, 15.6

The workstations for primary bridge functions should be arranged to serve their functions under all operating conditions and different manning of the bridge and provide the fields of vision required for visual observations and easy cooperation between bridge personnel, promoting effective and safe bridge resource management.

B 5.1 Workstations for navigating and manoeuvring and for monitoring should be arranged within an area spacious enough for two persons to carry out the tasks in close cooperation, but sufficiently close together to enable the watch officer to control and safely carry out all the tasks from one working area under normal operating conditions.
See Guidance note, Annex A.

Note:
The sketch below shows the relative location of working positions for route monitoring and traffic surveillance with easy access to equipment serving both functions, allowing efficient performance by a single watch officer or two persons in close cooperation as required by operating conditions. This arrangement is based on manual position-fixing in paper charts for route monitoring:

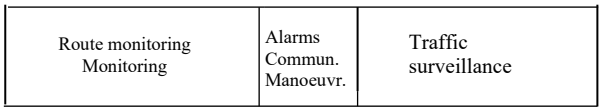


Figure B5.1 A: *Basic workstation arrangement for Navigating and manoeuvring – Monitoring*

The sketch below shows workstations arranged for the use of electronic chart system incorporating automatic position-fixing (ECDIS with back-up arrangement). When an electronic chart system is installed, enabling route monitoring, traffic surveillance and manoeuvring from one working position, the workstation for monitoring, may also serve as the conning position to be used by pilots if located close to centre windows.

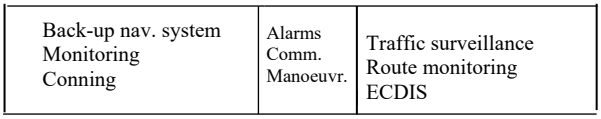


Figure B 5.1 B: *Workstation arrangement for Navigating and manoeuvring – Monitoring – Conning, based on the use of ECDIS w/backup arrangement*

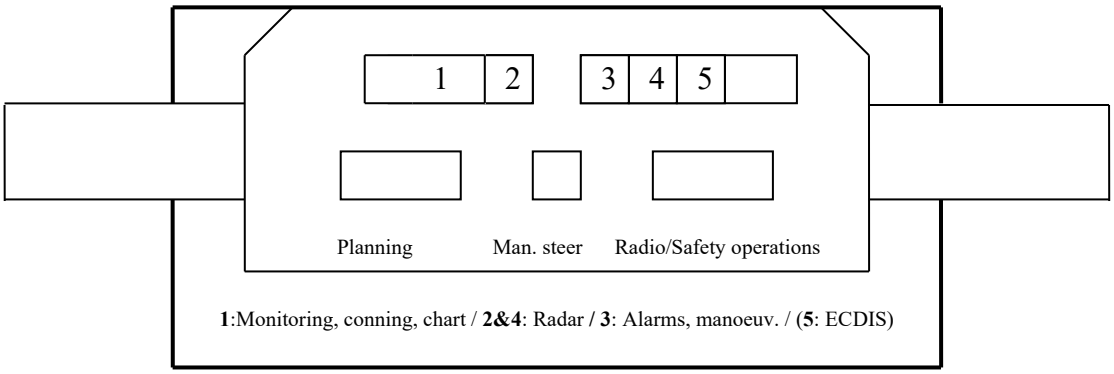


Figure B 5.1 C: *Example of basic bridge layout and location of main equipment for ships < 3000 grt*

Front chart table for paper charts (1) may serve as workstation for planning provided the ship is trading in waters not requiring re-planning of route during route monitoring and that the chart table is sufficiently dimensioned. ECDIS of flat panel type may preferably be included in the centre console (3), when installed on a narrow bridge.

B 5.2 The working positions at workstations for performance of route monitoring and traffic surveillance should be arranged for working in standing as well as seated position with optimum field of vision.

B 5.3 The view of the sea surface, blind sector limitations and the field of vision, specified in SOLAS regulation V/22 “Navigation bridge visibility” to facilitate the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions as specified in SOLAS regulation V/15.1 should be provided at bridge workplaces which include the task of conning,

- enabling the bridge team and the pilot to have convenient and continuous access to essential information (Reg.V/15.3) by visual observations;
- promoting effective and safe resource management (Reg.V/15.2);
- allowing for expeditious, continuous and effective information processing (Reg.V/15.5).

B 5.3.1 It should be possible to observe all objects of interest for the navigation such as ships and lighthouses, in any direction from inside the wheelhouse by providing a horizontal field of vision to the horizon of 360°.
See Guidance note, Annex A.

B 5.3.2 For safe performance of bridge functions, including conning, it should be possible for the bridge team and the pilot to eliminate the effect of blind sectors outside the wheelhouse by moving within the area of each their dedicated workplace and to eliminate blind sectors caused by divisions between windows without leaving the working position at the chair.

B 5.4 A conning position, the workstation for monitoring and the workstation for navigating and manoeuvring should provide a commanding view enabling maintenance of visual traffic surveillance for safe conning of the ship by the officer of the watch and the pilot, requiring that:

- the view of the sea surface is not obscured by more than two ship lengths (2 x LOA), or 500m, whichever is less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo.
- the horizontal field of vision extends over an arc of not less than 225° - that is from right ahead to not less than 22.5° abaft the beam on either side of the ship.

See Guidance note, Annex A.

Note:
For ships to be navigating narrow waters and harbour entrances requiring exact course-keeping, the owners should consider the need for the bridge to provide the field of vision as

required for using lights in line astern of the ship as a visual reference from the navigating and manoeuvring workstation, and include this requirement in the building specification.

B 5.5 The commanding view required for safe conning shall be complied with at a position equipped as required by Reg.V/19.2.5.4, providing a close view of the sea surface for safe directing of the steering and speed in narrow canals and buoy lanes.

B 5.5.1 A workstation for monitoring located close to the forward centre window, not required by the ship's personnel during pilotage may serve as the conning position specified in B 5.5.

Note:

a) The Panama Canal Commission (PCC) requires that the conning position be located "directly behind and next to" the centre front window and the nearest window thereto on each side that provides a clear and unobstructed view ahead for conning during canal transit. A minimum of 1 metre clearance from consoles or obstructions should be provided. Special requests for relaxation of this requirement may be considered on a case-by-case basis.

b) PCC requires that the conning position shall provide a view of the sea surface forward of the bow from 1.5 ship's length when at ballast load line and 1 ship's length at full load line.

B 5.6 Workstations for the functions of monitoring and navigation equipped with radar and navigational chart should provide a commanding view in accordance with the requirements for safe conning, to be used by the ship's officers and for serving as additional conning stations for alternative use by the pilot when equipment installed at the workstations is required for additional information and the view of the sea surface close to both sides of the ship's bow is not required.

Note:

The viewing point to be used for calculation of the required view and fields of vision from a conning position at the front bridge window should be the working position 75 cm aft of the window and the working position 35 cm aft of the radar consoles, whether the workstations are equipped with a chair or not. This also applies when a workstation with radar is located at a front window also serving as the position for conning.

B 5.7 Workstations for monitoring, navigating and manoeuvring should provide the required horizontal fields of vision from a seated working position and should not be located directly behind large masts, cranes, etc. which obstruct the view right ahead from the workstation. See Guidance note, Annex A.

B 5.8 No blind sector caused by obstructions outside of the wheelhouse forward of the beam which hampers the view of the sea surface as seen from a conning position and the workstation for navigating and manoeuvring, shall exceed 10˚. The clear sectors between blind sectors shall be at least 5˚. Within a sector from right ahead to at least 10˚ on either side, each individual blind sector shall not exceed 5˚. The total arc of blind sectors forward of the beam shall not exceed 20˚.

B 5.8.1 The total arc of additional blind sectors between the beam and 22.5° abaft the beam on either side should not exceed 10°, allowing a total of 30° within the required total field of vision of 225°. To ensure a total field of vision of 225° for proper look-out and safe conning, a clear sector of at least 5° shall extend from 22.5º abaft the beam and forward on either side of the ship. See also B 5.5.
See Guidance note, Annex A.

Note:

See Figure and Table B 5.8 below for overview of maximum allowed blind sectors and minimum clear sectors. See also Guidance note of B 5.16.

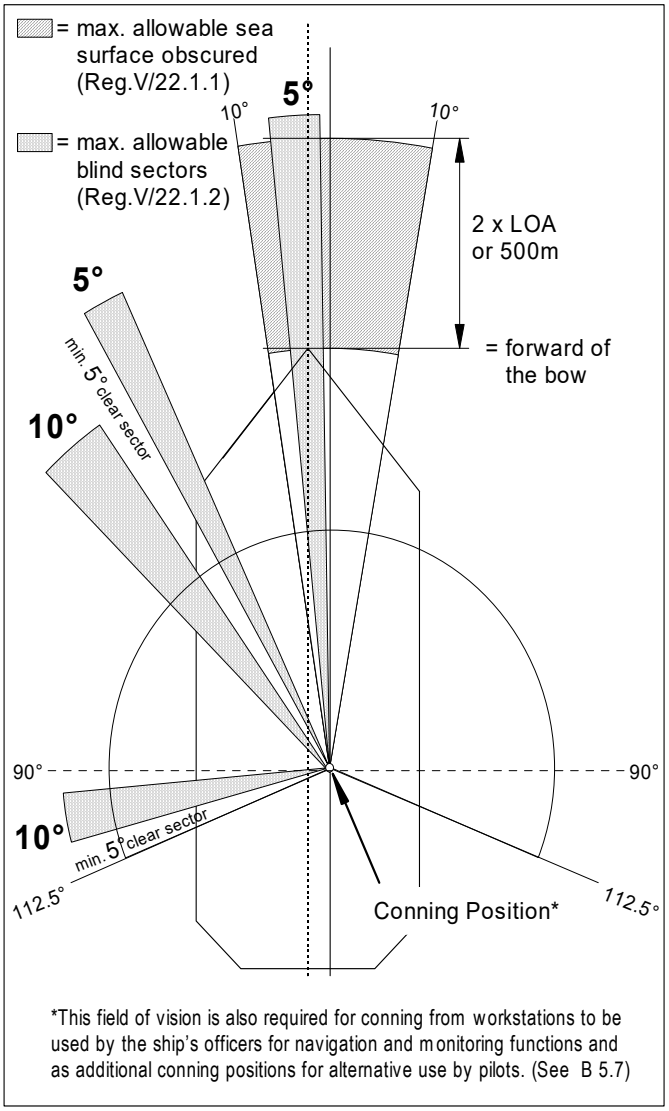


Figure B 5.8 (See B 5.4) Example illustrating the required horizontal field of vision of 225° with a maximum total arc of blind sectors of 20° forward of the beam and 10° abaft the beam, and indication of the vertical field of vision required within the sector of 20° right ahead.

Arc (size)	Max. individual blind sector	Max. allowed blind sector	Min. clear sector
Fwd. of the bow to 10° on each side (20°)	5°	10°	
Fwd. of the beam (180°)	10°	20°	
Abaft the beam (2 x 22.5°)	10°	10°	
Within total horizontal field of vision (225°)	10°	30°	
Clear sectors between blind sectors			5°
Min. clear sector from 112.5° and forward each side			5°

Table B 5.8

B 5.9 Blind sectors as specified in Reg.V/22.1.2, caused by cargo, cargo gear and other obstructions forward of the beam should be as few and small as possible and not in any way influence safe look-out from positions arranged, located and equipped to be used for conning by the bridge team and the pilot.
See A 5.7 and A 5.7.1.

B 5.9.1 Only blind sectors that cannot be avoided due to unusual structure and size of the cargo units to be stowed on deck and fixed structures regarded a prerequisite for the performance of specific ship functions and required for the purpose of safe operations of cargo and the ship may be included in the blind sector limits allowed by SOLAS regulation V/22, taking into account B 5.3.2 of this Recommendation.

Note:
Composition of the bridge team as required to ensure continuous look-out and safe conning by eliminating the effect of additional blind sectors caused by carriage of uncommon cargo on deck not enabling conformance with B 5.3.2 is considered the responsibility of the captain and the officer in charge of the navigational watch. Relevant considerations may need acceptance by the flag state Administration.

B 5.9.2 Regular cargo (such as cargo container units) stacked on deck in the field of vision forward of the beam should not obstruct the view of the sea surface at the horizon as seen from positions arranged, located and equipped to be used for conning by the bridge team and the pilot. See A 5.7 and A 5.7.1.

B 5.9.3 The height of stacked cargo should not exceed the line of sight of the sea surface forward of the bow specified in Reg.V/22.1.1.

B 5.10 The workstation for manual steering should preferably be located on the ship's centre line and should not interfere with the functions to be performed by the officer of the watch. The steering position should provide a forward field of vision not less than 60˚ to each side. If large masts, cranes, etc., obstruct the view in front of the workstation, it should be located some distance to starboard of the centre line, sufficiently to obtain a clear view ahead. It is not required to arrange the manual steering stand to be used in seated position.

B 5.11 When the workstation for manual steering is located off centre, or the bow of the ship cannot be seen from the steering position, special steering references (sighting marks) should be installed forward of the steering position. The steering references should be installed in line parallel to the ship's centre line for use by day and by night.

B 5.12 The ship's side should be visible from the bridge wing. Equipment for docking operations from the bridge wings, or a workstation console if installed, should be located to enable visual observations required for safe manoeuvring of the ship, monitoring of tug and mooring operations and should provide a field of vision from not less than 45˚ on opposite bow to right astern from the working position as shown in Figure A.

B 5.13 There should be a close approach access to at least one front window providing the view of the area in front of the accommodation superstructure. The access should not interfere with the use of a conning position arranged for pilots at the front window.

B 5.14 Workstations for additional functions which are of the category to be monitored and controlled by the watch officer as specified in B 2.3-A(a) should provide the field of vision required to maintain efficient look-out and enable monitoring of the ship's heading and rudder angle. (See also last part of the guidance note to B 5.5).

B 5.15 The location of a workstation for additional functions regarded essential for safe operation of the ship and to be used by other personnel than the watch officer should not in any way influence the performance of primary bridge functions.

B 5.16 Workstations for additional functions not essential to the safe operation of the ship, its engines and cargo, or furniture arranged for meetings or relaxation inside the wheelhouse should not be installed within the area of the navigating bridge or within fields of vision, which are required for traffic surveillance from workstations. If such workstation or furniture arrangement is installed close to these areas, the use of it should in no way influence the performance of primary bridge functions, neither by use of light, noise disturbance or visual distraction. Ref. IMO Res. A.708 (17).

Note:
The figure below shows the principles for bridge layout with front workstations arranged for operations in seated and standing position and with bridge wing bulkheads/window frames) in line of sight from the working positions in seated position.

Main positions for performance of the tasks for route monitoring and traffic surveillance, and the location of chairs if fitted, are at radar consoles with easy access to nautical charts.

Appropriate field of vision is required from the workstations for radio operations if it is to be used by the officer of the watch (see Figure B).

A bridge area which may be regarded outside the navigating bridge and the sectors of required *field of vision from workstations* is indicated.

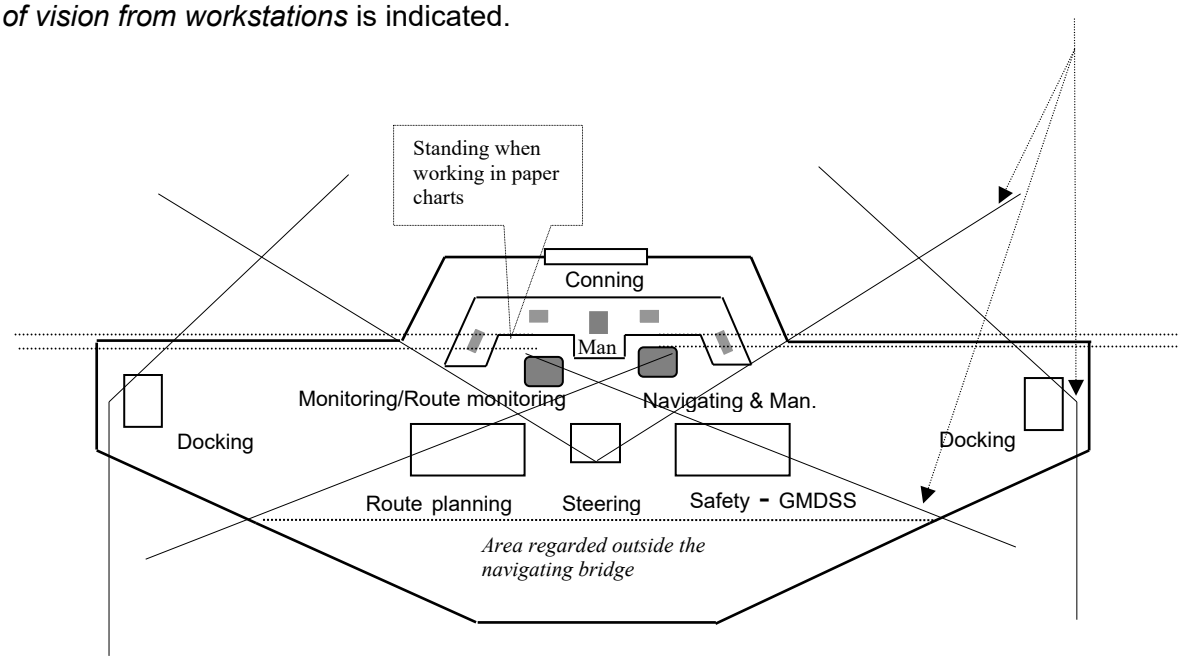


Figure A *Required field of vision from workstations and example of bridge layout promoting BRM.*
(Position-fixing in paper charts - Passageway and conning position in front.)

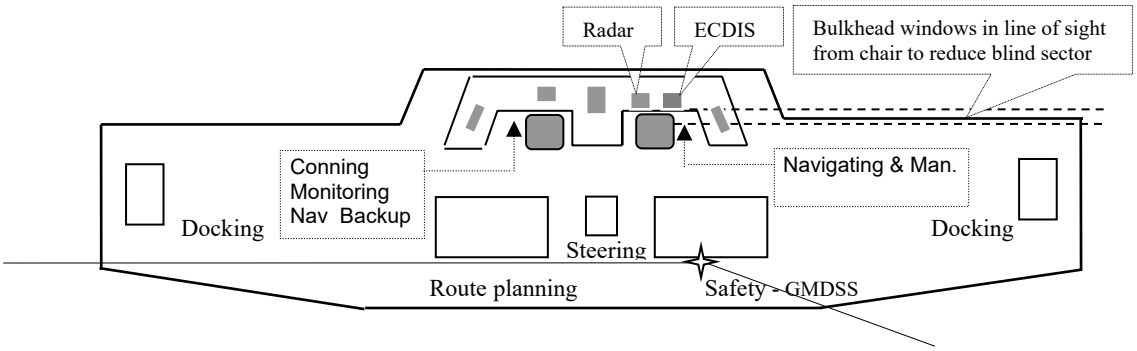


Figure B *Required field of vision from the radio station when to be controlled and infrequently used for short periods of time by the watch officer.*
(Navigation based on electronic chart system (ECDIS) – Conning position at console.)

Note to Figure B:
Location of ECDIS at the workstation for navigating and manoeuvring (incl. traffic surveillance) enables position-fixing at this position and makes the area a complete workstation (WS) for the navigation function and manoeuvring. This leaves the workstation for navigation backup/monitoring available to the pilot for conning when installed at the front bulkhead. Access to front windows is maintained.

B 6 Fields of vision and bridge window arrangement

The bridge should be designed with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot*

Ref. SOLAS V/15.5

B 6.1 The bridge front windows should be inclined from the vertical plane, top out, at an angle not less than 10˚ and not more than 25° to help avoid reflections. Polarized and tinted windows should not be fitted.

B 6.1.1 Side and rear windows should be inclined from the vertical plane top out at an angle not less than 4°~5° when required to avoid glare, stray image and mirror effects from light sources not arranged and located to prevent reflection.

Note:
Due to danger of damage during transit, the Panama Canal Authorities may not accept that side windows extend outside the maximum breath of the ship for certain sizes of ships.

B 6.2 The lower edge of windows should not present an obstruction to the view forward of the bow seen from a seated position at the workstations for monitoring, navigating and manoeuvring
See Guidance note, Annex A.

B 6.3 The upper edge of the front windows should allow a forward view of the horizon for a person with a height of eye of 1800 mm at the navigating and manoeuvring workstation when the ship is pitching in heavy seas. If 1800 mm height of eye is considered unreasonable and impractical, a reduction of the eye height may be accepted, but not to less than 1600 mm.
See Guidance note, Annex A.

Note:
The minimum height of the upper edge of front windows of 2000 mm may be accepted even if the vertical field of vision is less than 5° above the horizontal line from a standing height of 1800 mm, provided adequate chairs are installed for easy viewing from sitting position at the workstations when the ship is pitching in heavy seas and there is a passageway in front of the workstations enabling appropriate view from standing position.

B 6.4 Framing between windows should be kept to a minimum and not be installed immediately forward of any workstation or in the centreline. If stiffeners between windows should be covered, this should not cause further obstruction of the view.
See Guidance note, Annex A.

B 6.5 A clear view through at least two of the navigation bridge front windows and, depending on the bridge configuration an additional number of clear-view windows should be provided at all times, regardless of weather conditions, in accordance with Reg.V/22.1.9.4. The windows providing a clear view should include windows within the field of vision required for conning, seen from the viewing point at workplaces arranged to be used by the bridge team and the pilot for conning.

B 6.5.1 Sunscreens of roller blind type with minimum colour distortion, heavy duty blade type wipers,* fresh water window washing and efficient de-icing and de-misting system or other means should be installed as required to help maintaining a clear view through windows. A

catwalk or other means should be provided if required to help maintenance of window wipers and manual cleaning of bridge front windows.

Technical systems installed should comply with appropriate ISO standards*
* ISO 17899 Marine electric window wipers.

B 6.5.2 Clear view screens, if provided, should not be installed in windows in front of the manual steering position and radars, and not more than one to each side of the centre line, available for conning.

B 7 Workstation layout, consoles and chair arrangement

The configuration of workstations and consoles should provide a workplace for rational and user-friendly placing of equipment, with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *promoting effective and safe bridge resource management*
- *enabling the bridge team and the pilot to have convenient and continuous access to essential information*
- *allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot*
- *preventing, or minimizing, excessive or unnecessary work and any condition or distractions on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot*

Ref. SOLAS V/15.1, 15.2, 15.3, 15.5, 15.6

A functional workstation designed in accordance with the established overall operational and ergonomic requirements must provide:

- a sufficient area for performance of the tasks to be carried out by the number of people that may be required to attend

- consoles designed for operations at specific workstations in standing and seated position,
    - enabling installation of equipment to be within reach from the working position
    - avoiding obstruction of the view through bridge windows from seated position

- chairs suiting ergonomic requirements for efficient use of installed equipment and maintenance of fields of vision if chairs are to be installed.

B 7.1 The workstation for navigating and manoeuvring should have working positions for route monitoring, change of course and speed and traffic surveillance as close as possible for efficient use by the officer of the watch, but also enabling the tasks to be performed by two navigators in close co-operation.
See Guidance note, Annex A.

B 7.2 Consoles should principally be divided into two areas, when applicable:

- a vertical (slanting) part for location of information displays to be easily readable
- a horizontal part (desktop) for controls, switches and buttons to be within easy reach from the working position

B 7.3 The height of console desktops at the workplaces for navigation, manoeuvring, traffic surveillance and monitoring should enable easy use of equipment required for safe performance of the tasks to be performed from both standing and sitting position.

B 7.3.1 To provide a functional reach from standing position, the height of console desktops above bridge deck surface, equipped with means for operation, should preferably be 800 mm and not less than 750 mm, sloping forward to a height of 950 mm and not less than 900 mm for consoles having a depth of 800 mm from the working position. The height of desktops for frequent use of paper charts for route monitoring from standing position should preferably be 900 mm and not less than 800 mm. To provide easy operation of controls from sitting position, it should be possible to adjust the height of the seat to allow an elbow height 50 mm higher than the console desktop.

Note:
a. The type of work, means to be used and frequency of use during operations need to be taken into consideration when placing the means in relation to working positions.
b. The indication of preferable heights does not exclude acceptance of other dimensions when justified, provided other requirements and the overall bridge functionality are not adversely affected.
c. The height of consoles for route planning in paper charts should preferably be 950 mm and not less than 900 mm.

B 7.4 The console in front of a seated working position should provide sufficient leg room as required to ease the reach of equipment and controls to be used.
See Guidance note**,** Annex A**.**

B 7.5 Console configurations and location of displays should aim at providing the user with the information required for performance of main functions at his workstation within a viewing angle from right ahead to 95° to each side.

B 7.6 The consoles forming the front workstations should not be higher than required for efficient use in standing position and should not obstruct the fields of edge windows in front of the workstation from sitting position.

Note:
The height of front workstation consoles not exceeding 1200 mm. may be accepted for installation at a distance of 350 mm or more from windows with a lower medge of 1000 mm. This console height may also be considered acceptable even if it interferes with the line of sight from an eye height of 1400 mm, providing the height of the chair can be adjusted to compensate for the interference.

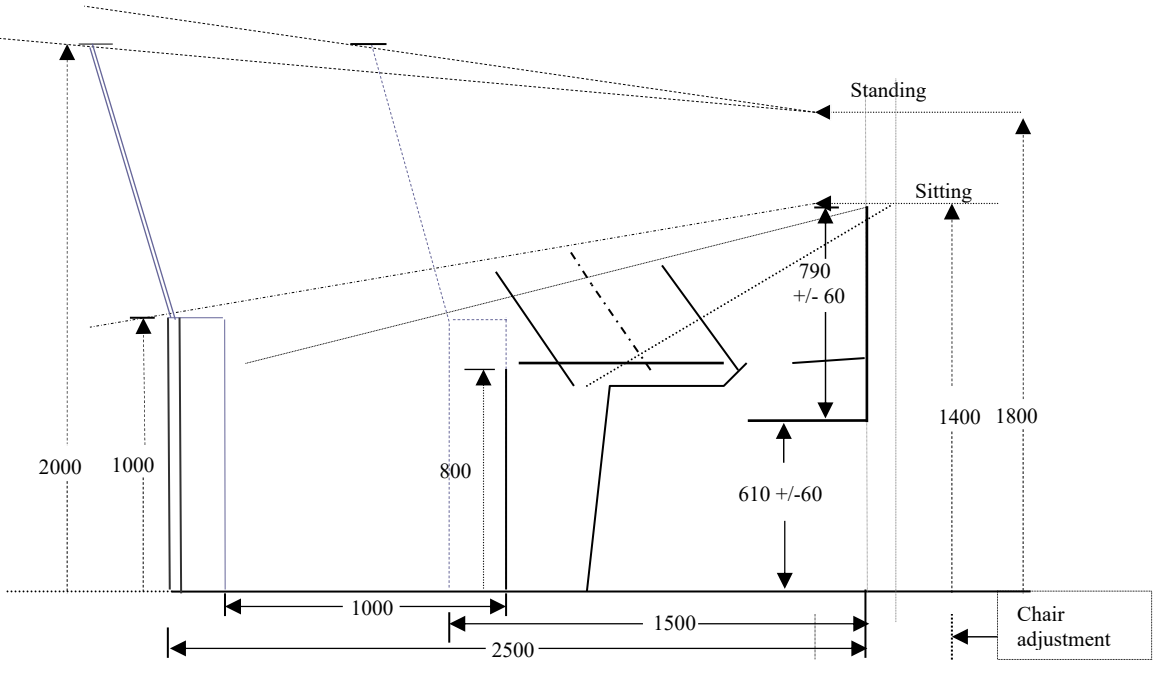


Figure B 7.6 Design principles in relation to lines of sight.

B 7.7 Consoles within the required fields of vision aft of the working position at front workstations should not obstruct the horizontal line of sight from the eye height in seated postion.
See Guidance note, Annex A.

B 7.8 The bridge design should permit installation of chairs allowing operations in both seated and standing working positions at dedicated workstations without degrading the required navigation visibility, even if the newbuilding is not to be equipped with chairs at the time of delivery.

Note:
Decision on installation of chairs on the bridge is left to current owners of the ship in consultation with their professional users, taking into consideration operating experience under conditions with high workloads related to the trade and type of the ship, putting focus on the need to mitigate fatigue and promote increased concentration and efficiency.

B 7.9 When a chair is installed at a workstation to be used for operations in both standing and seated position, it should be fastened to rails allowing fore and aft movement of the seat to enable easy reach of equipment when seated and sufficient room to stand in front of the console, preferably 700 mm, when the chair is pushed back. It should be possible to adjust the height of the seat to suit users of different heights for optimum view and reaching distance. Armrests, if provided, should be of fold away type and preferably adjustable in height. The chair should be equipped with an adjustable footrest.

C. DESIGN AND ARRANGEMENT OF NAVIGATIONAL SYSTEMS AND EQUIPMENT

Navigational systems and equipment should be designed with the aim of:

- *……..presenting the information in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays*
- *indicating the operational status of automated functions and integrated components, systems and/or sub-systems*
- *minimizing the risk of human error and detecting such error if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action*

Ref. SOLAS V/15.3, 15.4, 15.7

and be arranged with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *enabling the bridge team and the pilot to have convenient and continuous access to essential information*
- *allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot*

Ref. SOLAS V/15.1, 15.3, 15.5

The basic design of navigation systems and equipment allowed to be used for decision-making related to safety of navigation is governed by functional and technical requirements as well as ergonomic and human-machine interface criteria expressed in the performance standard for General requirements for shipborne radio equipment and electronic navigation aids* and individual IMO equipment performance standards.

Compliance is verified by tests carried out in accordance with appropriate IEC or ISO test standards endorsed by IMO and documented by type approval certificates issued by the flag state Administration. Choice of type approved equipment is considered the responsibility of the owners in consultancy with their professional users.

Selection and arrangement decisions should be made in accordance with the aims stated above, considering the bridge as a whole and ensuring that systems and equipment are located in compliance with design principles and functional requirements set forth in chapter B and C.
See Guidance note, Annex A related to principles for selection and arrangement of equipment.

* IMO Resolution A.694 (17)

C 1 Design and quality of navigational systems and equipment

The quality of the human engineering part of the design of equipment and alarm functions is to be determined in performance tests and trials carried out during the equipment type approval process based on the appropriate general and individual IEC test standards. See Annex B, 3.7.1.

All navigational systems and equipment, including integrated systems are subject to testing of system performance after installation. The tests should include accuracy of measurements, failure modes and alarm functions. See A 6.7.

C 1.1 Type approval certificates issued later than 2002 should include evidence of compliance with a general test standard, not inferior to current IEC test requirements*, or equivalent test data to the current version as regards ergonomics and usability.

* IEC 60945 ed.4 2008
See Note C 1.1 in Annex A regarding comparison of test requirements ed.3 and ed.4.

C 1.1.1 Alteration of hardware and software of type approved equipment requires review of the documentation by the type approving authority and may include re-testing to a certain extent, depending on the type of changes.

C 1.2 Navigational equipment and systems offering alternative modes of operation should indicate the actual mode in use. Ref. SOLAS regulation V/19.5.

C 1.3 In case of failure in one part of an integrated navigational system, it should be possible to operate every other individual item of equipment or part of the system separately. Ref. reg. V/19.6.

C 1.4 It should be possible to override or by-pass any automated functions, including the steering system by a single operator action.

Note:
A switch enabling immediate change from automatic to manual steering mode, located together with a steering tiller at the workstation dedicated the officer of the watch will meet the requirement for override of the automatic steering.

C 1.5 Categories of integrated navigation systems – INS – as identified in the IMO performance standard for INS should conform to the relevant requirements of the performance standard.

C 1.6 Each part of the INS should comply with applicable performance standards and requirements adopted by the IMO, including the requirements of the INS performance standards. Parts executing multiple operations should meet the requirements specified for each individual function they can control, monitor or perform.

C 1.7 An integrated bridge system – IBS – should conform to the IMO performance standards for IBS if supporting two or more of the following operations:

- passage execution*
- communications
- machinery control
- loading, discharging and cargo control
- safety and security

* *The function of passage execution in an Integrated Bridge system (IBS) may be performed by an INS which should at least be an INS(B),* covered by the relevant IMO performance standards.

C 2 Arrangement of navigational systems and equipment

The type and number of systems and equipment to be installed on board the newbuilding for the purpose of navigation should at least incorporate the means specified in SOLAS regulation 19. The systems and equipment should be installed and arranged to meet the relevant aims of SOLAS regulation V/15 specified under C.

The aims specified include promotion of bridge resource management (BRM) which should be met by arranging navigational bridge resources (see A 5.4.1) enabling continuous safe and effective bridge team management as defined in A 5.5.

C 2.1 Navigational systems and equipment should be arranged for performance of specific functions at dedicated workstations located for efficient and safe operations by the officer in charge of the navigational watch, the pilot and any composition of the bridge team as required under different operational conditions.

C 2.1.1 All information, controls, facilities and fields of vision required to carry out each of the tasks safely and efficiently should be provided at the corresponding workstations.

C 2.1.2 The relative location of individual equipment and their placement in relation to the distance of reach from the working position at the workstation should be based on:

- Type and range of equipment to be installed - See C 2.1.3
- Equipment relationship with tasks to be performed at the various workstations - See B 1 and C 2.1
- Primary tasks and importance of equipment functions and frequency of use - See B 1

The size and configuration of consoles to be included in workstations (see B 7) should be harmonized with the size of equipment and required space for installations and availability for effective and convenient use.

C 2.1.3 The table C 2.3 at the end of this sub-chapter specifies minimum carriage requirements for ships of different tonnage, the tasks or the purpose the equipment should serve and the type of workstation (WS) at which the equipment is to be used and should be installed. See also table in B 1 specifying equipment in relation to functions and tasks.

See Annex B, 3.7.2 regarding the choice of chart system.
See Note C 2.1.3 in Annex A related to the use of ECDIS and “Introduction of new technology”.

C 2.2 Other means than those specified in C 2.1.3 may be permitted, provided they serve the same functions and are approved in accordance with SOLAS regulation V/18.

C 2.3 Equipment to be installed at the workstations for route monitoring, manoeuvring, traffic surveillance and monitoring should be located for easy use from standing position, whereof means for traffic surveillance, heading and speed adjustments, internal and external communication should be located for easy use also from seated position.

Work in paper charts and manoeuvring requiring the use of lateral thrusters may be performed in standing position only, but controls for thruster systems should be grouped with controls for propulsion and manual steering at the workstation for navigating and manoeuevring.
See Guidance note, Annex A.

Note:
The position for operation of radars and the position at the centre console for harbour manoeuvres are regarded the main working positions at the workstation for navigating and manoeuvring. Figure **C 2.3** indicates location of main categories of equipment that should be within reach from the front workstation comprising three workplaces.
Examples of location of primary equipment are shown in Appendix 1 of Annex A.

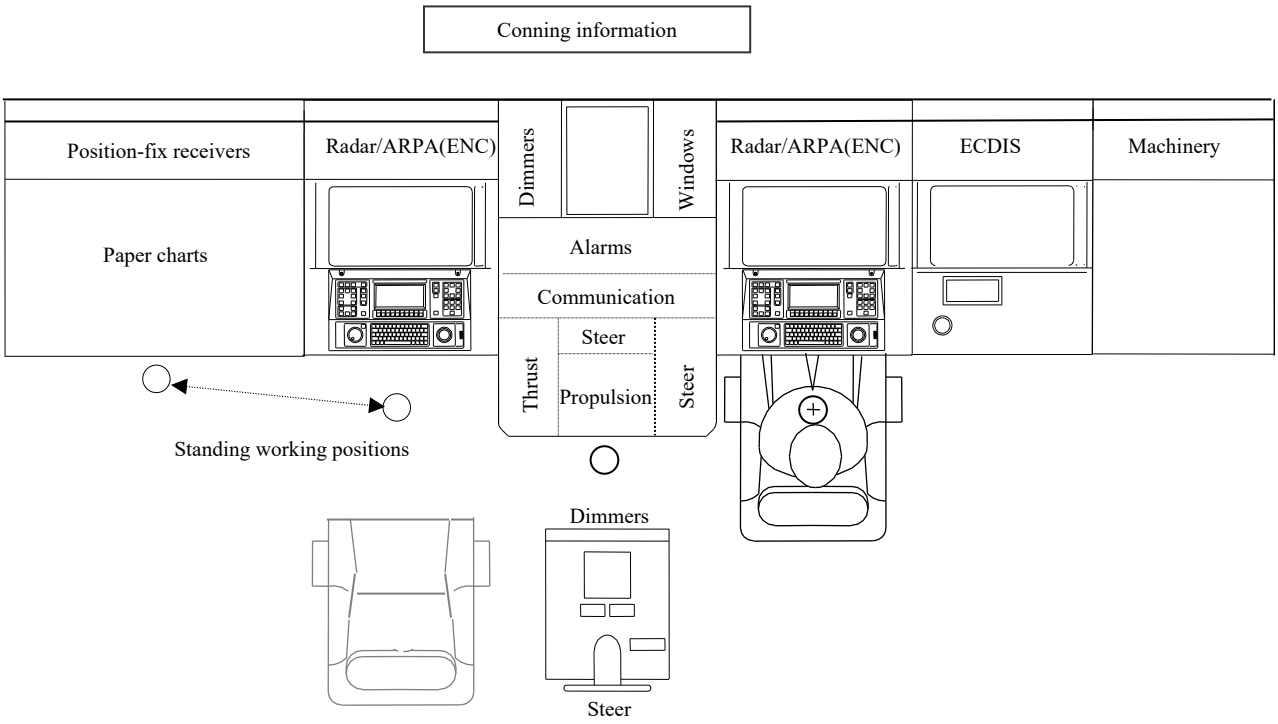


Figure C 2.3 Example of principles for location of main equipment in a centre console and of a general layout of workstation consoles covering the functions of monitoring, including conning as well as navigating and manoeuvring.
(Installation of "chart radars", ECDIS, conning display and thrusters are optional).

The concept meets user requirements for safe and efficient operations by the officer of the watch and by two officers in close co-operation. Additional consoles may be required for further installation of equipment. A passageway between the centre console and the left radar may be arranged to provide easy access from the workstations to front windows and ease the use of radar and charts for the pilot.

Table C 2.3

Equipment applicable for ships of various sizes (Ref. reg. V/19)				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equipm.***	***Remarks***
Applicable for all ships				
Check heading	Magnetic compass[1]			[1] Readable from WS for manual steering
Take optical bearings	Pelorus Means of correcting heading and bearing to true		Magnetic compass	Arc of 360˚ May be located outside the workstation area.
Route monitoring	GNSS Paper charts Chart table [1] ECDIS (w/back-up arr [2])			[1] Size sufficient for international paper charts. (at least 1200mm x 850 mm) [2] Optional chart system
Surveillance by hearing	Sound reception system	Sound direction		All ships w/ totally enclosed bridge

Equipment applicable for ships of various sizes (Ref. reg. V/19)				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equipm.***	***Remarks***
Communicate heading [1] - manual - automatic [2]	Telephone Gyro repeater			[1] To emergency steering position [2] Optional Gyro repeater (located in steering gear comp.)
Applicable for ships ≥ 150 grt				
Spare compass	Interchangeable magnetic compass (or other means)			Stored in bridge area Gyro compass also connected to emergency source of electrical power may be accepted.
Communicate ship/shore	Signalling lamp			Readily available
Applicable for ships ≥ 300 grt				
Traffic surveillance Navigation	Radar with electronic plotting aid (EPA)			9 GHz
Check keel clearance	Echo sounding device			
Check speed & distance	Speed & distance measuring device			Speed through the water
Transmitting heading [1]	Transmitting heading device [2]			[1] Trans. to Radar/EPA and AIS [2] Gyro required for ships >500 grt
Ship identification, tracking	AIS			Ref. Reg.19.2.4
External communication	VHF telephone			Compulsory (SOLAS Ch IV/7)
Applicable for ships ≥ 500 grt				
Determine heading Transmitting heading	Gyro compass	Gyro heading repeater		Trans. to Radar/ATA and AIS
Take bearings – arc 360˚		2 gyro bearing repeaters [1]	Main gyro	[1] Location bridge wings
Supply heading info to emergency steering pos.		Gyro heading repeater [1]	Main gyro	[1] Located at emerg. steering position
Manoeuvring - rudder angle		Rudder angle		
- RPM		RPM/(Pitch)		

Equipment applicable for ships of various sizes (Ref. reg. V/19)				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equipm.***	***Remarks***
- thruster force + direction - operational mode		Thruster settings		
		Actual mode of use		When equipment offers diff. modes
Traffic surveillance	ATA [1]		Radar	[1] Replaces EPA
Applicable for ships ≥ 3000 grt				
Traffic surveillance Navigation	Radar with ATA			3GHz or 9GHz (Add a second radar with ATA)
Applicable for ships >10000 grt				
Traffic surveillance	Automatic radar plotting aid (ARPA) [1]		Radar	[1] Replaces one ATA
Automatic steering	Heading or track control system			
Applicable for ships ≥ 50000 grt				
Monitor ship's turn		Rate-of-turn		
Measure speed & dist. forward + athwartship	2-axis speed log			Over ground

Workstation for navigating and manoeuvring Main functions: Observation of bridge operations and surrounding environment				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Traffic surveillance Navigation	Radar with ATA			
Route monitoring	ECDIS			If installed
Give sound signals	Whistle control			
Surveillance by hearing	Sound reception system	Sound direction		All ships w/ totally enclosed bridge
Internal communication	Auto telephone			
External communication	VHF telephone			

Workstation for navigating and manoeuvring Main functions: Observation of bridge operations and surrounding environment				
	Equipment and means			
Manoeuvring - rudder angle - RPM - Thrusters force + direction - operational mode		Rudder angle		Readable also from WS for monitoring + manual steering
		RPM/(Pitch)		Readable also from WS for monitoring
		Thruster settings		
		Actual mode of use		When equipment offers diff. modes
Automatic steering	Heading or track control system			
Override steering	Changeover switch, steering tiller			
Manual steering	Steering tiller			
Determine heading		Gyro – heading repeater		Also available to WS for monitoring
Monitor time		Clock		
Monitor ship's turn		Rate-of-turn		To be read from WS for monitoring + manual steering
Ship's speed		Speed indicator		
Water depth		Water depth indicator		
Wind force/speed & direction		Wind speed &direction indicator		
Ship's inclination		Inclinometer		
Monitor alarms and warnings	Alarm info system Accept button			
Cancel sounds, deduce reason				
Watch alarm	Accept button			If applicable

Workstation for monitoring Main functions: Observation of bridge operations and surrounding environment –				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Monitor Steering		Gyro repeater Rudder angle Rate-of-turn	Main gyro	
Monitor Speed Record distance		Speed & distance RPM main engine	Speed log	Pitch if relevant
Monitor time		Clock		

Give sound signals	Whistle control			
Accept watch alarms	Alarm accept button			If installed
Accept BNWAS prompts	BNWAS	Visual and audio		See SOLAS V/19.2.2.3
Route monitoring*	Paper charts** Chart table** Radar		GNSS/GPS	** Requiring info on ship's position* *** or Electronic ECDIS back-up*
Internal com. Public address Talk-back	Telephone Control unit/microphone			
External com.	VHF telephone			
Monitoring environment	Ctrls. for window wipers, washing & heating Binoculars			
Documentation	Log-book or equivalent		Conning info	*Recording of events*

Workstation for Manual steering Main functions: Steering in accordance with compass heading and visual marks				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Operating steering device	Wheel - tiller			
Monitoring compass heading		Compass heading Gyro repeater	Magnetic compass Main gyro	
Communicate bridge wings	Hands free talk-back telephone			

Workstation for Docking Main functions: Conning, course alterations, speed changes, mooring operations				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Determine manoeuvring - Heading - Speed - Steering - Propulsion		Gyro repeater Speed Rudder angle RPM Pitch if relevant	Main gyro Speed log*	* Optional
Manoeuvring operations	Main engine control[1]			[1]If installed
	Steering control[1]			
	Thruster control[1]			
Monitor external conditions		Wind speed & direction*		* Optional installation

Communicate wheelhouse (WS for navigating and manoeuvring)	Handsfree talk-back telephone			Open bridge wings: Always. Enclosed bridges: If distance is more than 10 metres
Communicate tugs/pilot boats	VHF (point)			Ref. SOLAS Ch. IV/7

Workstation for planning and documentation Main functions: Route planning – documenting ship operations				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Route planning	GNSS (GPS) Paper chart Chart table			
	Electronic chart			Optional

Workstation for Safety operations Main functions: Monitor safety state – Execute relevant measures – Organise operations				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Display alarm conditions		Remaining alarm indicators not available at WS for navigation/man.		Include acknowledgement of fire and emergency alarms
Provide information + other means for safety management	Remaining safety controls not available at WS for nav./man. Internal telephone			Info about ship's safety systems and contingency plan to be available at the WS

Workstation for communication Main functions: GMDSS				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
GMDSS	In relation to trading area			

Conning station (pilot) Main functions: External and internal observations for determination of safe course and speed				
	Equipment and means			
Task/Purpose	***Equipment***	***Indicators***	***Related equip.***	***Remarks***
Observe waters, navigational aids, traffic and ship's position in relation to route and waters	Binoculars AIS		Radar AIS pilot plug Nautical chart	Access to radar and updated nautical chart at regular conning position or additional conning station

Observe own ship's heading and steering, speed and propulsion Directing the ship's course and speed.		Gyro repeater Rudder angle Speed RPM Pitch if relevant		Easily readable from the conning position
Effect sound signals	Whistle button			Available at the conning position
Communicate other ships and shore side	VHF telephone			Easy access from working position

C 3 Bridge alarm management

Bridge alarm systems should be designed with the overall aim of:

- *minimizing the risk of human error and detecting such error, if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action*

Ref. SOLAS V/15.7

The overall aim includes the aim of:

- enabling the officer on watch to devote full attention to the safe navigation of the ship
- enabling immediate identification of any abnormal situation requiring action to maintain safe navigation of the ship
- avoiding distraction by alarms which require attention but have no direct influence on the safe navigation of the ship and which do not require immediate action to restore or maintain the safe navigation of the ship

Alarms and indicators on the navigating bridge should be minimized and only alarms and indicators required by appropriate IMO Resolutions should be placed on the navigating bridge, unless permitted by the flag administration. Ref. IMO Resolution A.1021(26)/4.18.

C 3.1 Alarm systems should be provided, indicating any fault requiring attention and should:

- activate an audible and visual alarm on the navigating bridge for any situation which requires action by or attention of the officer of the watch;
- as far as practicable be designed on the self-monitoring principle.

C 3.2 Means of accepting all alarms on the bridge (both the source of alarm and alarms of other equipment caused by the loss of sensor input) should be provided at the navigating and manoeuvring workstation to avoid distraction. The system should enable immediate identification of the alarm sources without requiring any operator action and enable immediate silencing of the alarms by single operator action. See Guidance note, Annex A.

C 3.3 Acknowledgement of an alarm at either the instrument or an alarm panel should cancel the audible warning at both sources and change the visual alarm from flashing to constant light.

C 3.4 Permanently inhibiting individual alarms should not be possible, but manual suppression of local audible alarms may be accepted when this is clearly and constantly indicated at the equipment and the unit is part of the alarm management system.

Note:
Local audible alarms may be manually suppressed by means of an on/off switch located on or close to the equipment or by other means, e.g. electronically. The off-position should enable suppression of the audible alarm when the equipment is part of a central alarm system and the on-position should engage the local alarm when the equipment serves as a stand-alone unit.

C 3.5 If an alarm channel in a computer-based system is inhibited manually, then this should be clearly indicated by a visual signal.

C 3.6 Audible alarms should be maintained until they are accepted and the visual identification of individual alarms should remain until the fault has been corrected.

Note:
Alarm volumes should be set sufficient to attract attention within the navigating bridge, but not to distract or disorientate. Alarm tones may be different for indication of equipment/system failure, operational warnings and alarms not related to safety of bridge operations respectively. (C 3.1)

C 3.7 Alarm indications should be red, or if on displays, red or otherwise highlighted. If alarm messages are displayed on colour VDUs, the alarm status should remain visible in the event of the failure of one colour of the display system. See Guidance, Annex A.

C 3.8 Alarm systems should be able to indicate more than one fault at the same time, and the acknowledgement of any alarm should not inhibit another alarm, meaning that if an alarm has been acknowledged and a second fault occurs before the first is rectified, the audible and visual alarms are to operate again.

C 3.9 A new alarm condition should be clearly distinguishable from those existing and already acknowledged showing a constant light, by indicating new alarms by a flashing light.
See Guidance, Annex A.

C 3.10 Provisions should be made for functional testing of required alarms and indicators.

C 3.11 Alarm systems should be continuously powered and should have an automatic change-over to stand-by power supply, like battery supply or other means, in case of loss of normal power supply.

C 3.11 Failure of the normal or backup power supply of the alarm system should be indicated by an alarm.

C 3.12 Loss of system communication should be indicated by an alarm.

D. BRIDGE PROCEDURES AND OPERATING CONDITIONS

D 1 Bridge team management

Navigating bridges complying with this Recommendation have been designed and arranged with the aim of:

- *facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions*
- *promoting effective and safe bridge resource management*

Ref. SOLAS V/15.1 and 15.2.
Ref. BCS Recommendation, B 2.

D 1.1 Procedures should be established enabling safe operations under all operational conditions by the manning required to master operational situations that may appear. Such procedures should be defined in the Company and ship specific bridge procedures manual and should take account of the requirements of the ISM and STCW Codes and include manning requirements, responsibilities and training requirements for all modes of operation.

D 1.2 The individual bridge workstations meeting the aims of SOLAS regulation 15 arranged and located in accordance with Chapter B, to suit the distribution of functions and tasks to be performed at different operating conditions, may be manned as indicated in the table below for efficient bridge team management by any composition of the team.
See A 5.5.

Bridge team compositions – provision of efficient co-operation
The table shows examples of workstations in use during different operational conditions requiring efficient co-operation by the members of the bridge team in charge. Compliance with STCW requirements by the users when determining the composition of the watch on the bridge is regarded a prerequisite.

Examples of workstations in use during different operational conditions					
Operational conditions	**Waters**				
	Ocean areas Coastal water	Narrow waters	Pilot waters		Harbours
			General	Confined	
Normal	W1	W1 + W2	W1+W2*	W1+(W3)+W8	W1+W3+W4
Irregular	W1+W2	W1+W2+W3	W1+W2*+W3	W1+W2+W3+ W8	W1+W3+W4
Abnormal	W1+W2+ W3	W1+W2+W3+ W8	W1+W2+W3+ W8	W1+W2+W3+ W8	W1+W2+W3+ W4
Emergency	W1+(W3)+ W6 +W7	W1+(W3)+W6 +W7	W1+(W3)+W8 +W6+W7	W1+(W3)+W8 +W6+W7	W1+(W3)+W4 +W6+W7

*When used by the pilot
WS = Workstation

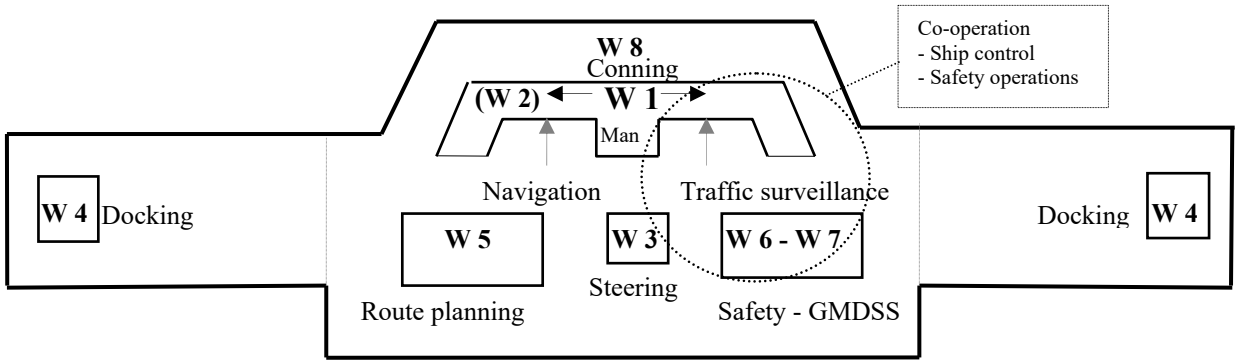
W1 : WS for navigating, manoeuvring (+ traffic surveillance)
W2 : WS for monitoring/conning (if ECDIS installed at workplace for traffic surveillance)
W3 : WS for manual steering
W4 : WS for docking
W5 : WS for planning
W6 : WS for safety operations
W7 : WS for communication
W8 : Conning station

Note:
It is emphasized that the table presents examples of workstations that may be in use during different operational conditions, demonstrating the ability of the workstation concept to promote bridge resource management and enable effective bridge team management. The examples are not meant to govern the factual manning during different operational conditions.

The manning of workstations and the use of a rating for the task of look-out duties in relation to safety of navigation under different conditions and in different areas is the sole responsibility of the master and the officer in charge of the navigational watch and include compliance with STCW Code, Part A VIII/2 Part 4 – Watchkeeping at sea.

It is recognized that the officer in charge of the navigational watch is the master's representative and is primarily responsible at all times for the safe navigation of the ship and for complying with the International SOLAS regulations for Preventing Collisions at Sea as well as with the STCW Code, Section A VIII/2 Part 4-1 – "Principles to be observed in keeping a navigational watch". This part of STCW addresses maintenance of proper Look-out, Watch arrangements, Taking over the watch, Performing the navigational watch and also:

- Watchkeeping under different conditions and in different areas, which includes clear weather, restricted visibility, in hours of darkness, coastal and congested waters, navigation with pilot on board and ship at anchor.



Design principles – *Example of location of workstations for effective bridge team management during different operating conditions*

The workstation for traffic surveillance and manoeuvring together with the workstation for safety operations and communication form an operational and emergency control centre wherefrom two persons can control the ship and handle emergency events in close co-operation.

D 2 Prevention of operational errors

D 2.1 Established operational procedures and work routines for performance of the navigating bridge functions by the officer of the watch as well as by any number of persons constituting the complement of a bridge team should endeavour of avoiding single operator failure that may affect safety of navigation.

Note:
Bridge team operations – prevention of one person error
When two navigators perform the tasks of navigation in close co-operation it is regarded imperative for safe performance that the navigator in command communicate any intended course and speed changes prior to execution, whether changes are related to route-keeping or collision avoidance, in order to enable the other navigator to verify, interfere or take immediate action as required to avoid mistakes. Any orders given to be executed by another member of the bridge team ought to be repeated to avoid misunderstandings.

Navigating in accordance with the advice of the pilot
It is the responsibility of the captain of the ship that the route has been planned from the port of departure to the port of destination. It is regarded imperative for safe navigation that the use of the planned route is confirmed by the pilot or adjusted by the pilot and accepted by the captain prior to the start of the pilotage. Alternatively, that the pilot's planned route for the waters is accepted by the captain and displayed for the use of navigating officers.

It is regarded imperative for avoidance of misunderstandings and to ensure correct task performance, that advice given by the pilot is repeated by the officer in command prior to execution and when relevant, and also by the member of the bridge team assisting in executing orders.

D 3 Procedures related to SOLAS regulation 24, 25, 27 and 28

D 3.1 The following routines should be included and emphasized in the regular bridge procedures:

- Use of heading and/or track control systems
- Testing of manual steering system after prolonged use of automatic steering system
- Operation of steering gear
- Updating of nautical charts and nautical publications
- Recording of navigational activities

Annex A Guidance and examples relating to requirements of the BCS Recommendation for application of SOLAS V/15 for newbuildings

Guidance notes and examples as to how various requirements may be met by acceptable technical solutions or other remedies are given in a separate document, Annex A to this BCS Recommendation. None of these guidance notes are mandatory in relation to the recommended requirements.

The guidance given does not exclude solutions that fulfil the purpose and intention of the functional requirement providing other requirements and the overall bridge functionality are not adversely affected.

Appendix 1 of Annex A Tasks and related means – Examples of location of main equipment. The title of the Annex indicates the content.

Annex B Facts and principles related to BCS Recommendation for application of SOLAS V/15 for newbuildings

Annex B serves as the interpretation of the content of SOLAS regulation V/15 and intends to provide information about the basis for the development of the Recommendation.

The annex summarizes certain facts that should assist in achieving a common understanding of SOLAS regulation 15 and the framework of the Recommendation. The information given may also make stakeholders more familiar with the approach and platform of the Recommendation based on the content of SOLAS regulation 15 and clarify the reason why certain comments received cannot be regarded applicable in the context of a Recommendation for application of SOLAS V/15 for newbuildings.

Appendix 1 of Annex B clarifies of the content of each aim specified in SOLAS regulation V/15. The appendix clarifies the understanding of each aim and by defining the terms and expressions used also indicates what compliance with the aims should entail.

ANNEX A

Guidance and examples relating to requirements of BCS Recommendation for application of regulation V/ 15

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Introduction

Guidance notes and examples as to how various requirements may be met by acceptable technical solutions or other remedies are given in this Annex to BCS Recommendation for application of SOLAS regulation V/15. None of these guidance notes exclude alternative solutions that may fulfil the purpose and intention of the requirement providing other requirements and the overall bridge functionality are not adversely affected.

The guidance given is related to specific requirements, but some are given to exemplify design and arrangement principles. The guidance may be improved and extended based on experience gained from the use of the Recommendation and organized feedback from owners, builders, manufacturers and the users on board the ships.

B 2 Type and range of workstations

B 2.3 Guidance note:
The type of tasks to be performed at the individual workstation and the operating procedures employed may conclude whether a workstation of category A should be of type a) or b). Workstations of category A, type a) should not include tasks that may prevent the officer in charge of primary bridge functions to leave a workstation for additional functions instantly at any time during operations.

B 3 Working environment

B 3.3 Guidance note:
The sound level measured 1 m from the outlets of air distribution systems should not exceed 60 dB(A).

B 3.6 Guidance note:
Red light should be used for dark adaptation. Fluorescent light is not feasible.

B 3.8 Guidance note:
Deckhead areas above workstations should preferably have a dark colour of matt, anti-gloss type minimizing light reflection. The colour of bridge bulkheads should have a calm and matt appearance.

B 5 Workstation arrangements and required fields of vision

B 5.1 Guidance note:
The workstation for navigating and manoeuvring should be arranged to allow an assisting officer to carry out route monitoring, which may include manual plotting of the ship's position, and course adjustments when required, while the officer in charge concentrates on traffic situations and adjustment of course and speed as required to follow the route and avoid danger of collision.

If a paper chart system, which includes chart table and means for position-fixing, is to be used for route monitoring, the system should be located at the workstation for monitoring. If an electronic chart system (ECDIS) meeting the chart carriage requirements in SOLAS regulations V/19.2.1.4 and 19.2.1.5 is to be used, the back-up arrangement should be located at the workstation for monitoring. The back-up arrangement may be electronic means, paper charts or a combination of both.

The workstation for monitoring, also incorporating the function of route monitoring, should be considered part of a workstation for navigating and manoeuvring. The workplaces for route monitoring and traffic surveillance should be adjacent to enable easy communication and cooperation when two navigators operate the workstation as well as providing the single officer of the watch with a workstation for safe and efficient performance of all the tasks when he is the only navigator on the bridge and is to use both the working position for route monitoring/position-fixing and the working position for traffic surveillance/manoeuvring.

B 5.3.1 Guidance note:
On a bridge with enclosed bridge wings it should be possible to obtain the view of 360˚ from inside the bridge area by using two positions, one on each side of the workstation for navigating and manoeuvring, not being more than 15 m apart. This guideline may also be applicable for providing the required field of vision within the confines of wheelhouses with a total breath of more than 18 metres.

B 5.4 Guidance note:
In general, it should be possible to achieve the view required forward of the bow from a sitting eye height of 1400 mm. If this is found unreasonable due to constructional matters related to carriage of cargo, a standing eye height as specified in B 6.3 may be accepted. See also B 7.8.

B 5.7 Guidance note:
The workstation for navigating and manoeuvring should be located on the starboard side close to the centreline if practicable.

B 5.8.1 Guidance note:
Location of bulwarks and bulkheads in a line of sight seen from a seated working position at the front workstations will help reducing the size of internal blind sector. A blind sector covering the view abaft the beam on port side may be considered acceptable for workstations to be used infrequently by the watch officer for short periods at a time (e.g. W.S. for communication).

B 6 Fields of vision and bridge window arrangement

B 6.2 Guidance note:
The height of the lower edge of windows above the floor surface should not exceed 1000 mm within the required field of vision.

B 6.3 Guidance note:
The height of the upper edge should be at least 2000 mm. A vertical angle of view of not less than 5° above a horizontal line from a standing eye height should be provided**.**

B 6.4 Guidance note:
The division between windowpanes within the required field of vision should not exceed 150 mm. If stiffeners are used, divisions should not exceed 100 mm in width, if practicable, and 120 mm in depth. The width of windowpanes within the field of vision required for traffic surveillance should not be less than 1200 mm in order to limit the number of stiffeners.

B 7 Workstation layout, consoles and chair arrangement

B 7.1 Guidance note:

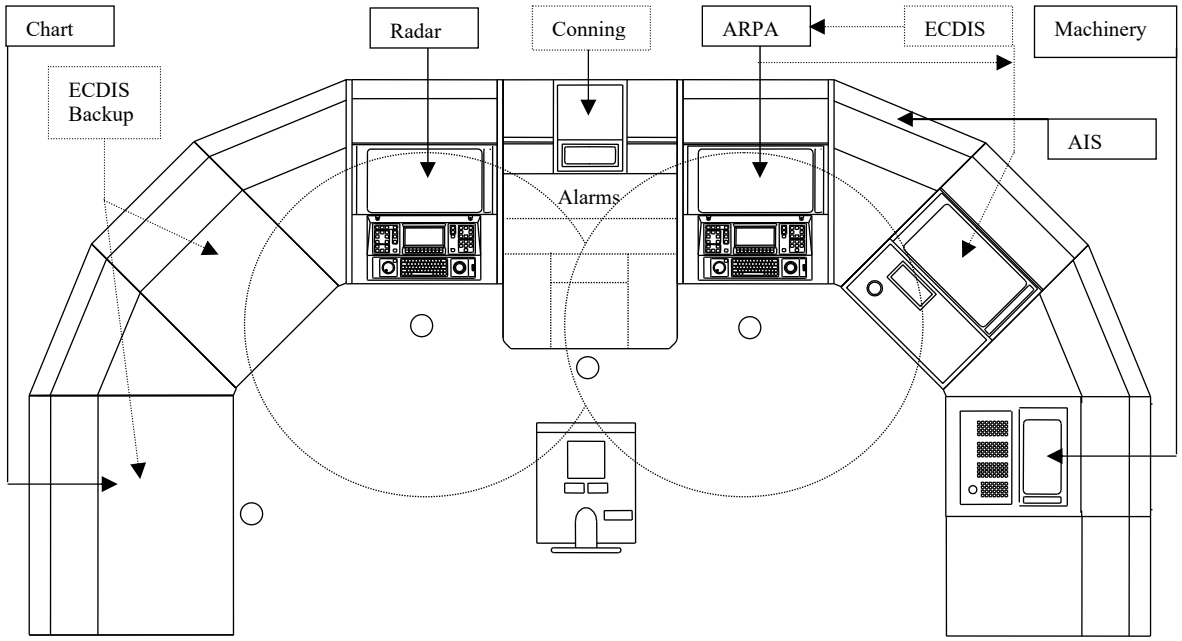


Figure B 7.1 – A: Workstation layout which may include ECDIS with combined electronic and paper chart backup arrangement as well as conning information display for visual monitoring of INS functions.

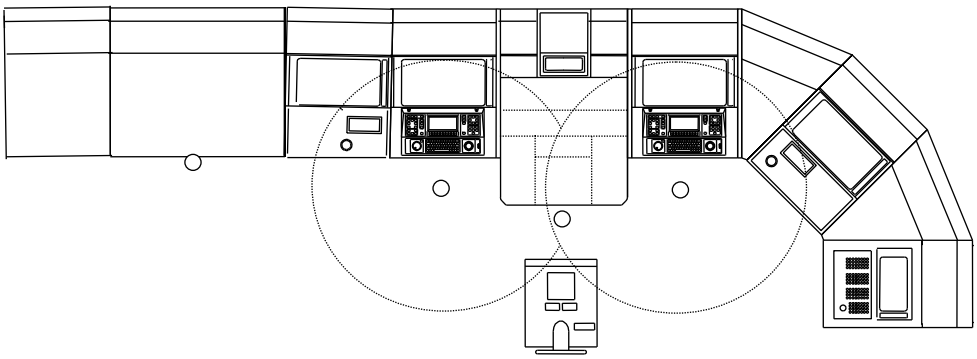


Figure B 7.1 – B: A modified workstation configuration, based on same principles as shown in Figure A. May suit wheelhouses with limited depth (longitudinal distance between front and rear bulkheads).

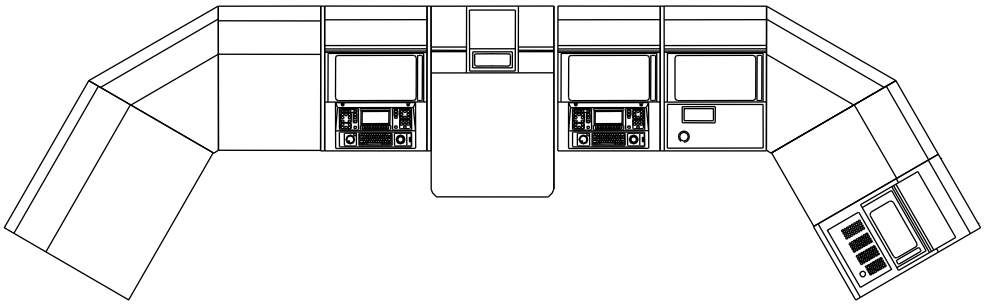


Figure B 7.1 – C: A modified version of figure B.

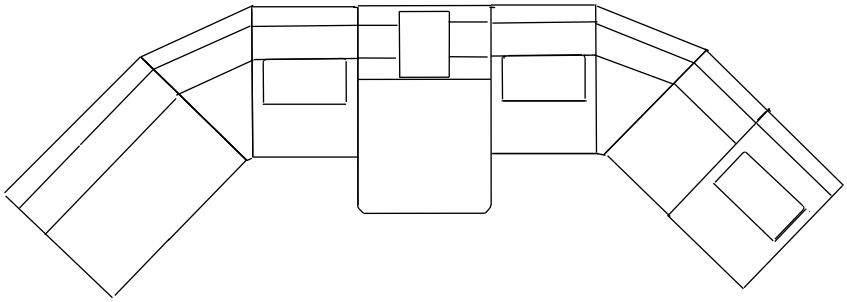
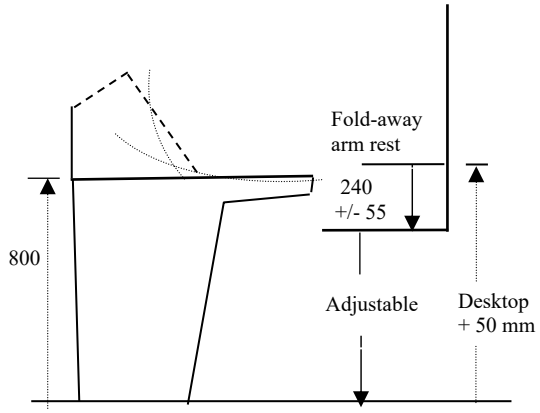


Figure B 7.1 – D: Design principles similar to figure C, but without electronic chart installations. Includes space for conning information display and machinery monitoring system.

B 7.3 Guidance note:
To provide a functional reach from standing position, the height of console desktops above bridge deck surface should be 800 mm and not less than 750 mm. The sitting height is governed by the elbow height in relation to console desktop.



To provide a functional reach of equipment and easy operation of controls from sitting position, the elbow height of the operator should preferably be 50 mm higher than the console desktop and not less than the height of the desktop.

To provide the elbow height required for persons of different size and build in relation to the console desktop, it should be possible to adjust the height of the seat to allow an elbow height of 240 mm +/- 55 mm above the seat. It should be possible to adjust chair armrests accordingly, if installed, and to fold the armrests away.

B 7.4 Guidance note:
The leg room required is governed by the seated working position suiting the user with regard to reach and effective operation of the equipment installed in the consoles, meaning the position of the chair in relation to the front of the console. The reach may be related to equipment installed in both front and side consoles. See Figure C 2.3.

B 7.7 Guidance note:
The height of the consoles should be 100 mm lower than the horizontal line of sight and should not exceed 1300 mm.

C. Design and arrangement of navigational systems and equipment

Guidance note:
Principles for selection and arrangement of navigational systems and equipment in accordance with applicable aims of SOLAS V/15.

Particularly important topics include, but are not restricted to, the following:

a. The design and arrangement of equipment on the bridge, particularly the display of user inputs and commands, should help to prevent single person error by facilitating monitoring and cross checks between members of the bridge team and pilot.
b. The design and arrangement of equipment on the bridge should facilitate validation of electronic information by actual observation of the surrounding environment and the use of any means available.
c. The design and arrangement of equipment on the bridge should provide convenient and continuous access to essential information for both the bridge team and pilot.
d. The current operating modes should at all times be clearly indicated to the bridge team and pilot. Indications of failure modes should be presented in a clear and unambiguous manner to enable the bridge team and pilot to understand the nature of the failure and its consequences.
e. Information (including control status) should be presented consistently within and between different sub-systems and items of equipment. Standardized symbols and coding should be used.
f. The functionality and automation to be provided should take account of the likely workload of the bridge team and pilot. This would typically influence selection of items including but not restricted to form of AIS implementation, ECDIS, autopilot functionality, bridge wing consoles, radar capability, alarm systems, dimmers.
g. Confirmation that the bridge design, equipment selection and arrangement, and the procedures meet the aims of SOLAS V/15 should be sought from representative users.

C 1.1 Note:
IEC general test standard for navigational systems and equipment
It should be noted that the current edition of the General test requirements, IEC 60945 ed.4, 2008, extends the detail of operational tests particularly for equipment which is operated through software menus. The layout of the Clause on minimum performance requirements has been changed to give a better grouping of ergonomics, hardware and software requirements. The EMC tests have been revised with the frequency range having been extended from 1 GHz to 2 GHz.

A comparison of the test requirements in the third and fourth editions is given in annex G of IEC 60945 to assist manufacturers and test houses in the use of the new edition, and may be informative to ship owners. The fourth edition cancels and replaces the third edition published in 1996 and constitutes a technical revision.

C 2.1.3 Note:
In order to meet relevant aims of Regulation 15, all ships should carry ECDIS with electronic back-up arrangement, provided ENC (electronic nautical charts) are available. The use of ECDIS enhances the safety and efficiency of route planning and monitoring thereby minimizing the danger of grounding, reducing workloads and increasing the quality of traffic surveillance. Because the carriage of electronic chart system is optional in regulation 19, it is left to the flag Administration to decide if the carriage should be regarded mandatory for their ships.

When using chart systems with automatic positioning of the ship in the chart, it is regarded imperative for safety of navigation that the navigation procedures and work routines specify the importance of controlling the ship’s position by other independent means.

Introduction of new technology for the purpose of enhancing safety of navigation
The requirement for a ship to carry charts is contained in Regulation 19, supported by Regulations 2, 9 and 27. Regulation 19 states that the chart carriage requirement may be met by the use of an Electronic Chart and Display and Information System (ECDIS) supported by back-up arrangement. In this respect, there are some key items to be aware of when a ship is to satisfy the chart carriage requirement by electronic means:

1) ECDIS equipment, specified in Resolutions A.817 (19), MSC 64 (67) Annex 5, MSC 86 (70) Annex 4 and MSC.232(82) must be type approved.

2) Charts to be used are Electronic Navigational Charts (ENC), which conform to standards defined by the International Hydrographic Organization (IHO).

3) The ECDIS Performance Standard permits ECDIS to operate optionally in the Raster Chart Display System (RCDS) mode of operation using Raster Navigational Charts (RNC). The RCDS mode of operation is only to be used for those areas where ENCs have not been published on the condition that the ECDIS is "used together with an appropriate folio of up-to-date paper charts".

4) ENC are superior to RNC and therefore of vital importance to safe navigation, especially in critical and complex waters. (See SN/Circ.207/Rev.1) However, individual Maritime States (to be identified) may accept the use of RNC for the purposes of Safety of Navigation within less complex waters under their jurisdiction for the time being until ENCs are available.

5) The ECDIS Performance Standard specifies the requirements for back-up arrangements but does not indicate which solutions may meet those requirements. Regulation 19 states that an "appropriate folio of paper charts" may be used.

6) The requirements for ECDIS back-up arrangements state that adequate independent back-up arrangements shall include facilities enabling a safe take-over of the ECDIS functions in order to ensure that an ECDIS failure does not result in a critical situation. In order to meet this requirement when paper charts are used for the purpose of ECDIS back-up arrangement, the following should be included in the navigation procedures and work routines:

- The planned route is to be inserted in the paper chart and the ship's position needs be updated regularly as required to enable an instant take-over of ECDIS functions, allowing a safe continuation of the navigation.

C 2.3 Guidance note:
In this workplace configuration (see Figure 2.3), a long centre console separating the front workstations (see Appendix 1, Annex A) may be accepted if the official chart system in use is an ECDIS installed at the workstation for navigating and manoeuvring (starboard), providing propulsion and manual steering (tiller) are within reach from the working position at the port workstation with backup chart system.

C 3 Bridge alarm management

C 3.2 Guidance note:
A bridge management system should separate alarms that affect safety of navigation and alarms that do not influence safety of navigation in two groups.

The group of alarms related to safety of navigation should incorporate all system alarms, equipment alarms and operational warnings that are critical to safety of navigation, including the detection of:

- operator disability (if detection system is installed)
- danger of collision
- heading deviations
- deviations from the route
- danger of grounding
- propulsion failure
- steering gear failure

Essential equipment and systems to be incorporated in such an alarm system should include:

- bridge navigational watch alarm system - BNWAS (if installed)
- heading information system
- heading / track control system
- position-fixing systems
- electronic chart system, if installed
- radar with electronic target plotting functions
- relevant machinery alarms for early warning

All groups of bridge alarms and warnings should preferably be centralised in a common panel or screen at the workstation for navigation and manoeuvring.

C 3.6 Guidance note:
The following method of indication should be applied:

1) Active alarm status:
   Red, blinking and audible
2) Active alarm status acknowledged:
   Red, static (cancelling the audible alarm)
3) Active warning message - not critical:
   Yellow, static (may be accompanied by a short audible attention signal)
4) Normal condition:
   No light (indication of a safe situation)

C 3.9 Guidance note:
In colour graphic systems, colours should not be used as the only means to distinguish between the status of alarms and warnings.

Appendix 1 to Annex A

TASKS AND RELATED MEANS

EXAMPLES OF LOCATION OF MAIN EQUIPMENT

at workstations to be used by

the officer in charge of the navigational watch
and
by two officers in close co-operation

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1 Table of tasks and related means for safe operations

Tasks and Means - Location					
Function/Tasks to be performed	**Equipment** to be operated	**L**	**Information** to be viewed	**L**	**Remarks**
Navigation – Grounding avoidance					**L** = Reference for location in console
Planning					
Plan route prior to departure Alter route while under way	Paper chart/table Nautical publications DGPS	N1 N2	GPS Position		
	ECDIS* ECDIS backup**	N3 N4			* Optional install. ** If replacing paper
In Transit					
Monitor route-keeping: - Determine position by bearings - Read position on display - Plot position	Pelorus/gyro repeater* Radar DGPS Paper chart/table	N5 N6 N2 N1			* One on each bridge wing (360°) and also at workstation if feasible
- Automatic determination and plotting of ship's position	ECDIS	N3			Optional installation
Monitor shallow water areas	Echo Sounder system	N7	Water depth	DN 7	(Anchoring)
Monitor performance of automatic functions	Conning display	N8*	Conning info route-keeping		* If provided
Maintain route/alter course by - manual steering - using autopilot - automatic route-keeping	Manual steering tiller** Heading ctrl. system Track ctrl. system* (ECDIS)	M1 M2 M2*			* Alternative to head ctrl. ** Alternative: M4 - Helmsman
Monitor heading, turn, rudder angle, speed, propulsion	Conning display*	N8*	Heading - rudder angle - rate-of-turn - RPM, Pitch - speed indicator	D0 D1 D2 D3 D4	* If provided
Give sound signals	Whistle ctrl.	C1			Fog - traffic
Receive sound signals	Sound reception syst.	C2	Loudspeakers		Enclosed bridge
Effect internal communication	Intercom (auto tlph.)	C3			
Effect external comm.	VHF	C4			Related to nav.
Receive/send distress message	GMDSS remote ctrl.	C5			
Monitor/Take action: - operational warnings - system failure alarms	Nav Alarm panel	A1			

Tasks and Means - Location					
Function/Tasks to be performed	**Equipment** to be operated	**L**	**Information** to be viewed	**L**	**Remarks**
- ship's safety state	Alarm system panels				Not specified

Traffic surveillance – Collision avoidance					
Detect floating targets Analyse traffic situations Observe visually	Radar with ETP* (may incl. AIS) Binoculars Window wiper - cleaning heating ctrl.	T1	Targets relative position, course, speed Expected passing distance/time		* Electronic target plotting
Decide on collision avoidance measures	AIS (automatic identification system)	T2	Target true position, course, speed		
Manoeuvring		M			(For route-keeping)
Change steering mode	Steering mode switch	M0			
Alter heading	Heading ctrl.	M2	Heading (Gyro)	DM 1	
Observe rudder angle			Rudder angle	DM 2	
Override steering*	Override/steering ctrl.	M1			*Officer
Manual steering*		M4			*Helmsman
Change speed	Propulsion ctrl.	M3	RPM/Pitch	DM 4	
Give sound signals	Whistle ctrl.	C1			
Receive sound signals	Sound reception syst.	C2	Loudspeaker	IC5	Enclosed bridges
Navigate back to route	Paper chart/table DGPS	N1 N2			
Maintain track of traffic	Radar with route and navigable waters	N6			
	ECDIS*	N3			* May replace paper
Harbour manoeuvring	Thruster*	M5			* If provided
Anchoring/ manoeuvring					
Steering Adjust speed Adjust ship's heading Positioning (Identify anchor position)	Manual steering ctr. Propulsion ctr. (Thruster ctrl.) Radar Chart DGPS	M4* M3 M5 N6 N1 N2	Heading Rudder angle RPM/Pitch Water depth	D0 D1 D3 D5	* Alternative: M1 Front workstations / docking station. Displayed Info to be provided for Pilots.
Observe ship's safety state					

Monitor alarm conditions: - Navigation alarms Equip. & system failures Operational warnings	Main alarm panel W/indicators and acceptance button		Alarm list		
- Machinery alarms	Alarm panel				
- Cargo alarms	Alarm panel				
- Fire alarm	Fire alarm panel				

Conning station					
Determine & direct course and speed in relation to waters and traffic					
Monitor:					
- heading			Gyro repeater	D0	Digital, readable 2 m
- rudder angle			Rudder angle	D1	
- rate-of-turn			RoT indicator	D2	
- propulsion			RPM/Pitch	D3	
- speed			Speed log	D4	
- water depth			Echo sounder display	D5	Anchoring
Give sound signals	Whistle ctrl. button	C1			
Effect communication	VHF				Available for pilot

Manual steering					*(Rating)*
Maintain, adjust, alter heading according to order	Steering ctrl. Intercom (Command)	M4 C6	Gyro repeater Magn. comp. Rudder angle Rate-of-turn		

Safety operations*	* Workstation not indicated on drawing				
Take action on alarm condition: - analyse situation - consult plans and drawings	Manuals - Drawings		Computer based info		
- observe ship's external operational situation					Cooperation with navigating officer
- organize and execute measures by communication - check status of ventilation system	Intercom (UHF) Emergency stop				
Monitor development of alarm conditions					
- Cargo alarms	Alarm panel				
- Fire detection & alarms	Fire detection and alarm panel				
- Gas & smoke detection					

External communication					
Distress - weather - safety	GMDSS station	C7			As required (Area)
Determine weather conditions Consider nav. warnings	Navtex receiver	C8			
Public correspondence	Additional equipment				Specified by owners

Docking operations (bridge wings*)	* Bridge wing workstations are not indicated on drawing				
Directing steering	Intercom (command)	C6	Heading Rudder angle	D0 D1	
Directing speed	Intercom (command)	C6	RPM/Pitch	D3	
Giving sound signals	Whistle control button	C1			
Receiving sound signals	Sound reception syst,	C2	Loudspeaker		Enclosed bridge
Perform manoeuvring – bridge wings*	Steering Prop. ctrls Thruster ctrl.	M4 M3 M5			* Installations not mandatory

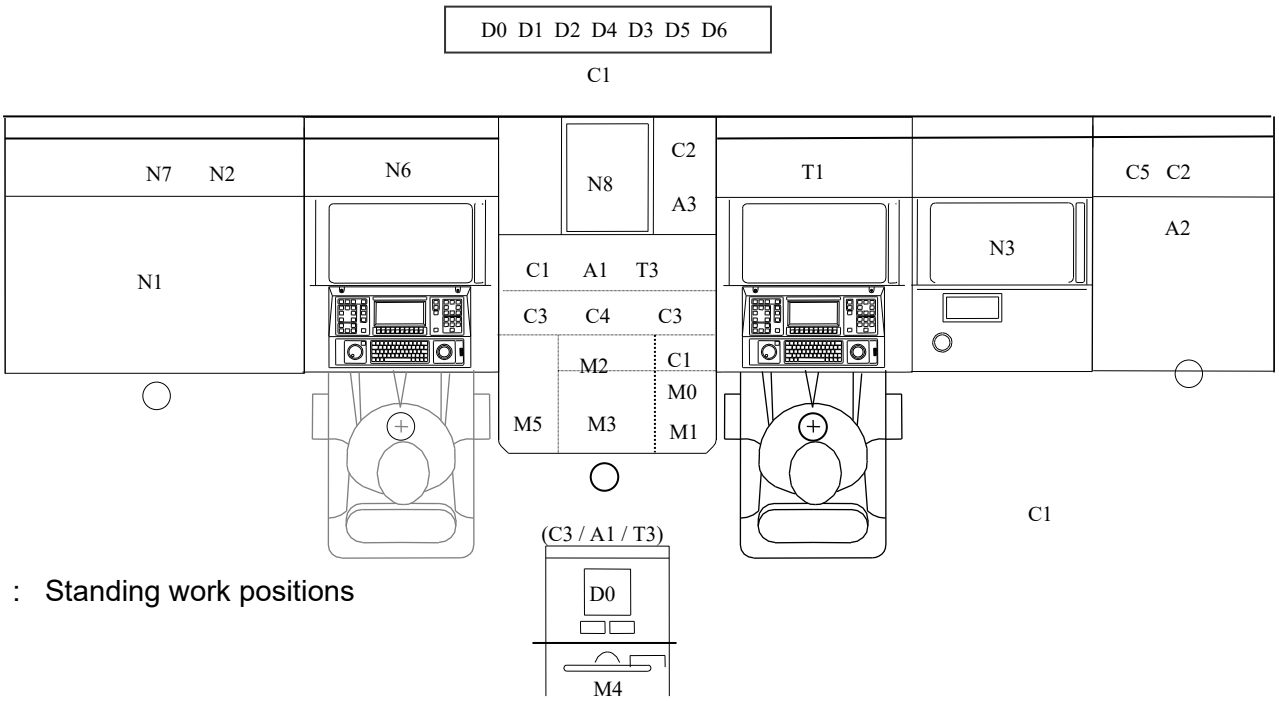
Indications on drawings

N1	Paper chart table	M0	Steering mode switch	C1	Whistle ctrl.
N2	GPS	M1	Override/steering tiller	C2	Sound reception syst.
N3	ECDIS	M2	Auto heading ctrl./track ctrl.*	C3	Intercom (auto tlph.)
N4	ECDIS back-up	M3	Propulsion ctr.	C4	VHF
N5	Pelorus/gyro repeater	M4	Main manual steering ctrl.	C5	GMDSS remote ctrl.
N6	Radar	M5	Thruster ctrl	C6	Internal command com. syst.
N7	Echo sounder				
N8	Conning display				

A1	Panel –warnings/alarms	D0	Heading display/gyro repater		
A2	Machinery systems	D1	Rudder angle indicator		
T1	Radar/ARPA	D2	Rate-of-Turn indicator		
T1+	Radar/ARPA w/ENC	D3	RPM/Pitch indicator		
T2	AIS	D4	Speed indicator		
T3	Window wipers	D5	Echo sounder display		

N : Means for Navigation
M: Means for Manoeuvring
C : Means for Communication
A : Alarm systems
T : Means for Traffic surveillance
D : Information - indicators/displays
HSV: SOLAS High Speed Vessels
OSV: Offshore Supply Vessels
ENC: Electronic Nautical Chart

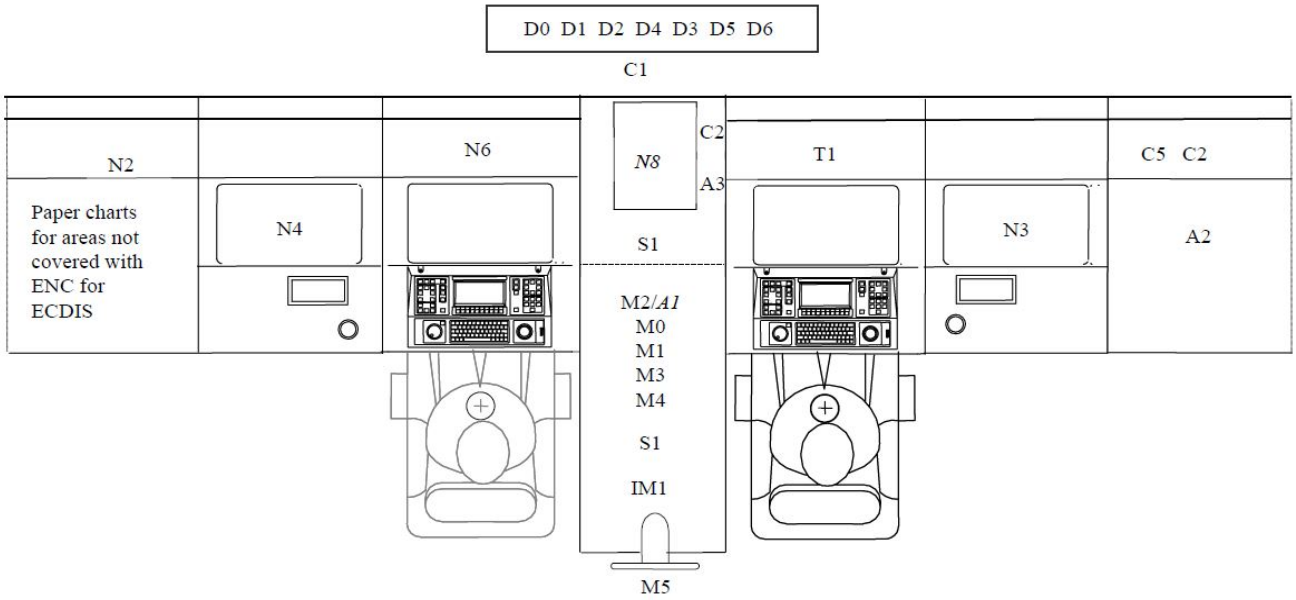
2 Individual workplaces arranged for internal access



◯ : Standing work positions

Example of location of main equipment in a centre console. Easy access to manoeuvring functions in standing position. Ref. clause C 3.3

3 Redundant workstations with ECDIS installations



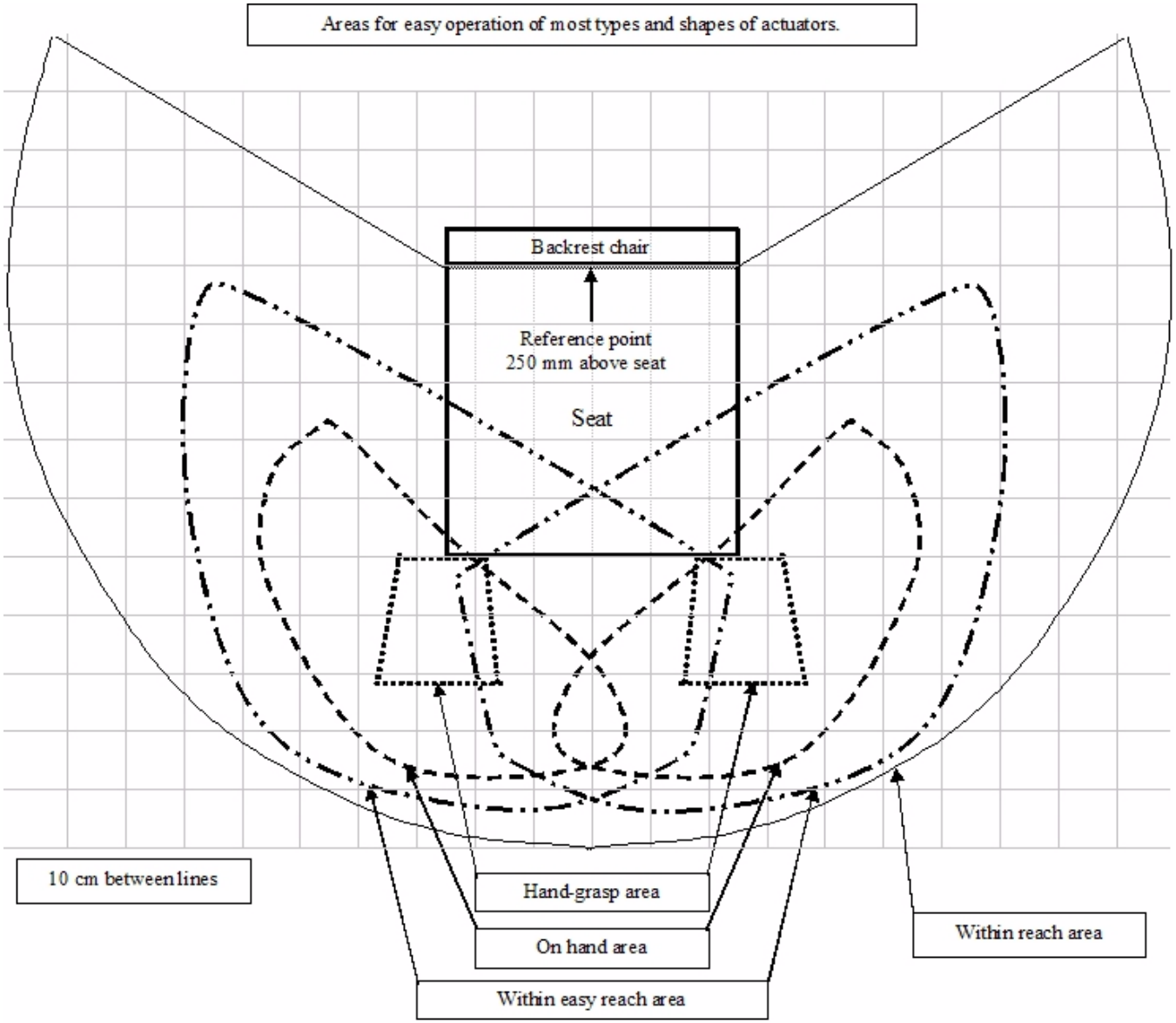
When all the means required for performance of navigation, traffic surveillance and manoeuvring are available at each of the two workplaces, a long centre console dividing the workstation may be used.

4 Self-explanatory diagram for location of equipment

Location in relation to reach for task performance in seated position.

The criteria should include the individual importance of equipment, harmonization of the information needed and means for the actions to be taken together with the frequency of use.

(HSV / OSV)



ANNEX B

SOLAS Regulation V/15

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SOLAS Regulation V/15

FACTS AND PRINCIPLES RELATED TO BCS RECOMMENDATION FOR APPLICATION OF SOLAS REGULATION V/15 FOR NEWBUILDINGS

This document intends to provide information about the basis for the development of the Recommendation and summarizes certain facts that should assist in achieving a common understanding of regulation 15 and the framework of the Recommendation. The information given may also make stakeholders more familiar with the approach and platform of the Recommendation based on the content of regulation 15 and clarify the reason why certain comments received cannot be regarded applicable in the context of this Recommendation.

1. HOW TO COMPLY IN RESPONSE TO THE PRINCIPLES AND AIMS OF SOLAS REGULATION V/15

Application of regulation 15 already in force will improve working conditions for the users responsible for the safe and efficient performance of navigation functions, thus reducing operational failures. A common implementation of the regulation has however proved difficult due to the lack of a suitable instrument for verifying compliance with the regulation.

BCS Recommendation has been developed to serve as a common reference for verification of compliance with regulation V/15 at the time of delivery of the newbuilding. The Recommendation is to be used for verification of compliance with regulation 15 and related regulations.

The use of the Recommendation implies that requirements of the SOLAS regulations V/19, 22, 24, 25, 27 and 28 will be met with due regard to applicable aims of regulation 15 for the benefit of the users. Furthermore, the use of the Recommendation should ascertain that shipbuilders and owners can expect a unified, consistent and predictable approval process.

The Recommendation relates to the IMO's regulatory regime of verifying compliance with regulations by documentation, survey and testing required to enable flag state Administrations to issue the certificates as required for legally allowing the ship to be put in service.

It is assumed that relevant IMO survey schemes are reviewed as required to ascertain that the regulation V/15 level of functionality and quality of the bridge system documented at the delivery of the ship will be maintained throughout the lifetime of the ship.

1.1 Regulation V/15 and the complexity of interpretation

Regulation V/15 requires consideration of 7 specific aims when decisions are made for applying the requirements of 6 individual regulations within 4 specific areas affecting the navigation bridge system and safety of navigation. Furthermore, the Recommendation should serve as a reference for verification of compliance with the complete regulation, as required at the delivery of newbuildings of all sizes, including types of ships that may be navigated at service speeds up to 30 knots.

The complexity indicates that for the purpose of serving as platform for the requirements of the Recommendation, the interpretation part needs to focus on the content of SOLAS regulation V/15 and the regulatory framework of the Recommendation, as well as what compliance with the aims may entail.

A common understanding of SOLAS regulation V/15 and its effect on regulations to be complied with prior to the ship being put in service is regarded essential for a common acceptance of the Recommendation and a successful implementation of the regulation. Some of the comments on the draft Recommendation revealed that there exists deviating understanding of the content of regulation 15 and what compliance with the regulation should entail.

Any dispute on the interpretation of SOLAS regulation V/15 or requirements of the Recommendation should point to deviating understanding of the relevant part(s) of the content of this Annex, clarifying the consequences for appropriate compliance with the regulations of concern prior to delivery of the ship and the effect on safety of navigation.

1.2 IMO considerations

At MSC 78, the working group on the Human Element considered the IACS Unified Interpretation (UI) SC 181 (now withdrawn) as contained in annex to document MSC 78/11.3. (The substance of the content of the UI discussed at MSC 78 is similar to the content of the IACS Recommendation for application of SOLAS regulation V/15).

Quote: “The group expressed appreciation to IACS for its efforts in addressing this difficult issue and agreed that the UI developed by IACS sets forth a set of requirements for the compliance with the principles and aims of SOLAS regulations V/15 relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures when applying the requirements of SOLAS regulations V/19, 22, 24, 25, 27 and 28, and that it would be a useful instrument to be applied for the purpose of survey and certification until the time of delivery of the ship.”

In response to the task of developing an appropriate instrument to be used to demonstrate compliance with SOLAS regulation V/15, the group stated that it felt there was no need to develop a new instrument.

2. THE CONCERN OF THE RECOMMENDATION AND THE APPROACH

The concern of the Recommendation is to ensure that all decisions which are made for the purpose of applying the requirements of SOLAS regulations V/19, 22, 24, 25, 27 and 28 and which affect bridge design, (design* and) arrangement of navigational systems and equipment on the bridge and bridge procedures** are taken in accordance with the applicable aims of SOLAS regulation V/15. Furthermore, that the regulations are complied with prior to the ship is put in service.

* Design of navigational systems and equipment, which is also addressed by SOLAS regulation V/15, is governed by IMO performance standards. Verification of compliance with aims related to design of systems and equipment (the last part of aim SOLAS regulation V/15.3 and the aim of SOLAS regulation V/15.4) is assumed to take place as part of the test program to be conducted for type approval by flag state Administrations.

** In general, it is regarded the responsibility of the owners and the bridge management to establish and implement bridge procedures as required by SOLAS regulation V and the STCW Code to the satisfaction of the ISM Code. Certain procedures need to be completed and available on the bridge prior to the ship is put in service.

In order to cater appropriately for the concern stated above and at the same time provide sufficient transparency to enable review by third parties, the Recommendation has been developed based on an analytical approach. (See Overview diagram, last page of this Annex)

The approach includes the tasks of:

- Identifying decisions that need to be made for the purpose of applying the requirements of each of the regulations addressed by SOLAS regulation V/15 (Annex B, 2.1);

- Defining and clarifying the expressions and text of each aim in order to establish a common understanding of the content and purpose of the individual aims, enabling a unified approach in meeting the aims as specified in the regulation (Appendix 1 of Annex B);

- Identifying the scope and purpose of the guidelines and standards referred to by regulation 15 for application of SOLAS regulations V/19, 22, 24, 25, 27 and 28;

- Identifying the purpose and main requirements of the various regulations to be applied, the areas affected by the individual regulation, the aims of regulation 15 relevant for each of the individual regulations and the corresponding guidelines of MSC/Circ.982.

2.1 Decisions to be made and aims to be met by individual regulations

The first step of the development, commencing with identifying the main decisions that need to be made for the purpose of applying the requirements of the individual regulations and indicating specific aims to be applied, is summarized below:

❖ Main decisions in the context of ***SOLAS regulation V/19*** are related to provision of a minimum range of navigational systems and equipment specified for various ship sizes and the installation on the bridge as required at defined workplaces for the use of the officer of the watch, the bridge team and the pilot. The decisions include determination of:

- system configurations and equipment to be selected for installation
- the range of workstations required for performance of all bridge functions
- location of systems and equipment at dedicated workstations in relation to the function(s) to be performed
- location of workstations in relation to
    - SOLAS regulation V/22 requirements, safeguarding provision of the field of vision required for visual observations
    - inter-relationship required for efficient bridge team operations

The decisions to be made in this context affect bridge design and arrangement of navigational systems and equipment, and should be taken with the aims as specified in .1, .2, .3*, .5, .6 and .7 of regulation V/15.

* First part

❖ Main decisions in the context of ***SOLAS regulation V/22*** are related to provision of the view through windows and fields of vision as required from defined workplaces on the bridge for the use of the officer in charge of the navigational watch, the bridge team and the pilot. The decisions include determination of:

- location, height and configuration of the bridge (wheelhouse), placing of permanent structures outside the wheelhouse, safeguarding optimum view as required from different workstations and avoiding excessive blind sectors
- location of windows and workstations in relation to provision of fields of vision and avoidance of blind sectors caused by permanent structures outside the wheelhouse
- the type and height of cargo to be carried on deck without obstructing the view from bridge workstations

The decisions to be made in this context affect bridge design and arrangement of navigational systems and equipment, and should be taken with the aims as specified in .1, .2, .3* and .5 of SOLAS regulation V/15.

Harmonization of decisions to be made for the purpose of applying SOLAS regulations V/19 and 22 is needed in order to safeguard that common aims are fully met by both regulations for the benefit of the user and safety of navigation.

* The aim apparently addresses information to be presented by equipment. However, convenient and continuous access to information provided by the view through windows within the required fields of vision is regarded equally important.

- Main decisions in the context of ***SOLAS regulation V/24*** is related to the use of heading and track control systems and include consideration of:

    - means for establishing immediate manual control of the ship's steering system when the track control system is in use
    - routines for safeguarding that a qualified helmsperson is instantly available at all times
    - routines for change-over from automatic to manual steering and vice versa
    - routines for testing of the manual steering before entering areas where it might be used

  The decisions to be made in this context affect bridge design and arrangement of navigational systems and equipment and procedures, and should be taken with the aims as specified in .1 and .2 of regulation V/15.

- Main decision in the context of ***SOLAS regulation V/25*** is related to operation of the steering and includes determination of:

    - routines for safeguarding that more than one steering gear is in operation in areas where navigation demands special caution

  The decisions to be made in this context affect arrangement of navigational systems and equipment and procedures, and should be taken with the aim as specified in .1 of SOLAS regulation V/15.

- Main decisions in the context of ***SOLAS regulation V/27*** are related to provision and implementation of updates to nautical charts and publications, and include determination of:

    - provision of system for appropriate updating
    - routines safeguarding that nautical charts and publications to be used for the intended voyage are adequate and up-to-date

  The decisions to be made in this context affect arrangement of navigational systems and equipment and procedures, and should be taken with the aim as specified in .1 of SOLAS regulation V/15.

- Main decision in the context of ***SOLAS regulation V/28*** is related to the availability of the record of navigational activities and incidents of sufficient detail to restore a complete record of the voyage. The decision includes determination of:

    - means to be provided for the recording
    - location of the means
    - routines for recording and storage

  The decisions to be made in this context affect arrangement of navigational systems and equipment and procedures, and should be taken with the aim as specified in .1 of SOLAS regulation V/15.

The regulations addressed by SOLAS regulation V/15 need to be complied with prior to the ship being put in service and, consequently, also the applicable aims to be taken into account when applying the requirements of the regulations addressed.

In Appendix 1 attached to this Annex, the content of each aim is defined and clarified to reveal the full extent of the aims. This is for the purpose of giving further understanding of what compliance with the parts relevant for the particular regulation would entail within the framework of the UI.

3. FACTS AND PRINCIPLES GOVERNING DECISIONS AND SOLUTIONS

3.1 Bridge watch resources and design principles

The requirements set forth by the Recommendation addressing bridge design and location of equipment are based on SOLAS regulations V/19, Carriage requirements for shipborne navigational systems and equipment, and V/22, Navigation bridge visibility, taking into account applicable aims of SOLAS regulation V/15, the guidelines of MSC/Circ. 982 and relevant bridge watch resources. IMO manning principles and operational practice are the basis for design criteria and bridge team compositions.

3.1.1 Number of certified navigators on board – Bridge watch duty intervals
The ordinary legal complement of certified navigators in addition to the master on board cargo ships, ranges from two officers on smaller ships to three or four on seagoing ships. Examples of watch duty intervals are 6 or 4 hours twice in periods of 24 hours.

3.1.2 Manning of the bridge – Design criteria
Examples of bridge watch manning ranges from the officer in charge of the navigational watch during daytime supported by a rating assisting as “look-out” during darkness, to a complement also including assisting officer, the master, pilot and helmsman.

It is noted that the officer in charge of the navigational watch may be the only certified navigator attending the bridge watch during a sea voyage from pilot station to pilot station under normal operating conditions, assisted by the master governed by the level of professional experience of the officer in charge and routines for interval checks. (See the Recommendation, A 5.14.1 and Note to D 1.2).

Permanent bridge watch manning by two fully qualified officers is used on certain high speed vessels (SOLAS/30 knots) when navigating short regular routes and as required on ships in certain trades.

3.1.3 Manning of the bridge for safe navigation – Responsibility of the bridge management
Manning of the bridge for safe navigation under different operational conditions is the responsibility of the master and the officer in charge of the navigational watch.

It is a prerequisite that watchkeeping regulations and specifications of the STCW Convention and Code are complied with at all times, during daytime and darkness under all operational conditions, meaning that compliance with the requirements of the Recommendation does not justify relaxation of manning requirements or any other requirement within the IMO regulatory regime.

3.1.4 Bridge design criteria – Overall requirements
The overall design requirement is to enable efficient and safe performance by the officer in charge of the navigational watch as well as by two navigators in close co-operation, the pilot and any other identified member of the bridge team who may be allocated specific functions and tasks. Furthermore, that the bridge layout, including location of workstations and outfitting, enables effective and safe bridge team management.

The composition of the bridge team, including permanent bridge watch manning by the officer of the watch (OOW) assisted by a rating or by a fully qualified officer, does not affect the responsibility of the OOW or the required field of vision and outfitting of the workstation, being based on safe performance of the tasks he is responsible for and prevention of human error.

3.2 User-oriented regulations

The content of the regulations to be applied is user-oriented, focusing on the need for bridge visibility and equipment to provide information and control necessary for the safe performance of navigation functions. Focus is also drawn on the need for establishing procedures to ensure instant availability of assistance to the bridge, technical efficiency of the steering gear, the use of adequate and up-to-date charts and recording of navigational activities.

This means that accepted solutions for application of the regulations need to be based on bridge functions and the tasks to be carried out based on the range of equipment and the fields of vision provided by the regulations, taking the relevant aims of SOLAS regulation V/15 into consideration, consulting MSC/Circ.982, developed for this purpose and referred to by SOLAS regulation V/15.

For further improving working conditions on the bridge, it has been regarded essential to include and organize requirements set forth in other IMO instruments related to performance of bridge functions. This includes the area of bridge alarm management. The chapter is valid until superseded by an IMO performance standard.

3.3 Bridge functions

Navigation functions, meaning the groups of tasks, duties and responsibilities necessary for safe bridge operation are basically the same for all ships. They are related to planning of the route prior to departure, keeping the ship on the course along the planned route from departure to destination, deviating from the route and adjusting speed for avoidance of collision and heavy weather damage while under way, and harbour manoeuvring.

Additional functions may include extended monitoring of machinery and domestic systems, tasks related to the carriage of different types of cargo and radio operations, or other relevant functions, all of which are regarded secondary to navigation functions if not carried out by a person additional to the officer of the watch.

3.3.1 Task performance

Performance of the tasks within the navigation functions may vary in accordance with operational conditions governed by the level of automation (integration) and the type of waters to be navigated, ranging from ocean areas to narrow waters with dense traffic and pilot waters. Change of speed and alteration of course and heading in relation to the route, waters, traffic and weather conditions are the essential decisions and actions related to navigation functions.

3.4 The workstation concept

A workstation should provide all basic information required and controls needed for safe performance of the function dedicated the workstation. The different workstations should be arranged and located for efficient co-operation by any number of a bridge team.

3.4.1 The workstation concept to be used on all SOLAS regulation V/15 bridges

The principles of the workstation concept are similar for all ships irrespective of ship types and sizes, operational conditions and methods of navigation. Should the special purpose of a ship cause a need to deviate from regular performance of navigation functions and bridge team management, the operational procedures need to be reviewed in relation to the bridge layout drawings. Ice-breaking, bow-mooring and dynamic positioning system may be some examples of special primary functions.

3.5 Responsibility of providing workplaces for safe and efficient operations

Appropriate functionality of bridge workplaces is governed by “User-oriented regulations” established by the flag states through IMO, addressing bridge design, arrangement of equipment,

information needs and minimum range of equipment to be installed. The functionality and quality of navigational systems and equipment are governed by the content of IMO performance standards and the quality of IEC test standards used for verification of compliance. “Bridge functions”, “Task performance” and “The workstation concept” are main elements to be considered both by the regulators when establishing regulations as well as by the owners assisted by their professional users when specifying applicable solutions in co-operation with the builder.

These elements also need to be considered by surveyors on the basis of documentation at the stage of plan approval, while the functioning of systems after installation needs to be verified by tests and trials before the ship is put in service.

3.6 Competence, procedures and BRM - Responsibility of the management

The responsibility for selection and training of bridge personnel and maintenance of the technical standard of bridge systems lie with the owners and the master. It is regarded the responsibility of the master to provide appropriate watchkeeping procedures and check lists, taking into account national and international guidance. Allocation and use of bridge watch resources based on bridge resource management (BRM) principles in accordance with STCW Code (Section A VIII/2 Part 3) is the responsibility of the master and the officer in charge of the navigational watch.

3.7 Use of type approved equipment - Responsibility of the user

It is the responsibility of the master and officers to navigate the ship safely under all operating conditions, utilizing all available means suitable for this purpose. However, when making decisions related to safety of navigation, it is unlawful to use information from equipment not type approved. If installed, it is considered the responsibility of the bridge team not to use such equipment for the purpose of navigation.

Type approved equipment may facilitate functions additional to the minimum required by the performance standards. This is accepted provided the display of information is not degraded and basic functions and equipment reliability are not affected. Compliance with these principles is to be considered during type approval.

A ship leaving port without being sufficiently equipped with type approved equipment (due to equipment failure) may be deemed not seaworthy by the port state control.

3.7.1 Selection of system configurations and equipment for installation

Consistency in the presentation of data and operation of individual equipment to be used for navigation (human/machine interface) is deemed essential to avoid misconception or misinterpretation of information and operational failures. Selection of equipment to be part of the configuration of systems integrated for the purpose of automation of navigation functions and the need for consistent and simple failure modes at system malfunction are deemed equally important.

However, the equipment and systems to be selected need to conform to IMO performance standards and appropriate test standards for equipment and integrated systems and be type approved. Choice of type approved equipment is considered the responsibility of the owner in consultancy with their professional users.

3.7.2 The authority of BCS on behalf of flag state Administrations

It is not regarded to be within the authority of this Recommendation to add equipment requirements to the content of current IMO standards. This would interfere with the IMO type approval regime and could deny acceptance of equipment and systems already type approved for their purpose and performance.

The authority of BCS Recommendation in the context of selection of equipment is to ensure that the equipment and systems are appropriately type approved.

Type approved electronic chart display and information system (ECDIS) with back-up arrangement is a legal option to paper charts, provided appropriate charts (ENC) are available for the area of navigation. The functions of ECDIS, including the function of automatic real time positioning of the ship in the chart, are regarded to improve safety in bridge operations and meet the relevant aims of regulation V/15 to a greater extent than what can be achieved by the use of paper charts.

However, if not made mandatory by the flag state Administration, the choice of chart system is left to the owners and users who need to consider the usability of ECDIS in relation to the ship's type and trade and availability of ENC.

3.8 Responsibility of verification - Unified and predictable approval procedures

The responsibility for verifying compliance with applicable part of SOLAS Chapter V rests with the responsible organization (RO) when acting on behalf of the Administration, recognizing that owners, shipbuilders, equipment manufacturers and Administrations are in their right to expect similar consideration of technical solutions and documentation submitted.

3.9 Compliance at the time of delivery of the ship - Responsibility of the shipbuilder

It is regarded the responsibility of the shipbuilder to deliver the ship with valid certificates ascertaining that the ship is "seaworthy". This includes verification of compliance with SOLAS regulations V/ 19 and 22, based on a specification agreed to by the owners and the shipyard taking into account the aims of regulation 15 and location of equipment for the purpose of simplifying procedures related to SOLAS regulations V/24, 25, 27 and 28.

4. CONCLUSIVE NOTE

In the context of safety of navigation and bridge operations, compliance with the aims of SOLAS regulation V/15 in accordance with the Recommendation prior to the ship being put in service, verifies that the bridge design and arrangement of navigational systems and equipment facilitate the tasks to be performed, allowing for expeditious, continuous and effective information processing and decision-making, minimizing unnecessary work, conditions or distractions that may cause fatigue or interfere with the vigilance of the bridge team and the pilot, thereby reducing the risk of human error.

By conforming to the workstation concept and bridge layout principles as required by the UI, the bridge design, layout and outfitting meet the aim of promoting effective and safe bridge resource management (BRM). The workstation and layout principles include provision of information and equipment in accordance with user requirements for performance of specific functions at dedicated workstations located for efficient and safe operations by the officer in charge of the navigational watch, the pilot and any composition of the bridge team under all operational conditions.

The use and allocation of bridge-watch resources, taking into consideration bridge resource management principles and operational concerns in accordance with the Guidance given by the STCW Code is the responsibility of the master and the officer in charge of the navigational watch.

More specifically, with reference to the STCW Code's guidance on BRM, compliance with the relevant requirements of the Recommendation verifies that applicable decisions relating to regulation 15 have been taken with the aim of promoting effective and safe bridge resource management by:

- enabling individuals to be assigned at all times to locations at which they can most efficiently and effectively perform their duties;

- making instruments and equipment considered necessary for effective performance of duties readily available to appropriate members of the navigational watch;

- enabling effective co-operation and easy communication between members of the watch at their individual locations;

- safeguarding that non-essential activity and distractions are avoided within the navigational area of the bridge;

- enabling easy collection, processing and interpretation of essential information at individual locations which may conveniently be made available as required by other members of the watch for the performance of their duties.

In addition to utilizing the functionality and facilities provided by bridge design and arrangement of navigational systems and equipment in accordance with principles for effective and safe bridge resource management, it is the obligation of the master and the officer in charge of the navigational watch:

- to ascertain that the bridge team comprises a sufficient number of qualified individuals to ensure all duties can be performed effectively;

- to take into account any limitation in qualifications or fitness of the individuals available when making navigational and operational decisions;

- to assign duties clearly and unambiguously to specific individuals, who should confirm that they understand their responsibilities;

- not to assign more duties or more difficult tasks than can be performed effectively;

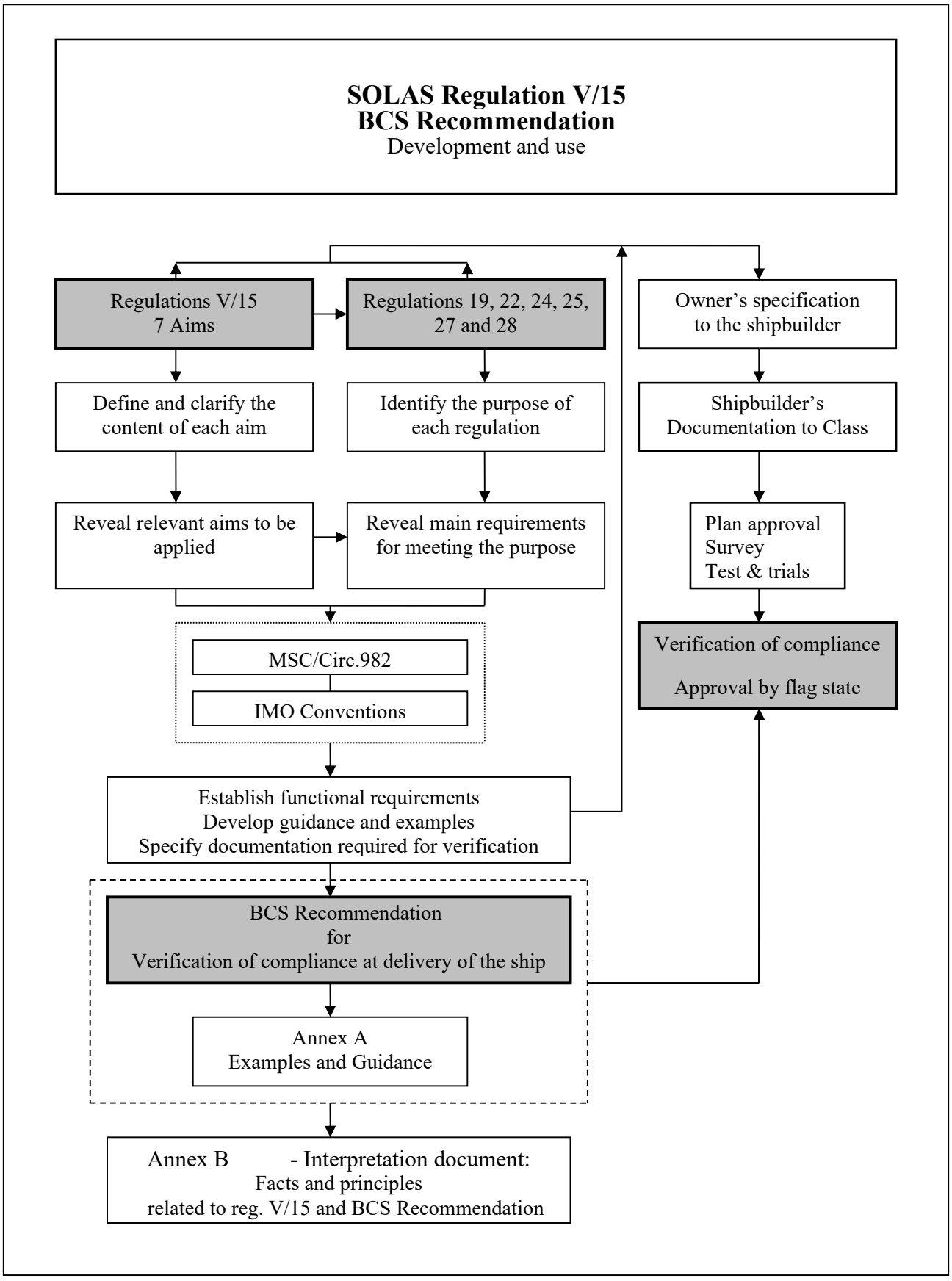
- to prevent fatigue in accordance with the guidance given in STCW Code, Section B-VIII/1.

4.1 Bridge team qualifications, training and operational procedures

The importance of a well trained, competent and motivated team for efficient and safe performance of bridge functions, supported by procedures tailored for maintaining the level of safety under different operational conditions, is not in doubt. This area, however, is related to the provisions and requirements of the STCW Convention, the STCW Code, various ILO Conventions as ratified by the flag state Administration, and the requirements of the International Safety Management Code (ISM).

Familiarization with duties, arrangements, equipment and systems, procedures and ship characteristics as required by the STCW Code as well as appropriate training and prevention of fatigue are regarded essential for efficient and safe bridge operation. Procedures for effective and safe bridge resource management (BRM), as well as for specific purposes specified in regulations 24, 25, 27 and 28 need to be established by the owner or operator and the master prior to the ship being put in service.

The Recommendation states basic points to be considered in this respect, relating to BRM, reduction of the risk of single person errors, concerns to be taken into account when introducing new technology (ECDIS) and provision of a familiarization scheme in compliance with the STCW Code. The procedures should become part of the ship’s safety management plan which should be available on the bridge for ISM certification.


SOLAS Regulation V/15
BCS Recommendation
Development and use
Regulations V/15
7 Aims
Regulations 19, 22, 24, 25, 27 and 28
Owner's specification to the shipbuilder
Define and clarify the content of each aim
Identify the purpose of each regulation
Shipbuilder's Documentation to Class
Reveal relevant aims to be applied
Reveal main requirements for meeting the purpose
Plan approval
Survey
Test & trials
MSC/Circ.982
IMO Conventions
Verification of compliance
Approval by flag state
Establish functional requirements
Develop guidance and examples
Specify documentation required for verification
BCS Recommendation
for
Verification of compliance at delivery of the ship
Annex A
Examples and Guidance
Annex B - Interpretation document:
Facts and principles
related to reg. V/15 and BCS Recommendation

Appendix 1

SOLAS Regulation V/15

Clarification of the content of each aim

The Aims of SOLAS Regulation V/15……. 14
Aim 15.1 ……..…….. 14
Aim 15.2…….. 16
Aim 15.3 ……..…….. 16
Aim 15.4…….. 16
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The aims of SOLAS regulation V/15

In the following, the aims of regulation 15 are defined and clarified to establish a common understanding of the content of the individual aims, enabling a common approach in meeting the aims as specified in the regulation.

A view of the full extent of the aims is regarded essential for safeguarding that the aims are correctly applied within the areas of bridge design, the design and arrangement of navigational systems and equipment on the bridge and bridge procedures when applying the regulations addressed in regulation 15.

AIM 15.1

*Facilitating the **tasks**[1] to be **performed by the bridge team and the pilot**[2] in making full appraisal of the situation and in navigating the ship safely under all **operational conditions**[3]*

1 Overall functions to be performed

- Route planning
- Navigation
- Traffic surveillance
- Manoeuvring
- Docking
- Manual steering
- Conning
- Internal and external communication related to the tasks to be performed
- Pilotage

2 Basic functions and tasks performed by the bridge team
(based on equipment carriage requirements and regular manning)

Officer in charge of the navigational watch:

- Navigation - Position-fixing by
  - optical system
  - radar system
  - reading ship's position from display
  - plotting ship's position
  - visual observations
  - monitoring - automatic pos.-fix. in electronic chart
- Route keeping
  - Adjusting ship's heading to follow route
  - Monitor automatic route-keeping
- Traffic surveillance
  - Monitoring radar/ARPA
  - Conning
- Collision avoidance
  - Adjusting ship's heading and speed in relation to traffic
- Manoeuvring
- External and internal communication related to safety in bridge operations

Rating assisting the watch officer:

- Visual look-out

Navigator assisting the watch officer (or watch officer assisting the master):
- Navigation - Route monitoring
- Position-fixing
- Plotting ship's position
- Adjusting course
- Monitoring the waters

Rating relieving the automatic heading control:
- Manual steering

Pilot assisting in safe navigation:
- Conning and determination of heading and speed in relation to waters and traffic
- Position-fixing and traffic surveillance by available means
- Communication

3 Operational conditions and situations

Normal condition:

When all shipboard systems and equipment related to primary bridge functions operate within design limits and weather conditions or traffic do not cause excessive operator workloads.

Irregular condition:

When external conditions cause excessive operator workloads requiring qualified assistance on the bridge.

Abnormal condition:

When internal technical system failures require operation of basic back-up systems or when they occur during an irregular operating condition, or when the officer of the watch becomes unfit to perform his duties and has not yet been replaced by another qualified officer.

Emergency situation:

When failure of internal ship systems not affecting the ability of navigation or manoeuvring, or fire incidents occur which need to be controlled and managed from the bridge.

Distress situations:

When the ship has lost its navigating or manoeuvring ability.

3.1 Example of bridge team composition under different operational conditions

Reference which may be used for the purpose of design only:

Normal:	watch officer - Darkness: + rating
Irregular:	watch officer + assisting navigator (+ rating)
Abnormal:	master + watch officer + look-out (+ helmsman)
Emergency:	master + watch officer + assisting navigator + look-out (+ helmsman)

(+ chief engineer/chief officer)

A pilot may be included in any of the above manning examples.

AIM 15.2

Promoting effective and safe bridge resource management[1]

1 Factors promoting safe resource management include:

- Organized distribution of tasks and responsibilities
- Functional workplace arrangement suiting different operational conditions, task distribution and task performance
- Instant availability of instruments and equipment necessary for efficient performance
- Qualifications and fitness of individuals
- Procedures for safe operations

AIM 15.3

Enabling the bridge team and the pilot to have convenient and continuous access to ***essential information[1]*** *which is presented in a clear and unambiguous manner,* ***using standardized symbols and coding systems for controls and displays[2]***

1 Essential information (and controls) required by the bridge team

The information and controls required, as well as what is to be regarded essential, are linked to the type and importance of tasks to be carried out by the individual members of the bridge team and the pilot.

The table showing Task and Means, which is included in chapter B 1 of the Recommendation identifies the essential information required. Easy access to information may be provided by outfitting and placing the workstations for efficient task performance by members of the bridge team in accordance with the content of chapter C 3.

2 Presentation of information and standardization

Requirements addressing presentation of information and coding of systems for controls and displays for equipment required to be carried are regulated by IMO performance standards and IEC test standards.

AIM 15.4

Indicating the ***operational status[4]*** *of* ***automated functions[1]*** *and* ***integrated components[2]****,* ***systems and/or sub-systems[3]***

1 Relevant automated functions include:

- Steering a set course
- Plotting ship’s position in an electronic chart system
- Steering along a planned route governed by ship’s position

- Adjusting the speed according to ship's position and pre-set values
- Manoeuvring operations (Semi automatic/Joystick)

2 Relevant integrated type approved components may include:

- Heading control unit
- Satellite position-fixing unit (GNSS/GPS)
- Electronic chart display unit (ECDIS)
- Radar display unit
- Track control unit
- Speed control unit

3 Relevant systems include:

- Track control system
- Integrated navigation systems (INS), including
- Grounding avoidance system for automatic route-keeping

4 Indicating the operational status (of automated functions and integrated components, systems and/or sub-systems)

Indication of operational status is provided by:

- supplying continuous information of relevant system activities related to the ship's course, speed, propulsion, steering and operating mode on one individual display

- enabling continuous visual observation of key values

- enabling checking of the functioning of system elements and operational performance

- enabling early detection of deviations from planned operations and system specifications

Categories of indications that may be included:

Normal operation:
- Available components in the total system configuration
- Configuration in use
- Activity status of individual components in use
- Second mode of operation at system failure, preferably based on system failure mode, effect and criticality analysis (FMEAC)

Early warning:
- Reduced accuracy
- Reduced reliability of integrated system performance
- Reduced reliability of propulsion and steering system

Alarm conditions:
- Equipment malfunction
- System failure

- Display freeze

Operational warnings:
- Danger of collision
- Danger of grounding
- Weather conditions

AIM 15.5

Allowing for expeditious, continuous and ***effective information processing and decision-making[1]*** *by the* ***bridge team and the pilot[2]***

1 Conditions allowing effective information processing and decision-making:

- When all information required for evaluation and decision-making is clearly presented and available at the location where action is to be taken on the decision made, including appropriate feedback on actions taken and updated information for continuous consideration.

- When information and equipment for performance of functions to be carried out by different members of the bridge team are available at specific workstations located for close co-operation.

2 See AIM 15.1, item 2

AIM 15.6

Preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or ***interfere with the vigilance of the bridge team and the pilot[1]***

1 Conditions that may interfere with the vigilance of the bridge team include:

- Poor working environment caused by unsuitable colours, lighting, ventilation and temperature, including excessive noise and vibrations from machinery

- Poor bridge layout, allocating workstations and areas for non-navigational functions too close to the navigation area

- Insufficient provision of information for decision-making at the workstation, forcing the need to leave essential information or equipment at the workstation when in need of additional information or controls located elsewhere

- Lack of harmonization of workplace functionality

- Presence of unauthorized persons on the navigation bridge

- Heavy workloads

AIM 15.7

Minimizing the risk of human error and detecting such error if it occurs[1]**, through **monitoring and alarm systems[2]**, **in time** for the bridge team and the pilot **to take appropriate action[3]

1 Factors minimizing human error include:

Workplace related:
- Functionality
- Information availability
- System reliability
- Human/machine interface
- Architecture of automation systems based on fail-to-safe philosophy with simple and reliable second mode of operations

Human related:
- Competence
- Attitude

Operational:
- Manning
- Working routines
- Allocation of task(s) in relation to competence
- Detection of inappropriate performance

2 Monitoring and alarm systems

Systems and methods enabling detection of human error and timely warning for appropriate action include:

- Monitoring and alarm transfer systems, monitoring personal activity and lack of response on operational warnings and alarm conditions related to safety of navigation and transfer of unacknowledged warnings and alarms to a qualified person

3 In time for appropriate action

Conditions affecting the time for appropriate action:

Operational warnings
- time to danger of collision and grounding (distance/speed)
- time to be allowed for required action

BCS-G 96 **Double Hull Oil Tankers -** Guidelines for Surveys, Assessment and Repair of Hull Structures

Contents

1 Introduction

2 Classification survey requirements
- 2.1 General
- 2.2 Annual Surveys
- 2.3 Intermediate Surveys
- 2.4 Special Surveys
- 2.5 Drydocking (Bottom) Surveys
- 2.6 Damage and Repair Surveys

3 Technical background for surveys
- 3.1 General
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- 3.3 Structural Load Descriptions
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4 Survey planning, preparation and execution
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- 4.5 Access arrangement and safety
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- 4.7 Personal equipment
- 4.8 Thickness measurement and fracture detection
- 4.9 Survey at sea or at anchorage
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- 4.11 Reporting and Evaluation of Survey

5 Structural detail failures and repairs
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- 5.2 Actions to be taken by the Classification Society when Fatigue Failures have been Identified
- 5.3 Catalogue of structural detail failures and repairs
  - 1 Bilge Hopper
  - 2 Wing Ballast Tank
  - 3 Bottom Ballast Tank
  - 4 Web Frames in Cargo Tanks
  - 5 Transverse Bulkhead in Cargo Tank
  - 6 Deck Structure
  - 7 Fore and Aft End Regions
  - 8 Machinery and Accommodation Spaces

1 Introduction

This manual gives guidelines for a double hull oil tanker which is constructed primarily for the carriage of oil in bulk and which has the cargo tanks protected by a double hull which extends for the entire length of the cargo area, consisting of double sides and double bottom spaces for the carriage of water ballast or void spaces. **Figures 1 & 2** show the general views of typical double hull oil tankers with two longitudinal bulkheads or one centreline longitudinal bulkhead respectively.

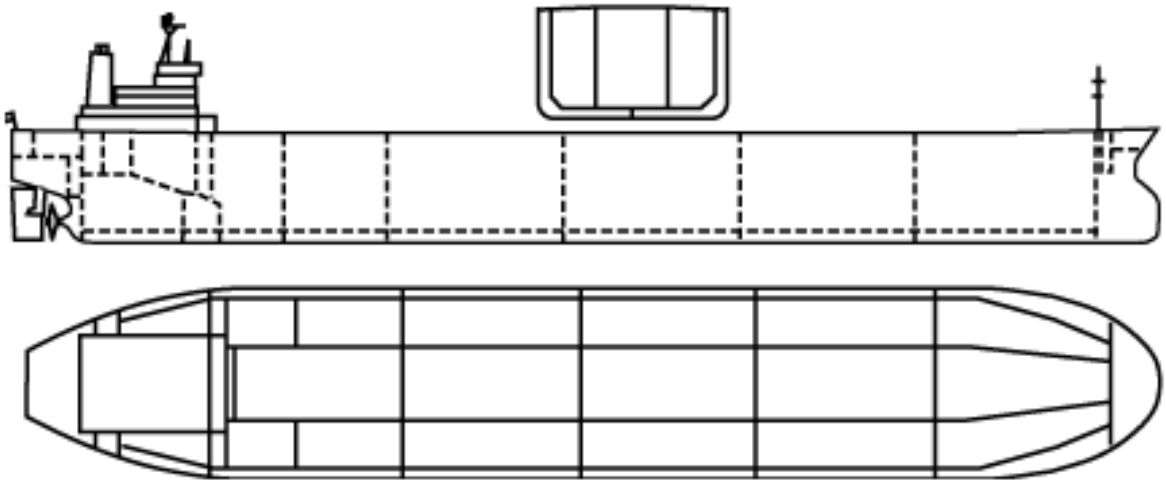


Figure 1 General view of a typical double hull oil tanker (150,000 DWT and greater)

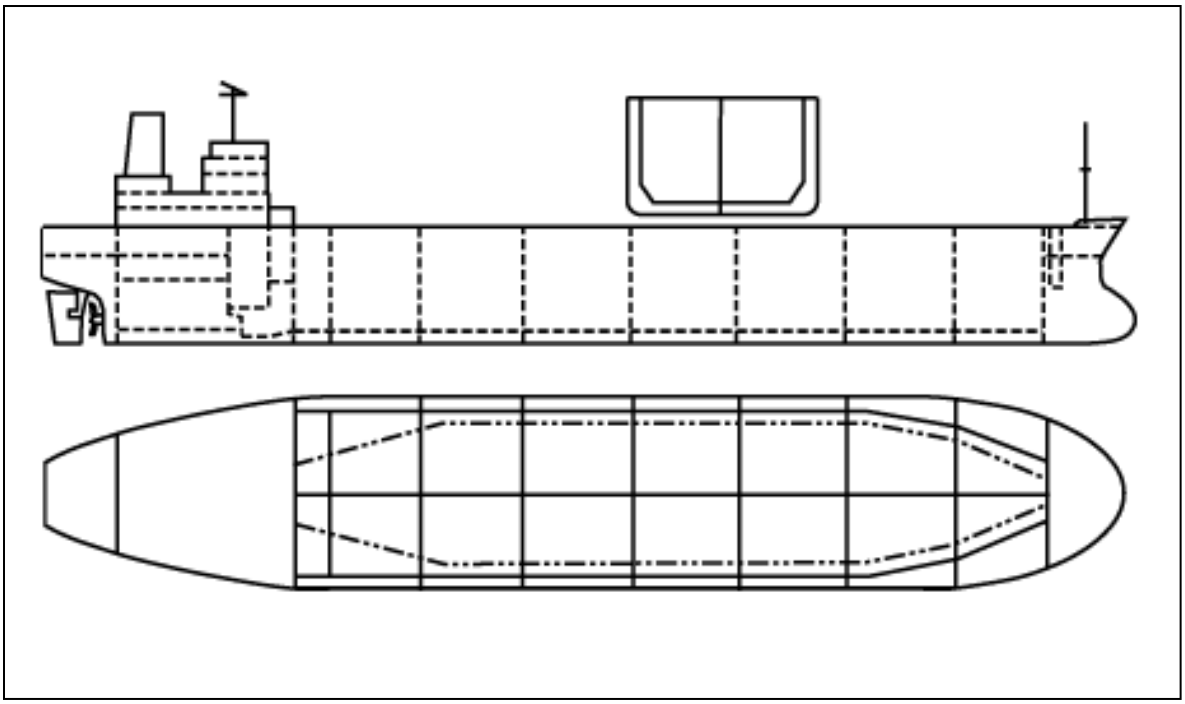


Figure 2 General view of a typical double hull oil tanker (150,000 DWT or less)

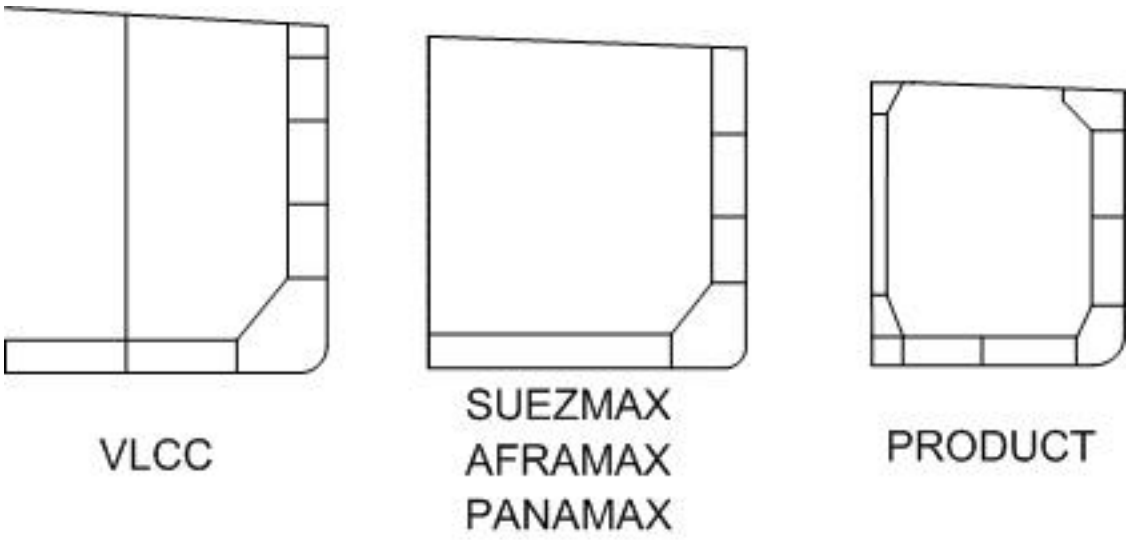


Figure 3 Categories of Bulkhead Configurations

Figures 4 to 6 show the typical nomenclature used for the midship section and transverse bulkhead.

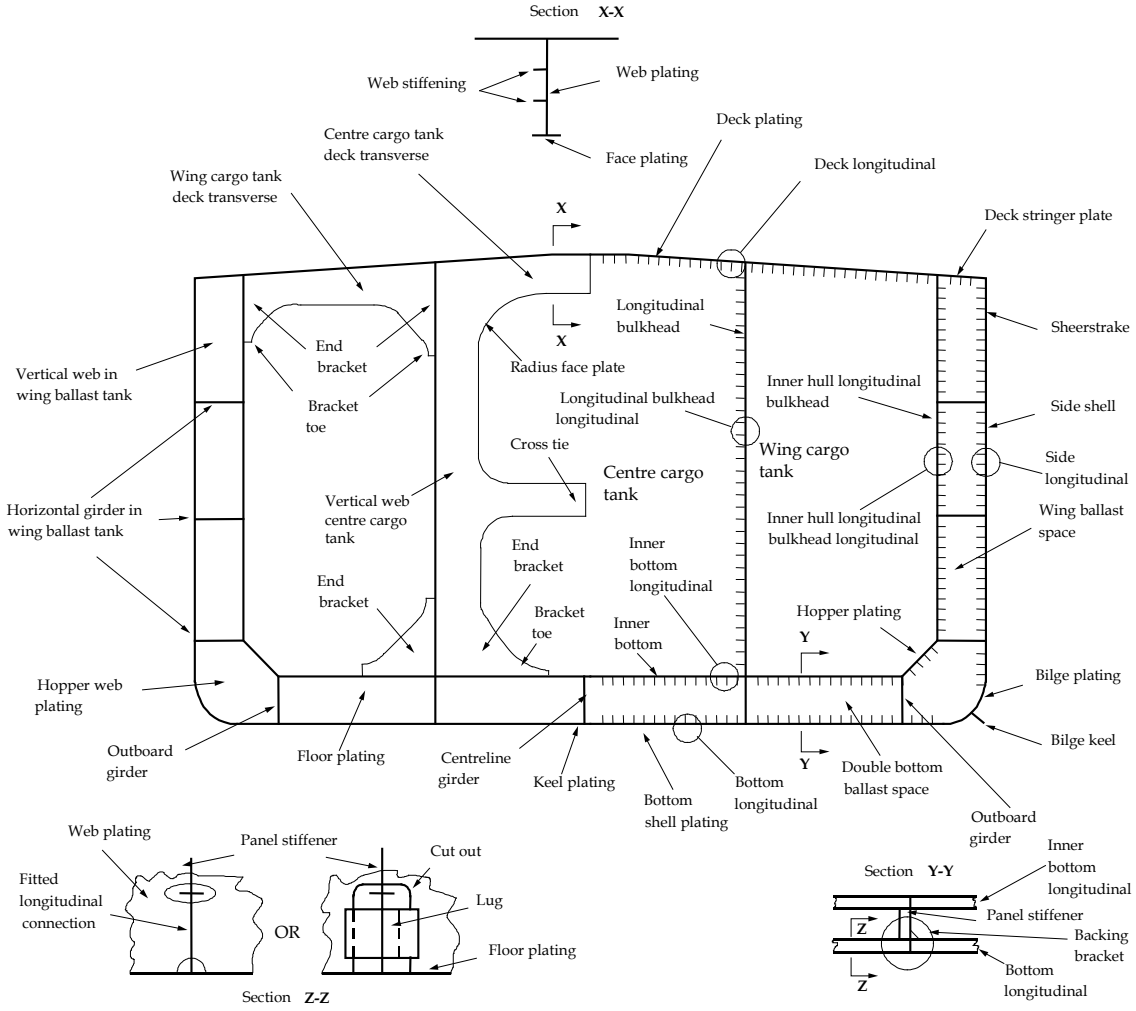


Figure 4 Typical midship section of a double hull oil tanker with two longitudinal bulkheads including nomenclature

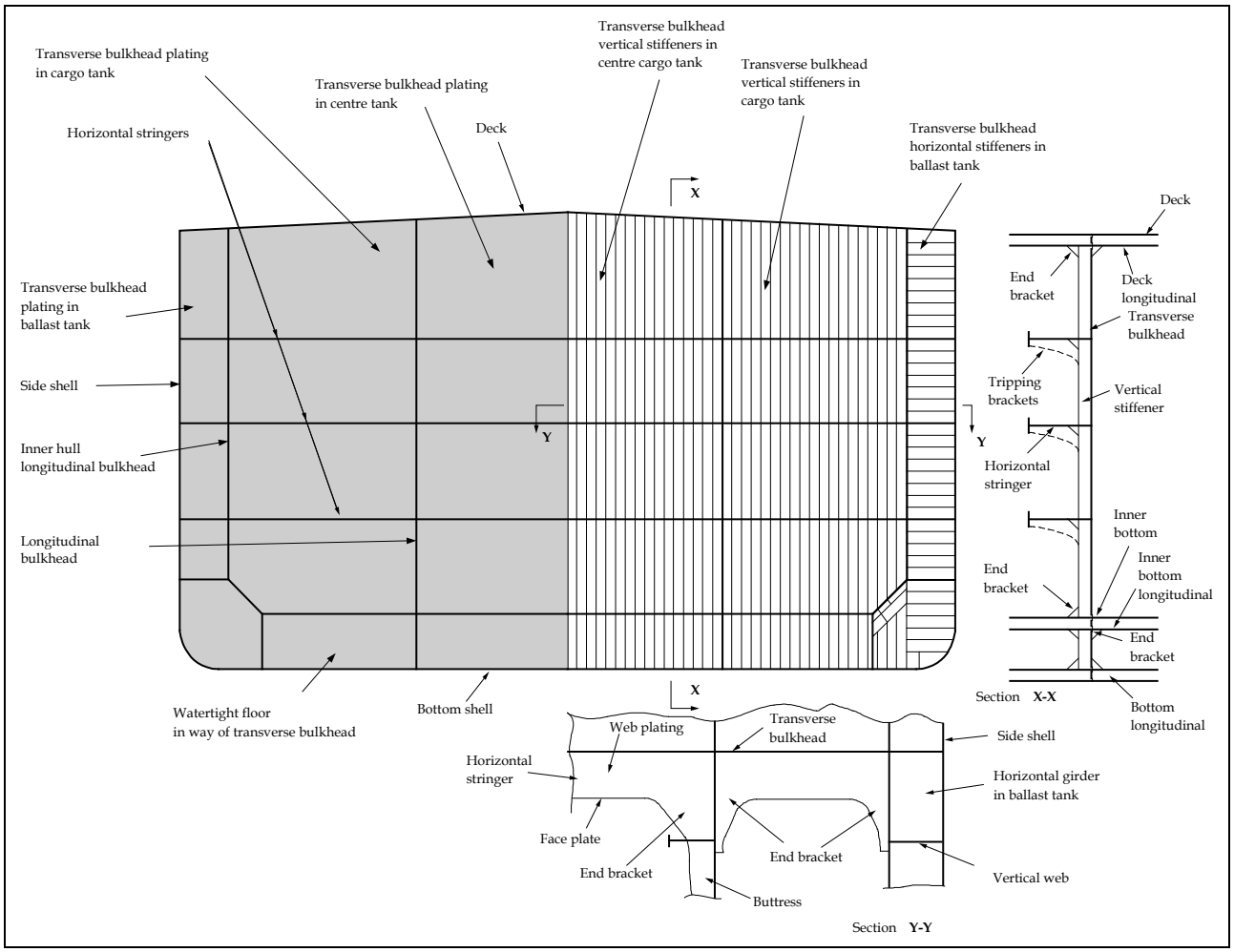


Figure 5 Double Hull Tanker – Typical Transverse Bulkhead

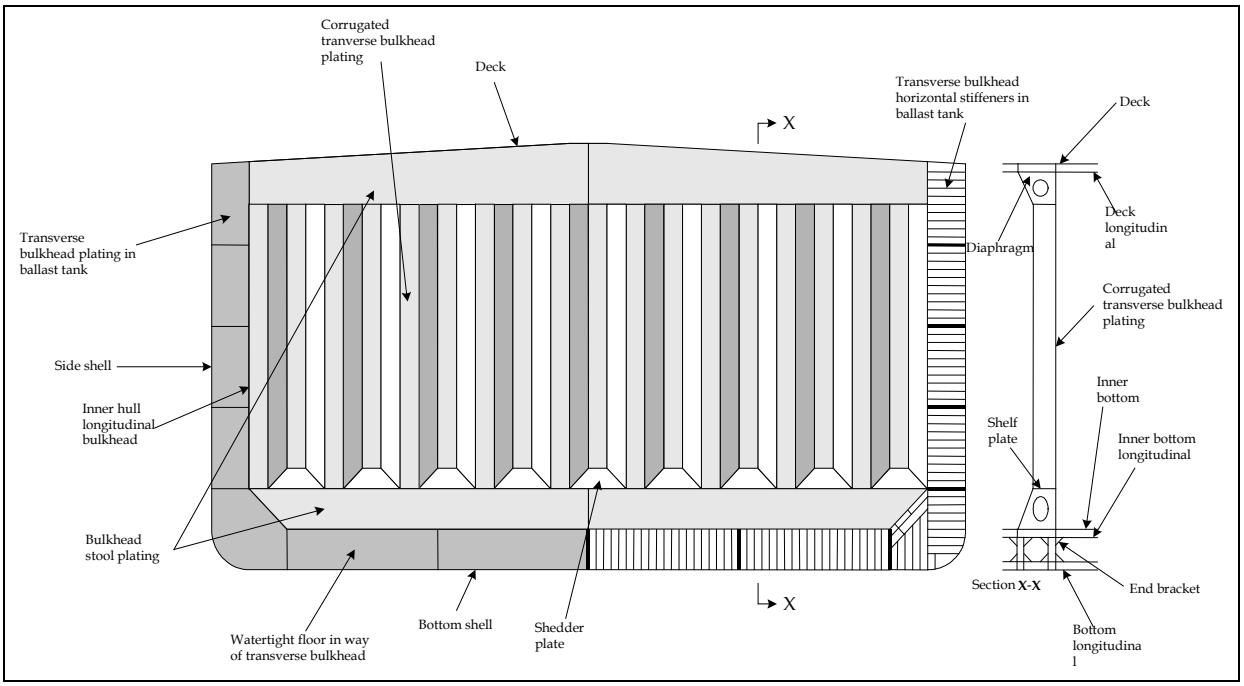


Figure 6 Corrugated Transverse Bulkhead Nomenclature

The guidelines focus on BCS's survey procedures but may also be useful in connection with survey/examination schemes of other regulatory bodies, owners and operators.

The manual includes a review of survey preparation guidelines, which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the preparation necessary before the surveys can be carried out.

The survey guidelines encompass the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

An important feature of the manual is the inclusion of the section, which illustrates examples of structural deterioration and damages related to each structural area and gives what to look for, possible cause, and recommended repair methods, when considered appropriate.

This manual has been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of Surveyors, and is to be used at the Surveyors' discretion. It is recognized that alternative and satisfactory methods are already applied by Surveyors. Should there be any doubt with regard to interpretation or validity in connection with particular applications, clarification should be obtained from the Classification Society concerned.

Surveyors dealing with single hull oil tankers should be encouraged to read the "Guidance Manual for Oil Tankers" by Tanker Structure Co-operative Forum.

BCS Common Structural Rules for Tankers implemented from April 2006 have been

developed in response to a consistent and persistent call from industry for an increased standard of structural safety. This has been achieved through enhancing the design basis and applying engineering first principles. The development of the CSR for Tankers included review of existing Rules, new development using a first principle approach, application of the net thickness philosophy, an enhanced design environment and a longer life i.e. 25 years North Atlantic. These Rules are applicable to double hull oil tankers exceeding a length of 150 metres.

Note: Throughout this document reference is made to various Requirements (BCS-R), Procedural Requirements (BCS-PR) and BCS-gs. All BCS-Rs and BCS-PRs and key BCS-Gs are available from the BCS website (https://www.bahriaclassificationsociety.org/)

2 Classification Survey Requirements

2.1 General

2.1.1 The programme of periodical surveys is of prime importance as a means for assessment of the structural condition of the hull, in particular, the structure of cargo and ballast tanks. The programme consists of Special (or Renewal) Surveys carried out at five-year interval with Annual and Intermediate Surveys carried out in between Special Surveys.

2.1.2 Since 1991, it has been a requirement for new oil tankers to apply a protective coating to the structure in water ballast tanks, which form part of the hull boundary.

2.1.3 From 1 July 2001, oil tankers of 20,000 DWT and above, to which the Enhanced Survey Programme (ESP) requirements apply, starting with the 3rd Special Survey, all Special and Intermediate hull classification surveys are to be carried out by at least two exclusive Surveyors. Further, one exclusive Surveyor is to be on board while thickness measurements are taken to the extent necessary to control the measurement process. From 1 July 2005, thickness measurements of structures in areas where close-up surveys are required are to be carried out simultaneously with close-up surveys. Refer to BCS-PR 19 and PR 20.

2.1.4 The detailed survey requirements complying with ESP are specified in the Classification and Survey Rules.

2.1.5 ESP is based on two principal criteria: the condition of the coating and the extent of structural corrosion. Of primary importance is when a coating has been found to be in a “less than good” condition (“good” is with only minor spot rusting) or when a structure has been found to be *substantially* corroded (i.e. a wastage between 75 % and 100 % of the allowable diminution for the structural member in question). Note, for vessels built under the BCS Common Structural Rules, substantial corrosion is an extent of corrosion such that the assessment of the corrosion pattern indicates a gauged (or measured) thickness between t_{net} + 0.5mm and t_{net}.

Reference is also made to SOLAS 74 as amended regulation Part A-1/3.2 regarding corrosion protection system for seawater ballast tanks at time of construction.

2.2 Annual Surveys

2.2.1 The purpose of an Annual Survey is to confirm that the general condition of the hull is maintained at a satisfactory level.

2.2.2 Generally as the ship ages, ballast tanks are required to be subjected to more extensive overall and close-up surveys at Annual Surveys.

2.2.3 In addition, a Ballast Tank is to be examined at annual intervals where:

a. a hard protective coating has not been applied from the time of construction, or
b. a soft coating has been applied, or
c. substantial corrosion is found within the tank at a previous survey, or
d. the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor at a previous survey.

2.3 Intermediate Surveys

2.3.1 The Intermediate Survey may be held at or between the second or third Annual Survey in each five year Special Survey cycle. Those items, which are additional to the requirements of the Annual Surveys, may be surveyed either at or between the 2nd and 3rd Annual Survey. The intermediate survey contains requirements for extended overall and close-up surveys including thickness measurements of cargo and ballast tanks.

2.3.2 Areas in ballast tanks and cargo tanks found suspect at the previous surveys are subject to overall and close-up surveys, the extent of which becomes progressively more extensive commensurate with the age of the vessel.

2.3.3 For oil tankers exceeding 10 years of age, the requirements of the Intermediate Survey are to be of the same extent as the previous Special Survey. However, pressure testing of cargo and ballast tanks and the requirements for longitudinal strength evaluation of Hull Girder are not required unless deemed necessary by the attending Surveyor.

2.4 Special Surveys

2.4.1 The Special (or Renewal) Surveys of the hull structure are carried out at five-year intervals for the purpose of establishing the condition of the structure to confirm that the structural integrity is satisfactory in accordance with the Classification Requirements, and will remain fit for its intended purpose for another five-year period, subject to proper maintenance and operation of the ship and to periodical surveys carried out at the due dates.

2.4.2 The Special Survey concentrates on close-up surveys in association with thickness measurements and is aimed at detecting fractures, buckling, corrosion and other types of structural deterioration. See Figure 7.

2.4.3 Thickness measurements are to be carried out upon agreement with the Classification Society concerned in conjunction with the Special Survey.

The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date.

2.4.4 Deteriorated protective coating in *less than good* condition in salt water ballast spaces and structural areas showing substantial corrosion and/or considered by the Surveyor to be prone to rapid wastage will be recorded for particular attention during the

following survey cycle, if not repaired at the special survey.

2.5 Drydocking (Bottom) Surveys

2.5.1 There is to be a minimum of two examinations of the outside of the ship's bottom and related items during each five-year special survey period. One such examination is to be carried out in conjunction with the special survey. In all cases the interval between any two such examinations is not to exceed 36 months. An extension of examination of the ship's bottom of 3 months beyond the due date can be granted in exceptional circumstances. Refer to BCS-R Z3.

2.5.2 For oil tankers of 15 years of age and over, survey of the outside of the ship's bottom is to be carried out with the ship in dry dock. For oil tankers less than 15 years of age, alternative surveys of the ship's bottom not conducted in conjunction with the Special Survey may be carried out with the ship afloat. Survey of the ship afloat is only to be carried out when; the conditions are satisfactorily and the proper equipment and suitably qualified staff are available.

2.6 Damage and repair surveys

2.6.1 Damage surveys are occasional surveys, which are, in general, outside the programme of periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or owner's representative to inform the Classification Society concerned when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages should be inspected and assessed by the Society's Surveyors and the relevant repairs, if needed, are to be performed. In certain cases, depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the planned periodical survey.

Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the vessel's structural watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered to are to include:

- bottom structure and bottom plating;
- side structure and side plating;
- deck structure and deck plating;
- watertight or oiltight bulkheads.

2.6.2 In cases of repairs intended to be carried out by riding crew during voyage, the complete procedure of the repair, including all necessary surveys, is to be submitted to and agreed upon by the Classification Society reasonably in advance.

2.6.3 BCS-R Z13 "Voyage Repairs and Maintenance" provides useful guidance for repairs to be carried out by a riding crew during a voyage.

2.6.4 For locations of survey where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage. A suitable condition of class will be imposed when temporary measures are accepted.

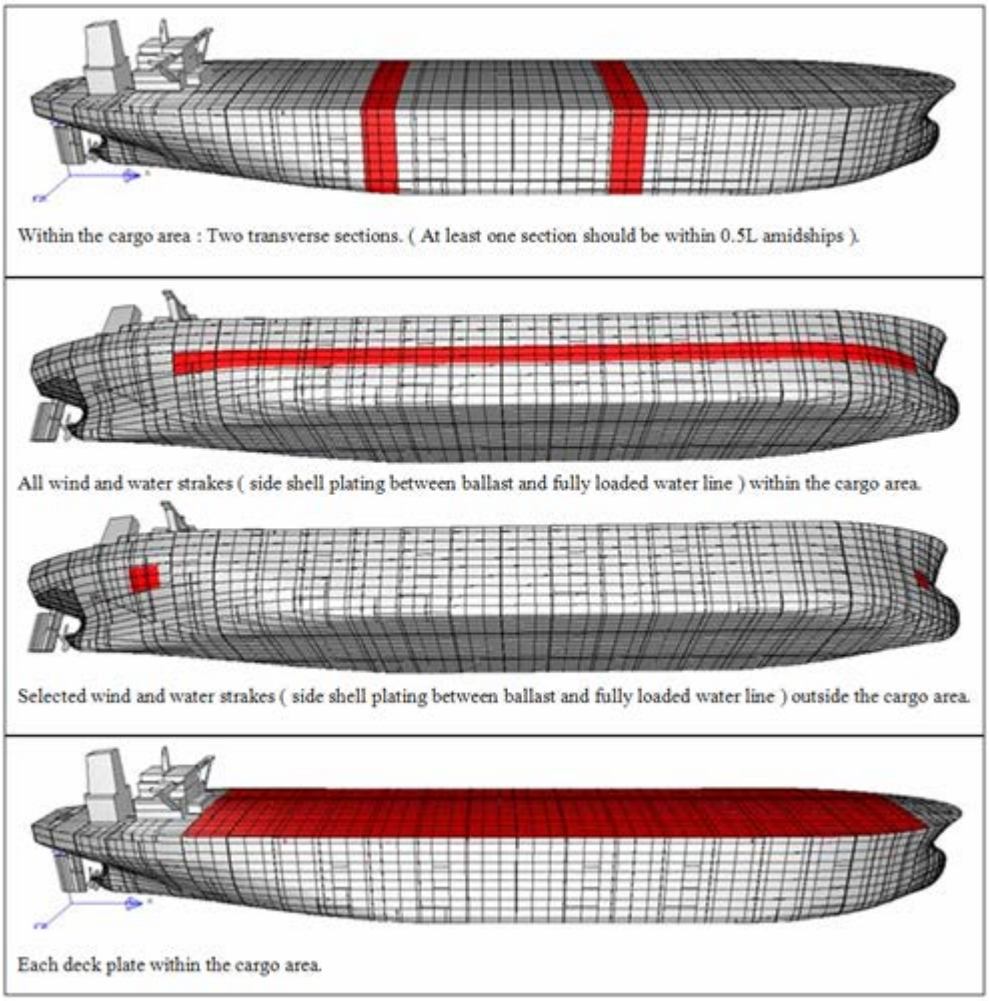


Figure 7 Example of Transverse Sections of Shell Plating and Main Deck Thickness Measurement Requirements for an oil tanker 15 years of age.

3 Technical Background for Surveys

3.1 General

3.1.1 The purpose of carrying out a structural survey of any tank is to determine the extent of corrosion wastage and structural defects present in the tank. To help achieve this and to identify key locations in the tank that might warrant special attention, the Surveyor should be familiar with the service record of the tank and any historical problems of the particular vessel or other vessels of a similar class.

An experienced Surveyor will be aware of typical structural defects likely to be encountered and some knowledge of the contributing factors to corrosion (including the effectiveness of corrosion control systems) will assist him in assessing the corrosion patterns he finds.

3.2 Definitions

3.2.1 For clarity of definition and reporting of survey data, it is recommended that standard nomenclature for structural elements be adopted. A typical midship section is illustrated in **Figures 4 to 6**. These figures show the generally accepted nomenclature.

The terms used in these guidelines are defined as follows:

(a) A **Ballast Tank** is a tank, which is used solely for the carriage of salt water ballast.

(b) A **Combined Cargo/Ballast Tank** is a tank, which is used for the carriage of cargo, or ballast water as a routine part of the vessel's operation and will be treated as a Ballast Tank. Cargo tanks in which water ballast might be carried only in exceptional cases per MARPOL I/13(3) are to be treated as cargo tanks.

(c) An **Overall Survey** is a survey intended to report on the overall condition of the hull structure and determine the extent of additional Close-up Surveys.

(d) A **Close-up Survey** is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. normally within reach of hand.

(e) A **Transverse Section** includes all longitudinal members such as plating, longitudinals and girders at the deck, sides, bottom, inner bottom and longitudinal bulkheads.

(f) **Representative Tanks** are those, which are expected to reflect the condition of other tanks of similar type and service and with similar corrosion prevention systems. When selecting Representative Tanks account is to be taken of the service and repair history onboard and identifiable Critical Structural Areas and/or Suspect Areas.

Note: Critical Structural Areas are locations, which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships (if available) to be sensitive to cracking, buckling or corrosion, which would impair the structural integrity of the ship. For additional details refer to Annex I of BCS-R Z10.4.

(g) **Suspect Areas** are locations showing Substantial Corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

(h) **Substantial Corrosion** is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75% of allowable margins, but within acceptable limits.

For vessels built under the BCS Common Structural Rules, substantial corrosion is an extent of corrosion such that the assessment of the corrosion pattern indicates a gauged (or measured) thickness between t_{net} + 0.5mm and t_{net}.

(i) A **Corrosion Prevention System** is normally considered a full hard coating. Hard Protective Coating is usually to be epoxy coating or equivalent. Other coating systems may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's specification.

(j) Coating condition is defined as follows:

- **GOOD** condition with only minor spot rusting,
- **FAIR** condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition,
- **POOR** condition with general breakdown of coating over 20% or more, or hard scale at 10% or more, of areas under consideration.

Reference is made to BCS-G 87 "Guidelines for Coating Maintenance & Repairs for Ballast Tanks and Combined Cargo / Ballast Tanks on Oil Tankers" which contains clarification of the above.

(k) **Cargo Area** is that part of the ship which contains cargo tanks, slop tanks and cargo/ballast pump-rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

(l) **Special consideration** or **specially considered** (in connection with close-up surveys and thickness measurements) means sufficient close-up survey and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

(m) A **Prompt and Thorough Repair** is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of class.

3.3 Structural Load Descriptions

(a) Structural Aspects

A tanker must maintain its structural integrity and water tight envelope when exposed to internal static and dynamic liquid loads, including sloshing loads, to external hydrostatic and dynamic sea loads, and to longitudinal hull girder bending. Longitudinally stiffened plate is typically the primary structure of a tanker. This stiffened plate is supported by web frames, girders and bulkheads. The hydrostatic and hydrodynamic pressures flow from the

plate through the stiffeners into the web frames, girders and bulkheads where they balance other loads or contribute to accelerations.

Most loads are cyclic with many different frequencies. The cyclic loads affecting fatigue are described in section 3.4.3. The following describe the loads that the major structural elements must resist.

(b) Tank Bottom Structures

The bottom structure must resist the axial loads from hull girder bending plus local bending from cargo, ballast and seawater pressure and structural loads from adjacent tanks. The hull girder bending loads are generally the highest midships and combine with the hydrostatic loads to generate the maximum stresses. The hydrostatic loads on the bottom are the highest in the vessel but are generally varying less than the side shell frame external wave loads.

(c) Side Shell, Longitudinal and Transverse Bulkheads

The side shell, longitudinal and transverse bulkheads maintain each tank's integrity and resist hydrostatic pressures as well as internal sloshing and external wave loads. The side shell and longitudinal bulkheads are also the webs of the hull girder and transmit the shear loads from tank to tank and along the length of the vessel. These members also contribute somewhat to resisting the longitudinal bending near the deck and bottom. The transverse bulkheads transmit the transverse shear loads and maintains the hull girder's form along with the transverse web frame rings.

The girders, stringers and vertical web frames that support the bulkheads resist bending and shear loads as they transmit the local pressure loads into the hull girder.

The hydrostatic loading increases linearly with depth and is often balanced with a liquid on the opposite side of the structure. The wave loading on the ship is cyclic and is the primary cause of the vessel fatigue, see section 3.4.3.

(d) Deckhead Structures

The main load on the deck is axial due to hull girder bending and transverse due to tank loading and waves. The axial stresses in the deck are the highest in the vessel as the upper deck is farthest from the neutral axis. While local loads are generally small on a tanker deck, equipment foundation loads, green water on deck and sloshing loads must be considered.

3.4 Structural defects, damages and deterioration

3.4.1 General

In the context of this manual, structural damages and deterioration imply deficiencies

caused by:
- excessive corrosion
- design faults
- material defects or bad workmanship
- weld defects
- buckling
- fatigue
- navigation in extreme weather conditions
- loading and unloading operations, water ballast exchange at sea
- wear and tear
- contact (with quayside, ice, lightering service, touching underwater objects, etc.) but not as a direct consequence of accidents such as collisions, groundings and fire/explosions.

Deficiencies are normally recognized as:
- material wastage
- fractures
- deformations

The various types of deficiencies and where they may occur are discussed in more detail in subsequent sections.

3.4.2 Structural Defects

Structural defects include weld defects, buckling and fractures, see also **3.4.3** Fatigue. Fractures initiating at latent defects in welding more commonly appear at the beginning or end of a run, or rounding corners at the end of a stiffener or at an intersection. Special attention should be paid to welding at toes of brackets and cut-outs or intersections of welds. Fractures may also be initiated by undercutting in way of stress concentrations. Corrosion of welds may be rapid because of the influence of the deposited metal or the heat affected zone, and this may lead to stress concentrations.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or damage. Elastic buckling will not be directly obvious but may be detected by coating damage, stress lines or shedding of scale.

Some fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of survey. It is therefore important to identify and closely inspect potential problem areas. Fractures will normally initiate at notches, stress concentrations or weld defects. Where these initiation points are not apparent on one side, the structure on the other side of the plating should be examined.

The following areas where structural defects might occur should have special attention at the survey:

(a) Cargo Tanks

i. Main deck deckhead: corrosion and fractures.
ii. Buckling in web plate of the underdeck web frame and fractures at end of bracket toes.
iii. Transverse bulkhead horizontal stringers: fractures in way of cut-outs and at end bracket toe connections to inner hull and longitudinal bulkhead.
iv. Longitudinal bulkhead transverse web frames: fractures at end bracket toe connection to inner bottom.
v. Necking effect of longitudinal web plating at longitudinal bulkhead plating.
vi. For plane transverse bulkheads, transverse bulkhead vertical stiffeners connected to inner bottom: for vertically corrugated bulkheads, corrugation connection to lower shelf plate and bulkhead plating connection to inner bottom: fractures caused by misalignment and excessive fit-up gap.
vii. Transverse bulkheads at the forward and after boundaries of the cargo space: fractures in way of inner bottom.
viii. Pitting and grooving of inner bottom plating.

(b) Double Hull Ballast Spaces
i. Main deck deckhead: corrosion and fractures.
ii. Inner hull plate and stiffener: coating breakdown.
iii. Buckling of the web plate in the upper and lower part of the web frame.
iv. Fractures at the side shell longitudinal connection to web frames due to fatigue.
v. Corrosion and fractures at knuckle joints in inner hull at forward and after parts of ship.
vi. Corrosion and fractures at the juncture where the sloped inner hull is connected to the inner bottom.
vii. Fractures at side and inner hull longitudinal connections to transverse bulkheads due to fatigue and/or high relative deflections.
viii. Inner bottom deckhead corrosion at inner bottom.
ix. Bottom corrosion wastage.
x. Cracks at inner bottom longitudinal connection to double bottom floor web plating.
xi. Fractures at inner bottom and bottom longitudinal; connection to transverse watertight floor due to high relative defections.

3.4.3 Fatigue

Fatigue is the most common cause of cracking in the structure of large tankers. The cracks generally develop at structural intersections of structural members or discontinuities where detailed design has led to a stress raiser such as a hot spot. Other reasons maybe related to material or welding defects, or some other type of notch.

Fatigue failures are caused by repeated cyclical stresses that individually would not be sufficient to cause failure but can initiate cracks, in particular in way of built in defects, which can grow to sufficient size to become significant structural failures. Typical cyclic loading mechanisms are:

- hull girder wave bending moments and shear forces;
- local pressure variation;
- cargo or ballast internal pressure variation.

If the crack remains undetected and unrepaired it can grow to a size where it can cause sudden fracture. However, it is unusual for a fatigue crack to lead directly to a catastrophic failure.

Fatigue failures can generally be considered to have three stages:

- Initiation
- Stable crack growth
- Unstable crack growth

In order to develop structural designs that will minimise the amount of fatigue cracking, and ensure that fatigue cracking does not cause a structural failure, it will be necessary to carry out greater investigation of fatigue strength than has traditionally been the case for large tankers.

Fatigue strength can be calculated using 2 methods:

- Compare calculated numbers of cyclic stress ranges with established fatigue criteria (S-N data).
- Calculate crack growth rates based on above stress range data and material properties.

(a) Typical Locations for High Sensitivity to Fatigue Failure

The following areas are considered to be prone to fatigue failure on double hull oil tankers:

- Side shell area below the load and ballast waterlines. These areas are subjected to the highest cycle loading through the ship's life due to the passage of waves along the side of the ship.
- Deck plating at connection to primary supporting members.
- Connection between transverse bulkheads to the upper and lower bulkhead stools.
- Connection between lower hopper sloping plating and inner bottom plating.

Where dynamic stresses are prevalent, the use of symmetrical profiles, such as "T" - section, will substantially reduce fatigue damage caused by biaxial bending on asymmetrical profiles.

The fatigue fractures in side longitudinal connections of higher tensile construction in certain single hull VLCCs has now been well documented, and design details in way of these connections to increase fatigue life are now incorporated by many Shipyards as standard in double hull designs.

These details include the incorporation of soft-toed panel stiffeners with either soft-toed

backing brackets or reversed radii at the heel of the panel stiffener.

It is therefore important that due consideration be given to this detail and other areas of potential problems at the design stage to reduce the risk of fatigue cracking during service.

(b) The Effect of Higher Tensile Steel

The higher yield strength of HTS has enabled a structure to be designed with higher stresses resulting in lighter scantlings. This does, however, also lead to an increase in the dynamic stress range. The fatigue damage is proportional to the stress range cubed, and HTS materials in welded connections have similar fatigue properties as mild steel. Therefore, it follows that the risk of high-cycle fatigue damage may increase for welded HTS connections in tankers when the increased strength capabilities are utilised.

The use of lighter scantlings often leads to higher deflections, which are particularly important at the side shell connections. In some HTS designs it is possible, that the deflections of the side shell web frames may be larger than in Mild Steel designs, due to the ability of the HTS material to accept higher stress levels in combination with structural arrangement such as wider web frame spacing and lack of cross ties. Such deflections add to the stress levels in the longitudinals at the intersections between the longitudinals and the transverse bulkheads, the additions being proportional to the deflections.

The notch toughness properties of all HTS used in the ship are verified by testing whereas mild steel A-grade is not. The notch toughness is an important parameter in the evaluation of resistance to brittle fracture. However, this would not have significant effect on the risk of crack initiation or the stable crack growth, but would have significant effect on the final unstable crack propagation.

The above factors have to be considered when designs of HTS are made, and today it is normal practice to improve the detail design in order to reduce the stress concentrations in areas where calculations show that high dynamic stress levels are expected. The shipside is particularly prone to high-cycle fatigue damage.

The overall effect when the higher strength of HTS is utilized for such locations, can be to significantly increase the risk of fatigue damage. By improving the detail design, it will usually be possible to obtain a fatigue life comparable to that for ordinary mild steel designs.

For locations where cracking is due to low-cycle fatigue, the use of HTS in local details may be very beneficial for the fatigue strength. This is the case for areas, which are subject to large static stress variations due to loading and unloading, such as the connection between the hopper plating and the double bottom plating. For such locations, local details with HTS will experience less plastic strains, and the low cycle fatigue strength therefore be increased compared with mild steel details. Nevertheless it should be

checked whether wave induced loads are marginal or not.

3.4.4 Typical Corrosion Patterns

In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible locations of corrosion that may occur to the structural members on decks and in tanks.

The main types of corrosion patterns, which may be identified, include the following:

(a) General Corrosion

General corrosion appears as non-protective, friable rust, which can occur uniformly on tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred. Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals.

(b) Grooving Corrosion

Grooving corrosion is often found in or beside welds, especially in the heat affected zone. This corrosion is sometimes referred to as 'inline pitting attack' and can also occur on vertical members and flush sides of bulkheads in way of flexing. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface, which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged. An example of grooving corrosion is shown in Figure 8.

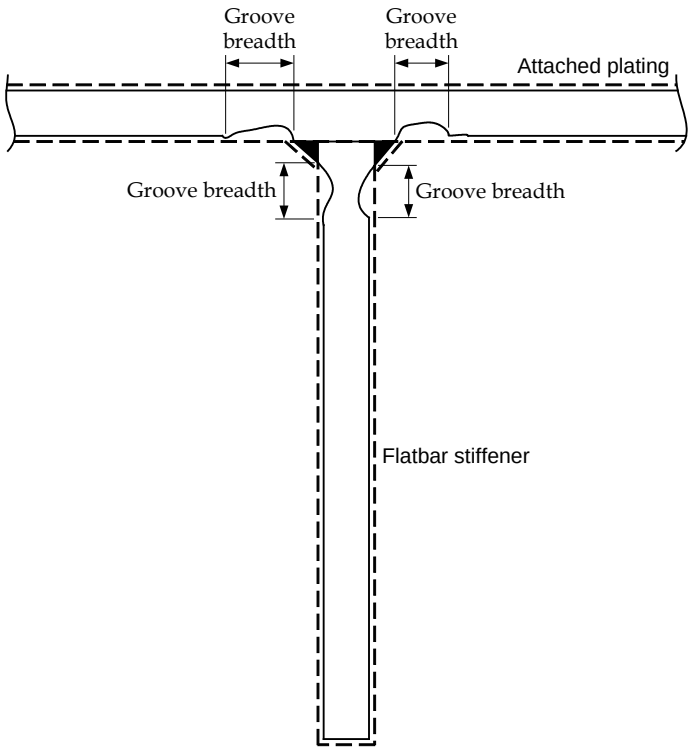


Figure 8 Grooving Corrosion

(c) Pitting Corrosion

Pitting corrosion is a localized corrosion often found in the inner bottom plating or on horizontal surfaces in cargo oil tanks and in the bottom plating of ballast tanks. Pitting corrosion is normally initiated due to local breakdown of coating. For coated surfaces the attack produces deep and relatively small diameter pits that can lead to hull penetration in isolated random places in the tank.

Pitting of uncoated tanks, as it progresses, forms shallow but very wide scabby patches (e.g. 300 mm diameter); the appearance resembles a condition of general corrosion. Severe pitting of uncoated tanks can affect the strength of the structure and lead to extensive steel renewals.

Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.

Erosion which is caused by the wearing effect of flowing liquid and abrasion which is caused by mechanical actions may also be responsible for material wastage.

(d) Edge Corrosion

Edge corrosion is defined as local corrosion at the free edges of plates, stiffeners, primary support members and around openings. An example of edge corrosion is shown in Figure 9.

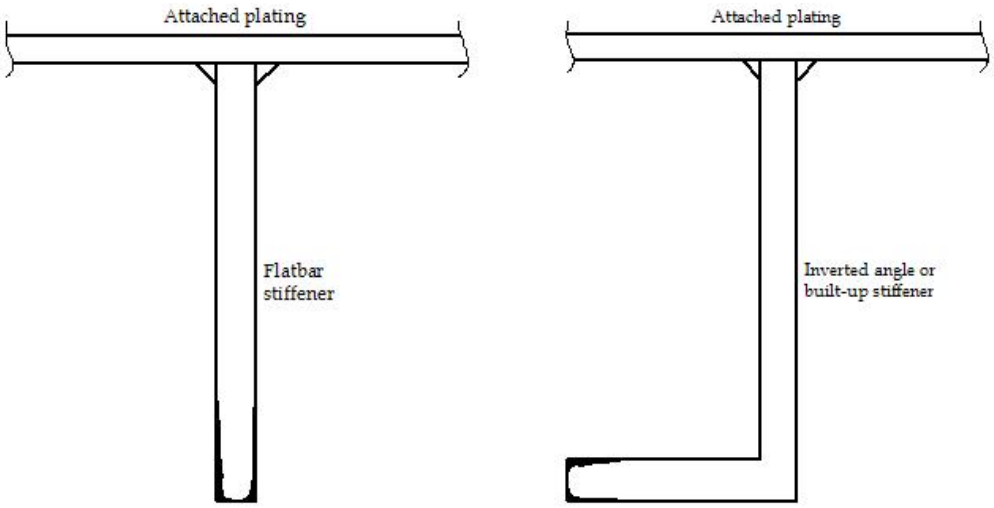


Figure 9 Edge Corrosion

3.4.5 Factors Influencing Corrosion

When corrosion problems occur it is important to have some understanding of the possible contributing factors to the corrosion so that remedial action taken will minimize the possibility of future repetition. The significance of each of these factors will vary depending upon the tank service. Similarly, for ballast tanks the effectiveness of the protection system and high humidity could be major factors. For cargo only tanks the method and frequency of tank washing and the sulphur content of the cargo could be factors of particular significance.

The following is a list of possible factors, which might be relevant in evaluating corrosion patterns being experienced:

(a) Frequency of Tank Washings

Increased frequency of tank washings can increase the corrosion rate of tanks. For uncoated tanks, it is often possible to see lines of corrosion in way of the direct impingement paths of the crude oil washing machines.

(b) Composition and Properties of Cargo

- Carriage of crude oil can result in the tank surfaces in contact with the cargo being coated with a "waxy" or "oily" film, which is retained after cargo discharge. This film can reduce corrosion. Less viscous cargoes such as gasoline do not leave behind a similar film.
- Carriage of crude oil that has high sulphur content can lead to high rates for general corrosion and tank bottom pitting corrosion. By reacting with water many sulphur compounds can form acids, which are very corrosive. This will often mean that water bottom dropping out of the cargo will be acidic and corrosive.
- Carriage of cargoes with high water content can increase corrosion rates.
- Carriage of cargoes with high oxygen content (e.g. gasoline) can lead to high corrosion

rates.
- Carriage of cargoes with low pH values (acidic) can lead to high corrosion rates.

(c) Time in Ballast
- For ballast tanks where the coating has started to fail, corrosion increases with the time in ballast.

(d) Microbial Induced Corrosion
- Microbial influenced corrosion is the combination of the normal galvanic corrosion processes and the microbial metabolism. The presence of microbial metabolites generates corrosive environments, which promote the normal galvanic corrosion.
- For tanks that remain filled with contaminated ballast water for a long time, the potential for microbial induced corrosion, in the form of grooving or pitting, is increased. The microbes could penetrate pinholes and accelerate the coating breakdown and corrosion in the infected areas. Proper procedures, such as flushing with clean (open sea) salt water, will help reduce the potential for this type of corrosion.
- Cargo oil often contains residual water, which may contain microbes leading to microbial induced corrosion attacks in the tank bottom or other locations where the water may collect.
- Biocide shock treatment to exterminate the microbes is a method that could be used in cargo and ballast tanks. In addition clean water flushing at regular intervals will help reduce the potential of microbial induced corrosion. Proper maintenance of coating integrity, or blasting and coating the uncoated surfaces, would be an effective method to deal with microbial induced corrosion.

(e) Humidity of Empty Tank

Empty tanks, e.g. segregated ballast tanks during laden voyages, can have high humidity and are thus susceptible to general atmospheric corrosion, especially if corrosion control is by anodes which are ineffective during these periods.

During prolonged periods, when the tanks are left empty, such as lay-ups, maintenance of low humidity atmosphere in the tanks should be considered to minimise corrosion.

(f) Temperature of Cargo in Adjacent Bunker or Cargo Tanks

Carriage of heated cargoes may lead to increased general corrosion rates at the ballast tank side of a heated cargo tank/unladen ballast tank bulkhead. This may also apply for tanks adjacent to heated bunker tanks.

(g) Coating Breakdown

Intact coatings prevent corrosion of the steel surface.

However:
- A local absence of coating (due to coating depletion, deterioration, damage, etc.) can

result in corrosion rates similar or greater than those of unprotected steel.
- Holidays or localized breakdown in coating can lead to pitting corrosion rates higher than for unprotected steel.

Periodic surveys at appropriate intervals and repair of coating as required are effective in minimising corrosion damage.

(h) Locations and Density of Anodes
- Anodes immersed in bottom water can afford protection against bottom corrosion.
- Anodes are not effective in reducing underdeck corrosion rates.
- Properly designed systems with high current densities may afford greater protection against corrosion.
- Electrical isolation or coatings, oily films, etc., on anodes can make anodes inoperative; abnormally low wastage rates of anodes may indicate this condition.

(i) Structural Design of Tank
- High velocity drainage effects can lead to increased erosion in the vicinity of cut-outs and some other structural details for uncoated surfaces.
- Horizontal internals and some details can trap water and lead to higher corrosion rates for uncoated surfaces.
- Less rigid designs, such as decreased scantlings and increased stiffener spacing, may lead to increased corrosion due to flexure effects, causing shedding of scale or loss of coating.
- Sloping tank bottoms (e.g. as with double bottom tanks) to facilitate drainage may reduce bottom corrosion by permitting full stripping of bottom waters.

(j) Gas Inerting
- Decreased oxygen content of ullage due to gas inerting may reduce corrosion of overhead surfaces.
- Sulphur oxides from flue gas inerting can lead to accelerated corrosion due to formation of corrosive sulphuric acid.

(k) Navigational Route
- Solar heating of one side of a ship due to the navigational route can lead to increased corrosion of affected wing tanks.
- Anodes used to protect ballast tanks on voyages of short duration may not be effective due to insufficient anode polarisation period when high corrosion may occur.

(l) Accelerated structural corrosion in water ballast and cargo tanks

A limited but significant number of double hull tankers have been found to be suffering from accelerated corrosion in areas of their cargo and ballast tanks. It is now generally agreed that the “thermos bottle effect”, in which heated cargoes retain their loading temperatures for much longer periods, promotes an environment within the cargo and

ballast tanks that is more aggressive from the viewpoint of corrosion (as temperatures rise, corrosion activity increases - warm humid salt laden atmospheres in ballast tanks, acidic humid conditions in upper cargo tank vapour spaces and warm water and steel eating microbes on cargo tank bottom areas - all factors which promote corrosion).

If corrosion remains undetected during surveys, loss of tank integrity and oil leakage into the double hull spaces may occur (increased pollution and explosion risk). In the worst cases, corrosion can lead to a major structural failure of the hull.

3.4.6 Items for Special Attention of the Surveyor

Taking into account all the possible factors, which might be relevant to a particular tank, the Surveyor should pay special attention to the following areas when looking for signs of serious corrosion:

- Horizontal surfaces such as bottom plating, face plates and stringers, particularly towards the after end of the structural element. The wastage may take the form of general corrosion or pitting. Accelerated local corrosion often occurs at the after bays and particularly in way of suctions.
- Deck heads and ullage spaces in uncoated ballast or cargo/ballast tanks (where anodes may not be effective) or non-inerted cargo tanks.
- Structure in way of lightening holes or cut-outs where accelerated corrosion may be experienced due to erosion caused by local drainage and flow patterns. Grooving may also take place on both horizontal and vertical surfaces.
- Areas in way of stress concentrations such as at toes of brackets, ends of stiffeners and around openings.
- Surfaces close to high pressure washing units where localised wastage may occur due to direct jet impingement.
- Bulkhead surfaces in ballast tanks adjacent to heated cargo or bunkers.
- Areas in way of local coating breakdown.
- One of the most effective means for preventing corrosion is to protect the hull structure with an efficient coating system. In double hulled tankers, the spaces most at risk from the effects of corrosion are the seawater ballast tanks and the underdeck structure and bottom areas within the cargo oil tanks.

3.4.7 Corrosion Trends in Tank Spaces

Depending on the tank function and location in the tank, some structural components are more susceptible to corrosion than others.

The following are some phenomena of corrosion observed in each type of tank space:

(a) Water Ballast Tank

- Necking occurs at the junction of the longitudinal bulkhead plating and longitudinals. The deflection of the bulkhead plating and longitudinals due to reverse, cyclic loading from cargo oil and water ballast plus the accumulated mixtures of water, mud and scale

at their junctures accelerates the corrosion rate. As the steel thins and weakens, the flexing consequently increases and hence corrosion accelerates (see Figure 10). The similar necking effect could also occur in the transverse bulkhead plating and stiffeners, or in the inner bottom plating and longitudinals inside the double bottom space. In the coated water ballast tanks, the plating is the principally affected area due to local corrosion in way of coating failure.

- Corrosion reduces not only the strength capability but also the stiffness (to resist the deflection) of the structural components as corrosion progresses during tanker ageing. The deflection tends to crack the hard scale formation on the steel surface and to expose the fresh steel to the water. Since the loading on corroded structural components remains unchanged, as the structure becomes weaker, the deflection becomes larger and the corrosion rate accelerates.
- For partially filled ballast tanks, the water level is constantly surging in the splash zone due to the ship motions. This accelerates coating breakdown in coated ballast tanks.
- If the intake ballast water is contaminated, the lower part of the ballast tank and bottom plating in particular, might be subjected to microbial influenced corrosion, particularly in the stagnant zone due to poor drainage and mud accumulation. The by-products released by the growing sulphate reducing bacteria can be acidic, which may penetrate and destroy coating, leading to accelerated corrosion in the infected areas.

(b) Cargo Oil Tanks

Residual water settling out from cargo oil can cause the pitting and grooving corrosion in the upper surface of horizontal structural components particularly on the inner bottom plating at the aft end of tanks where water accumulates due to the ship's normal trimming by the stern. In cases where the inner bottom plating has been protected with a hard coating, local breakdown of this barrier coating can lead to accelerated pitting corrosion where residual water has been lying.

Pitting corrosion to the inner bottom plating within cargo tanks can lead to cargo leakage into the double bottom spaces (giving increased risk of explosion and pollution during ballasting operations) whilst corrosion to the under deck structure within the cargo tank area can lead to a reduction in longitudinal strength which gives rise to the possibility of a more serious structural failure occurring.

One of the best methods of preventing corrosion within these spaces is that protective coatings be applied to the underdeck and inner bottom plating areas. In addition to protecting the steel structure in these areas, this measure would also enable easier and more effective surveys and surveys to be carried out ‘in service’.

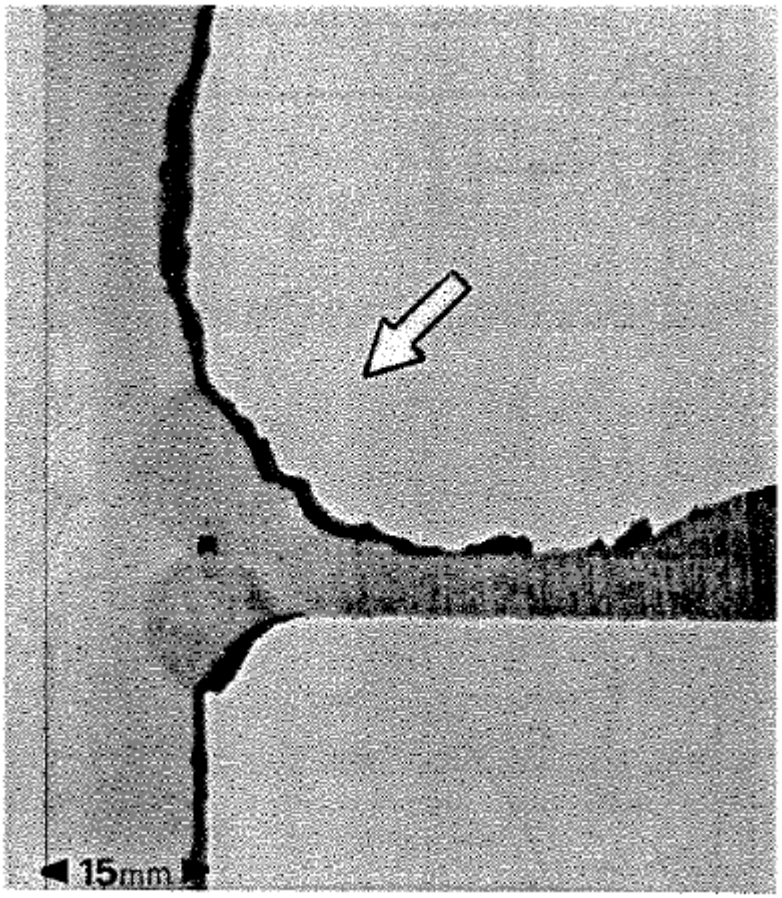


Figure 10 Detail of Necking Effect

3.4.8 In-Service Corrosion Rates

Since each tanker has a different corrosion control system, and is engaged in different trades, it usually has its own unique corrosion characteristics and its own corrosion rates.

3.4.9 Corrosion Prevention Systems

An understanding of the various options which are available to help prevent corrosion and also the limitations of each different system will assist the Surveyor in anticipating possible areas where corrosion problems may occur and thereby help to determine what remedial action may be taken to reduce the effects on structural deterioration.

If serious corrosion has already occurred, steel renewals may not be the only option available to maintain structural integrity. Installation or upgrading of a corrosion prevention system may be more attractive if the steel is within allowable loss limits.

For all types of tanker structures, the main areas, which are usually prone to severe corrosion, will be those in direct contact with seawater, such as water ballast tanks, external hull and main deck areas. In the case of cargo oil tanks, the corrosion prevention requirements are different for crude oil or white oil products, where the latter usually

requires full protection of the internal surfaces with a coating system that will be compatible with the cargo being carried and whose main function is to prevent contamination between different grades.

In general, the most common form of corrosion prevention system used in tanker structures will be the application of paint (hard) coatings to either internal or external steel works in various forms to suit the type and extent of prevention required. The basic function of a hard coating, such as paint, is to block access of water and oxygen to the steel structure itself. It follows therefore that its contact with the steel should be as good as practically achievable, i.e. it must be firmly adherent, otherwise there will always be a possibility that rust - hydrated iron oxide - will form beneath the paint and eventually rupture the paint film.

Maintaining this corrosion prevention system throughout the lifespan of the vessel is therefore an important feature in the initial choice of materials and will also be a measure of the continuing structural integrity of the vessel itself.

Potential corrosion of the internal structure in water ballast tanks is by far the most serious aspect of tanker maintenance and the prevention systems normally associated with these spaces can generally be grouped under three categories, i.e.

- Hard coatings (epoxy, vinyl, zinc silicate, bitumastic, etc.);
- Soft Coatings;
- Cathodic protection (zinc/aluminium anodes) (Note: Not subject to Classification Surveys).

The following text gives a brief description of each type of system but is not intended as an exhaustive evaluation.

(a) Hard Coatings

The very nature of this form of corrosion prevention system is to form a protective barrier on the steel surface, which will provide a semi-permeable membrane to protect against the elements of corrosion. Any subsequent breakdown of this 'barrier' will, however, allow the normal corrosion process to take place, and usually at a much more accelerated rate due to the limited surface area being exposed.

This problem is, therefore, very similar to that of local pitting corrosion, where, if early action is not taken, the overall integrity of the structure will be put at risk.

Further increases in the extent of breakdown of this 'barrier' will, however, reach a stage where the system is no longer considered effective and general corrosion of the structure is taking place.

If properly applied on blast-cleaned surfaces, recognised coating types, such as those on

an epoxy basis, should obtain a durability of at least 10 years service life**.**

Sacrificial type coatings such as inorganic zinc provide 'metal' that is anodic to the steel surface and will protect the steel cathodically.

(b) Soft Coatings

The effectiveness of these types of protective coatings is usually much more difficult to judge, especially those relying on chemical reactions with the steel surface.

By their very nature, the effective life of some of the protection systems is usually restricted to about one to three years only, before further maintenance and touch-up is required. Visual assessment of their existing condition can also be very difficult and somewhat misleading, especially if these have been used to cover-up already severely corroded areas of the structure.

Other typical problems that have been found with the use of soft coatings for ballast tank protection have been in respect to:

- Their 'greasy' nature, which makes physical survey very difficult, and may adversely impact safety.
- Their 'oily' base, which can contaminate the discharge of ballast water.
- Potential sagging of thick coatings attached to hot surfaces.
- Some vegetable based coatings are incompatible with sacrificial anodes.
- When exposed to mineral oil, some lanolin-based coatings go into an emulsion state requiring removal for hot-work or pollution risk.
- Soft coatings on horizontal surfaces will be damaged whenever any mucking out of sediment is carried out in the ballast tank.
- In the event of hot-work/welding on the outside or inside of coated plates, careful removal of the soft coating is necessary to prevent the risk of fires or explosions due to the potential build-up of gas when the coating is heated.

Much of the success with these soft coatings has usually been in connection with void spaces or water ballast tanks where there is a long retention time of the ballast (as in semi-submersibles). However, regular changes of ballast water, as in tanker operations, has the effect of depleting the amount of soft protection on the internal surfaces. For this reason, these protection systems should really be regarded as temporary and should be subjected to more regular and comprehensive thickness gauging and close-up surveys than that considered for hard coatings.

(c) Cathodic Protection (Sacrificial Anodes)

The principle of cathodic protection is to sacrifice the anodes in preference to the surrounding steel structures, and, therefore, relies entirely on these areas being immersed in seawater before this action can take place.

Anode material is generally zinc. Other types of materials, for example aluminium, are limited because of the danger of sparks when dropped or struck, although these materials do offer better current output for the same weight. The use of anodes of aluminium have an installation height restriction in cargo tanks equivalent to a potential energy of 275 Joules which effectively limits their use to bottom structure and requires that falling objects do not strike them.

The consumption rates and replacement of depleted anodes will not always be a true indication of the effectiveness of the corrosion protection system. Only regular and comprehensive visual and gauging surveys of the structure will give a correct assessment of effectiveness. Sacrificial anodes used as backup protection to a hard coating system do, however, have the benefit of controlling the accelerated rates of corrosion in way of any breakdown, but, again will only be effective when immersed in seawater. Recoating of any breakdown areas may still be required, but probably at a later date than without these back-up anodes.

(d) Selection of Corrosion Prevention System

The choice of Corrosion Prevention systems for water ballast tanks has, in the past, been determined by either the Shipowner or Shipbuilder. BCS-R Z8 requires coating in ballast tanks on new vessels. The continued effectiveness of these corrosion prevention systems must be monitored throughout the service life of the ship by regular assessment of the condition of the steel structure, which is being protected.

For hard coating prevention systems applied at new building, this thickness determination need only be monitored in way of any localised breakdown where accelerated corrosion of the exposed steel structure may be anticipated.

With soft coatings, semi-hard coatings or sacrificial anodes, more frequent and extensive gauging surveys will be needed to assess the overall wastage rates in these tanks, and will generally be more difficult to survey in the later stages of the ship's service life.

In view of the importance of preserving this structural integrity, effective maintenance programs should be set up from commencement of service to repair and replace the corrosion prevention system as it deteriorates.

3.4.10 Fractures

In most cases fractures are found at locations where stress concentration occurs. Weld defects, flaws, and where lifting fittings used during ship construction are not properly removed are often areas where fractures are found. If fractures occur under repeated stresses, which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses induced by wave forces, fatigue fractures can also result from vibration forces introduced by main engine(s) or propeller(s), especially in the aft part of the hull.

Some fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of survey. It is therefore important to identify and closely inspect potential problem areas. Fractures will normally initiate at notches, stress concentrations or welds especially those with defects. Where these initiation points are not apparent on one side, the structure on the other side of the plating should be surveyed.

Fracture initiating at latent defects in welds more commonly appears at the beginning or end of a run of welds, or rounding corners at the end of a stiffener, or at an intersection. Special attention should be paid to welds at toes of brackets, at cut-outs, and at intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations.

It should be noted that fractures, particularly fatigue fractures due to repeated stresses, may lead to serious damages, e.g. a fatigue fracture in a side shell longitudinal may propagate into shell plating and affect the watertight integrity of the hull.

3.4.11 Deformations

Deformation of structure is caused by in-plane load, out-of-plane load or combined loads. Such deformation is often identified as local deformation, i.e. deformation of panel or stiffener, or global deformation, i.e. deformation of beam, frame, girder or floor, including associated plating.

If in the process of the deformation large deformation is caused due to small increase of the load, the process is called buckling.

Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to bottom slamming and wave impact forces are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the aft part of the hull.

In the case of damages due to contact with other objects, special attention should be drawn to the fact that although damages to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged and the coating effectiveness compromised.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic buckling will not normally be directly obvious but may be detected by evidence of coating damage, stress lines or shedding of scale. Buckling damages are often found in webs of web frames or floors. In many cases, this may be attributed to corrosion of webs/floors, wide stiffener spacing or wrongly positioned lightening holes, man-holes or slots in webs/floors.

3.5 Structural detail failures and repairs

3.5.1 For examples of structural defects, which have occurred in service, attention is drawn to Chapter **5** of these guidelines. It is suggested that Surveyors should be familiar with the contents of Chapter **5** before undertaking a survey.

3.5.2 For Classification requirements related to prompt and thorough repairs refer to **2.6.1**.

3.5.3 In general, where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Generally doubler plates should not be used for the compensation of wasted plate. Repair work in tanks requires careful planning in terms of accessibility. Refer to Part B of BCS-G 47, Shipbuilding and Repair Quality Standard.

3.5.4 If replacement of defective parts must be postponed, temporary measures may be acceptable at the Surveyor's discretion and a suitable condition of class will be imposed.

4 Survey programme, preparation and execution

4.1 General

4.1.1 The owner should be aware of the scope of the coming survey and instruct those who are responsible, such as the master or the superintendent, to prepare necessary arrangements. If there is any doubt, the Classification Society concerned should be consulted.

4.1.2 Survey execution will naturally be heavily influenced by the type of survey to be carried out. The scope of survey will have to be determined prior to the execution.

4.1.3 The Surveyor should study the ship's structural arrangements and review the ship's operation and survey history and those of sister ships where possible, to identify any known potential problem areas particular to the type of ships. Sketches of typical structural elements should be prepared in advance so that any defects and/or ultrasonic thickness measurements can be recorded rapidly and accurately.

4.2 Survey Programme

4.2.1 The Owner in co-operation with the Classification Society is to work out a specific Survey Programme prior to commencement of any part of:

- the Special Survey;
- the Intermediate Survey for oil tankers over 10 years of age.

4.2.2 The Survey Programme is to be in a written format. The Survey programme at Intermediate Survey may consist of the Survey Programme at the previous Special Survey supplemented by the Executive Hull Summary of that Special Survey and later relevant survey reports.

The Survey Program is to be worked out taking into account any amendments to the survey requirements implemented after the last Special Survey carried out.

4.2.3 The Survey Programme should account for and comply with the requirements for close-up examinations, thickness measurements and tank testing, and take into consideration the conditions for survey, access to structures, cleanliness and illumination of tanks, and equipment for survey, respectively, and is to include relevant information including at least:

- basic ship information and particulars;
- main structural plans (scantling drawings), including information regarding the use of high tensile steels (HTS);
- plan of tanks;
- list of tanks with information on use, corrosion prevention and condition of coating;
- conditions for survey (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.);

- provisions and methods for access to structures;
- equipment for surveys;
- nomination of tanks and areas for close-up survey;
- nominations of sections for thickness measurement;
- nomination of tanks for tank testing;
- damage experience related to the ship in question.

4.2.4 In developing the Survey Programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas, and structural elements to be examined:

- survey status and basic ship information;
- documentation on-board, as described in 4.10;
- main structural plans (scantlings drawings), including information regarding the use of high tensile steels (HTS);
- relevant previous survey and inspection reports from both Classification Society and the Owner;
- information regarding the use of the ship's tanks, typical cargoes and other relevant data;
- information regarding corrosion prevention level on the new-building;
- information regarding the relevant maintenance level during operation.

4.2.5 In developing the Survey Programme, the Classification Society will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

4.2.6 Minimum requirements regarding close-up surveys and thickness measurements are stipulated in BCS-R Z10.4.

4.3 Survey Planning Meeting

4.3.1 Prior to the commencement of any part of the Special Survey and Intermediate Survey a survey planning meeting is to be held between the attending Surveyor(s), the Owner's Representative in attendance and the TM company representative, where involved.

4.4 Conditions for survey

4.4.1 The owner is to provide the necessary facilities for a safe execution of the survey.

4.4.2 Tanks and spaces are to be safe for access, i.e. gas freed, ventilated and illuminated.

4.4.3 In preparation for survey and thickness measurements and to allow for a thorough

examination, all spaces are to be cleaned including removal from surfaces of all loose accumulated corrosion scale. Spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. to reveal corrosion, deformation, fractures, damages, or other structural deterioration. However, those areas of structure whose renewal has already been decided by the owner need only be cleaned and descaled to the extent necessary to determine the extent of the areas to be renewed.

4.4.4 Sufficient illumination is to be provided to reveal significant corrosion, deformation, fractures, damages or other structural deterioration.

4.5 Access Arrangements and Safety

4.5.1 In accordance with the intended survey, measures are to be provided to enable the hull structure to be surveyed and thickness measurement carried out in a safe and practical way.

4.5.2 For close-up surveys in a cargo tank and ballast tanks, one or more of the following means for access, acceptable to the Surveyor, are to be discussed in the planning stage and provided:

a) permanent staging and passages through structures;
b) temporary staging, e.g. ladders and passages through structures;
c) lifts and movable platforms;
d) boats or rafts; and
e) other equivalent means.

4.5.3 In addition, particular attention should be given to the following guidance:

(a) Prior to entering tanks and other closed spaces, e.g. chain lockers, void spaces, it is necessary to ensure that the oxygen content has been tested and confirmed as safe. A responsible member of the crew should remain at the entrance to the space and if possible communication links should be established with both the bridge and engine room. Adequate lighting should be provided in addition to a hand held torch (flashlight).

(b) In tanks where the structure has been coated and recently de-ballasted, a thin slippery film may often remain on the surfaces. Care should be taken when inspecting such spaces.

(c) The removal of scale may be extremely difficult. The removal of scale by hammering may cause sheet scale to fall, and in cargo tanks this may result in residues of cargo falling from above. When using a chipping or scaling hammer care should be taken to protect eyes, and where possible safety glasses should be worn. If the structure is heavily scaled then it may be necessary to request de-scaling before conducting a satisfactory visual examination.

(d) When entering a cargo or ballast tank the access ladders and permanent access if fitted should be examined prior to being used to ensure that they are in good condition and rungs/platforms are not missing or loose. One person at a time should descend or ascend the ladder.

(e) If a portable ladder is used for survey purposes, the ladder should be in good condition and fitted with adjustable feet, to prevent it from slipping. Refer to BCS-G 78, Safe Use of Portable Ladders for Close-Up Surveys.

(f) Staging is the most common means of access provided especially where repairs or renewals are being carried out. It should always be correctly supported and fitted with handrails. Planks should be free from splits and lashed down. Staging erected hastily by inexperienced personnel should be avoided.
(g) In double bottom tanks there will often be a build up of mud on the bottom of the tank and this should be removed, in particular in way of tank boundaries, suction and sounding pipes, to enable a clear assessment of the structural condition.
(h) For ships built in compliance with SOLAS 74 (as amended) Regulation II-1/3-6, the approved ship structure access manual should be consulted before the survey.

4.5.6 Ventilation and Inerting Requirements for Double Hull Spaces

Due to the cellular construction of the double hull tanker, proper means of ventilation should be provided to avoid the accumulation of noxious or flammable gases, and to ensure a continuous safe environment for inspection and maintenance. It is also necessary to provide means of inerting and purging ballast tanks in the event of oil leak or hydrocarbon gas presence.

The most common method to provide a safe condition for personnel entry into double hull water ballast tanks is by ballasting and subsequently emptying the tank, thus allowing fresh air to fill all cellular compartments. However, this method may not be feasible during cargo laden voyages due to loadline, longitudinal strength and local strength limitations.

Conventional Tank Ventilation Method

Conventional means of tank ventilation and gas freeing by blowing fresh air through deck openings is effective for vertical side tanks and "U" shaped ballast tanks, but it is inadequate for "L" or "J" shaped ballast tanks

Ventilation by Ballast Pipe

One method of ballast tank venting and gas freeing is to supply fresh air through the ballast piping system. The inert gas fan can be used for the gas freeing operation. However, a separate ventilation fan should be provided to supply the fresh air for tank entry. This method has a significant drawback during cargo loading and discharging operations, since the ballast piping will be needed for ballast transfer, and will not be available for venting and gas freeing.

Ventilation by Purge Pipe

Another method of ballast tank venting and gas freeing is the use of portable gas freeing fans mounted on top of purge pipes to remove air from double bottom spaces. The fresh air is pulled down into the tank through open tank hatches on deck. Each purge pipe should extend from the upper deck to the double bottom space, and be lead inboard to the ship's centreline. This method is most effective for "L" or "J" shaped ballast tanks to allow fresh air to reach every corner in the double bottom space.

Inerting by Deck Inert Gas Lines

A method of inerting ballast tanks is to supply the inert gas by portable flexible ducts from the inert gas main lines on deck through access hatches and/or tank cleaning hatches. Alternatively, fixed gas deck branch lines may be installed. The tank atmosphere changing methods will be identical as for venting and gas freeing. Purge pipes will be needed for "L" and “J" shaped ballast tanks.

4.6 Use of Boats or Rafts

4.6.1 A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. This system must also include the personnel in charge of ballast pump handling.

4.6.2 Explosimeter, oxygen-meter, breathing apparatus, lifeline and whistles are to be at hand during the survey. When boats or rafts are used, appropriate life jackets are to be available for all participants. Boats or rafts are to have satisfactory residual buoyancy and stability even if one chamber is ruptured. A safety checklist is to be provided.

4.6.3 Surveys of tanks by means of boats or rafts may only be undertaken at the sole discretion of the Surveyor, who is to take into account the safety arrangements provided, including weather forecasting and ship response under foreseeable conditions and provided the expected rise of water within the tank does not exceed 0.25 metres.

4.6.4 Rafts or boats alone may be allowed for survey of the under deck areas for tanks or spaces, if the depth of the webs is 1.5 m or less.
If the depth of the webs is more than 1.5 m, rafts or boats alone may be allowed only:

.1 when the coating of the under deck structure is in GOOD condition and there is no evidence of wastage; or

.2 if a permanent means of access is provided in each bay to allow safe entry and exit. This means:

- .1 access direct from the deck via a vertical ladder and a small platform fitted approximately 2 m below the deck in each bay; or
- .2 access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform shall, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water level is to be assumed not more than 3m from the deck plate measured at the midspan of deck transverses and in the middle length of the tank. See Figure 11.

If neither of the above conditions are met, then staging or an “other equivalent means” is to be provided for the survey of the under deck areas.

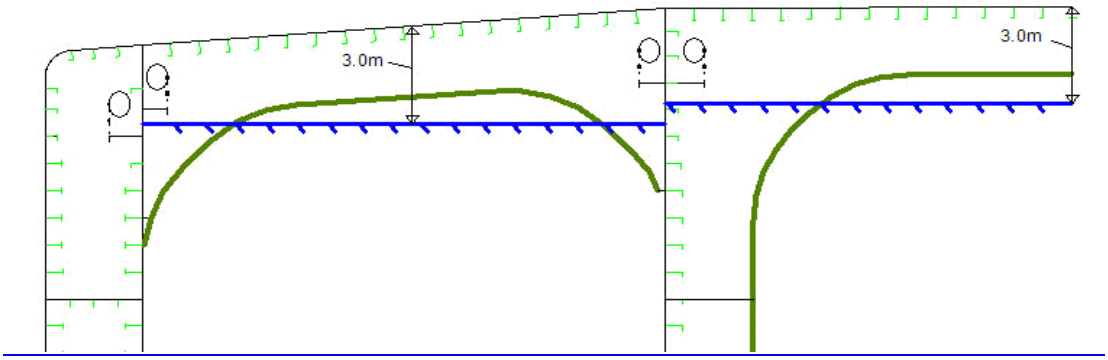


Figure 11

The use of rafts or boats alone does not preclude the use of boats or rafts to move about within a tank during a survey.

Reference is made to BCS-G 39 - Guidelines for the Safe Use of Rafts or Boats for Close- up surveys.

4.7 Personal equipment

4.7.1 The following protective clothing and equipment to be worn as applicable during the surveys:

(a) Working clothes: Working clothes should be of a low flammability type and be easily visible.

(b) Head protection: Hard hat (metal hats are not allowed) shall always be worn outside office buildings/unit accommodations.

(c) Hand and arm protection: Various types of gloves are available for use, and these should be used during all types of surveys. Rubber/plastic gloves may be necessary when working in cargo tanks.

(d) Foot protection: Safety shoes or boots with steel toe caps and non slip soles shall always be worn outside office buildings/unit accommodations. Special footwear may be necessary on slippery surfaces or in areas with chemical residues.

(e) Ear protection: Ear muffs or ear plugs are available and should be used when working in noisy areas. As a general rule, you need ear protection if you have to shout to make yourself understood by someone standing close to you.

(f) Eye protection: Goggles should always be used when there is danger of getting solid particles or dust into the eyes. Protection against welding arc flashes and ultraviolet light should also be considered.

(g) Breathing protection: Dust masks shall be used for protection against the breathing of harmful dusts, paint spraying and sand blasting. Gas masks and filters should be used by personnel working for short periods in an atmosphere polluted by gases or vapour.
(Self-contained breathing apparatus: Surveyors shall not enter spaces where such equipment is necessary due to unsafe atmosphere. Only those who are specially trained and familiar with such equipment should use it and only in case of emergency).

(h) Lifejacket: Recommended to be used when embarking/disembarking ships offshore from/to pilot boat.

4.7.2 The following survey equipment is to be used as applicable during the surveys:

(a) Torches: Torches (Flashlights) approved by a competent authority for use in a flammable atmosphere shall be used in gas dangerous areas. High intensity beam type is recommended for in-tank surveys. Torches are recommended to be fitted with suitable straps so that both hands may be free.

(b) Hammer: In addition to its normal purposes the hammer is recommended for use during surveys inside tanks etc. as it may be most useful for the purpose of giving distress signal in case of emergency.

(c) Oxygen analyser/Multigas detector: For verification of acceptable atmosphere prior to tank entry, pocket size instruments which give audible alarm when unacceptable limits are reached are recommended. Such equipment shall have been approved by national authorities.

(d) Safety belts and lines: Safety belts and lines should be worn where high risk of falling down from more than 3 metres is present.

4.8 Thickness measurement and fracture detection

4.8.1 Thickness measurement is to comply with the requirements of the Classification Society concerned. Thickness measurement should be carried out at points that adequately represent the nature and extent of any corrosion or wastage of the respective structure (plate, web, etc.). Thickness measurements of structures in areas where close-up surveys are required shall be carried out simultaneously with the close-up surveys.

4.8.2 Thickness measurement is normally carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven as required.

4.8.3 Thickness measurements required, if not carried out by the Society itself are to be witnessed by a Surveyor on board to the extent necessary to control the process.

4.8.4 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measurement equipment, names of personnel and their qualifications and has to be signed by the operator. Upon completion of the thickness measurements onboard, the Surveyor should verify and keep a copy of the preliminary thickness measurement report signed by the operator until such time as the final report is received. The Surveyor is to review the final thickness measurement report and countersign the cover sheet.

4.8.5 The thickness measurement company should be part of the survey planning meeting to be held prior to the survey.

4.8.6 One or more of the following fracture detection procedures may be required if deemed necessary and should be operated by experienced qualified technicians:

(a) radiographic equipment
(b) ultrasonic equipment
(c) magnetic particle equipment
(d) dye penetrant

4.9 Survey at sea or at anchorage

4.9.1 Voyage surveys may be accepted provided the survey party is given the necessary assistance from the shipboard personnel. The necessary precautions and procedures for carrying out the survey are to be in accordance with **4.1** to **4.8** inclusive. Ballast, cargo and inert gas piping systems must be secured at all times during tank surveys.

4.9.2 A communication system is to be arranged between the survey party in the spaces under examination and the responsible officer on deck.

4.10 Documentation on board

4.10.1 The following documentation is to be placed on board and maintained and updated by the owner for the life of ship in order to be readily available for the survey party.

4.10.2 Survey Report File: This file includes Reports of Structural Surveys, Executive Hull Summary and Thickness Measurement Reports.

4.10.3 Supporting Documents: The following additional documentation is to be placed on board, including any other information that will assist in identifying Suspect Areas requiring examination:

- Survey Programme as required by **4.2** until such time as the Special Survey or Intermediate Survey, as applicable, has been completed;
- main structural plans of cargo and ballast tanks;
- previous repair history;
- cargo and ballast history;
- extent of use of inert gas plant and tank cleaning procedures;
- surveys by ship's personnel;
- structural deterioration in general;
- leakage in bulkheads and piping;
- condition of coating or corrosion prevention system, if any;
- any other information that will help identify Suspect Areas requiring survey.

4.10.4 Prior to survey, the completeness of the documentation onboard, and its contents as a basis for the survey should be examined.

4.11 Reporting and Evaluation of Survey

4.11.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

4.11.2 In case of oil tankers of 130 m in length and upwards (as defined in the International Convention on Load Lines in force), the ship's longitudinal strength is to be evaluated by using the thickness of structural members measured, renewed and reinforced, as appropriate, during the special survey carried out after the ship reached 10 years of age in accordance with the criteria for longitudinal strength of the ship's hull girder for oil tankers.

4.11.3 The final result of evaluation of the ship's longitudinal strength required in 4.11.2, after renewal or reinforcement work of structural members, if carried out as a result of initial evaluation, is to be reported as a part of the Executive Hull Summary.

4.11.4 As a principle, for oil tankers subject to ESP, the Classification Society Surveyor is to include the following content in his report for survey of hull structure and piping systems, as relevant for the survey.

.1 General

1.1 A survey report is to be generated in the following cases:

- In connection with commencement, continuation and / or completion of periodical hull surveys, i.e. annual, intermediate and special surveys, as relevant.
- When structural damages / defects have been found.
- When repairs, renewals or modifications have been carried out.
- When condition of class has been imposed or deleted.

1.2 The purpose of reporting is to provide:

- Evidence that prescribed surveys have been carried out in accordance with applicable classification rules.
- Documentation of surveys carried out with findings, repairs carried out and condition of class imposed or deleted.
- Survey records, including actions taken, which shall form an auditable documentary trail. Survey reports are to be kept in the survey report file required to be on board.
- Information for planning of future surveys.
- Information which may be used as input for maintenance of classification rules and instructions.

.2 Extent of Survey

The extent of the survey in the report is to include the following:

- Identification of compartments where an overall survey has been carried out.

- Identification of locations, in each tank, where a close-up survey has been carried out, together with information of the means of access used.
- Identification of locations, in each tank, where thickness measurement has been carried out.
- For areas in tanks where protective coating is found to be in GOOD condition and the extent of close-up survey and / or thickness measurement has been specially considered, structures subject to special consideration are to be identified.
- Identification of tanks subject to tank testing.
- Identification of cargo piping on deck, including crude oil washing (COW) piping, and cargo and ballast piping within cargo and ballast tanks, pump rooms, pipe tunnels and void spaces, examined and where operational test to working pressure has been carried out.

.3 Result of the survey

Type, extent and condition of protective coating in each tank, as relevant (rated GOOD, FAIR or POOR).

Structural condition of each compartment with information on the following, as relevant:

Identification of findings, such as:

- Corrosion with description of location, type and extent;
- Areas with substantial corrosion;
- Cracks / fractures with description of location and extent;
- Buckling with description of location and extent;
- Indents with description of location and extent;
- Identification of compartments where no structural damages/defects are found.

The report may be supplemented by sketches/photos.

Evaluation result of longitudinal strength of the hull girder of oil tankers of 130 m in length and upwards and over 10 years of age. The following data is to be included, as relevant:

- Measured and as-built transverse sectional areas of deck and bottom flanges;
- Diminution of transverse sectional areas of deck and bottom flanges;
- Calculation of the transverse section modulus of hull girder, as relevant;
- Details of renewals or reinforcements carried out, as relevant (as per 4.2).

.4 Actions taken with respect to findings

Whenever the attending Surveyor is of the opinion that repairs are required, each item to be repaired is to be identified in a numbered list. Whenever repairs are carried out, details of the repairs effected are to be reported by making specific reference to relevant items in the numbered list.

Repairs carried out are to be reported with identification of:

- Compartment
- Structural member

- Repair method (i.e. renewal or modification)
- Repair extent
- NDT / Tests

For repairs not completed at the time of survey, condition of class ~~(recommendation)~~ is to be imposed with a specific time limit for the repairs. In order to provide correct and proper information to the Surveyor attending for survey of the repairs, condition of class is to be sufficiently detailed with identification of each item to be repaired.
For identification of extensive repairs, reference may be given to the survey report.

4.11.5 An Executive Hull Summary of the survey and results is to be issued to the Owner and placed on board the vessel for reference at future surveys. The Executive Hull Summary is to be endorsed by the Classification Society's head office or regional managerial office.

5 Structural detail failures and repairs

5.1 General

5.1.1 The catalogue of structural detail failures and repairs contained in this section of the Guidelines collates data supplied by BCS and is intended to provide guidance when considering similar cases of damage and failure. The proposed repairs reflect the experience of the Surveyors of BCS, but it is realized that other satisfactory alternative methods of repair may be available. However, in each case the repairs are to be completed to the satisfaction of BCS Surveyor concerned. Identified reoccurring failures after repairs may require further investigation.

5.2 Actions to be takeny BCS when Fatigue Failures have been Identified

5.2.1 Whenever a fatigue failure has been identified on a ship a detailed structural survey with close-up examination of similar locations on that ship should be carried out.

5.2.2 Assessment of fatigue failures should be carried out by BCS when fatigue failures are identified in the cargo area in the following cases:

a. Ships 5 years of age and less.
b. Ships 10 years of age and less when the fatigue failure occurs in the structural details, which are present in a large number onboard the ship or when the fatigue failure may have serious consequences.
c. When similar fatigue failures have been identified on sister ships 10 years of age and less.

In ships more than 10 years of age fatigue failure assessment may be waived at the discretion of BCS.

5.2.3 Assessment of fatigue failure implies structural analysis to be carried out with a scope of:

a. The possible cause of failure;
b. The need for proactive repairs, reinforcements and/or modifications;
c. The most effective and practical repair;
d. The need for detailed structural surveys on sister/similar ships as defined in BCS- PR 2.

The structural analysis may be carried out by means of simple beam or finite element analysis.

5.2.4 The proactive measures identified in the structural assessment are to be carried out to the satisfaction of BCS.

5.2.5 If applicable the requirements of BCS -PR 2, "Procedure for Failure Incident Reporting and Early Warning of Serious Failure Incidents – Early Warning Scheme- EWS " are to be applied.

5.3 Catalogue of structural detail failures and repairs

5.3.1 The catalogue has been sub-divided into groups to be given particular attention during the surveys:

Group No.	Description of Structural Group
1	Bilge Hopper
2	Wing Ballast Tank
3	Bottom Ballast Tank
4	Web Frames in Cargo Tanks
5	Transverse Bulkheads in Cargo Tank
6	Deck Structure
7	Fore and Aft End Regions
8	Machinery and Accommodation Spaces

Group 1 Bilge Hopper

Contents

1 General

2 What to look for – Bilge Hopper Plating survey
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for - Hopper Tank survey
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 What to look for - External bottom survey
- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures

5 General comments on repair
- 5.1 Material wastage
- 5.2 Deformations
- 5.3 Fractures

Examples of structural detail failures and repairs – Group 1

Example No.	Title
1	Fracture on the inner bottom plating at the connection of hopper plate to inner bottom
2	Fracture at connection of bilge hopper plate and inner bottom
3	Fracture at connection of bilge hopper plate and inner bottom
4	Fracture at connection of bilge hopper plate and inner bottom
5	Fractured floor and inner bottom plate in way of juncture of inner bottom to hopper plate
6	Fracture at connection of bilge hopper plate and web frame
7	Rounded hopper plate deformation in way of the floor
8	Fracture at the connection of hopper plate to outside longitudinal bulkhead
9	Fracture in gusset plate in line with inner bottom
10	Fracture in way of cut-out in hopper plate

1 General

1.1 The bilge hopper together with the double bottom and double side tanks and spaces, protect the cargo tanks or spaces, and are not to be used for the carriage of oil cargoes.

1.2 In addition to general corrosion, the welds and connections of the tank top/hopper sloping plating may be prone to fatigue.

1.3 The bilge hopper contributes to the longitudinal hull girder strength and supports the double bottom and double side construction.

1.4 Weld defects and/or misalignment between hopper plate, inner bottom and longitudinal girder may lead to problems in view of the stress concentrations at this juncture. This may also be the case at the upper end of the hopper plate connection with the inner hull longitudinal bulkhead and horizontal girder.

2 What to look for – Bilge Hopper Plating survey

2.1 Material wastage

2.1.1 The general corrosion condition of the bilge hopper structure may be observed by visual survey. The level of wastage of bilge hopper plating may have to be established by means of thickness measurement.

2.2 Deformations

2.2.1 Buckling of the bilge hopper plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses.

2.2.2 Whenever deformations are observed on the bilge hopper, further survey in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coating within the double bottom, which in turn may lead to accelerated corrosion rate in these unprotected areas.

2.3 Fractures

2.3.1 Fractures will normally be found by close-up survey. Fractures that extend through the thickness of the plating or through the welds may be observed during pressure testing of the double bottom tanks.

3 What to look for - Hopper Tank survey

3.1 Material wastage

3.1.1 The level of wastage of hopper side internal structure (longitudinals, transverses, floors, girders, etc.) may have to be established by means of thickness measurements.

Rate and extent of corrosion depends on the corrosive environment, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (also see **3.1.2** - **3.1.3**).

(a) Structure in corrosive environment:
- Transverse bulkhead and girder adjacent to heated fuel oil or cargo oil tanks.

(b) Structure subject to high stress:
- Face plates and web plates of transverse at corners;
- Connection of longitudinal to transverse.

(c) Areas susceptible to coating breakdown
- Back side of face plate of longitudinal;
- Welded joint;
- Edge of access opening.

(c) Areas subject to poor drainage:
- Web of side longitudinals.

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer severe localised corrosion. Transverse webs in the hopper tanks may suffer severe corrosion at their corners where high shearing stresses occur, especially where collar plate is not fitted to the slot of the longitudinal.

3.1.3 The high temperature due to heated cargo oil tanks may accelerate corrosion of ballast tank structure near heated cargo oil tanks. The rate of corrosion depends on several factors such as:

- Temperature and heat input to the ballast tank.
- Condition of original coating and its maintenance.
- Ballasting frequency and operations.
- Age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.2 Deformations

3.2.1 Where deformations are identified during bilge hopper plating survey (See **2.2**) and external bottom survey (See **4.2**), the deformed areas should be subjected to in tank survey to determine the extent of the damage to the coating and internal structure.

Deformations in the structure not only reduce the structural strength but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3 Fractures

3.3.1 Fractures will normally be found by close-up survey.

3.3.2 Fractures may occur in way of the welded or radiused knuckle between the inner bottom and hopper sloping plating if the side girder in the double bottom is not in line with the knuckle and also when the floors below have a large spacing, or when corner scallops are created for ease of fabrication. The local stress variations due to the loading and subsequent deflection may lead to the development of fatigue fractures which can be categorised as follows:

(a) Parallel to the knuckle weld for those knuckles which are welded and not radiused.

(b) In the inner bottom and hopper plating and initiated at the centre of a radiused knuckle.

(c) Extending in the hopper web plating and floor weld connections starting at the corners of scallops, where such exist, in the underlying hopper web and floor.

(d) Extending in the web plate as in (c) above but initiated at the edge of a scallop.

3.3.3 The fractures in way of connection of inner bottom plating/hopper sloping plating to stool may be caused by the cyclic deflection of the inner bottom induced by repeated loading from the sea or due to poor “through-thickness” properties of the inner bottom plating. Scallops in the underlying girders can create stress concentrations which further increase the risk of fractures. These can be categorised as follows: (See also **Examples of Structure Detail Failures of this Group**).

(a) In way of the intersection between inner bottom and stool. These fractures often generate along the edge of the welded joint above the centre line girder, side girders, and sometimes along the duct keel sides.

(b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with the watertight floors below the transverse bulkhead stools.

(c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets on the floors.

(d) Lamellar tearing of the inner bottom plate below the weld connection with a lower stool caused by high bending stresses. The size of stool and lack of full penetration welds could also be a contributory factor, as well as poor “through-thickness” properties of the tank top plating.

3.3.4 Transition region

In general, the termination of the following structural members at the collision bulkhead and engine room forward bulkhead is prone to fractures:

- Hopper tank sloping plating
- Panting stringer in fore peak tank
- Inner bottom plating in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

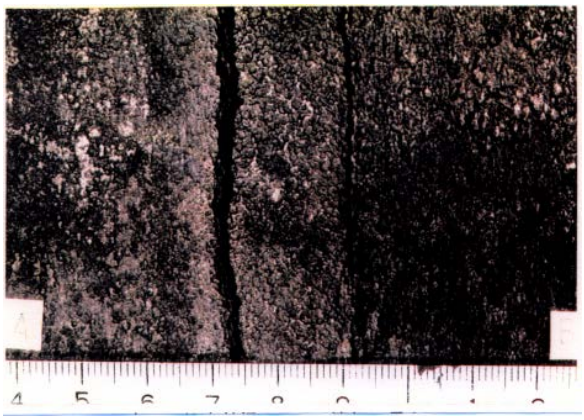
4 What to look for - External bottom survey

4.1 Material wastage

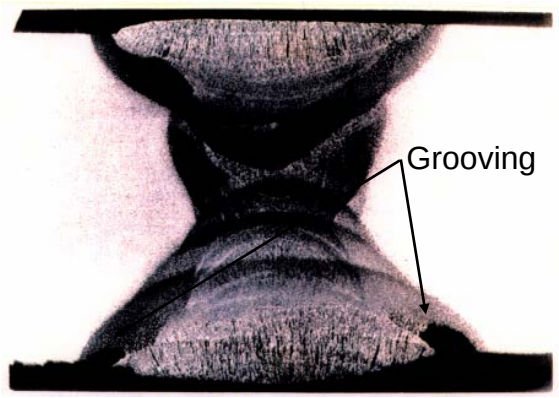
4.1.1 Hull structure below the water line can usually be inspected only when the ship is dry-docked. The opportunity should be taken to inspect the external plating thoroughly. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See **Photographs 1** and **2**). This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or “docking” plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating



Photograph 1
Grooving corrosion of welding of bottom plating



Photograph 2
Section of the grooving shown in Photograph 1

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations of bottom plating may also be attributed to dynamic force caused by wave slamming action at the forward part of the vessel, or contact with underwater objects. When deformation of the shell plating is found, the affected area should be inspected internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be inspected when the hull has dried since

fractures in shell plating can easily be detected by observing leakage of water from the cracks in clear contrast to the dry shell plating.

4.3.2 Fractures in butt welds and fillet welds, particularly at the wrap around at scallops and ends of bilge keel, are sometimes observed and may propagate into the bottom plating. The cause of fractures in butt welds is usually related to weld defect or grooving. If the bilge keels are divided at the block joints of hull, all ends of the bilge keels should be inspected.

5 General comments on repair

5.1 Material Wastage

5.1.1 Repair work in bilge hopper will require careful planning in terms of accessibility and gas freeing is required for repair work in cargo oil and fuel oil tanks.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit. When scattered deep pitting is found, it may be repaired by welding.

5.2 Deformations

Extensively deformed bilge hopper and bottom plating should be replaced together with the deformed portion of girders, floors or transverse web frames. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, the Classification Society concerned should be contacted.

5.3 Fractures

5.3.1 Repair should be carried out in consideration of nature and extent of the fractures.

(a) Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

(b) For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.

(c) For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

5.3.2 The fractures in the knuckle connection between inner bottom plating and hopper sloping plating should be repaired as follows.

(a) Where the fracture is confined to the weld, the weld is to be veed-out and renewed using full penetration welding, with low hydrogen electrodes or equivalent.

(b) Where the fracture has extended into the plating of any tank boundary, then the fractured plating is to be cropped, and part renewed.

(c) Where the fracture is in the vicinity of the knuckle, the corner scallops in floors and transverses are to be omitted, or closed by welded collars. The sequence of welding is important, in this respect every effort should be made to avoid the creation of locked in stresses due to the welding process.

(d) Where the floor spacing is 2.0m or greater, brackets are to be arranged either in the vicinity of, or mid-length between, floors in way of the intersection. The brackets are to be attached to the adjacent inner bottom and hopper longitudinals. The thickness of the bracket is to be in accordance with the Rules of the Classification Society concerned.

5.3.3 Fractures in the connection between inner bottom plating/hopper sloping plating and stool should be repaired as follows.

(a) Fractures in way of section of the inner bottom and bulkhead stool in way of the double bottom girders can be veed out and welded. However, reinforcement of the structure may be required, e.g. by fitting additional double bottom girders on both sides affected girder or equivalent reinforcement. Scallops in the floors should be closed and air holes in the non-watertight girders re-positioned.

If the fractures are as a result of differences in the thickness of adjacent stool plate and the floor below the inner bottom, then it is advisable to crop and part renew the upper part of the floor with plating having the same thickness and mechanical properties as the adjacent stool plating.

If the fractures are as a result of misalignment between the stool plating and the double bottom floors, the structure should be released to rectifying the misalignment.

(b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with watertight floors are to be cropped and partly renewed. In addition, brackets with soft toes are to be fitted in order to reduce the stress concentrations at the floors or stiffener.

(c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets are to be cropped and longitudinal part renewed if the fractures extend to over one third of the depth of the longitudinal. If fractures are not extensive these can be veed out and welded. In addition, reinforcement should be provided in the form of modification to existing bracket toes or the fitting of additional brackets with soft toes in order to reduce the stress concentration.

(d) Fractures at the corners of the transverse diaphragm/stiffeners are to be cropped and renewed. In addition, scallops are to be closed by overlap collar plates. To reduce the probability of such fractures recurring, consideration is to be given to one of the following reinforcements or modifications.

- The fitting of short intercostal girders in order to reduce the deflection at the

problem area.

(e) Lamellar tearing may be eliminated through improving the type and quality of the weld, i.e. full penetration using low hydrogen electrodes and incorporating a suitable weld throat.

Alternatively the inner bottom plating adjacent to and in contact with the lower stool plating is substituted with plating of “Z” quality steel, which has good “through-thickness” properties.

5.3.4 Bilge keel should be repaired as follows:

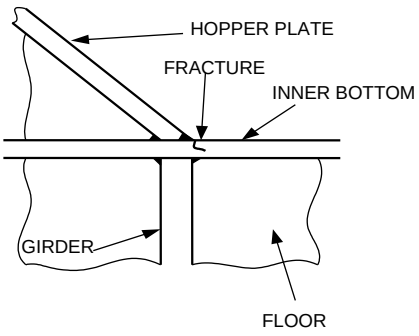
(a) Fractures or distortion in bilge keels must be promptly repaired. Fractured butt welds should be repaired using full penetration welds and proper welding procedures. The bilge keel is subjected to the same level of longitudinal hull girder stress as the bilge plating, fractures in the bilge keel can propagate into the shell plating.

(b) Termination of bilge keel requires proper support by internal structure. This aspect should be taken into account when cropping and renewing damaged parts of a bilge keel.

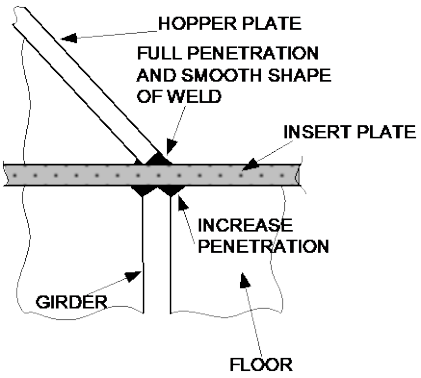
Group 1 Bilge Hopper

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	1
Detail of damage	Fracture on the inner bottom plating at the connection of hopper plate to inner bottom	

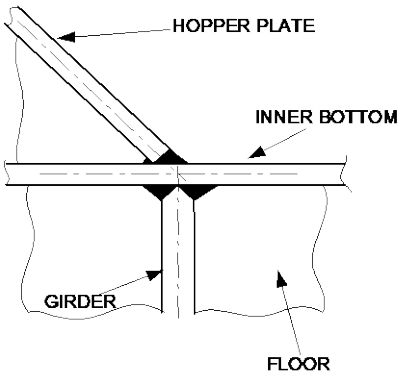
Sketch of damage



Sketch of repair



NEW CONSTRUCTION



Notes: Plate midlines intersect

Factors which may have caused damage

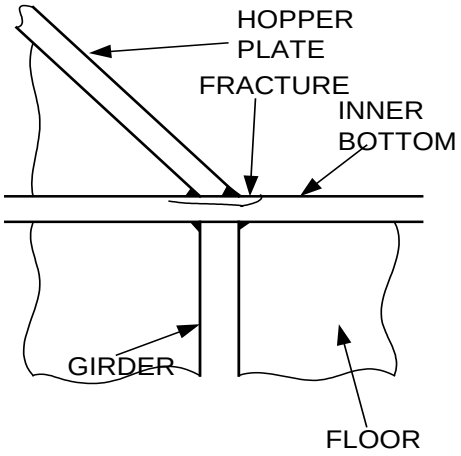
1. Stress concentration at juncture of hopper plate to inner bottom.
2. Insufficient welding connection.
3. Misalignment between hopper plate, inner bottom and girder.

Notes on repairs

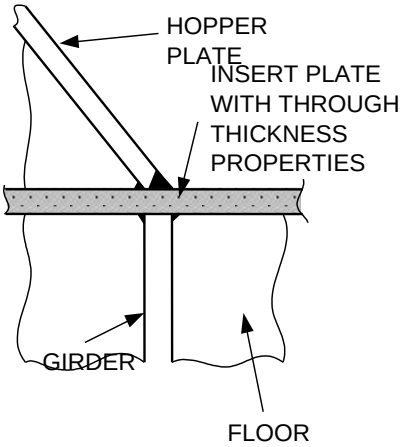
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	2
Detail of damage	Fracture at connection of bilge hopper plate and inner bottom	

Sketch of damage



Sketch of repair



Notes: Plate midlines intersect

Factors which may have caused damage

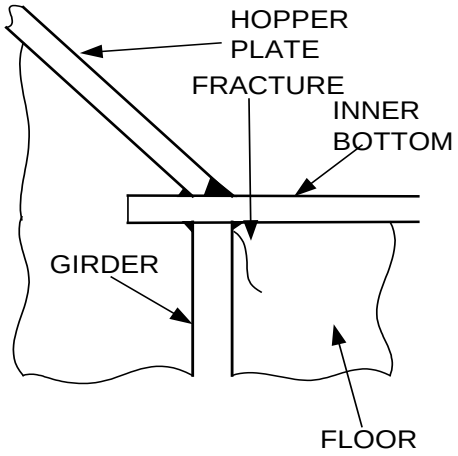
1. Stress concentration at the knuckle.

Notes on repairs

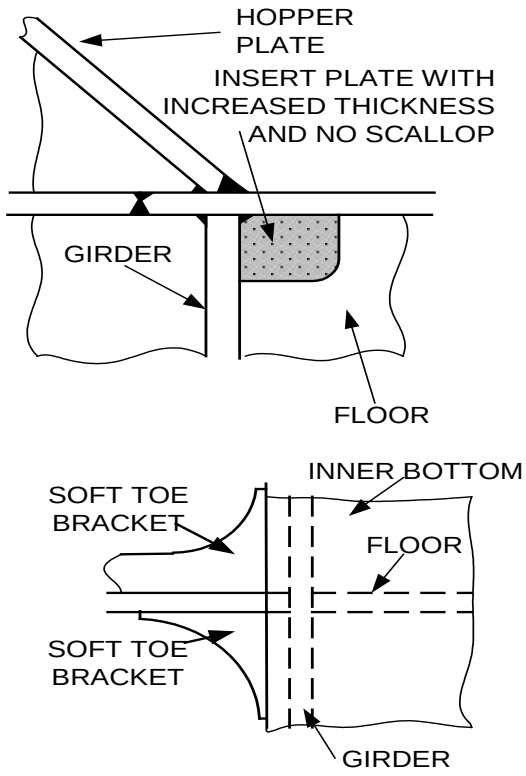
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	3
Detail of damage	Fracture at connection of bilge hopper plate and inner bottom	

Sketch of damage



Sketch of repair



Notes: Plate midlines intersect

Factors which may have caused damage

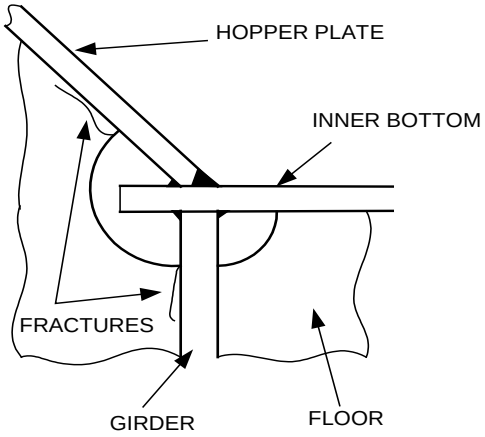
1. Stress concentration at the knuckle.

Notes on repairs

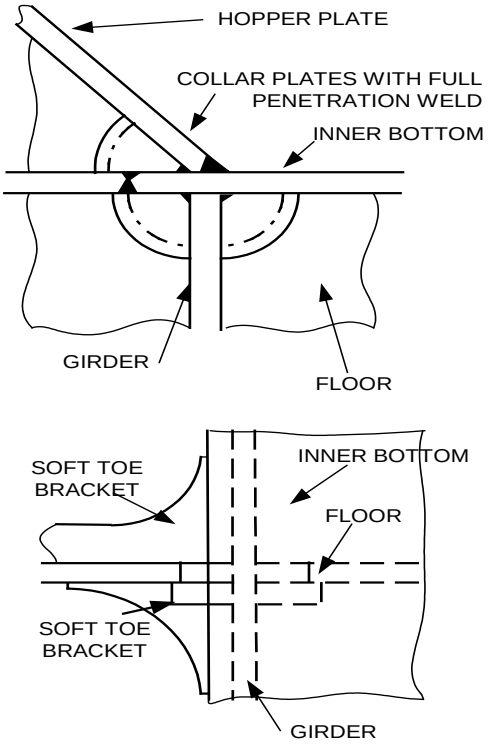
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	4
Detail of damage	Fracture at connection of bilge hopper plate and inner bottom	

Sketch of damage



Sketch of repair



Notes: Plate midlines intersect

Factors which may have caused damage

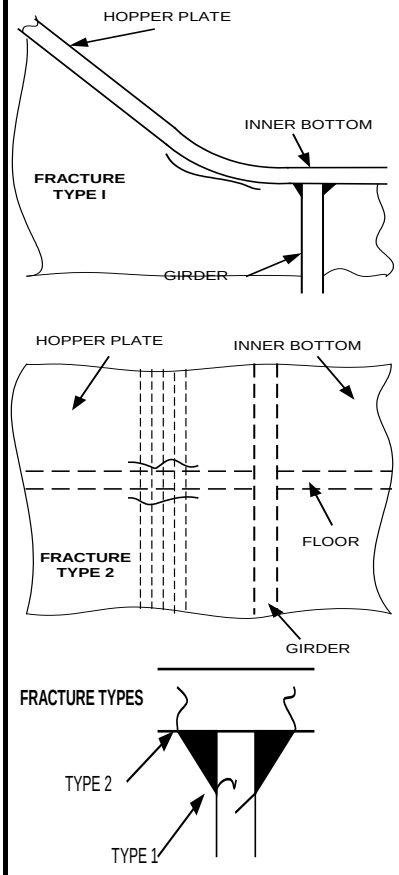
1. Stress concentration at the knuckle.

Notes on repairs

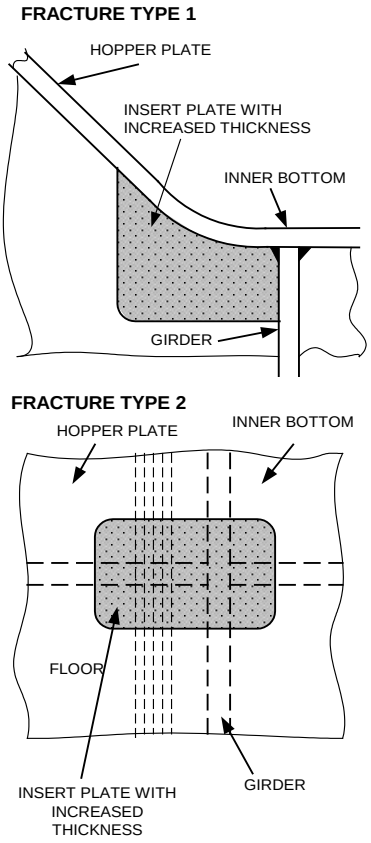
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	5
Detail of damage	Fractured floor and inner bottom plate in way of juncture of inner bottom to hopper plate	

Sketch of damage



Sketch of repair



Factors which may have caused damage

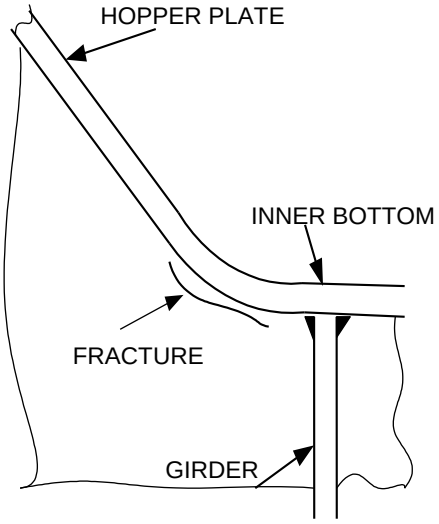
1. Misalignment. The three mid-lines do not cross at the same joint. This misalignment produces an out-of-plane deformation of inner bottom plate in way of knuckle line.
2. Stress concentration at connection between floor and inner bottom plate.
3. Static and dynamic load of ballast water.

Notes on repairs

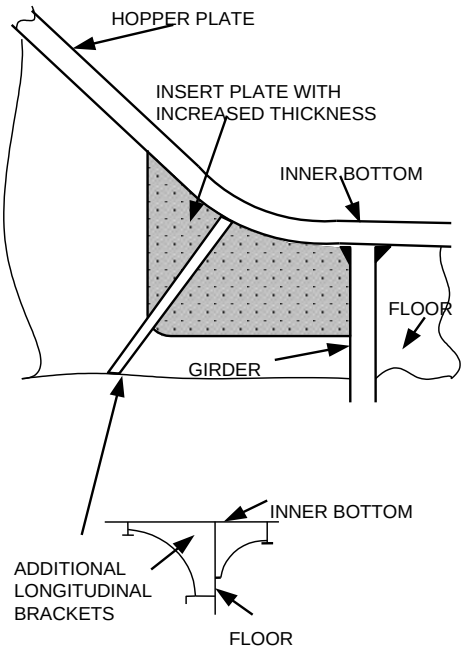
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	6
Detail of damage	Fracture at connection of bilge hopper plate and web frame	

Sketch of damage



Sketch of repair



Factors which may have caused damage

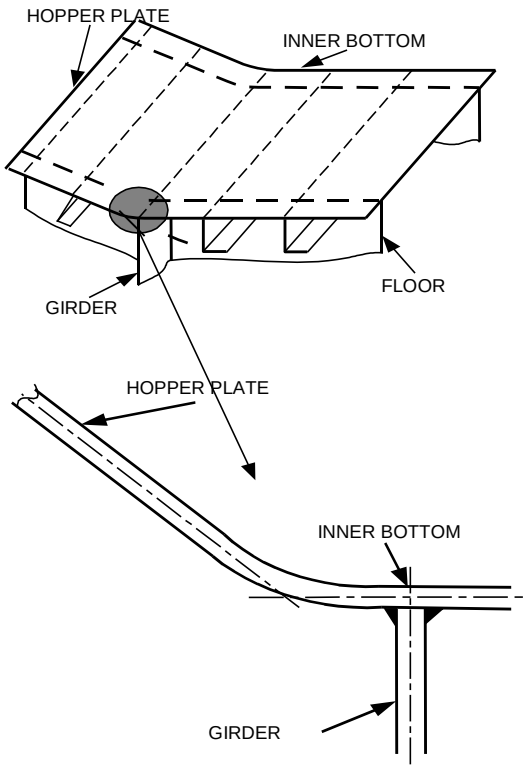
1. Stress concentration due to reduction of effective flange area at curved plate.

Notes on repairs

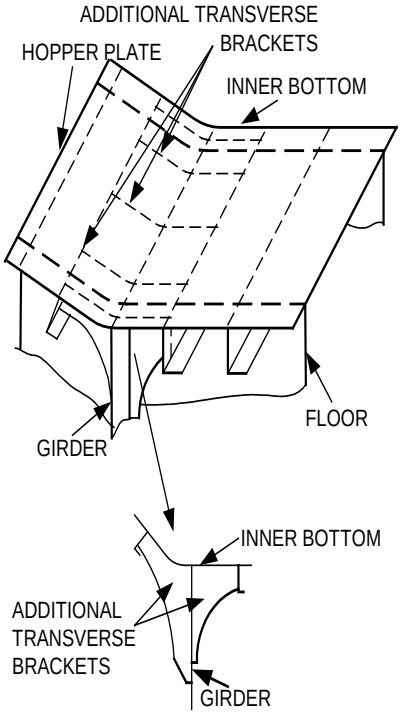
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	7
Detail of damage	Rounded hopper plate deformation in way of the floor	

Sketch of damage



Sketch of repair



Factors which may have caused damage

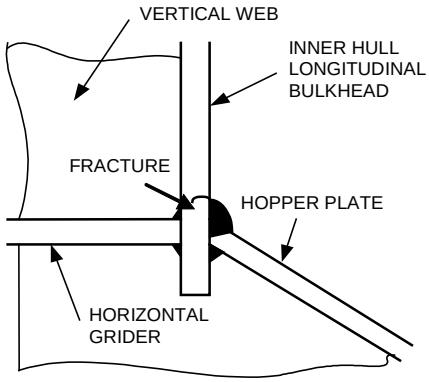
1. Misalignment. The three midlines do not cross at the same joint. This misalignment produces an out-of-plane deformation in knuckled plate in the vicinity of floor.
2. Insufficient stiffening between floors.

Notes on repairs

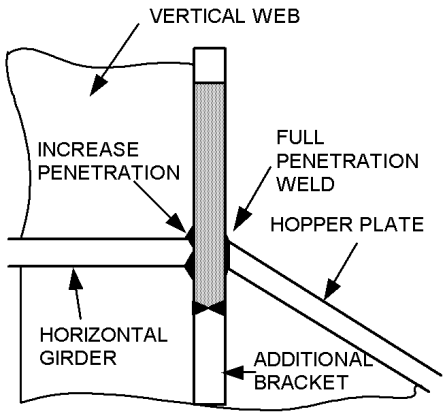
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Wing cargo tank	8
Detail of damage	Fracture at the connection of hopper plate to outside longitudinal bulkhead.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

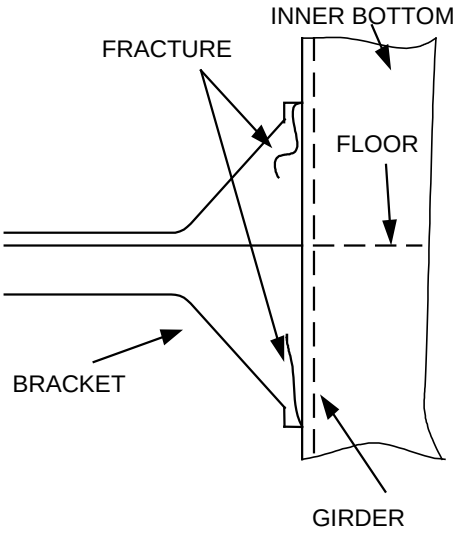
1. Stress concentration at junction of hopper plate to outside longitudinal bulkhead.
2. Insufficient welding connection and/or incorrect shape of the weld toe.
3. Misalignment between hopper plate, outside longitudinal bulkhead and side stringer.

Notes on repairs

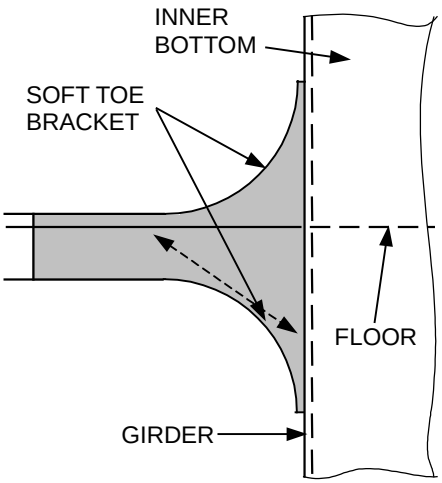
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper and double bottom ballast tank	9
Detail of damage	Fracture in gusset plate in line with inner bottom	

Sketch of damage



Sketch of repair



Notes: Bracket radii as large as practicable.
Bracket same thickness as inner bottom stiffener.
Toe height should be small as possible while still allowing return weld (wrapped weld).

Factors which may have caused damage

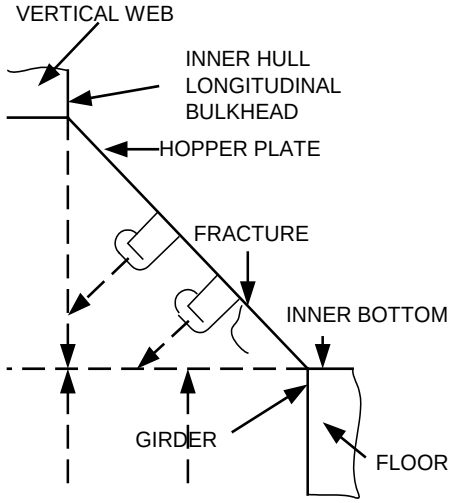
1. Stress concentration due to small radius and abrupt toe.
2. Insufficient welding.
3. Insufficient sectional area (thickness x breadth) of the connecting bracket.

Notes on repairs

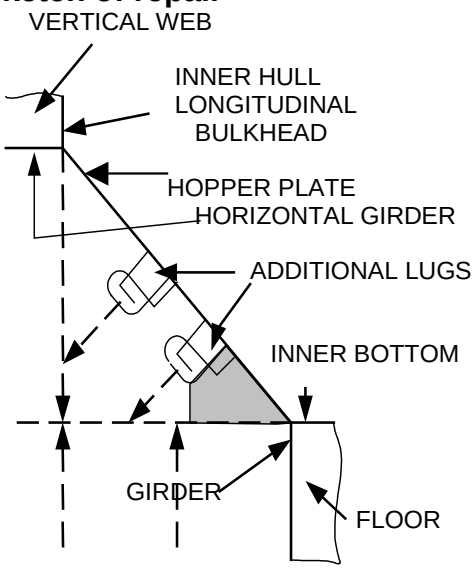
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 1	Cargo area	Example No.
	Hopper ballast tank	10
Detail of damage	Fracture in way of cut-out in hopper plate	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Stress concentration due to no collar plate.

Notes on repairs

See Sketch.

Group 2 Wing Ballast Tank

Contents

1 General

2 What to look for
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Examples of structural detail failures and repairs – Group 2

Example No.	Title
1	Crack in way of connection of longitudinals to transverse bulkhead
2	Crack in way of connection of longitudinals to transverse webs
3	Fracture in way of web and flat bar stiffener at cut outs for longitudinal stiffener connections
4	Fracture in way of web and flat bar stiffener at cut outs for longitudinal stiffener connections as Example 3 but with faceplate attached to underside of web. Flat bar lap welded.
5	Buckling in way of side web panels above hopper horizontal girder
6	Panels of side horizontal girders in way of transverse bulkhead
7	Fracture at connection of horizontal stringers to transverse web frames and horizontal girders

1 General

1.1 Wing Ballast tanks are highly susceptible to corrosion and wastage of the internal structure. This is a potential problem for all double hull tankers, particularly for ageing ships and others where the coatings have broken down. Coatings, if applied and properly maintained, serve as an indication as to whether the structure remains in satisfactory condition and highlights any structural defects.

In some ships wing ballast tanks are protected by sacrificial anodes in addition to coatings. This system is not effective for the upper parts of the tanks since the system requires the structure to be fully immersed in seawater, and the tanks may not be completely filled during ballast voyages.

1.2 Termination of longitudinals in the fore and aft regions of the ship, in particular at the collision and engine room bulkheads, is prone to fracture due to high stress concentration if the termination detail is not properly designed.

2 What to look for

2.1 Material wastage

2.1.1 The combined effect of the marine environment, high humidity atmosphere as well as adjacent heated cargo tanks within wing ballast tank will give rise to a high corrosion rate.

2.1.2 Rate and extent of corrosion depends on the environmental conditions, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion.

(a) Structure in corrosive environment:
- Deck plating and deck longitudinal
- Transverse bulkhead adjacent to heated fuel oil tank

(b) Structure subject to high stress:
- Connection of side longitudinal to transverse

(c) Areas susceptible to coating breakdown:
- Back side of faceplate of longitudinal
- Welded joint
- Edge of access opening

(d) Areas subjected to poor drainage:
- Web plating of side and sloping longitudinals

2.2 Deformations

2.2.1 Deformation of structure may be caused by contact (with quay side, ice, touching underwater objects, lightering service, etc.), collision, and high stress. Attention should be paid to the following areas during survey:

(a) Structure subjected to high stress
(b) Structure in way of tug/pier/fender contact

2.3 Fractures

2.3.1 Attention should be paid to the following areas during survey for fracture damage:

(a) Areas subjected to stress concentration
- Welded joints of faceplate of transverse at corners
- Connection of the lowest longitudinal to transverse web frame, especially with reduced scantlings.
- Termination of longitudinal in fore and aft wing tanks

(b) Areas subjected to dynamic wave loading
- Connection of side longitudinal to watertight bulkhead
- Connection of side longitudinal to transverse web frame

Photograph 1 Side shell fracture in way of horizontal stringer weld

2.3.2 The termination of the following structural members at the collision bulkhead prone to fracture damage due to discontinuity of the structure:
- Fore peak tank top plating (Boatswain’s store deck plating)

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

3 General comments on repair

3.1 Material wastage

3.1.1 If the corrosion is caused by high stress concentration, renewal with original thickness is not sufficient to avoid reoccurrence. Renewal with increased thickness and/or appropriate reinforcement should be considered in conjunction with appropriate corrosion protective measures.

3.2 Deformations

3.2.1 Any damage affecting classification should be reported to the classification society. If the deformation is considered to be related to inadequate structural strength, appropriate reinforcement should be carried out. Where the deformation is related to corrosion, appropriate corrosion prevention measures should be considered. Where the deformation is related to mechanical damages the structure is to be repaired as original.

3.3 Fractures

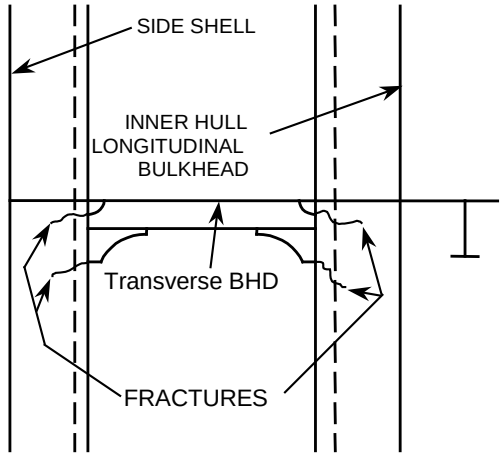
3.3.1 If the cause of the fracture is fatigue under the action of cyclic wave loading, consideration should be given to the improvement of structural detail design, such as provision of soft toe bracket, to reduce stress concentration. If the fatigue fracture is vibration related, the damage is usually associated with moderate stress levels at high cycle rate, improvement of structural detail may not be effective. In this case, avoidance of resonance, such as providing additional stiffening, may be considered.

Where fracture occurs due to material under excessive stress, indicating inadequate structural strength, renewal with thicker plate and/or providing appropriate reinforcement should be considered.

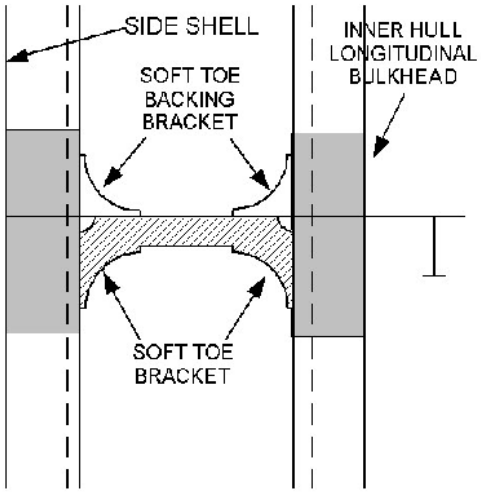
Group 2 Wing Ballast Tank

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	1
Detail of damage	Crack in way of connection of longitudinals to transverse bulkhead	

Sketch of damage



Sketch of repair



Factors which may have caused damage

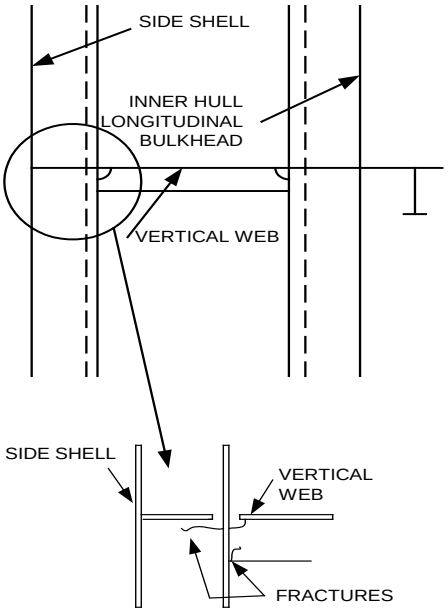
1. Asymmetrical connection of bracket without backing bracket.
2. Relative deflection of adjoining transverse web against transverse bulkhead.
3. Additional biaxial bending stresses due to asymmetry of the angle bar longitudinal instead of symmetric T section.
4. Dynamic load in the vicinity of the water line.
5. Large upstand at bracket toe.

Notes on repairs

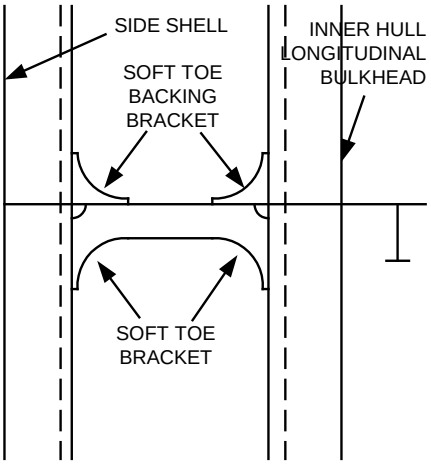
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	2
Detail of damage	Crack in way of connection of longitudinals to transverse webs	

Sketch of damage



Sketch of repair



Factors which may have caused damage

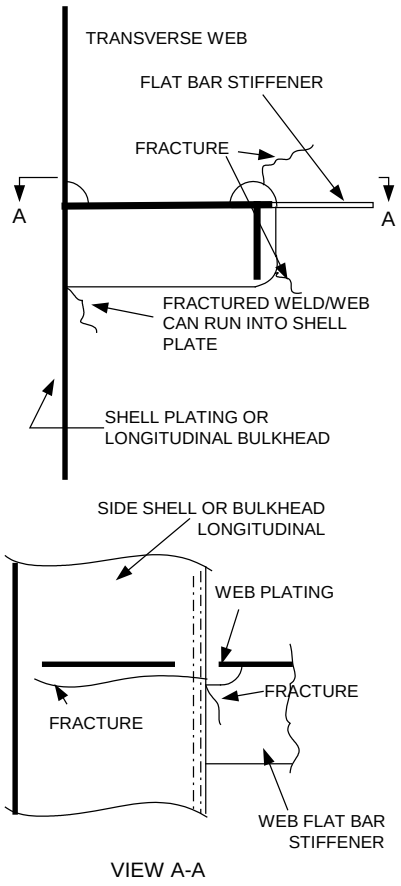
1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener.
2. Insufficient area of connection of longitudinal to web.
3. High bending stresses in the longitudinal.
4. Additional biaxial bending stresses due to asymmetry of the longitudinal (angle bar instead of symmetric T bar).
5. Stress concentration at the square angles at heel and toe of the connections.
6. High shear stress in the transverse web.

Notes on repairs

See Sketch.

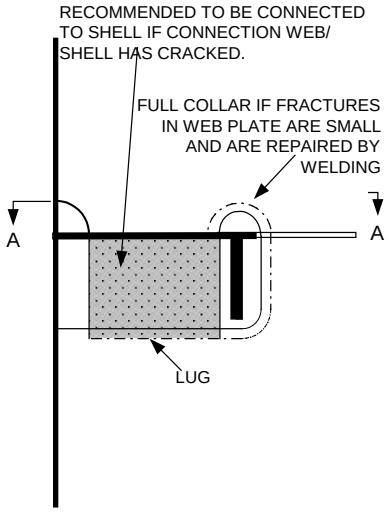
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	3
Detail of damage	Fracture in way of web and flat bar stiffener at cut outs for longitudinal stiffener connections.	

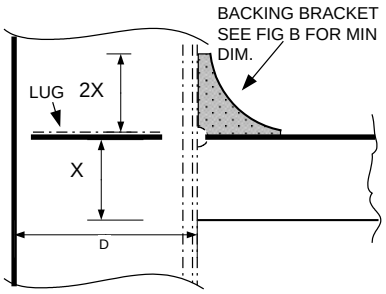
Sketch of damage



VIEW A-A

Sketch of repair





VIEW A-A

Insert longitudinal.

Factors which may have caused damage

1. Asymmetrical connection of flat bar stiffener resulting in high peak stress at heel of the stiffener under fatigue loading.
2. Insufficient area of connection of longitudinal to web plate.
3. Defective weld at return around the plate thickness.
4. High localized corrosion at areas of stress concentrations such as flat bar stiffener connections, corners of cut out for longitudinal and connection of web to shell at cut outs.
5. High shear stress in web of the transverse.
6. Dynamic seaway loads/motions.

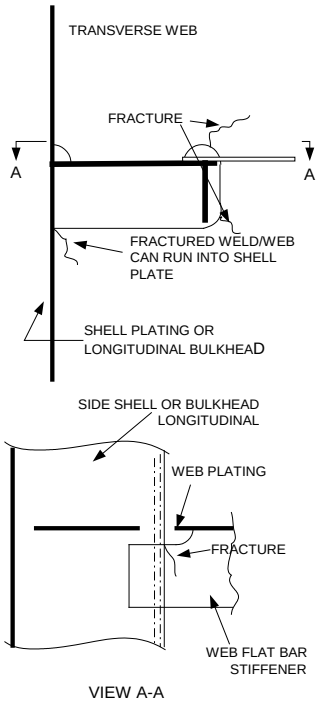
Notes on repairs

See Sketch.

May also fit a double bracket to avoid fracture from toe.

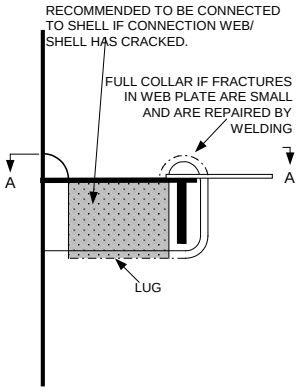
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	4
Detail of damage	Fracture in way of web and flat bar stiffener at cut outs for longitudinal stiffener connections as Example 3 but with faceplate attached to underside of web. Flat bar lap welded.	

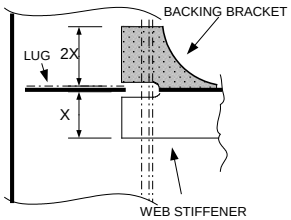
Sketch of damage



VIEW A-A

Sketch of repair





VIEW A-A

Insert web plate.

Factors which may have caused damage

1. Asymmetrical connection of flat bar stiffener resulting in high peak stress at heel of the stiffener under fatigue loading.
2. Fabricated longitudinal with welding onto exposed edge of the web resulting in poor fatigue strength of the connection of the longitudinal to the flat bar.
3. Insufficient area of connection of longitudinal to web plate.
4. Defective weld at return around the plate thickness.
5. High localized corrosion at areas of stress concentrations such as flat bar stiffener connections, corners of cut out for longitudinal and connection of lug to shell at cut outs.
6. High shear stress in web of the transverse.
7. Dynamic seaway loads/motions.

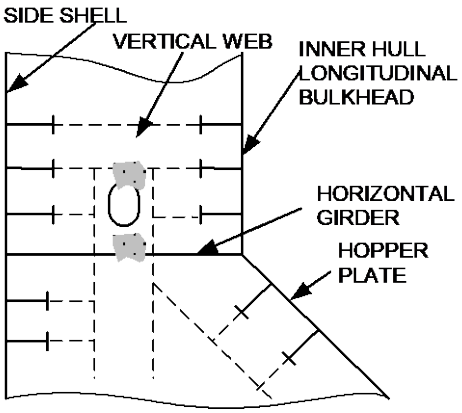
Notes on repairs

See Sketch.

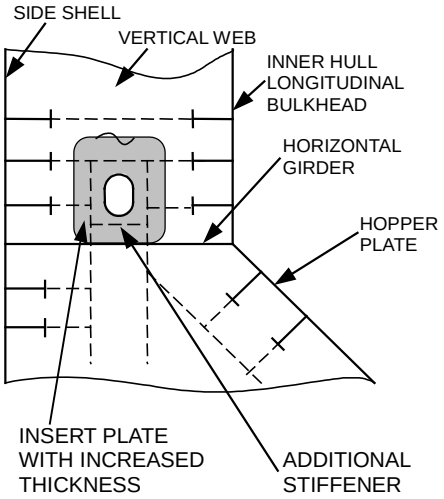
1. May also fit a double bracket to avoid fracture from toe.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	5
Detail of damage	Buckling in way of side web panels above hopper horizontal girder	

Sketch of damage



Sketch of repair



Factors which may have caused damage

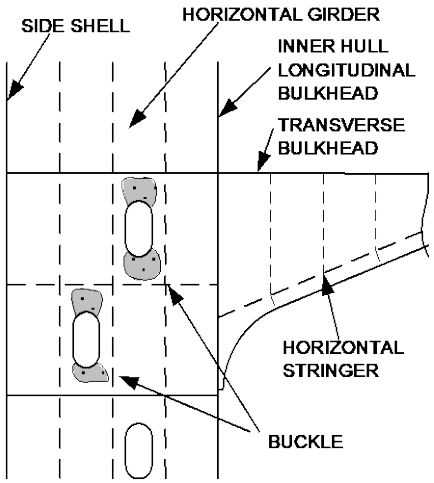
1. High shear stress in the transverse web.
2. Insufficient buckling strength.

Notes on repairs

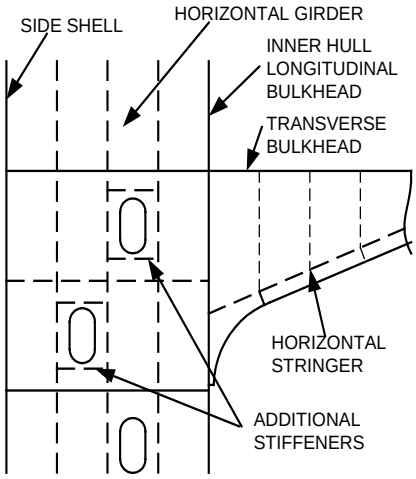
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	6
Detail of damage	Panels of side horizontal girders in way of transverse bulkhead	

Sketch of damage



Sketch of repair



Factors which may have caused damage

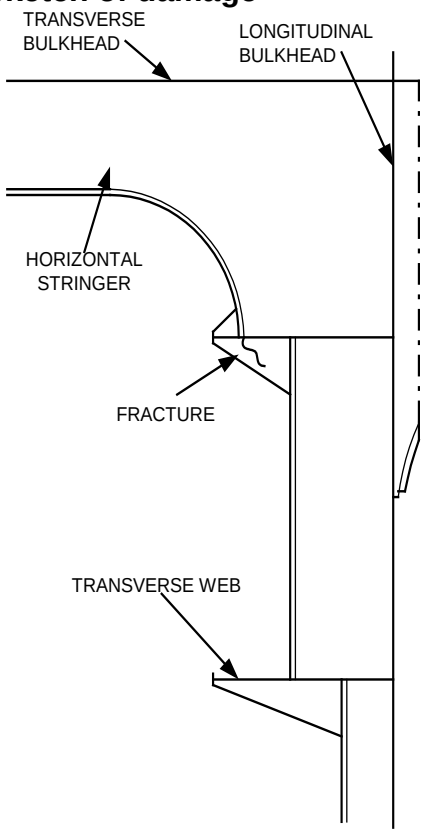
1. High shear or compressive stress in the stringer.
2. Insufficient buckling strength.

Notes on repairs

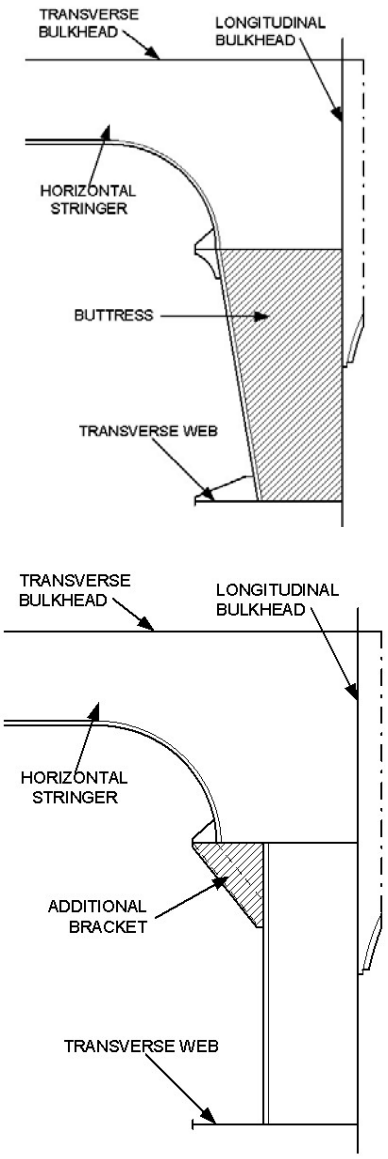
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 2	Cargo area	Example No.
	Wing ballast tank	7
Detail of damage	Fracture at connection of horizontal stringers to transverse web frames and horizontal girders	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Stress concentration due to discontinuous structure.
2. High shear stress in the horizontal stringer.

Notes on repairs

See Sketch.

Group 3 Bottom Ballast Tank

Contents

1 General

2 What to look for - Tank Top survey
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 What to look for - Double Bottom survey
3.1 Material wastage
3.2 Deformations
3.3 Fractures

4 What to look for - External Bottom survey
4.1 Material wastage
4.2 Deformations
4.3 Fractures

5 General comments on repair
5.1 Material wastage
5.2 Deformations
5.3 Fractures

Examples of structural detail failures and repairs – Group 3

Example No.	Title
1	Cracks in way of longitudinals connected to watertight floors
2	Fracture in way of stiffeners at connection of inner bottom and bottom shell to transverse bulkhead and floors
3	Connection of longitudinals to ordinary floors
4	Connection of longitudinals to ordinary floors
5	Panels of bottom girders in way of openings
6	Cut-outs on floors
7	Fractured stiffener connection to bottom and inner bottom longitudinals

1 General

1.1 In addition to contributing to the longitudinal bending strength of the hull girder, the double bottom structure provides support for the cargo in the tanks. The bottom shell at the forward part of the ship may sustain increased dynamic forces caused by slamming in heavy weather.

2 What to look for - Tank Top survey

2.1 Material wastage

2.1.1 The general corrosion condition of the tank top structure may be observed by visual survey. The level of wastage of tank top plating may have to be established by means of thickness measurement. Special attention should be paid to areas where pipes, e.g. cargo piping, heating coils, etc are fitted close to the tank top plating, making proper maintenance of the protective coating difficult to carry out.

2.1.2 Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface, which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

2.1.3 On uncoated areas or where the coating has broken down, pitting corrosion may occur in the tank top plating within cargo tanks. If not properly maintained, this may lead to cargo leakage into the double bottom ballast spaces.

2.2 Deformations

2.2.1 Buckling of the tank top plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses.

2.2.2 Whenever deformations are observed on the tank top, further survey in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coating within the double bottom, which in turn may lead to accelerated corrosion rate in these unprotected areas.

2.3 Fractures

2.3.1 Fractures will normally be found by close-up survey. Fractures that extend through the thickness of the plating or through the welds may be observed during pressure testing of the double bottom tanks.

3 What to look for - Double Bottom survey

3.1 Material wastage

3.1.1 The level of wastage of double bottom internal structure (longitudinals, transverses, floors, girders, etc.) may have to be established by means of thickness measurements. Rate and extent of corrosion depends on the corrosive environment, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (also see **3.1.2** - **3.1.4**).

(a) Structure in corrosive environment:
- Transverse bulkhead and girder adjacent to heated fuel oil tank.
- Under side of inner bottom plating and attached longitudinals if the cargo tank above is heated.

(b) Structure subject to high stress
- Face plates and web plates of transverse at corners

c) Areas susceptible to coating breakdown
- Back side of faceplate of longitudinal
- Welded joint
- Edge of access opening

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer severe localised corrosion. In general, structure at the upper part of the double bottom tank usually has more severe corrosion than that at the lower part.

3.1.3 The high temperature due to heated cargoes may accelerate corrosion of ballast tank structure near these heated tanks. The rate of corrosion depends on several factors such as:
- Temperature and heat input to the ballast tank.
- Condition of original coating and its maintenance.
- Ballasting frequency and operations.
- Age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.1.4 Shell plating below suction head often suffers localized wear caused by erosion and cavitation of the fluid flowing through the suction head. In addition, the suction head will be positioned in the lowest part of the tank and water/mud will cover the area even when the tank is empty. The condition of the shell plating may be established by feeling by hand beneath the suction head. When in doubt, the lower part of the suction head should be removed and thickness measurements taken. If the vessel is docked, the thickness can be measured from below. If the distance between the suction head and the underlying shell plating is too small to permit access, the suction head should be dismantled. The shell plating below the sounding pipe should also be carefully examined. When a striking plate has not been fitted or is worn out, heavy corrosion can be caused by the striking of the weight of the sounding tape.

3.2 Deformations

3.2.1 Where deformations are identified during tank top survey (See **2.2**) and external bottom survey (See **4.2**), the deformed areas should be subjected to internal survey to determine the extent of the damage to the coating and internal structure.

Deformations in the structure not only reduce the structural strength but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3 Fractures

3.3.1 Fractures will normally be found by close-up survey.

(a) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with the watertight floors below the transverse bulkhead stools.

(b) Lamellar tearing of the inner bottom plate below the weld connection with the stool in the cargo oil tank caused by large bending stresses in the connection when in heavy ballast condition. The size of stool and lack of full penetration welds could also be a contributory factor, as well as poor ‘‘through-thickness” properties of the tank top plating.

3.3.2 Transition region

In general, the termination of the following structural members at the collision bulkhead and engine room forward bulkhead may be prone to fractures:

- Hopper tank sloping plating
- Panting stringer in fore peak tank
- Inner bottom plating in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

4 What to look for - External Bottom survey

4.1 Material wastage

4.1.1 Hull structure below the water line can usually be surveyed only when the ship is dry-docked. The opportunity should be taken to inspect the external plating thoroughly. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See also **Photographs 1** and **2 in Group 1**). This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or ‘‘docking’’ plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating.

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations of bottom plating may also be attributed to dynamic force caused by wave slamming action at the forward part of the vessel, or contact with underwater objects. When deformation of the shell plating is found, the affected area should be surveyed internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be surveyed when the hull has dried since fractures in shell plating can easily be detected by observing leakage of water from the cracks in clear contrast to the dry shell plating.

4.3.2 Fractures in butt welds and fillet welds, particularly at the wrap around at scallops and ends of bilge keel, are sometimes observed and may propagate into the bottom plating. The cause of fractures in butt welds is usually related to weld defect or grooving. If the bilge keels are divided at the block joints of hull, all ends of the bilge keels should be surveyed.

5 General comments on repair

5.1 Material wastage

5.1.1 Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in cargo oil tanks.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit. When scattered deep pitting is found, it may be repaired by welding.

5.2 Deformations

Extensively deformed tank top and bottom plating should be replaced together with the deformed portion of girders, floors or transverse web frames. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, the Classification Society concerned should be contacted.

5.3 Fractures

5.3.1 Repair should be carried out in consideration of nature and extent of the fractures.

(a) Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

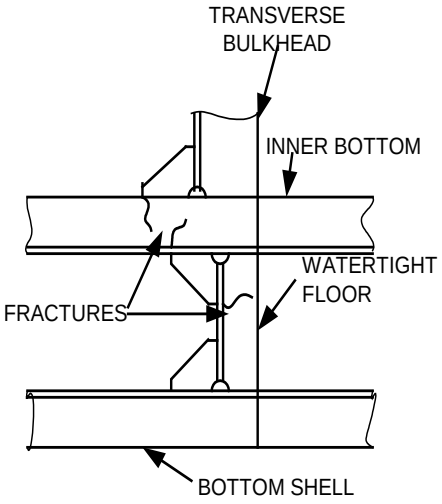
(b) For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.

(c) For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

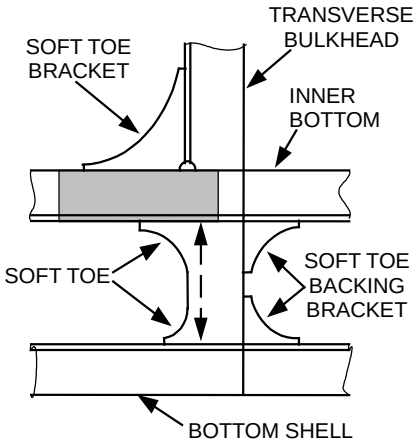
Group 3 Bottom Ballast Tank

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	1
Detail of damage	Cracks in way of longitudinals connected to watertight floors	

Sketch of damage



Sketch of repair



Factors which may have caused damage

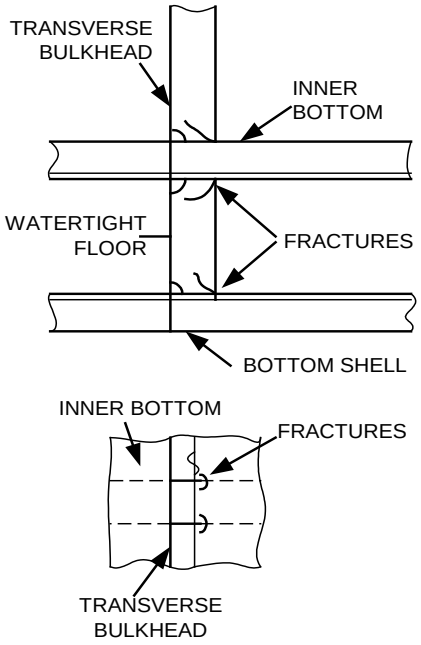
1. Asymmetrical connection of bracket in association with a backing bracket, which is too small.
2. Relative deflection between adjacent floor and transverse bulkhead.
3. Inadequate shape of the brackets.
4. High stresses in the inner bottom longitudinal and the floor stiffener.

Notes on repairs

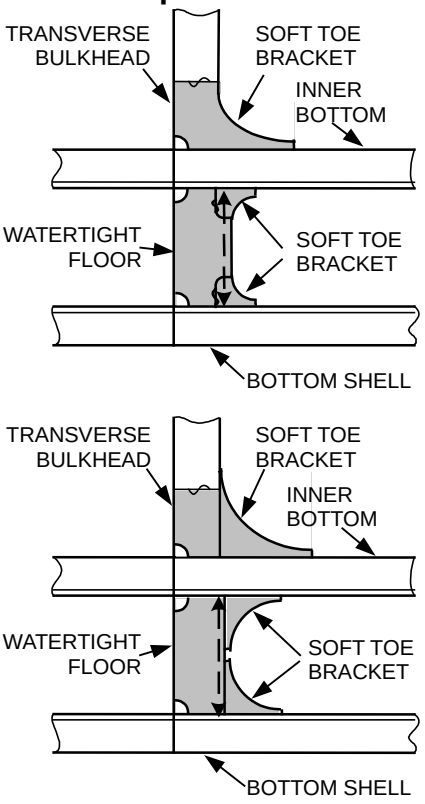
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	2
Detail of damage	Fracture in way of stiffeners at connection of inner bottom and bottom shell to transverse bulkhead and floors.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Misalignment between bulkhead stiffener and inner bottom longitudinal.
2. High stress concentration.

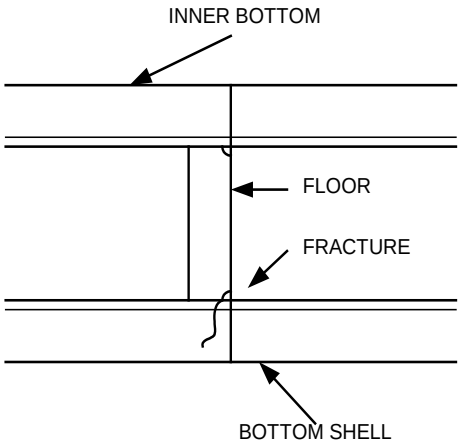
Notes on repairs

See Sketch.

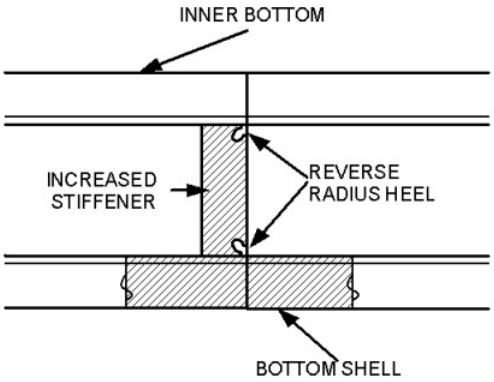
1. If tank top plating is fractured, part crop and insert.
2. Proper alignment between bulkhead stiffener and inner bottom longitudinal is critical for successful repair.
3. Soft backing brackets may also be added.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	3
Detail of damage	Connection of longitudinals to ordinary floors.	

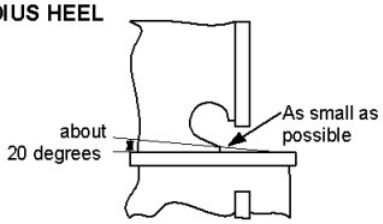
Sketch of damage



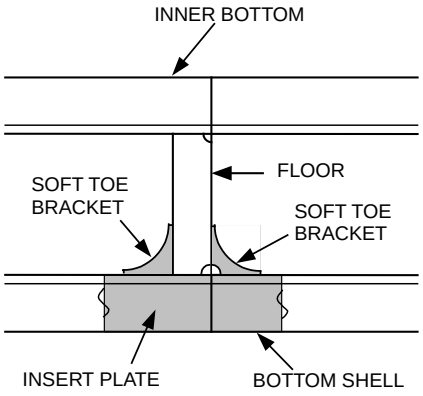
Sketch of repair



DETAIL OF REVERSE RADIUS HEEL



or



Factors which may have caused damage

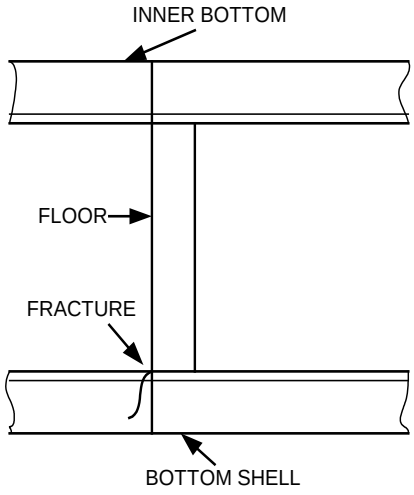
1. Asymmetrical connection.
2. Relative deflection of adjacent floor to transverse bulkhead.

Notes on repairs

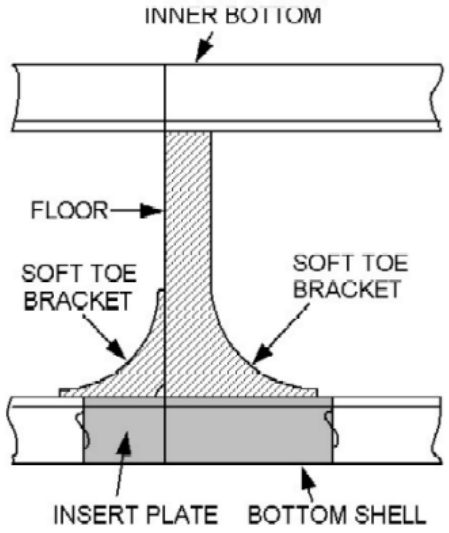
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	4
Detail of damage	Connection of longitudinals to ordinary floors	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Stress concentration at the connection of bottom longitudinal and stiffener on floor.

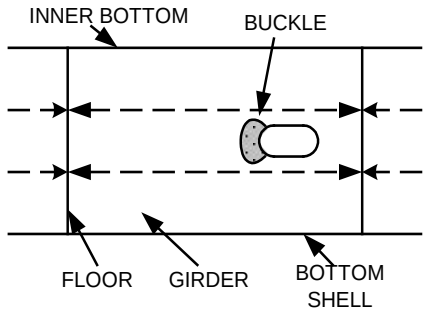
Notes on repairs

See Sketch.

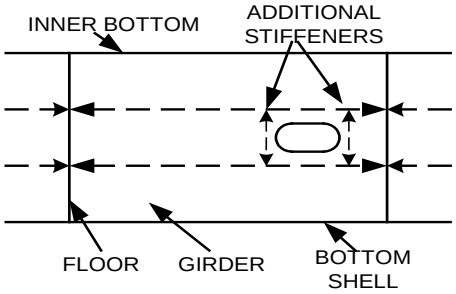
1. Butt welds in bottom longitudinal should be kept clear of the soft toe bracket toes.
2. If possible soft toe bracket and vertical stiffener should be integral.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	5
Detail of damage	Panels of bottom girders in way of openings.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

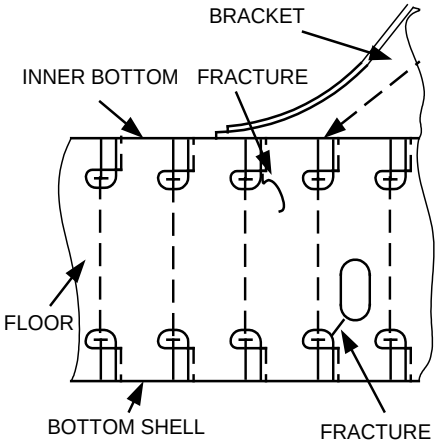
1. High shear or compressive stress in the side girder.
2. Insufficient buckling strength.

Notes on repairs

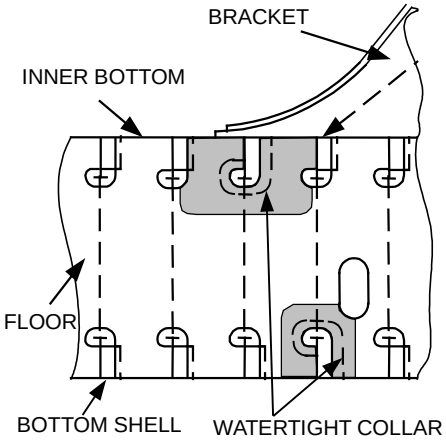
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	6
Detail of damage	Cut-outs on floors	

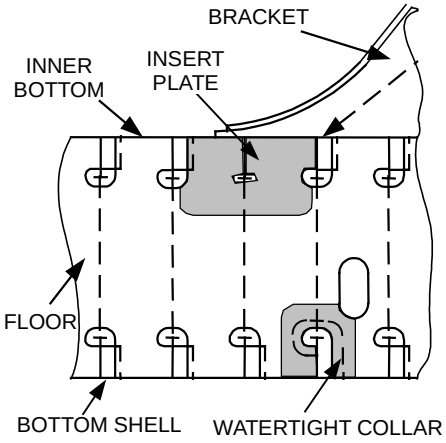
Sketch of damage



Sketch of repair



Above for relatively small fractures.



Above method for larger fractures.

Factors which may have caused damage

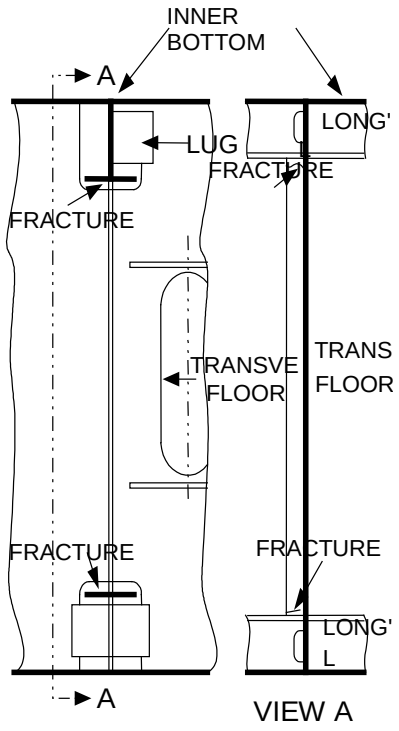
1. High stress in the vicinity of the transverse web frame bracket toe.
2. Lack of material between manhole and cut-out for bottom longitudinals.

Notes on repairs

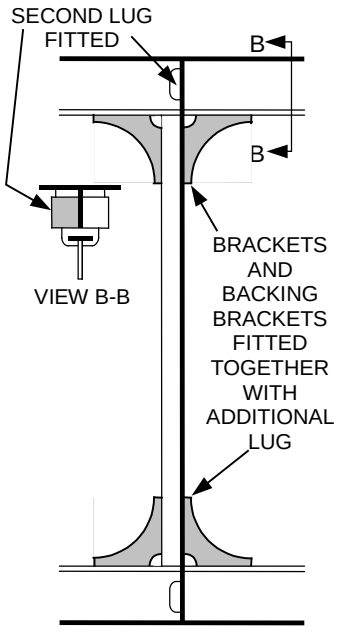
1. Top sketch: Gouge and reweld fractures then fit WT collars.
2. Bottom sketch: As an alternative to rewelding and fitting collar, crop and insert.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 3	Cargo area	Example No.
	Bottom ballast tank	7
Detail of damage	Fractured stiffener connection to bottom and inner bottom longitudinals.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Asymmetric connection leading to high local stresses at the connection of vertical stiffeners of the transverse floors to the inner and outer bottom longitudinals.
2. Wide slot for longitudinal leads to inefficient lug connection.
3. Sharp corners or flame-cut edges producing a notch effect.
4. Incomplete/defective weld at stiffener connection to the longitudinals.
5. Dynamic sea way loads/ship motions.

Notes on repairs

See Sketch.

Group 4 Web Frames in Cargo Tanks

Contents

1 General

2 What to look for – Web Frame survey
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Examples of structural detail failures and repairs – Group 4

Example No.	Title
1	Fracture at toe of web frame bracket connection to inner bottom
2	Cross ties and their end connections
3	Buckled transverse web plates in way of cross tie
4	Cut-outs around transverse bracket end
5	Fracture in way of connection of transverse web tripping brackets to longitudinal
6	Tripping brackets modification of the bracket toe

1 General

1.1 The web frame is the support for the transfer of the loads from the longitudinals. This structure has critical points at the intersections of the longitudinals, openings for access through the web frames and critical intersections such as found at the hopper knuckles as well as any bracket terminations. See also Figures 3 and 4 in **Chapter 1 Introduction**.

1.2 Depending upon the design or size of tanker web frames include deck transverse, vertical webs on longitudinal bulkheads and cross ties.

2 What to look for - Web Frame survey

2.1 Material wastage

2.1.1 The general condition with regard to wastage of the web frames may be observed by visual survey during the overall and close up surveys.

Attention is drawn to the fact that web frames may be significantly weakened by loss of thickness although diminution and deformations may not be apparent. Survey should be made after the removal of any scale, oil or rust deposit. Where the corrosion is smooth and uniform the diminution may not be apparent and thickness measurements would be necessary, to determine the condition of the structure.

2.1.2 Pitting corrosion may be found under coating blisters, which need to be removed before inspection. Pitting may also occur on horizontal structures, in way of sediments and in way of impingement from tank cleaning machines.

2.2 Deformations

2.2.1 Deformations may occur in web frames in way of excessive corrosion especially in way of openings in the structure. However, where deformation resulting from bending or shear buckling has occurred with a small diminution in thickness, this could be due to overloading and this aspect should be investigated before proceeding with repairs.

2.3 Fractures

2.3.1 Fractures may occur in way of discontinuities in the faceplates and at bracket terminations as well as in way of openings in structure. Fractures may also occur in way of cut outs for longitudinals.

3 General comments on repair

3.1 Material wastage

3.1.1 When the reduction in thickness of plating and stiffeners has reached the diminution levels permitted by the Classification Society involved, the wasted plating and stiffeners are to be cropped and renewed.

3.2 Deformations

3.2.1 Depending on the extent of the deformation, the structure should be restored to its original shape and position either by fairing in place and if necessary fitting additional panel stiffeners and/or by cropping and renewing the affected structure.

3.3 Fractures

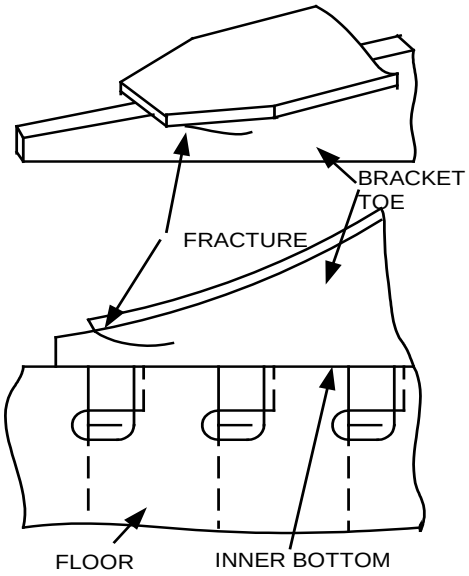
3.3.1 Because of the interdependence of structural components it is important that all fractures and other significant damage to the frames and their brackets, however localised, are repaired.

3.3.2 Repair of fractures at the boundary of a cargo tanks to ballast tanks should be carefully considered, taking into account necessary structural modification, enhanced scantlings and material, to prevent recurrence of the fractures.

Group 4 Web Frames in Cargo Tanks

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	1
Detail of damage	Fracture at toe of web frame bracket connection to inner bottom.	

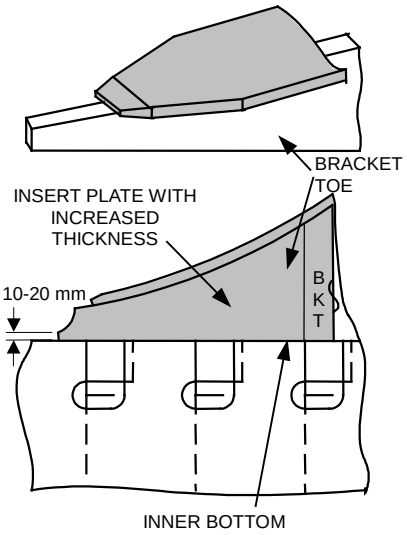
Sketch of damage



Sketch of repair

Modify Face Taper

1. Breadth taper 20 degrees.
2. Breadth at toe as small as practical.
3. Thickness taper 1 in 3 to 10mm.



Factors which may have caused damage

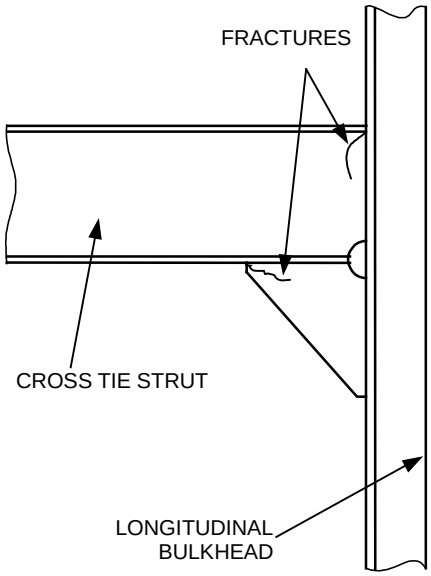
1. Inadequate tapering the toe end.
2. Insufficient tapering of flange.
3. Lateral flexing of the bracket.

Notes on repairs

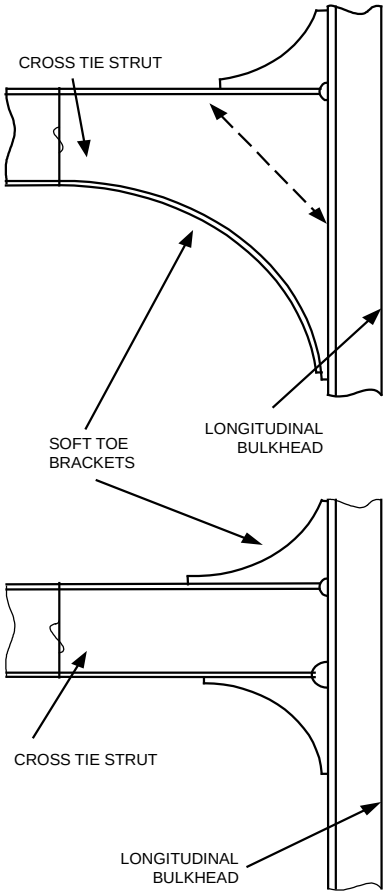
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	2
Detail of damage	Cross ties and their end connections	

Sketch of damage



Sketch of repair



Factors which may have caused damage

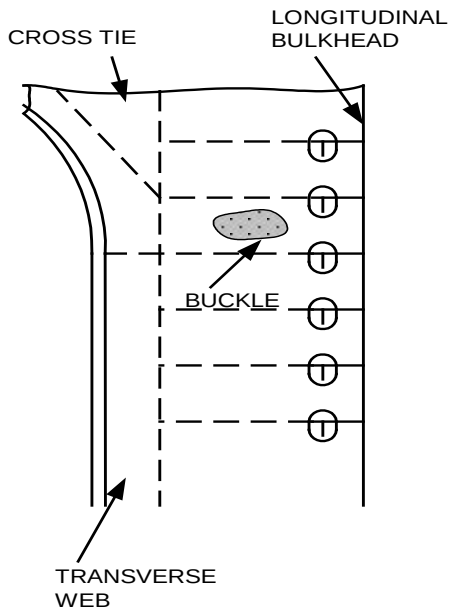
1. Stress concentration due to unsuitable bracket shape at juncture of cross tie to longitudinal.
2. Inadequate panel stiffening of web plate of cross-tie.

Notes on repairs

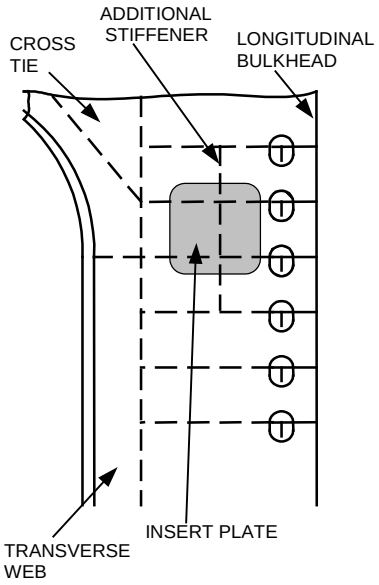
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	3
Detail of damage	Buckled transverse web plates in way of cross tie.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Insufficient panel stiffening on transverse web.

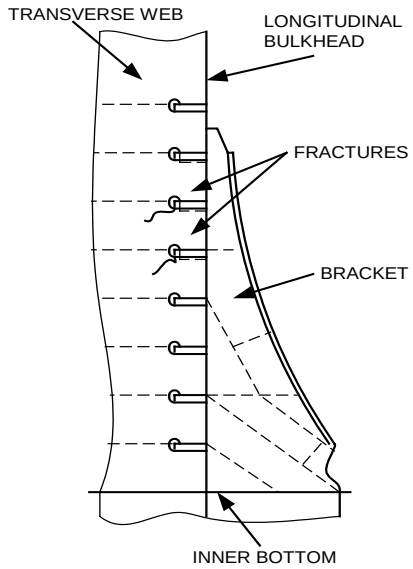
Notes on repairs

See Sketch.

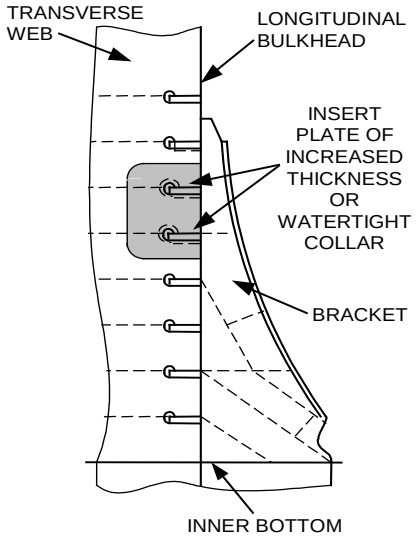
1. Depending upon size of deformation, additional stiffeners may be sufficient.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	4
Detail of damage	Cut-outs around transverse bracket end.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

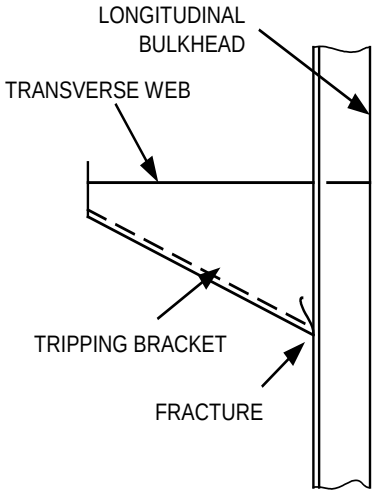
1. High stresses at toe of bottom transverse end bracket.
2. Sharp corner at cut-out.

Notes on repairs

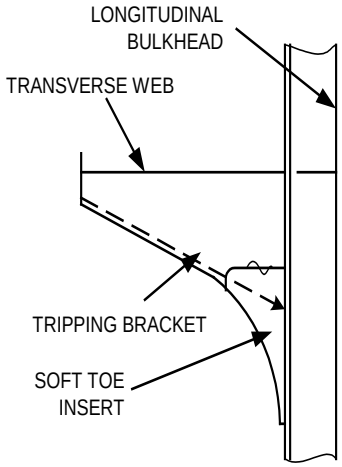
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	5
Detail of damage	Fracture in way of connection of transverse web tripping brackets to longitudinal	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Hard spot at the toe of bracket.
2. Vibration.

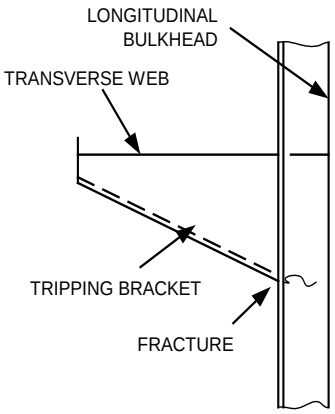
Notes on repairs

See Sketch.

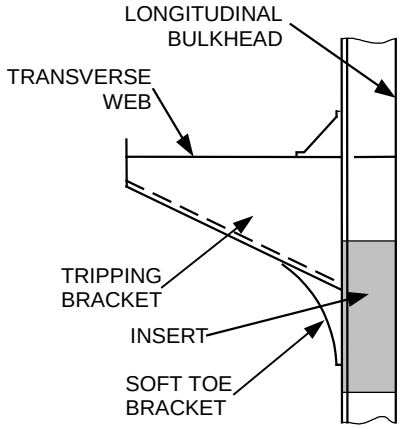
1. Soft bracket may be added on upper side of web, to avoid fracture at the heel.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 4	Cargo area	Example No.
	Web Frame in cargo tank	6
Detail of damage	Tripping brackets modification of the bracket toe.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Stress concentrations at toe of bracket.
2. High stress in longitudinal.

Notes on repairs

See Sketch.

1. Soft bracket may be added on upper side of web, to avoid fracture at the heel.

Group 5 Transverse Bulkheads in Cargo Tanks

Contents

1 General

2 What to look for - Bulkhead survey
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for - Stool survey
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 General comments on repair
- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures

Examples of structural detail failures and repairs – Group 5

Example No.	Title
1	Fracture in way of connection of transverse bulkhead stringer to transverse web frames and longitudinal bulkhead stringer
2	Horizontal stringer in way of longitudinal BHD cracked
3	Connection of longitudinals to horizontal stringers
4	Fractured inner bottom plate at the connection to access trunk wall
5	Bulkhead vertical web to deck and inner bottom
6	Vertically corrugated bulkhead without stool, connection to deck and inner bottom
7	Fracture at connection of vertically corrugated transverse bulkhead with stool to shelf plate and lower stool plate
8	Fracture at connection of lower stool plate to inner bottom tank. Lower stool plate connected to vertically corrugated transverse bulkhead
9	Fracture at connection of transverse bulkhead to knuckle inner bottom/girder

1 General

1.1 The transverse bulkheads at the ends of cargo tanks are oiltight bulkheads serving two main functions:
(a) As main transverse strength elements in the structural design of the ship.
(b) They are essentially deep tank bulkheads, which, in addition to the functions given in (a) above, are designed to withstand the head pressure of the full tank.

1.2 The bulkheads may be constructed as vertically corrugated with a lower stool, and with or without an upper stool. Alternatively plane bulkhead plating with one sided vertical stiffeners and horizontal stringers.

1.3 Heavy corrosion may lead to collapse of the structure under extreme load, if it is not rectified properly.

1.4 It is emphasised that appropriate access arrangement as indicated in **Chapter 4 Survey Programme, Preparation and Execution** of the guidelines should be provided to enable a proper close-up survey and thickness measurement as necessary.

2 What to look for – Bulkhead survey

2.1 Material wastage

2.1.1 Excessive corrosion may be found in the following locations:
(a) Bulkhead plating adjacent to the longitudinal bulkhead plating.
(b) Bulkhead plating and weld connections to the lower/upper stool shelf plates and inner bottom.

2.1.2 If coatings have broken down and there is evidence of corrosion, it is recommended that random thickness measurements be taken to establish the level of diminution.

2.1.3 When the periodical survey requires thickness measurements, or when the Surveyor deems necessary, it is important that the extent of the gauging be sufficient to determine the general condition of the structure.

2.2 Deformations

2.2.1 When the bulkhead has sustained serious uniform corrosion, the bulkhead may suffer shear buckling. Evidence of buckling may be indicated by the peeling of paint or rust. However, where deformation resulting from bending or shear buckling has occurred on a

bulkhead with a small diminution in thickness, this could be due to overloading and this aspect should be investigated before proceeding with repairs.

2.3 Fractures

2.3.1 Fractures usually occur at the boundaries of corrugations and bulkhead stools particularly in way of shelf plates, deck, inner bottom, etc.

3 What to look for – Stool survey

3.1 Material wastage

3.1.1 Excessive corrosion may be found on diaphragms, particularly at their upper and lower weld connections.

3.2 Fractures

3.2.1 Fractures observed at the connection between lower stool and corrugated bulkhead during stool survey may have initiated at the weld connection of the inside diaphragms (See **Example 7**).

3.2.2 Misalignment between bulkhead corrugation flange and sloping stool plating may also cause fractures at the weld connection of the inside diaphragms.

4 General comments on repair

4.1 Material wastage

4.1.1 When the reduction in thickness of plating and stiffeners has reached the diminution levels permitted by the Classification Society involved, the wasted plating and stiffeners are to be cropped and renewed.

4.2 Deformations

4.2.1 If the deformation is local and of a limited extent, it could generally be faired out. Deformed plating in association with a generalized reduction in thickness should be partly or completely renewed.

4.3 Fractures

4.3.1 Fractures that occur at the boundary weld connections as a result of latent weld defects should be veed-out, appropriately prepared and re-welded preferably using low hydrogen electrodes or equivalent.

4.3.2 For fractures other than those described in **4.3.1**, re-welding may not be a permanent solution and an attempt should be made to improve the design and construction in order to avoid a recurrence. Typical examples of such cases are as follows:

(a) Fractures in the weld connections of the stool plating to the shelf plate in way of the scallops in the stool's internal structure. The scallops should be closed by fitting lapped collar plates and the stool weld connections repaired as indicated in **4.3.1**. The lapped collar plates should have a full penetration weld connection to the stool and shelf plate and should be completed using low hydrogen electrodes prior to welding the collar to the stool diaphragm/bracket.

(b) Fractures in the weld connections of the corrugations and/or stool plate to the shelf plate resulting from misalignment of the stool plate and the flange of the corrugation (Similarly misalignment of the stool plate with the double bottom floor).

It is recommended that the structure be cut free, the misalignment rectified, and the stool, floor and corrugation weld connection appropriately repaired as indicated in **4.3.1**. Other remedies to such damages include fitting of brackets in the stool in line with the webs of the corrugations. In such cases both the webs of the corrugations and the brackets underneath are to have full penetration welds and the brackets are to be arranged without scallops. However, in many cases this may prove difficult to attain.

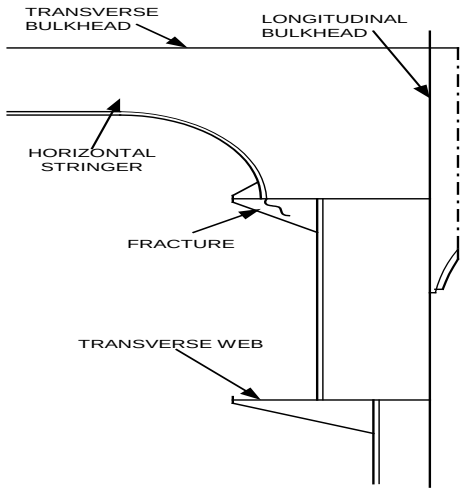
(c) Fractures in the weld connections of the corrugations to the hopper tank.

It is recommended that the weld connection be repaired as indicated in **4.3.1** and, where possible, additional stiffening be fitted inside the tanks to align with the flanges of the corrugations.

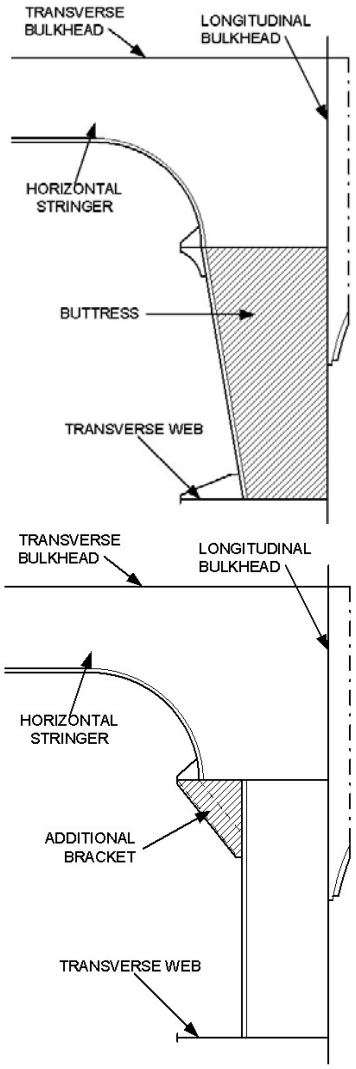
Group 5 Transverse Bulkheads in Cargo Tanks

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	1
Detail of damage	Fracture in way of connection of transverse bulkhead stringer to transverse web frames and longitudinal bulkhead stringer	

Sketch of damage



Sketch of repair



Factors which may have caused damage

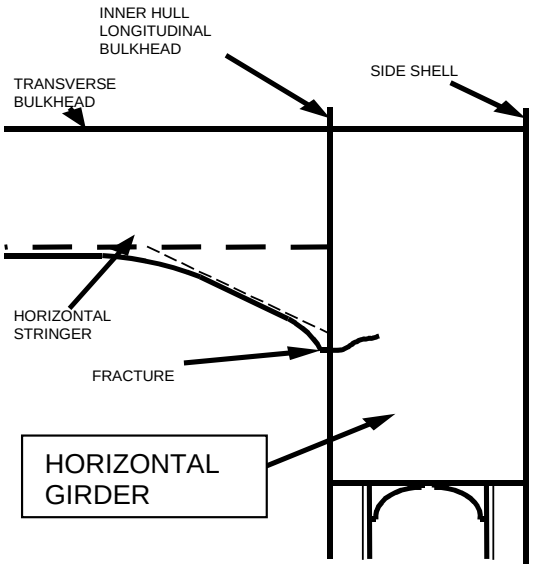
1. Stress concentration due to discontinuous structure.
2. High shear stress in the horizontal stringer.

Notes on repairs

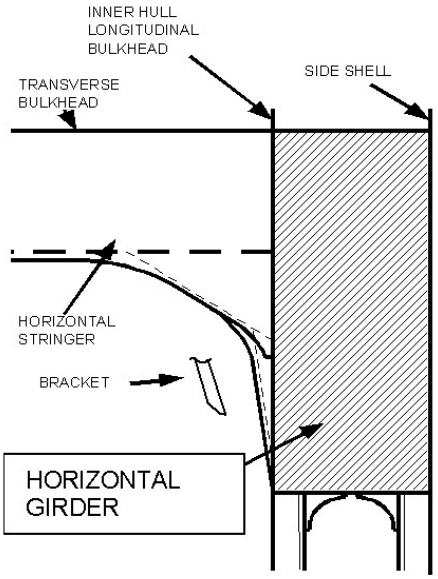
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	2
Detail of damage	Horizontal stringer in way of longitudinal BHD cracked	

Sketch of damage



Sketch of repair



Factors which may have caused damage

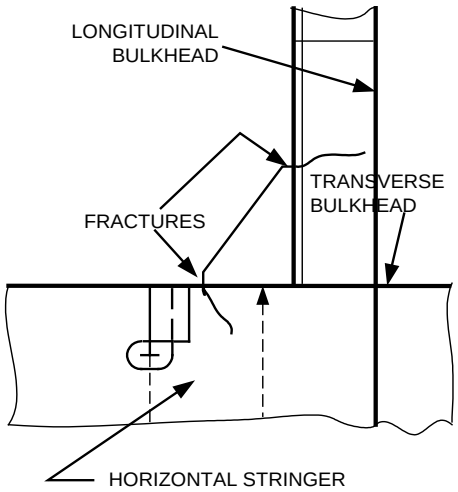
1. Misalignment between bracket end and side girder in wing tank.

Notes on repairs

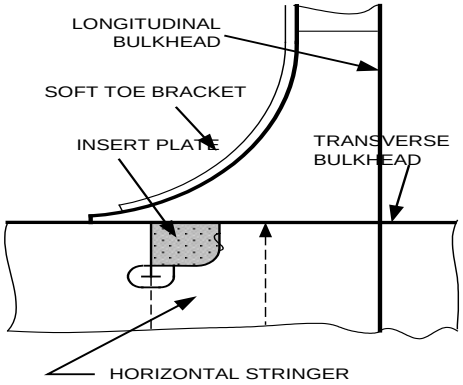
See Sketch.

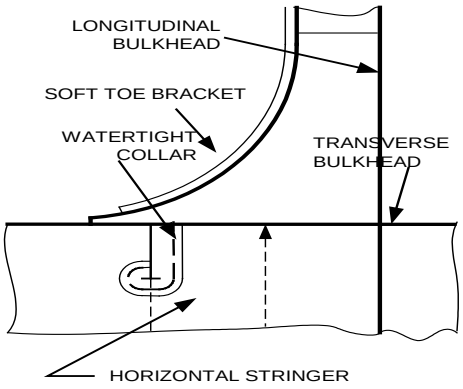
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	3
Detail of damage	Connection of longitudinals to horizontal stringers.	

Sketch of damage



Sketch of repair





Factors which may have caused damage

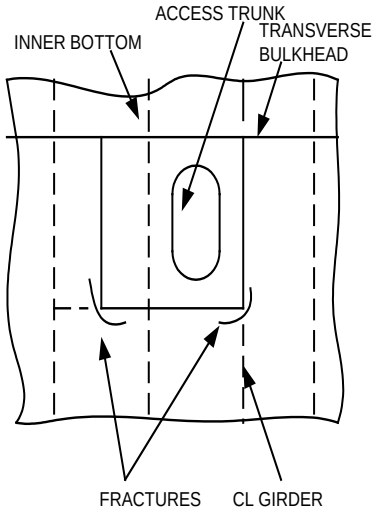
1. Stress concentration due to inadequate shape of the bracket.
2. Relative deflection of adjoining transverse web against transverse bulkhead.

Notes on repairs

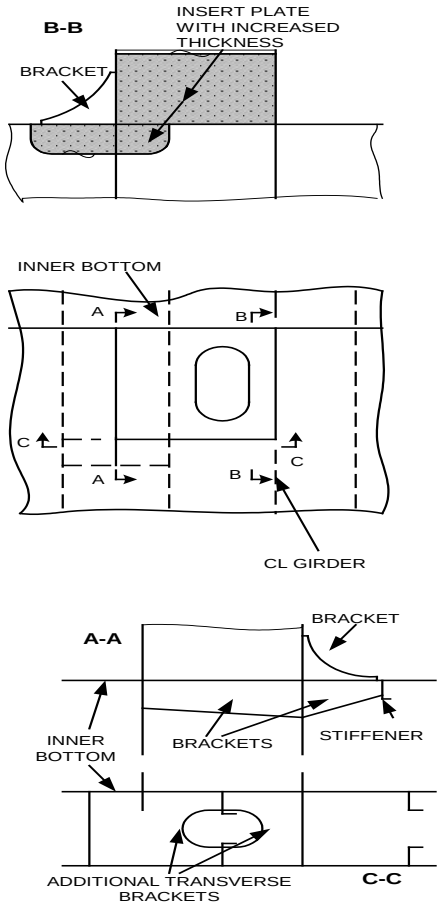
See Sketch

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	4
Detail of damage	Fractured inner bottom plate at the connection to access trunk wall	

Sketch of damage



Sketch of repair



Factors which may have caused damage

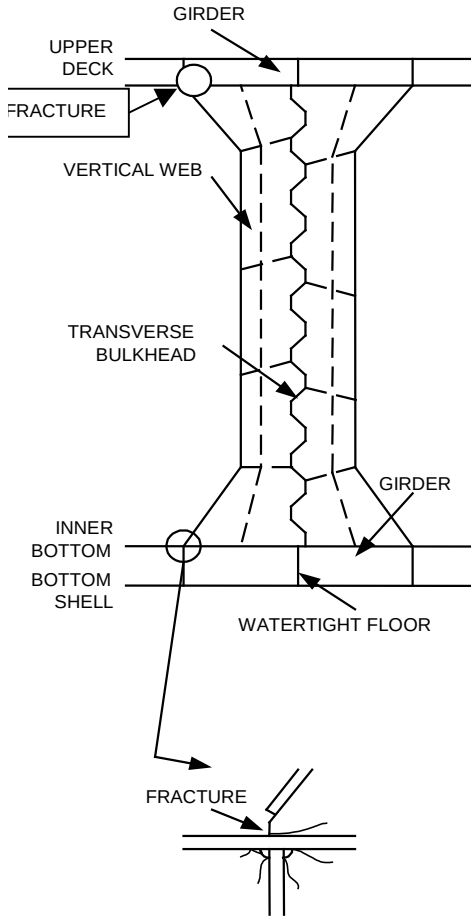
1. Stress concentration at the connection of trunk wall to inner bottom plate.
2. Relative deformation between horizontal stringer fitted on transverse bulkhead and inner bottom plate.
3. Static and dynamic load of cargo liquid.

Notes on repairs

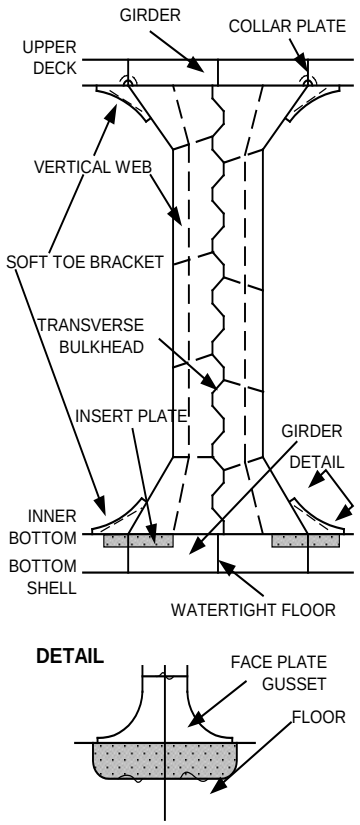
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	5
Detail of damage	Bulkhead vertical web to deck and inner bottom	

Sketch of damage



Sketch of repair



Factors which may have caused damage

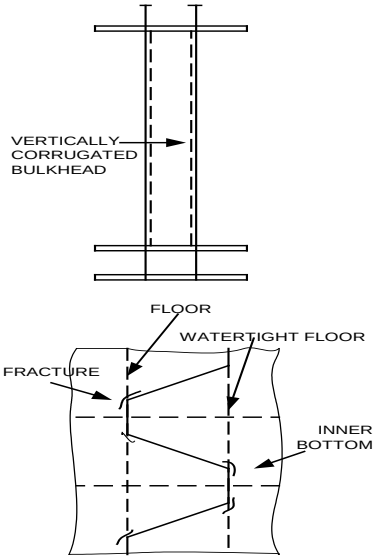
1. Stress concentration at toe of bracket due to sniped face plate and scallop in way.

Notes on repairs

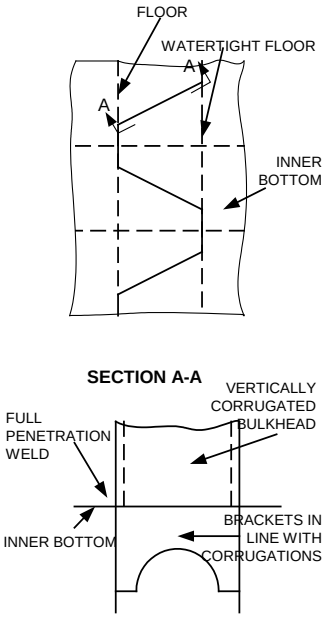
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	6
Detail of damage	Vertically corrugated bulkhead without stool, connection to deck and inner bottom	

Sketch of damage



Sketch of repair



Factors which may have caused damage

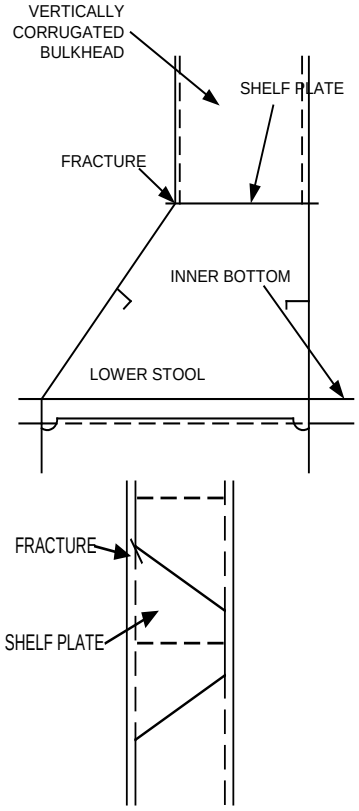
1. Stress concentration due to unsupported corrugation web.
2. High through thickness stress, lamellar tearing.
3. Weld details and dimensions.
4. Misalignment between face of corrugation and floor underneath.
5. Cut-outs and scallops or air holes increasing the stress in the floor.
6. Insufficient through thickness properties of inner bottom plate.

Notes on repairs

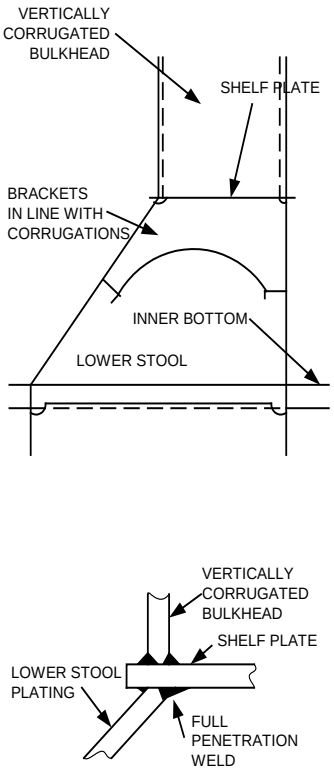
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	7
Detail of damage	Fracture at connection of vertically corrugated transverse bulkhead with stool to shelf plate and lower stool plate.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

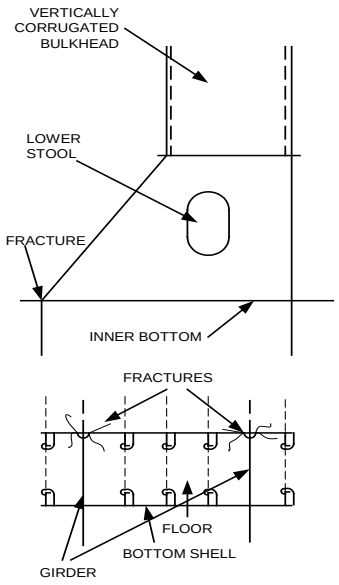
1. Stress concentration due to unsupported corrugation web.
2. High through thickness stress, lamellar tearing.
3. Weld details and dimensions.
4. Misalignment.
5. Insufficient thickness of stool side plating in relation to corrugation flange thickness.

Notes on repairs

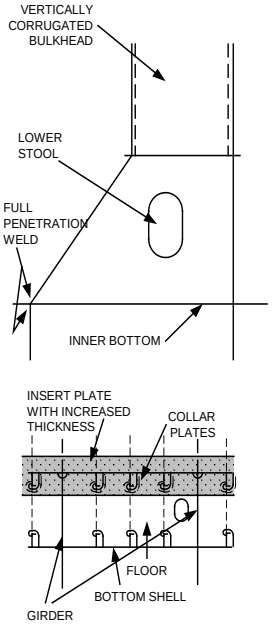
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	8
Detail of damage	Fracture at connection of lower stool plate to inner bottom tank. Lower stool plate connected to vertically corrugated transverse bulkhead.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

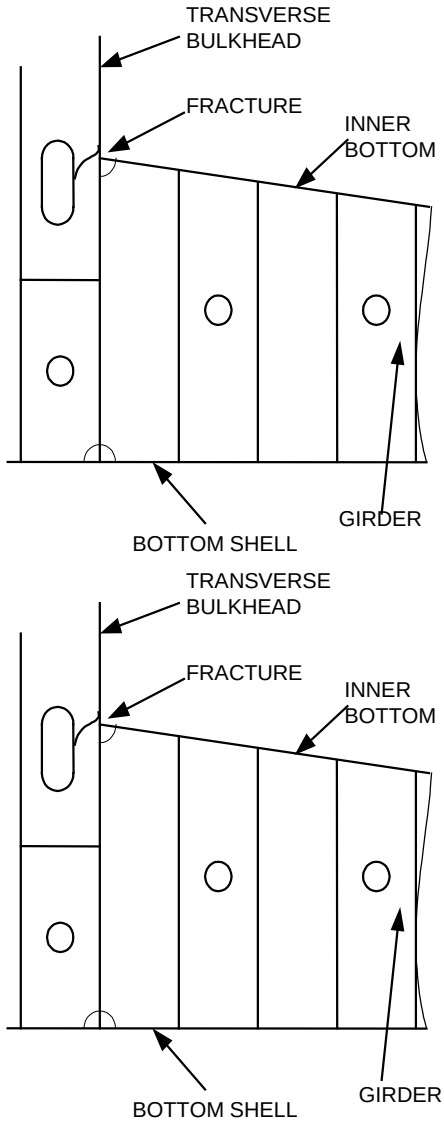
1. Misalignment between stool side plating and floor and/or stool webs and girders of double bottom.
2. Insufficient thickness of floor compared to stool thickness.
3. Scallops, cut-outs, air hole reducing the connecting area too much.
4. Weld details and dimensions.
5. Lamellar tearing of inner bottom plating.

Notes on repairs

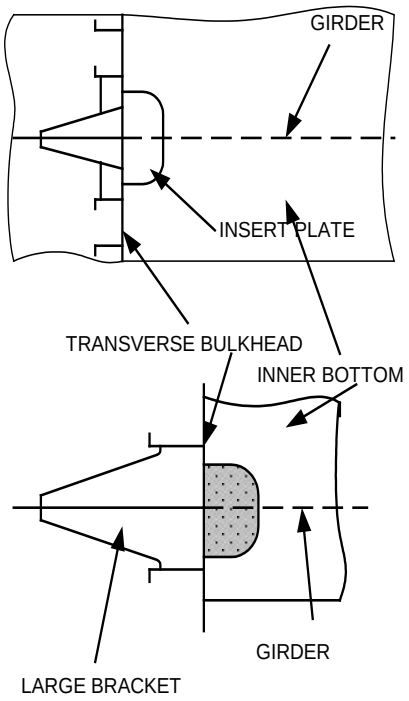
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 5	Cargo area	Example No.
	Transverse Bulkhead in cargo tank	9
Detail of damage	Fracture at connection of transverse bulkhead to knuckle inner bottom/girder	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. High stress concentration.
2. Discontinuity of structural members at knuckle joint.

Notes on repairs

See Sketch.

Group 6 Deck Structure

Contents

1 General

2 What to look for on deck
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for underdeck
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 General comments on repair
- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures
- 4.4 Miscellaneous

Examples of structural detail failures and repairs – Group 6

Example No.	Title
1	Deformed and fractured deck plating around tug bitt
2	Fracture at ends of deck transverse
3	Fractured deck longitudinal tripping bracket at intercostals deck girders
4	Fractured deck plating in crane pedestal support (midships)
5	Fractured deck plating in way of deck pipe support stanchions (midships)

1 General

1.1 Deck structure is subjected to longitudinal hull girder bending, caused by cargo distribution and wave actions. Moreover deck structure may be subjected to severe load due to green sea on deck. Certain areas of the deck may also be subjected to additional compressive stresses caused by slamming or bow flare effect at the fore ship in heavy weather.

1.2 The marine environment, the humid atmosphere due to the water vapour from the cargo in cargo tanks, sulphur contained in the cargo and the high temperature on deck plating due to heating from the sun may result in accelerated corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above.

2 What to look for on deck

2.1 Material wastage

2.1.1 General corrosion of the deck structure may be observed by visual inspection. Special attention should be paid to areas where pipes, e.g. cargo piping, COW piping, fire main pipes, hydraulic pipes, etc are fitted close to the plating, making proper maintenance of the protective coating difficult to carry out.

2.1.2 Grooving corrosion is often found in or beside welds, especially in the heat affected zone. This corrosion is sometimes referred to as 'inline pitting attack' and can also occur on vertical members and flush sides of bulkheads in way of flexing. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface, which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

2.1.3 Pitting corrosion may occur throughout the deck plating. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction.

2.2 Deformations

2.2.1 Plate buckling (between stiffeners) may occur in areas subjected to in-plane compressive stresses, in particular if corrosion is in evidence. Special attention should be paid to areas where the compressive stresses are perpendicular to the direction of the stiffening system.

2.2.2 Deformed structure may be observed in areas of the deck plating. In exposed deck area, in particular deck forward, deformation of structure may result from shipping green water.

2.3 Fractures

2.3.1 Fractures in areas of structural discontinuity and stress concentration will normally be detected by close-up survey. Special attention should be given to the structures at cargo hatches in general and to corners of deck openings in particular.

2.3.2 Fractures initiated in the deck plating may propagate across the deck resulting in serious damage to hull structural integrity.

2.3.3 Main deck areas subject to high concentration of stress especially in way of bracket toe and heel connections of the loading/discharge manifold supports to main deck are to be close up examined for possible fractures. Similarly the main deck in way of the areas of the stanchion supports to main deck of the hose saddles should be close up examined for possible fractures due to the restraints caused by the long rigid hose saddle structure.

3 What to look for underdeck

3.1 Material wastage

3.1.1 The level of wastage of under-deck stiffeners may have to be established by means of thickness measurements. The combined effect of the marine environment and the high humidity atmosphere within wing ballast tanks and cargo tanks will give rise to a high corrosion rate.

3.2 Deformations

3.2.1 Buckling should be looked for in the primary supporting structure. Such buckling may be caused by:

(a) Loading deviated from loading manual.
(b) Excessive sea water pressure in heavy weather.
(c) Sea water on deck in heavy weather.
(d) Combination of these causes.

3.2.2 Improper ventilation during ballasting/de-ballasting of ballast tanks or venting of cargo tanks may cause deformation in deck structure. If such deformation is observed, internal survey of the affected tanks should be carried out in order to confirm the nature and the extent of damage.

3.3 Fractures

3.3.1 Fractures may occur at the connection between the deck plating, transverse bulkhead and girders/stiffeners. This is often associated with a reduction in area of the connection due to corrosion.

3.3.2 Fatigue fractures may also occur in way of the underdeck longitudinals bracket toes directly beneath deck handling cranes, if fitted. Fractures may initiate at the deck longitudinal flange at the termination of the bracket toe and propagated through the deck longitudinal web plate. The crack may also penetrate the deck plating if allowed to propagate.

4 General comments on repair

4.1 Material wastage

4.1.1 In the case of grooving corrosion at the transition between two plate thicknesses consideration should be given to renewal of part of, or the entire deck plate.

4.1.2 In the case of pitting corrosion on the deck plating, consideration should be given to renewal of part of or the entire affected deck plate.

4.1.3 When heavy wastage is found on under-deck structure, the whole or part of the structure may be cropped and renewed depending on the permissible diminution levels allowed by the Classification Society concerned.

4.2 Deformations

4.2.1 When buckling of the deck plating has occurred, appropriate reinforcement is necessary in addition to cropping and renewal regardless of the corrosion condition of the plating.

4.3 Fractures

4.3.1 Fractured areas in the main deck plating should be cropped and inserted using good marine practice. The cause of the fracture should be determined because other measures in addition to cropping and inserting may be needed to prevent re-occurrence.

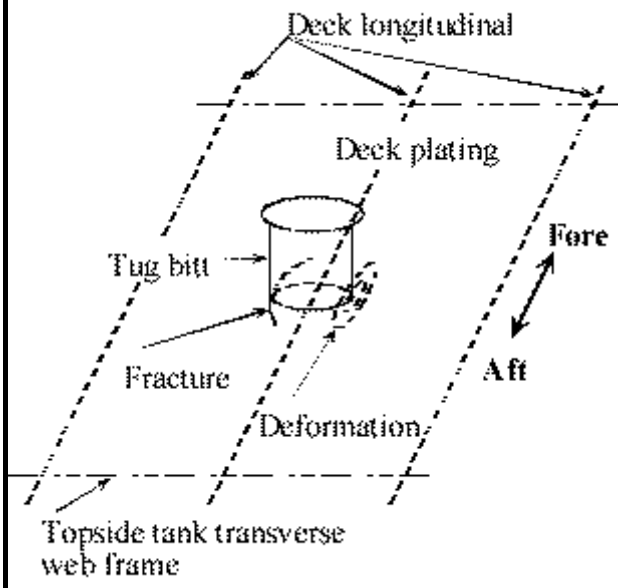
4.4 Miscellaneous

4.4.1 Main deck plating in way of miscellaneous equipment such as cleats, chocks, rollers, hose rails, mooring winches, etc. should be examined for possible defects.

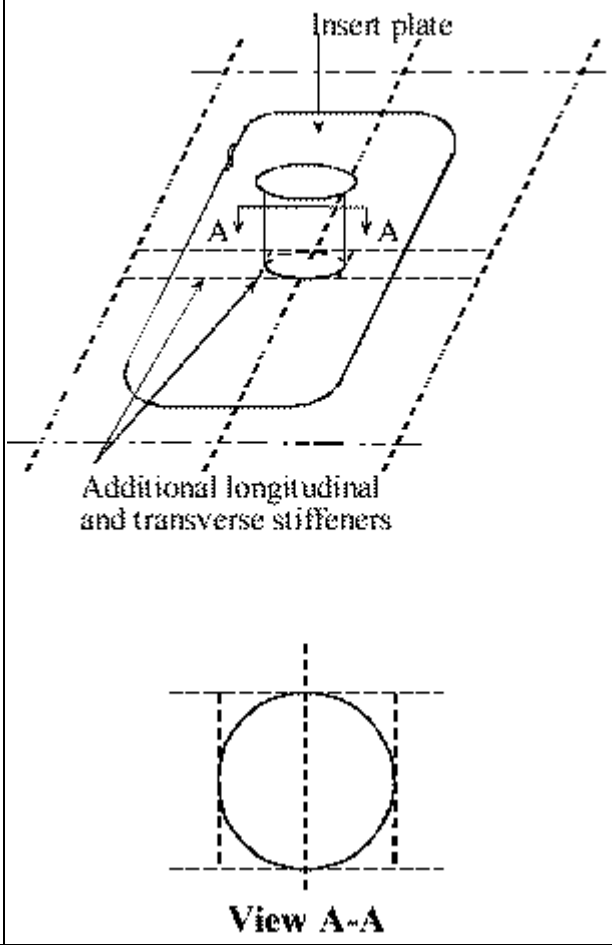
Group 6 Deck Structure

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 6	Deck Structure	Example No.
		1
Detail of damage	Deformed and fractured deck plating around tug bitt	

Sketch of damage



Sketch of repair



Factors which may have caused damage

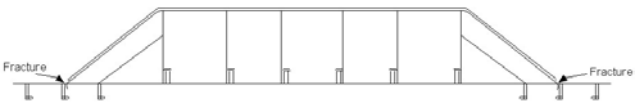
1. Insufficient strength

Notes on repairs

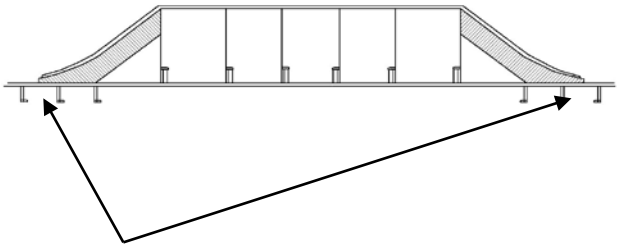
1. Fractured/deformed deck plating should be cropped and part renewed.
2. Reinforcement by stiffeners should be considered.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 6	Deck Structure	Example No.
		2
Detail of damage	Fracture at ends of deck transverse	

Sketch of damage



Sketch of repair



Under deck transverse is to be described as mentioned in the following "Note on repairs".
"Increase bracket length to end between under deck longitudinals and align end to under deck transverse."

Factors which may have caused damage

1. High stress due to toes bracket ending at cut out for longitudinal.

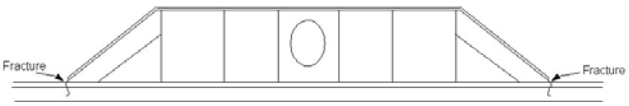
Notes on repairs

See Sketch.

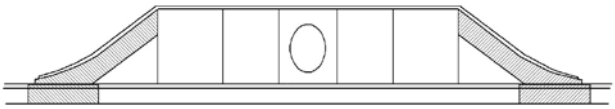
1. Increase bracket length to end between underdeck longitudinals and align end to underdeck transverse.
2. Install fitted collar rather than lapped collar.
3. Insert deck plating if fracture extends into deck.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 6	Deck Structure	Example No.
		3
Detail of damage	Fractured deck longitudinal tripping bracket at intercostals deck girders	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Fractures due to inadequate end bracket to deck plate resulting in high nominal stress.

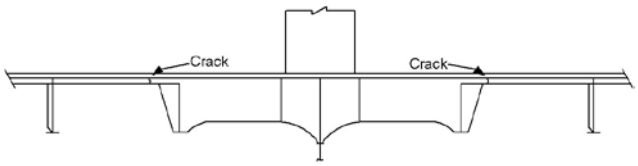
Notes on repairs

See Sketch.

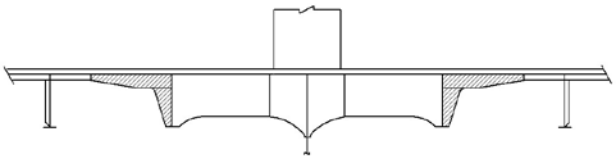
1. Taper face plate

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 6	Deck Structure	Example No.
		4
Detail of damage	Fractured deck plating in crane pedestal support (midships)	

Sketch of damage



Sketch of repair



Factors which may have caused damage

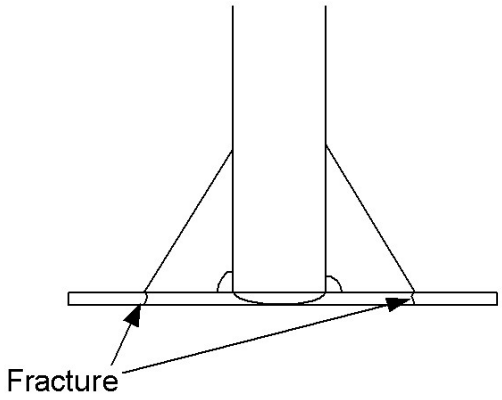
1. High stress concentrations at the bracket toes.

Notes on repairs

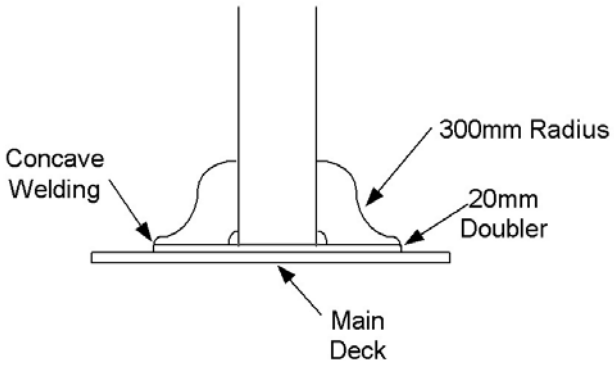
1. Deck plate insert to be thicker than original.
2. Soft brackets may also be used.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 6	Deck Structure	Example No.
		5
Detail of damage	Fractured deck plating in way of deck pipe support stanchions (midships)	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Stanchions experience more severe relative displacements from hull girder bending.

Notes on repairs

See Sketch.

Group 7 Fore and Aft End Regions

- Area 1 Fore End Structure
- Area 2 Aft End Structure

Area 1 Fore End Structure

Contents

1 General

2 What to look for
2.1 Material wastage
2.2 Deformations
2.3 Fractures

3 General comments on repair
3.1 Material wastage
3.2 Deformations
3.3 Fractures

Examples of structural detail failures and repairs – Group 7

Example No.	Title
1	Fracture in forecastle deck plating at bulwark
2	Fractures in side shell plating in way of chain locker
3	Fractures and deformation of bow transverse web in way of cut-outs for side longitudinals
4	Fractured vertical web at the longitudinal stiffener ending in way of the parabolic bow structure.
5	Fractured stringer end connection in way of the parabolic bow structure
6	Fracture at end of longitudinal at bow structure.
7	Fracture and buckle of bow transverse web frame in way of longitudinal cut-outs
8	Buckled and tripped breasthooks

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the forepeak ballast tank can be a major problem for many, and in particular ageing ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.

1.2 Deformation can be caused by contact, which can result in damage to the internal structure leading to fractures in the shell plating.

1.3 Fractures of internal structure in the fore peak tank and spaces can also result from wave impact load due to slamming and panting.

1.4 Forecastle structure is exposed to green water and can suffer damage such as deformation of deck structure, deformation and fracture of bulwarks and collapse of mast, etc.

1.5 Shell plating around anchor and hawse pipe may suffer corrosion, deformation and possible fracture due to movement of improperly stowed anchor.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at the locations as indicated in **Figure 1** and particular attention should be given to these areas. A close-up survey should be carried out with selection of representative thickness measurements to determine the extent of corrosion.

2.1.2 Structure in chain locker is liable to have heavy corrosion due to mechanical damage to the protective coating caused by the action of anchor chains. In some ships, especially smaller ships, the side shell plating may form boundaries of the chain locker and heavy corrosion may consequently result in holes in the side shell plating.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. A close-up survey of the damaged area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in the fore peak tank are normally found by close-up survey of the internal structure.

2.3.2 Fractures are often found in transition region and reference should be made to examples provided in the other Groups.

2.3.3 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of tanks.

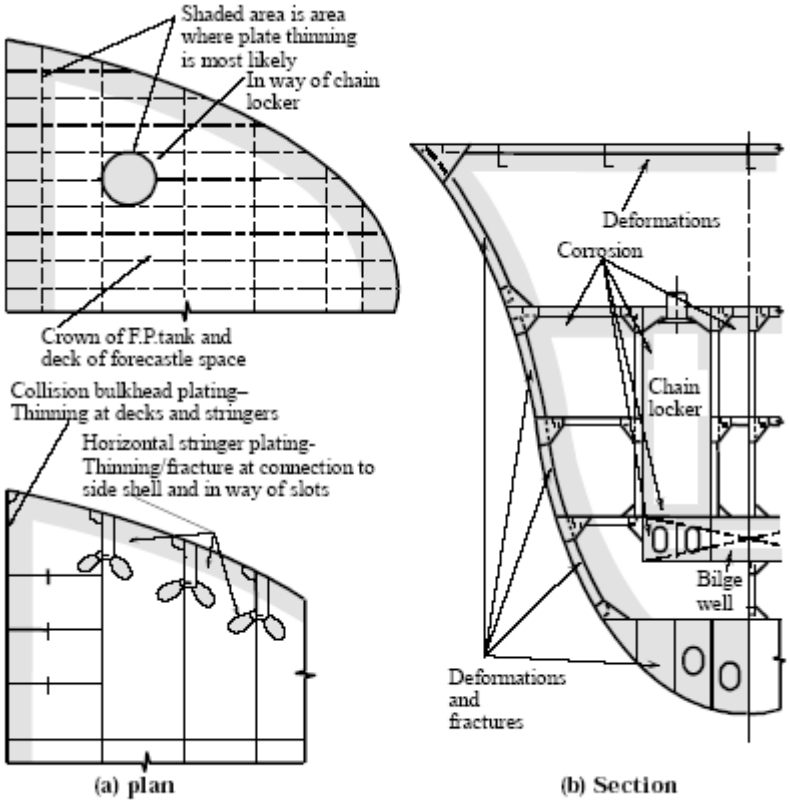


Fig 1 Fore end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the nature and extent of damage.

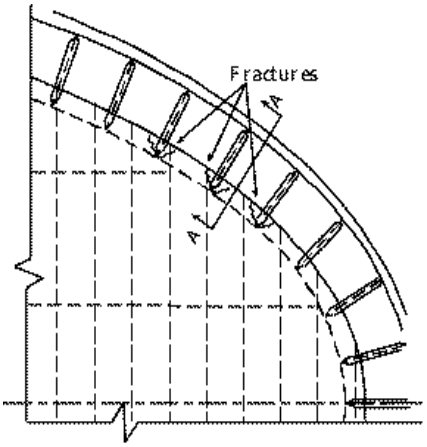
3.3 Fractures

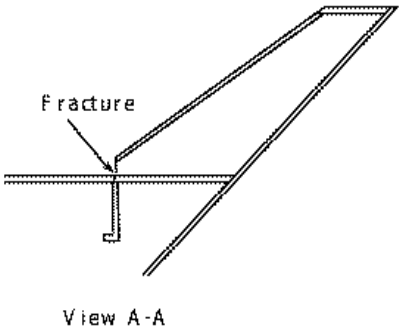
3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed. In the case of fractures caused by sea loads, increased thickness of plating and/or design modification to reduce stress concentrations should be considered (See Examples 1 and 5).

Group 7 Area 1 Fore End Structure

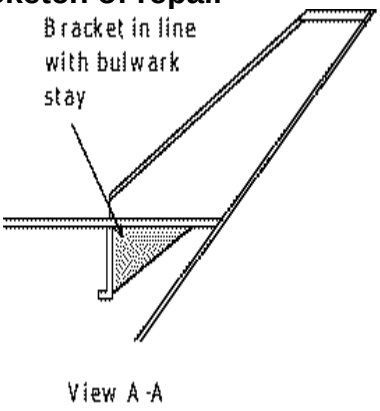
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Forecastle	1
Detail of damage	Fracture in forecastle deck plating at bulwark	

Sketch of damage





Sketch of repair



Factors which may have caused damage

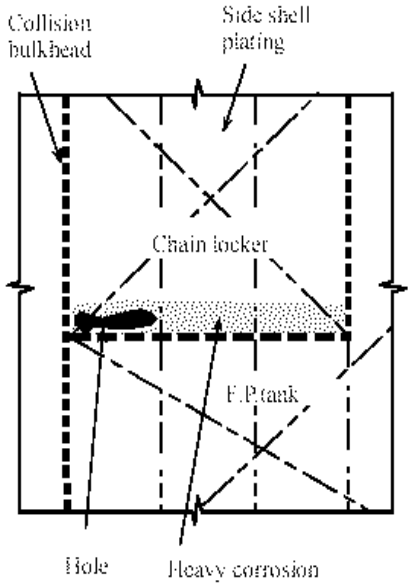
1. Bow Flare effect in heavy weather.
2. Stress concentration due to poor design.

Notes on repairs

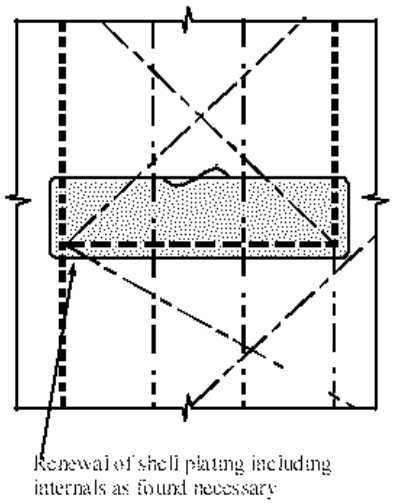
1. Fractured deck plating should be cropped and renewed.
2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Chain locker	2
Detail of damage	Fractures in side shell plating in way of chain locker	

Sketch of damage



Sketch of repair



Factors which may have caused damage

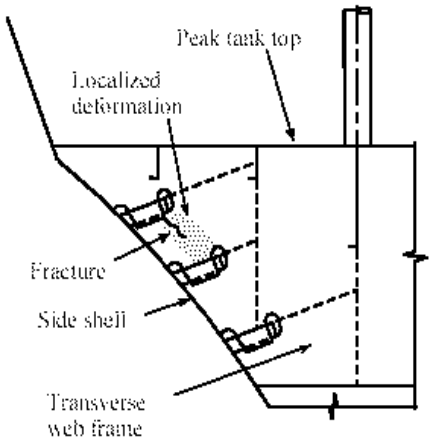
1. Heavy corrosion in region where mud is accumulated.

Notes on repairs

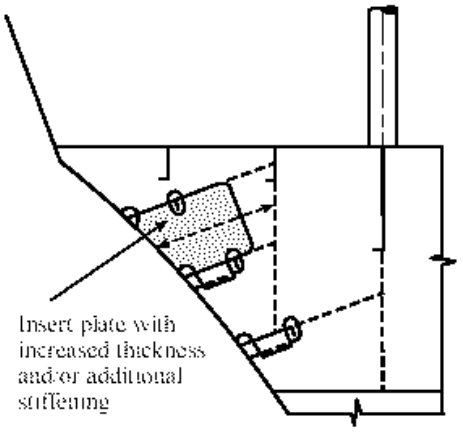
1. Corroded plating should be cropped and renewed.
2. Protective coating should be applied.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Forepeak ballast tank	3
Detail of damage	Fractures and deformation of bow transverse webs in way of cut-outs for side longitudinals	

Sketch of damage



Sketch of repair



Factors which may have caused damage

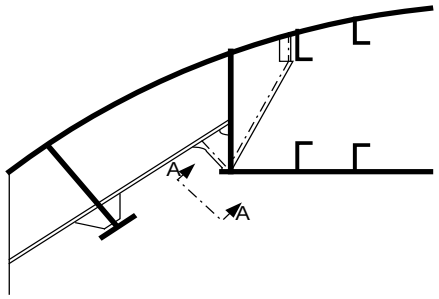
1. Localized material wastage in way of coating failure at cut-outs and sharp edges due to working of the structure.
2. Dynamic seaway loading in way of bow flare.

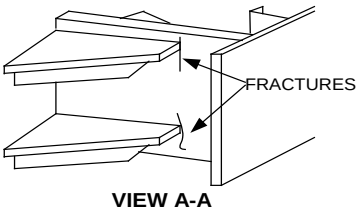
Notes on repairs

1. Sufficient panel strength to be provided to absorb the dynamic loads enhanced by bow flare shape.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Forepeak ballast tank	4
Detail of damage	Fractured vertical web at the longitudinal stiffener ending in way of the parabolic bow structure.	

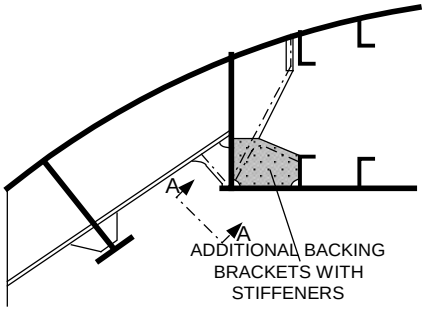
Sketch of damage

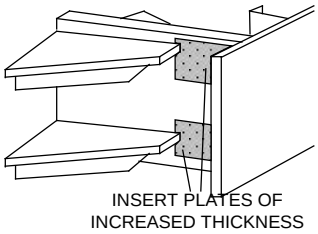




VIEW A-A

Sketch of repair





VIEW A-A

Factors which may have caused damage

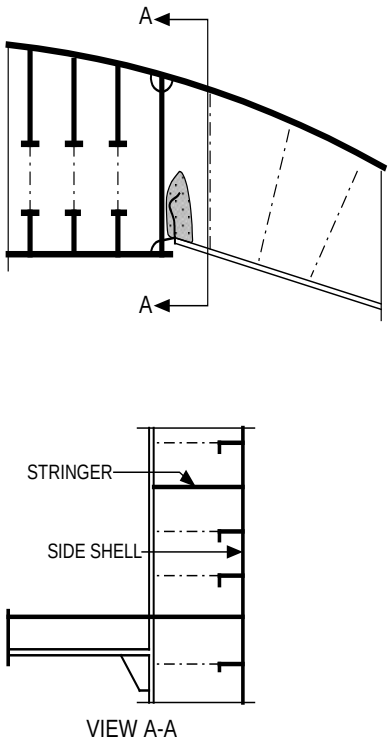
1. Stress concentrations at bracket ending due to inadequate support at bracket toes in way of connection to web frame members.
2. Localised thinning in way of coating failure at bracket endings due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing at bracket endings.

Notes on repairs

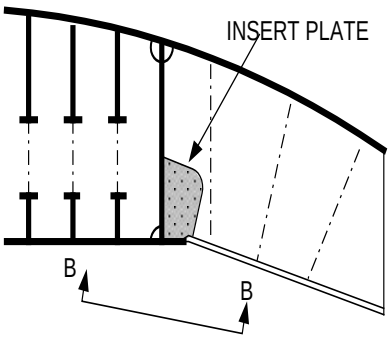
See Sketch.

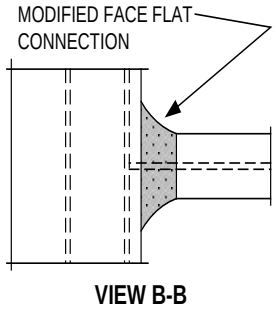
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Forepeak ballast tank	5
Detail of damage	Fractured stringer end connection in way of the parabolic bow structure	

Sketch of damage



Sketch of repair





Factors which may have caused damage

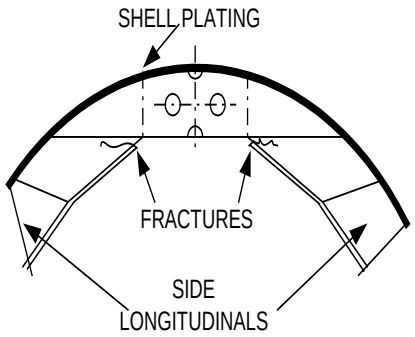
1. High stress concentration of stringer to stiff girder/deep web intersection due to discontinuity of faceplate.
2. Localised thinning in way of coating failure at stringer connection due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing in way of detail.

Notes on repairs

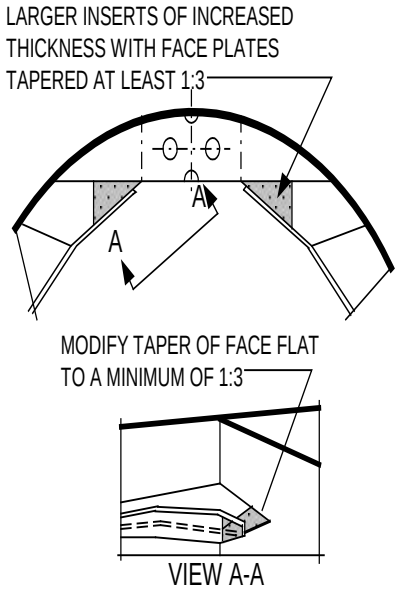
See Sketch.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	Fore region	Example No.
Area 1	Forepeak ballast tank	6
Detail of damage	Fracture at end of longitudinal at bow structure.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

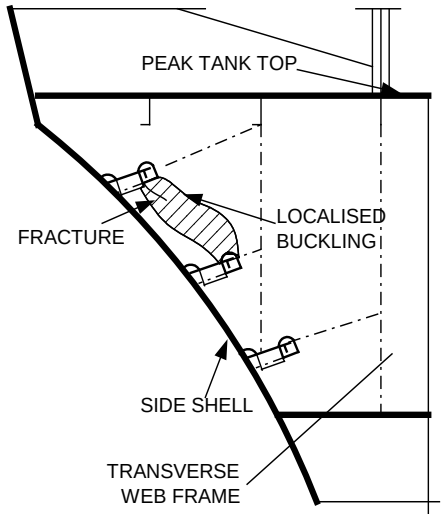
1. Inadequate brackets forming the longitudinal endings at bow structure.
2. Localised thinning in way of coating failure at longitudinal endings due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing at longitudinal endings.

Notes on repairs

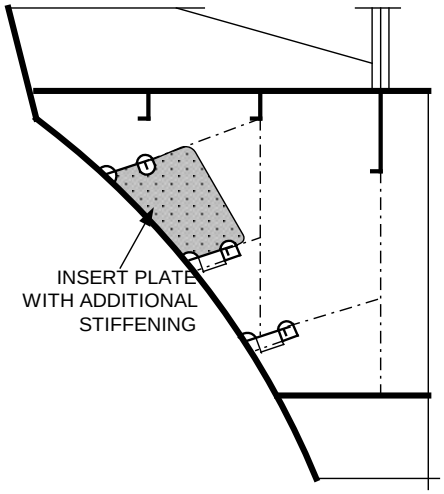
See Sketch.

OIL Tankers	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Group 7	**Fore region**	**Example No.**
Area 1	**Forepeak ballast tank**	**7**
Detail of damage	Fracture and buckle of bow transverse web frame in way of longitudinal cut-outs.	

Sketch of damage



Sketch of repair



Factors which may have caused damage

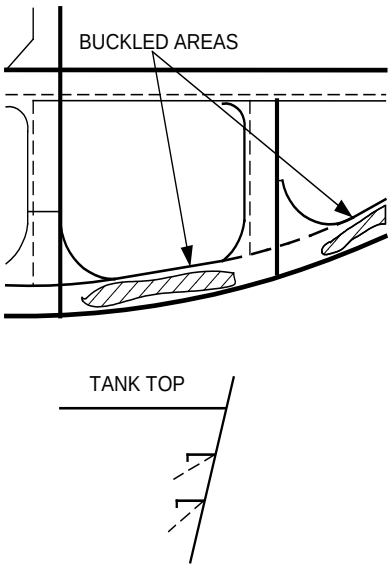
1. Localised thinning in way of coating failure at cut-outs and sharp edges due to working of the structure.
2. Dynamic seaway loadings in way of bow flare.

Notes on repairs

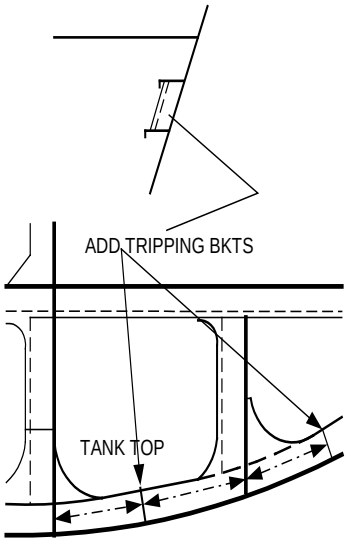
See Sketch.

OIL Tankers	**Guidelines for Surveys, Assessment and Repair of Hull Structure**	
Group 7	**Fore region**	**Example No.**
Area 1	**Fore peak ballast tank**	**8**
Detail of damage	Buckled and tripped breasthooks	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Bow impact load.
2. Low buckling resistance.

Notes on repairs

See Sketch.

Area 2 Aft End Structure

Contents

1 General

2 What to look for
- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair
- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Examples of structural detail failures and repairs – Group 7

Example No.	Title
9	Fractures in bulkhead in way of rudder trunk
10	Fractures at the connection of floors and girders/side brackets
11	Machinery space outside engine room
12	Machinery space outside engine room

1 General

1.1 Due to the high humidity salt water environment, wastage of the internal structure in the aft peak ballast tank can be a major problem for many, and in particular ageing, ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.

1.2 Deformation can be caused by contact or wave impact action from astern (which can result in damage to the internal structure leading to fractures in the shell plating).

1.3 Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

2 What to look for

2.1 Material wastage

2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at in the locations as indicated in **Figure 1**. A close-up survey should be carried out with selection of representative thickness measurements to determine the extent of corrosion. Particular attention should be given to bunker tank boundaries and spaces adjacent to heated engine room.

2.2 Deformations

2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and bulkheads. A close-up examination of the deformed area should be carried out to determine the extent of the damage.

2.3 Fractures

2.3.1 Fractures in weld at floor connections and other locations in the aft peak tank and rudder trunk space can normally only be found by close-up survey.

2.3.2 The structure supporting the rudder carrier may fracture and/or deform due to excessive load on the rudder. Bolts connecting the rudder carrier to the steering gear flat may also suffer damage under such load.

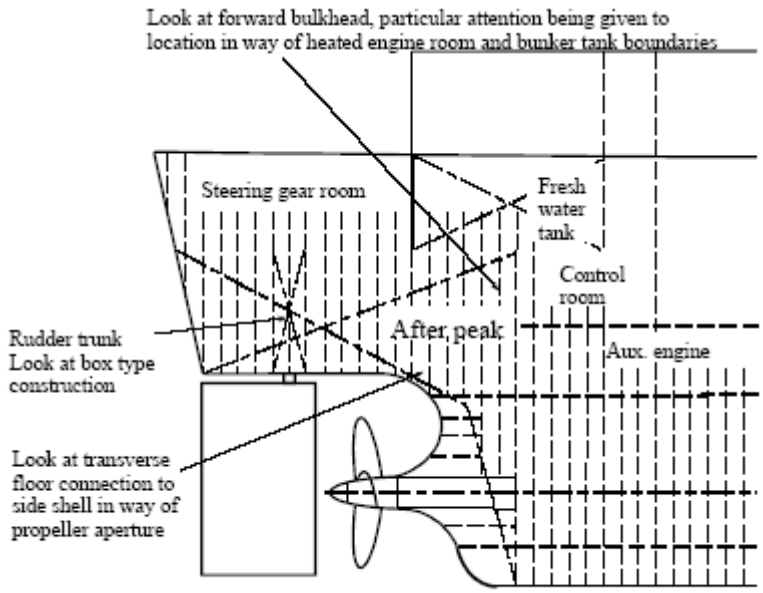


Figure 1 Aft end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the extent of damage.

3.3 Fractures

3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

3.3.2 In order to prevent recurrence of damages suspected to be caused by main engine or propeller excited vibration, the cause of the vibration should be ascertained and additional reinforcements provided as found necessary (See Examples 9 and 10).

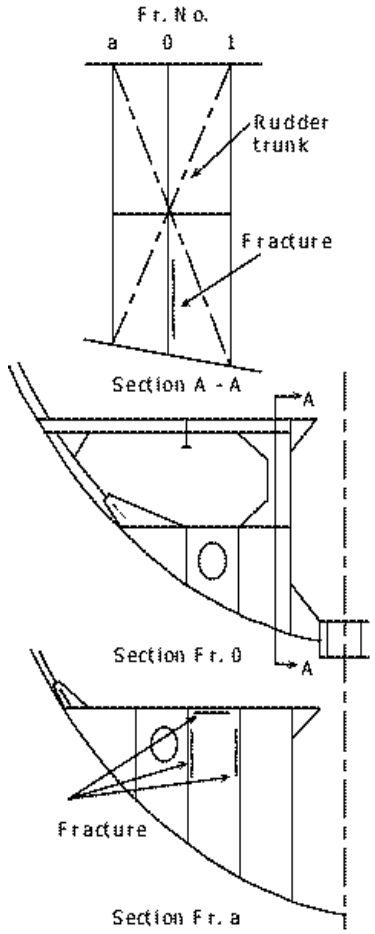
3.3.3 In the case of fractures caused by sea loads, increased thickness of plating and/or design modifications to reduce stress concentrations should be considered.

3.3.4 Fractured structure which supports rudder carrier is to be cropped, and renewed, and may have to be reinforced (See Examples 11 and 12).

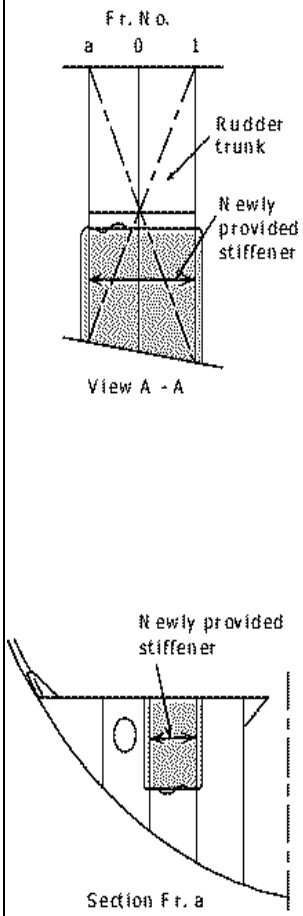
Area 2 Aft End Structure

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	**Aft region**	**Example No.**
Area 2	**Aft peak ballast tank**	**9**
Detail of damage	Fractures in bulkhead in way of rudder trunk	

Sketch of damage



Sketch of repair



Factors which may have caused damage

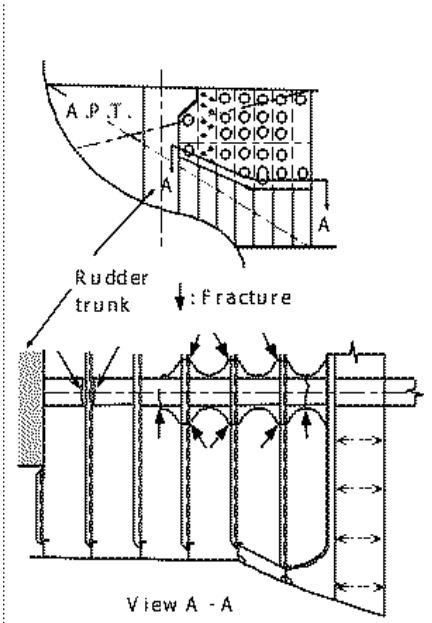
1. Vibration.

Notes on repairs

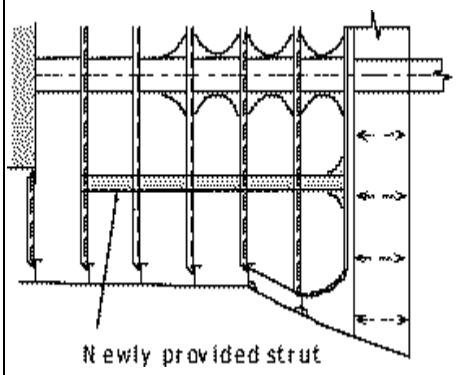
1. The fractured plating should be cropped and renewed.
2. Natural frequency of the plate between stiffeners should be changed, e.g. reinforcement by additional stiffeners.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	**Aft region**	**Example No.**
Area 2	**Aft peak ballast tank**	**10**
Detail of damage	Fractures at the connection of floors and girders/side brackets	

Sketch of damage



Sketch of repair



Factors which may have caused damage

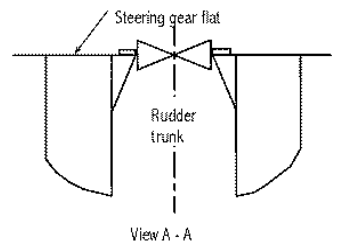
1. Vibration.

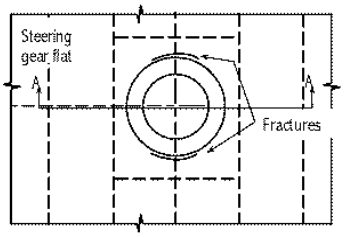
Notes on repairs

1. The fractured plating should be cropped and renewed.
2. Natural frequency of the panel should be changed, e.g. reinforcement by additional strut.

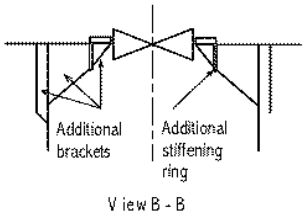
OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	**Aft region**	**Example No.**
Area 2	**Machinery space outside Engine room**	**11**
Detail of damage	Fractures in flat where rudder carrier is installed in steering gear room	

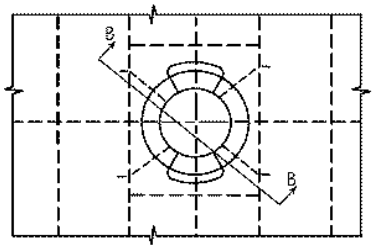
Sketch of damage





Sketch of repair





Factors which may have caused damage

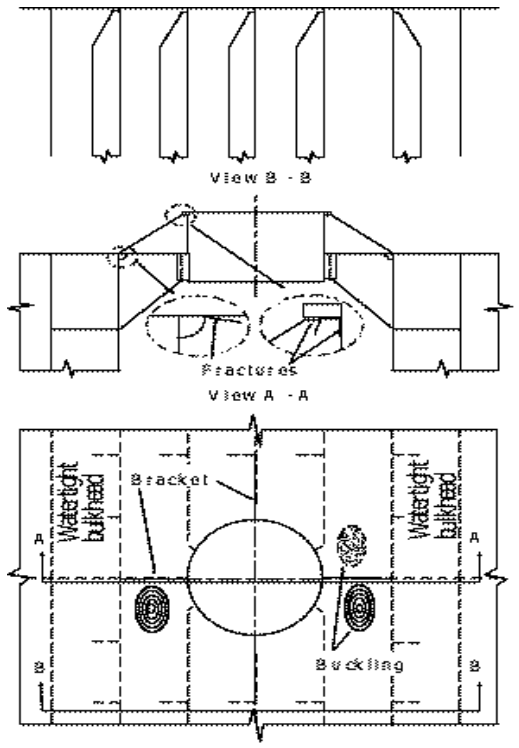
1. Inadequate design.

Notes on repairs

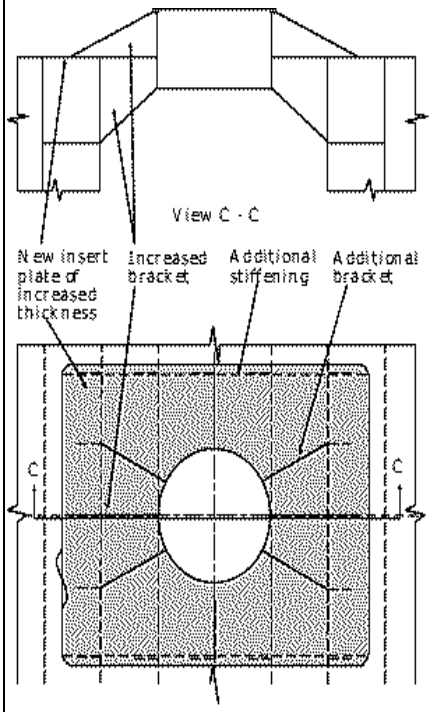
1. Fractured plating should be cropped and renewed.
2. Additional brackets and stiffening ring should be fitted for reinforcement.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 7	**Aft region**	**Example No.**
Area 2	**Machinery space outside engine room**	**12**
Detail of damage	Fractures in steering gear foundation brackets and deformed deck plate	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Insufficient deck strengthening (missing base plate).
2. Insufficient strengthening of steering gear foundation.
3. Bolts of steering gear were not sufficiently pre-loaded.

Notes on repairs

1. New insert base plate of increased plate thickness.
2. Additional longitudinal stiffening at base plate edges.
3. Additional foundation brackets above and under deck (star configuration).

Group 8 Machinery and Accommodation Spaces

- Area 1 Engine Room Structure
- Area 2 Accommodation Structure

Area 1 Engine Room Structure

Contents

1 General

2 What to look for - Engine room survey
2.1 Material wastage
2.2 Fractures

3 What to look for - Tank survey
3.1 Material wastage
3.2 Fractures

4 General comments on repair
4.1 Material wastage
4.2 Fractures

Examples of structural detail failures and repairs – Group 8

Example No.	Title
1	Fractures in brackets at main engine foundation
2	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room
3	Corrosion in bottom plating under inlet/suction/pipe in way of bilge tank in engine room

1 General

The engine room structure is categorized as follows:

- Boundary structure, which consists of upper deck, bulkhead, inner bottom plating, funnel, etc.
- Deep tank structure
- Double bottom tank structure

The boundary structure can generally be inspected routinely and therefore any damages found can usually be easily rectified. Deep tank and double bottom structures, owing to access difficulties, generally cannot be inspected routinely. Damage of these structures is usually only found during dry docking or when a leakage is in evidence.

2 What to look for - Engine room survey

2.1 Material wastage

2.1.1 Tank top plating, shell plating and bulkhead plating adjacent to the tank top plating may suffer severe corrosion caused by leakage or lack of maintenance of sea water lines.

2.1.2 Bilge well should be cleaned and inspected carefully for heavy pitting corrosion caused by sea water leakage at gland packing or maintenance operation of machinery.

2.1.3 Parts of the funnel forming the boundary structure often suffer severe corrosion, which may impair fire fighting in engine room and weathertightness.

3 What to look for - Tank survey

3.1 Material wastage

3.1.1 The environment in bilge tanks, where mixture of oily residue and seawater is accumulated, is more corrosive when compared to other double bottom tanks. Severe corrosion may result in holes in the bottom plating, especially under sounding pipe. Pitting corrosion caused by seawater entered through air pipe is seldom found in cofferdam spaces.

3.2 Fractures

3.2.1 In general, deep tanks for fresh water or fuel oil are located in engine room. The structure in these tanks often sustains fractures due to vibration. Fracture of double bottom structure in engine room is seldom found due to its high structural rigidity.

4 General comments on repair

4.1 Material wastage

4.1.1 Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

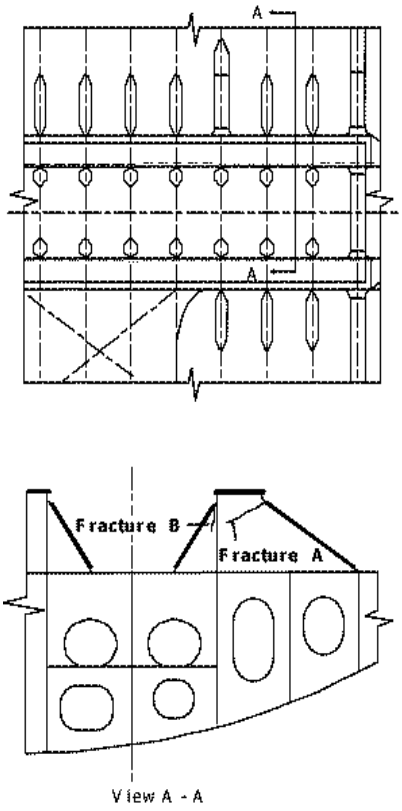
4.2 Fractures

4.2.1 For fatigue fractures caused by vibration, in addition to the normal repair of the fractures, consideration should be given to modification of the natural frequency of the structure to avoid resonance. This may be achieved by providing additional structural reinforcement, however, in many cases, a number of tentative tests may be required to reach the desired solution.

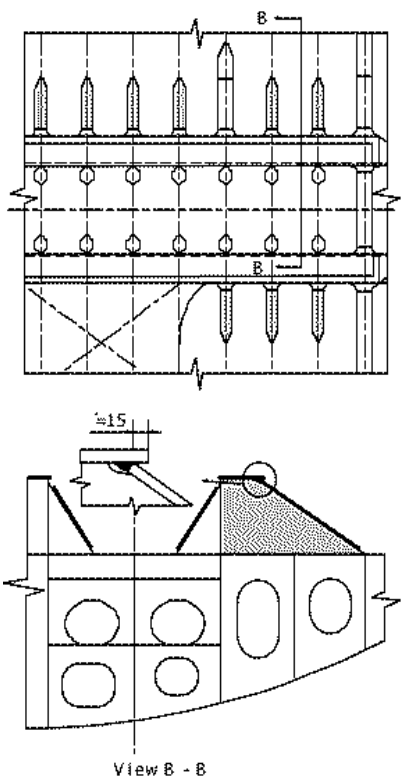
Group 8 Area 1 Engine Room Structure

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 8	Machinery and accommodation spaces	Example No.
Area 1	Engine room	1
Detail of damage	Fractures in brackets at main engine foundation	

Sketch of damage



Sketch of repair



Factors which may have caused damage

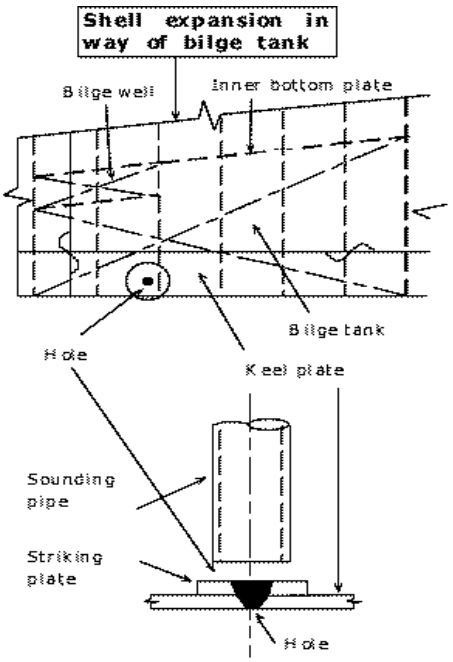
1. Vibration of main engine.
2. Insufficient strength of brackets at main engine foundation.
3. Insufficient pre-load of the bolts.

Notes on repairs

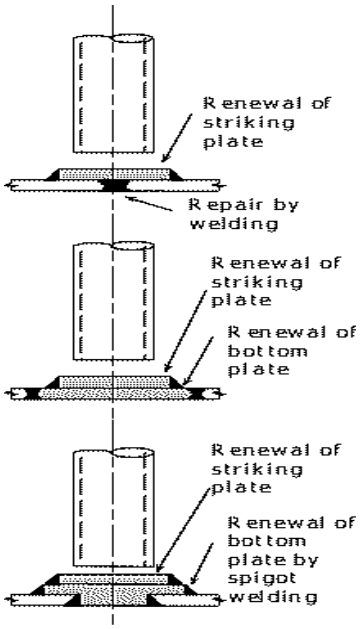
1. Fractures may be veed-out and rewelded.
2. New modified brackets at main engine foundation.
3. Or insert pieces and additional flanges to increase section modulus of the brackets.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 8	Machinery and accommodation spaces	Example No.
Area 1	Engine room	2
Detail of damage	Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Heavy corrosion of bottom plating under sounding pipe.

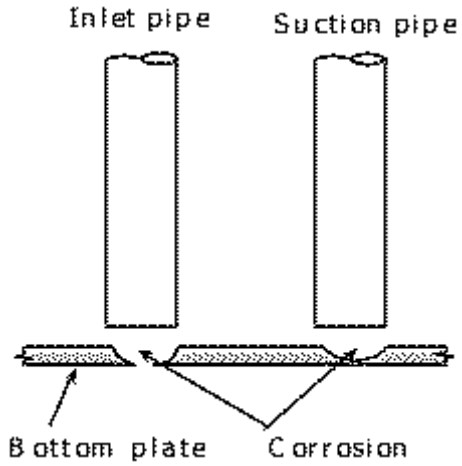
Notes on repairs

1. Corroded striking plating should be renewed.
2. Bottom plate should be repaired depending on the condition of corrosion.

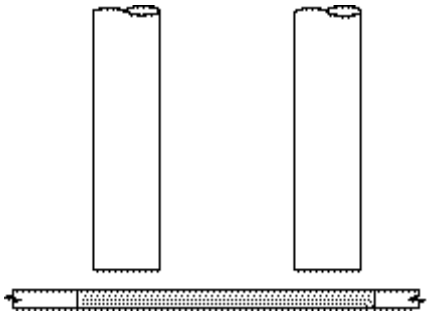
(Note):
Repair by spigot welding can be applied to the structure only when the stress level is considerably low. Generally this procedure cannot be applied to the repair of bottom plating of ballast tanks in cargo tank region.

OIL Tankers	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Group 8	Machinery and accommodation spaces	Example No.
Area 1	Engine room	3
Detail of damage	Corrosion in bottom plating under inlet/suction/pipe in way of bilge tank in engine room	

Sketch of damage



Sketch of repair



Factors which may have caused damage

1. Heavy corrosion of bottom plating under the inlet/suction pipe.

Notes on repairs

1. Corroded bottom plate is to be cropped and part renewed. Thicker plate is preferable.
2. Replacement of pipe end by enlarged conical opening (similar to suction head in ballast tank) is preferable.

Area 2 Accommodation Structure

Contents

1 General

Group 8 Figures and/or Photographs – Area 2

Example No.	Title
Photo 1	Corroded accommodation house side structure

1 General

Corrosion is the main concern in accommodation structure and deckhouses of aging ships. Owing to the lesser thickness of the structure plating, corrosion can propagate through the thickness of the plating resulting in holes in the structure.

Severe corrosion may be found in exposed deck plating and deck house side structure adjacent to the deck plating where water is liable to accumulate (See **Photograph 1**). Corrosion may also be found in accommodation bulkheads around cut-out for fittings, such as doors, side scuttles, ventilators, etc., where proper maintenance of the area is relatively difficult. Deterioration of the bulkheads including fittings may impair the integrity of weathertightness.

Fatigue fractures caused by vibration may be found, in the structure itself and in various stays of the structures, mast, antenna, etc.. For such fractures, consideration should be given to modify the natural frequency of the structure by providing additional reinforcement during repair.

Photograph 1 Corroded accommodation house side structure

BCS-G 98 Duties of Surveyors under Statutory Conventions and Codes

1. Preamble

1.1. The provisions of the statutory conventions and codes define in general terms the role of Surveyors of recognized organizations in the performance of surveys and their duties toward flag Administrations and Port Authorities. The same provisions define, again in general terms, the system of liaisons between the Flag Administrations or Port Authorities and the recognized organizations.

1.2. In line with the requirements of the statutory codes and conventions, Classification Societies, individually or in groups, have entered into agreements with several Flag Administrations. These agreements cover the application of the duties of surveyors in the performance of surveys and their duties toward Flag Administrations and take preference over any other guidelines for such surveys.

1.3. This Recommendation does not apply to the ISM Code, ISPS Code and MLC 2006 certification.

2. Definitions

2.1. A “Permanent/full term certificate” is a certificate issued upon satisfactory completion of an initial or renewal survey. A permanent/full term certificate is valid until the next periodical/renewal survey is due. A permanent/full term certificate may also be issued or re-issued when all deficiencies which led to the issuance of a conditional certificate are corrected.

2.2. An “Interim certificate” is a certificate issued by the attending surveyor upon satisfactory completion of a survey in order to permit the ship to trade while the permanent/full term certificate is prepared. An interim certificate is usually valid for five months from the date of issuance.

2.3. “Conditional certificate”* or a “conditionally issued certificate” is a certificate with the appropriate expiry dates that is issued by the attending surveyor when deficiencies/defects exist which cannot be corrected in the port of survey. A conditional certificate is valid only for a period long enough to permit the ship to proceed to the port where the correction will be made.

2.4. A “minor deficiency/defect” is an observed situation which does not prevent the ship from proceeding to sea as it is not considered to pose a danger to the ship, the environment or persons on board within the timeframe given for its rectification.

2.5. A “detainable deficiency/defect” is an identified deficiency/defect which is considered to endanger the people onboard, the stability or integrity of the vessel, the cargo or is likely to cause pollution. Refer to Annex A for guidance on detainable deficiencies related to various statutory certificates.

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* Some Administrations require that these certificates be called and annotated “Short Term certificates”.

2.6. Statutory Condition: requirements to the effect that specific measures, repairs, surveys are to be carried out within a specific time limit in order to retain statutory certification.

2.7. Condition(s) of Class: requirements to the effect that specific measures, repairs, surveys are to be carried out within a specific time limit in order to retain Classification.

3. Types of survey

3.1. The scope and specified intervals of any statutory survey (e.g. initial, annual, intermediate, periodical, renewal, etc.) are defined by each appropriate statutory convention or code and are further outlined in the IMO guidelines for statutory surveys given in the most updated version of IMO Res. A.1120(30) “Survey Guidelines under the Harmonized System of Survey and Certification”.

4. Notification of Flag Administration

4.1. Whether to notify Administrations of deficiencies/defects and issuance of certificates, and the means and timeliness of this notification, should be in accordance with the Society’s agreement with the Administration.

5. Issuance of certificates

5.1. If detainable deficiencies/defects are identified at the time of any survey (i.e. initial, annual, intermediate, periodical, renewal, additional survey for port state control, or other additional survey), and they are not permanently repaired or rectified in the port of survey, or temporarily compensated either as agreed between the Society and the Flag administration in their agreement or on a case-by-case basis no certificate should be issued or endorsed except in cases 5.2.1 and 5.3.1 below.

5.2.1. If detainable deficiencies/defects are identified at the time of an initial or renewal survey, and they cannot be permanently repaired or permanently rectified in the port of survey:

- A conditional or short term certificate should be issued to allow the vessel to proceed to a port where the permanent repairs are to be made.

- The certificate should be identified by the wording “Conditional” or “Short term” printed under the name of the certificate.

- Outstanding deficiencies/defects, with the details of any relevant requirements or provisos and the assigned due date for the time needed to rectify, should be noted on or attached to the Conditional or short term Certificate.

- Flag Administration should be contacted as per agreement between the individual Society and the Flag Administration.

5.2.2. If the Owner satisfactorily rectifies the deficiencies/defects the “conditional” or “short term” certificate should be withdrawn and a “permanent/full term” certificate issued. The Society may also issue an “Interim” certificate in this case if that is their practice.

5.3.1. If detainable deficiencies/defects are identified at the time of an annual, intermediate, periodical, additional survey for port state control or other additional survey and they cannot be permanently repaired or permanently rectified in the port of survey:

- The existing “permanent/full term” certificate should not be endorsed.

- The existing “permanent/full term” certificate should be withdrawn.

- A conditional or short term certificate should be issued.

- The certificate should be identified by the wording “Conditional” or “Short term” printed under the name of the certificate.

- Outstanding deficiencies/defects, with the details of any relevant requirements or provisos and the assigned due date for the time needed to rectify, should be noted on or attached to the Conditional Certificate.

- Flag Administration should be contacted as per agreement between the individual Society and the Flag Administration.

5.3.2. If the Owner satisfactorily rectifies the deficiencies/defects the “conditional or short term” certificate should be withdrawn and the “permanent/full term” certificate restored.

5.4. In case of minor deficiencies/defects not rectified at time of the survey:

- if the deficiency/defect also relates to class*, a condition of class may be issued with the details of any relevant requirements or provisos and an assigned due date for the time needed to rectify.

- if the deficiency/defect is limited only to statutory certificates, a statutory condition with assigned due date may be issued, with the details of any relevant requirements or provisos and an assigned due date for the time needed to rectify, with or without a conditional or short term certificate issued.

The above actions are to be reported to the Administration to the extent required by the agreement with the individual Society.

If deemed necessary by the attending surveyor, a combination of deficiencies/defects of a less serious nature may also result in the withdrawal of the permanent/full term statutory certificate and its replacement with a conditional or short term certificate subject to the concurrence by the Flag Administration to the extent required by the agreement with the individual Society.

* this includes minor deficiencies/defects related to structural, mechanical and/or electrical requirements of the classification society recognized by the flag Administration (e.g., SOLAS II-1/3-1).

5.5. The final decision on the severity of the deficiency/defect should be left to the professional judgment of the surveyor.

Annex A

Detainable Deficiencies

To assist the surveyor, the following list, grouped under relevant conventions and codes, indicates those deficiencies which may be considered of such a serious nature as to be categorized as detainable deficiencies. This list is not considered exhaustive but is intended to give examples of relevant items.

SOLAS Convention

1. Failure of proper operation of propulsion and other essential machinery, as well as electrical installations.

2. Excess amount of oily-water mixture in bilges, insulation of piping, including exhaust pipes in engine room contaminated by oil, and improper operation of bilge pumping arrangements.

3. Failure of proper operation of emergency generator, lighting, batteries, and switches.

4. Failure of proper operation of the main and auxiliary steering gear.

5. Absence, insufficient capacity or serious deterioration of personal life-saving appliances, survival craft, and launching arrangements.

6. Absence, non-compliance, or substantial deterioration to the extent that it cannot comply with its intended use of fire detection system, fire alarms, fire-fighting equipment, fixed fire-extinguishing installations, ventilation valves, fire dampers, and quick-closing devices.

7. Absence, substantial deterioration or failure of proper operation of the cargo deck area fire protection on tankers.

8. Absence, non-compliance, or serious deterioration of lights, shapes, or sound signals.

9. Absence or failure of the proper operation of the radio equipment for distress and safety communication.

10. Absence or failure of the proper operation of navigation equipment, taking the relevant provisions of SOLAS regulation V/16.2 into account.

11. Absence of corrected navigational charts, and/or all other relevant nautical publications necessary for the intended voyage, taking into account that electronic charts may be used as a substitute for the charts.

12. Absence of non-sparking exhaust ventilation for cargo pump rooms.

13. Failure of the proper operation of inert gas system.

14. Non-implementation or failure to carry out the enhanced survey programme in accordance with SOLAS regulation XI-1/2 and the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code), as amended.

15. Absence or failure of a voyage data recorder (VDR), when its use is compulsory.

Chemical Codes

1. Missing or damaged high pressure safety devices.

2. Electrical installations not intrinsically safe or not corresponding to the code requirements.

3. Sources of ignition in hazardous locations.

4. Insufficient heat protection for sensitive products.

5. Pressure alarms for cargo tanks not operable.

Gas Codes

1. Missing closing devices for accommodation or service spaces.

2. Bulkhead not gas tight.

3. Defective airlocks.

4. Missing or defective quick closing valves.

5. Missing or defective safety valves.

6. Electrical installations not intrinsically safe or not corresponding to the code requirements.

7. Ventilators in cargo area not operable.

8. Pressure alarms for cargo tanks not operable.

9. Gas detection plant and/or toxic gas detection plant defective.

Load Line Convention

1. Significant areas of damage or corrosion, or pitting of plating and associated stiffening in decks and hull affecting fitness to proceed or strength to take local loads, unless properly authorized temporary repairs for a voyage to a port for permanent repairs have been carried out.

2. The absence of sufficient stability information, in an approved form.

3. Absence, substantial deterioration, or defective closing devices, hatch closing arrangements, and watertight/weathertight doors.

4. Overloading.

5. Absence of, or impossibility to read, draught marks and / or Load Line marks.

MARPOL 73/78, Annex I

1. Absence, serious deterioration, or failure of proper operation of the oily-water filtering equipment, the oil discharge monitoring and control system, or the 15 ppm alarm arrangements.

2. Remaining capacity of slop and/or sludge tank insufficient for the intended voyage.

3. Oil record book not available.

4. Unauthorized discharge bypass fitted.

5. Failure to meet the requirements of Reg. 20.4 or alternative requirements specified in regulation Reg. 20.7.

MARPOL 73/78, Annex II

1. Absence of approved P&A Manual.

2. No cargo record book available.

3. Unauthorized discharge bypass fitted.

MARPOL 73/78, Annex IV

1. A sewage treatment plant is not of an approved type in accordance with the standards and test methods developed by an Organization.

2. Systems fitted to comminute and disinfect sewage are not of an approved type.

3. Holding tank capacity not approved by the Administration insufficient for the intended voyage.

4. A pipeline for the discharge of sewage to a reception facility, provided with a standard shore connection is not fitted.

MARPOL 73/78/97, Annex VI

1. A marine diesel engine, with a power output of more than 130 kW, which is installed on board a ship constructed on or after 1 January 2000, or a marine diesel engine having undergone a major conversion on or after 1 January 2000, which doesn't comply with the NOx Technical Code or that does not comply with the relevant NOx emission limit.

2. A marine diesel engine, with a power output of more than 5000 kW and a per cylinder displacement at or above 90 litres, which is installed onboard a ship constructed on or after 1 January 1990 but prior to 1 January 2000, and an Approved Method for that engine has been certified by an Administration and was commercially available, for which an Approved Method is not installed after the first renewal survey specified in MARPOL Annex VI Reg. 13 Par 7.2.

3. Depending on the method used for demonstrating SOx compliance, the sulphur content of any fuel oil being used onboard exceeds 3.5% m/m on and after 1 January 2012, 0.5% m/m on and after 1 January 2020 and 0.1% m/m on and after 1 January

2015 while operating within a SOx emission control area, taking into account provisions of MARPOL Annex VI Reg.14 respectively.

4. Non-compliance with the relevant requirements while operating within an Emission Control Area for SOx.

5. An incinerator installed onboard the ship on or after 1 January 2000 does not comply with requirements contained in Appendix IV to the Annex, or the standard specifications for shipboard incinerators developed by IMO.

BCS- G 99 Recommendations for the Safety of Cargo Vessels of less than Convention Size

Preamble

Cargo vessels of less than 500 Gross Tonnage (except vessels down to 300 GT with respect to radio-communication) are not covered by the SOLAS Convention, and there exist no uniform regulations or guidance that provides an internationally accepted level of safety for such vessels.

As in the SOLAS Convention, a cargo vessel may be taken to mean any vessel which is not a passenger vessel, gas carrier or chemical tanker, and includes tugs, dredgers, pilot craft, etc in addition to cargo vessels. Smaller vessels due to a combination of their size and constant exposure to coastal hazards are particularly vulnerable and therefore careful consideration should be given to all aspects of their safety.

Fishing vessels are not part of these Recommendations. For fishing vessels, equal or greater than 24 m in Load Line Length, reference should be made to the Recommendations of the Torremolinos International Convention for the Safety of Fishing Vessels, 1993 Protocol. Fishing vessels less than 24 m in length, are generally covered by the Requirements as specified by the Administration.

The purpose of these Recommendations is to provide a generally applicable code of safe practice in particular for fire protection, detection and extinction; safety equipment, radio installations and navigational equipment.

The Recommendations are intended to be applied by BCS, with the consent of the Administration concerned, where no national regulations exist; they may also be offered for consideration by Administrations, who may wish to establish national statutory Recommendations for such vessels or consider their revision.

It is recognised that the Recommendations are used as a basis for contract specifications by builders and owners, but care should be taken to ensure an appropriate level of safety, having regard to both the type and service area of the vessels involved. Vessels engaged on coastal voyages may encounter widely varying weather and sea conditions depending upon the geography of the area involved and the advice of the classification society should be sought in all cases when applying the Recommendations.

Materials and equipment specified in these recommendations should be of an approved type in accordance with national or International Requirements.

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CHAPTER I GENERAL PROVISIONS

1. Application

The recommendations as specified in this document, are within the spirit of the International Conventions and Protocols, and are applicable for cargo vessels of less than Convention size.

The provisions of these recommendations are intended to apply to new and - as far as reasonable and practicable, or as found necessary by the relevant Administration – to existing cargo vessels of less than 500 Gross Tonnage (GT).

Vessels carrying dangerous goods- chemicals, and/or liquefied gasses in bulk, should comply with IMDG*, IGC and IBC Codes, as applicable.

***** Refer to MSC/Circ 858 ***Document of compliance with SOLAS regulation 11-2/54***

2. Definitions

The terms, used in these Recommendations are as defined in SOLAS 1974 (as amended) and the classification rules of BCS, as applicable at the date of shipbuilding or major conversion contract.

The term Gross Tonnage (GT) is as defined in IMO Resolution A.493 (XII), calculated in accordance with the International Convention of Tonnage Measurements of Ships of 1969.

2.1 Service Area Definitions

Unrestricted service means a vessel engaged on International voyages, and not bounded by any limitations on operating environment.

Service restrictions are broken down into 2 broad categories:

1. vessels operating coastal or specified operating areas,

2. vessels operating within protected or extended protected waters.

1. Restricted Service:

(a) **Specified coastal service.** Service along a coast the geographical limits of which should be defined and for a distance out to sea generally not exceeding 20 nautical miles, unless some other distance is specified for 'coastal service' by the Administration with which the vessel is registered, or by the Administration of the coast off which it is operating.

(b) **Specified operating or service areas.** Service between two or more ports or other geographical features, or service within a defined geographical area such as: "Red Sea Service", "Piraeus to Thessaloniki and Islands within the Aegean Sea".

2. Protected Service:

(a) **Protected water service.** Service in sheltered water adjacent to sand banks, reefs, breakwaters to other coastal features, in sheltered waters between islands and lagoons.

(b) **Extended protected water service.** Service in protected waters and also short distances (generally less than 15 nautical miles) beyond protected waters in 'reasonable weather'.

3. Surveys and Maintenance

3.1 The hull, machinery and all equipment of every vessel should be constructed and installed so as to be capable of being regularly maintained to ensure that they are at all times, in all respects, satisfactory for the vessel's intended service.

3.2 An organisation, recognized by the Administration, should carry out surveys of vessel during construction and, at regular intervals after completion, generally as prescribed within Chapter I of SOLAS 1974 (as amended). It is recommended that such surveys should be carried out by BCS.

3.3 (a) The condition of the vessel and its equipment should be maintained to conform with the provisions of the Recommendations to ensure that the vessel will remain fit for the intended operation. The hull structure and machinery, not forming part of these Recommendations, should also be similarly surveyed and maintained.

(b) No change should be made in the structural arrangements, machinery, equipment and other items covered by the survey, without the approval of the Administration or recognized organization.

(c) Whenever an accident occurs to a vessel or a defect is discovered, the master or owner of the vessel should report to the Administration or surveying authority without delay.

CHAPTER II WATERTIGHT INTEGRITY AND EQUIPMENT

1. Load Line Recommendations

For vessels greater than 24 metres in length, the requirements set forth in LL Convention 1966 (LLC 66), as amended*, should be met.

* subject to ratification of protocols by the Administrations.

Unless specified otherwise by the Administration, vessels of less than 24 metres in length, should comply with the relevant conditions of assignment and the assignment of freeboard, as specified in the International Load Line Convention 1966, as amended, as far as practicable.

CHAPTER III STABILITY

1. Application

The following IMO Resolutions should be applied to vessels greater than 24 metres in length:

- The 2008 Intact Stability Code (IMO Resolution MSC.267(85))

The Requirements, if any, of the Administration, should be taken into consideration.

Due regard should also be paid to particulars of either the vessel concerned or its cargo, for assessing, whether additional or amended criteria need to be applied.

CHAPTER IV FIRE FIGHTING

Fire safety objectives

The fire safety objectives of this chapter are to:

- prevent the occurrence of fire and explosion;
- reduce the risk to life caused by fire;
- reduce the risk of damage caused by fire to the vessel, its cargo and the environment;
- contain, control and suppress fire and explosion in the compartment of origin; and
- provide adequate and readily accessible means of escape for crew.

Achievement of the fire safety objectives

The fire safety objectives set out above could be achieved by ensuring compliance with Sections 1 to 6, or by alternative design and arrangements which comply with Section 7. A ship could be considered to achieve the fire safety objectives set out in first paragraph when either:

- the vessel's designs and arrangements, as a whole, comply with Sections 1 to 6, as applicable;
- the vessel's designs and arrangements, as a whole, have been reviewed and approved in accordance with Section 7; or
- part(s) of the vessel's designs and arrangements have been reviewed and approved in accordance with Section 7 and the remaining parts of the vessel comply with the relevant Recommendations in Sections 1 to 6.

Section 1 Fire Pumps and Fire Main Systems

1.1 Purpose

The purpose of this Recommendation is to suppress and swiftly extinguish a fire in the space of origin. For this purpose, the following functional Recommendations should be met:

- fixed fire extinguishing systems should be installed, as applicable, having due regard to the fire growth potential of the protected spaces; and
- fire extinguishing appliances should be readily available.

1.1.1 Capacity

The total capacity of the main fire pump(s) is not to be less than:

$$Q = (0{,}145\,(L\,(B+D))^{½} + 2{,}170)^2 \quad \text{but need not exceed } 25 m^3/\text{hour}$$

Where

B = greatest moulded breadth of vessel, in metres
D = moulded depth to bulkhead deck, in metres
L = Freeboard Length, in metres
Q = total capacity, in m^3/hour

1.1.2 Fire pumps

Generally one main power pump and one portable fire pump should be provided as specified below.

1.1.2.1 Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil, and that, if they are subject to occasional duty for the transfer or pumping of fuel oil, suitable changeover arrangements are fitted.

1.1.2.2 A power pump is a fixed pump driven by a power source other than by hand.

1.1.2.3 In cargo vessels classed for navigation in ice, the fire pump sea inlet valves should be provided with ice clearing arrangements.

1.1.2.4 Relief valves should be provided in conjunction with any fire pump if the pump is capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves should be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

1.1.2.5 Where a centrifugal pump is provided in order to comply with this sub-Section, a non-return valve should be fitted in the pipe connecting the pump to the fire main.

1.1.3 Portable fire pumps

1.1.3.1 Portable fire pumps should comply with the following:

(a) The pump should be self-priming.

(b) The total suction head and the net positive suction head of the pump should be determined taking account of actual operation, i.e. pump location when used.

(c) The portable fire pump, when fitted with its length of discharge hose and nozzle, should be capable of maintaining a pressure sufficient to produce a jet throw of at least 12 m, or that required to enable a jet of water to be directed on any part of the engine room or the exterior boundary of the engine room and casing, whichever is the greater.

(d) Except for electric pumps, the pump set should have its own fuel tank of sufficient capacity to operate the pump for three hours. For electric pumps, their batteries should have sufficient capacity for three hours.

(e) Except for electric pumps, details of the fuel type and storage location should be carefully considered. If the fuel type has a flashpoint below 60°C, further consideration to the fire safety aspects should be given.

(f) The pump set should be stored in a secure, safe and enclosed space, accessible from open deck and clear of the Category 'A' machinery space.

(g) The pump set should be easily moved and operated by two persons and be readily available for immediate use.

(h) Arrangements should be provided to secure the pump at its anticipated operating position(s).

(i) The overboard suction hose should be non-collapsible and of sufficient length, to ensure suction under all operating conditions. A suitable strainer should be fitted at the inlet end of the hose.

(j) Any diesel-driven power source for the pump should be capable of being readily started in its cold condition by hand (manual) cranking. If this is impracticable, consideration should be given to the provision and maintenance of heating arrangements, so that readily starting can be ensured.

1.1.3.2 Alternatively to the Recommendations of 1.1.3.1 a fixed fire pump may be fitted, which should comply with the following:

(a) The pump, its source of power and sea connection should be located in accessible positions, outside the compartment housing the main fire pump.

(b) The sea valve should be capable of being operated from a position near the pump.

(c) The room where the fire pump prime mover is located should be illuminated from the emergency source of electrical power, and should be well ventilated.

(d) Pump is required to supply water for a fixed fire-extinguishing system in the space where the main fire pump is situated, it should be capable of simultaneously supplying water to this system and the fire main at the required rates.

(e) The pump may also be used for other suitable purposes, subject to the approval in each case.

(f) Pressure and quantity of water delivered by the pump being sufficient to produce a jet of water, at any nozzle, of not less than 12 m in length. For vessels of less than 150 GT, the jet of water may be specially considered.

1.1.3.3 For vessels less than 150 GT fitted with an approved fixed fire-fighting system in the engine room, portable pumps may be omitted.

1.1.3.4 Means to illuminate the stowage area of the portable pump and its necessary areas of operation should be provided from the emergency source of electrical power.

1.2 Fire main

1.2.1 The diameter of the fire main should be based on the required capacity of the fixed main fire pump(s) and the diameter of the water service pipes should be sufficient to ensure an adequate supply of water for the operation of at least one fire hose.

1.2.2 The wash deck line may be used as a fire main provided that the Recommendations of this sub-Section are satisfied.

1.2.3 All exposed water pipes for fire-extinguishing should be provided with drain valves for use in frosty weather. The valves should be located where they will not be damaged by cargo.

1.3 Pressure in the fire main

1.3.1 When the main fire pump is delivering the quantity of water required by 1.1.1, or the fire pump described in 1.1.3.2, through the fire main, fire hoses and nozzles, the pressure maintained at any hydrant should be sufficient to produce a jet throw at any nozzle of not less than 12 m in length. (For vessels less than 150 GT, the jet of water may be specially considered).

1.4 Fire Hydrants

1.4.1 Number and position of hydrants

1.4.1.1 For vessels less than 150 GT the number and position of the hydrants should be such that at least one jet of water may reach any part normally accessible to the crew, while the cargo vessel is being navigated and any part of any cargo space when empty. Furthermore, such hydrants should be positioned near the accesses to the protected spaces. (At least one hydrant should be provided in each Category 'A' machinery space).

1.4.1.2 For vessels equal or greater than 150 GT the number and position of hydrants should be such that at least two jets of water not emanating from the same hydrant, one of which should be from a single length of hose, may reach any part of the vessel normally accessible to the crew while the vessel is being navigated and any part of any cargo spaces when empty. Furthermore, such hydrants should be positioned near the accesses to the protected spaces. Other Requirements specified by the Administration may be considered.

1.4.2 Pipes and hydrants

1.4.2.1 Materials readily rendered ineffective by heat should not be used for fire mains. Where steel pipes are used, they should be galvanized internally and externally. Cast iron pipes are not acceptable. The pipes and hydrants should be so placed that the fire-hoses may be easily coupled to them. The arrangement of pipes and hydrants should be such as to avoid the possibility of freezing. In vessels where deck cargo may be carried, the positions of the hydrants should be such that they are always readily accessible and the pipes should be arranged, as far as practicable, to avoid risk of damage by such cargo. There should be complete interchangeability of hose couplings and nozzles.

1.4.2.2 A valve should be fitted at each fire hydrant so that any fire-hose may be removed while the fire pump is at work.

1.4.2.3 Where a fixed fire pump is fitted outside the engine room, in accordance with 1.1.3.2:

(a) an isolating valve should be fitted in the fire main so that all the hydrants in the vessel, except that or those in the Category 'A' machinery space, can be supplied with water. The isolating valve should be located in an easily accessible and tenable position outside the Category 'A' machinery space; and

(b) the fire main should not re-enter the machinery space downstream of the isolating valve.

1.5 Fire-hoses

1.5.1 Fire-hoses should be of approved non-perishable material. The hoses should be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their length, in general, is not to exceed 18 m. Each hose should be provided with a nozzle and the necessary couplings. Fire-hoses, together with any necessary fittings and tools, should be kept ready for use in conspicuous positions near the water service hydrants or connections.

1.5.2 For vessel less than 150 GT, one hose should be provided for each hydrant. In addition one spare hose should be provided onboard.

1.5.3 Vessel equal or greater than 150 GT should be provided with fire hoses the number of which should be one for each 30 m length of the ship and one spare, but in no case less than three in all. Unless one hose and nozzle is provided for each hydrant in the ship, there should be complete interchangeability of hose couplings and nozzles.

1.6 Nozzles

1.6.1 For the purpose of this Chapter, standard nozzle sizes are 12 mm, 16 mm or 19 mm, or as near thereto as possible, so as to make full use of the maximum discharge capacity of the fire pump(s).

1.6.2 For accommodation and service spaces, the nozzle size need not exceed 12 mm.

1.6.3 The size of nozzles used in conjunction with a portable fire pump need not exceed 12 mm.

1.6.4 All nozzles should be of an approved dual purpose type (i.e. spray/jet type) incorporating a shut-off.

Section 2 Fire Safety Measures

2.1 Purpose

The purpose of this regulation should contain a fire in the space of origin. For this purpose, the following functional Recommendations should be met:

- the vessel should be subdivided by thermal and structural boundaries;
- thermal insulation of boundaries should have due regard to the fire risk of the space and adjacent spaces;
- the fire integrity of the divisions should be maintained at openings and penetrations.

2.1.1 Structural fire protection

The minimum fire integrity of bulkheads and decks should be as prescribed in Table 1.

Table 1 Minimum fire integrity of bulkheads and decks

[Item]	Space	Separation By	From Space
[(1)]	Machinery Space Class 'A'	A-60	Accommodation / control stations / corridors / staircases / service spaces of high fire risk / ro-ro spaces / vehicle spaces
[(2)]	Machinery Space Class 'A'	A-0	Other than above [item (1)]
[(3)]	Galley	A-0	Unless specified otherwise
[(4)]	Service space of high fire risk other than galley	B-15	Unless specified above [item (1)]
[(5)]	Corridor Staircase	B-0	Unless specified above [item (1)]
[(6)]	Cargo Space (other than ro-ro spaces and vehicle space)	A-0	Unless specified above [item (1)]
[(7)]	Ro-ro space and vehicle space (except weather deck)	A-60	Control stations/machinery spaces of category 'A'
[(8)]	Ro-ro space and vehicle space (except weather deck)	A-0	Unless specified above [item (1)]

Category 'A' machinery spaces should be enclosed by A-60 Class divisions, where adjacent to:

1. Accommodation spaces
2. Control stations
3. Corridors and staircases
4. Service spaces of high fire risk,

and by A-0 Class divisions elsewhere.

The divisions used to separate spaces, not mentioned above, should be of non-combustible material.

2.1.1.1 The hull, superstructure, structural bulkheads, decks and deckhouses should be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material, as given in SOLAS, the 'applicable fire exposure' should be one hour. Vessels built of materials other than steel should be specially considered.

2.1.1.2 Stairways should be enclosed, at least at one level, by divisions and doors or hatches, in order to restrict the free flow of smoke to other decks in the vessel and the supply of air to the fire. Doors forming such enclosures should be self-closing.

2.1.1.3 Openings in 'A' Class divisions should be provided with permanently attached means of closing which should be at least as effective for resisting fires as the divisions in which they are fitted.

2.1.1.4 Interior stairways serving machinery spaces, accommodation spaces, service spaces or control stations should be of steel or other equivalent material.

2.1.1.5 Doors should be self-closing in way of Category 'A' machinery spaces and galleys, except where they are normally kept closed.

2.1.1.6 Where 'A' Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for girders, beams or other structural members, arrangements should be made to ensure that the fire resistance is not impaired. Arrangements should also prevent the transmission of heat to un-insulated boundaries at the intersections and terminal points of the divisions and penetrations by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 mm.

2.1.2 Materials

2.1.2.1 Paints, varnishes and other finishes used on exposed interior surfaces should not be capable of producing excessive quantities of smoke, toxic gases or vapours and should be of the low flame spread type in accordance with the IMO FTP Code, Annex 1, Parts 2 and 5.

2.1.2.2 Except in cargo spaces or refrigerated compartments of service spaces, insulating materials should be non-combustible.

2.1.2.3 Where pipes penetrate 'A' or ‘B’ Class divisions, the pipes or their penetration pieces should be of steel or other approved materials having regard to the temperature and integrity Recommendations such divisions are required to withstand.

2.1.2.4 Pipes conveying oil or combustible liquids through accommodation and service spaces should be of steel or other approved materials having regard to the fire risk.

2.1.2.5 Materials readily rendered ineffective by heat should not be used for overboard scuppers, sanitary discharges and other outlets which are close to the waterline, and where the failure of the material in the event of fire would give rise to the danger of flooding.

2.1.2.6 Primary deck coverings within accommodation spaces, service spaces and control stations should be of a type which will not readily ignite, or give rise to toxic or explosive hazards at elevated temperatures in accordance with the IMO FTP Code, Annex 1, Parts 2 and 6.

2.1.2.7 Materials used for insulating pipes, etc., in machinery spaces and other compartments containing high fire risks should be non-combustible. Vapour barriers and adhesives used in conjunction with insulation, as well as the insulation of pipe fittings, for cold service systems

need not be of non-combustible materials, but they should be kept to the minimum quantity practicable and their exposed surfaces should have low flame spread characteristics.

2.1.3 Surface of insulation

2.1.3.1 In spaces where penetration of oil products is possible, the surface of the insulation should be impervious to oil or oil vapours. Insulation boundaries should be arranged to avoid immersion in oil spillage.

2.1.4 Ventilation systems

2.1.4.1 Ventilation fans should be capable of being stopped and main inlets and outlets of ventilation systems closed from outside the spaces being served.

2.1.4.2 Ventilation ducts for Category 'A' machinery spaces, ro-ro spaces and vehicle spaces should not pass through accommodation spaces, galleys, service spaces or control stations, unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

2.1.4.3 Ventilation ducts for accommodation spaces, service spaces or control stations should not pass through Category 'A' machinery spaces or galleys unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

2.1.4.4 Ventilation arrangement for store rooms containing highly flammable products should be specially considered.

2.1.4.5 Ventilation systems serving Category 'A' machinery spaces and galley exhaust ducts should be independent of systems serving other spaces.

2.1.4.6 Ventilation should be provided to prevent the accumulation of gases that may be emitted from batteries.

2.1.4.7 Ventilation openings may be fitted in and under the lower parts of cabin, mess and dayroom doors in corridor bulkheads. The total net area of any such openings is not to exceed 0,05 m^2. Balancing ducts should not be permitted in fire divisions.

2.1.5 Oil fuel arrangements

2.1.5.1 In a cargo vessel in which oil fuel is used, the arrangements for the storage, distribution and utilization of the oil fuel should be such as to ensure the safety of the vessel and persons on board.

2.1.5.2 Oil fuel tanks situated within the boundaries of Category 'A' machinery spaces should not contain oil fuel having a flashpoint of less than 60°C.

2.1.5.3 Oil fuel, lubricating oil and other flammable oils should not be carried in fore peak tanks.

2.1.5.4 For vessels of 150 GT or more, and as far as practicable:

(a) oil fuel lines shall be arranged far apart from hot surfaces, electrical installations or other sources of ignition and shall be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition. The number of joints in such piping systems shall be kept to a minimum.

(b) surfaces with temperatures above 220°C which may be impinged as a result of a fuel system failure shall be properly insulated. Precautions shall be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

(c) External high-pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors shall be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. A suitable enclosure on engines having an output of 375 kW or less having fuel injection pumps serving more than one injector may be used as an alternative to the jacketed piping system.

2.1.6 Special arrangements in Category 'A' machinery spaces and where necessary other machinery spaces

2.1.6.1 The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces should be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the cargo vessel.

2.1.6.2 Skylights should be of steel and are not to contain glass panels. Suitable arrangements should be made to permit the release of smoke, in the event of fire, from the space to be protected.

2.1.6.3 Windows should not be fitted in machinery space boundaries. This does not preclude the use of glass in control rooms within the machinery spaces.

2.1.6.4 Means of control should be provided for:

(a) opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation, and closure of ventilator dampers;

(b) permitting the release of smoke;

(c) closing power-operated doors or actuating release mechanism on doors other than power-operated watertight doors;

(d) stopping ventilating fans; and

(e) stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps.

2.1.6.5 The controls required in 2.1.6.4 should be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve. Such controls and the controls for any required fire-extinguishing system should be situated at one control position or grouped in as few positions as possible. Such positions should have a safe access from the open deck.

2.1.7 Arrangements for gaseous fuel for domestic purposes

2.1.7.1 Where gaseous fuel is used for domestic purposes, the arrangements for the storage, distribution and utilization of the fuel should be specially considered.

2.1.8 Space heating

2.1.8.1 Space heaters, if used, should be fixed in position and so constructed as to reduce fire risks to a minimum. The design and location of these units should be such that clothing, curtains or other similar materials cannot be scorched or set on fire by heat from the unit.

2.2 Means of escape

Purpose

The purpose of this Recommendation is to provide means of escape so that persons onboard can safely and swiftly escape to the lifeboat and liferaft embarkation deck. For this purpose, the following functional Recommendations should be met:

- safe escape routes should be provided;
- escape routes should be maintained in a safe condition, clear of obstacles; and
- additional aids for escape should be provided as necessary to ensure accessibility, clear marking, and adequate design for emergency situations.

2.2.1 Stairways, ladders and corridors serving crew spaces and other spaces to which the crew normally have access should be arranged so as to provide ready means of escape to a deck from which embarkation into survival craft may be effected.

2.2.2 There should be at least two means of escape, as widely separated as possible, from each section of accommodation and service spaces and control stations.

(a) The normal means of access to the accommodation and service spaces below the open deck should be arranged so that it is possible to reach the open deck without passing through spaces containing a possible source of fire (e.g. machinery spaces, storage spaces of flammable liquids).

(b) The second means of escape may be through portholes or hatches of adequate size and preferably leading directly to the open deck.

(c) Dead-end corridors having a length of more than 7m should not be accepted.

2.2.3 At least two means of escape should be provided from machinery spaces, except where the small size of a machinery space makes it impracticable. Escape should be by steel ladders that should be as widely separated as possible.

Section 3 Fixed fire detection and fire-alarm systems

An approved and fixed fire detection system should be installed in all Category ‘A’ machinery spaces and cargo pump rooms.

Section 4 Fire-Extinguishing Arrangements

Purpose

The purpose of this Recommendation should suppress and swiftly extinguish a fire in the space of origin. For this purpose, the following functional Recommendations should be met:

- fixed fire-extinguishing systems should be installed, as applicable, having due regard to the fire growth potential of the protected spaces; and
- fire-extinguishing appliances should be readily available.

4.1 Fixed Fire-extinguishing arrangements in Category 'A' machinery spaces

4.1.1 Machinery spaces of category 'A' on vessels with GT greater than or equal to 150 and operating in unrestricted or restricted waters, should be provided with an approved fixed fire-extinguishing system, as specified in paragraph 4.2. Machinery spaces of category 'A' on vessels operating in protected areas may be exempted from this recommendation.

4.2 Fixed Fire-extinguishing systems

4.2.1 Fixed fire-fighting systems where required, should be in accordance with the requirements of the IMO FSS Code.

4.3 Protection of paint lockers and flammable liquid lockers

4.3.1 The Recommendations for the protection of paint lockers and flammable liquids lockers should be specially considered.

4.4 Fixed Fire-extinguishing systems not required by this Chapter

4.4.1 If such a system is installed, it should be of an approved type.

4.5 Portable Fire-extinguishers (UNRESTRICTED, RESTRICTED and PROTECTED)

PORTABLE FIRE EXTINGUISHERS	
Accommodation and service spaces.	
Vessels greater than or equal to 150 GT	≥ 3
Vessels less than 150 GT (see 4.5.6.1)	≥ 1
Machinery spaces (one extinguisher per every 375 kW of internal combustion engine power)	≥ 2, ≤ 6

4.5.1 Approved types

4.5.1.1 All fire-extinguishers should be of approved types and designs.

4.5.2 Extinguishing medium

4.5.2.1 The extinguishing media employed should be suitable for extinguishing fires in the compartments in which they are intended to be used.

4.5.2.2 The extinguishers required for use in the machinery spaces of cargo vessels using oil as fuel should be of a type discharging foam, carbon dioxide gas, dry powder or other approved media suitable for extinguishing oil fires.

4.5.3 Capacity

4.5.3.1 The capacity of required portable fluid extinguishers should not exceed more than 13,5 litres but not less than 9 litres. Other extinguishers should be at least as portable as the 13,5 litre fluid extinguishers, and should have a fire-extinguishing capability at least equivalent to a 9 litre fluid extinguisher.

4.5.3.2 The following capacities may be taken as equivalents:

- 9 litre fluid extinguisher (water or foam).
- 5 kg dry powder.
- 5 kg carbon dioxide.

4.5.4 Spare charges

4.5.4.1 A spare charge should be provided for each required portable fire-extinguisher that can be readily recharged on board. If this cannot be done, duplicate extinguishers should be provided.

4.5.5 Location

4.5.5.1 The extinguishers should be stowed in readily accessible positions and should be spread as widely as possible and not be grouped.

4.5.5.2 One of the portable fire-extinguishers intended for use in any space should be stowed near the entrance to that space.

4.5.6 Portable fire-extinguishers in accommodation spaces, service spaces and control stations

4.5.6.1 Accommodation spaces, service spaces and control stations should be provided with a sufficient number of portable fire-extinguishers to ensure that at least one extinguisher will be readily available for use in every compartment of the crew spaces. In any case, their number should be not less than three, except where this is impractical for very small vessels, in which case one extinguisher should be available at each deck having accommodation or service spaces, or control stations.

Section 5 Fire Fighting Equipment

The fire fighting equipment should comply with the minimum Recommendations as specified below, regardless of UNRESTRICTED, RESTRICTED or PROTECTED service.

5.1 Fire blanket

5.1.1 A fire blanket should be provided.

5.2 Fire-fighter’s outfit (which includes an axe)

5.2.1 All cargo vessels greater than or equal to 150 GT should carry at least one firefighter's outfit complying with the Requirements of the IMO FSS Code.

5.3 Fire control plans

5.3.1 Description of plans

5.3.1.1 In all cargo vessels, general arrangement plans should be permanently exhibited for the guidance of the vessel's officers, using graphical symbols that are in accordance with IMO Resolution A.952(23), which show clearly for each deck the control stations, the various fire sections enclosed by steel or 'A' Class divisions, together with particulars of:

- the fire detection and fire-alarm systems;
- fixed fire-fighting system;
- the fire-extinguishing appliances;
- the means of access to different compartments, decks, etc.;
- the position of the fireman's outfits;
- the ventilating system, including particulars of the fan control positions, the position of dampers and identification numbers of the ventilating fans serving each section; and
- the location and arrangement of the emergency stop for the oil fuel unit pumps and for closing the valves on the pipes from oil fuel tanks.

5.3.1.2 Alternatively, the details required by 5.3.1.1 may be set out in a booklet, a copy of which should be supplied to each officer, and one copy is at all times to be available on board in an accessible position.

5.3.1.3 The plans and booklets should be kept up to date, any alterations being recorded thereon as soon as practicable. Description in such plans and booklets should be in the official language of the Flag State and in the language as shown in the following Table 2. In addition, instructions concerning the maintenance and operation of all the equipment and installations on board for the fighting and containment of fire should be kept under one cover, readily available in an accessible position.

Table 2 Language in Fire Control Plan

Service Restrictions	Language
UNRESTRICTED	English
RESTRICTED PROTECTED	Official language(s) of the Administration(s) concerned with the ship's service, or language(s) recognized by such Administration(s) (possibly English) However, description in such plans and booklets for ships engaged in domestic service only may be in the official language of the Flag State only.

5.3.1.4 In all cargo vessels greater than or equal to 150 GT, a duplicate set of fire-control plans or a booklet containing such plans should be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shoreside fire-fighting personnel.

Section 6 Additional Fire Safety Measures for tankers

6.1 General

6.1.1 The requirements for tankers of SOLAS Chapter II-2 should apply to tankers carrying crude oil and petroleum products, having a flash point not exceeding 60°C, and other liquid products having a similar fire hazard.

6.2 Application

6.2.1 The additional requirements for tankers of SOLAS Chapter II-2 should apply to tankers carrying crude oil and petroleum products having a flash point not exceeding 60°C (closed cup test), as determined by an approved flash point apparatus, and a Reid vapour pressure which is below atmospheric pressure, and other liquid products having a similar fire hazard.

6.2.2 Tankers carrying petroleum products having a flashpoint exceeding 60°C (closed cup test), as determined by an approved flashpoint apparatus, should comply with the provisions of 6.3 of the Recommendations.

6.3 Cargo area deck protection

6.3.1 At least one mobile foam appliance should be provided for use on the cargo tank deck including the cargo manifolds. It should be capable of simple and rapid operation. Where the appliance is of the inductor type it should comply with 6.3.2 of the Recommendations. Self-contained appliances should have a foam solution capacity of at least 135 litres.

6.3.2 A portable foam applicator unit should consist of an air foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 litres of foam-making liquid and one spare tank. The nozzle should be capable of producing effective foam, suitable for extinguishing an oil fire, at the rate of at least 1,5 m^3/min.

6.3.3 The type of foam used should be suitable for the cargoes to be carried.

Section 7 Alternative design and arrangements

7.1 Purpose

The purpose of this recommendation should provide a methodology for alternative design and arrangements for fire safety.

7.2 General

7.2.1 Fire safety design and arrangements may deviate from Sections 1 to 6 of this Chapter, provided that the design and arrangements meet the fire safety objectives and the functional Recommendations.

7.2.2 When fire safety design or arrangements deviate from the Recommendations of this Chapter, engineering analysis, evaluation and approval of the alternative design and arrangements should be carried out in accordance with this regulation*.

* Reference can be made to MSC/Circ. 1002 ***Guidelines on alternative design and arrangements for fire safety***

7.3 Engineering analysis

7.3.1 The engineering analysis should be prepared and submitted to BCS, based on the guidelines developed by the International Maritime Organization and should include, as a minimum, the following elements:

(a) determination of the vessel type and space(s) concerned;

(b) identification of recommendation(s) with which the vessel or the space(s) will not comply;

(c) identification of the fire and explosion hazards of the vessel or the space(s) concerned:

- identification of the possible ignition sources;
- identification of the fire growth potential of each space concerned;
- identification of the smoke and toxic effluent generation potential for each space concerned;
- identification of the potential for the spread of fire, smoke or of toxic effluents from the space(s) concerned to other spaces;

(d) determination of the required fire safety performance criteria for the vessel or the space(s) concerned:

- performance criteria should be based on the fire safety objectives and on the functional Recommendations of this Chapter;
- performance criteria should provide a degree of safety not less than that achieved the recommendation in Sections 1 to 6; and
- performance criteria should be quantifiable and measurable;

(e) detailed description of the alternative design and arrangements, including a list of the assumptions used in the design and any proposed operational restrictions or conditions; and

(f) technical justification demonstrating that the alternative design and arrangements meet the required fire safety performance criteria.

7.4 Evaluation of the alternative design and arrangements

7.4.1 The engineering analysis required in paragraph 7.3 should be evaluated and approved by BCS taking into account the guidelines developed by the International Maritime Organization.

7.4.2 A copy of the documentation, as approved by BCS, indicating that the alternative design and arrangements comply with this regulation should be carried onboard the vessel.

7.5 Re-evaluation due to change of conditions

7.5.1 If the assumptions, and operational restrictions that were stipulated in the alternative design and arrangements are changed, the engineering analysis should be carried out under the changed condition and should be approved by BCS.

Section 8 Fire extinguishing Recommendations for vessels not fitted with propelling machinery

8.1 Basic Recommendations

8.1.1 Arrangements for fire protection, detection and extinction in vessels not fitted with propelling machinery should be specially considered in each case and should depend on the size and purpose of the vessel and the presence of accommodation spaces, machinery and combustible materials on board.

CHAPTER V LIFE SAVING APPLIANCES

The minimum Recommendations for the carriage of life saving equipment is specified in the table below unless specified otherwise by the Administration.
The equipment specified in the table below, should comply with the IMO Life Saving Appliances Code or specified otherwise by the Administration.

CHAPTER V LIFE SAVING APPLIANCES X indicates items to be provided * see notes	**Unrestricted**	**Restricted**	**Protected**
All cargo vessels excluding tankers, chemical tankers and gas carriers should be provided with liferafts on each side of the vessel capable of accommodating the total number of persons on board.	X*[1)]	X*[1)]	X*[2)]
Oil tankers, chemical tankers and gas carriers carrying cargoes having a flashpoint not exceeding 60°C (closed-cup test), not engaged on International voyages, should be provided with totally enclosed fire protected lifeboats capable of accommodating the total number of persons on board on each side of the vessel or a single free-fall lifeboat.	X	X	X
Chemical tankers and gas carriers, not engaged on International voyages, carrying cargoes emitting toxic vapours or gases should carry lifeboats as above with the addition of a self contained air support system.	X	X	X
Oil tankers, chemical tankers and gas carriers, not engaged on International voyages, should in addition be provided with life-rafts for 200% of the persons on board in the case of a free-fall lifeboat or 100% in the case of davit launched lifeboats which should be capable of being launched on each side of the vessel.	X	X	X
All cargo vessels should be provided with a rescue boat and launching appliance, a lifeboat may be accepted as a rescue boat provided that it also complies with the Recommendations for a rescue boat.	- X if length greater than 20m - X*[3)] if length under/equal 20m	X*[3)]	-
A satellite EPIRB complying with GMDSS Requirements, appropriate to the sea area within which the vessel operates.	X	X*[4)]	X*[4)]
A radar transponder complying with GMDSS Requirements.	X	X	-
At least 2 two-way portable VHF radiotelephone apparatus complying with GMDSS Requirements.	X	X	-

A minimum of 6 lifebuoys, 2 fitted with a self-activating smoke and light signal, 2 with a self-igniting light and 2 with a buoyant lifeline.	X	X	X
A lifejacket for each of the persons on board, and in addition a minimum of two lifejackets for persons on watch. All life jackets should be fitted with an approved lifejacket light.	X	X	X
An immersion suit to be provided for each person on board, which may include those provided for the rescue boat crew.	X*[5)+6)]	X*[5)+6)]	X*[5)+6)]
Rocket parachute flares.	12	12	6
Line-throwing apparatus.	1	1	-
General emergency alarm.	X	X*[7)]	X*[7)]
Muster lists, operating instruction etc. as applicable	X	X*[8)]	X*[8)]

Notes:

1) If such liferafts cannot be readily transferred for launching on either side of the vessel, then liferafts capable of accommodating 150% the total number of persons on board should, where practicable considering vessel's size, be provided on each side.

   The arrangement should be such that in the event of failure or loss of any one liferaft, sufficient liferafts remain, on each side of the vessel capable of accommodating the total number of persons on board.

   All liferafts should be provided with a hydrostatic or similar automatic release to enable the liferafts to float free in the event of the vessel sinking.

2) Vessels operating within the extended protected waters should, where practicable, be provided with liferafts on each side.

   Vessels operating within protected waters should, where practicable, be provided with at least one liferaft capable of accommodating the total number of persons on board. Craft of 24 m or less may be provided with buoyant apparatus or additional lifebuoys (1 per 2 persons) in place of liferafts.

3) Wherever practicable vessels should be provided with a rescue boat or on smaller vessels a suitable inflated boat with engine, however, the design and operational Recommendations of some vessels such as small tugs may preclude this.

4) If the vessel operates within an area designated as A1 a VHF EPIRB may be provided in place of the satellite EPIRB in accordance with GMDSS Recommendations.

5) Immersion suits and thermal protective aids may be omitted on vessels operating permanently between the latitudes 20°N and 20°S or within other defined areas where water temperatures and climatic conditions are satisfactory to the administration.

6) Each person assigned to crew the rescue boat, including combined lifeboat/rescue boats, should be provided with an immersion suit.

Where totally enclosed lifeboats and/or davit launched liferafts are provided a minimum of 3 immersion suits should be provided.

Vessels provided with throw overboard liferafts should be provided with immersion suits for each person on board, which may include those provided for the rescue boat crew, unless exempted by 5) above or especially protected service.

Thermal protective aids should be provided in accordance with SOLAS Requirements where they form part of a lifeboat and liferaft equipment.

7) General emergency alarm may be omitted where the design of the vessel is such as to make it unnecessary.

8) The extent to which such notices are required and can be posted is dependent upon the size and type of vessel.

CHAPTER VI RADIO INSTALLATIONS

The minimum Recommendations for the radio installations should be as given in the table below unless specified otherwise by the Flag Administration.

CHAPTER VI RADIO INSTALLATIONS	Unrestricted	Restricted	Protected
GMDSS Requirements as contained in SOLAS IV as amended, appropriate to the sea area involved, A1, A2, A3 and A4, should apply to all vessels 300 GT and above regardless of service area and to all vessels regardless of size engaged on unrestricted service.	X	X	X
Vessels engaged on restricted service should comply as above when 300 GT and above, for vessels less than 300 GT GMDSS Requirements appropriate to the sea area involved should be complied with unless otherwise specified by the Administration.	-	X	-
Vessels engaged on protected service should comply as above when 300 GT and above, for vessels less than 300 GT GMDSS Requirements appropriate to the sea area involved should be complied with unless otherwise specified by the Administration.	-	-	X

CHAPTER VII NAVIGATIONAL EQUIPMENT

The Requirements, as specified in SOLAS 1974, as amended, Chapter V, as applicable based on ship's size, should be complied with unless the Flag Administration specifies otherwise.

CHAPTER VIII PREVENTION OF COLLISIONS

The Requirements, as specified by the Convention on International Regulations for Preventing Collisions at Sea (COLREG, 1972) as amended, should be complied with.

BCS- G 101 Model Report for IMO Resolution MSC.215(82) Annex 1 "Test Procedures for Coating Qualification"

EXAMPLE COATING PRODUCER

BALLAST TANK COATING TEST OF 2 * 160 µM EXAMPLE EPOXY PAINT ON EXAMPLE SHOP PRIMER

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1 SUMMARY

The coating system, 2 * 160 µm Example Epoxy Paint from Example Coating Producer, applied to Example zinc silicate shop primed panels has been tested in accordance with the IMO Performance Standard for protective Coatings /1/. The coating was applied after 2 months weathering of the shop primer.
The results from the testing show that the Example Epoxy Paint from Example Coating Producer has passed all the requirements given in the Performance Standard for Protective Coatings /1/.

2 SCOPE OF WORK

The following work and tests have been performed:

- Identification of the coating system
- Film thickness measurements and pin hole detection on panels before testing
- 180 days testing in condensation chamber
- 180 days testing in wave tank
- 180 days testing in heating cabinet
- Evaluation of results after testing, including blister detection, undercutting from scribe, adhesion and coating flexibility
- Evaluation of cathodic protection during testing (wave tank)

3 WORK CARRIED OUT PRIOR TO EXPOSURE

3.1 Identification

The coating system was identified by infrared scanning (by means of a ….(name and model of the instrument)) and by determination of specific gravity (according to ISO 2811 -1) by means of an Pyknometer (name and model of the instrument) .

3.2 Surface preparation

Surface preparation was carried out according to the data given in Table B-1 Appendix B.

3.3 Application

3.3.1 Application procedure

Example zinc silicate shop primer was applied to the blast cleaned panels according to the data given in Table 2. The shop primed panels were then exposed out-door for 2 months. The environmental data for the exposure period is given in Appendix A.

Two coats (specified dry film thickness 160 μm per coat) of Example Epoxy Paint were applied to the weathered and cleaned zinc silicate shop primed panels. The application data are given in Table B-2 Appendix B.

3.3.2 Coding

The panels were coded as shown in Figure B-1 in Appendix B.

3.4 Dry film thickness

The dry film thickness measurements were carried out by means of a (name and model of the instrument) dry film thickness unit before testing. Templates, as given in Figure B-2 in Appendix B, were used for the measurements. The results from the measurements are given in Table B-3 in Appendix B.

3.5 Pin hole detection

Pin hole detection was performed on the coated test panels before testing. The detection was carried out by means of a (name and model of the instrument) Pinhole detector at 90 volts.

4 EXPOSURE

The testing was carried out according to the IMO Performance Standard for Protective Coatings /1/. The exposure was started 02.11.07 and terminated 14.06.08.

5 TESTS CARRIED OUT AFTER EXPOSURE

Evaluation of blisters and rust, adhesion, undercutting from scribe and flexibility was carried out according to specifications and standards referred to in the IMO Performance Standard /1/.

6 TEST RESULTS

The results of the product identification are given in Table 1.

The results of the examination of the coated test panels are schematically given in Table 2 and more detailed in Appendix B. Pictures of the panels after exposure are enclosed as Appendix C.

Table 1 Results of analyses (Product identification)

Product	Batch no.	IR identification (main components)	Specific gravity (g/cm^3)
Example, part A	123	Ethyl silicate	0.93
Example, part B	234	NA*	2.21
Example Epoxy Paint Grey, base	345	Epoxy	1.48
Example Epoxy Paint hardener	456	Amide	0.96
Example Epoxy Paint Buff, base	567	Epoxy	1.47

* Identified and spectres stored. No generic correlation to the spectres in the data base found.

Table 2 Results of examination of the coated test samples

Test parameter	Acceptance criteria	Test results	Passed / failed
Pin holes (no)	No pinholes	0	Passed
Blisters and rust (all panels) [1)]	No blisters or rust	0	Passed
Adhesion values (MPa) – wave tank panels [2)]	>3.5 adhesive failure >3.0 cohesive failure	Average: 5.4 Maximum: 7.4 Minimum: 4.2 70 – 80 % cohesive failure 20 – 30 % adhesive failure	Passed
Adhesion values (MPa) – condensation chamber panels [3)]	>3.5 adhesive failure >3.0 cohesive failure	Average: 5.6 Maximum: 6.9 Minimum: 4.1 70 – 80 % cohesive failure 20 – 30 % adhesive failure	Passed
Undercutting from scribe (mm) - average maximum values wave tank panels [4)]	< 8	3.5	Passed
Cathodic disbondment (mm) – Wave tank bottom panel [5)]	< 8	7.2	Passed
Current demand (mA/m^2) – bottom panel [5)]	< 5	3.3	Passed
U-beam [1)]	No degradation (defects, cracking or detachment at the angle or weld)	No degradation	Passed

1) Details of blister and rust and u-beam in Table B-4 Appendix B.
2) Details of Pull-off adhesion test, wave tank and heat exposed panels in Table B-5 Appendix B.
3) Details of Pull-off adhesion test, condensation chamber in Table B-6 Appendix B.
4) Details of physical testing in Table B-7 Appendix B.
5) Details of Cathodic Protection in Table B-8 Appendix B.

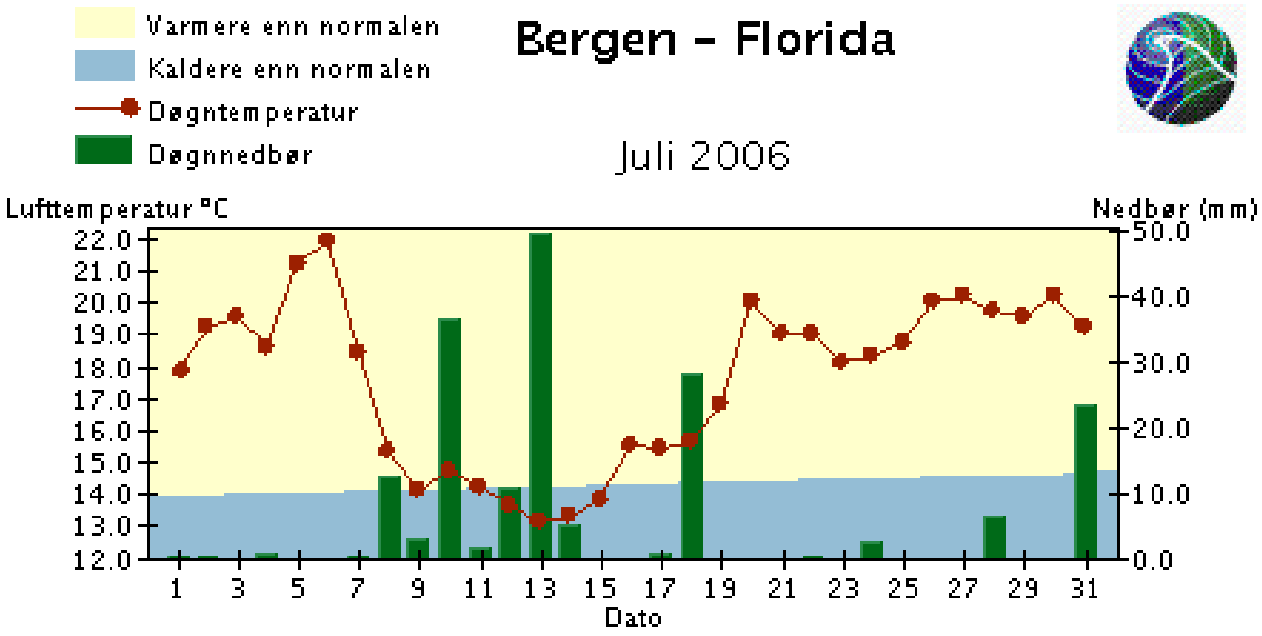
7 CONCLUSION

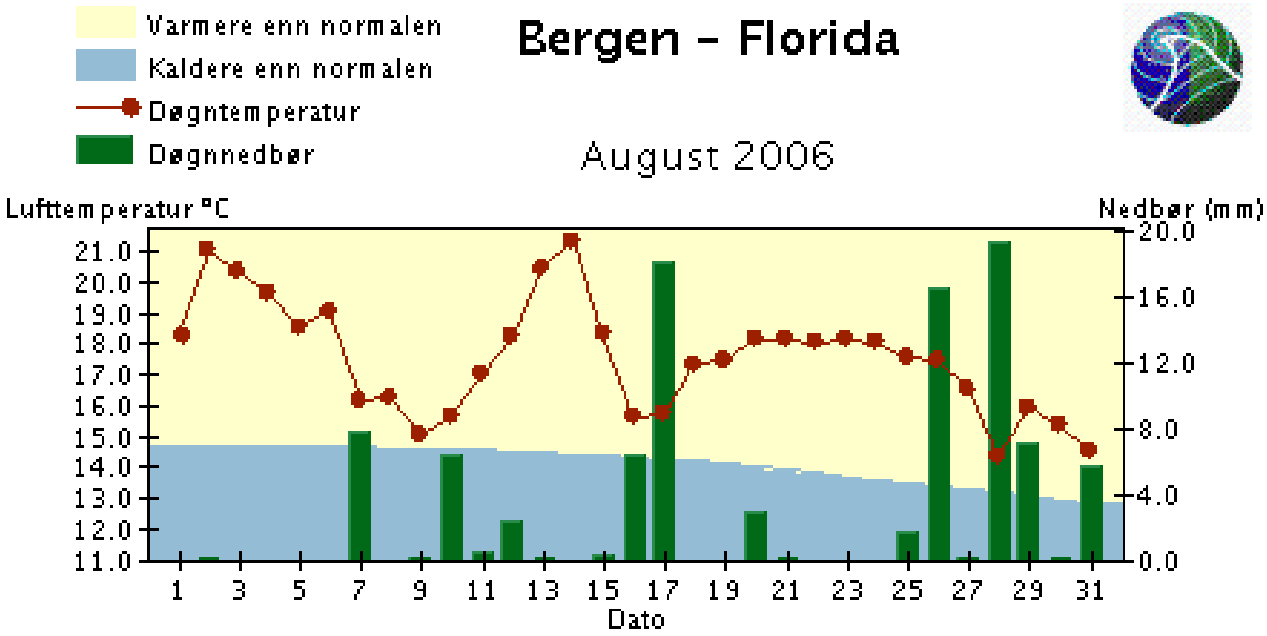
The results from the testing show that Example Epoxy Paint from Example Coating Producer has passed all the requirements given in the Performance Standard for Protective Coatings /1/.

8 REFERENCES

/1/ MSC 215 (82) :2006 Performance Standard for Protective Coatings for dedicated sea water ballast tanks in all types of ships and double-side skin spaces of bulk carriers

9 APPENDIX A - ENVIRONMENTAL DATA - WEATHERING OF SHOP PRIMED PANELS





10 APPENDIX B - DETAILS OF SURFACE PREPARATION, APPLICATION AND TEST RESULTS

Table B-1 Surface preparation data.

Surface preparation date	November 2007 The prepared panels were stored at ambient in- door conditions until use
Surface preparation method	Blast cleaning
Blasting standard	Sa 2 ½
Abrasive used	AlSil A3+ steel shot
Roughness (µm)	R_{max} 50 -75
Water soluble salts	32, 38 and 40 mg / m^2 Spot check performed on 3 out of 30 panels produced at the same time
Dust and abrasive inclusions	No dust or abrasive inclusions observed by visual examination.
Treatment of shopprimer after weathering	Low pressure washing
Water soluble salts after treatment of shopprimer	Spot check 28, 41 and 38 mg / m^2

Table B-2 Application data.

Coating data:	Shop primer	1st coat	2nd coat
Paint system:	Example red	Example Epoxy Paint Al Grey	Example Epoxy Paint Buff
Manufacturer:	Example Coating Producer		
Date	20.11.07	22.01.08	23.01.08
Time	10:00	10:00	10:00
Batch No. curing agent			
Batch No. base			
Thinner name (if used)			
Batch No. thinner(if used)			
Equipment used	Graco King 68:1	Graco King 68:1	Graco King 68:1
Air pressure (bar)	100	170	170
Size nozzle (inches)	0.021	0.021	0.021
Fan width (º)	60	60	60
Mix. ratio (volume)	A: B = 3:1	3:1	3:1
Volume solid (volume)	30 ± 2	80	80
Wet film thickness (µ)	55-70	275	275
Dry film thickness (µ)	15-25	See Table 3	See Table 4
Thinner (%)	0	0	0
Air temperature (ºC)	25	25	25
Humidity (% RH)	78	80	82
Steel temp. (ºC)	25	25	25
Dew point (ºC)	20	20	20

Present at application of shop primer: nn – MM Group (painter) and mm – laboratory. Present at application of test coating: kk - Example Coating Producer, nn – MM Group, and mm – laboratory.

Comments:

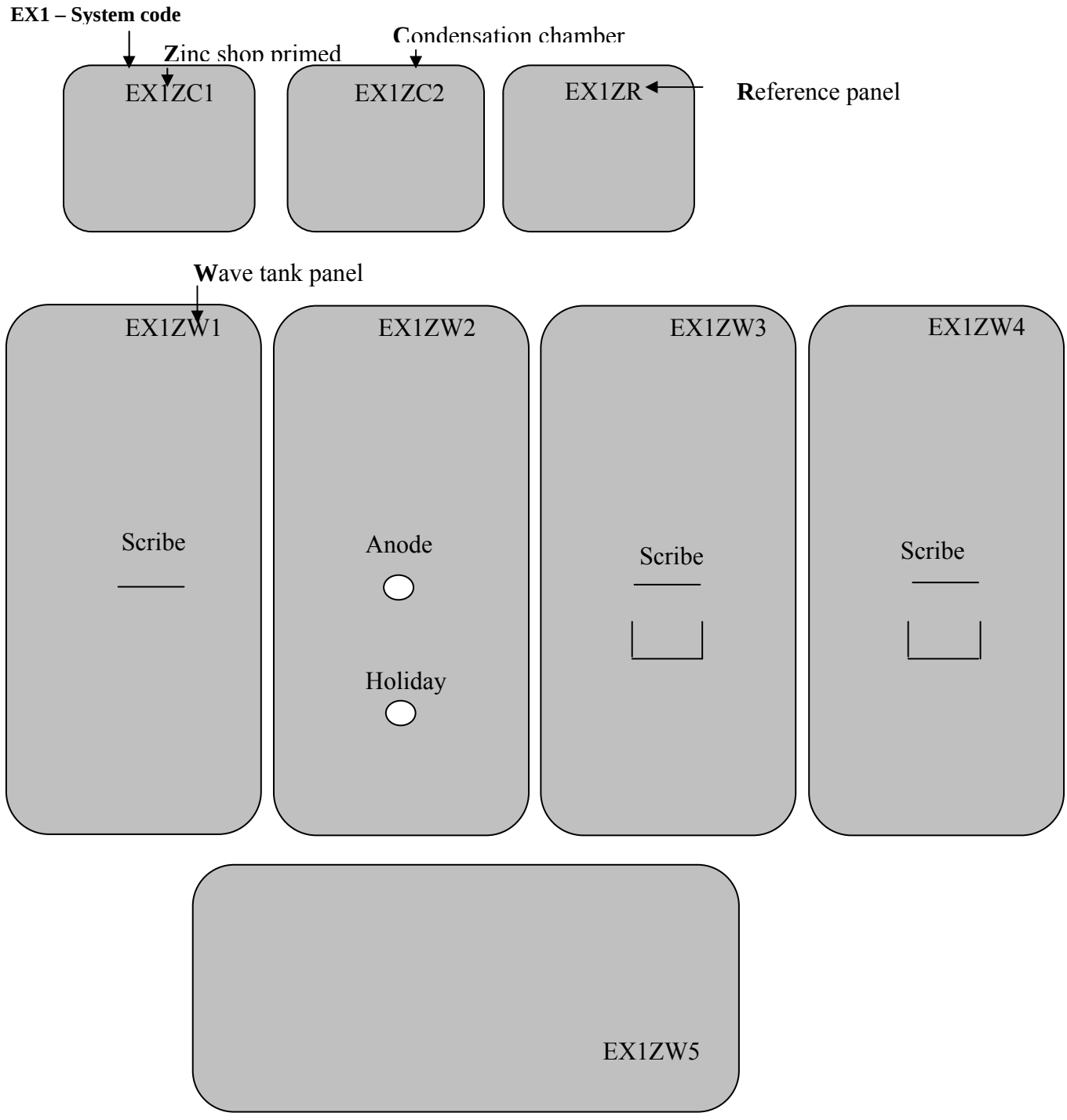


Figure B-1 Coding.

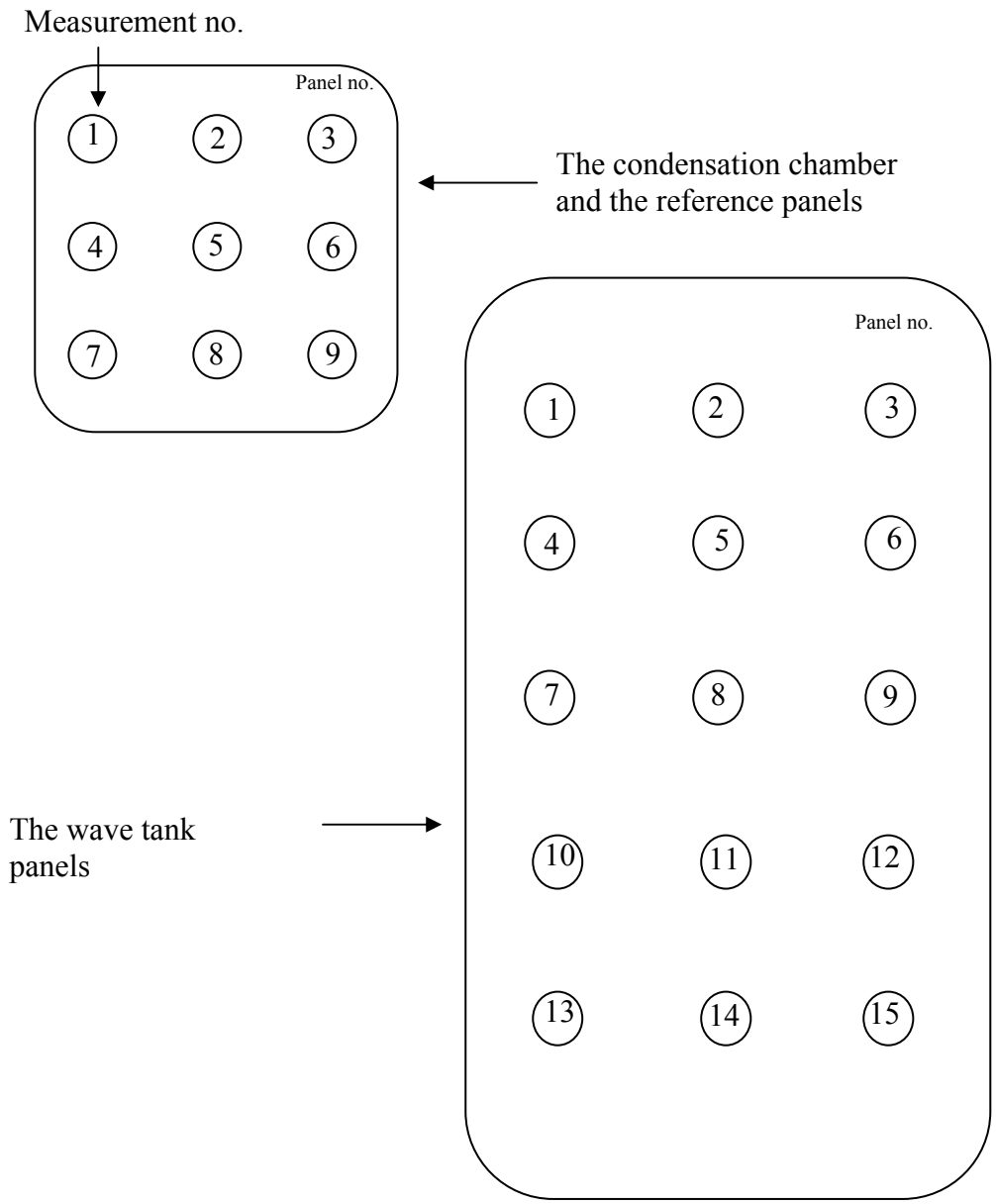


Figure B-2 Thickness measurement locations.

Table B-3 Total Dry Film Thickness – Example Epoxy Paint (20 µm subtracted for shop primed substrate).

Measurement	Panel no EX1-								
	ZW1	ZW2	ZW3	ZW4	ZW5	ZC1	ZC2	ZR	Total
1	332	330	338	322	324	325	320	354	
2	324	356	362	360	388	360	322	320	
3	320	320	328	326	336	342	334	322	
4	320	344	368	320	320	330	340	364	
5	352	356	412	350	326	346	358	336	
6	340	320	340	320	320	362	342	342	
7	320	326	366	356	320	340	330	320	
8	380	348	428	398	348	358	320	346	
9	338	320	380	364	330	338	322	320	
10	320	319	356	338	316				
11	342	360	408	456	340				
12	316	320	326	324	324				
13	320	344	356	332	320				
14	366	424	410	380	366				
15	342	348	330	350	346				
Max	380	424	428	456	388	362	358	364	456
Min	316	319	326	320	316	325	320	320	316
Average	**335**	**342**	**367**	**353**	**335**	**345**	**332**	**336**	**344**
StDev	19	27	34	37	20	13	13	17	27

Table B-4 Development of blisters and rust after exposure.

Code	Description	Blister size	Blister density	Rust	Other defects
EX1ZW1	Top wave tank panel with scribe	0	0	0	0
EX1ZW2	Bottom wave tank panel with anode	0	0	0	0
EX1ZW3	Side wave tank panel with scribe and U-beam Cooling	0	0	0	0
EX1ZW4	Side wave tank panel with scribe and U-beam No cooling	0	0	0	0
EX1ZW5	Panel exposed to 70 ºC air (heating chamber)	0	0	0	0
EX1ZC1	Condensation chamber	0	0	0	0
EX1ZC2	Condensation chamber	0	0	0	0

Table B-5 Results of the Pull-off adhesion test, wave tank and heat exposed panels.

Panel no.	Adhesion strength (MPa)	Fracture
Top wave tank panel with scribe W1	4.5	30 % B, 20 % C, 30 % C/D, 20 % D
	5.2	20 % B, 30 % C, 30 % C/D, 20 % D
	4.8	30 % B, 20 % C, 20 % C/D, 30 % D
Bottom wave tank panel with anode W2	5.3	30 % B, 20 % C, 20 % C/D, 30 % D
	4.2	30 % B, 20 % C, 30 % C/D, 20 % D
	6.1	20 % B, 30 % C, 30 % C/D, 20 % D
Side wave tank panel with scribe and U-beam Cooling W3	7.0	20 % B, 30 % C, 30 % C/D, 20 % D
	4.6	30 % B, 20 % C, 20 % C/D, 30 % D
	5.3	30 % B, 20 % C, 30 % C/D, 20 % D
Side wave tank panel with scribe and U-beam No cooling W4	5.3	30 % B, 20 % C, 30 % C/D, 20 % D
	7.4	20 % B, 30 % C, 30 % C/D, 20 % D
	5.1	30 % B, 20 % C, 20 % C/D, 30 % D
Panel exposed to 70 ºC air (heating chamber) W5	4.6	30 % B, 20 % C, 20 % C/D, 30 % D
	6.6	30 % B, 20 % C, 30 % C/D, 20 % D
	5.3	20 % B, 30 % C, 30 % C/D, 20 % D
Average	5.4	70 – 80 % Cohesive failure, 20 – 30 % Adhesive
Max	7.4	
Min	4.2	

A/B	Fracture between the steel surface and 1st coat (shop primer).
B	Fracture in the 1st coat.
B/C	Fracture between the 1st and 2nd coat.
C	Fracture in the 2nd coat.
C/D	Fracture between the 2nd and 3rd coat.
D	Fracture in the 3rd coat
-/Y	Fracture between the outer coat and the glue.

Table B-6 Results of the Pull-off adhesion test, condensation chamber and reference panels.

Condensation chamber panel C1	6.1	20 % B, 30 % C, 30 % C/D, 20 % D
	4.1	30 % B, 20 % C, 20 % C/D, 30 % D
	6.9	30 % B, 20 % C, 30 % C/D, 20 % D
Condensation chamber panel C2	4.6	30 % B, 20 % C, 30 % C/D, 20 % D
	5.2	20 % B, 30 % C, 30 % C/D, 20 % D
	6.4	30 % B, 20 % C, 20 % C/D, 30 % D
Average	5.6	70 – 80 % Cohesive failure, 20 – 30 % Adhesive
Max	6.9	
Min	4.1	
Reference panel (not exposed) R	4.1	30 % B, 20 % C, 20 % C/D, 30 % D
	4.5	30 % B, 20 % C, 30 % C/D, 20 % D
	5.0	20 % B, 30 % C, 30 % C/D, 20 % D

A/B	Fracture between the steel surface and 1st coat (shop primer).
B	Fracture in the 1st coat.
B/C	Fracture between the 1st and 2nd coat.
C	Fracture in the 2nd coat.
C/D	Fracture between the 2nd and 3rd coat.
D	Fracture in the 3rd coat
-/Y	Fracture between the outer coat and the glue.

Table B-7 Results of physical testing.

Panel	Undercutting from scribe (mm)*	Flexibility**	Comment
Top wave tank panel EX1ZW1	5.7	150 mm	≤ 2 % elongation
Cooled side wave tank panel EX1ZW3	2.2	NA	
Not cooled side wave tank panel EX1ZW4	2.6	NA	
Average	3.5		
Reference panel (not exposed) EX1ZR	Not applicable	75 mm	≤ 4 % elongation

* *Evaluated by scraping with knife.*

** *Flexibility[1)] modified according to panel thickness (3 mm steel, 300 µm coating, 150 mm cylindrical mandrel gives 2% elongation) for information only;1) Reference standards: ASTM D4145:1983. Standard Test Method for Coating Flexibility of Prepainted Sheet.*

Undercutting from scribe:

"Rinse the test panel with fresh tap water immediately after exposure, blowing off residues of water from the surface using compressed air if necessary, and inspect for visible changes. Carefully remove any loose coating using a knife blade held at an angle, positioning the blade at the coating/substrate interface and lifting the coating away from the substrate." (From ISO 4628-8:2005, section 5.3.1.)

"Calculate the degree of delamination d, in millimetre using the equation d=(d1-w)/2 where d1 is the mean overall width of the zone of delamination, in millimetres; w is the width of the original scribe, in millimetres." (From ISO 4628-8:2005, section 6.1.)

"Calculate the degree of corrosion c, in millimetre using the equation c=(wc-w)/2 where wc is the mean overall width of the zone of corrosion, in millimetres; w is the width of the original scribe, in millimetres." (From ISO 4628-8:2005, section 6.2.)

Additionally interpretation of IMO PSPC: Undercutting from scribe can be either corrosion of the steel substrate or delamination between the shop primer and the epoxy coating (compability test). For PSPC maximum width is used (MSC.215(82), Appendix 1, section 2.2.6 and not mean overall width as in the ISO standard. The average of the three maximum records (three panels with scribe) is used for acceptance and shall be less than 8 mm for epoxy based systems to be acceptable. Cohesive adhesion failure in the shop primer is not to be included as part of the delamination.

Table B-8 Results of Cathodic Protection (CP).

Panel	Cathodic disbondment (mm)	Blisters / rust	Zinc anode weight loss (g)	Current demand (mA/ m^2)
EX1ZW2	7.2	0	1.2345	3.32

Exposure time: *120 days (Total time 180 days. Each cycle consists of 2 weeks seawater immersion and 1 week exposure in air)*

Utilisation factor: *0.8*

Consumption rate for Zn-anodes: 11.3 kg/A year

Cathodic protection; disbonding from artificial holiday:

"On completion of the test, thoroughly rinse the panel with tap water, taking care not to damage the coating." (From ISO 15711:2003)

"Assess loss of adhesion at the artificial holiday by using a sharp knife to make two cuts through the coating to the substrates, intersection at the holiday. With the point of the knife, attempt to lift and peel back the coating from around the holiday. Record whether the adhesion of the coating to the substrate has been reduced and the approximate distance, in millimetres, that the coating can be peeled." (From ISO 15711:2003)

Additionally interpretation of IMO PSPC: Repeat the cutting and lifting all around the artificial holiday to find the maximum loss of adhesion. Disbonding from artificial holiday can be either loss of adhesion to the steel substrate or between the shop primer and the epoxy coating and shall be less than 8 mm for epoxy based systems to be acceptable (compability test). Cohesive adhesion failure in the shop primer is not to be included as part of the loss of adhesion.

11 APPENDIX C – PHOTO DOCUMENTATION

(It should be overview pictures of the panels and close up pictures of the undercutting from scribe and the disbonding from artificial holiday)

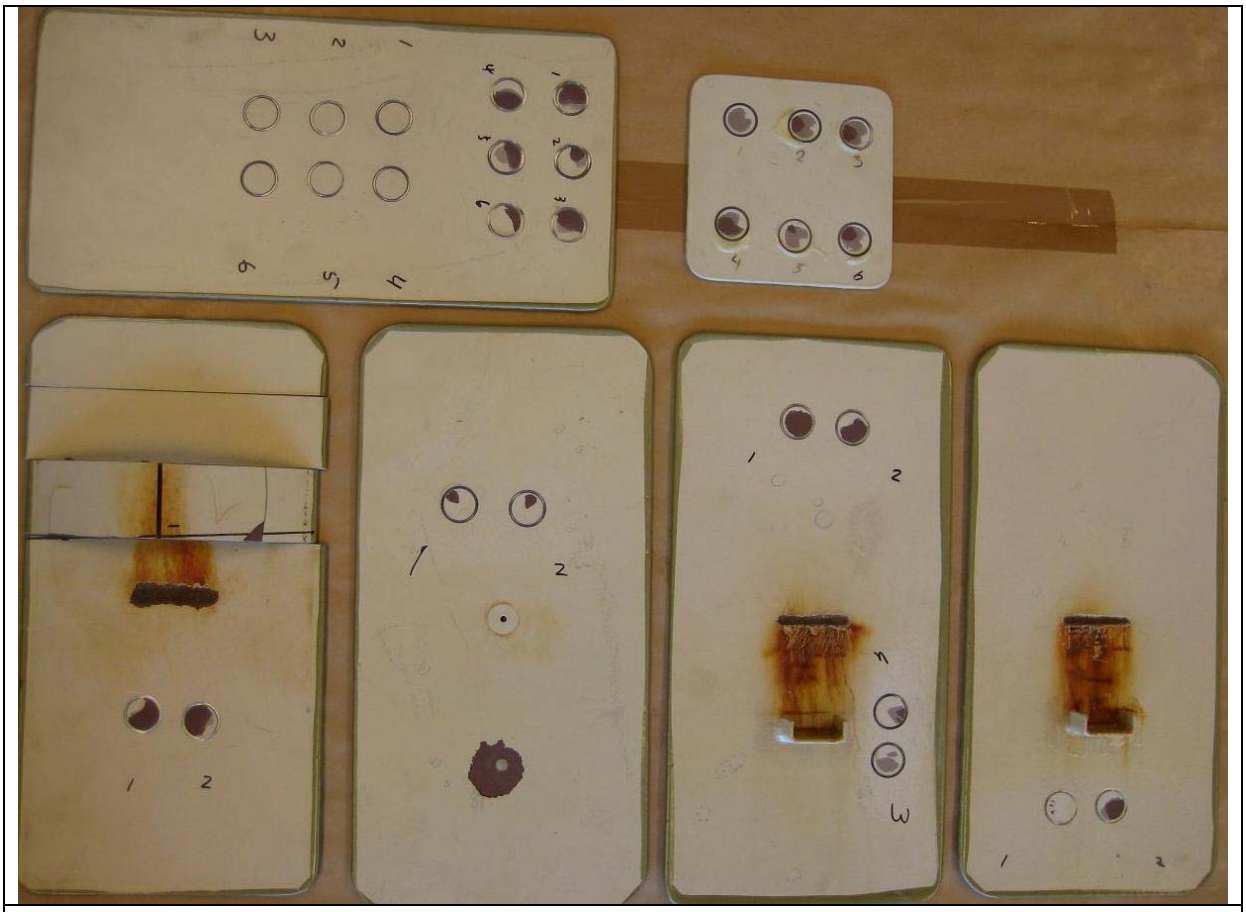


Figure C-1 Overview picture of the panels after exposure in the wave tank and the heating chamber. Reference panel not exposed on the top right. Picture taken after examination (example picture not connected to example results in this model report).

Picture missing

Figure C-2 Overview picture of the panels exposed in condensation chamber (example picture not connected to example results in this model report).

Figure C-3 Scribe area of top wave tank panel before removing of loose coating (example picture not connected to example results in this model report).

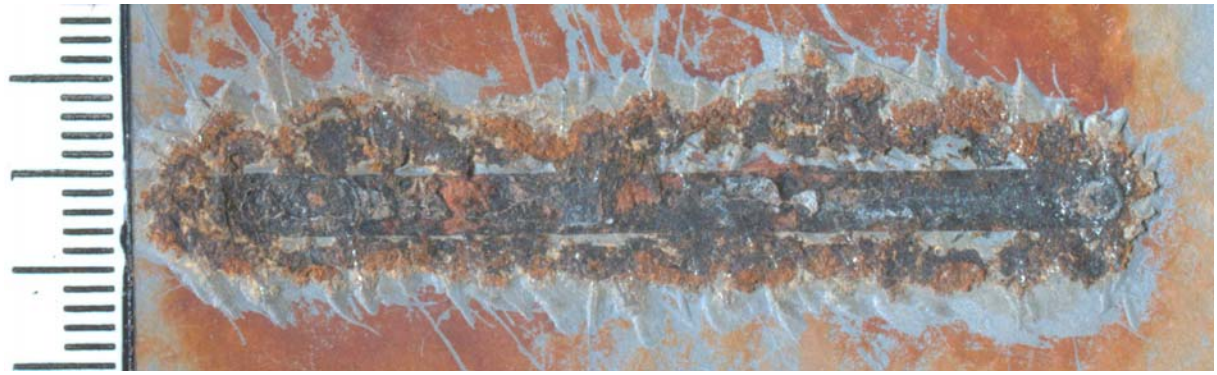


Figure C-4 Undercutting from scribe, top wave tank panel (example picture not connected to example results in this model report).

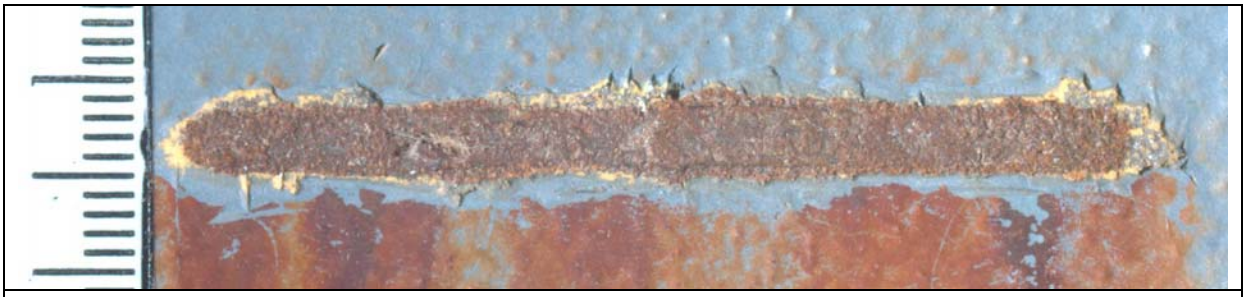


Figure C-5 Undercutting from scribe, side wave tank panel without cooling (example picture not connected to example results in this model report).

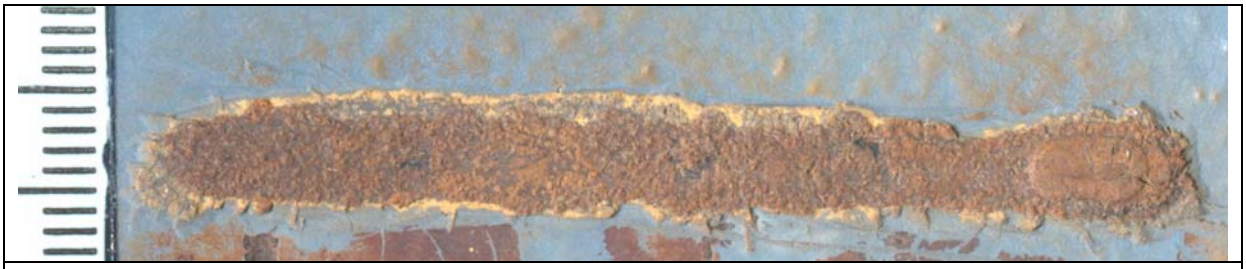


Figure C-6 Undercutting from scribe, side wave tank panel with cooling (example picture not connected to example results in this model report).

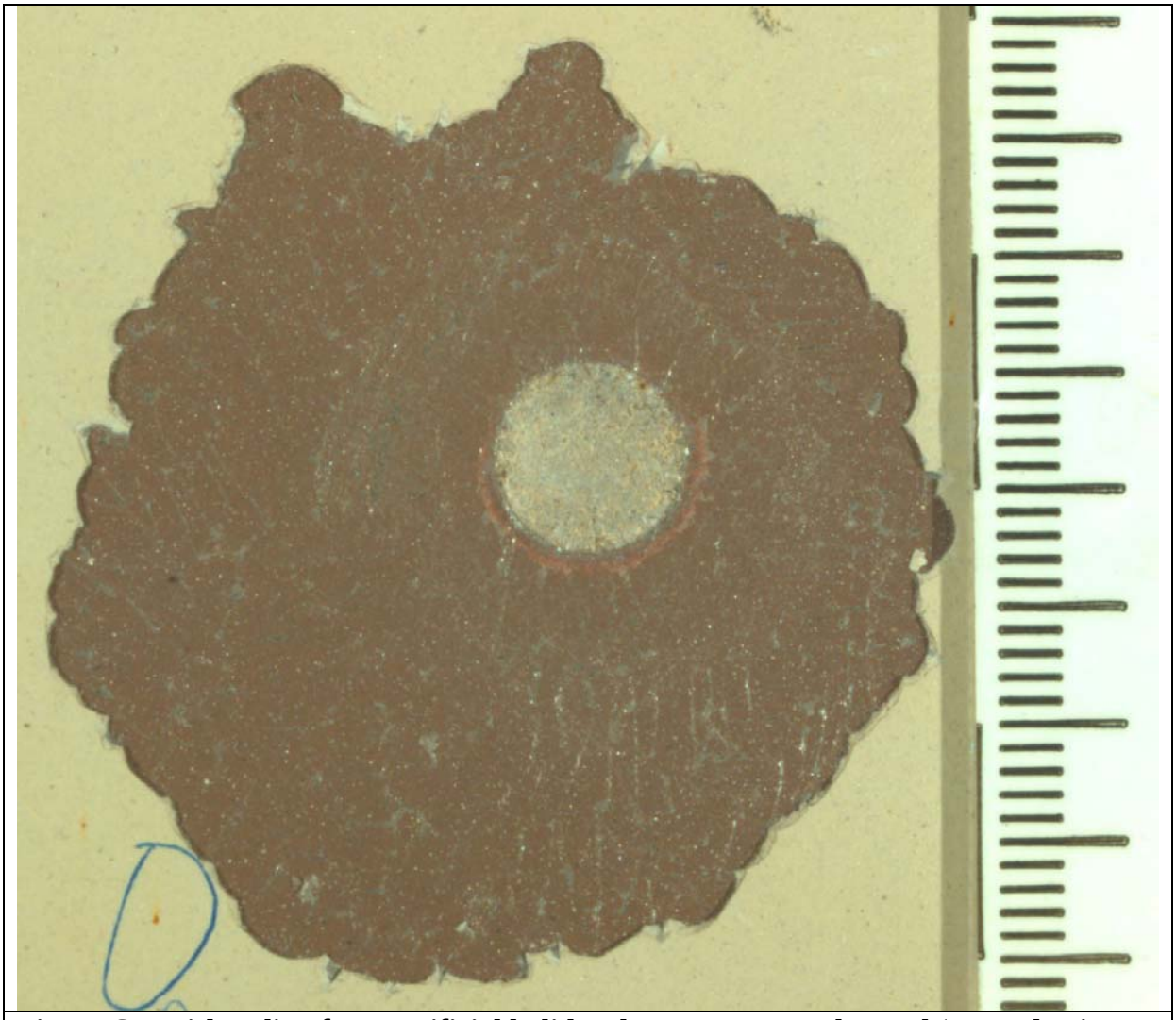


Figure C-7 Disbonding from artificial holiday, bottom wave tank panel (example picture not connected to example results in this model report).

BCS -G 102

Model Report for IMO Resolution MSC.215(82) Annex 1 “Test Procedures for Coating Qualification”, Section 1.7 - Crossover Test

EXAMPLE COATING PRODUCER

BALLAST TANK COATING TEST OF 2 * 160 µM EXAMPLE EPOXY PAINT ON EXAMPLE SHOP PRIMER

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1 SUMMARY

The coating system, 2 * 160 µm Example Epoxy Paint from Example Coating Producer, applied to Example zinc silicate shop primed panels has been tested in accordance with the IMO Performance Standard for protective Coatings /1/, section 1.7 of appendix 1 to annex 1 without wave movement (crossover test). The coating was applied after 2 months weathering of the shop primer.

The results from the testing show that the Example Epoxy Paint from Example Coating Producer has passed all the requirements given in the Performance Standard for Protective Coatings /1/.

2 SCOPE OF WORK

The following work and tests have been performed:

- Identification of the coating system
- Film thickness measurements and pin hole detection on panels before testing
- 180 days testing in wave tank conditions, but without wave movement
- Evaluation of results after testing, including blister detection, disbonding from artificial holiday and adhesion

3 WORK CARRIED OUT PRIOR TO EXPOSURE

3.1 Identification

The coating system was identified by infrared scanning (by means of a ….(name and model of the instrument)),and by determination of specific gravity (according to ISO 2811 -1) by means of an Pyknometer (name and model of the instrument).

3.2 Surface preparation

Surface preparation was carried out according to the data given in Table B-1 Appendix B.

3.3 Application

3.3.1 Application procedure

Example zinc silicate shop primer was applied to the blast cleaned panels according to the data given in Table 2. The shop primed panel were then exposed out-door for 2 months. The environmental data for the exposure period is given in Appendix A.

Two coats (specified dry film thickness 160 μm per coat) of Example Epoxy Paint were applied to the weathered and cleaned zinc silicate shop primed panel. The application data are given in Table B-2 Appendix B.

3.3.2 Coding

The panel were coded as shown in Figure B-1 in Appendix B.

3.4 Dry film thickness

The dry film thickness measurements were carried out by means of a (name and model of the instrument) dry film thickness unit before testing. Templates, as given in Figure B-2 in Appendix B, were used for the measurements. The results from the measurements are given in Table B-3 in Appendix B.

3.5 Pin hole detection

Pin hole detection was performed on the coated test panel before testing. The detection was carried out by means of a (name and model of the instrument) Pinhole detector at 90 volts.

4 EXPOSURE

The testing was carried out according to the IMO Performance Standard for Protective Coatings /1/. The exposure was started 02.11.07 and terminated 14.06.08.

5 TESTS CARRIED OUT AFTER EXPOSURE

Evaluation of blisters and rust, adhesion, undercutting from scribe and flexibility was carried out according to specifications and standards referred to in the IMO Performance Standard /1/.

6 TEST RESULTS

The results of the product identification are given in Table 1.

The results of the examination of the coated test panels are schematically given in Table 2 and more detailed in Appendix B. Pictures of the panels after exposure are enclosed as Appendix C.

Table 1 Results of analyses (Product identification)

Product	Batch no.	IR identification (main components)	Specific gravity (g/cm^3)
Example, part A	123	Ethyl silicate	0.93
Example, part B	234	NA*	2.21
Example Epoxy Paint Grey, base	345	Epoxy	1.48
Example Epoxy Paint hardener	456	Amide	0.96
Example Epoxy Paint Buff, base	567	Epoxy	1.47

* Identified and spectres stored. No generic correlation to the spectres in the data base found.

Table 2 Results of examination of the coated test samples

Test parameter	Acceptance criteria	Test results	Passed / failed
Pin holes (no)	No pinholes	0	Passed
Blisters and rust [1)]	No blisters or rust	0	Passed
Adhesion values (MPa) [2)]	>3.5 adhesive failure >3.0 cohesive failure	Average: 5.2 Maximum: 6.1 Minimum: 4.2 70 – 80 % cohesive failure 20 – 30 % adhesive failure	Passed
Cathodic disbondment (mm) [3)]	< 8	7.2	Passed
Current demand (mA/m^2) [3)]	< 5	3.3	Passed

1) Details of blister and rust Table B-4 Appendix B.
2) Details of Pull-off adhesion test in Table B-5 Appendix B.
3) Details of Cathodic Protection in Table B-6 Appendix B.

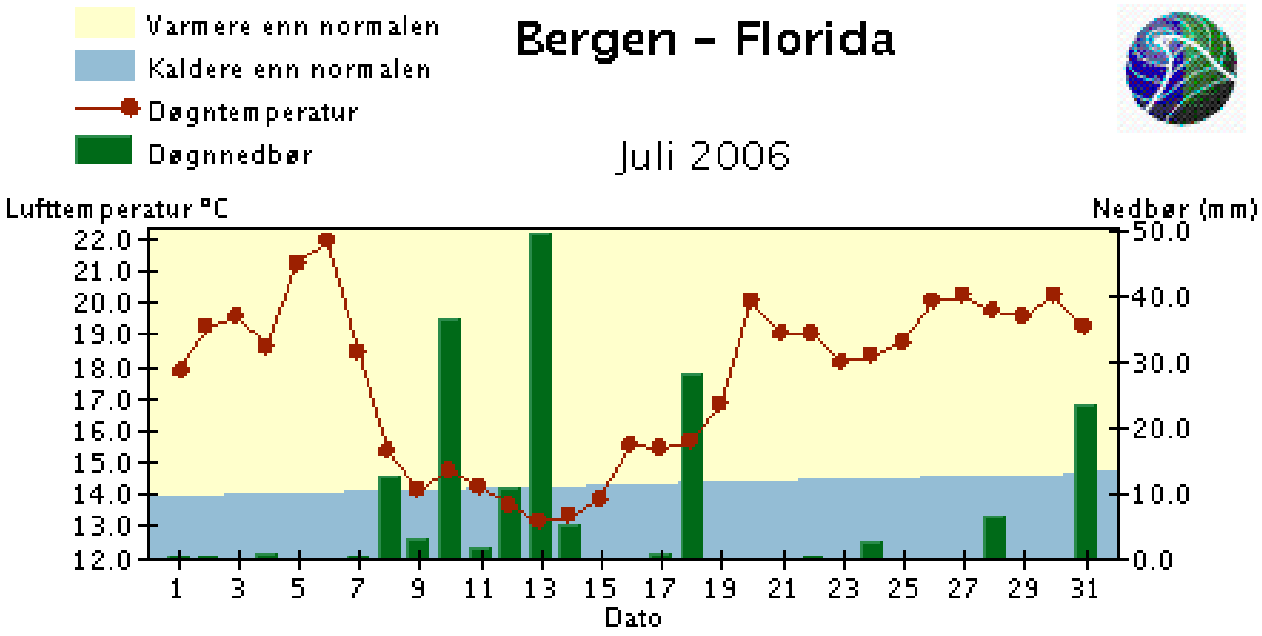
7 CONCLUSION

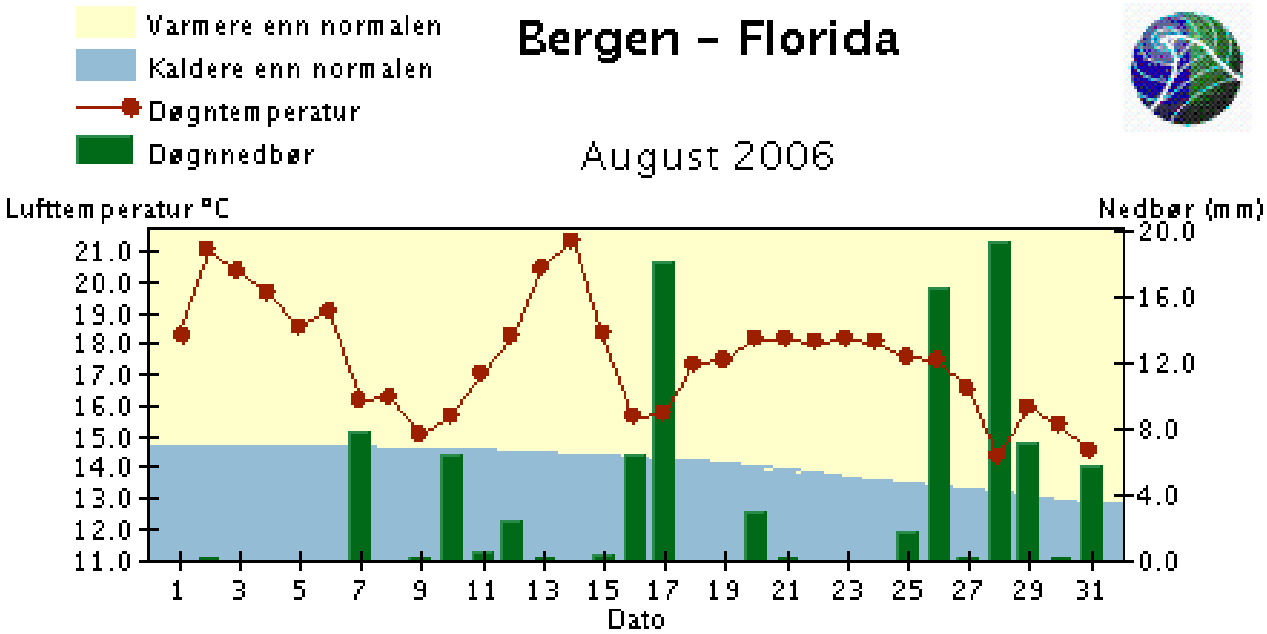
The results from the testing show that Example Epoxy Paint from Example Coating Producer has passed all the requirements for the crossover test given in the Performance Standard for Protective Coatings /1/.

8 REFERENCES

/1/ MSC 215 (82) :2006 Performance Standard for Protective Coatings for dedicated sea water ballast tanks in all types of ships and double-side skin spaces of bulk carriers

9 APPENDIX A - ENVIRONMENTAL DATA - WEATHERING OF SHOP PRIMED PANELS





10 APPENDIX B - DETAILS OF SURFACE PREPARATION, APPLICATION AND TEST RESULTS

Table B-1 Surface preparation data.

Surface preparation date	November 2007 The prepared panels were stored at ambient in- door conditions until use
Surface preparation method	Blast cleaning
Blasting standard	Sa 2 ½
Abrasive used	AlSil A3+ steel shot
Roughness (µm)	R_{max} 50 -75
Water soluble salts	32, 38 and 40 mg / m^2 Spot check performed on 3 out of 30 panels produced at the same time
Dust and abrasive inclusions	No dust or abrasive inclusions observed by visual examination.
Treatment of shopprimer after weathering	Low pressure washing
Water soluble salts after treatment of shopprimer	Spot check 28, 41 and 38 mg / m^2

Table B-2 Application data.

Coating data:	Shop primer	1st coat	2nd coat
Paint system:	Example red	Example Epoxy Paint Al Grey	Example Epoxy Paint Buff
Manufacturer:	Example Coating Producer		
Date	20.11.07	22.01.08	23.01.08
Time	10:00	10:00	10:00
Batch No. curing agent			
Batch No. base			
Thinner name (if used)			
Batch No. thinner(if used)			
Equipment used	Graco King 68:1	Graco King 68:1	Graco King 68:1
Air pressure (bar)	100	170	170
Size nozzle (inches)	0.021	0.021	0.021
Fan width (º)	60	60	60
Mix. ratio (volume)	A: B = 3:1	3:1	3:1
Volume solid (volume)	30 ± 2	80	80
Wet film thickness (µ)	55-70	275	275
Dry film thickness (µ)	15-25	See Table 3	See Table 4
Thinner (%)	0	0	0
Air temperature (ºC)	25	25	25
Humidity (% RH)	78	80	82
Steel temp. (ºC)	25	25	25
Dew point (ºC)	20	20	20

Present at application of shop primer: nn – MM Group (painter) and mm – laboratory. Present at application of test coating: kk - Example Coating Producer, nn – MM Group, and mm – laboratory.

Comments:

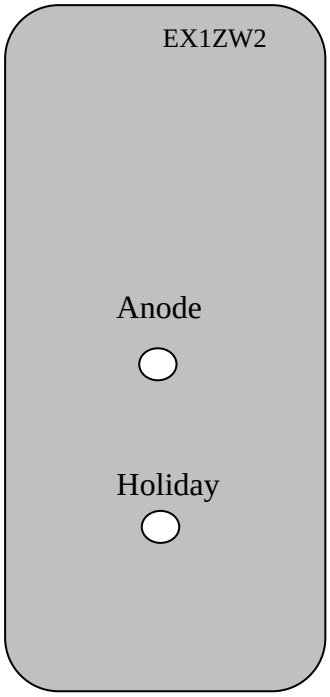


Figure B-1 Coding.

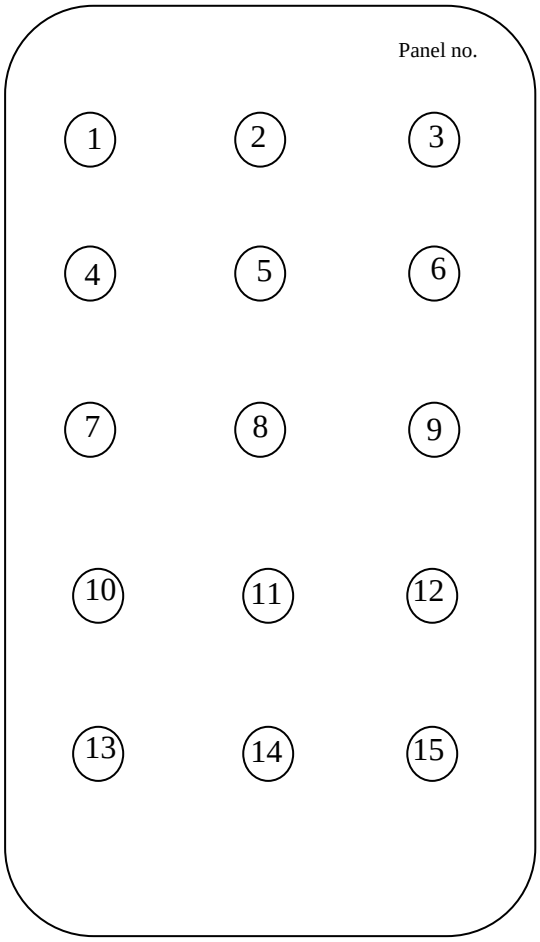


Figure B-2 Thickness measurement locations.

Table B-3 Total Dry Film Thickness – Example Epoxy Paint (20 µm subtracted for shop primed substrate).

Measurement	Panel no EX1ZW2
1	330
2	356
3	320
4	344
5	356
6	320
7	326
8	348
9	320
10	319
11	360
12	320
13	344
14	424
15	348
Max	424
Min	319
Average	**342**
StDev	27

Table B-4 Development of blisters and rust after exposure.

Code	Description	Blister size	Blister density	Rust	Other defects
EX1ZW2	Bottom wave tank panel with anode	0	0	0	0

Table B-5 Results of the Pull-off adhesion test, wave tank and heat exposed panels.

Panel no.	Adhesion strength (MPa)	Fracture
Bottom wave tank panel with anode W2	5.3	30 % B, 20 % C, 20 % C/D, 30 % D
	4.2	30 % B, 20 % C, 30 % C/D, 20 % D
	6.1	20 % B, 30 % C, 30 % C/D, 20 % D
Average	5.2	70 – 80 % Cohesive failure, 20 – 30 % Adhesive
Max	6.1	
Min	4.2	

A/B	Fracture between the steel surface and 1st coat (shop primer).
B	Fracture in the 1st coat.
B/C	Fracture between the 1st and 2nd coat.
C	Fracture in the 2nd coat.
C/D	Fracture between the 2nd and 3rd coat.
D	Fracture in the 3rd coat
-/Y	Fracture between the outer coat and the glue.

Table B-8 Results of Cathodic Protection (CP).

Panel	Cathodic disbondment (mm)	Blisters / rust	Zinc anode weight loss (g)	Current demand (mA/ m^2)
EX1ZW2	7.2	0	1.2345	3.32

Exposure time: *120 days (Total time 180 days. Each cycle consists of 2 weeks seawater immersion and 1 week exposure in air)*

Utilisation factor: *0.8*

Consumption rate for Zn-anodes: 11.3 kg/A year

Cathodic protection; disbonding from artificial holiday:

"On completion of the test, thoroughly rinse the panel with tap water, taking care not to damage the coating." (From ISO 15711:2003)

"Assess loss of adhesion at the artificial holiday by using a sharp knife to make two cuts through the coating to the substrates, intersection at the holiday. With the point of the knife, attempt to lift and peel back the coating from around the holiday. Record whether the adhesion of the coating to the substrate has been reduced and the approximate distance, in millimetres, that the coating can be peeled." (From ISO 15711:2003)

Additionally interpretation of IMO PSPC: Repeat the cutting and lifting all around the artificial holiday to find the maximum loss of adhesion. Disbonding from artificial holiday can be either loss of adhesion to the steel substrate or between the shop primer and the epoxy coating and shall be less than 8 mm for epoxy based systems to be acceptable (compability test). Cohesive adhesion failure in the shop primer is not to be included as part of the loss of adhesion.

11 APPENDIX C – PHOTO DOCUMENTATION

(It should be overview picture of the panel and close up picture of the disbonding from artificial holiday)

Figure C-1 Disbonding from artificial holiday, bottom wave tank panel (example picture not connected to example results in this model report).

Figure C-2 Disbonding from artificial holiday, bottom wave tank panel (example picture not connected to example results in this model report).

BCS-G103 Guidance for the compilation of the IOPP Supplement

1. Preamble

1.1 Form B Supplement to IOPP Certificate indicates the level of compliance of a tanker to Annex I to MARPOL 73/78.

1.2 In order to avoid misunderstandings of the different annotations seen by owners and Port State Control Officers for the worldwide fleet and consider that questions will likely intensify as greater focus is placed on checking the documentation, the following Table should be considered by the Surveyor when filling in the above mentioned Supplement.

1	2	3	4	5	6	7	8	9	10	11
IOPP Form B Item "Date" is the applicable date according to the referenced regulation relative to the date of contract, keel laying date or delivery date of the vessel	Oil tankers > R19 Date (DWT ≥ 5000 t)	R19 Oil Tankers < R19 Date (DWT ≥ 5000 t)	R20.1.3 or R21.1.2	Cat.2 or Cat.3 Oil tanker (DWT ≥ 5000 t)	Oil Tankers > R19 Date (600 ≤ DWT < 5000 t)	Oil tankers > R19 Date (600 ≤ DWT < 5000) and in compliance with R21.4.2	Oil tankers < R19 Date (600 ≤ DWT < 5000 t)			Oil tankers (DWT < 600 t)
							SH(2)	DB(2)	DH(2)	
5.6 Double hull construction 5.6.1 The ship is required to be constructed in accordance with regulation 19 and complies with the requirements of: -Regulation 19.3 (double hull construction) -Regulation 19.4 (mid-height deck tankers with double side construction) -Regulation 19.5 (alternative method approved by the Marine Environment Protection Committee)	X	X	-	-	X(3)	-	-	-	-	-
5.6.2 The ship is required to be constructed according to and complies with the requirements of regulation 19.6	-	-	-	-	X(3)	X(4)	-	X	X(4)	-
5.6.3 The ship is not required to comply with the requirements of regulation 19	-	X	X	-	-	-	X	X	X	X
5.6.4 The ship is subject to regulation 20 and:	-	-	-	X	-	-	-	-	-	-
5.6.5 The ship is not subject to regulation 20	X	X	X	-	X	X	X	X	X	X
5.6.6 The ship is subject to regulation 21 and:	-	-	-	X (1)	X (1)	-	X (1)	X (1)	-	-
5.6.7 The ship is not subject to regulation 21	X	X	X	X (1)	X (1)	X	X (1)	X (1)	X	X

(1) The appropriate sub-item(s) under 5.6.6 is(are) to be annotated with "X" if tanker carries HGO. Or if the tanker does not carry HGO, item 5.6.7 is to be annotated with "X".

(2) SH: Single Hull Construction, DB: Double Bottom Construction in accordance with R19.6, DH: Double Hull Construction in accordance with 21.4.2

(3) Either 5.6.1 or 5.6.2 is to be marked, but not both. Footnote (1) is applicable when item 5.6.2 is annotated with "X". Regulation 19.5 does not apply under 5.6.2.

(4) Item 5.6.2 is to be annotated with the proviso: "(Complies with double hull requirements as per 21.4.2)"

BCS -G 105 Qualification scheme for welders of aluminium alloys

1. Scope

1.1 This document provides guidance for a qualification scheme for welders intended to be engaged in welding of aluminium alloys specified in **BCS** Rules Chapter 2, Section 8 for Hull Structures.

1.2 The qualification scheme for welders of hull structural steel is given in BCS-R W32.

1.3 This qualification scheme does not cover fully mechanized welding process or full. automatic welding processes. Each welder intended to be engaged in those welding processes should have experience of the specific welding work concerned

2. General

2.1 Those welders intended to be engaged in welding of hull structures in shipyards and manufacturers should be tested and qualified in accordance with this scheme and issued with a qualification certificate endorsed by **BCS**.

2.2 This guidance document is applicable to welding of hull structures both during new construction and the repair of ships.

2.3 The training of welders, control of their qualification and maintenance of their skills are normally the responsibility of the Shipyards and manufacturers.

2.4 Welders qualified in accordance with national or international standards may be also be engaged in welding of hull structures, at the discretion of **BCS**.

3. Qualification of welders

3.1 A welder should be qualified in relation to the following variables of welding:

a) base material
b) welding process
c) types of welded joint
d) plate thickness
e) welding position

3.2 The material for qualification is shown in Table 1.

3.3 The welding processes for welder's qualification are to be classified in Table 2 as Semi-automatic welding (S) and TIG welding (T).

3.4 The types of welded joints for welder's qualification are to be classified as given in Table 3 in accordance with the qualification test.

A qualification test performed using butt welds automatically qualifies fillet welding.

BCS may qualify as FW, welders who are employed to perform fillet welding only. However, where such welders are engaged to weld fillet with groove are to be qualified for butt welds.

Table 1 Materials for welder's qualification

Symbol	Materials in actual welding works
AL	Aluminium alloys specified in **BCS** Rules Chapter 2, Section 8

Table 2 Welding processes for welder's qualification

Symbol	Welding process in actual welding works		ISO 4063:2009
S	Semi-automatic welding	Metal inert gas (MIG) welding	131
T	TIG welding	Tungsten inert gas (TIG) welding	141

Table 3 Types of welded joint for welder's qualification

Type of welded joint used in the test assembly for the qualification test				Type of welded joint qualified
Butt welds	one side	With backing	WB	WB, WG, FW
		Without backing	NB	WB, NB, WG, NG, FW
	both side	With gouging	WG	WB, WG, FW
		Without gouging	NG	WB, WG, NG, FW
Fillet welds			FW	FW

3.5 The qualified plate thickness range arising from the welder qualification test plate thickness is shown in Table 4.

Table 4 Plate thicknesses for welder's qualification

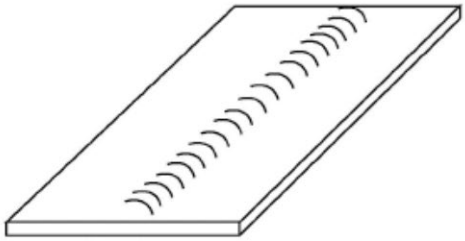
Thickness of test assembly T (mm)	Qualified plate thickness range t (mm)
$T \leq 6$	$0.7T \leq t < 2.5T$
$6 < T \leq 15$	$6 < t \leq 40$ [1)]

Note: 1) A special test is required for material thicknesses greater than 40mm. Such a special test shall be indicated on the welder's certificate.

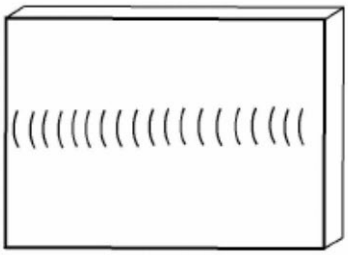
3.6 The welding positions qualified as a result of the actual welding position used in a satisfactory welder's qualification test, are shown in Table 5. Diagrams showing the definitions of weld position used in Table 5 are shown in Fig. 1, Fig. 2, Fig. 3 and Fig. 4.

Table 5 Welding positions for welder's qualifications

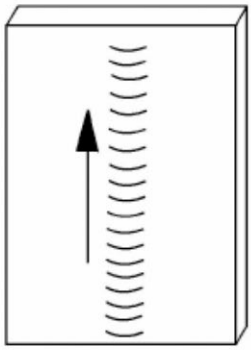
Qualification Test Positions (See Fig. 3 and Fig. 4)	Welding positions in actual welding works	
	Butt welds (See Fig. 1)	Fillet welds (See Fig. 2)
1G	F	F, H
2G	F, H	F, H
3G-up	F, H, VU	F, H, VU
3G-down	F, VD	F, VD
4G	F, H, OH	F, H, OH
2G+3G-up+4G	F, H, VU, OH	F, H, VU, OH
1F	-	F
2F	-	F, H
3F-up	-	F, H, VU
3F-down	-	F, VD
4F	-	F, H, OH
2F+3F-up+4F	-	F, H, VU, OH



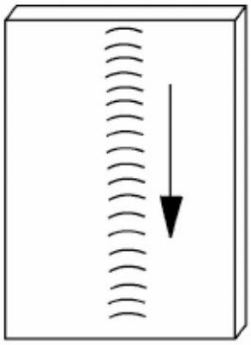
(a) Flat position (F)



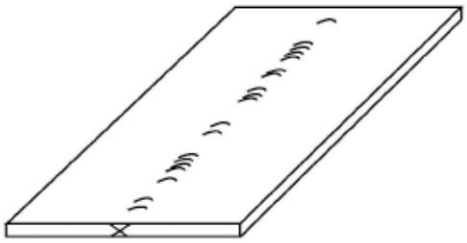
(b) Horizontal position (H)



(c) Vertical upward position (VU)

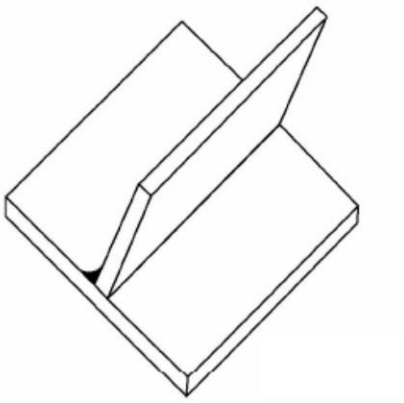


(d) Vertical downward position (VD)

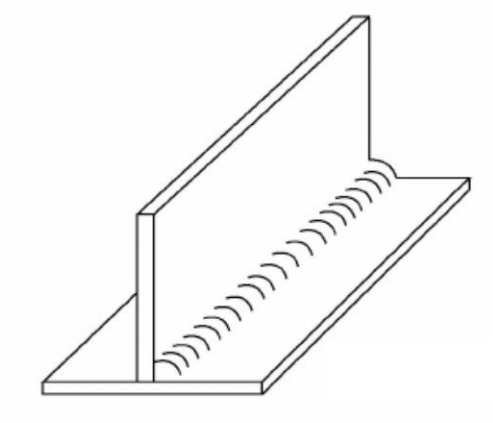


(e) Overhead position (OH)

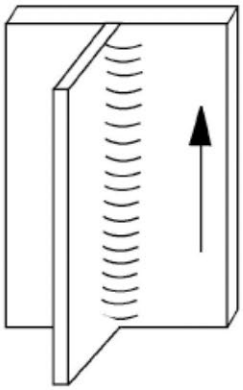
Fig. 1 Welding positions (Butt welds)



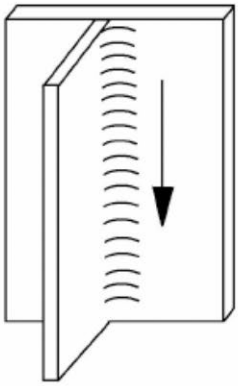
(a) Flat position (F)



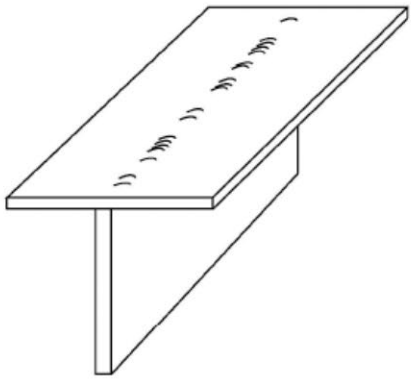
(b) Horizontal position (H)



(c) Vertical upward position (VU)

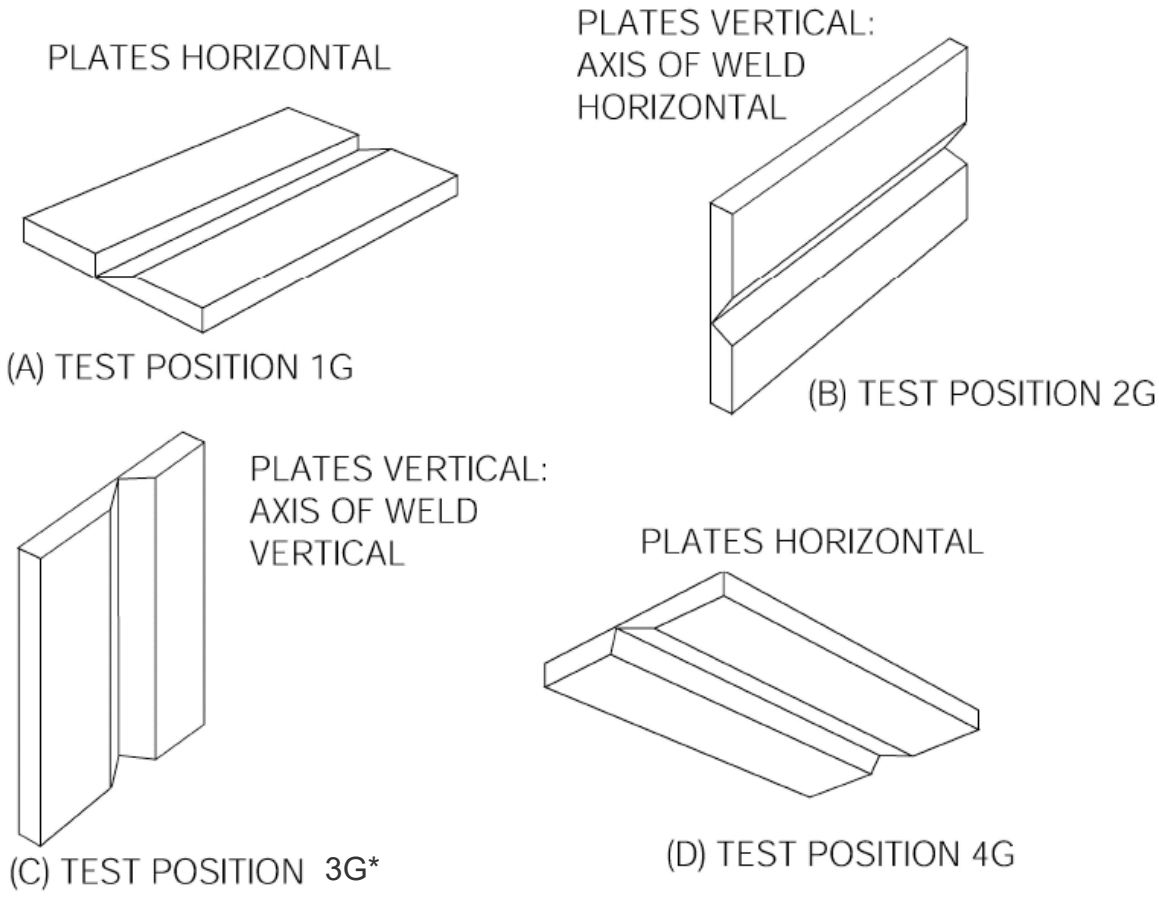


(d) Vertical downward position (VD)



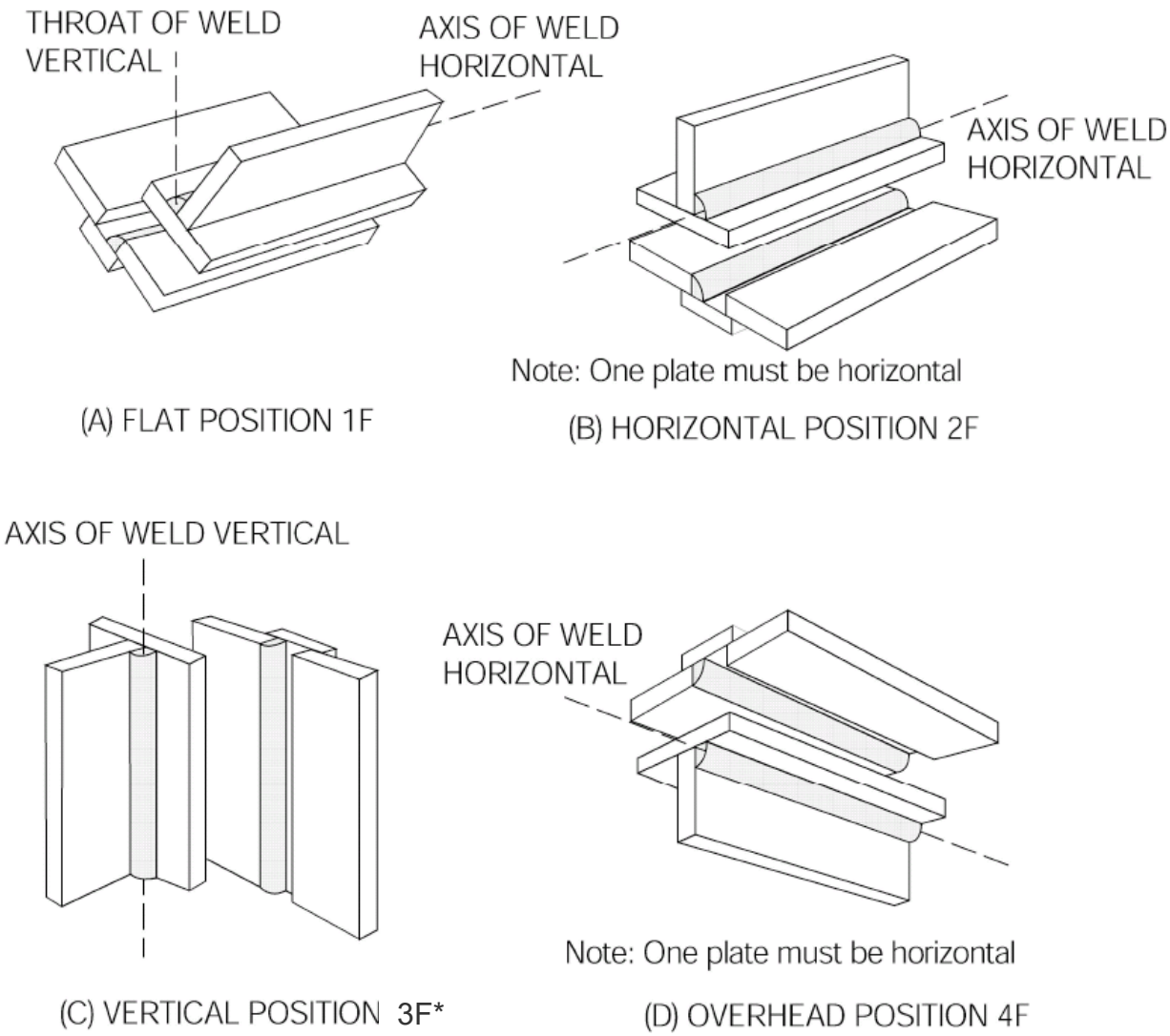
(e) Overhead position (OH)

Fig. 2 Welding positions (Fillet welds)



* 3G-up : The welding position is VU (Butt welds).
3G-down : The welding position is VD (Butt welds).

Fig. 3 Test positions (Butt welds)



* 3F-up : The welding position is VU (Fillet welds).
3F-down : The welding position is VD (Fillet welds).

Fig. 4 Test positions (Fillet welds)

3.7 Welders engaged in tack welding should be qualified for either butt welds or fillet welds, for the welding process (Table 2) and the position (Table 5) corresponding to the joint to be welded.

BCS may qualify those welders engaged in tack welding works only.

4. Qualification test

4.1 General

4.1.1 Welding of the test assemblies and testing of test specimens should be witnessed by the Surveyor.

4.2 Test assemblies

4.2.1 Test assemblies for butt welds and for fillet welds are to be prepared as shown in Fig. 5 and Fig. 6 in each qualification test.

4.2.2 Testing materials and welding consumables are to conform to one of the following requirements or to be of equivalent grade approved by **BCS**.

a) Testing materials

- Aluminium alloys for hull construction and marine use specified in **BCS** Rules Chapter 2, Section 8.

b) Welding consumables

- Consumables for aluminium alloys specified in BCS Rules Chapter 3, Section 5.

4.3 Examination and test

4.3.1 The test assemblies specified in 4.2 should be examined and tested as follows:

a) For butt welds:

- Visual examination

- Bend test

Note: Radiographic tests or fracture tests may be carried out in lieu of bend tests.

b) For fillet welds:

- Visual examination

- Fracture test

Note: Two macro sections may be taken in lieu of fracture tests.

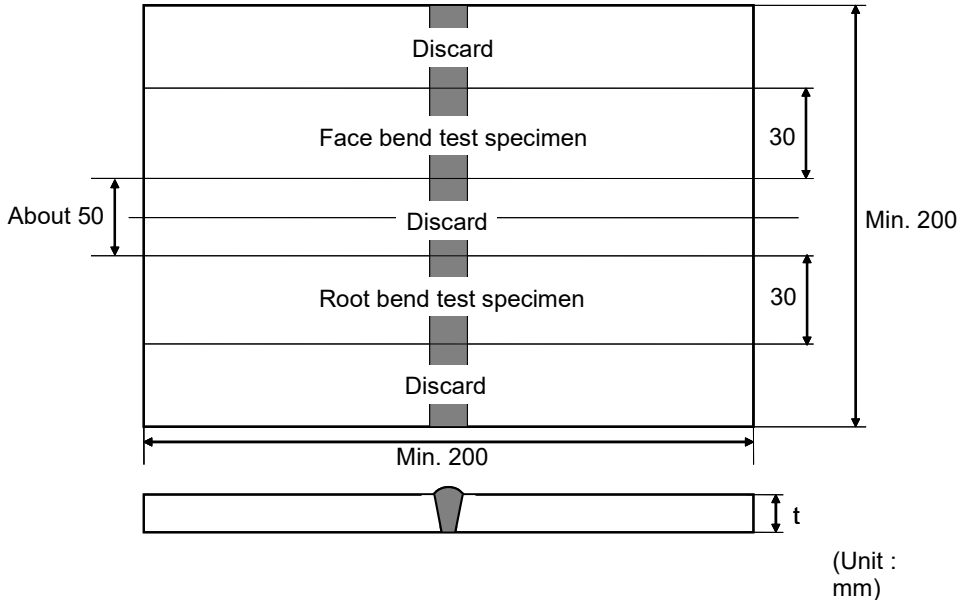


Fig. 5 Dimensions and types of test assembly for butt welds

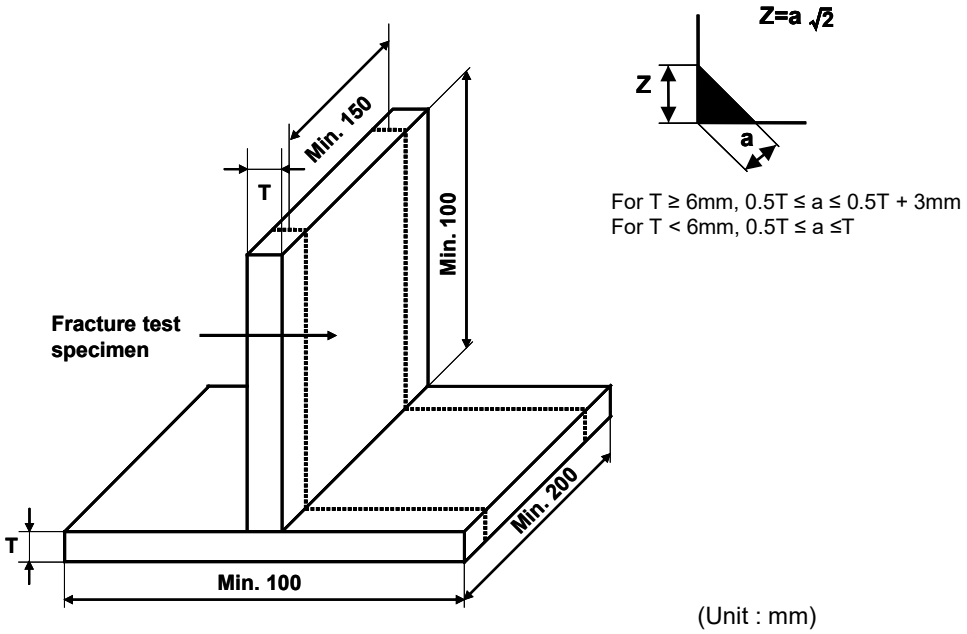


Fig. 6 Dimensions and types of test assembly for fillet welds

4.3.2 Visual examination

The welds should be visually examined prior to cutting of the test specimen for the bend test.

Welds are to be free from cracks.

Other imperfections detected are to be assessed in accordance with ISO 10042:2018, level B, except for the following imperfection types for which the level C applies:

- excess weld metal
- excess penetration
- excessive convexity
- excessive throat thickness

4.3.3 Bend test

Transverse bend test specimens are to be in accordance with BCS-R W2.

The mandrel diameter to thickness ratio (i.e. D/t) is to be that specified for welding consumable (BCS Rules Chapter 3, Section 5) for aluminium alloys.

The test specimens are to be bent through 180 degrees.

One face bend test and root bend test specimen are to be tested. For thickness 12mm and over, two side bend specimens may be tested as an Alternative.

After the test, the test specimens should not reveal any open defects in any direction, greater than 3mm. Defects appearing in the corners of a test specimen during testing are to be investigated case by case.

4.3.4 Radiographic examination

When radiographic testing is used for butt welds, imperfections detected should be assessed in accordance with ISO 10042:2018, level B, except for the following imperfections for which the level C applies:

- excess weld metal
- excessive convexity
- excessive penetration

4.3.5 Fracture test (Butt welds)

When fracture test is used for butt welds, full test specimen in length is to be tested in accordance with ISO 9017:2017. Imperfections detected should be assessed in accordance with ISO 10042:2018, level B, except for the following imperfections for which the level C applies:

- excess weld metal
- excessive convexity
- excessive penetration

4.3.6 Fracture test (Fillet welds)

The fracture test is to be performed by folding the upright plate onto the through plate. Evaluation is to concentrate on cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration. Imperfections detected should be assessed in accordance with ISO 10042:2018, level B, except for the following imperfections for which the level C applies:

- excess weld metal
- excessive convexity
- excessive penetration

4.3.7 Macro examination

When macro examination is used for fillet welds, the test specimens are to be prepared and etched on one side to clearly reveal the weld metal, fusion line, root penetration and the heat affected zone.

Macro sections should include about 10mm of unaffected base metal.

The examination is to reveal a regular weld profile, through fusion between adjacent layers of weld and base metal, sufficient root penetration and the absence of defects such as cracks, lack of fusion etc.

4.4 Retest

4.4.1 When a welder fails a qualification test, the following should apply.

4.4.1.1 In cases where the welder fails to meet the requirements in part of the tests, a retest may be welded immediately, consisting of another test assembly of each type of welded joint and position that the welder failed. In this case, the test is to be done for duplicate test specimens of each failed test.

All retest specimens must meet all of the specified requirements.

4.4.1.2 In cases where the welder fails to meet the requirements in all parts of the required tests or in the retest prescribed in 4.4.1.1, the welder should undertake further training and practice.

4.4.1.3 When there is specific reason to question the welder's ability or the period of effectiveness has lapsed, the welder should be re-qualified in accordance with the tests specified in 4.1 and 4.2.

4.4.2 Where any test specimen does not comply with dimensional specifications due to poor machining, a replacement test assembly should be prepared for testing.

5. Period of Validity

5.1 Initial approval

5.1.1 The validity of the welder's approval begins from the date when all the required tests are satisfactorily completed.

A welder's approval normally remains valid for a period of time left at the discretion of **BCS** provided that the certificate or the relevant document is signed at six-month intervals by the shipyards/manufacturers responsible for weld quality, and that all the following conditions are fulfilled.

a) The welder should be engaged with reasonable continuity on welding work within the current range of approval. An interruption for a period no longer than six months is permitted;

b) The welder's work should in general be in accordance with the technical conditions under which the approval test is carried out;

c) There should be no specific reason to question the welder's skill and knowledge.

5.1.2 If any of these conditions are not fulfilled, the approval should be cancelled.

5.2 Extension of approval

5.2.1 The validity of the approval on the certificate may be prolonged for further periods within the original range of approval, provided each of the following conditions in accordance with 5.1.1 are fulfilled and:

a) the production welds made by the welder are of the required quality;

b) records of tests, e.g. documentation of radiographic or ultrasonic inspections or test reports on fracture tests or comments of the appointed coordinators, are maintained on file with the welder's approval certificate.

BCS may request tests in order to extend the validity of the approval on the certificate.

5.2.2 **BCS** should verify compliance with the above conditions and sign the extension of the welder's approval certificate.

6. Certification

6.1 Qualification certificates are normally issued when the welder has passed the qualification test by **BCS**. Each Shipyard and Manufacturer should be responsible for the control of the validity of the certificate and the range of the approval. Other procedure to control qualifications such as approval of list of qualified welders may be applied at the discretion of **BCS**.

6.2 The following items should be specified in the certificate:

a) Range of qualification for materials, welding processes, types of welded joint, plate thicknesses and welding positions;

b) Expiry date of the validity of the qualification;

c) Name, date of birth, identification and the photograph of the welder;

d) Name of shipbuilder / manufacturer.

6.3 The status of approvals of each individual qualification is to be demonstrated to **BCS** when requested.

BCS- G 109 Acceptance criteria for cargo tank filling limits higher than 98% (on ships constructed before 1 July 2016)

The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), (MSC.5(48)) as amended by resolutions MSC.17(58), MSC.30(61), MSC.32(63), MSC.59(67), MSC.103(73), MSC.177(79) and MSC.220(82), 15.1.3 reads:

"The Administration may allow a higher filling limit (FL) than the limit of 98% specified in 15.1.1 at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging and the difference between the loading temperature and the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves, provided the conditions specified in 8.2.17 are maintained."

1. General

1.1 Functional requirements

The maximum filling limit of cargo tanks shall be so determined that the vapour space has a minimum volume at reference conditions (temperature of liquid corresponding to the opening pressure of pressure relief valves) to account for:

- tolerance of level gauges and temperature gauges;
- volume expansion due to pressure rise in cargo tanks above set opening pressure of pressure relief valves under maximum relieving conditions;
- an operational margin to account for liquid drained back to cargo tanks after stop of loading, closing time of valves and operator reaction time.

1.2 Definitions

Filling limit (FL) means the maximum liquid volume in a cargo tank relative to the accepted total tank volume when the liquid cargo has reached the reference temperature.

Loading limit (LL) means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded.

2. Acceptance criteria for a higher filling limit than 98%

2.1 According to para. 15.1.3 a higher filling limit than 98% may be allowed at the reference temperature taking into account the following parameters:

.1 accuracy of level gauges;

.2 accuracy of temperature gauges;

.3 pressure rise above opening pressure when pressure relief valves are relieving at maximum flow rate under fire condition;

.4 an operational margin to account for liquid in loading lines drained back to cargo tanks, closing time of loading valves and operators reaction time; and

.5 shape of the tank and arrangement of pressure relief valves,

provided the conditions specified in 8.2.17 are maintained.

2.2 The parameters specified under 2.1.1 – 2.1.5 may be expressed by the expansion factors α_1 through α_4 as follows:

α_1 = relative increase in liquid volume due to tolerance of level gauges

α_2 = relative increase in liquid volume due to the tolerance of temperature gauges

α_3 = expansion of cargo volume due to pressure rise when pressure relief valves are relieving at maximum flow rate

α_4 = operational margin of 0.1%

The factors α_1 through α_4 are to be determined as follows:

$$\alpha_1 = \frac{dV}{dh} \cdot \frac{\Delta h}{V} \cdot 100(\%)$$

where:

$\frac{dV}{dh}$ = variation of tank volume per metre filling height at the filling height h (m^3/m)

h = filling height (m) at the filling limit FL to be investigated (FL > 98%)

V = accepted total tank volume (m^3)

Δh = max. total tolerance of level gauges (m)

$$\alpha_2 = \beta \cdot \Delta T(\%)$$

where:

β = volumetric thermal expansion coefficient at reference temperature (%/ºK)

ΔT = max. tolerance of temperature gauge (ºK)

$$\alpha_3 = \left(\frac{\rho_{PRV}}{\rho_{PRV \cdot 1.2}} - 1 \right) \cdot 100(\%)$$ expansion due to pressure rise when relieving at full capacity

ρ_{PRV} = ρ_R cargo density at reference conditions, i.e. corresponding to the temperature of the cargo at set opening pressure of the pressure relief valve (PRV)

$\rho_{PRV\cdot 1.2}$ = cargo density corresponding to the temperature of the cargo at 1.2 times the set opening pressure of the pressure relief valve (PRV)

$\alpha_4 = 0.1\%$ operational margin

2.3 Based on the factors α_1 through α_4 the following total expansion factor α_t is to be determined

$$\alpha_t = \sqrt{\alpha_1^2 + \alpha_2^2} + \alpha_3 + \alpha_4 (\%)$$

2.4 The filling limit at reference temperature may now be taken

$$FL_{(\max)} = (100 - \alpha_t)\%$$

In no case is $FL_{(max)}$ to exceed 99.5%.

2.5 Subsequently the sloped liquid level under conditions of 15° list and 0.015L trim is to be determined.

It is to be verified that under these conditions the suction funnels of the pressure relief valves remain above the sloped liquid level at a minimum distance of 40% of the diameter of the suction funnel measured at the centre of the funnel. Risk of vapour pockets formed not communicating with the vapour / liquid domes, where the vapour line and cargo tank pressure relief valves (PRVs) are located, should be considered.

2.6 The maximum allowable loading limit results from the following formula:

$$LL = (100 - \alpha_t)\frac{\rho_R}{\rho_L}(\%)$$

ρ_L, ρ_R = cargo densities as defined in 15.1.2 of the Code.

BCS -G 110 Guideline for Scope of Damage Stability Verification on new oil tankers, chemical tankers and gas carriers

1 Application

This recommendation applies for oil tankers, chemical tankers and gas carriers, excluding combination carriers.

2 Reference

2.1 IMO Instruments

2.1.1 General Instruments

- SOLAS Chapter II-1, Regulations 4.1, 4.2, 5-1 and 19;
- Part B, chapter 4 of the International Code on Intact Stability, 2008 (2008 IS Code), adopted by resolution MSC.267(85), as amended;
- Res. MSC.143(77) "Adoption of amendments to the Protocol of 1988 relating to the International Convention on Load Lines, 1966", Regulations 27(2), 27(3), 27(11), 27(12) and 27(13) [1)];

Note:

1. This recommendation applies for new oil tankers, chemical tankers and gas carriers contracted for construction on or after 1 July 2021.

2. The ‘contracted for construction’ date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of ‘contract for construction’, refer to BCS-PR 29.

Footnotes:

1) The application of ICLL Protocol 1988, Reg.27 is explained in Annex 1.

- Res. MSC.429(98) "Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations" - special attention should be paid to Guidelines for the Preparation of Subdivision and Damage Stability Calculations specified in the Appendix;

- Res. MSC.429(98)/Rev.1 "Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations" - special attention should be paid to Guidelines for the Preparation of Subdivision and Damage Stability Calculations specified in the Appendix;

- Res. MSC.362(92)"Revised Recommendation on a Standard Method for Evaluating Cross-Flooding Arrangements";

- MSC.1/Circ.1245 "Guidelines for Damage Control Plans and Information to the Master"; and

- MSC.1/Circ.1229 "Guidelines for the Approval of Stability Instruments", paragraph 4.

2.1.2 Instruments applicable to oil tankers

- MARPOL Annex I, Regulation 28; and

- ICLL 66/88 Annex I, Reg.27 for type “A” ships with a length of more than 150m and assigned freeboard less than type “B”. An overview is shown in Annex I of this document.

2.1.3 Instruments applicable to gas carriers

- International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), Chapter 2, Paragraphs 2.1, 2.4, 2.5, 2.6.2, 2.6.3, 2.7, 2.8 and 2.9;

- MSC/Circ.406/Rev.1 "Guidelines on Interpretation of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and Guidelines for the Uniform Application of the Survival Requirements of the IBC and IGC Codes"; and

- ICLL 66/88 Annex I, Reg.27 for type “A” ships with a length of more than 150m and assigned freeboard less than type “B”. An overview is shown in Annex I of this document.

2.1.4 Instruments applicable to chemical tankers

- International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), Chapter 2, Paragraphs 2.1, 2.4, 2.5, 2.6.2, 2.7, 2.8 and 2.9;

- MSC/Circ.406/Rev.1 “Guidelines on Interpretation of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and Guidelines for the Uniform Application of the Survival Requirements of the IBC and IGC Codes”; and

- ICLL 66/88 Annex I, Reg.27 for type “A” ships with a length of more than 150m and assigned freeboard less than type “B”. An overview is shown in Annex I of this document.

2.2 Resolutions

- BCS-R L5 “Onboard Computers for Stability Calculations”;

- BCS-PR7 “Procedure for the Training and Qualification of Survey and Plan Approval Staff”;

and • BCS-I SC 156 “Doors in watertight bulkheads of cargo ships and passenger ships”.

3 General

3.1 Education and training

3.1.1 Plan approval staff engaged in damage stability verification of new oil tankers, chemical tankers and gas carriers should have as minimum the following formal educational background:

- a degree or equivalent from a tertiary institution recognized within the field of marine engineering or naval architecture; and

- competent in the English language commensurate with their work.

3.1.2 Plan approval staff engaged in damage stability verification of new oil tankers, chemical tankers and gas carriers should be trained according to theoretical and practical modules defined by BCS to acquire and develop general knowledge and understanding applicable to the a/m types of ship and stability assessment according to the BCS Rules and Instruments and Resolutions referred in paragraph 2 above.

3.1.3 Methods of training may include monitoring, testing, etc. on regular basis according to the Society’s system. Evidence of training provided should be documented.

3.1.4 Updating of qualification may be done through the following methods:

- self-study;

- extraordinary seminars in case of significant changes in BCS’s Rules or International Conventions, Codes, etc.; and

- special training on specific work, which is determined by a long absence of practical experience.

Maintenance of qualification should be verified at annual performance review.

3.2 Scope of stability verification

The scope of damage stability verification is determined by the required damage stability standards (applicable damage stability criteria) and aims at providing the ship’s master with a sufficient number of approved loading conditions to be used for the loading of the ship. In general, for non-approved loading conditions (by the Administration or RO), approved KG/GM limit curve(s) or approved loading instrument software satisfying the stability requirements (intact and damage) for the draught range to be covered should be used to verify compliance on board.

Within the scope of the verification determined as per the above, all potential or necessary damage scenarios should be determined and assessed taking into account the damage stability criteria.

Damage stability verification and approval requires a review of submitted calculations and supporting documentation with independent check calculations to confirm damage stability calculation results comply with relevant stability criteria.

Examination and approval of the loading instrument software installed on board (and to be used for assessing intact and damage stability) shall also be carried out. A loading instrument comprises hardware and software. The accuracy of the computation results and actual ship data used by the software is to be verified.

3.3 Assumptions

For all loading conditions, the initial metacentric height and the righting lever curve should be corrected for the effect of free surfaces of liquids in tanks.

Superstructures and deckhouses not regarded as enclosed can be taken into account in stability calculations up to the angle at which their openings are flooded. Flooding points (including windows) incapable of weathertight closure are to be included in any list determined in accordance with paragraph 3.4.2.6. Full compliance with residual stability criteria must be achieved before any such point becomes immersed.

When determining the righting lever (GZ) of the residual stability curve, the constant displacement (lost buoyancy) method of calculation should be used (see paragraph 6.1).

Conditions of loading and instructions provided by the submitter for use of the applicable KG/GM limit curve(s) and variation of loading patterns and representative cargoes are taken to be representative of how the ship will be operated.

3.4 Documentation to be submitted for review

3.4.1 Presentation of documents

The documentation should begin with the following details: principal dimensions, ship type, designation of intact conditions, designation of damage conditions and pertinent damaged compartments, KG/GM limit curve(s).

3.4.2 General documents and supporting information

.1 lines plan, plotted or numerically;

.2 hydrostatic data and cross curves of stability (including drawing of the buoyant hull);

.3 definition of watertight compartments with moulded volumes, centres of gravity and permeability;

.4 layout plan (watertight integrity plan) for the watertight compartments with all internal and external opening points including their connected sub-compartments, and particulars used in measuring the spaces, such as general arrangement plan and tank plan;

.5 Stability Booklet/Loading Manual including at least fully loaded homogeneous condition at summer load line draught (departure and arrival) and other intended operational conditions[2]; in addition, when verifying the damage stability according to MSC/Circ.406/Rev.1 and MSC.1/Circ. 1537 the tropical freeboard needs to be considered, however, the fresh water allowance and tropical fresh water allowance need not to be taken into account according to MARPOL, IBC and IGC.

.6 coordinates of opening points with their level of tightness (e.g., weathertight, unprotected) [3], including reference to the compartment that the opening is connected to.

.7 watertight door location;

.8 cross and down flooding devices and the calculations thereof according to resolution MSC.362(92) with information about diameter, valves, pipe lengths and coordinates of inlet/outlet. Cross/down flooding should not be considered for the purpose of achieving compliance with the stability criteria (see also paragraph 9.2);

.9 pipes in damaged area when the breaching of these pipes results in progressive flooding (see paragraph 10.1);

.10 damage extents and definition of damage cases; and

.11 any initial conditions or restrictions which have been assumed in the derivation of critical KG or GM data, and which must therefore be met in service.

3.4.3 Special documents

.1 Documentation

Design documentation should include: damage stability calculations (including residual stability curves), the arrangements, configuration and contents of the damaged compartments, and the distribution, relative densities and the free surface effect of liquids.

Operational documentation should include: loading and stability information booklet (stability booklet), Damage Control Plan; and Damage Control Booklet [3].

Footnote:

2) For the purpose of making a submission of stability information for approval, the minimum number of loading conditions which should be submitted for approval is a function of the mode of operation intended for the ship. MSC/Circ.406/Rev.1 offers guidance in this respect, and identifies the concepts of the "dedicated service tanker" and "parcel tanker" for the purpose of undertaking stability approval of ships certified under the IBC and IGC Codes and the appropriate treatment of ships assigned tropical freeboards.

3) Details of watertight, weathertight and unprotected openings should be included in the Damage Control Plan and Damage Control Booklet in accordance with MSC.1/Circ.1245.

The cases and extent of progressive flooding assumed in the damage stability analysis should be indicated in the Damage Control Booklet and the Documents for Submission in accordance with the Appendix to MSC.429(98). Arrangements to prevent further flooding are to be indicated on the Damage Control Plan and in the Damage Control Booklet.

.2 Special consideration

For intermediate flooding stages before cross-flooding (see paragraphs 6.8 and 9.2), or before progressive flooding (see paragraph 6.9), occur, an appropriate scope of the documentation covering the aforementioned items is needed. The intermediate stages for cargo outflow and sea water inflow should be checked. If any stability criteria during intermediate stages shows more severe values than in the final stage of flooding these intermediate stages should also be submitted.

4 Operating Limits – Descriptions/Assumptions

In considering the scope of the verification to be conducted, consideration of the operating limits is needed.

The following loading options should be permitted:

a) Service loading conditions identical to the approved loading conditions of the stability booklet (see paragraph 4.2); or

b) Service loading conditions complying with the approved intact and damage stability limiting curves (where provided) (see paragraph 4.3); or

c) Service loading conditions which have been checked with an approved on-board stability software with the capability to perform damage stability calculations (Type 2 or 3 of BCS-R L5,) either based on KG/GM limit curve(s) or based on direct damage stability assessment (see paragraph 4.5).

If above mentioned proof of compliance is not possible, then the intended loading conditions should be either prohibited or be submitted for specific approval to the Administration or RO. Suitable instructions to this effect should be included in the stability booklet/loading manual. An approved loading condition is one which has been specifically examined and endorsed by Administration/RO.

4.1 Specific loading patterns

Ship specific design loading patterns and loading restrictions should be clearly presented in the stability booklet. The following items should be included:

a) Any required and intended loading conditions (including the ones corresponding to multiple freeboards when so assigned to the vessel), i.e. symmetrical/unsymmetrical, homogeneous/alternating or ballast/partial/full;

b) Types (e.g. oil, noxious liquid substances and LNG) of liquid cargo allowed to be carried;

c) Restrictions to different liquid loads to be carried simultaneously;

d) Range of permissible densities of liquid loads to be carried; and

e) Minimum tank filling levels required to achieve compliance with the applicable stability criteria.

For the verification of damage stability all loading conditions presented in the stability booklet except for ballast, light ship and docking conditions are to be examined.

4.2 Matrix of permissible loading conditions

In the absence of stability software and KG/GM limit curve(s), in lieu of approved specific loading conditions, a matrix clearly listing the allowable range of loading parameters (draft, trim, KG, cargo loading pattern and SG) that the vessel is allowed to load in order to be in compliance with the applicable intact and damage stability criteria can be developed for the stability booklet when a greater degree of flexibility than that afforded by approved specific loading conditions is needed. If this information is to be used it should be in an approved form.

4.3 KG/GM Limit Curve(s)[4)]

Where KG/GM limit curves are provided, a systematic investigation of damage survival characteristics should be undertaken by making calculations to obtain the minimum required GM or maximum allowable KG at a sufficient number of draughts within the operating range to permit the construction of a series of curves of "required GM" or "allowable KG" in relation to draught and cargo tank content in way of the damage. The curves should be sufficiently comprehensive to cover operational trim requirements.

The verification of KG/GM limit curves should be conducted without any free surface correction. The actual loading condition uses the free surface correction (see paragraph 6.5) when comparing actual and KG/GM limit values.

It is to be noted that any change of filling level, draught, trim, cargo density might have a major influence to the results of a damage case; therefore the following items should be considered carefully for the calculation of the KG/GM limit curves:

a) Intact and damage stability criteria applicable to the vessel;

b) The maximum required damage extent and lesser extents of damage which provide the most severe damage cases;

c) Draught range of the vessel: when verifying the damage stability, according to MSC/Circ.406/Rev.1 and MSC.1/Circ 1537 the tropical freeboard needs to be considered, however, the fresh water allowance and tropical fresh water allowance need not be taken into account under MARPOL, IBC and IGC;

d) Trim range of the vessel (see paragraph 6.6);

e) Full and empty cargo tanks;

f) Partially filled cargo tanks (consideration of increments as necessary);

g) Minimum tank fillings if required;

h) Maximum/minimum densities of cargoes; and

i) Ballast tank filling levels as necessary to achieve compliance.

Footnote:

4) To avoid difficulties associated with developing suitable KG/GM limit curves and their restriction on operational capacity it is recommended that an approved Type 3 stability software is fitted on board.

Damage stability calculations, on which the KG/GM limit curve(s) is(are) based, should be performed at the design stage. The KG/GM limit curve(s) drawn out taking stability criteria (intact and damage) into account should be inserted in the stability booklet.

4.4 Initial heel

The stability booklet should contain a note for the master to avoid initial heel greater than 1 degree. A steady heeling angle may have major influence to the stability of the vessel especially in case of damage.

4.5 Direct calculation onboard (Stability software)

The use of stability software for stability calculations is not a class requirement.

However, stability software installed onboard shall cover all stability requirements (intact and damage) applicable to the ship.

The following types of stability softwares, if approved by a classification society, (according to IACS UR L5 Rev.4 June 2020) are applicable for calculation of service loading conditions for tankers:

a) Type 2: software calculating intact stability and checking damage stability on basis of a limit curve (e.g. for vessels applicable to SOLAS Part B-1 damage stability calculations, etc.) or checking all the stability requirements (intact and damage stability) on the basis of a limit curve; and

b) Type 3: software calculating intact stability and damage stability by direct application of pre-programmed damage cases based on the relevant Conventions or Codes for each loading condition (for some tankers etc.)

The software shall be approved by the Society. The stability instrument is not a substitute for the approved stability documentation, but used as a supplement to facilitate stability calculations.

Damage Stability of Type 3 stability software shall be based on a hull form model, that is, directly calculated from a full three-dimensional geometric model.

All damages, taking into account lesser damages, and variation of draft, cargo density, tank loading patterns and extents of tank filling should be performed to ensure that for any possible loading condition the most onerous damages have been examined according to relevant stability criteria.

All applicable combinations of damage that are possible within the relevant MARPOL Convention / Codes (IGC, IBC…) should be performed. These are all damages within the maximum applicable damage extents for side, bottom and raking; the lesser extent damages for side, bottom and raking.

Lesser extent of damages should be generated on the principle of reduction in any longitudinal, transverse or vertical extent; whist maintaining adjacent (shared boundary) compartment logic, including L-shaped damages.

The methodologies for determining compliance with relevant stability criteria should be as set out in these guidelines.

5 Hull and Compartment Modelling Tolerances

Depending on the type and scope of programs, the acceptable tolerances are to be determined differently, according to 5.1 or 5.2. Deviation from these tolerances shall not be accepted unless the Society considers that there is a satisfactory explanation for the difference and that there will be no adverse effect on the safety of the ship.

Examples of pre-programmed input data include the following:

Hydrostatic data: Displacement, LCB, LCF, VCB, KM_t and MCT versus draught.

Stability data: KN or MS values at appropriate heel/ trim angles versus displacement, stability limits.

Compartment data: Volume, LCG, VCG, TCG and FSM/ Grain heeling moments vs level of the compartment's contents.

Examples of output data include the following:

Hydrostatic data: Displacement, LCB, LCF, VCB, KM_t and MCT versus draught as well as actual draughts, trim.

Stability data: FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, allowable grain heeling moments, derived stability criteria, e.g. areas under the GZ curve, weather criteria.

Compartment data: Calculated Volume, LCG, VCG, TCG and FSM/ Grain heeling moments vs level of the compartment's contents.

The computational accuracy of the calculation program results shall be within the acceptable tolerances, specified in 5.1 or 5.2, of the results using an independent program or the approved stability information with identical input.

5.1 Programs which use only pre-programmed data from the approved stability information as the basis for stability calculations, shall have zero tolerances for the printouts of input data.

Output data tolerances are to be close to zero, however, small differences associated with calculation rounding or abridged input data are acceptable.

Additionally differences associated with the use of hydrostatic and stability data for trims that differ from those in the approved stability information, are acceptable subject to review by the individual Society.

5.2 Programs which use hull form models as their basis for stability calculations, shall have tolerances for the printouts of basic calculated data established against either data from the approved stability information or data obtained using the approval authority's model.

Acceptable tolerances shall be in accordance with Table 1.

Table 1

Hull Form Dependent	
Displacement	+/- 2%
Longitudinal center of buoyancy, from AP	+/- 1% / 50 cm
Vertical center of buoyancy	+/- 1% / 5 cm
Transverse center of buoyancy	+/- 0.5% of B / 5 cm
Longitudinal center of flotation, from AP	+/- 1% / 50 cm
Moment to trim 1 cm	+/- 2%
Transverse metacentric height	+/- 1% / 5 cm
Longitudinal metacentric height	+/- 1% / 50 cm
Cross curves of stability	+/- 5 cm
Compartment dependent	
Volume or deadweight	+/- 2%
Longitudinal center of gravity, from AP	+/- 1% / 50 cm
Vertical centre of gravity	+/- 1% / 5 cm
Transverse center of gravity	+/- 0.5% of B / 5 cm
Free surface moment	+/- 2%
Shifting moment	+/- 5%
Level of contents	+/- 2%
Trim and stability	
Draughts (forward, aft, mean)	+/- 1% / 5 cm
GMt (both solid and corrected for free surfaces)	+/- 1% / 5 cm
GZ values	+/- 5% / 5 cm
Downflooding angle	+/- 2^0
Equilibrium angles	+/- 1^0
Distance from WL to unprotected and weathertight openings, or other relevant point, if applicable	+/- 5% / 5 cm
Areas under righting arm curve	+/- 5% / 0.0012mrad

Notes:

1. Deviation in % = {(base value-applicant's value)/base value} *100
Where the "base value" may be from the approved stability information or the society's computer model.

2. When applying the tolerances in Table 1 having two values, the allowable tolerance is the greater of the two values.

3. Where differences in calculation methodology exist between the programs used in the comparison, this may be a basis for accepting deviations greater than that specified in Table 1 provided a software examination is carried out in sufficient detail to clearly document that such differences are technically justifiable.

4. Deviation from these tolerances shall not be accepted unless BCS considers that there is a satisfactory explanation for the difference and that it is clearly evident from the BCS 's stability calculations that the deviation does not impact compliance with the required stability criteria for the ship under consideration.

6 Methodology

6.1 Method of analysis

Independent analysis uses the "constant displacement"/"lost buoyancy" method.

Within the scope of damage stability analysis with the deterministic approach, depending on the subdivision of the ship, the result of applying the standard of damage as specified in the applicable requirements is the creation of a number of damage cases, where one or more compartments are open to sea.

The compartment(s) once damaged, are not considered as contributing to the buoyancy of the ship. Consequently, a new condition of equilibrium occurs. In order to define the new equilibrium condition and to assess the stability of the ship after damage the lost buoyancy/constant displacement method is used.

The new floating position can be determined by assuming that the damaged displacement is equal to the intact displacement (constant displacement) minus the weight of liquids which were contained in the damaged compartments.

Due to the lost buoyancy of the damaged compartment(s), the remaining intact ship has to compensate by sinkage, heel and trim until the damaged displacement is reached. Once the equilibrium has been reached and the final waterline is determined, the metacentric height (GM), the righting lever curves (GZ) and the centre of gravity positions (KG), can be calculated in order to verify the stability of the ship against the applicable requirements.

For the intermediate stages of flooding and the equalisation with compartments cross-connected by small ducts, i.e. not opened to the sea directly, the added weight method is used.

6.2 Arguments used in calculations

The Arguments used in the calculation for the verification of damage stability are the following:

.1 Trim: The calculation should be done for the ship freely trimming;

.2 Heel angle at equilibrium: The heel angle at equilibrium, due to unsymmetrical flooding should not exceed the maximum values as indicated in the applicable requirements. Concerning the range of positive righting levers (GZ), this should be calculated beyond the position of equilibrium to the extent as so required by the applicable requirements;

.3 Free surface of liquid: For the calculation of the position of the centre of gravity (KG), the metacentric height (GM) and the righting lever curves (GZ), the effect of the free surfaces of liquids (see paragraph 6.5) should be taken into account;

.4 Immersion of weathertight and unprotected openings (see paragraph 6.7 and 10.1)

Unprotected openings:

- The positive range of righting levers is calculated from the angle of equilibrium until the angle of immersion of the unprotected openings leading to intact spaces;

Weathertight points: see paragraph 10.1 (ii);

.5 Progressive flooding through internal pipes: In case of damage of an internal pipe which is connected to an undamaged compartment, the undamaged compartment should also be flooded, unless arrangements are fitted (e.g. check valves or valves with remote means of control), which can prevent further flooding of the undamaged compartments;

.6 Permeabilities: Care should be taken to apply the permeabilities as specified in the applicable regulations. Special attention should be paid in case compartments which are separated by weathertight boundaries are modeled as one compartment. This simplified method of modeling the compartments should apply only to compartments belonging to the same category (same permeability); and

.7 Heel angles for the calculation of the GZ curve: Evaluation of damage stability criteria should generally be determined from data calculated over a range of angles from 0 to 60 degrees. It is recommended to use an increment not exceeding 5 degrees.

6.3 Adjustments for cargo run-off

.1 In cases where the damage involves the cargo hold, it is assumed that cargo is flowing out and that water starts to ingress. During the intermediate stages of flooding it is considered that both cargo and sea water are existing in the damaged tank (see paragraph 9.3).

At the final stage it is assumed that the cargo is completely lost and that the tank is filled with sea water up to the level of the waterline.

.2 The impact on the stability of the ship, due to the inflow and outflow of liquid cargo is also dependent on the following parameters:

- the density of the cargo: Liquid cargo with density greater than 0.95 t/m^3 should be considered as heavy liquid cargo. In case of lesser vertical extent of damage, i.e. damage above the tank top (see Annex 4), the release of heavy liquid cargo might lead to large angle of heel on the intact side of the ship. Depending on intact draught and cargo tank filling level, outflow of cargo of lesser density may also cause heel to the opposite side; and

- the permeability of the cargo space, taking into account that permeabilities smaller than the those specified in the applicable rules can be applied if justified.

6.4 Handling of permeabilities

.1 Permeability of a space means the ratio of the volume within that space, which should be assumed to be occupied by water, to the total volume of that space. The total volume should be calculated to moulded lines and no reduction in total volume should be taken into account due to structural members (i.e stiffeners, etc.). Account of structural members is taken in the applicable permeabilities (see also MSC/Circ.406/Rev.1, paragraph 3.11).

.2 Depending on the applicable requirements, the permeabilities assumed for spaces flooded as a result of damage should be as shown in the Table 2.

Table 2:

Spaces	Permeabilities			
	MARPOL	ICLL [1)]	IBC	IGC
Appropriated to stores	0.6	0.95	0.6	0.6
Occupied by accommodation	0.95	0.95	0.95	0.95
Occupied by machinery	0.85	0.85	0.85	0.85
Voids	0.95	0.95	0.95	0.95
Intended for consumable liquids	0 to 0.95*	0.95	0 to 0.95*	0 to 0.95*
Intended for other liquids	0 to 0.95*	0.95	0 to 0.95*	0 to 0.95*

* The permeability of partially filled compartments should be consistent with the amount of liquid carried in the compartment.

[1)] Regarding application of ICLL damage stability requirements please refer to Annex 1.

.3 Whenever damage penetrates a tank containing liquids, it should be assumed that the contents are completely lost from that compartment and replaced by sea water up to the level of the final plane of equilibrium.

.4 Other figures for permeability may be used for the damaged case both during cargo run-off and the final equilibrium condition under the following provisions:

.4.1 The detailed calculations and the arguments used for determining the permeability of the compartment(s) in question, is to be included in the damage stability booklet;

.4.2 The water tightness/resistance to water pressure and the means by which internal fittings/material are secured to the tank should substantiate the use of such fittings/material in reducing the permeability of a compartment. Where a ship is fitted with significant quantities of cargo insulation, the permeabilities of the relevant cargo spaces and/or the void spaces surrounding such cargo spaces may be calculated by excluding the volume of insulation material in those spaces from the flooded volume, provided that the insulating material is shown to comply with the following conditions:

.1 it is impermeable to water under hydrostatic pressure at least corresponding to the pressure caused by the assumed flooding;

.2 it will not crush or break up due to hydrostatic pressure at least corresponding to the pressure caused by the assumed flooding;

.3 it will not deteriorate or change its properties over the long term in the environment anticipated in the space it is installed;

.4 it is highly resistant to the action of hydrocarbons, where relevant; and

.5 it will be adequately secured so that it will remain in position if subjected to collision damage and consequent displacement, distortion of its supporting and retaining structure, repeated rapid ingress and outflow of seawater and the buoyant forces caused by immersion following flooding;

.4.3 The applied permeability should reflect the general conditions of the ship throughout its service life, rather than specific loading conditions; and

.4.4 Permeabilities other than those indicated in Table 2 should be considered only in cases, where it is evident that there is a significant discrepancy between the values shown in the regulations and the actual values (i.e. due to specific tank structure or insulating material).

6.5 Free-surface calculation (upright, as vessel heels and after cargo run-off)

With respect to the approval of actual **loading conditions** the following should be applied:

.1 The free surfaces of liquids lead to the increase of the centre of gravity (KG) and the reduction of the metacentric height (GM) and the righting arm (GZ curve) of the ship. Therefore corrections should be made, taking into account the change of the centre of gravity of the ship due to the moving of the centre of gravity of the liquids.

Depending on the filling level, free surfaces can exist in tanks with consumable liquids, sea water ballast and liquid cargo.

.1.1 For consumable liquids account of~~n~~ the free surfaces should be taken whenever the filling level is equal to or less than 98%.

.1.1.1 In calculating the free surface effects in tanks containing consumable liquids, it should be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account should be those where the effect of free surfaces is the greatest.

.1.1.2 Taking into account .1.1.1 the free surfaces should correspond to the maximum value attainable between the filling levels envisaged.

.1.2 During ballasting between departure and arrival condition, the correction for the free surfaces should correspond to the maximum value attainable between the filling levels envisaged. This applies also for the situation where in the departure condition the filling level of a ballast tank is 0% and in the arrival 100% (or the opposite).

.1.3 For the category of liquids referred under paragraph .1.1 and .1.2, as an alternative intermediate loading conditions may be considered, as deemed necessary, covering the stage where the free surfaces are the greatest. It may be calculated with varying free surface moments (i.e. actual liquid transfer moments), taking into account actual heel and trim, depending on the interval angles of the GZ curve. This is a more accurate method.

.1.4 Except as indicated in 1988 LL/27(11)(v), for liquid cargo the effect of free surface should be taken into account for filling level equal or smaller to 98%. If the filling level is fixed actual free surfaces can be applied.

The following two methods can be used for the calculation of the GZ curve taking into account the effect of the free surface moments for the intact compartments:

- Calculation with constant effect of free surfaces, without taking into account the change in heel and trim, for the interval angles of the GZ curve.

- Calculation with varying free surface moments, actual liquid transfer moments, taking into account actual heel and trim, depending on the interval angles of the GZ curve (see Annex 2).

.2 For the damaged compartments, whenever the damage is involving cargo tanks, account should be taken on the following:

- The impact on the stability of the ship due to the outflow of cargo and ingress of sea water can be verified with the calculation of the intermediate stages of flooding (see Section 9); and

- At the final equilibrium the free surface correction should exclude the free surface moment of the cargo.

.3 The free surface effect should be calculated at an angle of heel of 5 degrees for each individual compartment or as per paragraph 6.5.1.3.

6.6 Treatment of operational trim

.1 For the assumed damage and the resultant damage cases, the damage stability should be assessed for all anticipated conditions of loading and variations in draught and trim.

.2 Significant forward/aft trim (greater than 1% L_{pp}) can appear in the departure and arrival condition.

In that case, damage cases involving the aft/fore part of the ship might be critical for achieving compliance with the applicable criteria. In order to limit the trim ballast water is used during the voyage, as deemed necessary. Under the provision of paragraph 6.5.1.2 and 6.5.1.3, for taking account of the free surface effect during ballasting, if intermediate stages of the voyage are considered then the loading conditions representing these stages, should be also calculated for damage stability.

6.7 Downflooding points

Downflooding point is the lower edge of any opening through which progressive flooding may take place. Such openings should include air-pipes, ventilators and those openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, watertight doors including hinged type, which comply with SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable and sidescuttles of the non-opening type.

All openings through which progressive flooding may take place should be defined: both weathertight and unprotected. As an alternative it might be accepted to consider only the most critical openings, which are considered to be the openings with the lowest vertical position and close to the side shell. Concerning the longitudinal position it depends on the aft or fore trim of the initial condition and the trim after damage at equilibrium. Unprotected openings should not be immersed within the minimum range of righting-lever curve required for the ship. Within this range, the immersion of any of openings capable of being closed weathertight may be permitted, except openings required to be fitted with weathertight closing devices under the SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable, that, for operational reasons, are required to be kept open and should be considered as downflooding points in stability calculation (refer to MSC.1/Circ.1535/Rev.1, MSC.1/Circ.1539/Rev.1, MEPC.1/Circ.867, MSC.1/Circ.1543 and MSC-MEPC.5/Circ.11).

6.8 Cross-flooding time

Cross-flooding time should be calculated in accordance with Recommendation on a standard method for evaluating cross-flooding arrangements (resolution MSC.362(92)).

If complete fluid equalization occurs in 60 seconds or less, the equalized tank should be assumed flooded with the tanks initially to be flooded and no further calculations need to be carried out. Otherwise, the flooding of tanks assumed to be initially damaged and equalized tank should be carried out in accordance with paragraph 9.2. Only passive open cross-flooding arrangements without valves should be considered for instantaneous cases.

Where cross-flooding devices are fitted, the safety of ship should be demonstrated in all stages of flooding (see paragraph 9.2 and Section 10). Cross-flooding equipment, if installed, should have the capacity to ensure that the equalization takes place within 10 min.

Tanks and compartments taking part in such equalization should be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.

Spaces which are linked by ducts of a large cross-sectional area may be considered to be common, i.e. the flooding of these spaces should be interpreted as instantaneous flooding with the equalization of duration of less than 60 seconds.

6.9 **Progressive flooding** (internal/external) (see also paragraph 10.1 and 10.2)

Progressive flooding is the flooding of compartments situated outside of the assumed extent of damage. Progressive flooding may extend to compartments, other than those assumed flooded, through downflooding points (i.e. unprotected and weathertight openings), pipes, ducts, tunnels, etc.

The flooding of compartment(s) due to progressive flooding occurring in a predictable and sequential manner through a downflooding point which is submerged below the damage waterline may be permitted provided all intermediate stages and the final stage of flooding meet the required stability criteria.

Minor progressive flooding through the pipes situated within the assumed extent of damage may be permitted by the Administration, provided the pipes penetrating a watertight subdivision have a total cross-sectional area of not more than 710 mm^2 between any two watertight compartments.

If the opening (unprotected or fitted with a weathertight means of closure) connects two spaces, this opening should not be taken into account if the two connected spaces are flooded or none of these spaces are flooded. If the opening is connected to the outside, it should not be taken into account only if the connected compartment is flooded.

7 Extents of Damage Considered

7.1 Maximum extents

The following provisions regarding the maximum extent and the character of the assumed damage should be applied:

.1	**Side damage:**	MARPOL / IBC / IGC	ILLC (Type A ships)
.1.1	Longitudinal extent:	1/3$L^{2/3}$ or 14.5m, whichever is less	Single compartment between adjacent transverse bulkheads as specified in ILLC paragraph 12(d) [1)]
.1.2	Transverse extent:	B/5 or 11.5m, whichever is less (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line)	B/5 or 11.5, whichever is the lesser (measured inboard from the side of the ship perpendicularly to the centreline at the level of the summer load waterline) [1)]
.1.3	Vertical extent:	upwards without limit (measured from the moulded line of the bottom shell plating at centreline)	From baseline upwards without limit
.2	**Bottom damage** [2)]**:**	MARPOL / IBC / IGC	
		For 0.3L from the forward perpendicular of the ship	**Any other part of the ship**
.2.1	Longitudinal extent:	1/3 $L^{2/3}$ or 14.5m, whichever is less	MARPOL / IBC: 1/3 $L^{2/3}$ or 5m, whichever is less IGC: 1/3 $L^{2/3}$ or 14.5m, whichever is less
.2.2	Transverse extent:	B/6 or 10m, whichever is less	B/6 or 5m, whichever is less
.2.3	Vertical extent:	MARPOL / IBC: B/15 or 6m, whichever is less (measured from the moulded line of the bottom shell plating at centreline) IGC: B/15 or 2m, whichever is less (measured from the moulded line of the bottom shell plating at centreline)	MARPOL / IBC: B/15 or 6m, whichever is less (measured from the moulded line of the bottom shell plating at centreline) IGC: B/15 or 2m, whichever is less (measured from the moulded line of the bottom shell plating at centreline)
.3	**Bottom raking damage** [3)]**:**	MARPOL	

.3.1	Longitudinal extent:	in tankers of 75,000 tonnes deadweight and above: 0.6L(m) measured from the forward perpendicular of the ship
		in tankers of less than 75,000 tonnes deadweight: 0.4L(m) measured from the forward perpendicular of the ship
.3.2	Transverse extent:	B/3 anywhere in the bottom
.3.3	Vertical extent:	Breach of the outer hull
[1)] See Annex 3 [2)] Bottom damage is not required in the ICLL [3)] Bottom raking damage is required only for oil tankers of 20,000 tonnes deadweight and above		

7.2 Lesser extents

7.2.1 If any damage of a lesser extent than the maximum damage specified in 7.1 would result in a more severe condition, such damage should be considered (see paragraph 4.5).

7.2.2 In the case of gas carrier, local damage anywhere in the cargo area extending inboard distance "d" as defined in 2.4.1 of IGC Code (Res. MSC.370(93)), measured normal to the moulded line of the outer shell shall be considered. Bulkheads shall be assumed damaged when the relevant subparagraphs of 2.6.1 of IGC Code (Res. MSC.370(93)) apply.

If a damage of a lesser extent than "d" would result in a more severe condition, such damage shall be assumed.

7.3 Rationale for reviewing lesser extents including symmetrical vs. unsymmetrical tank arrangement/geometry - Calculation on weakest side

For a given loading condition, following examples of damages of lesser extent may result in a more severe situation than that caused by a maximum damage specified in 7.1:

.1 Example of damage on double bottom tanks with watertight centre girder:

- Damage of lesser extent which could occur at the bottom plate of the ship, without damaging the centre girder, will lead to flooding of the double bottom tank on one side of the ship only . This is the case of unsymmetrical flooding. For the same location, damage of maximum extent would cause damage on the centre girder and therefore flooding of the double bottom tanks on both sides. This is the case of symmetrical flooding. (see Annex 4).

Compared to the symmetrical flooding in the case of maximum damage extent, unsymmetrical flooding of spaces, caused by damage of lesser extent might lead to a more severe situation. Of course, in case of non-watertight centre girder, the effect of damage of lesser and maximum extent would be the same.

.2 Example of damage with lesser vertical extents:

- Damage starting from above a tank top would flood the spaces only above the double bottom (see Annex 4). This may result in a more onerous residual stability or heeling angle.

Taking into account above examples, it is necessary to review damages of lesser extents considering the symmetrical or unsymmetrical nature of tank arrangements of the ship and

geometry of the ship. The ship's damage stability is to be ensured, in the most severe or weakest case of damage of lesser extents.

8 Rationale Applied for Loading Pattern Evaluation

For damage stability calculations of tankers the following effects due to different loading methods should be taken into account in determining the scope of verification and specific cases of damage to be investigated.

8.1 Homogeneous vs. alternate/partial loading

For homogeneous loading conditions the damage of cargo tanks may have a major effect on residual stability. Outflow of the loaded cargo liquids (and less inflow of sea water) may reduce the vessels displacement and cause heel to opposite side of the damage. For alternate loading conditions the residual stability depends on the damaged cargo tank. Damage of a fully loaded cargo tank might cause reduction of the initial displacement and heel to the opposite side, but damage on an empty cargo tank might cause the opposite effect. For the damage of two adjacent cargo tanks, one filled and one empty, the total effect might be less severe due to two (partly) neutralizing effects.

Partial loading of liquid cargo tanks will cause a high free surface moment when the surface does not intersect with the tank overhead and will increase the heel in case of damage. However, reductions of the initial displacement and heel to the opposite side may not be as significant. Trim to the vessel as consequence of damage can be significant due to many partially filled cargo tanks.

8.2 Symmetrical and unsymmetrical loading pattern

In general damage stability calculations should be performed for both ship sides. However, the damage stability calculation for one side of the ship may be accepted for symmetrical load (alternate, homogeneous, full, partial or empty), if the ship and all openings are also symmetrical and initial heel to portside or starboard is zero.

8.3 MSC/Circ.406, Rev.1

Additional information regarding intact and damage stability matters for tankers can be found in MSC/Circ.406/Rev.1 which also recommends application of the *"Guidelines for the Uniform Application of the Survival Requirements of the Bulk Chemical Code (BCH Code) and the Gas Carrier Code (GC Code)"* to the IBC and IGC codes.

9 Intermediate Stages of Flooding Including Equalization, if any, and Cargo Run-off

Intermediate stages of flooding cover the flooding process from the commencement of flooding up to but excluding the final equilibrium damage condition (see also paragraph 3.4.3.2).

Intermediate stages should be comprehensively checked for all ships at the design appraisal stage.

9.1 Basis for checking intermediate cases of flooding and Minimum Stability Criteria Applied

The stability criteria applicable to the final equilibrium stage should also be satisfied for all intermediate stages. If any stability criteria during intermediate stages shows more severe values than in the final stage of flooding this intermediate stages should also be submitted.

9.2 Number of intermediate stages considered

A sufficient number of intermediate stages should be examined for all damage cases. It is generally recommended to apply 5 intermediate stages of flooding (see also paragraphs 6.8, 6.9 and 10.1).

If the vessel is equipped with non-instantaneous (greater than 60 secs) passive equalization arrangements or non-passive equalization arrangements of any size the following procedure is to be used:

1) Compliance with the relevant criteria should be demonstrated without using equalisation arrangements for intermediate and final stages; and

2) For subsequent equalisation additional 2 intermediate stages and final stages the compliance should also be demonstrated.

9.3 Cargo outflow and flood water inflow

During intermediate flooding stages a practical method of calculating the floating position and residual righting moments is the added mass method where the intact condition is corrected for the weights of inflowing floodwater and outflowing cargo.

During each stage an assumed amount of added floodwater and/or cargo outflow should be used. The following method is recommended:

i) For a loaded tank an equal loss of liquid cargo mass and equal inflow of floodwater mass at each stage resulting in a total loss of liquid cargo at and total inflow of floodwater to the final damage equilibrium waterline; and

ii) For an empty tank an equal inflow of floodwater mass at each stage resulting in total inflow of floodwater to the final damage equilibrium waterline.

See Annex 5 for example calculation.

Alternative methods may be accepted, for example:

i) For a loaded tank the loss of liquid cargo mass and inflow of floodwater mass is based on a linear change of total tank content density over each intermediate stage from pure cargo at the intact condition to pure floodwater at the final damage equilibrium waterline.

ii) For an empty tank an increasing depth of water at each stage based on the difference between the depth of water in the tank and the depth to the waterline in way of the tank, divided by the number of remaining stages, resulting in total inflow of floodwater to the final damage equilibrium waterline.

Noting that calculation of stability in the final damage condition assumes both the liquid cargo and the buoyancy of the damaged spaces to be lost it is therefore considered both reasonable and consistent to base the residual GZ curve at each intermediate stage on the intact displacement minus total liquid cargo loss at each stage.

9.4 Treatment of free surface and KG adjustment

Taking due account of the requirements of paragraph 6.5.1.1 it is generally recommended to apply actual liquid transfer moments for all tank filling levels in determining compliance with the relevant damage stability criteria through direct calculations of actual loading conditions.

With regard to the treatment of free surfaces of flooded spaces and noting that there will be combinations of empty and loaded tanks within the damaged extent all damaged compartments should be considered individually flooded during the intermediate stages – i.e. individual free surfaces. (The compartments are considered open to the sea in the final damage condition).

The correction for the free surfaces for the compartments assumed to be damaged in the final stage of flooding is not needed; the correction for the free surfaces for the compartments assumed to be damaged in intermediate stages of flooding should be considered when added weight method is used.

10 Final Stage of Flooding (Resolution MSC.281(85) to be referred to)

10.1 Watertight and weathertight integrity

The mandatory instruments referenced in paragraph 2.1 require the final waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding may take place. Such openings shall include air-pipes (irrespective of closing devices) and those which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, watertight doors including hinged type, which comply with SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable and sidescuttles of the non-opening type.

Within the required range of residual stability, the immersion of any of the openings listed above and other openings capable of being closed weathertight may be permitted except openings required to be fitted with weathertight closing devices under the ICLL that, for operational reasons, are required to be kept open.

In the final equilibrium condition watertight escape hatches should not be submerged below the equilibrium damage waterline and should be treated as weathertight openings [5)].

For emergency generator room the lowest point of the room should remain above the final equilibrium damage waterline. Any opening leading to this room should be treated as unprotected or weathertight, as applicable.

Footnote:

5) This specification applies only to the escapes from spaces other than tanks.

The following principles apply:

i) Progressive flooding due to damage or submersion of air pipes

Progressive flooding may be accepted subject to the air pipes leading to relatively small compartments which are progressively flooded in a predictable and sequential manner in which all intermediate stages of flooding (with the exception of ~~on~~ no progressive flooding) and the final stage of flooding meet the required stability criteria.

ii) Hinged watertight doors which do not comply with SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable, and weathertight doors on the aft bulkhead of forecastle under the final waterline after flooding

Hinged watertight doors which do not comply with SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable, and weathertight doors at the aft bulkhead of a forecastle space are permitted to be submerged after damage only when possible progressive flooding is limited to one relatively small compartment which is progressively flooded in a predictable and sequential manner in which all intermediate stages of flooding (with the exception of no progressive flooding) and the final stage of flooding meet the required stability criteria. No further progressive flooding is permitted beyond the initial flooding of that one relatively small compartment.

10.2 Unprotected openings

Residual GZ curves should be terminated at the lowest angle of submersion of an unprotected opening.

ANNEX 1

DAMAGE STABILITY REQUIREMENTS APPLICABLE TO NEW OIL TANKERS, CHEMICAL TANKERS AND GAS CARRIERS

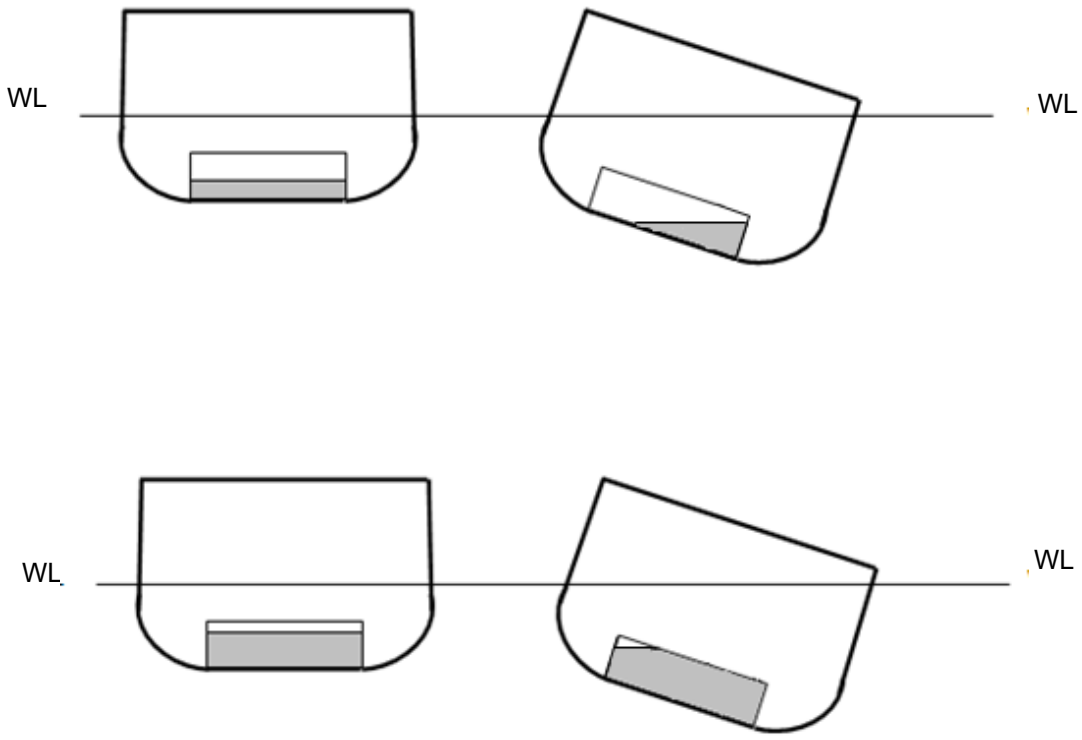
SHIP TYPE	ASSIGNED FREEBOARD	LENGTH	RULES
OIL TANKER [1)]	Type “A” ship with assigned freeboard less than type “B”	L ≤ 150 m	MARPOL, ANNEX I
		L > 150 m	MARPOL, ANNEX I + ICLL, Reg.27
	Not less than type “B”	Regardless of length	MARPOL, ANNEX I
LIQUEFIED GAS CARRIER [1)]	Type “A” ship with assigned freeboard less than type “B”	L ≤ 150 m	IGC
		L > 150 m	IGC +ICLL, Reg.27
	Not less than type “B”	Regardless of length	IGC
CHEMICAL TANKER [1)]	Type “A” ship with assigned freeboard less than type “B”	L ≤ 150 m	IBC
		L > 150 m	IBC +ICLL, Reg.27
	Not less than type “B”	Regardless of length	IBC

[1)] Ships complying with the above Regulations do not need to comply with the damage stability requirements of SOLAS, Chapter II-1, Part B-1.

ANNEX 2

EXPLANATORY NOTES TO THE FREE SURFACE CALCULATION WITH VARYING FREE SURFACE MOMENTS, ACTUAL LIQUID TRANSFER MOMENTS, TAKING INTO ACCOUNT ACTUAL HEEL AND TRIM, DEPENDING ON THE INTERVAL ANGLES OF THE GZ CURVE

In the figure below it is shown that the free surface moments can be reduced significantly, depending on the filling level and on the heel. Therefore calculations according to the actual liquid transfer moment represent a more realistic situation. In cases where the effect of free surfaces has a significant impact (i.e. large tanks) this method provides a more realistic account and can be used for the calculations of damage stability.



ANNEX 3

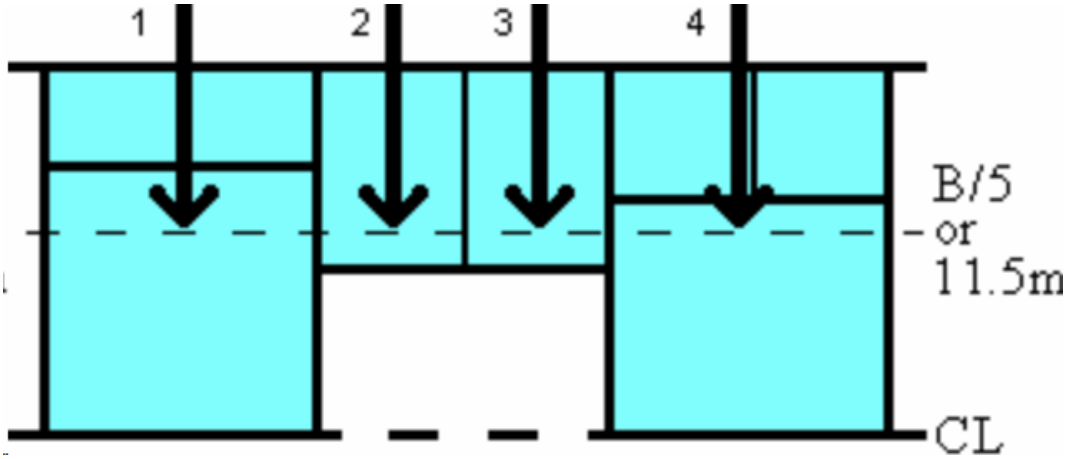
DESCRIPTION OF THE LONGITUDINAL EXTENT OF DAMAGE ACCORDING TO ICLL PROTOCOL 1988, REGULATION 27(12)(d)

The longitudinal extent of one compartment may vary depending if transversal wing tank bulkheads exceed B/5 (or 11.5m, whichever is less) or not. Please see the damages of sketch below.

1. Normal B/5 or 11.5m damage;

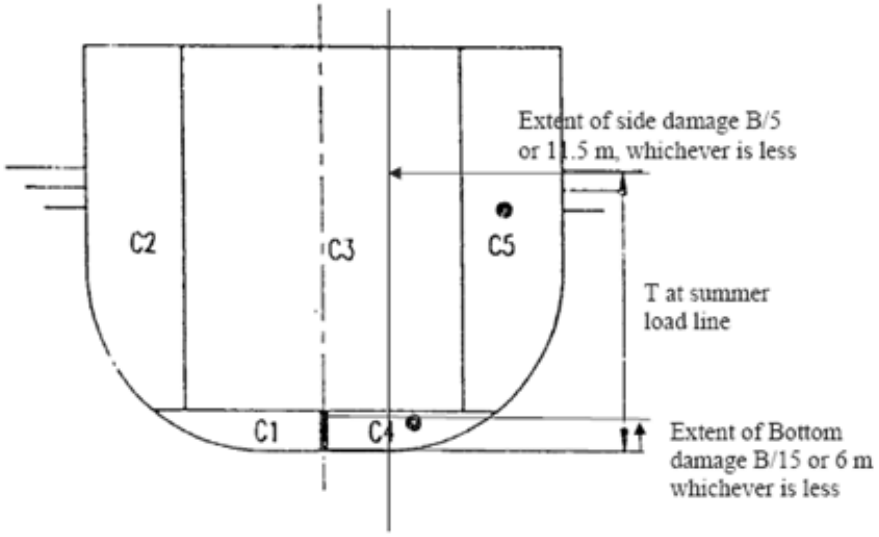
2. and 3.Transverse bulkhead exceeding B/5 or 11.5 m undamaged (two single one compartment damage cases); and

4. Transverse bulkhead not exceeding B/5 or 11.5m damaged; partial transverse bulkhead not considered effective (one single one compartment damage case).



ANNEX 4

EXAMPLE ON HOW TO DEFINE DAMAGES OF LESSER EXTENT



1. SIDE DAMAGE
1.1 Damaged compartments for maximum extent:

1.1.1 C5, C3, C4

1.2 Damaged compartments for lesser extent:
1.2.1 C5
1.2.2 C5, C4
1.2.3 C3, C5

2. BOTTOM DAMAGE
2.1 Damaged compartments for maximum extent:

2.1.1 C4, C1

2.2 Damaged compartments for lesser extent:

2.2.1 C4

ANNEX 5

EXAMPLE CALCULATION OF THE LOSS OF LIQUID CARGO MASS AND INFLOW OF FLOODWATER MASS

Initial filling = 540 tonnes at SG = 1.800

Final filling at equilibrium = 240 tonnes at SG = 1.025

Stage	Assumed total mass in compartment	Assumed mass at original SG	Assumed Mass of sea water	Total volume assumed in compartment	SG assumed in compartment
0	540	540	0	300.0	1.800
1	490	450	40	289.0	1.695
2	440	360	80	278.0	1.583
3	390	270	120	267.1	1.460
4	340	180	160	256.1	1.328
5	290	90	200	245.1	1.183
6	240	0	240	234.1	1.025

BCS- G 111 PASSENGER SHIPS – Guidelines for preparation of Hull Structural Surveys

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1 Introduction

This publication provides guidelines for preparation of hull structural surveys on passenger ships, with focus on areas with accessibility problems.

Within the scope of ship's classification, the periodical surveys are of prime importance as far as structural assessment of the ship is concerned.

The purpose of hull classification periodical surveys is to confirm that the hull and equipment comply with the applicable Classification requirements and will remain in satisfactory condition, based on the understanding that ships are to be maintained and operated at all times at the diligence of the Owners in proper condition complying with the relevant requirements and regulations.

These Guidelines include a review of survey preparation guidelines which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the preparation necessary before the surveys can be carried out.

An important feature of this guideline is the section on accessibility to different parts of the ship structures for passenger ships due to the wide variety of configurations and possible limited access.

These Guidelines have been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of owners, and is to be used at the owners' discretion, except for 2.2 and 2.3, which are extracts from BCS- R Z7 and, as such, are mandatory requirements. Should there be any doubt with regard to interpretation or validity in connection with particular applications, clarification should be obtained from BCS.

2 Preparations for Survey

2.1 General

The owner's representative should be aware of the scope of the coming survey and instruct those who are responsible, such as the Master or the Superintendent, to prepare the necessary arrangements. Execution will naturally be heavily influenced by the type and scope of the survey to be carried out. If there is any doubt, the Classification Society concerned should be consulted.

Parts 2.2 and 2.3 below are extracts from BCS- R Z7, and are mandatory requirements that have to be fulfilled.

2.2 Conditions for survey

2.2.1 The Owner is to provide necessary facilities for a safe execution of the survey.

2.2.2 Tanks and spaces are to be safe for access, i.e. gas freed, ventilated and illuminated.

2.2.3 In preparation for survey and thickness measurements and to allow for a thorough examination, all spaces are to be cleaned including removal from surfaces of all loose accumulated corrosion scale. Spaces are to be sufficiently clean and free from water, scale, dirt, oil residues etc. to reveal corrosion, deformation, fractures, damages, or other structural deterioration. However, those areas of structure whose renewal has already been decided by the Owner need only be cleaned and descaled to the extent necessary to determine the limits of the areas to be renewed.

2.2.4 Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration.

2.2.5 Where soft or semi-hard coatings have been applied, safe access is to be provided for the surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft or semi-hard coating is to be removed.

2.3 Access to structures

2.3.1 For survey, means are to be provided to enable the surveyor to examine the hull structure in a safe and practical way.

2.3.2 For survey in cargo holds and water ballast tanks, one or more of the following means for access, acceptable to the Surveyor, is to be provided:

- permanent staging and passages through structures;
- temporary staging and passages through structures;
- lifts and movable platforms;
- boats or rafts;
- other equivalent means.

2.4 Survey planning meeting

The survey planning meeting is a requirement in BCS- R Z7 for intermediate and special surveys. It is however good practice to hold such a meeting also before commencing annual survey and any other periodical and non-periodical survey.

During this meeting, issues described in 2.2 and 2.3 above and in 4.2 should be addressed accordingly, in particular access to the areas mentioned in 3.3 - 3.10, using the accessibility document described in 3.2.

Also refer to BCS- G 44, “Survey Guidelines for tanks in which soft coatings have been applied”.

2.5 Documentation on Board

The following documentation should be readily available when planning the survey.

(a) structural plans of the areas to be surveyed;

(b) accessibility document as detailed in 3.2 below.

Prior to survey, it is recommended that the documents on board the ship be reviewed as a basis for the current survey.

3 Accessibility to ship structure

3.1 General accessibility

The areas relevant for structural surveys depend on the design and there are large differences between different ship configurations. The structural survey of a passenger ship may involve a large variety of differing access problems due to the complexity of the structure.

Surveyable items are not specifically confined to tank examination, but will involve access to various other parts of the internal structure and the shell plating.

3.2 Access and inspection planning

It is recommended that an accessibility document is developed for each ship or class of ship containing the relevant information for accessing the structures indicated in 3.3 to 3.10 below.

The document should be retained onboard for use by owner's representatives and surveyors intending to examine the relevant spaces, structure and items.

This document should also be referred to in the owners planned maintenance scheme.

The accessibility document should refer to the operator's Safety Management System and should include the following as applicable:

- discontinuities and/or openings in continuous longitudinal bulkheads
- manhole/inspection opening arrangement and location(s)
- ladders and hand-holds
- specific safety issues for the individual item where extra precaution or procedures for access is required
- damage stability subdivision zones/boundaries
- location of and means for inspection of ventilation duct valves and fire flaps with controls

3.3 Longitudinal bulkheads

The continuous longitudinal bulkheads are, together with the ship sides, the webs of the hull girder, carrying the shear loads created by the differences in buoyancy and weight distribution along the ship as well as those created by sea loads. The longitudinal bulkheads also contribute to resisting the longitudinal bending, particularly near the upper decks and the bottom structure.

Wherever there are discontinuities/openings in the longitudinal bulkheads the stresses from the loads above will have to flow "around" these discontinuities resulting in stress concentrations at the corners. It should be noted that fractures may be observed, particularly at the upper and lower zones of the bulkheads.
Examples of discontinuities include fire-screen door openings, cable and pipe penetrations, elevator access arrangements and ventilation duct openings. (An example of such fractures is shown in Fig.1).

Access to these areas may be required in connection with Class Special or Continuous Surveys, or more often where considered necessary.

Figure 1: Openings in longitudinal bulkhead – a fracture in way of a door frame

3.4 Downflooding ducts

Downflooding ducts are fitted in order to meet the SOLAS damage stability criteria. Their purpose is to transfer water to a lower compartment in case of water ingress and thereby improve stability in the damaged condition.

Downflooding ducts are normally found on the ship sides, integrated into the structure by using the side shell plating as one of their boundaries.

Under certain conditions accelerated corrosion can take place to the internal structure and associated shell plating in way of these ducts. Maintenance and regular inspection is of vital importance to ensure the watertight integrity of the ship.

3.5 Ventilation ducts

The ventilation ducts may in general be categorized in two groups, structural and non-structural.

- **Structural** ventilation ducts are stiffened in such a way that the boundaries can withstand loads other than just the loads from air pressure and may be integrated with the ship structure or self supporting. These ducts are used in cases where a ventilation duct is crossing a watertight bulkhead, or in spaces that may be filled in case of damages according to the damage scenarios calculated for the ship.

- **Non-structural** ventilation ducts are “thin” compared to the structural ducts and are normally only designed to withstand the air pressure. They are thus only used within one vertical division and for areas above the waterline where water filling is not likely to occur in case of damages.

Of the two types of ventilation ducts, access to and inspection of the structural ventilation ducts is considered particularly important as a potential transfer of water along a ventilation duct from one compartment to another may have severe consequences for the ship.

The condition of the ventilation ducts using the ship’s side shell plating as one of the duct boundaries, both structural and non-structural (layout is shown in Fig. 2), is particularly important for both maintenance and regular inspection.

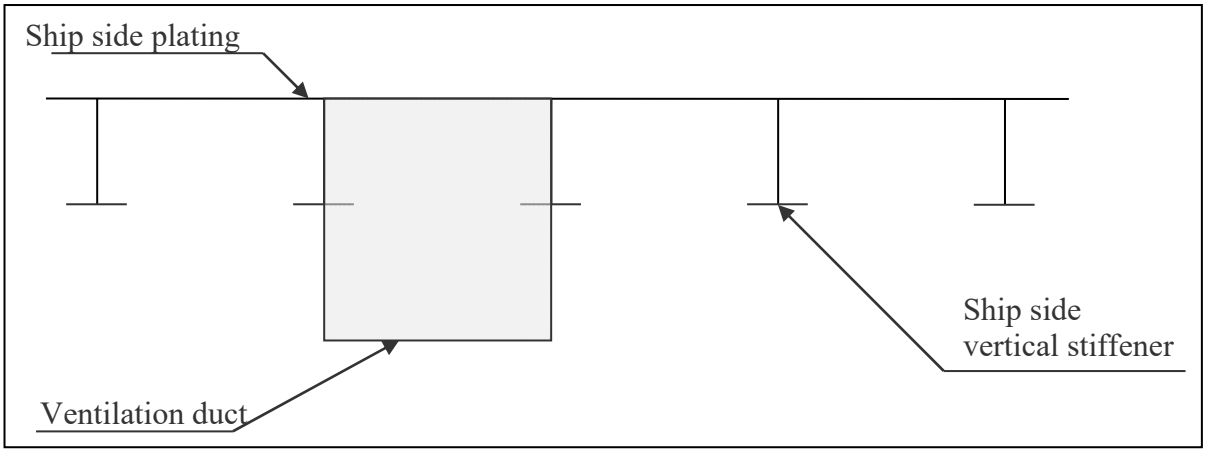


Figure 2: Plan view of ventilation duct using ship side shell as one of the boundaries

3.6 Air Pipes

All internal tanks will have air pipes to prevent overpressure or vacuum in case of filling or discharging. Air pipes may end in the engine room for smaller tanks, but are normally extended to higher external decks or led directly overboard above the waterline.

Where extended to higher decks or led overboard, the air pipes may be crossing other compartments and will, in service or accommodation decks, often be hidden behind panels. Some of the air pipes will be subject to a corrosive environment adversely affecting the pipe itself and also the vent heads.

3.7 Grey and black water tanks, including biological treatment system tanks

The main challenges with these tanks are the corrosive environment, the lack of access and time window for routine internal inspection and maintenance whilst the ship is in service.

If the internal structures are kept unprotected, the corrosive environment may cause leaks and water ingress/egress, giving rise to a risk of pollution or a reduced tank capacity as a result.

Surveys of these tanks are recommended to be planned well in advance to coincide with planned dockings. Some biological treatment systems may require a lead time to re-establish operational capability.

3.8 Stabiliser housings

Due to the limited access opportunities for inspection, it is recommended that during dry docking survey, the fin housings and in particular the welds in the fin/hull connection, with the fin extended, should be surveyed.

3.9 Structures adjacent to refrigerated rooms

Structures adjacent to refrigerated rooms may have an increased risk of condensation leading to deterioration of the structures. In particular, the structures below the refrigerated rooms may be subject to deterioration.

In cases where refrigerated stores are located adjacent to the side shell, there may be an increased risk of condensation leading to deterioration of the side shell structure.

As the access to the side shell structure in these areas will be restricted, it is recommended that, in addition to the deck below, the surrounding structure also be examined as far as practicable, in particular the connection to the ship side structure below the refrigerated store.

3.10 Permanent ballast

In some ships, permanent or fixed ballast may be fitted in some of the ballast tanks. Such ballast may be of a corrosive or non-corrosive type. When corrosive ballast is used, it should be protected from the main factors causing corrosion and kept under observation.

For a type of ballast that needs to be kept under observation, a manual describing these procedures should be retained onboard.

In cases of liquid permanent ballast, a material test piece may be fitted to the access cover of the tank, hanging into the liquid for monitoring of the corrosion activities in the tank. In addition, a chemical test of the ballast fluid from mid-depth should be done to confirm that the inhibitors are still effective.

In cases of non-liquid ballast, sample areas may be required to be cleared to enable access for survey and ballast material should be visually examined for shifting or settling and excessive moisture.

4 Tank corrosion

4.1 General

In tanks with a corrosive environment, the corrosion of the structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structures and the tank boundaries. When corrosion occurs, it may be accelerated by factors like higher temperatures, humidity, salinity and presence of oxygen.

In water ballast tanks, wastage of the internal structure can be a major problem, in particular on older ships.

Whilst corrosion may be found in all parts of a tank, the ullage space of tanks with a corrosive environment is known to be prone to accelerated rates of corrosion.

4.2 Tanks with constant water levels

In order to ensure a proper survey onboard, it is important to take into account operational information such as constant water levels of certain ballast tanks.

For tanks with a “typical” or stable filling level, and in particular those with a corrosive environment, e.g. water ballast tanks, high corrosion rates may normally be found in the splash zone right above the filling level. (see Fig. 3)

At the survey planning meeting, it should be established if any of the tanks to be surveyed have a normal/stable working level of liquid content, and the surveyor is to be made aware of this level.

The surveyor is further to be made aware of any previous problems associated with the tanks to be examined.

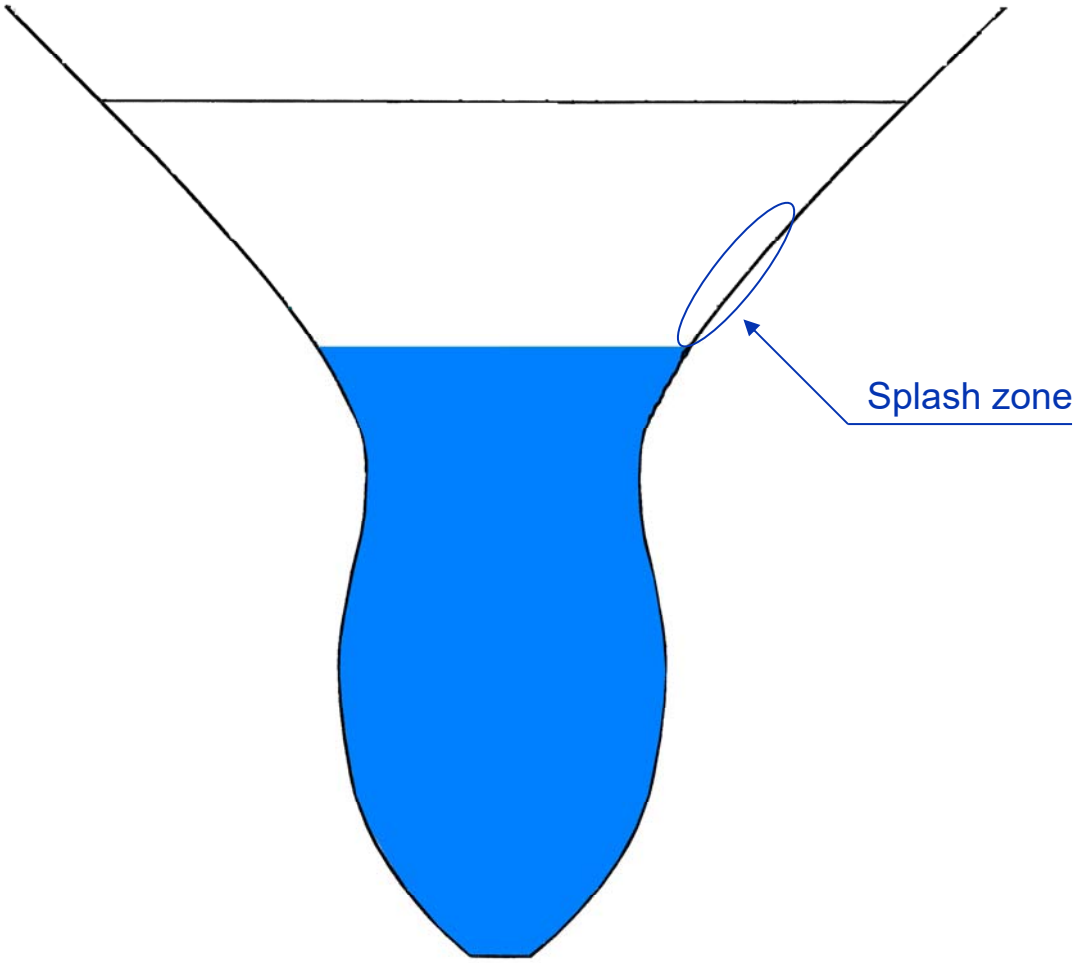


Figure 3: Fore peak tank with “typical” filling level

BCS-G113 Expert Parties Engaged in Visual and/or Sampling Checks for Preparation of Inventory of Hazardous Materials

1. Introduction

This recommendation gives guidelines intended for ship owners regarding the use of expert parties for onboard visual and/or sampling checks, including the use of services from laboratories carrying out testing of samples.

2. Expert parties engaged in visual and/or sampling checks

2.1 General

The following guidance may be used by ship owners when selecting expert parties engaged in visual and/or sampling checks for hazardous materials onboard existing ships as specified in “2015 Guidelines for the development of the Inventory of Hazardous Materials, as amended” and Appendix 1 and 2 of the Annex to the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, and which can advise on quantities and locations of samples, taking of samples in a safe manner as well as prepare reports on the quantities, locations and estimates of these onboard materials.

Visual and/or sampling checks shall be executed by persons with professional knowledge of hazardous materials licensed as required and, who are trained and equipped experts, in particular with regards to the evaluation and sampling of hazardous materials and materials containing hazardous materials as:

Appendix 1

- Asbestos;
- PCB;
- Ozone depleting substances; and
- Anti-fouling systems containing organotin compounds as a biocide.

Appendix 2

- Cadmium and Cadmium Compounds;
- Hexavalent Chromium and Hexavalent Chromium Compounds;
- Lead and Lead Compounds;
- Mercury and Mercury Compounds;
- Polybrominated Biphenyl (PBBs);
- Polybrominated Diphenyl Ethers (PBDEs);
- Polychlorinated Naphthalenes (more than 3 chlorine atoms);
- Radioactive Substances;
- Certain Shortchain Chlorinated Paraffins (Alkanes, C10-C13, chloro).

Expert parties should have documented quality systems covering all relevant activities. An accredited quality system that complies with the current version of the ISO 9000 series would be acceptable.

2.2 Expert parties engaged in visual and/or sampling checks

Expert parties carrying out sampling checks shall use appropriate laboratories engaged in the testing of samples which should be accredited or certified according to recognized standards. Specific equipment used on-board the ship for the purpose of sampling checks should be duly calibrated and/or certified according to recognized standards.

Expert parties carrying out visual and/or sampling checks of relevant hazardous materials shall have professional knowledge of ship structures, equipment, hazardous materials and materials used for ship structures and equipment, taking of samples handling of such materials.

2.3 Work shall be executed in accordance with documented work and safety procedures that contain at least the following:

- information on survey preparation;
- safety procedures relevant to the hazards;
- selection and identification of visual and/or sampling check locations;
- material preparation;
- sample removal;
- reinstatement of safe conditions for the material once the sample is taken;
- sample storage, identification and transport requirements; and
- report preparation and content.

Reports shall be based on the 2015 IMO Guidelines for the Development of the Inventory of Hazardous Materials, as amended.

2.4 Expert parties engaged in visual and/or sampling checks shall document each job by including the signatures of operator's designated responsible person in the final report for verification purposes.

2.5 Such expert parties shall provide evidence of all the necessary training, qualifications, licenses or equivalent thereto and the work and safety procedures for visual and/or sampling checks and the handling of specified hazardous material(s), in accordance with recognized national or international standards or the equivalent thereto, and other associated work practices as applicable.

BCS-G114 Recommendation for operational testing, inspection and documentation of emergency shutdown valves for liquefied gas carriers

Reference is made to IGC Code (Res.MSC.5(48) as amended by Res.MSC.370(93)) Reg. 18.10.5 and 18.6.2.

1 Scope

This document is to provide guidelines on the operational testing, inspection and documentation of emergency shut down valves (ESD) for Liquefied Gas Carriers.

2 Emergency Shut Down Valves

2.1 Testing and Inspection

The IGC Code Reg 18.10.5 states:

“Cargo emergency shutdown and alarm systems involved in cargo transfer shall be checked and tested before cargo handling operations begin.

The IGC Code Reg 18.6.2 states:

Essential cargo handling controls and alarms shall be checked and tested prior to cargo transfer operations.”

Ship operators should periodically verify that the ESD valves onboard their vessels function correctly. The test results should be recorded.

Also, as part of the check on the integrity of the cargo containment system, the ESD valves should be pressure tested and internally inspected. Pressure testing at the same pressure as working pressure is recommended to be conducted every 5 years.

2.2 Documentation

The instruction manual produced by the ESD valve manufacturer providing information on installing, servicing and reassembly of the valves should be retained on board the ship.

BCS -G 117 Exchange of Statutory Documentation upon Transfer of Class

1. When a ship changes class, it is recommended that the losing Society, be willing, upon request of the Head Office of the gaining Society, to submit copies of the following statutory documentation, as applicable, within the limitations set by the Flag state concerned and by national legal constraints:

- freeboard calculation (LLC 1930/1966)
- initial freeboard survey report
- subdivision calculation (Reg. 27, LLC 66)
- stability manual as approved and placed onboard ship
- safety equipment record (SOLAS 74 as amended)
- MARPOL 73/78 Documentation in case of Oil Tankers:
  - COW survey reports according to IMO Resolution A 446(XI), para. 4.2.10
  - Approved calculations of limitation of size and arrangement of cargo tanks
  - Approved calculations of sub-division and stability
- statutory certificates including their supplements
- certificates issued in accordance with other international statutory instruments, e.g. Codes
- text of statutory recommendations
- Condition Evaluation Reports for vessels subject to Enhanced Survey Requirements
- EEDI Technical File

and that

2. transfer of additional material supporting the issuance of statutory certification be favourably considered by the losing Society, upon request by the gaining Society, within the limitations set by the Flag state concerned and by national legal constraints.

BCS-G 120 Survey of electrical equipment installed in hazardous areas on tankers

1. Application

The recommendations in this document apply for survey of electrical installation in hazardous areas on tankers, both for new construction and ships in service.

2. General Requirements

2.1 Marking

The equipment marking is to be in accordance with IEC 60079 or the relevant standards to which it is constructed. Normally, all Ex equipment is to be marked with protection type, test institute and certificate number, maker, type, gas group and temperature class (if applicable). In case, this information is not possible to read on the equipment it will normally be considered as not suitable for hazardous areas.

2.2 Certificates

2.2.1 All electrical equipment constructed for use in Zone 0 and Zone 1 are to have a certificate from a recognised accredited test laboratory.

Note:
A list of organisations which have successfully completed the IECEx assessment process and are approved to operate within the IECEx Scheme can be found under http://www.iecex.com/bodies.htm

The Ex- protection and IP degree are to be suitable for the hazardous zone and the location, and special conditions are to be complied with.

Note:
Simple apparatus (thermocouples, photocells, junction boxes, etc.), as defined in IEC 60079-11, in intrinsically safe or energy-limited circuits do not require any of the evidence given above.

2.2.2 Electrical equipment for use in Zone 2 is to comply with one of the following:

- covered by an Ex certificate for Zone 2 (or 0 or 1), for acceptance criteria see 2.2.1 above, or
- have a manufacturer's conformity declaration, stating that the equipment is suitable for installation in Zone 2, declaring conformity with specified standard/standards such as IEC 60079-15, or
- be of a type designed to prevent spark and arcs and unacceptable surface temperatures (above the limits of the required temperature class) during its normal operation, or
- having enclosure of at least IP55 and acceptable surface temperature (within the limits of the required temperature class).

Simple apparatus (thermocouples, photocells, junction boxes, strain gauges, switching devices, etc.), as defined in IEC 60079-11, in intrinsically safe or energy-limited circuits do not require any of the evidence given above.

Note: Information on the nameplate of equipment is to be consistent with information given in the manufacturer's conformity declaration or Ex certificate.

2.3 Modifications

Unauthorised modifications are not permitted. If equipment has been subjected to unauthorised modifications, it will be considered as not suitable for hazardous areas.

Note:
Some examples of unauthorised modifications are:

- *Additional holes drilled in an Ex-d enclosure.*
- *Gaskets fitted to enclosures not certified with it.*
- *Flame paths taped, painted or tighten by other means for preventing corrosion.*

Drawings (as mentioned in clause 3.1) are to be submitted to the Society for approval for new installations or conversion of electrical installations in hazardous areas, which may affect classification.

The modifications are to be carried out in accordance with IEC 60079.

2.4 Cable glands and plugs for Ex-d and Ex-e enclosures are marked and of same Ex type as the enclosure, unless certified for use of different type.
For Ex-d enclosures, the gas group is also stated on the gland. If this information is not readable on the equipment it will normally be considered as not suitable for hazardous areas.
For Zone 1, glands with rubber seal can only be used for enclosure with internal volume less than 2 litres and gas group IIA & IIB.

Note: Cable glands are marked individually (IEC 60079-0 Appendix A.4.1). However, individual marking of cable glands is not required when the cable glands form an integral and permanently fixed part of the enclosure having been certified as one single unit.

2.5 Flame paths on Ex-d enclosures can be protected by the following:

- Suitable non-hardening grease.
- Gaskets, if the equipment has been certified with gaskets.
- One layer of soft tape, but not for gas group IIC (and not on threads).
- Maker's recommendation.

Cable glands are to be also Ex-d.

2.6 If a gasket is damaged and needs replacement, it is of the same type as originally fitted or another acceptable type as stated in the certificate. Any change of gaskets is typically an item that is to be recorded in the maintenance record onboard and thereby easy to identify.

2.7 Repair of equipment.
Minor Maintenance by shipboard personnel such as changing gaskets, covers for light fittings, etc. is permitted, but is to be recorded.
Major repairs such as the change of motor bearings, etc. are to be done by qualified personnel, and recorded and marked with the symbol:

R

Note that the Flag state might have further requirements for repair of Ex equipment.

2.8 Maintenance procedures and records for all electrical equipment located in hazardous areas are documented and kept onboard.

The record includes the following as a minimum:

- Date of inspection
- Identification of any maintenance found necessary
- Details of maintenance and date when it was completed
- Name of companies and persons who carried out the inspection and maintenance

3. Surveys on new construction

3.1 Documentation to be submitted:

3.1.1 The following plans and documents are to be submitted to the Society for approval before the new construction survey:

a) Area classification drawing of the ship showing gas-dangerous zones and spaces. Spaces requiring over-pressure/under-pressure, ventilation openings, air-locks, etc. are to be indicated in the drawing or its attachments.

b) Layout drawing of electrical equipment in hazardous areas.

c) List of all electrical equipment in hazardous areas, including the following details:

- Zone classification of location
- Reference to equipment identification used on layout / area classification drawing
- Type of equipment and manufacturer
- Type of explosion protection
- Apparatus group
- Temperature class
- Ingress Protection(IP) rating
- Test authority and Ex-certificate number
- Ambient temperature range for the equipment[1)]

Note [1)]
If ambient temperature is not stated it is to be understood as the temperature range as -20 deg to +40 deg, as per IEC 60079-14.

d) Verification of the compatibility between the barrier and the field component for Intrinsically Safe (IS) circuits.

3.1.2 The documentation as per 3.1.1 is to be available and approved. The actual installation is to be compared with relevant approved drawings. Manufacturer's declarations and certificates for certified Ex equipment are to be delivered with the vessel. All nameplates on equipment are to be consistent with the certificate or declaration.

3.2 Survey of Installation
The installation of electrical equipment in hazardous area is to be verified in accordance with approved drawings.
All equipment is subject to survey, including the checking of connections, conditions and functions and the opening of enclosures by appropriate tools. Proper electrical installation and compliance with possible special conditions from the Ex-certificate are to be verified.

It is to be verified that:

3.2.1 Cables are properly fixed and mechanically protected. The type of cable is appropriate for the hazardous area (screened or armoured) or has been installed in a pipe.

3.2.2 There is no obvious damage to cables. There are normally no cable joints in hazardous areas, but for repairs this may be acceptable provided the continuity of the cable is maintained. Except for intrinsically safe circuits, cable joints are not accepted in Zone 0.

3.2.3 There is no undue accumulation of dust and dirt.

3.2.4 Earth fault monitoring devices are in normal operation and no active alarm due to abnormal low level of insulation resistance or high level of leakage current.

3.2.5 Measurement of insulation resistance: All applicable electrical equipment are able to read minimum 1 MΩ. Confirm that earthing and bonding are made with proper resistance to earth.

Note: The measurement of insulation resistance for IS equipment is to be carried out only after isolating the circuitry, where otherwise damage to the equipment may result.

3.2.6 The hazardous area end of spare cables / cores are connected to earth or spare terminals suitable for the zone. Insulation by tape alone is not permitted on spare cable / cable pairs. Cables containing IS circuits are marked to identify them as being part of IS circuit.

3.2.7 Intrinsically safe cable and non-intrinsically safe cable are not laid in the same cable bunch or pipe unless provided with an earthed metal partition. Ex-ia circuits and Ex-ib circuits are not to be run in the same cable.
Terminals for intrinsically safe circuits and terminals for non-intrinsically safe circuits are separated by a physical distance of 50 mm or a separating panel. Terminals for intrinsically safe circuits are marked as such.

3.2.8 Sealing of gas tight cable penetrations separating hazardous and non-hazardous area are satisfactory.

3.2.9 Earthing of cable braiding or other metallic coverings. Power and lighting circuits are earthed in both ends. Single core cables above 20 A in one end only, preferable in hazardous area.

3.2.10 Drainage of cable pipes are arranged and located at the lowest part of the pipe.

3.2.11 There are no obstructions adjacent to flameproof flanged joints.
Minimum clearance:

- 10 mm IIA
- 30mm IIB
- 40mm IIC

3.2.12 For spaces in which ventilation is required, e.g. cargo pump room, cargo compressor room, etc., the ventilation capacity on the fans nameplate is to be verified according to the approved ventilation capacity to ensure that a sufficient number of air changes are provided. Ventilation failure is to be alarmed.
Purging time of spaces protected by overpressure is to be determined or verified according to approved drawings.

3.2.13 For spaces protected by over-pressure, actions upon the loss of pressure are to be verified according to approved drawings. These may be automatic or manual disconnections depending on the type of Ex- protection used and audible and visual alarms. Alarms are to be given at a manned station.

Note: Loss of overpressure means less than 0.25mbar in the protected area.

3.2.14 Setting of overload or thermal protection for Ex-e motor is in accordance with approved drawings.

3.2.15 The flame path protection of Ex-d equipment is to comply with 2.5. Corrosion or paint blocking the path is not accepted.

3.2.16 Condition of equipment is such that it allows safe operation.
Corrosion damages are not acceptable as these can cause Ex equipment to lose its protective function and its watertight integrity.
The protective gas pressure and flow for Ex-p equipment is according to design and flow is adequate.
The resin for Ex-m equipment in the enclosure is not damaged.
A suitable safety barrier/isolator is provided for Ex-ia/-ib equipment.

4. Surveys on ships in service

4.1 General
The maintenance record, as per 2.8, is to be reviewed for updates carried out the last 12 months. Repaired or replaced Ex equipment is to be surveyed by checking connections, conditions and function including opening enclosures by appropriate tools, including updated document (Refer IEC 60079-17).

4.1.1 Electrical equipment in gas-dangerous spaces and zones are to be examined with respect to:

- The enclosure is in satisfactory condition.
- No unauthorised modifications
- Bolts of the enclosure are tight and in satisfactory condition.
- There are no strains, poor insulation /or loosen connection to the electrical equipment in the enclosure.
- Cable glands are tight and in good condition.
- Gasket is in good condition.
- Equipment marking in order
- Equipment earthing / bonding in order
- Cables in good condition

Specific for protection type:

- Ex-d: The flame path is in satisfactory condition.
- Ex-p: The protective gas pressure and flow are adequate.
- Ex-m: The resin in the enclosure is not damaged.

Areas protected by overpressure:

- Test audible and visual alarm in manned station upon loss of pressure.
- Check automatic or manual disconnection. Ref. 3.2.13

4.2 Annual Surveys

Visual inspection of installations and spot-checking of equipment is to be carried out. In case of any findings, the surveyor may extend the survey as deemed necessary, requiring the examination of covering connections, conditions and functions including opening enclosures by appropriate tools.

4.3 Special Surveys

The following items are to be checked for satisfactory condition during special surveys in addition to 4.2:

- Scope is as for Annual Survey. Surveyor may ask for function testing if defects are found or suspected.
- Insulation monitoring with alarm to be tested.
- Megger testing of power circuits.
  Note that Megger testing in gas dangerous spaces may involve risk of explosion due to sparks.
- In spaces protected by overpressure: audible and visual alarm upon loss of pressure to be tested and automatic or manual disconnection of power supply to be checked.

BCS-G 121 Uniform Application of MARPOL Annex I, Revised Regulation 12

1. History of Revised Regulation 12 of MARPOL Annex I

- Following an increase in the number of prosecutions due to MARPOL Annex I sludge tank related issues, at MEPC 55 in October 2006 commenced a review of MARPOL Annex I Regulation 12.

- A correspondence group looked into all sludge tank issues including Oil Record Books, IBTS and plan approval, reporting to DE 51 through paper DE 51/18/1.

- DE 51 reviewed the CG report and a new Regulation 12.1bis was introduced to further define sludge tanks.

- This was discussed at MEPC 58 where Regulation 12 was again reviewed and amended, Regulation 12.1bis becoming Regulation 12.2. MEPC.1/Circs 641 and 642 were also issued.

- MEPC 59 further developed the text, issuing MEPC 187(59) and MEPC.1/Circ 676 (IBTS).

- Korean paper MEPC 61/7/7 introduced a new Unified Interpretation concerning oil residue (sludge) service tanks. This text still included original UI 17.1.3 which stated that, *".3. there should be no interconnections between the sludge tank discharge piping and bilge-water piping other than possible common piping leading to the standard discharge connection referred to in regulation 13."* During discussions at MEPC 61, new MARPOL Unified Interpretations were approved and the old UI 17.1.3 was deleted.

- MEPC.187(59) entered into force on 1 January 2011.

- In July 2011 at MEPC 62 a new Unified Interpretation was agreed, published as MEPC.1/Circ 753 confirming that Regulation 12.2.2 should not be retroactively applied to ships delivered before 1 January 2014, and reinstating the text from old UI 17.1.3 stating that, *"There should be no interconnections between the sludge tank discharge piping and bilge-water piping other than possible common piping leading to the standard discharge connection referred to in regulation 13."*

- In March 2012 MEPC 63, having considered documents MEPC 63/7/9 (IACS) and MEPC 63/7/5 (Denmark, Spain and BIMCO), providing further comments and proposals to the matter, referred both documents to DE 57 for further consideration and advice*".* DE 57 agreed to consider the proposed draft amendments to regulation 12 of MARPOL Annex I at its next session, and recommended further amendments to the UI MEPC.1/Circ.753.

- In May 2013, MEPC 65 having considered the draft text prepared by DE 57 approved the revised Unified Interpretation and distribute it through MEPC.1/Circ.753/Rev.1 (20 June 2013). The revised UI clarified that the use of screw-down non return valves arranged in lines connecting to common piping leading to the standard discharge connection required by regulation 13, provide a means equivalent to an arrangement that has "no interconnection" or "no discharge connections" as so specified in regulation 12.2.

- In March 2014 the Sub-Committee on Ship Systems and Equipment (SSE 1) prepared draft amendments to MARPOL Annex I with a view to subsequent adoption and draft revised UI of regulation 12.3.3 intended to replace the UI MEPC.1/Circ.753/Rev.1, as set out respectively in annexes 11 and 12 of document SSE 1/21. The MEPC 67 approved the draft amendments with a view to adoption at MEPC 68 and agreed to keep the draft revised UI in abeyance for approval by MEPC 70.

- MEPC 68 in May 2015 adopted the draft amendments to MARPOL Annex I with resolution MEPC.266(68).

- MEPC 73 in Oct 2018 issued the 2018 Guidelines for the application of the revised MARPOL Annex I requirements to floating production, storage and offloading facilities (FPSOs) and floating storage units (FSUs) with resolution MEPC.311(73).

2. Implications for ships:

- This applies to new and existing vessels.

- In effect, the change moved IMO Unified Interpretation 17.1.3 for vessels with keel laying after 31 December 1990; to all vessels after 1 January 2017.

- Incinerator oil mixing tanks are now regarded as Oil Residue (sludge) service tanks.

- In July 2011, at MEPC 62 a new Unified Interpretation was approved stating that Regulation 12.2.2 should not be retroactively applied to ships delivered before 1 January 2014 (contract before 1 January 2011; or in absence of contract keel laying before 1 January 2012; or delivered before 1 January 2014).

- However, MEPC.266(68) no longer allows for existing arrangements where an oil residue (sludge) tank may have discharge connections to the bilge system, oily bilge water holding tank(s), tank top or oily water separators, as could be allowed under MEPC.1/Circ.753/Rev.1. Any modifications that may be required for ships constructed before 1 January 2017 with arrangements that are not compliant with the revised Regulation 12 requirements are to be completed no later than the first renewal survey carried out on or after 1 January 2017.

- In MEPC 311(73) the Annexed table clarifies that MARPOL Annex I, Regulation 12 is applicable to FPSOs and FSUs.

3. Documents referenced:

- MARPOL consolidated edition 2006.

- MEPC.187(59).

- MEPC 61 Meeting report Annex 14, modified by IMO MEPC.1/Circular 753

- MEPC.1/Circular 641.

- MEPC.1/Circular 642, modified by MEPC.1/Circular 676.

- MEPC.1/Circ.753/Rev.1.

- Resolution MEPC.266(68).

- MEPC.1/Circ.867.

- MEPC.311(73).

4. Revised Regulation 12.3.2 - Designated Pump

- Regulation 12.3.2 states that, *"The oil residue (sludge) tank(s) shall be provided **with a designated pump** for disposal that is capable of taking suction from the oil residue (sludge) tank(s)."*

- The Unified Interpretation to new Regulation 12.3 (previous Regulation 12.2) states that, *"A designated pump should be interpreted as any pump used for the disposal of oil residue (sludge) through the standard discharge connection referred to in regulation 13, or any pump used to transfer oil residue (sludge) to any other approved means of disposal such as an incinerator, auxiliary boiler suitable for burning oil residues (sludge) or other acceptable means which are prescribed in paragraph 3.2 of the Supplement to IOPP Certificate Form A or B."*

- A *"Dedicated"* pump is not necessary.

- The Unified Interpretation requires that the pump is used as the means for the disposal of sludge.

- It also implies that it may also pump oily bilge water to the standard discharge connection for disposal ashore.

5. Revised Regulation 12.3.3 - Decanting Sludge to Bilge & Sludge discharge piping

- Regulation 12.3.3 states that *"The oil residue (sludge) tank(s) shall have no discharge connections to the bilge system, oily bilge water holding tank(s), tank top or oily water separators except that:*

  .1 the tank(s) may be fitted with drains, with manually operated self-closing valves and arrangements for subsequent visual monitoring of the settled water, that lead to an oily bilge water holding tank or bilge well, or an alternative arrangement, provided such arrangement does not connect directly to the bilge discharge piping system; and

  .2 the sludge tank discharge piping and bilge-water piping may be connected to a common piping leading to the standard discharge connection referred to in regulation 13; the connection of both systems to the possible common piping leading to the standard discharge connection referred to in regulation 13 shall not allow for the transfer of sludge to the bilge system;"

  Ships constructed before 1 January 2017 shall be arranged to comply with the revised regulation 12.3.3 not later than the first renewal survey carried out on or after 1 January 2017.

6. Revised Regulation 12.3.3.1 - Decanting Sludge to Bilge

- Revised regulation 12.3.3.1 states that, *"The oil residue (sludge) tank(s) shall have no discharge connections to the bilge system, oily bilge water holding tank(s), tank top or oily water separators except that the tank(s)* ***may be fitted with drains, with manually operated self-closing valves and arrangements for subsequent visual monitoring of the settled water****, that lead to an oily bilge water holding tank or bilge well, or an alternative arrangement, provided such arrangement does not connect directly to the bilge discharge piping system."*

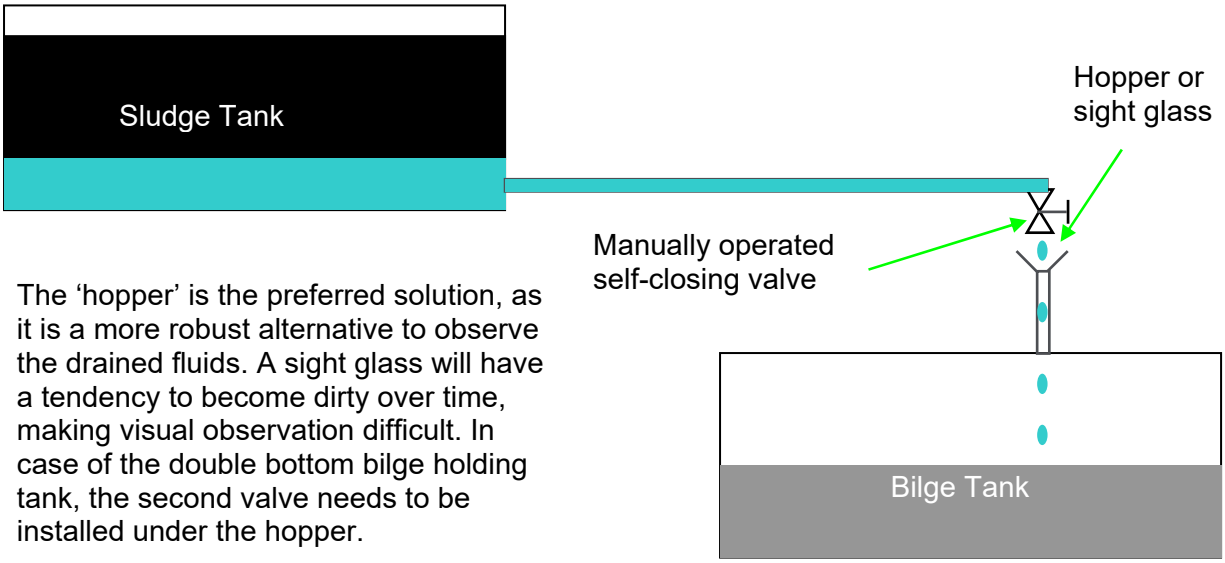
- The exception to this general rule allows draining of settled water from the sludge tank if certain conditions are met.

    1. the water is drained **only** to the bilge water holding tank or bilge well (not to the bilge piping system or other bilge areas); and

    2. the drains have a manually operated self-closing valve; and

    3. the draining operation is visually monitored.

- "Visually monitored" means monitoring the draining operation in real-time either through a site glass or through a funnel, whereby the draining can be stopped immediately if oil is seen.



The 'hopper' is the preferred solution, as it is a more robust alternative to observe the drained fluids. A sight glass will have a tendency to become dirty over time, making visual observation difficult. In case of the double bottom bilge holding tank, the second valve needs to be installed under the hopper.

- If the previous arrangement is not possible, such as in way of double bottom spaces, then the following could be a possible solution (an exemption would be required from the Flag Administration):

- Pumping settled water from the double bottom oil residue (sludge) tank to an oily bilge water holding tank provided that the requirements of MARPOL Annex I, Regulation 12.3 are met and the other requirements of Regulation 12.3.3 are satisfied i.e.:

    1. the water is pumped **only** to the oily bilge water holding tank or bilge well by a small oily sludge pump; and

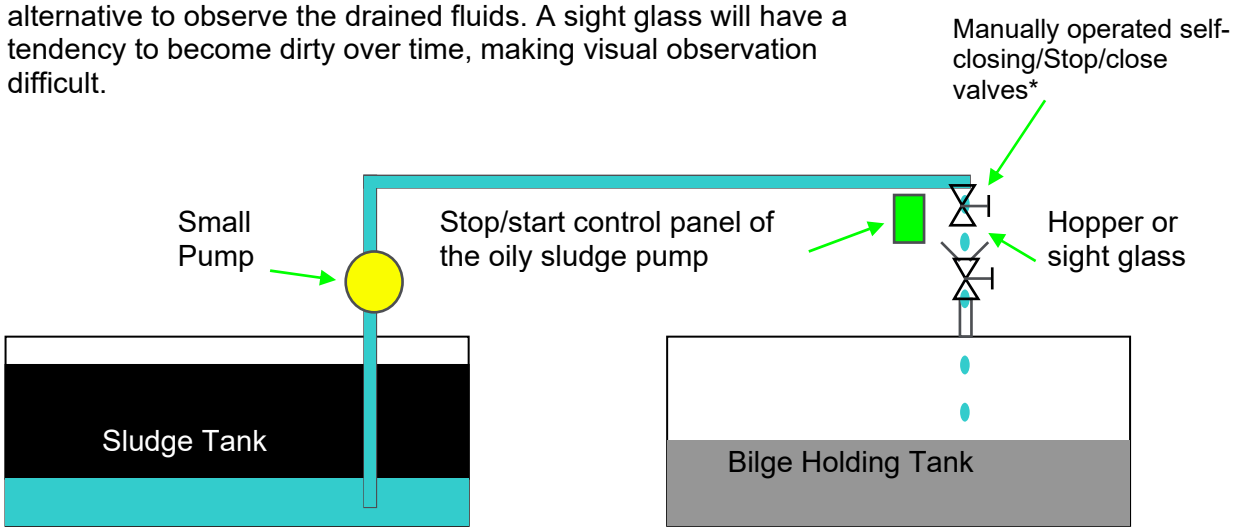
    2. the pumping operation is visually monitored by a responsible person; and

    3. the stop/start control panel of the oily sludge pump must be located close to the operator checking the transfer of settled water.

- If settled water is removed from the oil residue (sludge) tank using this method, the discharge line leading from the oil residue (sludge) tank must be connected directly to the oily bilge water holding tank or bilge well and **must not under any circumstances connect directly to any section of the bilge piping system or bilge area**.

- In the event that the double bottom oil sludge or bilge holding tanks are damaged by grounding or stranding, the engine room may progressively flood via the transfer line to the bilge holding tank or via hopper as shown below. To prevent this situation, the above transfer lines are to be provided with manually operated self-closing valves or stop/close valves where appropriate to prevent the ER flooding in the event of damage to these double bottom tanks.

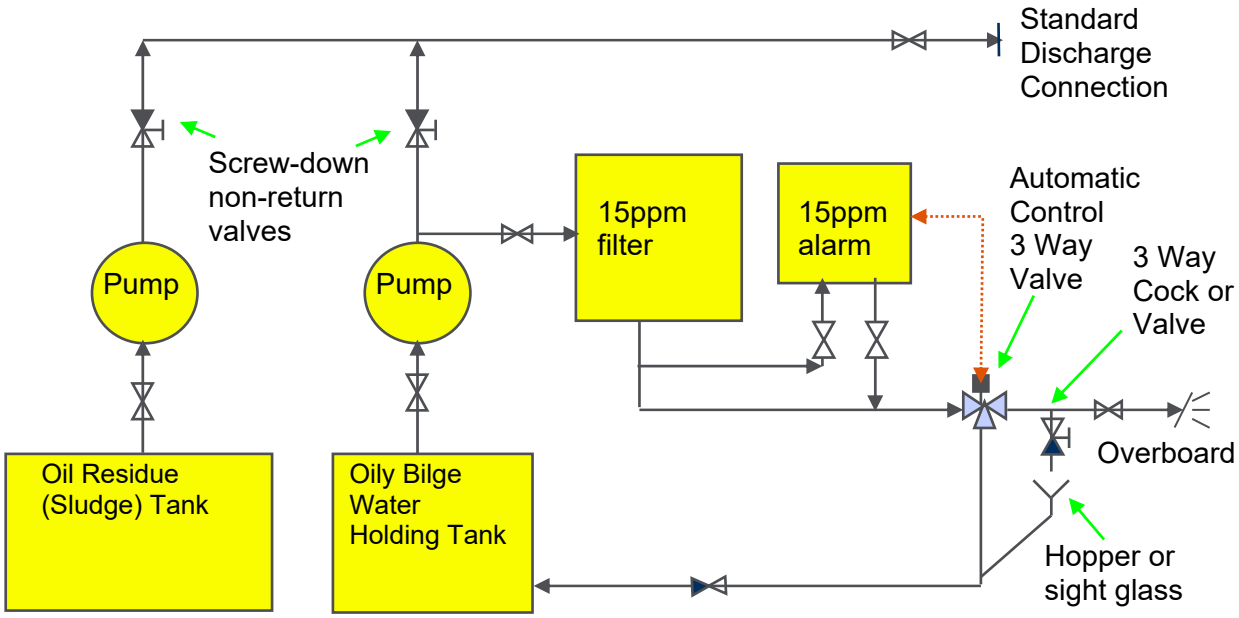
The 'hopper' is the preferred solution, as it is a more robust alternative to observe the drained fluids. A sight glass will have a tendency to become dirty over time, making visual observation difficult.



* The second valve needs to be installed under the hopper, if settled water is transferred to the bilge holding tank. No valve needs to be installed under the hopper in case where settled water is transferred to the bilge well.

7. Acceptable Arrangements to Revised Regulation 12.3.3.2

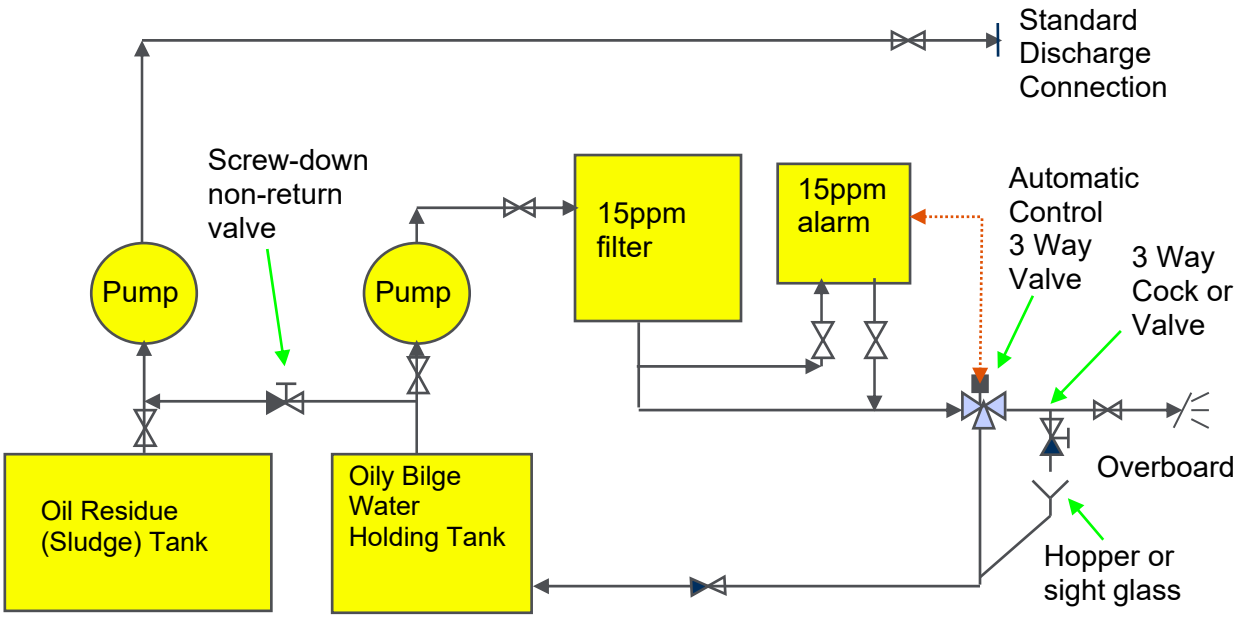
The following diagrams describe, in simplified form, some common compliant arrangements found on ships:



The above arrangement is considered acceptable:

- Where common arrangements are provided for the discharge of bilge water and sludge through the standard discharge connection, a screw-down non-return valve must be provided to prevent the accidental discharge of sludge to the bilge system.

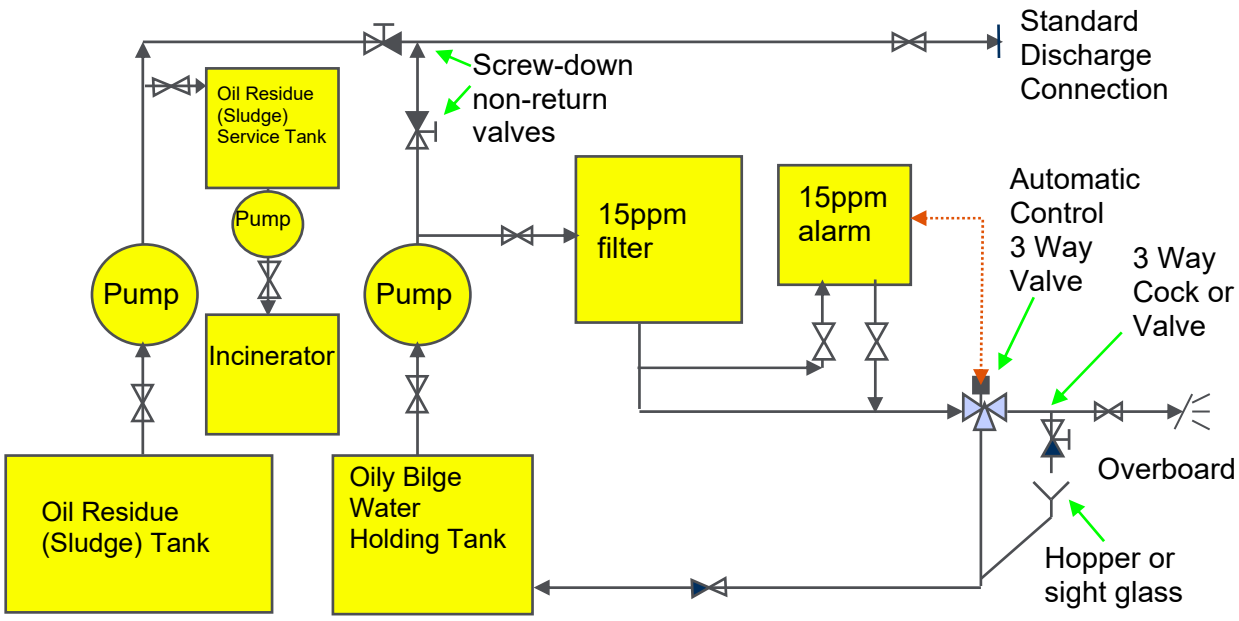
- The screw-down non-return valve stops possible discharge of oil residue (sludge) to the 15 ppm Filter Unit and also the Oil Bilge Water Holding Tank.



The above arrangement is considered acceptable:

- Where there are common arrangements for discharge of bilge water and sludge through the standard discharge connection, a screw-down non-return valve is arranged in the line to the common piping leading to the standard discharge connection required by Regulation 13. To satisfy this interpretation, the common line with a screw-down non-return valve is to be arranged on the suction side of the pumps; and

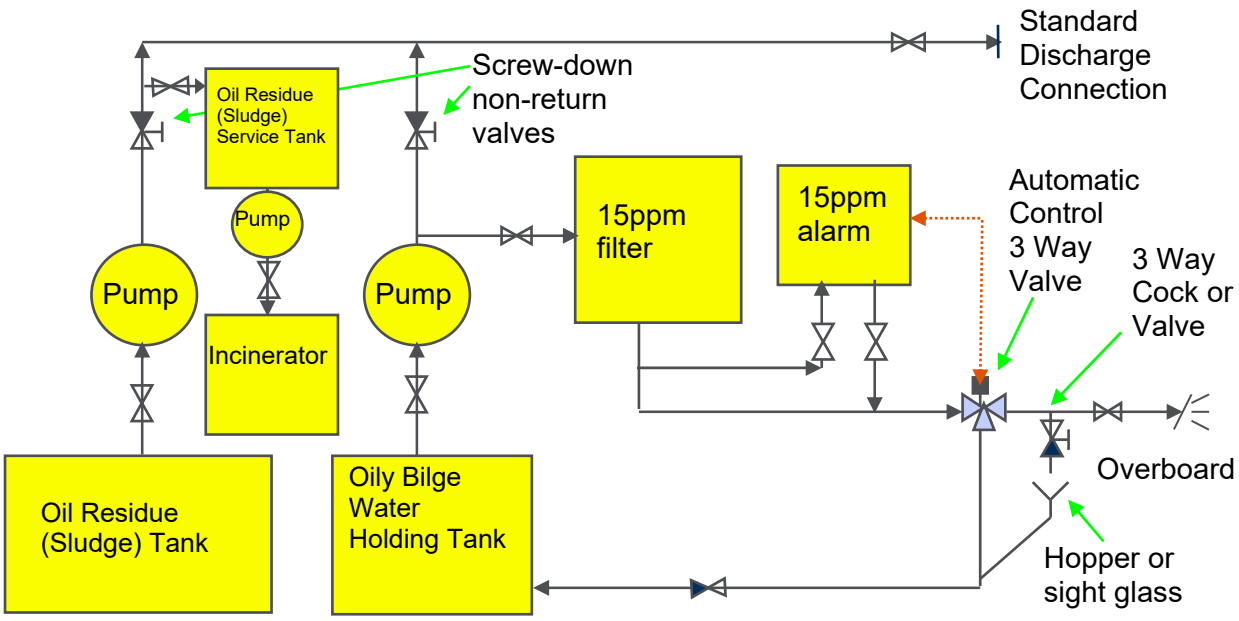
- The screw-down non-return valve stops possible discharge of oil residue (sludge) to the 15 ppm Filter Unit and also to the Oil Bilge Water Holding Tank.



The above arrangement is considered acceptable:

- Where common arrangements are provided for the discharge of bilge water and sludge through the standard discharge connection, and the sludge can also be transferred to an incinerator, screw-down non-return valves must be provided to prevent the accidental discharge of sludge to the bilge system.

- The screw-down non-return valve stops possible discharge of oil residue (sludge) to the 15 ppm Filter Unit and also the Oil Bilge Water Holding Tank.



The above arrangement is considered acceptable:

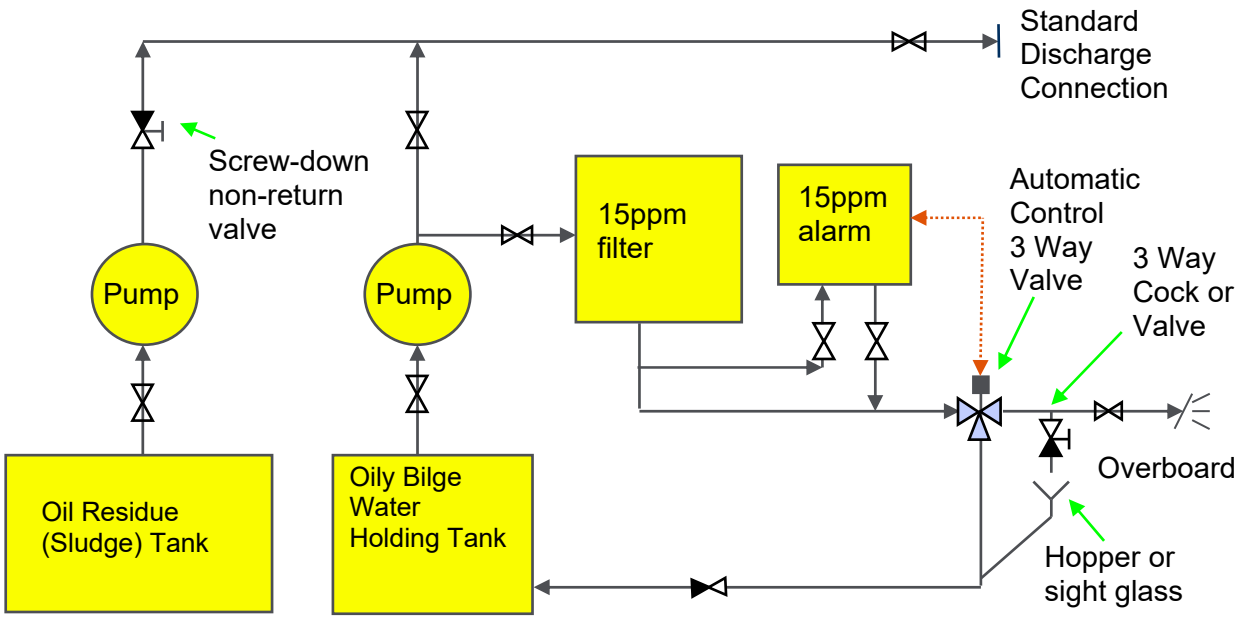
- Where common arrangements are provided for the discharge of bilge water and sludge through the standard discharge connection, and the sludge can also be transferred to an incinerator, screw-down non-return valves must be provided to prevent the accidental discharge of sludge to the bilge system.

- This arrangement also allows for the transfer of suitable oily bilge water to the incinerator oil residue (sludge) service tank for burning.

- The screw-down non-return valve stops possible discharge of oil residue (sludge) to the 15 ppm Filter Unit and also the Oil Bilge Water Holding Tank.

8. Non-Compliant Arrangements to Revised Regulation 12.3.3.2

The following diagrams describe, in simplified form, some common non-compliant arrangements:



The arrangement above is not acceptable as there is a sludge discharge connection to the oily water separator, bilge system and Oily Bilge Water Holding Tank – prohibited under Regulation 12.3.3.

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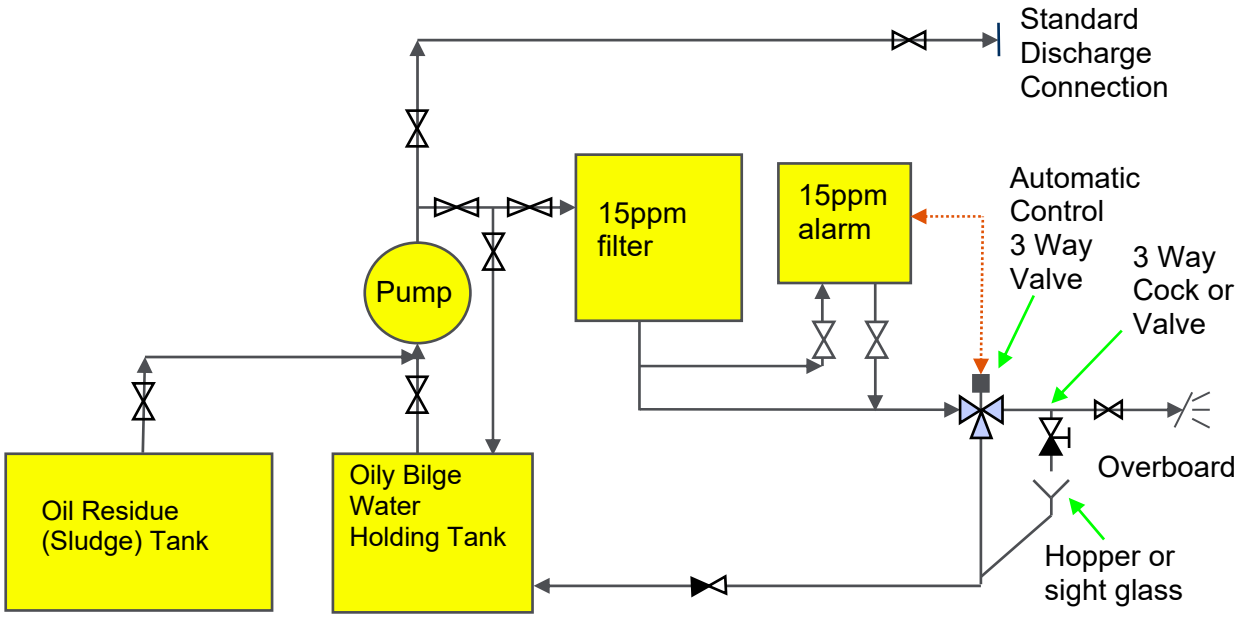
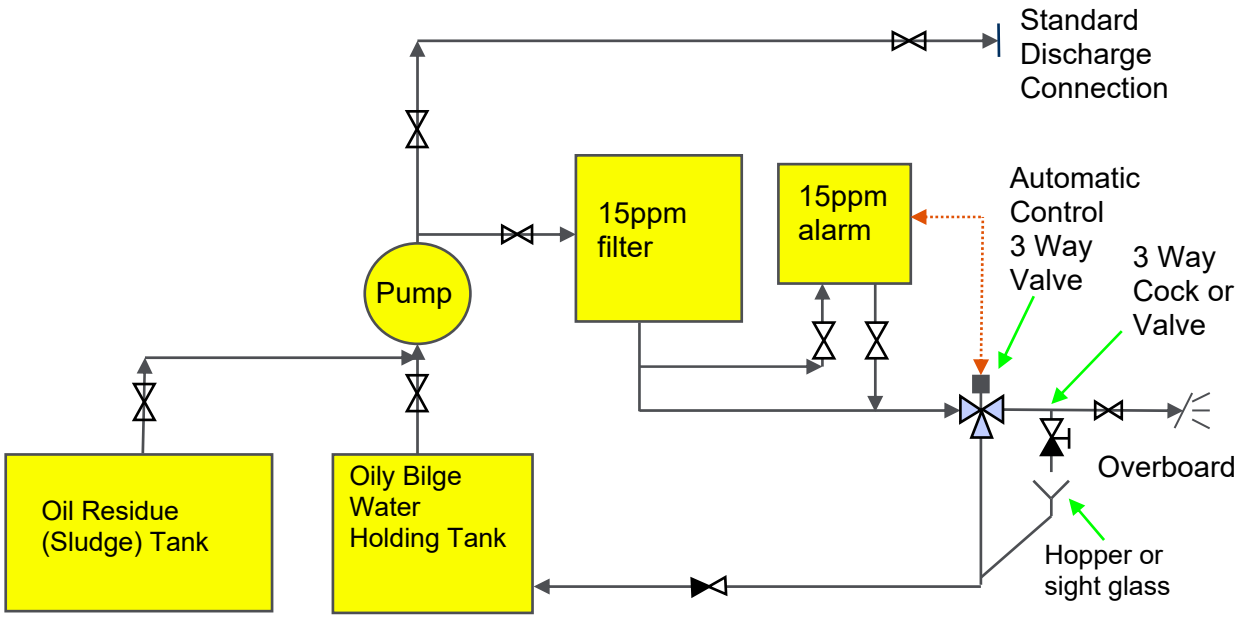
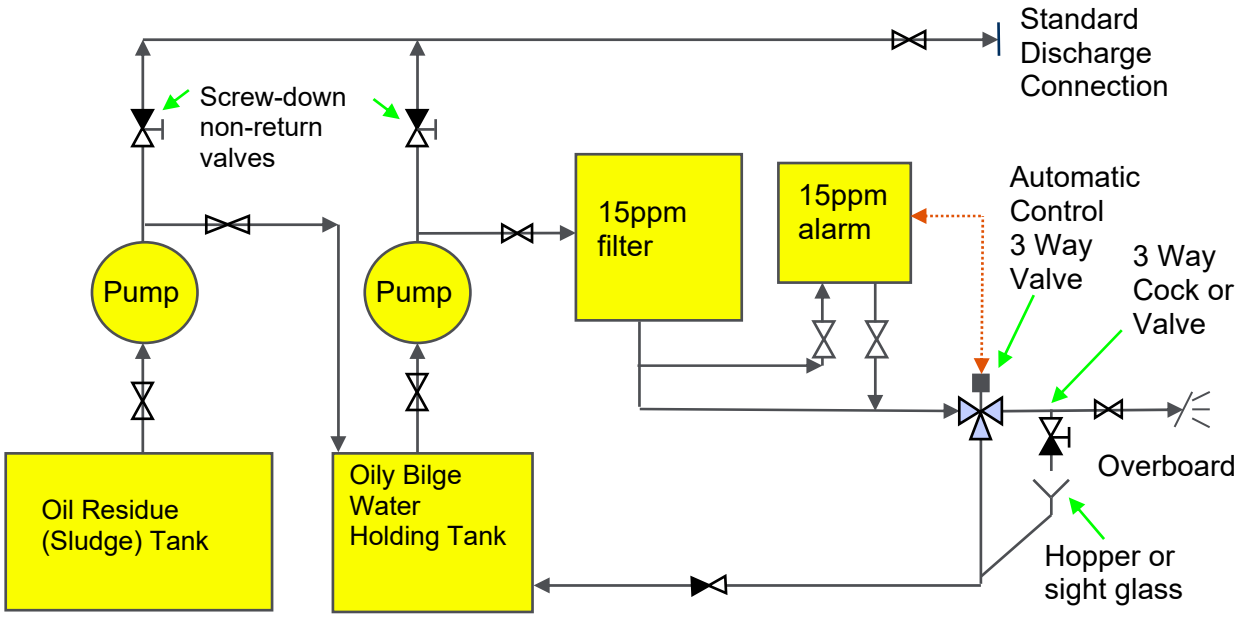


The arrangement above is not acceptable as there is a sludge discharge connection to the oily water separator, bilge system and Oily Bilge Water Holding Tank – prohibited under Regulation 12.3.3.

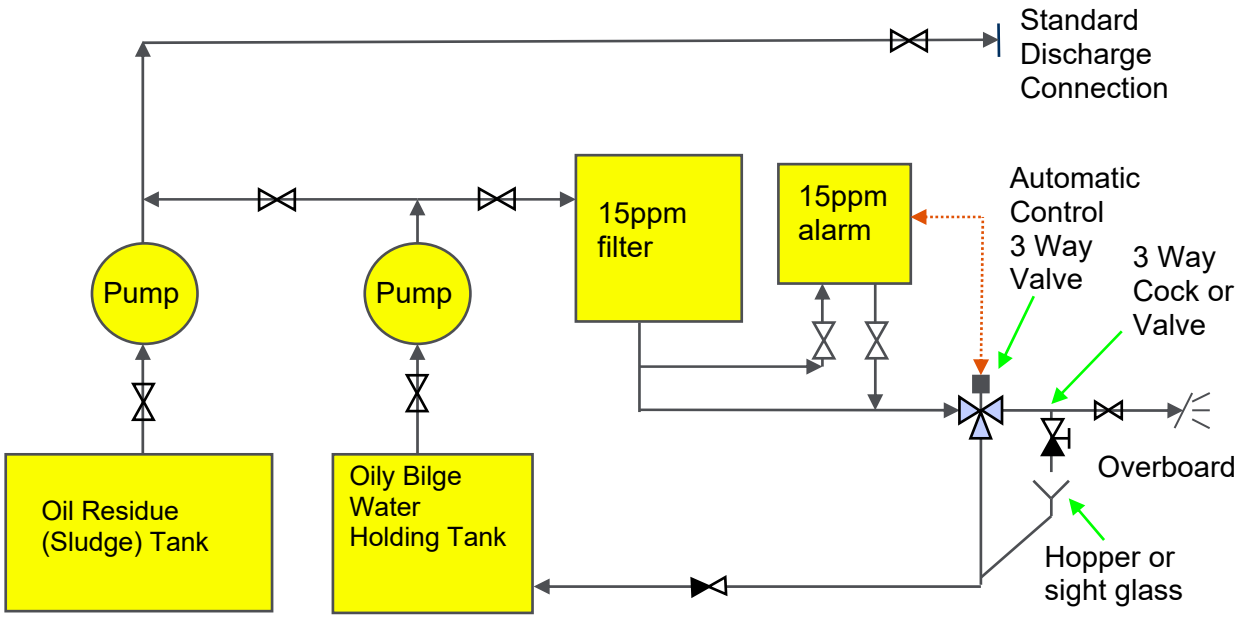


The arrangement above is not acceptable as there is a sludge discharge connection to the oily water separator and bilge system – prohibited under Regulation 12.3.3.

****

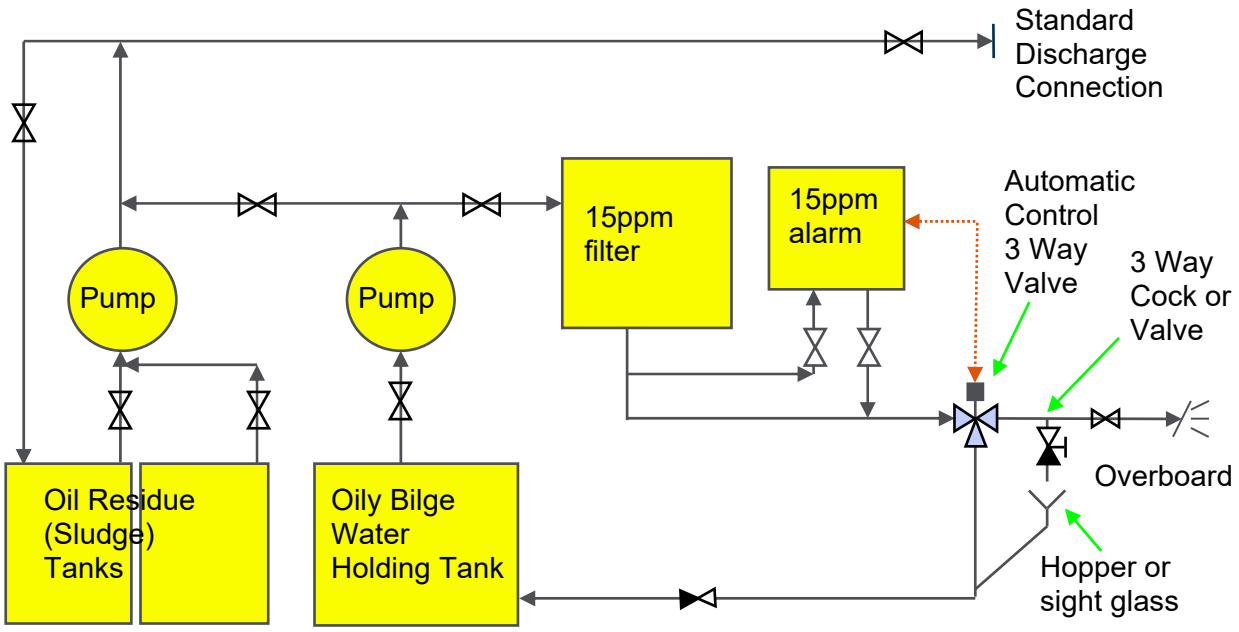


The arrangement above is not acceptable as there is a sludge discharge connection to the oily bilge water holding tank – prohibited under Regulation 12.3.3.



The arrangement above is not acceptable as there is a sludge discharge connection to the oily water separator, Bilge system and Oily Bilge Water Holding Tank – prohibited under Regulation 12.3.3.

****



The arrangement above is not acceptable as there is a sludge discharge connection to the oily water separator, Bilge system and Oily Bilge Water Holding Tank – prohibited under Regulation 12.3.3.

This arrangement is also not acceptable under MEPC.1/Circ.641 paragraph 5.3, as it is not permissible to use a common discharge pipe as an internal sludge transfer pipe between sludge tanks.

BCS-G 128

Record of approved Ship Safety Equipment

To meet the provisions of the

INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AND AMENDMENTS THERETO

This form should be kept on board and be available for inspection by a nominated surveyor or recognized organization at all times.

1 Ship Data

Name of ship

Port of registry

Flag | *IMO No.*

Builders | *Newbuilding/Hull No.*

Date keel laid | *Gross tonnage*

Freeboard length m | *Length overall* m | *B.P. length* m | *Max. breadth* m | *Draught* m

Type of ship | *Range of Service*

Max. number of crew | *Max. number of passengers* | *Total number of persons for which LSA are provided*

Call sign | *Official Number*

Previous names | *Previous flags*

Main engine maker | *Total number*

Model type | *Power output* kW

Auxiliaries engine | *Output* kW

Emergency Generator | *Output* kW

Type of Main/Aux. boilers | *Number of Main/Aux. boilers*

2 Safety of Navigation

2.1 Shipborne Navigation Equipment (V/19 and V/20)

		Manufacturer / Model
2.1.1		
2.1.1.1	Standard magnetic compass*	
	Means of communication between standard magnetic compass and normal navigation control position	
	Steering magnetic compass	
2.1.1.2	Spare magnetic compass*	
2.1.1.3	Gyro-compass*	
2.1.1.4	Gyro-compass heading repeater*	
2.1.1.5	Gyro-compass bearing repeater*	
2.1.1.6	Heading or track control system*	
2.1.1.7	Pelorus or compass bearing device*	
2.1.1.8	Means of correcting heading and bearings	
2.1.1.9	Transmitting heading device (THD)*	
2.1.2		
2.1.2.1	Nautical charts (paper charts)	Provided: ☐ Yes ☐ No
	Electronic chart display and information system (ECDIS)	
2.1.2.2	Back-up arrangements for ECDIS	
2.1.2.3	Printed nautical publications	Provided: ☐ Yes ☐ No
	Electronic nautical publications	Provided: ☐ Yes ☐ No
2.1.2.4	Back-up arrangements for electronic nautical publications	Provided: ☐ Yes ☐ No
2.1.3		
2.1.3.1	Receiver for a global navigation satellite system (GNSS)*	
	Terrestrial radionavigation system*	
2.1.3.2	9 GHz radar*	
2.1.3.3	Additional 3 GHz radar	
	Additional 9 GHz radar*	
2.1.3.4	Automatic radar plotting aid (ARPA)*	
2.1.3.5	Automatic tracking aid (ATA)*	
2.1.3.6	Second automatic tracking aid*	
2.1.3.7	Electronic plotting aid (EPA)*	
2.1.4		
2.1.4.1	Automatic identification system (AIS)	
2.1.4.2	Long Range Identification and Tracking (LRIT)	

		Manufacturer / Model
2.1.5		
2.1.5.1	Voyage data recorder (VDR)	
2.1.5.2	Simplified voyage data recorder (S-VDR)	

** Alternative means of meeting this requirement are permitted under regulation V/19. In case of other means, they shall be specified in 2.5 of this Record.*

2.1.6		
2.1.6.1	Speed and distance measuring device (through the water)*	
2.1.6.2	Speed and distance measuring device (in the forward and athwartships directions over the ground)*	
2.1.7	Echo sounding device*	
2.1.8		
2.1.8.1	Rudder angle indicator*	
2.1.8.1.1	Propeller revolution indicator*	
2.1.8.1.2	Propeller pitch and mode indicator*	
2.1.8.1.3	Thruster indicator*	
2.1.8.2	Rate-of-turn indicator*	
2.1.9	Sound reception system*	
2.1.10	Telephone to emergency steering position*	
2.1.11	Daylight signalling lamp* (Source of power:)	
2.1.12	Radar reflector*	
2.1.13		
2.1.13.1	International Code of Signals	Provided: ☐ Yes ☐ No
2.1.13.2	Copy of Volume III of IAMSAR Manual	Provided: ☐ Yes ☐ No
2.1.14	Night vision equipment (HSLC requirement)	Provided: ☐ Yes ☐ No
2.1.15	Bridge navigational watch alarm system (BNWAS)	
2.1.16		
2.1.17		

** Alternative means of meeting this requirement are permitted under regulation V/19. In case of other means, they shall be specified in 2.5 of this Record*

2.2 Sound Signal Appliances and Shapes (COLREG 1972, as amended)

	Apparatus	Number	Manufacturer	Type	Location
2.2.1	Forecastle bell				
2.2.2	Gong				
2.2.3	Ship's whistle				
2.2.4	Black ball shape				
2.2.5	Black diamond shape				
2.2.6	Black cylindrical shape				

2.3 Navigation Lights (COLREG 1972, as amended)

2.3.1 Horizontal distance

Foremast light abaft top of stem _____ m

Between foremast and mainmast lights _____ m

2.3.2 Vertical height above waterline in lightest ballast condition

Foremast light _____ m

Mainmast light _____ m

2.3.3 Vertical height above uppermost continuous deck

Foremast light _____ m

Mainmast light _____ m

Sidelights _____ m

	Navigation Lights	Power type electric		Miles range	Duplex type (two tier)		Source of electrical power (SOLAS II-1/41, 42, 43)
		Yes	No		Yes	No	
2.3.4	Fore masthead light (225°, white)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.5	Main masthead light (225°, white)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.6	Port side light (112,5°, red)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.7	Starboard side light (112,5°, green)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.8	Stern light (135°, white)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.9	Towing light (135°, yellow)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.10	Forward anchor light (360°, white)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.11	Aft anchor light (360°, white)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.12	Upper NUC light (360°, red)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.13	Lower NUC light (360°, red)	☐	☐	nm	☐	☐	☐ main ☐ emergency
2.3.14	RAM lights	☐	☐	nm	☐	☐	☐ main ☐ emergency

	Navigation Lights Approval	Manufacturer
2.3.4.a	Fore masthead light (225°, white)	
2.3.5.a	Main masthead light (225°, white)	
2.3.6.a	Port side light (112,5°, red)	
2.3.7.a	Starboard side light (112,5°, green)	
2.3.8.a	Stern light (135°, white)	
2.3.9.a	Towing light (135°, yellow)	
2.3.10.a	Forward anchor light (360°, white)	
2.3.11.a	Aft anchor light (360°, white)	
2.3.12.a	Upper NUC light (360°, red)	
2.3.13.a	Lower NUC light (360°, red)	
2.3.14.a	RAM lights	

2.4 Pilot transfer arrangement on either side of the ship (V/23)

2.4.1 Pilot ladder

Manufacturer _____

Material _____

Length _____ m

2.4.2 Accommodation ladder, if used in conjunction with pilot ladder
(the accommodation ladder shall be sited leading aft, with lower end firmly rested against ship's side)
Manufacturer

Material *Length*

m

Falls
Number *Diameter* *Material* *Length*

mm m

2.4.3 Bulwark ladder/hinged rail
Manufacturer

Material

2.5 Additional information

Item number	Remark / Comment

3 Life-Saving appliances

3.1	Rockets and signals (III/6, 18)	Type Approved	Amount
3.1.1	Line throwing appliances with 4 rockets and lines	☐ Yes ☐ No	
3.1.2	12 rocket parachute flares	☐ Yes ☐ No	

3.2	Communications (III/6)	Manufacturer	Type	Approved by	Cert. No.
3.2.1	Portable two-way VHF radio-telephone apparatus				
3.2.2					
3.2.2.1	Search and rescue locating device				
3.2.2.2	One search and rescue locating device in free-fall lifeboat (may be 1 of the required 2)				
3.2.2.3	Satellite EPIRB (capable of being carried into survival craft)				
3.2.3	Emergency means for two-way communications between emergency control stations, muster and embarkation stations and strategic positions on board				
3.2.4	Means of communication between embarkation station and platform (for ships fitted with MES only)				
3.2.5	Public address system				
3.2.5.1	Location of control(s)				
3.2.6	General emergency alarm system				

3.2.6.1	Means of abandon ship warning	☐ Provided	☐ Not provided
3.2.6.2	Location of control(s)		

3.3 Survival craft, Muster, Launching and Embarkation arrangement, Launching station

3.3.1		No.	No. of persons	Location	
				Deck	Position (frame, port, starboard, stern)
3.3.1.1	Muster station				
3.3.1.2	Muster station				
3.3.1.3	List of additional Muster Stations	Attachment: ☐ Yes ☐ No			
3.3.2					
3.3.2.1	Embarkation station				
3.3.2.2	Embarkation station				
3.3.2.3	Embarkation station				
3.3.2.4	Embarkation station				

3.3.3		No.	Length	Location	
				Deck	Position (frame, ship side)
3.3.3.1	Embarkation ladder		m		
3.3.3.2	Embarkation ladder		m		
3.3.3.3	Alternative means (descent unit)		m		

Sketch of arrangement of lifeboats, rescue boats, MES and liferafts

3.4 Lifeboats

3.4.1	Lifeboats (III/16, 21, 31)						
3.4.1.1	Position (Starboard Side (SB); Port Side (PS); Stern (S)	☐SB ☐PS ☐S	☐SB ☐PS ☐S	☐SB ☐PS ☐S	☐SB ☐PS ☐S	☐SB ☐PS ☐S	☐SB ☐PS ☐S
3.4.1.2	Capacity (Number of persons)						
3.4.1.3	Dimensions Length:	m	m	m	m	m	m
	Breadth:	m	m	m	m	m	m
	Depth:	m	m	m	m	m	m
3.4.1.4	Weight (fully loaded and equipped)						
3.4.1.5	Material						
3.4.1.6	Manufacturer						
3.4.1.7	Type/Trade name						
3.4.1.8	Serial No.						
3.4.1.9	Approved by						
3.4.1.10	Approval No.						
3.4.1.11	Free-fall	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.12	Totally enclosed	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.13	Partially enclosed	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.14	Open[1]	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.15	Motor	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.16	Mechanically propelled[1]	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.17	Rowing[1]	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.18	Self-righting	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.19	Fire-Protected[2]	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.20	With self-contained air supply system[2]	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.21	Approved and used as rescue boat	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.4.1.22	Used as passenger tender boat	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐

3.4.2 Release mechanism for lifeboats

Release hook mechanism type _____ *Manufacturer* _____

Approved by: _____ *Approval No.* _____

On-Load Release Hooks compliant with LSA Code, as amended _____ Yes☐ No☐

3.4.3 Lifeboat equipment (III and LSA Code)

Each lifeboat is equipped as follows (indicate number or Yes, No, N.A. as appropriate)

[1] Keel laid before 1st July 1986

[2] On Tankers only

	Item	Lifeboat number					
3.4.3.1	Number of rowing oars (including spare oars), except freefall lifeboat						
3.4.3.2	Crutches or equivalent for each oar						
3.4.3.3	Automatic valves (with cap or plug)						
3.4.3.4	Rudder (attached with tiller)						
3.4.3.5	Lifeline becketed around the outside of the boat						
3.4.3.6	Bilge pump(s) manually operated						
3.4.3.7	Lockers for small items of equipment						
3.4.3.8	Painters, 1 secured to stem, 1 secured forward, with release device able to operate under tension						
3.4.3.9	Painters (2) of at least 15 m in length stowed near the bow (for free-fall lifeboats only)						
3.4.3.10	Boat hooks (2)						
3.4.3.11	Buoyant bailer with lanyards						
3.4.3.12	Buckets (2) with lanyards						
3.4.3.13	Survival manual						
3.4.3.14	Sea anchor (1) with shock-resistant hawser and tripping line (if fitted)						
3.4.3.15	Hatchets (axes, one at each end of the boat						
3.4.3.16	Rustproof dipper with lanyard						
3.4.3.17	Rustproof graduated drinking vessel (1)						
3.4.3.18							
3.4.3.18.1	Fresh water (3 litres per person in watertight receptacles), or						
3.4.3.18.2	Water desalting apparatus and 2 litres fresh water per person, or						
3.4.3.18.3	Manually powered reserve-osmosis desalinator and 1 litre fresh water per person						
3.4.3.19	Means for collecting and storing rainwater						
3.4.3.20	Food ration of approved type in airtight receptacles stowed in watertight containers totalling not less than 10,000 kJ per person						
3.4.3.21	Waterproof electric torch (1) with one spare set of batteries and one spare bulb in waterproof container						
3.4.3.22	Daylight signalling mirror (1)						
3.4.3.23	Whistle (1) or equivalent sound signal						
3.4.3.24	Fishing tackle (1 set)						
3.4.3.25	Buoyant rescue quoits (2) attached to						

	Item	Lifeboat number					
	not less than 30 m of buoyant lifeline						
3.4.3.26	Jack knife (1) attached to boat with lanyard						
3.4.3.27	Tin-openers (3)						
3.4.3.28	Life-saving signals (table) on a waterproof card or in waterproof container						
3.4.3.29	First-aid outfit in a waterproof case (1)						
3.4.3.30	Anti-seasickness medicine sufficient for at least 48 hours for each person						
3.4.3.31	Seasickness bag (1) for each person						
3.4.3.32	Short ladder or other means of climbing into upright boat from the water						
3.4.3.33	Skates or fenders (and skids if required) to facilitate launching against adverse list						
3.4.3.34	Hand holds on underside of hull (only for non-self-righting boats)						
3.4.3.35	Retro-reflective material						
3.4.3.36	Safety belt fitted at each seating position (totally enclosed lifeboats only)						
3.4.3.37	Manually controlled internal and external lamps able to be operated for 12 hours						
3.4.3.38	Rocket parachute flares (4)						
3.4.3.39	Hand flares (6)						
3.4.3.40	Buoyant smoke signals (2)						
3.4.3.41	Searchlight able to operate continuously for at least 3 hours (1) (not required for oar or mechanically propelled lifeboat)						
3.4.3.42	Thermal protective aids for 10 % or 2 whichever is greater						
3.4.3.43							
3.4.3.43.1	Radar reflector (1) or						
3.4.3.43.2	Search and rescue locating device stowed in lifeboat						
3.4.3.44	Compass in binnacle, efficiently luminized or illuminated						
3.4.4	Additional requirements for open lifeboats						
3.4.4.1	Grablines gunwale to gunwale (2 minimum)						
3.4.4.2	Mast with galvanised wire stays and orange sail (not required for motor or mechanically propelled boats)						
3.4.4.3	Cover, highly visible for protecting occupants with stanchions						
3.4.4.4	A lamp with sufficient oil for 12 hours						
3.4.4.5	Matches in watertight container (2)						
3.4.4.6	Storm oil (4.5 litres)						

	Item	Lifeboat number					
3.4.4.7	Storm oil container for attaching to sea anchor						
3.4.4.8	Bowsing tackles to hold boat against ship's side						
3.4.4.9	Number of rowing thwarts						
3.4.4.10	Steering oar						
3.4.4.11	Plugs (2 for each plug hole with chain attachment), or						
3.4.5	Additional requirements for partially enclosed lifeboats						
3.4.5.1	Adjustable closing arrangements from inside and outside the boat						
3.4.5.2	Means for collecting rainwater						
3.4.6	Motor lifeboats						
3.4.6.1	Engine Manufacturer						
3.4.6.2	Engine type, diesel						
3.4.6.3	Engine power (kW)						
3.4.6.4	Fuel capacity – litres (sufficient for 24 hours running with 6 knots)						
3.4.6.5	Means provided for recharging all engine starting, radio and searchlight batteries						
3.4.6.6	Means provided for recharging lifeboat batteries from the ships power supply or by means of a solar battery charger						
3.4.6.7	Water-resistant instructions for starting and operating the engine provided and placed near the engine starting controls						
3.4.6.8	Towing force of the rescue boat as indicated in the type approval certificate (sufficient to tow the largest fully loaded liferaft on board at a speed of two knots) (kN)						
3.4.7	Additional requirements for free-fall lifeboats (BCS-I SC 248)						
3.4.7.1	Free-fall certification height Note: The free-fall certification height is the greatest launching height for which the free-fall lifeboat is approved.	m	m	m	m	m	m
3.4.7.2	Ready to launch position height Note: The "ready to launch position" height is to be measured from the still water surface to the lowest point on the lifeboat with the ship in its lightest seagoing condition. This height must be equal or less than the free-fall certification height.	m	m	m	m	m	m

3.5 Rescue Boats

			Rescue boat No. 1	Rescue boat No. 2
3.5.1	Rescue Boats (III/21, 26, 31) (excluding lifeboats approved as rescue boats and already included in 3.4 above)			
3.5.1.1	Position:	Ship side:	☐PS ☐SB	☐PS ☐SB
		Deck:		
		Frame area:		
3.5.1.2	Capacity (No. of persons)			
3.5.1.3	Dimensions	Length:	m	m
		Breadth:	m	m
		Depth:	m	m
3.5.1.4	Manufacturer			
3.5.1.5	Type/Trade name			
3.5.1.6	Material			
3.5.1.7	Serial No.			
3.5.1.8	Approved by			
3.5.1.9	Approval No.			
3.5.1.10	Rigid rescue boat		☐	☐
3.5.1.11	Inflated rescue boat		☐	☐
3.5.1.12	Fast rescue boat		☐	☐
3.5.1.13	Engine manufacturer			
3.5.1.14	Engine type			
3.5.1.15	Engine power (kW)			
3.5.1.16	Towing force of the rescue boat as indicated in the type approval certificate (sufficient to tow the largest fully loaded liferaft on board at a speed of two knots) (kN)			

3.5.2. Release mechanism for rescue boat

Release hook mechanism type _____ Manufacturer _____

Approved by: _____ Approval No. _____

On-Load Release Hooks compliant with LSA Code, as amended Yes ☐ No ☐

3.5.3 Rescue boat equipment (III and LSA Code)

	Each rescue boat is equipped as follows:	Rescue boat No. 1	Rescue boat No. 2
3.5.3.1	Oars or paddles (sufficient to make headway)		
3.5.3.2	Thole pins, crutches or equivalent for each oar		
3.5.3.3	Thole pins or crutches attached to the boat by lanyards or chains		
3.5.3.4	Buoyant bailer (1)		
3.5.3.5	Binnacle containing an efficient luminous compass		
3.5.3.6	Sea anchor with tripping line not less than 10 m in length (1)		
3.5.3.7	Painter of sufficient length and strength at fore end (1)		
3.5.3.8	Buoyant line not less than 50 m in length and sufficient strength to tow a liferaft (1)		

	Each rescue boat is equipped as follows:	Rescue boat No. 1	Rescue boat No. 2
3.5.3.9	Waterproof electric torch suitable for Morse signalling (1)		
3.5.3.10	Spare set of batteries and spare bulb in waterproof container (1)		
3.5.3.11	Whistle or equivalent (1)		
3.5.3.12	First-aid outfit in waterproof case (1)		
3.5.3.13	Buoyant rescue quoits attached to buoyant line of not less than 30 m in length (2)		
3.5.3.14	Portable fire-extinguishing equipment of an approved type (suitable for oil fires)		
3.5.3.15	Effective means of bailing or fitted with automatic self-bailing arrangements		
3.5.3.16	Searchlight able to operate continuously for at least 3 hours		
3.5.3.17	Radar reflector		
3.5.3.18	Thermal protective aids for 10% or 2 whichever is greater		

3.5.4	Additional requirements for inflated rescue boats	Rescue boat No. 1	Rescue boat No. 2
3.5.4.1	Buoyant safety knife (1)		
3.5.4.2	Sponges (2)		
3.5.4.3	Efficient manually operated bellows or pump		
3.5.4.4	Repair kit in suitable container for repairing punctures		
3.5.4.5	Safety boat-hook		

3.5.5	Additional requirements for rigid rescue boats	Rescue boat No. 1	Rescue boat No. 2
3.5.5.1	Boat-hook (1)		
3.5.5.2	Bucket (1)		
3.5.5.3	Knife or hatchet (1)		

3.6 Liferafts (III/21, 31; LSA Code) excluding any liferaft stowed forward or aft for compliance with III/31.1.4 (Ro-Ro Passenger Ships only: at least every fourth liferaft should be provided with a search and rescue locating device)

3.6.1 Stowage position of liferafts or liferaft-groups

3.6.1.1	Liferaft No(s).					
3.6.1.2	Position	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB
3.6.1.3	Stowed at deck						
3.6.1.4	Frame Area						
3.6.1.5	Maximum permitted stowage height above waterline (m)						
3.6.1.6	Actual stowage height above waterline (m)						

3.6.2

3.6.2.1	Manufacturer						
3.6.2.2	Type						
3.6.2.3	No. of Persons						
3.6.2.4	Approved by						
3.6.2.5	Approval No.						
3.6.2.6	A or B pack						
3.6.2.7	Transferable from side to side	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.6.2.8	Auto self-righting	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐

3.6.2.9	Canopied reversible	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.6.2.10	Davit launched	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.6.2.11	Search and Rescue Locating Device	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.6.2.12	Served by MES	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐

3.6.3	Float free arrangement						
3.6.3.1	Hydrostatic Relase Unit	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.6.3.2	Manufacturer						
3.6.3.3	Type						

3.6.4 Additional liferaft(s) stowed forward or aft (III/31.1.4) (hydrostatic release not required)

3.6.4.1	Liferaft No(s).						
3.6.4.2	Manufacturer						
3.6.4.3	Type						
3.6.4.4	No. of Persons						
3.6.4.5	Approved by						
3.6.4.6	Approval No.						
3.6.4.7	A or B pack						

3.7 Marine Evacuation System "MES" (III/21, III/26 and LSA Code)

3.7.1	MES No.						
3.7.2	Position	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB
3.7.3	Frame area						
3.7.4	Maximum permitted stowage height above waterline (m)						
3.7.5	Manufacturer						
3.7.6	Type						
3.7.7	No. of Persons						
3.7.8	Approved by						
3.7.9	Approval No.						
3.7.10	MES	☐Slide ☐Chute	☐Slide ☐Chute	☐Slide ☐Chute	☐Slide ☐Chute	☐Slide ☐Chute	☐Slide ☐Chute

3.8 Additional information

Item number	Comment

3.9 Means of rescue "MOR" (III/26.4, MSC/Circ. 810)

3.9.1 Means of rescue acc. to III/26.4.3 Yes☐ No☐

3.9.2 Device providing a suitable floating platform

3.9.2.1 Inflatable device _____

3.9.2.2 Rigid device _____

Description: _____

Hoisting arrangement: _____

3.10 Lifeboat launching appliance (III/16, 21 and 31; LSA Code)

3.10.1	Lifeboat-Davits						
3.10.1.1	Lifeboat No.						
3.10.1.2	Position	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB
3.10.1.3	Manufacturer						

3.10.1.4	Type						
3.10.1.5	Approved by						
3.10.1.6	Approval No.						
3.10.1.7	Max. SWL (Kg)						
3.10.2	Winches						
3.10.2.1	Manufacturer						
3.10.2.2	Type						
3.10.2.3	Serial No.						
3.10.2.4	Approval No.						
3.10.2.5	Remote controlled	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.10.3	Falls						
3.10.3.1	Length (m)						
3.10.3.2	Diameter (mm)						
3.10.3.3	Breaking Load (kg)						
3.10.3.4	Construction (number of designating number of wires and strands)						
3.10.3.5	Core type	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel
3.10.3.6	Corrosion resistant	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.10.3.7	Rotation resistant	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐

3.10.4	Launching and recovery arrangement	FRB (MSC.1/Circ.809)	MOR (MSC.1/Circ.810)	Hanging Off Pendants LB	Free Fall Lifeboat
3.10.4.1	Length (m)				
3.10.4.2	Diameter (mm)				
3.10.4.3	Breaking Load (kg)				
3.10.4.4	Corrosion resistant	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐
3.10.4.5	Rotation resistant	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐

3.10.5 Means of launching lifeboats _____

3.10.6 Maximum number of persons on board the fully equipped lifeboat which the launching appliance is capable to recover _____

3.10.7 Liferaft launching arrangements (III/16; LSA Code)

3.10.7.1 Liferaft-Davit(s) / Crane(s)

Liferaft No.						
Position	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB
Manufacturer						
Type						
Approved by						
Approval No.						
Max SWL (Kg)						
3.10.7.2 Winch No.						
Manufacturer						
Type						
Approved by						
Approval No.						
3.10.7.3 Falls						
Length (m)						
Diameter (mm)						
Breaking load						
Construction (number of designating number of wires and strands)						
Core type	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel
Corrosion resistant	☐	☐	☐	☐	☐	☐
Rotation resistant	☐	☐	☐	☐	☐	☐

3.10.8 Launching and recovery arrangement for rescue boat (III/17; LSA Code)

3.10.8.1 Rescue Davit

Rescue Boat No.						
Position	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB	☐PS ☐SB
Manufacturer						
Type						
Approved by						
Approval No.						
Max SWL (Kg)						
3.10.8.2 Winch						
Manufacturer						
Type						
Approved by						
Approval No.						
3.10.8.3 Falls						
Length (m)						
Diameter (mm)						
Breaking load						
Construction (number of designating number of wires and strands)						
Core type	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel	☐Fibre ☐Steel
Corrosion resistant	☐	☐	☐	☐	☐	☐
Rotation resistant	☐	☐	☐	☐	☐	☐

3.11 Other life-saving appliances (III/7, 22, 26 and 32; LSA Code)

For Ro-Ro passenger ships: a sufficient number of lifejackets is stored at the muster station

		Number	Manufacturer	Location
3.11.1	Life jackets for adults with whistle and light			
3.11.1.1	Life jackets for persons on watch and for use at remotely located survival crafts stations			
3.11.1.2	Life jackets for children (equal to at least 10 % of the number of passengers)			
3.11.1.3	Additional lifejackets for infants			
3.11.1.3.1	Additional lifejackets (for 5 % of the total number of persons on board passenger ships only)			
3.11.1.3.1 bis	Additional lifejackets for passengers in staterooms remotely from direct routes between public spaces and muster stations (passenger ships constructed on or after 1998-07-01)			
3.11.1.3.2	Number of adult lifejackets designed with suitable accessories to fit persons weighing up to 140kg and with a chest girth of up to 1.750mm			
3.11.2[1]	Immersion suits			
3.11.2.1	Immersion suits (one for every person on cargo ship)			
3.11.2.1 bis	Immersion suits for persons on watch and for use at remotely located work stations on cargo ship			
3.11.2.2	Number of immersion suits complying with the requirements for lifejackets			
3.11.2.3	Anti-exposure suits for every person assigned to the crew the rescue boat or assigned to the MES party			

[1] Additional immersion suit shall be added to the total number of immersion suits.

		Number	Manufacturer	Type	Location
3.11.3	Lifebuoys				
3.11.3.1	With light and smoke signal, capable of quick release from the bridge (at least 2)				
3. 11.3.2	With self-igniting light only (not less than half the total number)				
3. 11.3.3	With buoyant lifelines (1 on each side)				
3. 11.3.4	Without attachments				

3.12 Additional information

Item number	Comment

4 Fire Fighting Equipment (Ch. II-2)

4.1 Fire-fighter's outfit (FSS Code Ch. 3. Reg 2.1, II-2/10.10)

4.1.1 Personal equipment (please indicate number of provided equipment)

ID No.	Location	Protective suit(s)	Boots	Gloves	Rigid helmet	Lifeline	Axe	Safety lamp	Safety belt harness	Radios	Others
1											
2											
3											
4											
5											
6											
7											
8											

	Personal equipment	Manufacturer	Type
4.1.1.1	Protective suits		
4.1.1.2	Boots		
4.1.1.3	Gloves		
4.1.1.4	Rigid helmet		
4.1.1.5	Lifeline		
4.1.1.6	Axe		
4.1.1.7	Safety lamp		
4.1.1.8	Safety belt harness		
4.1.1.9	Radios		
4.1.1.10	Others		
4.1.1.11	Number of Spare set of cylinders for use provided _____		
4.1.1.12	Number of Spare set of cylinders for training and drill provided _____		

4.1.2 Self-contained breathing apparatus

ID No.	Location	Type / Manufacturer	Capacity (litres) (at least 1.200 l)	Spare capacity (at least 2.400 l)
1				
2				
3				
4				

ID No.	Location	Type / Manufacturer	Capacity (litres) (at least 1.200 l)	Spare capacity (at least 2.400 l)
5				
6				
7				
8				
9				
10				

4.1.2.1 Air compressor for filling of air bottles ☐ Yes ☐ No

4.1.3 Smoke helmet or smoke mask with air pump and hose, if provided

	Location	Manufacturer	Type
4.1.3.1			
4.1.3.2			
4.1.3.3			
4.1.3.4			

4.2 Fire Extinguishers (II-2/10.3, 10.5, 18.5, 19.3.7, 20.6.2; FSS Code, Chapter 4)

	Item	Location	Number	Extinguishing medium (i.e. CO_2, Foam, etc)	Capacity	No. of spare charges
4.2.1	Portable extinguishers	Accommodation spaces				
		Service spaces				
		Machinery spaces				
		Cargo spaces and cargo pump rooms				
		Helicopter landing area				
		Dangerous goods				
		Ro-Ro spaces				

	Item	Location	Number	Type	Capacity	No. of spare charges
4.2.2	Portable foam applicator units	Machinery spaces				
4.2.3	Non-Portable (wheeled) extinguishers	Machinery spaces				
4.2.4	Water fog applicator	Machinery spaces				

4.3 Fire pumps, fire main, hydrants, hoses, etc. (II-2/10.2)

4.3.1 Fire pumps and fire main

	Fire Pump	Capacity m³/h	Prime mover	Location	Remote controlled from	
					Bridge	Central fire control station
4.3.1.1	Main fire pump				☐	☐
4.3.1.2	Main fire pump				☐	☐
4.3.1.3	Main fire pump				☐	☐
4.3.1.4	Emergency fire pump*				☐	☐

4.3.1.5 *Source of power/Location _____

4.3.1.6 Fire main diameter (nominal bore (NB)) _____ mm

4.3.1.7 Location of machinery space fire main riser isolating valve(s) _____

4.3.1.8 Specify means for maintaining a permanent pressure in the fire main (pump and tank) _____

4.3.1.9 Main pressure in fire main with two pumps and two jets of water _____ N/mm²

4.3.1.10 Relief valves Yes☐ No☐

4.3.2 Hydrants

	Location	Number	Diameter (NB) mm	Type of coupling
4.3.2.1	Machinery spaces			
4.3.2.2	Others			
4.3.2.3	Weather deck			
4.3.2.4	Accommodation and service spaces			
4.3.2.5	Ro-Ro cargo spaces			

4.3.3 Hoses and nozzles

	Location	Number	Hose diameter mm	Hose Length (m)	Spray / jet nozzle with shut-off	Nozzle Approved by / No.
4.3.3.1	Machinery spaces				Yes☐ No☐	
4.3.3.2	Weather deck				Yes☐ No☐	
4.3.3.3	Accommodation and service spaces				Yes☐ No☐	
4.3.3.4	Ro-Ro cargo spaces				Yes☐ No☐	
4.3.3.5					Yes☐ No☐	

4.4 International shore connection (II-2/ 10.2.1.7; FSS Code, Chapter 2)

4.4.1

Number	Location(s)

5 Fire extinguishing systems (II-2) in Engine room, Cargo spaces, Pump room, Accommodation, Service spaces, etc.

5.1 Arrangement

Space protected	CO_2	Halon	Fixed foam	Fixed pressure water spray or mist (drenching)	Automatic sprinkler or equivalent	Dry powder	Other gas system	Others[1]
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	
Others								

[1] In case of others please specify

5.2 CO_2 system(s) (II-2/10.5, 10.6.3, 10.7, 10.9, 20.6.1; FSS Code, Chapter 5)

Space(s) protected	Bottles			Location of remote control	Type of audible alarm (Horn, Siren, Others)	Operation instructions posted – location
	Number	Capacity each kg	Location			

5.3 Systems using gases other than CO_2 (II-2/10.5, 10.6.3, 10.7, 10.9, 20.6.1; FSS Code, Chapter 5.2.5)

Type of gas: _____ System Approved by: _____ Approval No.: _____

Space(s) protected	Bottles			Location of remote control	Type of audible alarm (Horn, Siren, Others)	Operation instructions posted – location
	Number	Capacity each kg	Location			

5.4 Halon system (II-2/10.4.1.3)

5.4.1

Space(s) protected	Stowage containers			Location of remote control	Type of audible alarm	Release of the system*	Operation instructions posted – location
	Number	Capacity each kg	Location				

5.4.2

Type of propellant gas:	

* A – automatically M – manually

Note: Only local systems are permitted to have automatic release

5.5 Fixed foam fire extinguishing system(s) (II-2/10.5, 10.8, 10.9, 20.6.1; FSS Code, Chapter 6 and 14)

	Details		Space protected		
			Engine/Boiler room	Cargo area/Cargo tank	Cargo pump room
5.5.1	Foam	Type			
		Manufacturer			
		Quantity litres			
		Concentration ratio			
		Expansion ratio			
5.5.2	Foam fire extinguishing system pump	Type			
		Location			
		Capacity m^3/h			
5.5.3	Location of foam tank				
5.5.4	Location of controls				
5.5.5	Makers service instruction manual provided				
5.5.6	Means of supply	Monitors on tank deck	Manufacturer		Capacity litres/min
			Type		Number
		Applicators/foam generators		Machinery spaces	Tank deck
			Manufacturer		
			Type		
			Number		
		Number of hydrants			
		Number of hoses			

5.6 Fixed pressure water-spraying or water mist system(s) (II-2/10.5, 10.6.3, 10.9; FSS Code, Chapter 7)

5.6.1

Space(s) protected	Pump(s)		Nozzle(s)		Location of control
	Location	Capacity (m^3/h)	Type	Manufacturer	

5.6.2 Number of type approval certificate: _____

5.7 Drencher (deluge) system (II-2/19.3.1.3, 19.3.9, 20.6.1)

5.7.1

Space(s) protected	Pumps		Location of control (section valves)
	Location	Capacity (m^3/h)	

5.8 Dry chemical powder fire-extinguishing system

Details		Space protected	
		Cargo area	Bow or stern cargo handling area
System	Manufacturer		
	Type		
	No. of self contained units		
Means of supply: Hoses	Number		
	Manufacturer		
	Type		
	Length		
	Capacity		
Means of supply: Monitors	Number		
	Manufacturer		
	Type		
	Capacity		

5.9 Automatic sprinkler or equivalent, fire detection and fire alarm system(s) (II-2/10.6.1 and 10.6.2; FSS Code, Chapter 8)

5.9.1

Space(s) protected	Automatic independent power pump		Sources of power	Sprinkler plan posted	Location of stop (section) valves
	Location	Capacity (m^3/h)			

5.9.2 Sources of emergency power for electrically driven pumps _____

5.9.3 Location of emergency source of power _____

5.9.4 Fresh water tank capacity _____ m^3

5.9.5 Sprinkler head type _____ Manufacturer _____ Number of spaces _____

5.9.6 No. of type approval certificate: _____

5.9.7 Location of cross-connection valve to fire main _____

5.10 Galley range exhaust duct protective system (II-2/9.7.5)

5.10.1 Type of system: _____ Number of bottles: _____ Total capacity: _____ kg

5.10.2 Locations of controls for release and closing of fire dampers _____

5.10.3 Locations of exhaust fan shut-off controls _____

5.11 Fixed local application fire extinguishing system(s) (II-2/10.5.6)

5.11.1 Manufacturer and type of the system(s) _____

5.11.2 No. of type approval certificate: _____

5.11.3 Release of the system: ☐ Automatically ☐ Manually

5.11.4 Pump unit: _____ Location: _____ Capacity: _____ m^3/h

5.11.5 Location of remote controls _____

5.11.6 Type designation of the spraying nozzles _____

5.11.7 Protected areas:

5.11.7.1 Engine top of internal combustion machinery used for ship's main propulsion ☐

5.11.7.2 Engine top of internal combustion machinery used for the ship's power generation ☐

5.11.7.3 Oil burners of boilers and thermal oil heaters ☐

5.11.7.4 Oil burners of incinerators ☐

5.11.7.5 Oil burners of inert gas generators ☐

5.11.7.6 Purifiers of heated fuel oil ☐

5.11.7.7 Other areas ☐

Details: _____

5.12 Fire extinguishing system for deep-fat cooking equipment (II-2/10.6.4)

5.12.1 Manufacturer and type of the system _____

5.12.2 No. of type approval certificate:

5.12.3 Object(s) protected: _____ _____ _____ _____

5.12.4 Release of the system: ☐ Automatically ☐ Manually

5.12.5 Location of control _____

5.13 Sand receptacles and shovels or equivalent arrangement (II-2/10.5.1.2.3)

5.13.1 In each firing space, there is a sand receptacle with shovel / an approved fire extinguisher. (+) ☐

(+) Delete as appropriate.

5.14 Spaces containing flammable liquids (paint lockers) – II-2/10.6.3

System	Manufacturer	Type	Approved by	Approval No.
Carbon dioxide				
Dry powder				
Water spraying or sprinkler				
Portable CO_2				
Other:				

5.15 Additional information

Item number	Comment

6 Fire protection, fire detection and alarm system(s) (II-2/7.5, 7.7, 8.5, 9.2, 10.6; FSS Code, Chapter 9 and 10)

6.1 Method of fire protection and alarm systems in accommodation and service spaces on cargo ships (II-2/7.5.5, 7.7, 9.2.3.2.2, 10.6.2)

Method IC Smoke detection and manually operated call points in all corridors, stairways and escape routes within accommodation spaces ☐

Method IIC Automatic sprinkler, fire detection and fire alarm system of an approved type in accommodation spaces, galleys and other service spaces ☐

Method IIIC Fixed fire detection and fire alarm system of an approved type in accommodation and service spaces ☐

6.2 Fire protection and alarm systems on passenger ships in accommodation and service spaces and control stations (II-2/7.5.2, 7.5.3, 10.6.1)

Passenger ships carrying not more than 36 passengers

6.2.1 Fixed fire detection and fire alarm system in accommodation and service spaces, and control stations provided, and smoke detection system in corridors, stairways and escape routes within accommodation spaces provided ☐

6.2.2 Automatic sprinkler, fire detection and fire alarm system in accommodation and service spaces and control stations provided, and smoke detection system in corridors, stairways and escape routes within accommodation spaces provided ☐

6.3 Location of control panel _____

6.4 Location of indicating units _____

6.5 *Passenger ships carrying more than 36 passengers*

6.5.1 Automatic sprinkler, fire detection and fire alarm system as well as smoke detection system in all accommodation and service spaces and control stations including corridors, stairways and escape routes provided ☐

6.5.2 Smoke extraction system of an approved type (II-2/8.5; applicable to atriums only) ☐

6.6 Gas detection – portable instruments and fixed system (II-2/4.5.7, VI/3, XI-1/7)

Gas	Manufacturer	Type	No. of Spares
6.6.1 Portable			
Oxygen			
Flammable vapor			
Hydrogen sulphide			
Carbon monoxide			
Other:			

6.6.2 Fixed			Spaces Fitted
Hydrocarbon gas			
Other:			

6.7 Marking of Escape routes (II-2/13.3.2.5)

6.7.1	Low – location lighting
	a) Photoluminiscent system
	b) Electrical powered system
6.7.2	Alternative evacuation guidance system

6.8 Additional information

Item number	Comment

7 Emergency control/Special arrangements in machinery and accommodation spaces (II-2/5.2, 7.9.3, 8.3, 9.5)

7.1 Means for stopping ventilation fans and pumps and other auxiliary machinery

			Means	Location
7.1.1	Ventilation fans	Machinery spaces		
		Accommodation		
7.1.2	Boiler fans			
7.1.3	Purifiers			
7.1.4	Oil fuel transfer pumps			
7.1.5	Oil fuel and lubricating oil tank valves			
7.1.6	Lube Oil Service Pumps			
7.1.7	Thermal Oil Circulating Pumps			

7.1.8 Capable of being closed from outside the space concerned

☐ Ventilators ☐ Funnel annular spaces ☐ Skylights ☐ Doorways ☐ Tunnel door

7.2 Additional information

Item number	Comment

8 Personnel protection (Chapter II-2)

8.1 Emergency escape breathing devices (EEBDs) (II-2/13.3.4, 13.4.3; FSS Code, Chapter 3, para. 2.2)

Number of EEBDs:	In machinery spaces	Accommodation spaces	Spare devices	Training devices	Total o.b.

No.	Location	Type	Manufacturer

9 Special arrangements

9.1 Inert gas system (II-2/4.5.5; FSS Code, chapter 15)

9.1.1	Manufacturer		Type of the system(s)*			
	Approved		Approval No.		Instruction manual provided:	

** State whether Flue Gas (FG), Gas Generator (GC) or Gas Turbine (GT) is fitted*

9.1.1.1 General requirements for all inert gas systems

(a)	The system is capable of producing a gas delivery rate of at least 125% of the maximum rate of discharge capacity of cargo pumps	
(b)	Gas scrubber locator	
(c)	Number and locator of gas blowers	
(d)	Location of gas regulation valve	
(e)	Location of deck waterseal	
(f)	Type and location of other non-return devices	
(g)	Each cargo tank may be isolated by a stop valve / a blank spade (+)	
(h)	Blank flanges are provided to isolate slop tanks (only for combination carriers)	
(i)	Satisfactory tank ventilation arrangements are provided	
(j)	Satisfactory arrangements for purging of empty tanks are provided	
(k)	Number and location of pressure-vacuum devices	
(l)	Satisfactory means are provided for continuously indicating the inert gas temperature and pressure at the discharge side of blowers, when they are operating	
(m)	Instrumentation and alarms as per operating and service manual are provided	
(n)	A close ullage system is provided	

9.1.1.2 Instruments for measuring oxygen and flammable vapours concentration in the inert gas / cargo tank (see also 6.6)

(a)	Number, manufacturer and type of portable explosion meters	
(b)	Number, manufacturer and type of portable oxygen level meters	
(c)	Number and location of flue gas isolating valves (only for flue gas systems)	
(d)	Number and location of fuel oil pumps (only for gas generator and gas turbines systems)	
(e)	Manufacturer and type of oxygen content Indicator and recorder in cargo control room	
(f)	Manufacturer and type of oxygen content meter in machinery control room	
(g)	Manufacturer and type of continuous indicating/recording meter of IG pressure for slop tank pressure for combination carrier on bridge	
(h)	Means of zero and span calibration of both fixed and portable instruments mentioned above	

9.2 Ships carrying dangerous goods (II-2/19)

9.2.1 The ship is intended for the carriage of dangerous goods ☐ Applicable ☐ N.A.

9.2.2 Protective clothing (II-2/19.3.6.1) ☐ Applicable ☐ N.A.

ID No.	Location	Manufacturer	Type
1			
2			
3			
4			

9.2.3 Self-contained breathing apparatus (II-2/19.3.6.2) ☐ Applicable ☐ N.A.

ID No.	Location	Type/Manufacturer	Capacity (litres)	Spare capacity
1				
2				

9.2.3.1 Air compressor for filling of air bottles (See 4.1.2.1) ☐ Yes ☐ No

9.2.4 Fire extinguishers (II-2/19.3.7) ☐ Applicable ☐ N.A.

Type	Location	Number	Type	Capacity
Dry powder extinguishers or Others ( ) (+)				

(+) Delete as appropriate.

9.3 Ships with helicopter facilities (Reg. II-2/18)

9.3.1 The ship is fitted with special facilities for helicopters ☐ Applicable ☐ N.A.

9.3.1.1 Helicopter overall length (D): _____ m

9.3.2 Fire extinguishers (II-2/18.5.1) ☐ Applicable ☐ N.A.

Item	Location	Number	Type	Capacity
Dry powder extinguishers				
CO_2 extinguishers				

9.3.3 Foam application system (II-2/18.5.1)

Location	Means of supply	Discharge rate	Operating period

9.3.4 Fire hoses and nozzles (II-2/18.5.1.5)

Location	Number of hoses	Hose length	Number of nozzles

9.3.5 Fire-fighter's outfits (II-2/18.5.1.6) (for the characteristics, see 4.1)

9.3.5.1 In addition to the requirements Reg.II-2/10.10, two sets should be provided. ☐

9.3.6 Location of the following equipment: _____

Adjustable wrench	☐	Blanket, fire resistant	☐
Cutters, bolt 60 cm	☐	Hook, grab or salving	☐
Hacksaw, heavy duty complete with 6 spare blades	☐	Ladder	☐
Lift line 5 mm diameter x 15 m in length	☐	Pliers, side cutting	☐
Set of assorted screwdrivers	☐	Harness knife complete with sheath	☐

9.3.7 An operations manual including a description and a checklist of safety precautions, procedures and equipment requirements is provided. ☐

9.4 Ships with vehicle, Special category and Ro-Ro spaces (Reg. II-2/20) ☐ Applicable ☐ N.A.

9.4.1 A fixed fire detection and fire alarm system / a sample extraction smoke detection system (+) (II-2/20.4)

Location	Maker	Type

(+) Delete as appropriate.

9.4.2 A fixed fire-extinguishing system (II-2/20.6.1) ☐ Applicable ☐ N.A.

A fixed fire-extinguishing system is fitted. (for the system's characteristics, see 5) ☐

9.4.3 A fixed pressure water-spraying systems (II-2/20.6.1.4) ☐ Applicable ☐ N.A.

9.4.3.1 Drainage and pumping arrangements sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. ☐

9.4..3.2 Stability information being taken the adverse effect upon stability of the added weight and free surface of water into account in the Stability Booklet approved. ☐

9.4.4 Fire extinguishers (II-2/20.6.2.1) ☐ Applicable ☐ N.A.

9.4..4.1 Fire extinguishers are spaced not more than 20 m apart on both sides of the space. ☐

Item	Location	Number	Type	Capacity
	Ro-Ro cargo spaces			

9.4.5 Water fog applicators and portable foam (II-2/20.6.2) ☐ Applicable ☐ N.A.

Item	Location	Number	Type	Capacity
Water fog applicator	Ro-Ro cargo spaces			
Portable foam applicator	Ro-Ro cargo spaces			

9.5 Vehicle and Ro-Ro space Fire Protection (II-2/20-1)

9.5.1 Portable Gas detectors (minimum two to be provided)

Total number of gas detectors provided: ____

9.6 Container Ship Fire Extinguishing system (II-2/10)

9.6.1 Water mist lance (minimum one to be provided)

Total number of water mist lances provided: ____

9.6.2 Mobile water Monitors (Five or more tiers of containers on weather deck)

9.6.3 Mobile water monitors

Ships with breadth up to	Minimum Numbers	Material	Type of Nozzle	Monitor capacity
30m	02			
30m or more	04			

9.7 Additional information

Item number	Comment

The information contained in this record is a correct description of the Safety Equipment on board.

Place/Date	*Stamp*	*Signature of Surveyor*

Enclosures: _____

_____

_____

_____

_____

10 Equipment renewals, alterations and/or additions effected since the Record was prepared

10.1 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.2 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.3 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.4 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.5 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.6 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

10.7 _____
Item number

Port/Date	*Stamp*	*Signature of Surveyor*

BCS-G 129 Guidance on DMLC Part II review, inspection and certification under the Maritime Labour Convention, 2006

Section 1: Introduction

1.1 Scope and Application

This guidance is intended for use by BCS's inspectors when performing inspection and certification service under the Maritime Labour Convention, 2006 (the Convention) unless the relevant Administration has provided special instructions that indicate otherwise.

This document is also intended to promote inspection consistency and uniformity of inspection among BCS by providing examples and guidance, which, however, are not to be interpreted as prescriptive solutions or checklists.

Reference is made to the following documents adopted by the International Labour Organization (ILO):

(a) Maritime Labour Convention, 2006 adopted by the 94th (Maritime) Session of the International Labour Conference of the International Labour Organization (ILO) in February 2006, as amended;

(b) Resolutions adopted by the International Labour Conference at its 94th (Maritime) Session of the International Labour Conference of the International Labour Organization (ILO) in February 2006;

(c) The Guidelines for flag State inspections under the Maritime Labour Convention, 2006, adopted by the ILO in September 2008, for implementing flag State responsibilities under the Convention;

1.2 The Maritime Labour Convention, 2006 and how it is intended to operate

The Convention was developed by a tripartite committee made up of member states, shipowners' organisations and seafarers' representatives. It sets out a number of provisions relating to the employment, working and living conditions of seafarers.

Ratifying member states are obliged to adopt and implement laws that give full effect to those provisions, some of which are detailed and prescriptive while others are more broadly expressed. Many simply refer to the need for measures to be, for example, "adequate", "acceptable" or "sufficient", leaving it to individual member states to specify appropriate criteria in each case. Examples include the requirement that mess rooms be "of adequate size and comfort and properly furnished and equipped" and the need for "appropriately situated and furnished laundry facilities".

Consequently, it is the national requirements developed to implement the Convention with which shipowners must comply, and many of the Convention's provisions have been drafted in such a way as to permit member states a degree of flexibility when deciding on the precise criteria to be applied. However, exemptions, substantial equivalences or other variations may be adopted only after consultation with the shipowners' and seafarers' representatives concerned.

The RO inspectors are expected to verify that the seafarer's working and living conditions specified in the Appendix A5-I of the Convention correspond to the relevant flag State's national requirements implementing the Convention. A Maritime Labour Certificate is issued to the vessel after the vessel has been inspected and verified to be in compliance with the requirements of the Convention, and the provisions of the flag State's Declaration of Maritime

Labour Compliance Part I and shipowner's Declaration of Maritime Labour Compliance, Part II.

1.3 Certification process

The verification of compliance with mandatory rules and regulations, required as part of the MLC, 2006 inspection neither duplicates nor replaces the audits or surveys required by the other statutory certificates. Compliance with the MLC, 2006 does not relieve the Company, the master or any other entity or person involved in the management or operation of the ship of their responsibilities.

The inspection process involves review of shipowner measures for seafarer working and living conditions onboard as described in the Declaration of Maritime Labour Compliance Part II, and onboard verification of those measures through review of documentation and records, visual observation, general discussion and private interviews with seafarers. Any inspection is a sampling process and inspectors use their professional judgment and expertise when determining the depth of inspection for each requirement subject to inspection under the MLC, 2006. The inspection is not exhaustive in nature and is merely a snapshot of the working and living conditions onboard at the time of inspection.

Issuance of certification is based upon verification that the sample is in compliance with the Convention, and the national requirements of the relevant flag State. Where non-conformities have not been found and reported, it does not mean that none exist.

1.4 Situations where there are not adequate national requirements

Regulation 5.1.4 "Inspection and enforcement" of the Convention requires that Members should verify, through an effective and coordinated system of regular inspections, monitoring and other control measures, that ships flying its flag comply with the Convention's requirements as implemented within the national laws and regulations of the member state.

Where RO has been authorized to carry out MLC inspections on behalf of the flag State, the RO may face a situation where the national legislation does not fully address an inspection requirement or appropriate criteria for expressions such as sufficient, adequate or proper has not been defined. In such situations, RO should seek clarification from the flag Administration to avoid inconsistent application of the national requirements.

1.5 Shipowner

Shipowner means the owner of the ship or another organization or person, such as the manager, agent or bareboat charterer, who has assumed the responsibility for the operation of the ship from the owner and who, on assuming such responsibility, has agreed to take over the duties and responsibilities imposed on shipowners in accordance with this Convention, regardless of whether any other organization or persons fulfil certain of the duties or responsibilities on behalf of the shipowner.

This definition is taken to mean that the shipowner is the same entity as the Company as defined in the ISM Code, unless specified otherwise by the flag Administration.

1.6 Editorial principles

For convenience, this document incorporates the actual text from Chapter 3 of the Guidelines for flag State inspections under the Maritime Labour Convention, 2006, followed by the relevant recommended guidance for BCS inspectors. The document will be updated as necessary consistent with BCS's experience in the inspection process.

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3. Qualifications of seafarers
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5. Use of any licensed or certified or regulated private recruitment and placement service
6. Hours of work or rest
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Part I

Review of the DMLC Part II and inspection

Inspection and certification items

Scope of Inspection

This paragraph is intended to assist an inspector in determining the scope of inspection.

The table below identifies areas that must be “Inspected and Certified” (Appendix A5-I of the Convention). These areas are identified as “I/C”. In addition, five areas which must be “Inspected”, as required by the ILO Guidelines for flag State inspections under the Maritime Labour Convention, 2006, are identified as “I”.

The Competent Authority in the flag State is required to address “Inspected and Certified” areas (items 1-16) in the DMLC Part I, hence the shipowner must address these items in their DMLC Part II.

The inspector should not expect to find “Inspected” areas in the DMLC Part I.

Regardless, the inspector is required to verify these items during on-board inspections. Inspectors should note that items 17-20 are normally addressed in the seafarer employment agreement (SEA) and/or collective bargaining agreement (CBA) and information regarding these items should be readily available on board during inspections.

Item	Topic	Inspection / Certification
1	Minimum age	I/C
2	Medical certification	I/C
3	Qualification of seafarers	I/C
4	Seafarers’ employment agreements	I/C
5	Use of any licensed or certified or regulated private recruitment and placement service	I/C
6	Hours of work or rest	I/C
7	Manning levels for the ship	I/C
8	Accommodation	I/C
9	On-board recreational facilities	I/C
10	Food and catering	I/C
11	Health and safety and accident prevention	I/C
12	On-board medical care	I/C
13	On-board complaint procedures	I/C
14	Payment of wages	I/C
15	Financial security for repatriation	I/C
16	Financial security relating to shipowners’ liability	I/C
17	Entitlement to leave	I
18	Repatriation	I
19	Shipowners’ liability	I
20	Social security	I
21	General principles (copy of MLC, 2006 on board)	I

1. Minimum age (Reg. 1.1)

General

Regulation 1.1 sets out requirements for minimum age of seafarers. The purpose of this regulation is that no under-age persons work on board a ship. The Convention requires that the minimum age of the seafarer be at least 16 years of age at the time of employment. A higher minimum age is required for certain category of personnel such as cooks.

Inspected and certified

Basic requirements

- *Persons below the age of 16 shall not be employed or engaged or work on a ship (Standard A1.1, paragraph 1).*
- *Seafarers under the age of 18 shall not be employed or engaged or work where the work is likely to jeopardize their health or safety (Standard A1.1, paragraph 4).*
- *Special attention must be paid to the safety and health of seafarers under the age of 18, in accordance with national laws and regulations (Standard A4.3, paragraph 2(b)).*
- *Night work* for seafarers under the age of 18 is prohibited, except to the extent that an exemption has been made by the competent authority under Standard A1.1, paragraph 3, in the case of training programs (Standard A1.1, paragraph 2).*

* *"Night" is defined in accordance with national law and practice. It covers a period of at least nine hours starting no later than midnight and ending no earlier than 5 a.m. (Standard A1.1, paragraph 2).*

How to check the basic requirements

- *Check a crew list, or passports or other official documents confirming seafarers' birth dates.*
- *Check work schedule with respect to seafarers under the age of 18 to determine hours and nature of work.*
- *Check to see that types of work on board that are likely to jeopardize the safety of seafarers under the age of 18 have been identified.*
- *Check recent accident reports and safety committee reports to determine whether seafarers under the age of 18 were involved.*
- *Confirm information through interviews, in private, with a representative number of seafarers.*

Examples of deficiencies

- *Person under the age of 16 working as a seafarer.*
- *Seafarer under the age of 18 working at night (and not as part of a training program).*

- *Seafarer under the age of 18 carrying out tasks that are likely to jeopardize their safety or health.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Minimum age;

- Night work periods are specified, including handling of exemptions, if any;

- Hazardous work is identified, including control measures for assignment of such work;

- Any other relevant requirements of the flag State, including substantially equivalent provisions, if any.

Guidance for Inspection

While carrying out the MLC inspection, the inspector should review the national requirements and the company's own criteria for the minimum age of seafarers. Minimum age for seafarers is 16 years (or higher if required by competent authority of the flag State). Ship cooks must not be less than 18 years of age. A check should also be made of the shipowner's measures for ensuring that the age verification is performed before the seafarers are employed on board.

Seafarers between the age of 16 and 18 are considered young seafarers under the Convention. The inspector should verify through sampling of records and private interviews of seafarers that young seafarers are not engaged in night work unless authorized by the competent authority as part of their training program. Additionally, a check should be made to ensure that the young seafarers are not engaged in any work which is likely to jeopardize their health and safety. Types of work that are considered hazardous for young seafarers are normally identified by the competent authority in their national laws or the DMLC Part I.

2. Medical certification (Reg. 1.2)

General

Regulation 1.2 sets out requirements for medical certification of seafarers. The purpose of this regulation is that seafarers should not work on a ship unless they are certified as medically fit to perform their duties.

Inspected and certified

Basic requirements

- *Seafarers are not allowed to work on a ship unless they are certified* as medically fit to perform their duties.*
- *For seafarers working on ships ordinarily engaged on international voyages the certificate must be provided in English (Standard A1.2, paragraph 10).*
- *The medical certificate must have been issued by a duly qualified medical practitioner and must be still valid.*
- *The period of validity for a certificate is determined under national law in accordance with the following:*
    - *two-year maximum for medical certificates except for seafarers under 18; then it is one year;*
    - *six-year maximum for a colour vision certificate.*

* *Certificates issued in accordance with, or meeting the substance of the applicable requirements, under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), as amended, are to be accepted as meeting these requirements (Standard A1.2, paragraph 3).*

How to check the basic requirements

- *Check the crew list.*
- *Check for valid medical certificates stating that seafarers are medically fit to perform their duties.*
- *Check for valid colour vision certificates, where appropriate.*
- *Check (by reviewing work schedules and interviews, in private) that medical restrictions on work for individual seafarers are being respected and that seafarers are not assigned to or carrying out work contrary to these restrictions.*
- *In urgent cases where the competent authority of the flag State has permitted a seafarer to work without a valid or with an expired certificate, the authorization or permit should be checked to ensure it is still valid (subject to a three-month maximum).*
- *In cases where a medical certificate has expired while at sea, the certificate must be obtained within a maximum of three (3) months.*

- *Check that the medical certificates of seafarers on ships ordinarily engaged in international voyages are in English.*

- *Check that the medical certificate has been issued by a duly qualified medical practitioner.*

Examples of deficiencies

- *Seafarer on board without a valid medical or colour vision certificate (where appropriate) or authorization from the competent authority in urgent cases.*

- *Seafarer working on the ship or performing tasks contrary to a restriction on a medical certificate.*

- *Seafarer's medical certificate not in the English language on a ship ordinarily engaged in international voyages.*

- *A medical certificate that has not been issued by a qualified medical practitioner.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Control of seafarers' medical and colour vision certificates and their validity;

- Format of medical certificate, and language;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should verify during shipboard inspection that all seafarers are holding medical certificates relevant to their duties on board and that these certificates are valid in accordance with the requirements of its flag State. For example, the medical certificates for young seafarers are considered valid for up to one year from the date of issuance, the medical certificates for seafarers of 18 or higher may be valid for up to two years except in cases where the flag Administration limits the validity of the medical certificates to less than two years.

The certificates solely concerning eyesight / colour vision may be issued by a person recognised by the competent authority other than a duly qualified medical practitioner. In such cases, the inspector should verify that the validity of colour vision certificates is not greater than six years.

Where restrictions are stated on the seafarers' medical certificates, the inspector should review on-board work schedules for the seafarers in question to confirm that such restrictions are observed during the shipboard work assignments, and the shipowner's measures for controlling such restrictions are effective.

The medical certificates are required to be issued in English language if the ship is ordinarily engaged in international voyages. Inspectors should be mindful that for a ship engaged in domestic voyages only, the seafarers' medical certificates may be in languages other than English. The medical certificates should be issued by duly qualified medical practioners. In

some cases, the flag State may have published a list of duly qualified medical practitioner. The flag States may also recognize medical practioners who are duly qualified by the other members states.

Certificates complying with the Medical Examination (Seafarers) Convention, 1946 (ILO No. 73), or International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW) are generally considered acceptable by most flag States. In case of seafarers not covered by STCW Convention, a medical certificate meeting the substance of those requirements may be accepted.

The inspector should be mindful of any national provisions related to the issuance and the validity of the medical certificates as stated in DMLC Part I, including any specific flag State authorizations for urgent cases or special provisions for certificates which expire at sea during the course of a voyage.

3. Qualifications of seafarers (Reg. 1.3)

General

Regulation 1.3 sets out requirements for training and qualifications of seafarers. The purpose of this regulation is to ensure that seafarers are trained and qualified to carry out their duties on board ship. The Convention states that seafarers should not work on a ship unless they are trained or certified as competent or otherwise qualified to perform their duties, and have successfully completed training for personal safety on board ship.

Inspected and certified

Basic requirements

- *Seafarers must be trained or certified* as competent or otherwise qualified to perform their duties in accordance with flag State requirements.*

- *Seafarers must have successfully completed training for personal safety on board ship.*

* *Training and certification in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), as amended, is to be accepted as meeting these requirements.*

How to check the basic requirements

- *Check the minimum safe manning document (SMD) to verify the required qualifications of the seafarers.*

- *Check certificates and endorsements for STCW personnel confirming seafarers' competency with respect to their duties (check crew list to determine duties).*

- *Check documentary evidence (from a shipowner or, if relevant to the position concerned, a national authority or otherwise) confirming that seafarers have any qualifications that may be required under national law for those performing other duties on board ship (for example, ships' cooks – see below, Regulation 3.2).*

- *Check for evidence confirming that all seafarers have successfully completed training for personal safety on board ship.*

- *Check a copy of the appropriate training material that is available to the crew.*

- *Confirm training through interviews, in private, with a representative number of seafarers.*

Examples of deficiencies

- *Seafarer's qualifications not in accordance with the SMD.*

- *Seafarer working on the ship who is not trained or certified or otherwise qualified to perform required duties.*

- *Certificates or endorsements are not up to date or have expired.*

- *Seafarer working on the ship who has not successfully completed personal safety training.*

Items for review of DMLC Part II

The inspector should check shipowner's measures in DMLC Part II to ensure initial and ongoing compliance with the relevant requirements in accordance with the flag State's DMLC Part I for:

- Training and Qualifications of seafarer's and their validity;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

The inspector should review whether the implementation and control measures for Training and Qualifications of seafarers have been identified in the DMLC Part II or associated documentation.

Guidance for Inspection

The inspector should review the minimum safe manning document (SMD), crew list, training records, certificate of competencies, including relevant endorsements, for each seafarer to confirm that they are appropriate to their position on board, and that these documents are valid and comply with the requirements of the flag State and the shipowner's DMLC Part II.

4. Seafarers' employment agreements (Reg. 2.1)

General

Regulation 2.1 set out requirements to ensure that seafarers have a fair employment agreement. Where allowed by the national law and practice, a collective bargaining agreement (CBA) complementing the seafarer employment agreement (SEA), may incorporate one or more elements from Regulation 2.1.

Inspected and certified

Basic requirements

- *All seafarers must have a copy of their seafarers' employment agreement (SEA) signed by both the seafarer and the shipowner or shipowner's representative (or, where they are not employees, other evidence of contractual or similar arrangements).*
- *A SEA must, as a minimum, contain the matters set out in Standard A2.1, paragraph 4(a)–(k) of the MLC, 2006 (Standard A2.1, paragraph 4).*
- *Seafarers must also be given a document containing a record of their employment on the ship (such as a discharge book) (Standard A2.1, paragraph 1(e)).*
- *Where a collective bargaining agreement (CBA) forms all or part of the SEA, the agreement must be on board the ship with relevant provisions in English (except for ships engaged only in domestic voyages) (Standard A2.1, paragraph 2).*

How to check the basic requirements

- *Check a copy of the SEA and any applicable CBAs for seafarers and, at a minimum, a standard form of the SEA (in English) for the ship.*
- *Check, where possible, given the timing of the inspection relative to employment period, possession by seafarers of a record of their employment (or request that such records are submitted to the inspector at a later date).*
- *Check that seafarers' records of employment do not contain statements as to the quality of their work or as to their wages.*
- *Interview, in private, a representative number of seafarers to confirm that, on signing a SEA, seafarers were given an opportunity to examine and seek advice and freely accepted the agreement before signing.*

Examples of deficiencies

- *A seafarer without a SEA working on the ship.*
- *A seafarer with a SEA that does not contain all the items in Standard A2.1, paragraph 4(a)–(k).*
- *A seafarer with a SEA that is inconsistent with the national requirements.*
- *No system or provisions for seafarers to have their employment recorded.*

- *Seafarers are not given a record of their employment on the ship on completion of engagement.*

- *A CBA that forms all or part of the SEA is either not on board or, if on board, not in English on a ship that engages in international voyages.*

- *Standard form SEA is not in English.*

- *The SEA contains clauses that violate seafarers' rights.*

Items for review of DMLC Part II

The inspector should check that the shipowner's measures in the DMLC Part II are in accordance with the relevant requirements of the flag State relating to the SEA and Record of Employment, as identified in the DMLC Part I, ensuring that:

- Where DMLC Part II provides for signing the SEA on board, there are adequate procedures to ensure that the SEA has been agreed and accepted by the seafarer prior to the travel on board or the seafarer is entitled to repatriation at the shipowner's expense from the ship in case he/she cannot accept the terms and conditions of the SEA;

- The SEA, as a minimum, contains the matters set out in Standard A2.1, paragraph 4(a)–(k) of the MLC, 2006 and is consistent with the national requirements;

- The SEA and relevant parts of CBA, if applicable, are available in English (except for ships engaged only in domestic voyages);

- Notice period, both for the seafarer and for the shipowner, is at least 7 days. National legislation may define circumstances to ensure the need of the seafarer to terminate, without penalty, the employment agreement on shorter notice or without notice taken into account urgent reasons;

- The SEA should not contain any clauses that violate the following fundamental, employment and social rights of seafarers stated in Article III and IV of the Convention:

    (a) freedom of association and the effective recognition of the right to collective bargaining;
    (b) the elimination of all forms of forced or compulsory labour;
    (c) the effective abolition of child labour;
    (d) the elimination of discrimination in respect of employment and occupation;
    (e) the right of every seafarer to:

        - safe and secure workplace that complies with safety standards,
        - fair terms of employment,
        - decent working and living conditions on board ship,
        - health protection, medical care, welfare measures and other forms of social protection.

- Seafarers are given Records of Employment and that it does not include any statement on the quality of their work or to wages;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions.

Guidance for Inspection

The inspector should verify that the SEA is signed by both the seafarer and the shipowner (or a representative of the shipowner) and that it satisfies national requirements. The inspector should also confirm through interviews that the seafarers are given an opportunity to review and seek advice on the agreement before signing. Clear information as to the conditions of employment should be readily available on board.

If the SEA is signed by a recruitment and placement service (RPS) or other representatives, a (copy of) document confirming the representative‘s right to sign SEA on behalf of the shipowner should be demonstrated (manning agreement or power of attorney, etc.).

Irrespective of whether the seafarers on board are employed directly by the shipowner or indirectly via sub-contractors, the inspector should confirm that all contractual or similar arrangement provide the same level of protection required by the Convention. Alternatively, the “contractual or similar arrangement” may make a reference to a SEA used by the shipowner, in order to fill the gaps. In this case, the SEA to be annexed to the “contractual or similar arrangement” in order to demonstrate compliance.

The inspector should verify that the Seafarers are given a Record of Employment at the end of their contract and that it does not contain any statement related to the quality of work or to wages. Also, the inspector should confirm that such document is issued in the format specified by the flag State, if applicable. Such record may be given in the seafarer’s discharge book or as a separate document.

5. Use of any licensed or certified or regulated private recruitment and placement service (Reg. 1.4)

General

Regulation 1.4 sets out requirements to ensure that seafarers have access to an efficient and well-regulated seafarer recruitment and placement system.

Inspected and certified

Basic requirements

- *Where a shipowner has used a private seafarer recruitment and placement service (RPS),* it must be licensed or certified or regulated in accordance with the MLC, 2006.*
- *Seafarers shall not be charged for use of these services.*
- *Shipowners using services based in States not party to the MLC, 2006, must ensure, as far as practicable, that these services meet the requirements of the MLC, 2006 (Standard A1.4, paragraph 9).***

* *If private recruitment and placement services are operating in their territory, flag States are responsible for establishing an effective inspection and monitoring system with respect to those services (Regulation 5.3; Standard A5.3, paragraph 1).*

** *Flag States are responsible for ensuring that shipowners have a proper system for verifying that the recruitment and placement services conform to the national requirements implementing Standard A1.4 if they use recruitment and placement services based in States not party to the MLC, 2006. This responsibility may be fulfilled by continuously monitoring shipowners' compliance with those requirements, by monitoring recruitment and placement services in relevant non-MLC countries through a quality management system, and by providing information on the extent to which services in such countries have been found to meet the requirements of Standard A1.4.*

How to check the basic requirements

- *Check the national web sites of the competent authority regarding the licensing or regulation of seafarer recruitment and placement services (manning agencies).*
- *Check documentation or other information to allow the inspector to ascertain the following:*

1. Direct engagement

Seafarers were recruited and engaged by the shipowner. If this is the case, this fact should be noted and no further action is necessary.

2. Recruited through a public service

Seafarers were engaged through a public seafarer recruitment and placement service in either the flag State or in another State to which the MLC, 2006, applies. If this is the case, this should be noted and no further action is necessary.

3. *Recruited through a private service (or a service operated by a seafarers' organization) in a country that has ratified the MLC, 2006*

A. *If the seafarers were engaged through a private seafarer recruitment and placement service in the flag State, check for documentary evidence confirming that the service concerned is operating in accordance with the national laws or regulations or other measures implementing the MLC, 2006, requirements. Where the supervision of such services is entrusted to another national authority in the flag State, a statement by that authority that the service has been found to be operating in accordance with the relevant law is sufficient for this purpose.*

B. *If the seafarers were engaged through a private seafarer recruitment and placement service in another State that has ratified the MLC, 2006, no action need be taken unless the inspector has received a clear indication that basic rights have been violated (such as charging seafarers for use of services).*

4. *Recruited through a service that is based in a country that has not ratified the MLC, 2006*

If the seafarers were engaged through a seafarer recruitment and placement service based in a country that has not ratified the MLC, 2006, check documentation showing that the shipowner has, as far as practicable, verified through a proper system that the service is operated consistently with the MLC, 2006. This system may, for example, take account of information collected by the flag State, as well as any audits or certifications concerning the quality of services operating in countries that have not ratified the MLC, 2006. Other evidence which shipowners could provide might be checklists against the MLC, 2006 requirements or an RO audit of a recruitment and placement service based in a country that has not ratified the MLC, 2006.

- *Check, through interviews, in private, with a representative number of seafarers, that they have not paid a fee or other charge to a recruitment or placement service and have been informed of their rights and duties.*

- *Check, through interviews, in private, with a representative number of seafarers, that the recruitment and placement service used does not operate a blacklist.*

Examples of deficiencies

- *No documentary evidence available to indicate that the service or agency is operated in accordance with the MLC, 2006.*

- *A seafarer who was recruited through a private seafarer recruitment and placement service that was not licensed or certified or regulated in accordance with the MLC, 2006, or whose licence or certificate or any other similar document is no longer valid.*

- *Use of a recruitment and placement service requiring the seafarer to pay a fee or otherwise making a charge for employment services (if this is a possibility then it should also be reported to the competent authority in the State where the service is based).*

- *A seafarer working on board who was recruited by a recruitment and placement service operating in a country that has not ratified the MLC, 2006, in cases where the shipowner cannot support its conclusion of consistency with the MLC, 2006.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Selection and recruitment of qualified and medically fit seafarers, and how such seafarers are sourced;

- Verifying that the private recruitment and placement service operating in a ratifying country is licenced or certified as appropriate;

- Verifying that the recruitment and placement service operating in a non ratifying country, as applicable, are operating in accordance with the requirements of the Convention;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions.

Guidance for Inspection

As a first step the inspector has to ascertain how the seafarers on board were recruited and placed. Since types of recruitment and placement may vary depending upon the nationality and position of the seafarers onboard, the inspector should use his professional judgement in deciding the samples to be checked.

If the shipowner has used a private recruitment and placement service located in the flag State's territory or a recruitment and placement service in a non-ratified country, the inspector should verify documentary evidence that the shipowner has taken measures to ensure that the recruitment and placement service meets the requirements of this Convention and the national requirements of the competent authority in the flag State.

6. Hours of work or rest (Reg. 2.3)

General

Regulation 2.3 requires that seafarers have regulated hours of work or hours of rest in order to provide adequate rest to the seafarers taking into account dangers posed by the fatigue.

Inspected and certified

Basic requirements

- *The minimum hours of rest* must not be less than 10 hours in any 24-hour period and 77 hours in any seven-day period, if the relevant national law relates to hours of rest, or, if the relevant national law relates to hours of work, the maximum hours of work** must not exceed 14 hours in any 24-hour period and 72 hours in any seven day period (Standard A2.3, paragraph 5, as implemented in national standards).****

- *Hours of rest may be divided into no more than two periods, one of which must be at least 6 hours; the interval between consecutive periods of rest must not exceed 14 hours (Standard A2.3, paragraph 6, as implemented in the national standards).****

- *Account must be taken of the danger posed by the fatigue of seafarers (Standard A2.3, paragraph 4).*

* *"Hours of rest" means time outside hours of work; this term does not include short breaks (Standard A2.3, paragraph 1(b)).*

** *"Hours of work" means time during which seafarers are required to do work on account of the ship (Standard A2.3, paragraph 1(a)).*

*** *With respect to the national standards implementing Standard A2.3:*
Standard A2.3, paragraph 3 provides that "Each Member acknowledges that the normal working hours' standard for seafarers, like that for other workers, shall be based on an eight-hour day with one day of rest per week and rest on public holidays. However, this shall not prevent the Member from having procedures to authorize or register a collective agreement which determines seafarers' normal working hours on a basis no less favourable than this standard."
Standard A2.3, paragraph 13 provides that "Nothing in paragraphs 5 and 6 of this Standard shall prevent a Member from having national laws or regulations or a procedure for the competent authority to authorize or register collective agreements permitting exceptions to the limits set out. Such exceptions shall, as far as possible, follow the provisions of this Standard but may take account of more frequent or longer leave periods or the granting of compensatory leave for watchkeeping seafarers or seafarers working on board ships on short voyages."

How to check the basic requirements

- *Check that there is an approved standardized table of shipboard working arrangements setting out the national requirements for maximum hours of work or the minimum hours of rest and the schedule for service at sea and in port, posted in an easily accessible place on the ship.*

- *Check the working arrangement listed in the table.*

- *Check documents (the SEA or the relevant collective agreement and other documents, such as the bridge and engine room logbooks, that can also be checked) to confirm compliance with the basic requirements concerning minimum hours of rest or maximum hours of work.*

- *Check for a table of working arrangements or schedule in the working language or language of the ship and in English.*

- *Check that there are up to date records of work or rest, as required under national standards, for each seafarer serving on the ship.*

- *Check for seafarer fatigue, possibly indicated by hours of work that are consistently at the upper limits and by other contributory factors, such as disrupted rest periods. If there are seafarers that show symptoms such as lack of concentration, irrelevant and inconsistent replies to questions, yawning and slow reaction times, further investigation may be considered.*

Examples of deficiencies

- *A seafarer's work schedule does not conform to the applicable standards.*

- *Table of working arrangements is not posted or does not contain required information.*

- *Table of working arrangements is not in English and the working language(s) of the ship.*

- *Records of work or rest are not available or are not maintained.*

- *Evidence of exceeding the limits of work and no record of suspension of the schedule, in accordance with Standard A2.3, paragraph 14, has been noted in a logbook or other document.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Minimum hours of rest or maximum hours of work;

- Table of working arrangements;

- Young seafarers under the age of 18, as applicable;

- Compensatory rest period;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any;

- Exceptions, if any.

Guidance for Inspection

The inspector should verify that the maximum number of hours of work or minimum number of hours of rest criteria established in the National Requirements, or DMLC Part I has been implemented on board through sampling of records, log books, and private interviews, etc.

The inspector should verify that a table of shipboard working arrangements setting out the national requirements with the schedule for service at sea and in port, is posted in an easily accessible place on the ship. This table should be in a standardized format and in the working language or languages of the ship and in English.

Inspectors should verify that short breaks are not counted towards rest periods. Any authorized exceptions to the hours of rest criteria or suspension of the work schedule are properly recorded in the log book or similar document, and compensatory rest given to the seafarers, as applicable.

Inspectors should be aware that repeated breaches of the requirement of hours of work and rest or an accident that has occurred due to the seafarer’s fatigue may be indicative of inadequate manning on board.

7. Manning levels for the ship (Reg. 2.7)

General

Regulation 2.7 requires that all ships have a sufficient number of seafarers employed on board to ensure that ships are operated safely, efficiently and with due regard to security under all conditions, taking into account concerns about seafarer fatigue and the particular nature and conditions on the voyage.

Inspected and certified

Basic requirements

- *Ship must have a sufficient number of seafarers employed on board to ensure that ships are operated safely, efficiently and with due regard to security under all conditions, taking into account concerns about fatigue and the particular nature and conditions of voyage.*

- *Ship must comply with the manning levels listed on the Safe Manning Document (SMD) or equivalent issued by the competent authority (Standard A2.7, paragraph 1).*

How to check the basic requirements

- *Check safe manning document (SMD) or applicable equivalent.*

- *Check crew list for number, category (such as cooks and those responsible for food preparation and those who are responsible for medical care) and qualifications of seafarers working on board.*

- *Check on-board table of working arrangements to confirm that safe manning requirements are being implemented.*

- *Interview, in private, a representative number of seafarers to confirm that requirements are met.*

Examples of deficiencies

- *Number and/or categories of seafarers working on board does not correspond with those stated in the SMD.*

- *No SMD or equivalent on board.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Manning levels;

- Qualification and certification of seafarers;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should verify that the ship is manned in accordance with the Safe Manning Document (SMD) issued by the flag State.

8. Accommodation (Reg. 3.1)

General

Regulation 3.1 requires that seafarers are provided with decent accommodation and recreational facilities for promoting the seafarers' health and well-being, while on board.

Inspected and certified

Basic requirements

- *Ships must be in compliance with the minimum standards established by the MLC, 2006, providing and maintaining decent recreational facilities for seafarers working or living on ships, or both, consistent with promoting seafarers' health and well-being.*

- *Seafarer recreational facilities must be safe and decent and must meet national requirements implementing the MLC, 2006 (Standard A3.1, paragraph 1).*

- *Frequent inspections of seafarer recreational facilities are carried out by the master or a designate (Standard A3.1, paragraph 18) and are recorded and the records are available for review.*

Notes:

For ships coming into service:

- *The attending inspector should be aware of the plan approval process undertaken during the construction of the ship with respect to the seafarer accommodation arrangements. As part of the first inspection of a ship the inspector will need to verify that the recreational facilities have been constructed in accordance with the approved drawings. The same applies to ships that have been substantially altered. This process need not be repeated for subsequent inspections.*

For ships that were in existence before entry into force of the MLC, 2006, for the flag State:

- *Account must be taken of any national provisions that may have been adopted with respect to this issue. These ships will still need to be inspected in connection with seafarers' accommodation and recreational facilities to verify that the ship:*

    - *meets the standards set out in either ILO Conventions Nos. 92, 133, 147 or the Protocol of 1996 to Convention No. 147 (if applicable in the flag State); and/or*

    - *provides and maintains decent recreational facilities for seafarers working or living on board, or both, consistent with promoting the seafarers' health and well-being in accordance with national legislation.*

How to check the basic requirements

- *Check the construction plan of the ship that shows dimensions and identifying the use to be made of each room or other area.*

- *Check the crew list compared to the number of sleeping rooms and berths.*

- *Carry out a visual observation of seafarers' on-board recreational facilities with particular attention paid to the following requirements in the MLC, 2006:*

  - *general requirements (Standard A3.1, paragraph 6);*

  - *the size of rooms and other accommodation spaces (Standard A3.1, paragraphs 9 and 10);*

  - *heating and ventilation (Standard A3.1, paragraph 7);*

  - *noise and vibration and other ambient factors (Standard A3.1, paragraph 6(h));*

  - *sanitary and related facilities (Standard A3.1, paragraphs 11 and 13);*

  - *lighting (Standard A3.1, paragraph 8);*

  - *hospital accommodation (Standard A3.1, paragraph 12);*

  - *recreational facilities (Standard A3.1, paragraphs 14 and 17);*

  - *occupational safety and health and accident prevention requirements on ships, in light of the specific needs of seafarers who both live and work on ships (Standard A3.1, paragraphs 2(a) and 6(h));*

- *Check the on-board records to confirm that frequent inspections are carried out by, or under the authority of, the ship's master, as well as (for ships that carry a Maritime Labour Certificate) that other inspections or actions provided for in the shipowners' approved measures found in the DMLC Part II, have been carried out.*

- *Check that measures are being taken on the ship to monitor noise and vibration levels in seafarers' working and living areas.*

Examples of deficiencies

- *Location of sleeping rooms on the ship does not conform to national standards implementing the MLC, 2006.*

- *Number and/or size (including height) of sleeping rooms does not conform to national standards implementing the MLC, 2006.*

- *More than one seafarer per berth.*

- *Recreational facilities do not conform to national standards implementing the MLC, 2006.*

- *Heating, lighting or ventilation is inadequate or not functioning correctly.*

- *Fittings and fixtures within seafarer accommodation areas, including the hospital, mess rooms and recreational rooms, do not conform to national standards implementing the MLC, 2006.*

- *Separate sleeping rooms are not provided for males and females.*

- *Separate sanitation facilities are not provided for males and females.*

- *Sanitary facilities are inadequate and not functioning.*

- *Hospital is being used to accommodate persons who are not sick.*

- *Seafarer recreational facilities are not being maintained in a clean and tidy condition.*

- *Regular inspections of seafarer recreational facilities are not being carried out by the master or another designated person.*

- *Laundry facilities are inadequate or not functioning correctly.*

- *Exposure to hazardous levels of noise and vibration and other ambient factors and chemicals in the seafarer accommodation or recreational or catering facilities.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Providing and maintaining decent accommodation facilities on board for seafarers working or living on board, or both, and consistent with promoting the seafarers' health and well-being;

- Frequent inspection of accommodation under the authority of the master and that records are maintained.

In addition, the inspector should request documentary evidence (i.e. certificate/Statement of Fact/survey report, or a letter from the Administration) attesting to the fact that the vessel was built to the applicable standards and its accommodation design and construction has been accepted by the Administration.

Documentary evidence for existing ship as follows:

- meets the standards set out in either ILO Conventions Nos. 92, 133, 147 or the Protocol of 1996 to Convention No. 147 (if applicable in the flag State);

- where ILO Convention Nos. 92, 133, 147 are not applicable for the existing ship, because, for example the flag State has not ratified any of those Conventions or there is no national legislation, a confirmation from flag State should be obtained indicating that the flag State has accepted the accommodation arrangement as it is.

Documentary evidence for the new ship as follows:

- meet the standards set out in MLC, 2006 Standard A3.1.

RO responsible for MLC, 2006 certification may accept a Certificate/Statement of Compliance or other form of evidence confirming compliance with design and constructions requirements with ILO Conventions 92/133 or Regulation 3.1 of the MLC, 2006 provided it is issued by the flag State or an authorized RO of the flag State.

Guidance for Inspection

On existing ships or at the first inspection following a new building, the inspectors should verify that documentary evidence confirming compliance with the requirements of Regulation 3.1 which relate to ship construction and equipment is available on board.

During subsequent inspections, the inspectors should perform visual inspections of the accommodation spaces and sample the approved arrangements to confirm that no alterations or modifications have been made resulting in non-compliance, and that the accommodation continues to be maintained in safe and hygienic condition and in accordance with the national requirements. Additionally, records of frequent inspections by or under the authority of the master should be verified on board.

According to Regulation 3.1 all ships should provide and maintain decent and safe accommodation for seafarers, working or living on board.

Regulation 3.1 contains elements related to construction and equipment as well as those which relate to “operational” matters.

For elements related to design and construction, the inspector should verify that the existing vessel has some documentation (i.e. certificate/Statement of Fact/report, etc.) attesting to the fact that the vessel was built to C 92 and/or C 133, or national requirements as applicable. Similarly, for new vessels constructed after the MLC, 2006 enters into force for the flag State, the documentation indicating that the vessel was built to the MLC, 2006 should be verified during MLC inspections.

Items related to “operational” matters should be inspected during each regular inspection and include:

- Lighting, hot and cold water supply, drainage, heating and ventilation arrangements in the accommodation with respect of state of repair and functionality;
- Furniture and equipment in the sleeping rooms is in a good state of repair to ensure reasonable comfort and to facilitate tidiness. Separate sleeping rooms for men and women and a separate berth for each seafarer is provided in all circumstances;
- Mess rooms, sanitary facilities, hospital, recreational and catering facilities with respect to cleanliness and hygiene;
- Measures implemented for monitoring and maintenance of conditions in respect of noise and vibration levels as specified in the national requirements;
- Laundry facilities with respect of maintenance and equipment;
- Mosquito protection devices on ships regularly trading to mosquito-infested areas with respect of state of repair and functionality;
- Recreational facilities, amenities and services provided as required by the flag Administration;
- Records of inspections carried out on board ships, by or under the authority of the master, to ensure that seafarers’ accommodation is clean, decently habitable and maintained in a good state of repair and results of these inspections.

9. On-board recreational facilities (Reg. 3.1)

General

Regulation 3.1 requires that decent recreational facilities on board are provided for seafarers working or living on board, consistent with promoting the seafarers' health and well-being.

Refer to section 8 (Accommodation) for basic requirements for inspection, how to check basic requirements, and examples of deficiencies in recreational facilities.

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Provision of on-board recreational facilities;

- Frequent inspection of on-board recreational facilities under the authority of the master and the records to be maintained.

Guidance for Inspection

When carrying out on-board inspection, the inspector should ascertain that on-board recreational facilities are maintained in a clean and hygienic condition, and maintained in a good state of repair. The inspector should sample records of shipboard inspections, by the master or his designee, to confirm ongoing compliance with the national requirements relative to these facilities is being maintained.

10. Food and catering (Reg. 3.2)

General

Regulation 3.2 requires that seafarers have access to free of charge good quality food and drinking water provided under regulated hygienic conditions and that they are of appropriate nutritional value and quantity that adequately covers the requirements of the ship and takes into account the differing cultural and religious backgrounds. The ships' cooks employed with the responsibility for food preparation should be trained and qualified for their position.

Inspected and certified

Basic requirements

- *Food and drinking water must be of appropriate quality, nutritional value and quantity, taking into account the requirements of the ship and the differing cultural and religious backgrounds of seafarers on the ship.*

- *Food is to be provided free of charge to seafarers during the period of engagement.*

- *Seafarers employed as ship's cooks* with responsibility for preparing food must be trained and qualified for their positions.*

- *Seafarers employed as ship's cooks* must not be less than 18 years old (Standard A3.2, paragraph 8).*

- *Frequent and documented inspections of food, water and catering facilities are carried out by the master or a designate (Standard A3.2, paragraph 7).*

* *"Ship's cook" means a seafarer with responsibility for food preparation (Regulation 3.2, paragraph 3; Standard A3.2, paragraphs 3 and 4)*

How to check the basic requirements

- *Check documents (see Regulation 1.1 on minimum age) to confirm that ship's cooks are 18 years old or older and that the ship's cooks are trained, qualified and competent for their positions in accordance with national requirements. In cases where a fully qualified cook is not required, check that seafarers processing food in the galley are trained or instructed on food and personal hygiene and handling and storage of food on board ships.*

- *Check on-board records to confirm that frequent and documented inspections are made of:*

    - *supplies of food and drinking water;*

    - *spaces used for handling and storage of food;*

    - *galleys and other equipment used in the preparation and service of meals;*

    - *visual observation of catering facilities, including galleys and store rooms, to check that they are hygienic and fit for purpose.*

- *Check that food and drinking water are of an appropriate quality (for example, not out of date) and quantity and nutritional value by:*

- *checking drinking water quality and ascertaining how the quality is monitored;*
- *reviewing menu plans together with visual observation of food supplies and storage areas to ensure that the food supplied is varied in nature.*

- *Check, by interviewing, in private, a representative number of seafarers, that they are not charged for food and are provided with drinking water and that food and drinking water are of appropriate quality and quantity.*

Example of deficiencies

- *Food and drinking water are not of appropriate quality, nutritional value and quantity, for the seafarers on the ship.*
- *Seafarer is charged for food and/or is not provided with drinking water.*
- *Seafarer who has responsibility for preparing food or water or the preparation /storage/handling areas are not being carried out.*
- *Ship's cook is not trained and qualified.*
- *Ship's cook is under 18 years of age.*
- *Frequent and documented inspections of the food or water or the preparation /storage/handling areas are not being carried out.*
- *Catering facilities are not hygienic or are otherwise unfit for purpose.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Quantity, nutritional value, quality and variety of food and water;
- Organization and provision of suitable equipment;
- Age verification of cooks and training and qualifications of catering staff;
- Frequent documented inspections;
- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The following areas should be inspected, and compliance with the national requirements ascertained by means of private interviews, review of documentation and physical inspection of facilities, as appropriate to verify proper implementation of the convention requirements on board:

- Inventory of food and drinking water and related records;
- Drinking water quality tests and schedule of the inspections and their records;

- Seafarers menus to verify that the food supplied is varied in nature;
- Inspection records (accommodation, mess-rooms, galleys, food storage areas, etc.);
- Galley and mess-rooms maintenance records;
- Training certificates and records for the ship's cook(s) and catering staff;
- Records for demonstrating age of ship's cook(s).

Inspectors should be aware that a cook is required to be on board where the prescribed manning is 10 or more seafarers. In exceptional cases, the flag State may issue a dispensation permitting a non-qualified cook for a limited period, not to exceed one (1) month. Where such permission is granted, the inspector should verify that the dispensation issued by the flag State is valid and relevant personnel have been trained or instructed in handling and storage of food, and personnel hygiene.

11. Health and safety and accident prevention (Reg. 4.3)

General

Regulation 4.3 sets out requirements to ensure that seafarers' work environment on board ships promotes occupational safety and health. The purpose of this regulation is to ensure that seafarers on ships are provided with occupational health protection and live, work and train on board ship in a safe and hygienic environment.

Inspected and certified

Basic requirements

- *The working, living and training environment on ships must be safe and hygienic and conform to national laws and regulations and other measures for occupational safety and health protection and accident prevention on board ship. Reasonable precautions should be taken to prevent occupational accidents, injuries and diseases on board ship, including measures to reduce and prevent the risk of exposure to harmful levels of ambient factors and chemicals as well as the risk of injury or disease that may arise from the use of equipment and machinery on board ships (Standard A4.3, paragraph 1(b)).*

- *Ship must have an occupational safety and health policy and program to prevent occupational accident injuries and diseases, with a particular concern for the safety and health of seafarers under the age of 18 (Standard A4.3, paragraphs 1(c) and 2(b)).*

- *A ship safety committee, that includes participation by the seafarer safety representative, is required (for ships with five or more seafarers) (Standard A4.3, paragraph 2(d)).*

- *Risk evaluation is required for on-board occupational safety and health management (taking into account relevant statistical data) (Standard A4.3, paragraph 8).*

How to check the basic requirements

- *Check relevant documents, such as the on-board occupational accident reports, and the reports of risk evaluations undertaken for the management of occupational safety and health on the ship.*

- *Check documents evidencing membership and meetings of the safety committee (e.g. records and minutes of the meetings, etc) if the ship has more than five seafarers.*

- *Check documents related to the ship's on-board ongoing occupational safety and health policy and program, to confirm that:*

    - *it is available to seafarers;*

    - *it is consistent with national provisions;*

    - *it includes risk evaluation, training and instruction for seafarers;*

    - *it pays special attention to the health and safety of young seafarers;*

    - *adequate preventive measures are being taken;*

- *appropriate personal protective equipment is being used and maintained correctly.*

- *Check that relevant occupational safety and health and accident prevention notices and official instructions with respect to particular hazards on the ships are posted on the ship in a location that will bring it to the attention of seafarers (Standard A4.3, paragraph 7).*

- *Check that appropriate protective equipment is available for seafarers to use.*

- *Check that a reporting procedure for occupational accidents is in place.*

- *Interview, in private, a representative number of seafarers to confirm on-board occupational safety and health programs and practices.*

- *Check that, with respect to health and safety protection and accident prevention, special consideration is given to any national requirements covering:*

  - *the structural features of the ship, including means of access and asbestos related risks;*

  - *machinery;*

  - *the effects of the extremely low or high temperature of any surfaces with which seafarers may be in contact;*

  - *the effects of noise in the workplace and in shipboard accommodation;*

  - *the effects of vibration in the workplace and in shipboard accommodation;*

  - *the effects of ambient factors (other than noise and vibration) in the workplace and in shipboard accommodation, including tobacco smoke;*

  - *special safety measures on and below deck;*

  - *loading and unloading equipment;*

  - *fire prevention and fire-fighting;*

  - *anchors, chains and lines;*

  - *dangerous cargo and ballast;*

  - *personal protective equipment for seafarers;*

  - *work in enclosed spaces;*

  - *physical and mental effects of fatigue;*

  - *the effects of drug and alcohol dependency;*

  - *HIV/AIDS protection and prevention;*

  - *emergency and accident response.*

Examples of deficiencies

- *Conditions exist on board which may impair efforts to prevent accidents.*
- *No evidence of an on-board policy and/or programs for the prevention of occupational accidents, injuries and diseases.*
- *No established or functioning ship's safety committee when there are five or more seafarers working on board.*
- *Personal protective equipment is in poor condition or being incorrectly used or not being used.*
- *Risk assessments are missing.*
- *Seafarers are unaware of the measures adopted by the management to provide OSH and to prevent accidents.*
- *Risks posed to young seafarers have not been addressed.*
- *Occupational accidents are not being investigated or reported in accordance with the ship's procedures.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I:

- Occupational safety and health policies;
- On-board program for the prevention of occupational accidents, injuries and diseases with special attention being paid to the safety and health of seafarers under the age of 18;
- Procedure for investigating and reporting on-board occupational accidents;
- Risk evaluation procedure in relation to management of occupational safety and health;
- List of hazardous works;
- Appointment of safety representative on board the ship;
- Ship's safety committee;
- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should verify that the shipowner has carried out a risk assessment of all possible hazards, and the seafarers are provided with appropriate occupational health protection, and a safe and hygienic environment.

The inspector should verify that health and safety policy, and occupational health and safety programs are implemented on board with special attention being paid to seafarers under the age of 18.

When dangerous goods are carried on board, the inspector should verify that adequate additional protection equipment is available on board in accordance with the national requirements.

The inspectors should verify that the shipowner has undertaken investigations into the causes and circumstances of all occupational accidents, injuries and diseases, and they are reported in accordance with the company's procedures and national requirements.

During inspection, the inspector should pay special attention to the following areas:

- Machinery is adequately guarded where necessary;
- Safe operating instructions are clearly displayed;
- Safety signs are clearly displayed;
- Permits-to-work system is used when necessary;
- Seafarers are wearing necessary protective clothing, and have proper equipment suitable for the task;
- Protective clothing and equipment are in good condition and being correctly used;
- Activities of the safety committee to confirm that it is functional.

12. On-board medical care (Reg. 4.1)

General

Regulation 4.1 sets out requirements for medical care of seafarers while they are employed on board ship. The purpose of this regulation is to protect the health of seafarers and ensure their prompt access to medical care on board ship and ashore.

Inspected and Certified

Basic requirements

- *Seafarers must be covered by adequate measures for the protection of their health and have access to prompt and adequate medical care, including essential dental care, whilst working on board.*

- *Health protection and care are to be provided at no cost to the seafarer, in accordance with national law and practice.*

- *Shipowners are to allow seafarers the right to visit a qualified medical doctor or dentist without delay in ports of call, where practicable (Standard A4.1, paragraph 1(c)).*

How to check the basic requirements

- *Check documents (such as the SEA) to confirm that, to the extent consistent with national law and practice, medical care and health protection services while seafarers are on board ship or landed in a foreign port, are provided free of charge (see Standard A4.1, paragraph 1(d)).*

- *Check documents (such as the SEA) to confirm that seafarers are given the right to visit a qualified medical doctor or dentist, without delay, when calling at a port, where practicable (see Standard A4.1, paragraph 1(c)).*

- *Check records and equipment to confirm that general provisions on occupational health protection and medical care are being observed (Standard A4.1, paragraph 1(a)).*

- *Undertake visual observation to confirm that the ship is equipped with sufficient medical supplies including a medicine chest and equipment, including either the most recent edition of the International Medical Guide for Ships or a medical guide as required by national laws and regulations.*

- *Check documents (such as the SMD and crew list) to confirm that a qualified medical doctor is working on board ships that carry 100 or more people and that are ordinarily engaged in voyages of more than three days' duration.*

- *Check that, where ships are not required to carry a medical doctor, they have at least one seafarer on board (who is trained and qualified to the requirements of STCW) to be in charge of medical care or is competent to provide medical first aid as part of their regular duties.*

- *Check that medical report forms are carried on board the ship.*

- *Interview, in private, a representative number of seafarers to confirm that seafarers have access to medical care on board without charge and are given leave to obtain medical and dental care services when calling in a port, where practicable.*

- *Check that procedures are in place for radio or satellite communications for medical assistance.*

Examples of deficiencies

- *A seafarer working on the ship is denied, without justification, shore leave by the master and/or shipowner to go ashore for medical or dental care.*
- *A seafarer is not provided with appropriate health protection and medical care on board ship.*
- *Medical personnel, with appropriate qualifications, as required by national laws or regulations, are not on board.*
- *Medical chest or equipment does not meet national standards and/or no medical guide is on board.*
- *No medical report forms are on board.*
- *Evidence that a seafarer is being charged for medical or dental care, contrary to national law or practice.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Coverage of medical care including dental care (reference could be made in SEA(s) and complementary documents);
- Use of medical report form;
- Maintenance of medical chest and equipment in accordance with the national requirements;
- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should verify that the shipowner provides medical and essential dental care for seafarers in accordance with the national requirements of its flag State and the SEA/CBA. These services are generally provided free of charge when the seafarer is on board or landed in a foreign port.

The inspector should sample SEA, qualifications and required number of medical care providers on board, medical logs, medical chest, medical equipment, ship's hospital, medical publications, medical reports, radio and satellite communication procedures, etc. to confirm that the flag State requirements have been complied with.

13. On-board complaint procedures (Reg. 5.1.5)

General

Regulation 5.1.5 sets out requirements for on-board complaint procedure for seafarers that are employed on board a ship. The purpose of this regulation is to provide a mechanism by which seafarers can file their grievances and complaints to the master, shipowner, and relevant external authorities such as the competent authority in the flag State.

Inspected and certified

Basic requirements

- *Ships must have on-board procedures for the fair, effective and expeditious handling of seafarer complaints alleging breaches of the requirements of the MLC, 2006 (including seafarers' rights).*

- *All seafarers must be provided with a copy of the on-board complaint procedures applicable on the ship. This should be in the working language of the ship.*

- *Victimization of seafarers for filing complaints under the MLC, 2006, is prohibited.*

How to check the basic requirements

- *Check the document outlining the on-board complaint procedures to confirm that the procedures are functioning on the ship, paying particular attention to the right of representation and to the required safeguards against victimization.*

- *Check that seafarers are provided with a copy of the on-board complaint procedures in the working language of the ship.*

- *Check a document outlining the on-board complaint procedures to confirm that seafarers are able to complain directly to the ship's master or an external authority.*

- *Interview, in private, a representative number of seafarers to confirm that seafarers are given a copy of the procedures and that they are able to complain directly to the ship's master or an external authority and that there is no victimization.*

Examples of deficiencies

- *No document setting out the on-board complaint procedures.*

- *Ship's on-board complaint procedures are not operating.*

- *Victimization of a seafarer for making a complaint.*

- *Seafarer is not provided with a copy of the complaint procedures in the working language of the ship.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements of the flag State relative to on-board complaint procedures.

A copy of on-board complaint procedure should be requested at the time of DMLC Part II review to verify that it:

- Seeks to resolve complaints at the lowest possible level;

- Provides the right of the seafarer to complain directly to the master and/or external authorities;

- Provides the right of the seafarer to be accompanied or represented;

- Provides for safeguards against the possibility of victimization;

- Includes contact information of the competent authority in the flag State and where different, in the seafarer's country of residence;

- Includes names/positions of person or persons who can, on confidential basis, provide seafarers with impartial advice and assist them in following the complaint procedures;

- Any other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should verify that the seafarers are provided with a copy of on-board complaint procedures in the working language of the ship, and that the seafarers are familiar with these procedures, including their rights and responsibilities. The inspector should confirm, through private interviews, that seafarers are aware of their ability to complain directly to the master and/or external authorities.

14. Payment of wages (Reg. 2.2)

General

Regulation 2.2 sets out requirements for payment of seafarers wages. All seafarers should be paid for their work regularly in full and in accordance with their employment agreements. Seafarers must be paid at no greater than monthly intervals.

Inspected and certified

Basic requirements

- *Seafarers must be paid at no greater than monthly intervals and in full for their work in accordance with their employment agreements.**
- *Seafarers are entitled to an account each month indicating their monthly wage and any authorized deductions such as allotments.*
- *No unauthorized deductions, such as payments for travel to or from the ship.*
- *Charges for remittances/allotment** transmission services must be reasonable and exchange rates in accordance with national requirements.*

* *Flag States may wish to consider requiring shipowners to carry on board their ships' documents such as a copy of payroll or electronic record sheets.*

** *An allotment is an arrangement whereby a proportion of seafarers' earnings are regularly remitted, on their request, to their families or dependants or legal beneficiaries whilst the seafarers are at sea (Standard A2.2, paragraphs 3 and 4).*

How to check the basic requirements

- *Check the SEA and documentation, such as the payroll records to confirm wages are being paid at intervals no greater than one (1) month as specified in their SEA or relevant collective agreements.*
- *Check relevant documents showing service charges and exchange rates applied to any remittances made to the seafarers' families or dependants or legal beneficiaries at their request.*
- *Check relevant documents to confirm the payment of wages including the requirement that a monthly account (such as a wage slip) is provided to the seafarers. Copies of individual accounts should be available to inspectors at their request.*
- *Check that the wages set out in the SEA are consistent with national wages for seafarers, if national laws or regulations or collective bargaining agreements governing seafarers' wages have been adopted.*
- *Interview, in private, a representative number of seafarers to confirm compliance with requirements on the payment of wages.*

Examples of deficiencies

- *A seafarer is not paid regularly (at least monthly) and in full in accordance with the national legislation (DMLC Part I), SEA or CBA.*

- *A seafarer is not given a monthly account (such as a wage slip) of wage.*
- *Allotments are not being paid or are not being paid in accordance with the seafarer's instructions.*
- *Charge for converting and transmitting currencies is not in line with national requirements.*
- *More than one set of wage accounts is in use.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- Procedure for payment of wages, including intervals at which they are paid;
- Remittance/allotment requested by seafarers and application of exchange rate/service charge(s), if any;
- other relevant requirements of the flag State, including any substantially equivalent provisions, if any.

Guidance for Inspection

The inspector should check through documentary evidence and private interviews with representative number of seafarers that seafarers receive their wages regularly at the specified interval. The amount of the paid monthly wage should correspond to the agreed sum or as per calculation method defined in the SEAs.

The inspectors should verify through documentary inspection and private interviews that all seafarers are given wage slips at least monthly, either in hard copy or in electronic form, indicating all allotments and deductions, if any. No unauthorized deductions are allowed.

The inspector should verify that the requirements of national laws, SEAs and CBAs regulating the wages are met.

15. Financial security for repatriation (Reg. 2.5)

General

Regulation 2.5 sets out requirements for establishing an expeditious and effective financial security system which shall provide direct access, sufficient coverage and expedited financial assistance to any abandoned seafarer. The system may be in the form of a social security scheme or insurance or a national fund or other similar arrangements.

Inspected and certified

Basic requirements

- *A certificate or other documentary evidence of financial security for seafarers repatriation, issued by a financial security provider, is carried on board.*

- *A copy of the document(s) is posted in a conspicuous place on board where it is available to seafarers.*

How to check the basic requirements

- *Check that the document(s) of financial security for seafarers repatriation is carried on board and a copy of it is available to seafarers.*

Examples of deficiencies

- *Absence of or invalid document(s) of financial security.*

- *The document has not been posted in a conspicuous place on board where it is available to seafarers.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- The carriage on board of a valid document(s) confirming that the shipowner provides financial security for seafarers' repatriation.

Note:

The named shipowner on the financial security certificate (the same as the owner named in the IMO Liability Conventions i.e. Bunkers Convention, Wreck Removal Convention, Athens Convention, Civil Liability Convention) may be different to the person or entity named on the DMLC. It is because the P&I clubs cannot issue certificates to persons or entities that are not named on the P&I club entry, in other words to a third person who has no relationship with the P&I club. Where a financial security certificate is issued by one of the 13 member clubs comprising the International Group of P&I Clubs such certificates should be accepted as bona fide evidence of the shipowners financial security.

Guidance for Inspection

The inspector should verify that the document or documents (where more than one financial security provider provides cover) confirming financial security for seafarers repatriation issued by the financial security provider(s) is carried on board and a copy of the document(s) is

posted in a conspicuous place on board where it is available to the seafarers. The document(s) shall be in English or be accompanied by an English translation and contain the following information:

- Name, port of registry, call sign and IMO number of the ship;
- Name and address of the provider(s) of the financial security;
- Contact details of the person or entity responsible for handling seafarers' requests for relief;
- Name of the shipowner;
- Period of validity of the financial security;
- An attestation from the financial security provider(s) that the financial security meets the requirements of Standard A2.5.2 and/or the flag State, as appropriate.

16. Financial security relating to shipowners' liability (Reg. 4.2)

General

Regulation 4.2 sets out requirements for the provision of a system of financial security to ensure compensation for contractual claims related to death or long term disability of seafarers due to an occupational injury, illness or hazard as set out in national law, the seafarers' employment agreement or collective agreement. The system may be in the form of a social security scheme or insurance or fund or other similar arrangements.

Inspected and certified

Basic requirements

- *A certificate or other documentary evidence of financial security issued by a financial security provider is carried on board.*

- *A copy of the document(s) is posted in a conspicuous place on board where it is available to seafarers.*

How to check the basic requirements

- *Check that the document(s) of financial security is carried on board and a copy of it is available to seafarers.*

Examples of deficiencies

- *Absence of or invalid document(s) of financial security.*

- *The document is not posted in a conspicuous place on board where it is available to seafarers.*

Items for review of DMLC Part II

Check that the DMLC Part II has measures to ensure initial and on-going compliance with the requirements in accordance with the flag State's DMLC Part I for:

- The carriage on board of a valid document(s) confirming that the shipowner provides financial security to assure compensation for the consequences of seafarers sickness, injury or death while they are serving under a SEA or arising from their employment under such agreement.

Note:

The named shipowner on the financial security certificate (the same as the owner named in the IMO Liability Conventions i.e. Bunkers Convention, Wreck Removal Convention, Athens Convention, Civil Liability Convention) may be different to the person or entity named on the DMLC. It is because the P&I clubs cannot issue certificates to persons or entities that are not named on the P&I club entry, in other words to a third person who has no relationship with the P&I club. Where a financial security certificate is issued by one of the 13 member clubs comprising the International Group of P&I Clubs such certificates should be accepted as bona fide evidence of the shipowners financial security.

Guidance for Inspection

The inspector should verify that the document or documents (where more than one financial security provider provides cover) confirming seafarers protection from financial consequences of sickness, injury or death occurring in connection with their employment issued by the financial security provider(s) is carried on board and a copy of the document(s) is posted in a conspicuous place on board where it is available to the seafarers. The document(s) shall be in English or be accompanied by an English translation and contain the following information:

- Name, port of registry, call sign and IMO number of the ship;
- Name and address of the provider(s) of the financial security;
- Contact details of the person or entity responsible for handling seafarers' requests for relief;
- Name of the shipowner;
- Period of validity of the financial security;
- An attestation from the financial security provider(s) that the financial security meets the requirements of Standard A4.2.1 and/or the flag State, as appropriate.

Inspection only items

General guidance

“Inspections only” items are not required to be addressed in DMLC Part I, but must be inspected as per the Guidelines for the flag State inspections under the Maritime Labour Convention, 2006. Where a flag State has included “inspection only” items in their DMLC Part I, the inspector should verify that the corresponding requirements of the flag State have been addressed in the shipowner’s DMLC Part II.

17. Entitlement to leave (Reg. 2.4)

General

Regulation 2.4 sets out requirements for ensuring that the seafarers have adequate leave, and that they are granted shore leave to benefit their health and well-being.

Inspected

Basic requirements

- *Seafarers must be allowed paid annual leave* in accordance with national laws and regulations implementing the MLC, 2006.*
- *Unauthorized agreements to forgo the minimum annual leave with pay are prohibited (Standard A2.4, paragraph 3).*
- *Seafarers are to be granted shore leave to benefit their health and well-being and consistent with the operational requirements of their positions.*

* *The MLC, 2006, allows for differing calculations but establishes a minimum annual paid leave calculated on the basis of 2.5 calendar days per month of employment. In addition to the minimum period of annual leave, seafarers may also be entitled to a number of public and customary holidays recognized by the flag State. This is regardless of whether they fall within the individual seafarer's period of annual leave. For additional guidance see Guideline B2.4.1, paragraph 4.*

How to check the basic requirements

- *Check documents, such as the national legislation (DMLC Part I), SEA or the relevant collective agreement, to confirm that seafarers are provided with the annual leave with pay entitlement required by the flag State (at a minimum, to be calculated on the basis of 2.5 calendar days per month of employment).*
- *Check that seafarers' employment and wage records confirm that this requirement is met.*
- *Interview, in private, a representative number of seafarers to confirm that they receive paid annual leave and are allowed an appropriate level of shore leave by the shipowner.*

Examples of deficiencies

- *Seafarer is not given paid annual leave.*
- *Seafarer who has an annual leave entitlement that is less than the national requirement (if more than 2.5 calendar days per month) or less than 2.5 calendar days per month of employment.*
- *Seafarer does not have an entitlement to paid annual leave in the SEA.*
- *Seafarer has agreed to forgo minimum annual leave with pay (and the competent authority has not authorized the agreement) (Standard A2.4, paragraph 3).*

- *Seafarer not allowed shore leave (although leave would be consistent with operational requirements of the seafarer's position).*

Guidance for Inspection

Inspectors should verify that seafarer employment agreements have provisions of paid annual leave in their SEA/CBA which cannot be less that the entitlement to leave prescribed under the national requirements of the flag State. Inspectors should note that the Convention prohibits agreements to forgo the minimum annual leave except in cases where such arrangements are authorized by the competent authority in the flag State. In such cases, inspectors should verify that proper documentation authorizing such agreements is available on board.

18. Repatriation (Reg. 2.5)

General

Regulation 2.5 sets out requirements and entitlement for repatriation of seafarers, and obligation of the shipowner for seafarers' repatriation and provision of financial security.

Inspected

Basic requirements

- *Seafarers are to be repatriated, at no cost to themselves, in accordance with the national provisions implementing the MLC, 2006.*

- *Shipowners are required to provide financial security to ensure that repatriation will occur. Regulations related to financial security documents are addressed in the inspection and certification requirements – see section 15. Financial security for repatriation.*

- *A copy of the applicable national provisions regarding repatriation must be carried on ships and available to seafarers in an appropriate language (Standard A2.5, paragraph 9).*

- *At a minimum seafarers are entitled to repatriation in the following circumstances:*

  - *if the SEA expires while they are abroad;*

  - *when their SEA is terminated:*

    - *by the shipowner; or*
    - *by the seafarer for justified reasons; and*

- *when the seafarers are no longer able to carry out their duties under their employment agreement or cannot be expected to carry them out in the specific circumstances (Standard A2.5, paragraphs 1 and 2).*

How to check the basic requirements

- *Check that a copy of the national provisions or SEA or relevant CBA regarding repatriation is available (in an appropriate language) to seafarers.*

- *Check for compliance with any national provision that seafarers under the age of 18 are to be repatriated after a prescribed period if it is apparent that they are unsuited to a career at sea (Guideline B2.5.2, paragraph 3).*

Examples of deficiencies

- *Seafarer is not repatriated in accordance with national requirements, or SEA or CBA.*

- *Ship does not have a copy of the national provisions on repatriation on board and accessible to seafarers.*

- *No provision for seafarer repatriation is in place.*

Guidance for Inspection

The inspector should verify during shipboard inspection that the seafarer's entitlement to repatriation is identified in the SEA. Additionally, the repatriation is required to be inspected under the Flag State Guidelines for Maritime Labour Convention, 2006.

19. Shipowners' liability (Reg. 4.2)

General

Regulation 4.2 sets out requirements for protecting the seafarers from the financial consequences of sickness, injury or death occurring in connection with their employment.

Inspected

Basic requirements

- *Seafarers have a right to material assistance and support from the shipowner with respect to the financial consequences of sickness, injury or death occurring while they are serving under a SEA or arising from their employment under such agreement.*

- *Shipowners are liable to defray the expense of medical care, including medical treatment and the supply of the necessary medicines and therapeutic appliances, and board and lodging away from home until the sick or injured seafarer has recovered, or until the sickness or incapacity has been declared of a permanent character (Standard A4.2, paragraph 1(c)).*

- *Shipowners are to provide financial security to assure compensation in the event of the death or long-term disability of seafarers due to an occupational injury, illness or hazard, as set out in national law, the SEA or CBA (Standard A4.2, paragraph 1(b)). Regulations related to financial security documents are addressed in the inspection and certification requirements – see section 16. Financial security relating to shipowners' liability.*

- *Measures are to be taken to safeguard the property of seafarers left on board by sick, injured or deceased seafarers (Standard A4.2, paragraph 7).*

How to check the basic requirements

- *Check the SEA and/or relevant CBA to verify that seafarers have the coverage required by national law implementing the MLC, 2006.*

- *Check for on-board procedures with respect to property that is left on board by sick, injured or deceased seafarers.*

Examples of deficiencies

- *No information on coverage in the SEA or relevant CBA.*

- *Provisions in the SEA or CBA are not consistent with national requirements implementing the MLC, 2006.*

- *No procedures are in place to safeguard seafarers' property left on board.*

Guidance for Inspection

The inspector should verify that the measures are in place for protecting properties left on board by sick, injured and deceased seafarers.

20. Social security (Reg. 4.5)

General

Regulation 4.5 requires that measures are taken with a view to providing seafarers with access to social security protection as specified under the national requirements. This protection is considered complementary to protection provided under other areas of the Convention.

Inspected

Basic requirements

- *Seafarers who are subject to the flag State's social security legislation, and, to the extent provided for in its national law, their dependants, are entitled to benefit from social security protection no less favorable than that enjoyed by shore workers.*

Note: *The MLC, 2006, requires that all seafarers be provided with social protection. This covers a number of complementary requirements including prevention-based approaches in connection with occupational safety and health, medical examinations, hours of work and rest and catering. Social protection is mainly addressed in the Title 4 with respect to Medical care (Regulation 4.1); Shipowners' liability (Regulation 4.2); and Social security (Regulation 4.5). Regulation 4.5 and the related Standard A4.5 reflect an approach that recognizes the wide range of national systems and schemes and differing areas of coverage with respect to the provision of social security. Under Standard A4.5, paragraph 3, a ratifying country is required to "take steps according to its national circumstances to provide the complementary social security protection referred to in paragraph 1 of this Standard to all seafarers ordinarily resident in its territory". The resulting protection must be no less favourable than that enjoyed by shore workers resident in its territory. The main responsibility of flag States is to ensure that the shipowners' social security obligations are respected for seafarers on their ships, particularly those set out in Regulations 4.1 and 4.2 (see Standard A4.5, paragraph 5). A more general duty, referred to in Standard A4.5, paragraph 6, and Guideline B4.5, paragraph 5, is also applicable to flag States. ILO member States are to give consideration to ways in which comparable benefits could be provided to seafarers who do not have adequate social security coverage and to possibly themselves arrange for the needed protection to be provided. This responsibility reflects the fact that all States have an important role in promoting the protection of all seafarers and in cooperating to help ensure such protection. In this way flag States can make an important contribution to the achievement of adequate social security protection for seafarers worldwide. In the context of flag State inspection of ships the main concern lies with confirming the complementary protection to be provided by shipowners and stated in the SEA (Standard A2.1, paragraph 4(h)).*

How to check the basic requirements

- *Check for evidence that, for seafarers covered by the national social security system, the appropriate contributions are being made if it is a contributory system.*

- *Check the SEA to confirm the protection to be provided by the shipowner.*

- *Interview, in private, a representative number of seafarers to confirm that mandatory contributions, if any, are made.*

Examples of deficiencies

- *No information on protection in the SEA.*

- *Mandatory contributions are not being made.*

Guidance for Inspection

The inspector should be aware that social security protection is primarily the responsibility of the labour supplying country for seafarers ordinarily resident in their territory and is complementary to the benefits provided under Regulation 4.1 (Medical care) and Regulation 4.2 (Shipowners' liability). The flag State may elect to provide certain social security protection benefits to those seafarers who serve on their ships in the absence of adequate coverage regardless of their residence in accordance with its national law and practice. In such cases, the inspector should verify that the social security protection benefits as specified by the flag State and/or in the SEA/CBA are being provided and any contributions, if applicable, are being made.

21. General principles (Reg. 5.1.1)

General

Standard A5.1.1 of the Maritime Labour Convention, 2006 requires that all ships have a copy of the Convention available on board.

Inspected

Basic requirements

- *Ships are required to have a copy of the MLC, 2006, available on board.*

How to check the basic requirements

- *Check to confirm that there is a copy of the MLC, 2006, on board.*

Examples of deficiencies

- *No copy of the MLC, 2006, on board.*

Guidance for Inspection

Inspector should verify that the current copy of the Convention is available on board, either in hard copy or electronic format and accessible to all seafarers on board.

Part II

General guidance

22. Inspection process

1) Review of the DMLC Part II and inspection

Background

The Maritime Labour Convention, 2006, Regulation 5.1.3 requires a DMLC to be established for each ship and it must be reviewed and certified by a flag Administration or RO on behalf of the Administration.

The DMLC consists of two parts. The Part I is drawn up by the flag State and states the national requirements implementing the Maritime Labour Convention, 2006 and any substantial equivalent provision and exemption adopted by the Administration. The DMLC Part II is drawn up by the shipowner and describes the measures the shipowner has established to implement the national requirements identified in the DMLC Part I. The DMLC Part I and II must be attached to the Maritime Labour Certificate.

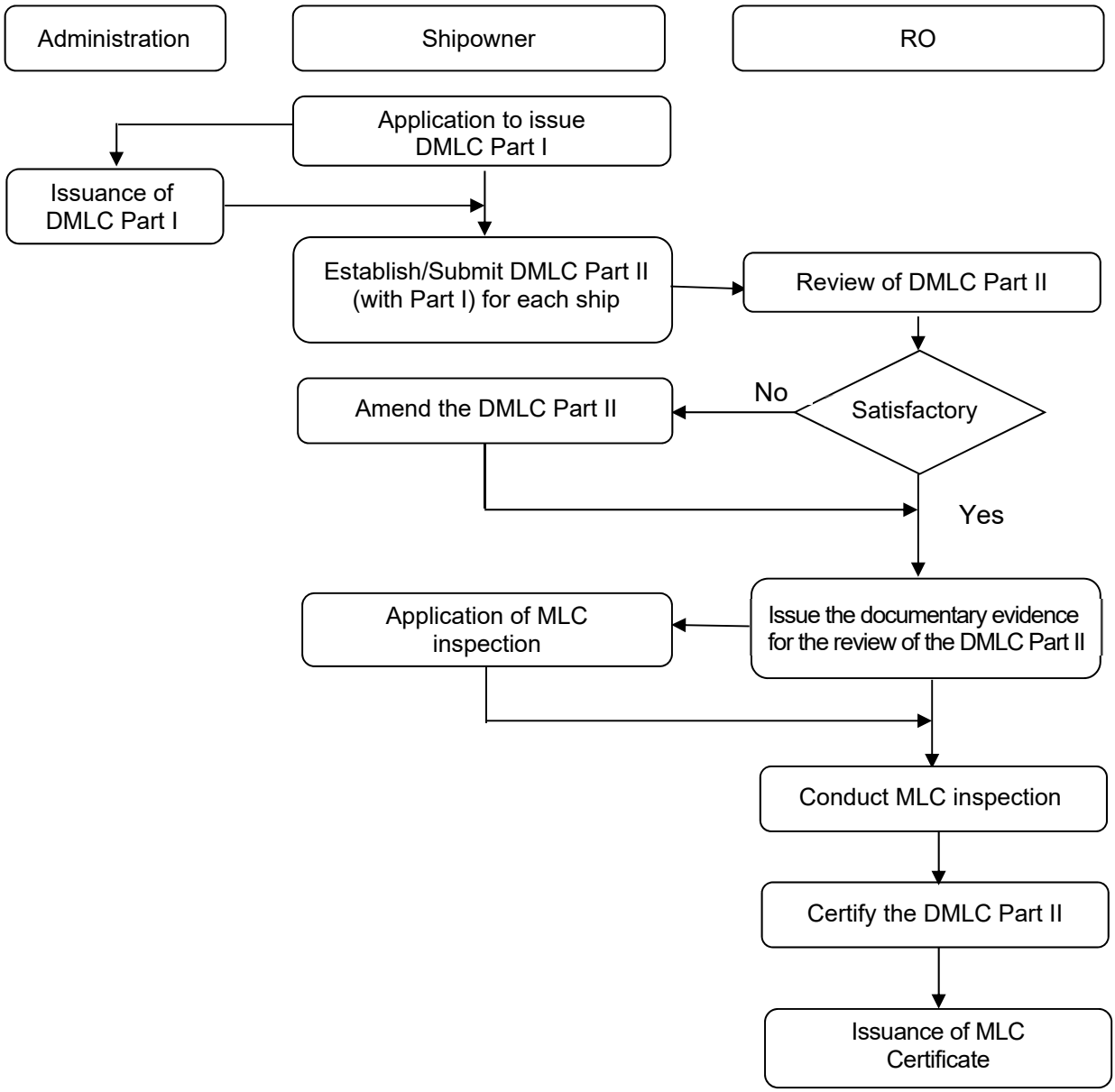
Paragraph 84 of Guidelines for flag State inspections under the Maritime Labour Convention, 2006, states that “a full inspection, including the document review, must be completed before the Maritime Labour Certificate and the attached DMLC can be issued”.

The review of DMLC Part II is conducted prior to the inspection to ensure that all national requirements are fully addressed in the DMLC Part II and associated documentation, but certified only after satisfactory completion of the inspection on board. This procedure ensures that focus of inspection is on the verification of implementation of measures already reviewed by the flag State or RO inspector and facilitates the inspection process. Unless the relevant flag State provides otherwise, the minimum implementation period of the shipowner established measures (i.e. the period between interim and initial inspection on board) shall not be less than one (1) month.

In some cases, RO may be fully authorized to carry out the DMLC Part II review and inspections. However, in other cases, a flag State may only provide partial authorization to the RO. Prior to performing any work, RO inspector should confirm the extent of authorization provided to the RO. Some examples of types of authorizations and relative review and/or inspection process are described in the flow charts below:

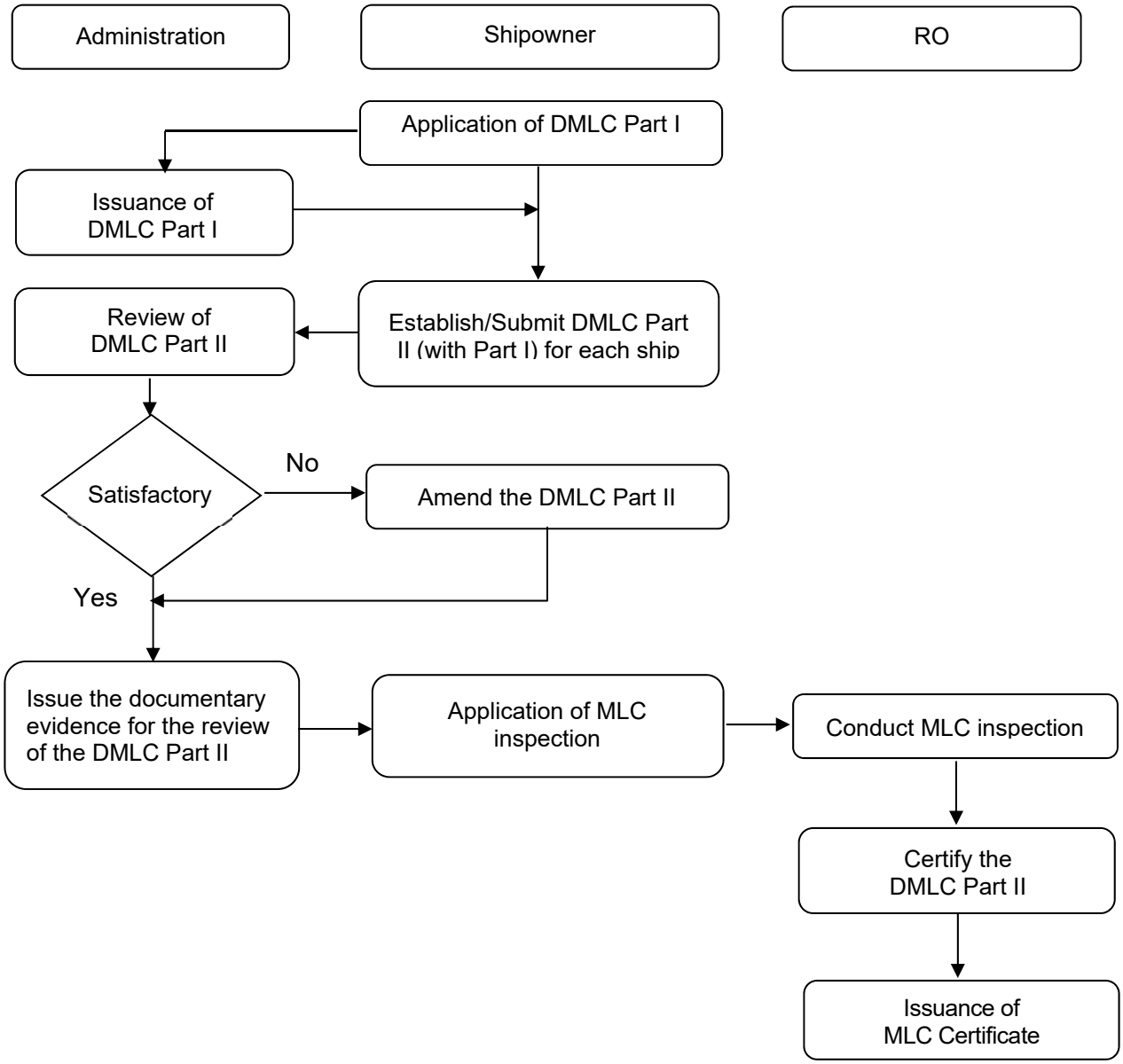
1. RO is authorized to review the DMLC Part II, carry out inspections, and issue relevant certifications.

Flow Chart



2. Flag State reviews the DMLC Part II and RO is authorized to conduct inspection and issue relevant certifications.

Flow Chart



Obligations of the shipowner

The shipowner should obtain the DMLC Part I from the competent authority in the flag State and develop the DMLC Part II identifying measures that will be implemented to ensure initial and ongoing compliance with national requirements defined in the DMLC Part I.

Once the DMLC Part II is drawn up, it should be submitted for review to the flag State or an RO authorized by the flag State for documental review. Upon satisfactory completion of review of the DMLC Part II, the shipowner should present the ship for initial inspection for verification of implementation on board. If the inspection confirms that the shipowner measures implementing the national requirements are satisfactory, the Maritime Labour Certificate will be issued and DMLC Part II certified.

Any amendments to the DMLC Part II during the certification period should be submitted to the flag State or the RO which carried out the initial review and inspection.

2) How to conduct the interview

For a satisfactory inspection to be completed, it is likely that the inspector will need to employ different methods, including document review, visual observation, general discussions with seafarers, and interviews with seafarers in private.

When inspectors are interviewing seafarers, they will need to be sensitive to what may be considered personal or potentially controversial matters, and take into account work and rest schedules of the seafarers. Interviews with seafarers should be conducted, in private, in order to preserve the confidentiality of information presented.

The manner in which an inspector initiates the interview process may well determine the success of the interview. Inspectors should be able to elicit information from the seafarers, without challenging them, to confirm that the shipowner's measures have been implemented in accordance with the national requirements implementing the Convention.

Conducting the interview

The interview should:

- have a tone that is formal, friendly, and non-threatening;

- follow a predetermined structure; and

- result in meaningful information.

An inspector should prepare a set of questions and an introductory statement that explains the purpose of the interview. This preparation will set the tone for a serious, purposeful, and effective interview.

The assessment of compliance or noncompliance should always be based on visual observation, objective evidence presented, and information obtained during interviews with seafarers using professional judgment.

3) Sampling

Paragraph 103 of the Guidelines for flag State inspections under the Maritime Labour Convention, 2006 states: "It should be noted that, whilst all the requirements of the MLC, 2006 must be inspected, any inspection is a sampling process and inspector should use their

professional judgment and expertise when determining the depth of inspection for each requirement."

The inspector may take into consideration the following factors before deciding on the extent of the sampling.

- flag State's requirements implementing the Convention;
- number of seafarers and departments on board;
- seafarers' nationality and gender;
- types of recruitment and placement services in use;
- results of previous inspections, etc.

The sampling process may be used during document review, visual observation, general discussions with seafarers, and interviews with seafarers to obtain objective evidence of compliance.

23. Interim certification

The interim certification in terms of MLC, 2006 is addressed in Standard A5.1.3 of the MLC, 2006.

The provisions in paragraphs 5 to 8 of the Standard appear to have been introduced in recognition of the fact that it is not possible to verify full and effective implementation of a set of procedures immediately following their introduction. On a new ship, or a ship that has recently been transferred from one management company to another or has changed flag, it will take time to generate sufficient evidence for a full inspection to be carried out and for an inspector to be able to draw firm conclusions about the effectiveness of the system.

Interim Maritime Labour Certificate may be issued under the following conditions:

- to new ships on delivery;
- when a ship changes flag;
- when a shipowner assumes responsibility for the operation of a ship which is new to that shipowner.

An Interim Maritime Labour Certificate may be issued for a maximum period of six (6) months. No subsequent Interim Maritime Labour Certificate may be issued.

Declaration of Maritime Labour Compliance

According to Standard A5.1.3, paragraph 7(d), the shipowner must submit to the competent authority or RO the DMLC Part II for review.

A confirmation of submission of this document should be available on board. A copy of the submitted DMLC Part II and Part I (or generic Part I) should also be available on board during the interim inspection.

24. Handling of seafarer complaints by ROs

The Maritime Labour Convention, 2006, Regulation 5.1.5 requires an On-board Complaint Procedure to be established and made available to each seafarer on board the ship. The Convention also provides seafarers with the right to complain directly to the master, and where they consider necessary, to appropriate external authorities. These external authorities may be the shipowner and the competent authorities in the flag State, the port State, or the seafarer's country of residence. In addition, On-board Complaint Procedure should contain the contact information of relevant external authorities as designated by the flag State for handling of seafarer complaints.

Guidelines for flag State inspections under the Maritime Labour Convention, 2006, paragraph 63, clearly specifies that it is the responsibility of the flag State to receive, investigate and take appropriate enforcement action for seafarer complaints. Accordingly, a flag State is expected to have in place procedures for receiving and responding to such complaints and ensuring the necessary confidentiality. A RO may in some circumstances be specifically authorized by the flag State to carry out an inspection following a particular seafarer complaint. However, the responsibility for resolution of a complaint remains with the flag State.

Where a ship is inspected under the MLC, 2006 by a RO on behalf of the flag State, a seafarer or seafarer representative may contact the RO to register a seafarer complaint.

Verbal Complaints

Where a RO receives a verbal complaint, the complainant should be referred to the on-board complaint procedure and encouraged to seek resolution of the complaint at the shipboard level. If the seafarer feels unable to use the complaints procedure (perhaps for fear of victimization or lack of faith in its effectiveness) the RO should point out that the on-board complaint procedure (a copy of which should be in the seafarer's possession) contains contact details of the competent authority in the flag State and, where different, in the seafarer's country of residence, and the name of a person or persons on board who can provide confidential assistance.

If the seafarer insists that he/she does not want to use on-board complaint procedure and would like to register the complaint with the RO, as the flag State's representative on board, the RO should not refuse to pass on a complaint to the flag State. However, the seafarer should be advised that the RO can do so only if the complaint is made in writing and signed by the complainant. Verbal complaints may be retracted or altered later giving rise to arguments about what was said and can lead to an unacceptable outcome for all parties involved in handling the complaint.

Written Complaints

Written complaints that are received should clearly specify the source of the complaint including identifying information of the shipowner, seafarer(s) and the ship involved.

The following scenarios describe the measures a RO should take subsequent to receiving a written complaint from a seafarer on a ship that has been inspected and/or certified under the Maritime Labour Convention, 2006.

1 Complaint received during a MLC inspection

If a seafarer written complaint is received during a MLC inspection, the inspector should not intervene to resolve the complaint but instead check to see if the seafarer is aware of the on-board complaint procedure and whether the seafarer has made use of the procedure. Additionally, the inspector should conduct the inspection taking into account the seafarer complaint(s) by selecting the appropriate sample size for the inspection and areas to be inspected in order to ascertain if the seafarer working and living conditions on board comply with the requirements of the Convention and the national requirements of the flag State, and whether the on-board complaint procedure is effective. Any non-compliance discovered during the inspection, including deficiencies pertaining to the seafarer complaint should be documented in the inspections report keeping in mind the confidentiality requirements of the Convention.

A written complaint provided by the seafarer should nevertheless be attached to the copy of the report submitted to the flag State.

Where the working and living conditions are alleged to be defective to the extent that a clear hazard to the safety, health or security of seafarers exists, the written complaint should be forwarded to the flag State without delay.

2 Complaint received by the RO other than during a MLC inspection

A written complaint received by the RO other than during a MLC inspection should be forwarded to the competent authority in the flag State for resolution. No further action by RO is required unless instructed otherwise by the flag State.

In summary, ROs should concern themselves only with matters of regulatory compliance that can be substantiated by objective evidence. This includes verifying the existence and satisfactory operation of on-board complaints procedures in accordance with the flag State's national requirements implementing the Convention. ROs should not discuss or attempt to resolve allegations of harassment, victimization and other complex matters or personal disputes. These should be passed to the flag State for resolution, but only when the complainant has put them in writing.

25. Handling of technical deficiencies

Definition

"Technical deficiency" means a defect in, or failure in the operation of, a part of the ship's structure or its machinery, equipment or fittings.

Guidance for inspection

When a technical deficiency is found on board, the inspector must first evaluate the seriousness of the deficiency. If the technical deficiencies affect the MLC certificate, they must be addressed and reported during the MLC inspection regardless of its seriousness.

If the technical deficiency does not relate to MLC matters, the RO should report the deficiencies to the shipowner's representative on board. Where such technical deficiencies are considered to be serious, the shipowner and the flag State should be notified without delay.

An inspector identifying a technical deficiency deemed to present a serious threat to health, safety and security of seafarers, safety of the ship or the environment or that requires attention by class or the flag Administration should:

(i) establish if the ship has taken appropriate action to correct the technical deficiency. In every case, the inspector should also establish that such technical deficiencies have been reported to the responsible Class Society and/or the flag Administration as appropriate;
(ii) establish whether the technical deficiency constitutes or is symptomatic of a serious deficiency. If so, such deficiency should be handled in accordance with the Guidance given in Section 26 of this document.

26. Grading of deficiencies

Grading of deficiencies

Where an inspector identifies that the ship is not in conformity with the requirements of the Convention and/or the relevant requirements of the flag State, the inspector should notify the shipowner or shipowner's representative. Deficiencies should be graded as follows according to their nature and seriousness.

- "Serious Deficiency" means a deficiency that constitute a serious or repeated breach of the requirements of MLC, 2006 (including seafarers' rights), or represent a significant danger to seafarers' safety, health or security.

- "Deficiency" means a deficiency other than serious deficiency and an observed situation where objective evidence indicates that the ship is not in conformity with MLC, 2006 or the relevant requirements of the flag State.

- "Observation" means a statement of fact made during an inspection substantiated by objective evidence. It may also be an identified situation which may lead to a deficiency in the future if no action is taken.

When grading the deficiency, the nature and number of findings and frequency of the deficiencies should also be taken into account: for example, several instances of deficiencies may be determined to be serious, even if they are not hazardous to the safety, health or security of seafarers. In other cases, a single deficiency could be considered as serious.

Whether or not deficiencies are determined to be **SERIOUS** will depend upon the professional judgment of the inspector concerned if:

(a) the conditions on board are clearly hazardous to the safety, health or security of seafarers; or

(b) the deficiency constitute a serious or repeated breach of the requirements of MLC, 2006 (including seafarers' rights).

Handling of deficiencies

The shipowner is responsible for the rectification of any deficiency identified by the inspector(s) within the agreed time period.

A deficiency is the record by which an inspector reports the non-compliance. The purpose of the deficiency is:

- to formally convey inspector's findings to the shipowner;

- to present a complete record of finding that can be reviewed remotely.

The content of a deficiency recorded in the report should be:

- complete and concise, containing a reference to a non-fulfilled specified requirement,

- classified against the respective requirement of the DMLC or the Convention (in case of an item that is not subject to certification and therefore not described in the DMLC),

- be written in such a manner to be easily understood by a third party which may not be present during the inspection.

Any deficiency found during the on-board inspection is to be rectified. Inspectors will need to use their professional judgment as to whether a ship should be allowed to sail before the deficiency is rectified and, if it is not rectified, to decide on what action to take. In any case, before a ship is allowed to sail and before a certificate may be issued or endorsed, the inspector needs to confirm that:

- All deficiencies found during the inspection have been rectified through immediate corrective action; or

- A rectification plan has been provided by the master or other representative of the shipowner and agreed by the inspector.

A serious deficiency may be downgraded if the inspector is satisfied that effective rectification is being taken. A serious deficiency raised during an on-board inspection must be corrected or downgraded before the ship sails and before the Maritime Labour Certificate is issued or endorsed. The Administration should be notified of all serious deficiencies whether downgraded or not at the earliest opportunity.

Where a serious deficiency has been corrected or downgraded, at least one additional inspection should be carried out within the time frame as agreed with the shipowner to verify the effectiveness of the actions that have been taken.

An additional inspection may also be required to verify the implementation of corrective actions taken in response to deficiencies, depending on the number and nature of the deficiencies identified. In such cases, the inspector should clearly specify the due date by which the additional inspection is to be held. If no additional inspection is deemed necessary, the verification of the effectiveness of the corrective actions should take place as part of the next scheduled inspection.

Any deficiency found during the inspection is to be recorded together with the overall results of the inspection. These records should, in accordance with national laws or regulations, be inscribed upon or appended to the DMLC.

All deficiencies should be formally presented by the inspector at the closing meeting. A copy of the report, including all deficiencies, should be provided to the shipowner/master. Inspectors are responsible for verification of the effective rectification of deficiencies identified during previous inspection.

Deficiencies not effectively addressed by the shipowner by its due date may be upgraded as serious deficiencies and may result in invalidation of certification.

27. Confidentiality

General

The Maritime Labour Convention, 2006 refers to the need for confidentiality in relation to several areas, but the extent of the confidentiality in each case, and the individual or organisation on which the duty of confidentiality is placed, are not always identified or explained. In some cases, the duty of confidentiality is placed on the inspector. In others, it may be the company or a particular crew-member.

The term “confidential” does not mean that information can never be disclosed or that documents can never be seen. It refers to information that should not be made public and that should be restricted to those who have a legitimate interest in its contents. In other words, confidentiality ensures that information is accessible only to those who are authorised to see it.

Confidentiality is important not only to safeguard the rights of the person or organisation to which the information relates. It is essential in creating the confidence in the company and its employees that is necessary if the inspector is to be given unrestricted access to the information he or she needs to complete an inspection.

In addition to the specific confidentiality requirements set out in the Convention, inspectors should be aware that more general privacy and data protection regulations may apply in certain jurisdictions.

In summary, the inspector must be very clear in his or her mind about which information should be treated in confidence, upon whom the duty to maintain confidentiality is placed and what the extent of the confidentiality is in terms of who should be allowed to see it.

It is important to remember that confidentiality is as much an ethical matter as it is a regulatory one.

Some Specific Cases

Standard A.5.1.4.11 forbids the inspector from disclosing commercially sensitive and personal information obtained during an inspection even after his employment by the flag or the RO comes to an end. This prohibition is presented as absolute but, clearly, the inspector cannot be prevented from informing the flag of any fact that is material to the validity of the certification.

When considering the requirement in Standards A.5.1.4.10 to treat the sources of any complaint or grievance as confidential, the inspector should also refer to Section 24 of this Guidance, especially as it applies to the submission of written complaints to the flag Administration.

An inspector is not bound by confidentiality in situations in which confidentiality is being used to conceal illegal or improper practices. All such wrong-doing should be reported to the flag Administration.

28. Ad hoc certification scenarios

For ad hoc certification scenarios refer to BCS-PR 40.

BCS-G130 Procedures for verifying that materials are asbestos free

1. New Building Shipyards

1.1 As per BCS-I SC249, the RO should verify that the shipyard has established written procedures for purchasing and controlling the supply of asbestos free material, equipment and components, which contain:

- supplier evaluation and selection methods,
- asbestos free verification practices for supplied products, and
- issuance of an asbestos-free declaration by the manufacturer/supplier as supporting documentation.

1.2 As per BCS-I SC249, the RO should randomly verify that material, equipment and components are supplied with asbestos free declarations.

1.3 As per BCS-I SC249, the shipyard, repair yard and equipment manufacturer/ supplier should provide the RO with an asbestos-free declaration and relevant supporting documentation by the manufacturer/supplier prior to delivery of every vessel. (Example form is attached in Annex 1)

1.4 As per BCS-I SC249, the RO should review this documentation during initial surveys of Passenger or Cargo Ship Safety Construction certificates and Cargo Ship Safety Equipment certificates.

2. Ships in Service

2.1 The RO should verify that the owner or management company has established written procedures for purchasing and controlling the supply of asbestos free material and components for repairs, modifications and maintenance.

2.2 The procedures may be part of the Safety Management System (SMS) Manual and should require:

- asbestos free verification methods for supplied products.

2.3 The owner or management company should make available to the RO all asbestos-free declarations for new material, equipment and components (Annex 2) and an overall declaration of the vessel (Annex 3).

"Manufacturer/Supplier" means a company which provides products, which may be a manufacturer, trader or agency. Such company should establish a company policy*. The company policy on the management of the chemical substances in products which the manufacturer/supplier manufactures or sells should cover:
.1 Compliance with law:
The regulations and requirements governing the management of chemical substances in products should be clearly described in documents which should be kept and maintained; and
.2 Obtaining of information on chemical substance content:
In procuring raw materials for components and products, manufacturers/suppliers should be selected following an evaluation, and the information on the chemical substances they supply should be obtained.
(* A recognized quality management system may be utilized.)

2.4 As per BCS-I SC249, the RO should review this documentation during annual surveys for Passenger or Cargo Ship Safety Construction and Cargo Ship Safety Equipment Certificates.

3. Manufacturers/suppliers of Equipment and Components

3.1 The RO should verify the manufacturers/suppliers of equipment and components, being certified by the RO, have established written procedures for purchasing and controlling the supply of asbestos free materials and components, for any kind of equipment, component or spare, which contain:

- supplier evaluation and selection methods,
- asbestos free verification practices for supplied products, and
- issuance of asbestos-free declarations as the supporting documentation.

3.2 As per BCS-I SC249, the RO should verify the issuance of an asbestos-free declaration (Example form is attached in Annex 2) and review supporting documentation, if any, prior to issuing or endorsing any certificate mentioned in 1.4 or 2.4.

4. The documentation generated from the activities in 1, 2 and 3 should be kept on board the ship.

The Annexes to this Recommendation contain the forms of the Declaration of Conformity stating that the ship, its equipment, components and material are asbestos free, in accordance with SOLAS Regulation II-I/3-5.

The shipyards, equipment, component and material manufacturers/suppliers as well as the Companies are encouraged to implement the forms in their quality management systems.

* * *

Annex 1

Declaration of Conformity

Asbestos Free Construction in accordance with SOLAS Regulation II-I/3-5

This is to declare that;

_____

Shipyard

Has constructed the following ship in accordance with SOLAS Regulation II-1/3-5 and that therefore the ship does not contain asbestos:

Name of Ship:
Distinctive number or letters:
Port of Registry:
IMO Number:
Hull Construction Number:
Date on which keel was laid or ship was at a similar stage of construction:
Date of delivery:

This Declaration is based upon the following Requirements and procedures of the shipyard:

SOLAS Regulation II-I/3-5, New Installation of Asbestos
IMO MSC.1/Circ.1379
ISO 9001
IMO MSC.1/Circ.1426
Shipyard's other relevant internal procedures (to be listed):

Place and date; Shipyard's representative (Name, position, title).

Annex 2

Declaration of Conformity

Asbestos Free* Construction in accordance with SOLAS Regulation II-I/3-5

This is to declare that;

_____

Equipment / component / material manufacturer/supplier

Has supplied the following equipment / components / material ……and that these components / equipment / material do not contain asbestos.

These components / equipment / material is installed in the following ship** in accordance with SOLAS Regulation II-1/3-5:

Name of Ship:
Distinctive number or letters:
Port of Registry:
IMO Number:
Hull Construction Number:
Components / equipment / material type, number

This Declaration is based upon the following Requirements and procedures of the components / equipment / material manufacturer/supplier:

SOLAS Regulation II-I/3-5, New Installation of Asbestos
IMO MSC.1/Circ.1379
ISO 9001
IMO MSC.1/Circ.1426
Resolution MEPC.269(68) - 2015 Guidelines for the Development of the Inventory of Hazardous Materials
Manufactures' other relevant internal procedures (to be listed):

Place and date; Manufacturer/supplier's representative (Name, position, title).

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* According to the UN recommendation "Globally Harmonized System of Classification and Labelling of Chemicals (GHS)" adopted by the United Nations Economic and Social Council's Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals (UNSCEGHS), the UN's Sub-Committee of Experts, in 2002 (published in 2003), carcinogenic mixtures classified as Category 1A (including asbestos mixtures) under the GHS are required to be labelled as carcinogenic if the ratio is more than 0.1%. However, if 1% is applied, this threshold value should be recorded.

** If specific ship is known by the manufacturer/supplier.

Annex 3

Declaration of Conformity

Asbestos Free Construction in accordance with SOLAS Regulation II-I/3-5

_____

Company (as defined in SOLAS Chapter IX - ISM Code)

declares that the new installations since the last annual/periodical survey on the following ship are asbestos-free is accordance with SOLAS Regulation II-1/3-5:

Name of Ship:
Distinctive number or letters:
Port of Registry:
IMO Number:

This Declaration is based upon the following Requirements and procedures of the Company:

SOLAS Regulation II-I/3-5, New Installation of Asbestos
IMO MSC.1/Circ.1379
ISO 9001
IMO MSC.1/Circ.1426
Company other relevant internal procedures (to be listed):

Place and date; Company representative (Name, position, title).

BCS- G 131 Uniform application of SOLAS Ch.II-2 Reg. 4.5.7.3.2.1 for accepting a constant operative inerting systems (COIS) as an alternative to fixed hydrocarbon gas detection equipment in double hull and double-bottom spaces on oil tankers

Background:

1. SOLAS Regulation II-2/4.5.7.3.2 gives an alternative to fixed hydrocarbon gas detection systems in double hull spaces.

2. BCS has agreed the following interpretation:

A "constant operative inerting system" is a permanently fitted inert gas system connected to those spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 in lieu of a fixed hydrocarbon gas detection system. The system complies with the requirements for inert gas systems for cargo tanks and is capable of constantly maintaining such spaces under an inert atmosphere at all times except when all adjacent spaces have been confirmed gas free for the purpose of entry.

3. Anticipating that designers would probably prefer to utilize the ship's existing inert gas system for the purpose of fulfilling the requirement for a COIS, there is a need to assess additional features that may be applied to such systems. For the purpose of ensuring harmonized practices regarding the approval of such systems the following additional requirements should be considered:

Applicability:

4. The requirement in SOLAS Regulation II-2/4.5.7.3.2 applies to all spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 and includes *"all ballast tanks and void spaces in the double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks"*. Due to the safety hazards related to inerting of spaces that are arranged for normal entry during operation, the use of COIS should not be permitted for such spaces.

Inert gas distribution piping:

5. SOLAS Regulation II-2/4.5.5.1.3 requires the following:

Tankers required to be fitted with inert gas systems shall comply with the following provisions:

.1 double hull spaces shall be fitted with suitable connections for the supply of inert gas;

.2 where hull spaces are connected to a permanently fitted inert gas distribution system, means shall be provided to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system; and

.3 where such spaces are not permanently connected to an inert gas distribution system, appropriate means shall be provided to allow connection to the inert gas main.

6. The above does not consider the hazards related to hydrocarbon gas backflow from spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 to non-hazardous spaces. These spaces are typically defined as hazardous zones 1 on tankers. Hence, means for prevention of gas backflow from ballast tanks to the inert gas unit and the non-hazardous area in which it is located are required. The following is therefore proposed:

Prevention of hydrocarbon gas backflow from spaces detailed in SOLAS Regulation II-2/4.5.7.3.1:

7. In addition to SOLAS Regulation II-2/4.5.5.1.3, the COIS should be provided with means for prevention of backflow of hydrocarbon gas from spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 to the inert gas unit and the non-hazardous space in which it is located. Acceptable means are;

- Double block and bleed arrangements as per BCS- R F20 or,

- At least two non-return devices as per FSS Code Ch.15 Reg.2.3.1.4.1.

8. Transfer of inert gas between spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 and cargo tanks should not be permitted.

Prevention of gas backflow from cargo tanks to spaces detailed in SOLAS Regulation II-2/4.5.7.3.1:

9. Considering that the COIS has to be continuously operated (even during inerting and topping up of cargo tanks), the above means are also required for connections allowing gas backflow from cargo tanks into spaces detailed in SOLAS Regulation II-2/4.5.7.3.1.

10. Transfer of inert gas between cargo tanks and spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 should not be permitted.

Prevention of water ingress into cargo tanks and void spaces/cofferdams:

11. To prevent water ingress (due to overfilling of ballast tanks) into the inert gas generator unit and the space in which it is located, a non-return valve with a positive means of closure should be provided in the main COIS distribution line.

12. Unless alternative means of prevention of water ingress are provided, where a common distribution system is arranged for ballast tanks and void spaces/cofferdams, a high level alarm should be provided in the ballast tank and a water ingress detector should be provided in the void space.

13. If the COIS is interconnected with the inert gas system serving cargo tanks, a non-return valve with a positive means of closure should be so located that water ingress into cargo tanks is also prevented.

Means for isolation for the purpose of safe entry:

14. Means should be provided for isolating each space detailed in SOLAS Regulation II-2/4.5.7.3.1 from a common COIS distribution system. Where stop valves are fitted, they should be provided with locking arrangements which should be under the control of the responsible ship’s officer. There should be a clear visual indication of the operational status of the valves or other acceptable means.

Piping design:

15. The COIS distribution system should be so designed as to prevent accumulation of water in the system under all normal conditions.

Consequences of system failure:

16. The COIS is an alternative to fixed HC gas detection and thus requires continuous operation. The system must therefore be arranged with redundancy in accordance with the requirements for inert gas systems in The FSS Code Ch.15. In case of failure of the COIS, emergency manual gas detection is required as a temporary means. Compliance with SOLAS Regulation II-2/4.5.7.2 is therefore required also for ships with COIS.

Automation:

17. The COIS is required to be constantly operating. This implies that the system should be arranged as follows:

- The COIS provides a continuous overpressure supply of inert gas (padding).

- The inert gas system serving the COIS is arranged for automatic start in case of low pressure.

Monitoring:

18. The COIS may be arranged to supply inert gas to spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 independently or simultaneously with the supply of inert gas to cargo tanks for topping up purposes. Accordingly, the following independent instrumentation is required for a COIS distribution system serving the spaces detailed in SOLAS Regulation II-2/4.5.7.3.1:

- Low water level in deck water seals as per FSS Code Ch.15.2.4.3.1.7 (if provided for the COIS).

- Double-block and bleed activation and alarms as per BCS- R F20 (if provided for the COIS).

- Low pressure in the COIS distribution piping as per FSS Code Ch.15.2.4.3.1.8.

- High pressure in the COIS main distribution piping as per FSS Code Ch.15.2.4.3.1.9.

Air pipe/ventilation arrangements:

19. Spaces detailed in SOLAS Regulation II-2/4.5.7.3.1 are required to be maintained in an inert condition. Accordingly, unless arrangements are made for continuously purging such spaces with inert gas, means should be required to ensure that inert gas does not escape via individual air pipes fitted to such spaces when inert gas is not supplied with due care taken to provide protection from overpressure and underpressure from additional thermal variation in the event the tank becomes isolated in the process of ensuring the gas does not escape[1].

1 In determining the type of inerting system to be provided the following should be considered:

a. If the spaces are required to be fully inerted and pressurised then a closed pressurised system with P/V valves should be fitted with low pressure alarms, high pressure alarms and automatic make up.

b. An open venting system constantly leaking inert gas onto the deck is possible. In this case a constant supply of inert gas is required. A low pressure alarm would not be effective and a constant low flow of inert gas to all spaces irrespective of pressure should be provided. Arrangements should prevent the build-up of pockets of inert gas on deck and the introduction of inert gas into ventilation inlets.

c. A simple 'partly inerted' ballast tank philosophy with an open venting system is possible. As inert gas is slightly heavier than air, the tank will be mainly inerted but could have a layer of air on top of the gas. In time there would be dilution of the inert gas and mixing of air and inert gas. Occasional make up with inert gas is required.

d. In all cases the venting system should be arranged to effectively disperse the inert gas when the ballast tanks are being filled. The aggregate area of the venting system opening should be not less than 125% of the effective area of the ballast tank filling line.

20. Arrangements for isolation of ballast tanks from the tank venting system should be such that inadvertent isolation does not lead to structural failure due to ballast operations.

21. The capacity of the means must not result in overpressure (static and dynamic) exceeding structural design limits, even in the event of overfilling of ballast tanks. Additionally, the capacity of the means must not result in under-pressure exceeding structural design.

22. For common venting systems, considerations should be made with respect to damage stability and progressive flooding.

System capacities:

23. Where an inert gas production plant provides inert gas for both the cargo inerting and COIS system then the following should be applied[2]:

- At least 125% of the combined maximum discharge rate of the cargo and ballast tanks where systems and operational procedures available onboard permit simultaneous cargo and ballast discharge; or

- At least 125% of the combined maximum discharge rate of the cargo or ballast tanks, whichever is greater, where the system has an interlocking arrangement for the gas regulating valves that do not permit simultaneous inerting of cargo and ballast tanks and operational procedures available onboard are limited to this type of inerting.

If ballast tanks are arranged for gravity drainage, the maximum discharge rate of ballast tanks should be taken as the maximum discharge rate using ballast pumps or the maximum obtainable gravity discharge rate, whichever is greater.

24. Where a separate inert gas production plant is provided for the COIS system then the plant should have a capacity of at least 125% of the maximum discharge rate of the ballast tanks.

2 This assumes that there will be one I.G. system serving both the cargo tanks and COIS. This is not necessarily the case.

BCS- G 132 Human Element Recommendations for structural design of lighting, ventilation, vibration, noise, access and egress arrangements

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Section 1 - Introduction

1.1 Scope and objectives

The objectives of this recommendation are to summarise information for human element and ergonomics during the structural design and arrangement of ships, including:

a) Stairs, vertical ladders, ramps, walkways and work platforms used for permanent means of access and/or for inspection and maintenance operations according to 9.2.1.1 and 9.3.1 of IMO Resolution MSC.296(87).

b) Structural arrangements to facilitate the provision of adequate lighting, ventilation, and to reduce noise and vibration in manned spaces according to 9.2.1.2, 9.3.2, and 9.3.3 of IMO Resolution MSC.296(87).

c) Structural arrangements to facilitate the provision of adequate lighting and ventilation in tanks or closed spaces for the purpose of inspection, survey and maintenance according to 9.2.1.3 and 9.3.4 of IMO Resolution MSC.296(87).

d) Structural arrangements to facilitate emergency egress of inspection personnel or ships' crew from tanks, holds, voids according to 9.2.1.4 and 9.3.5 of IMO Resolution MSC.296(87).

1.2 Application

This document is BCS non mandatory recommendation on human element considerations during the structural design and arrangement of ships under the scope and objectives specified in 1.1 above. In addition, this document also provides information for industry best practices regarding human element considerations for design of lighting, ventilation, vibration, noise, access & egress.

1.3 Definitions

Ergonomics: 'Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.' (Source: International Ergonomics Association, 2013)

Human element: 'A complex multi-dimensional issue that affects maritime safety, security and marine environmental protection. It involves the entire spectrum of human activities performed by ships' crews, shore-based management, regulatory bodies, recognised organizations, shipyards, legislators, and other relevant parties, all of whom need to co-operate to address human element issues effectively.' (Source: IMO Resolution A.947(23))

1.4 Recommendation overview

This document is laid out in a number of sections and annexes with the purpose of presenting clear guidance on applying good ergonomic practice for design for lighting, ventilation, vibration, noise, access & egress.

- **Section 2** – The purpose of this section is to explain why the human element is increasingly seen as an important topic and how the regulations that govern shipping are increasingly putting more emphasis on the human element.

- **Section 3** – The purpose of this section is to present a rationale for why the human element should be considered for the recommendation criteria – lighting, ventilation, vibration, noise, access and egress arrangements – and how this will have an implication for structures.

- **Section 4** – The purpose of this section is to present more detailed structural arrangement recommendations for each of the criteria – lighting, ventilation, vibration, noise, access and egress arrangements.

- **Annex A** – The Annex provides designers with measurement values for some of the criteria that can aid designers when applying design recommendations. They provide the designer with additional information that can assist in making design judgements.

- **Annex B** – The Annex presents a list of relevant standards that bear some relation to good ergonomic practice.

Section 2 - The Human Element

2.1 Regulatory expectations

The regulations that govern the marine industry are gradually putting more emphasis on the human element. In general, the interest in the 'people aspects' of regulations is increasing due to the many rapid changes in the marine environment.

IMO Resolution A.947(23): Human Element Vision, Principles and Goals for the Organization

The IMO (according to Resolution A.947(23)) refers to the human element as:

"A complex multi-dimensional issue that affects maritime safety, security and marine environmental protection. It involves the entire spectrum of human activities performed by ships' crews, shore-based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to co-operate to address human element issues effectively."

In other words, anything that influences the interaction between a human and any other human, system or machine onboard ship, while accounting for the capabilities and limitations of the human, the system, and the environment.

IMO Resolution A.947(23) further states ***"the need for increased focus on human-related activities in the safe operation of ships, and the need to achieve and maintain high standards of safety, security and environmental protection for the purpose of significantly reducing maritime casualties";*** and that ***"human element issues have been assigned high priority in the work program of the Organization because of the prominent role of the human element in the prevention of maritime casualties."***

ILO Maritime Labour Convention

The ILO's Maritime Labour Convention (MLC), 2006, provides comprehensive rights and protection at work for the world's seafarer population. It sets out new requirements specifically relating to the working and living conditions on board ships.

Aimed at seafarer health, personal safety and welfare in particular, the new MLC has specific requirements in Regulation 3.1 and Standard A3.1 for accommodation design and construction, especially in relation to living accommodation, sanitary facilities, lighting, noise, vibration, heating and ventilation.

2.2 Human Element Considerations

The human element in a maritime sense can be thought of as including the following;

a) Design and Layout Considerations

Design and layout considers the integration of personnel with equipment, systems and interfaces. Examples of interfaces include: controls, displays, alarms, video-display units, computer workstations, labels, ladders, stairs, and overall workspace arrangement.

It is important for designers and engineers to consider personnel's social, psychological, and physiological capabilities, limitations and needs that may impact work performance. Hardware and software design, arrangement, and orientation should be compatible with personnel

capabilities, limitations, and needs. Workplace design includes the physical design and arrangement of the workplace and its effect on safety and performance of personnel.

In addition, designers and engineers should be aware of the cultural and regional influences on personnel's behavioural patterns and expectations. This includes, for example, understanding that different cultural meanings with regard to colour exist, or that bulky clothing is needed when using equipment in cold weather. Awareness of potential physical differences (e.g., male/female, tall/short, North American versus South-East Asian) is needed so that the design, arrangement, and orientation of the work environment reflects the full range of personnel.

If these factors are not considered, the workplace design may increase the likelihood of human error. Additional training, operations, and maintenance manuals, and more detailed written procedures cannot adequately compensate for human errors induced by poor design.

b) Ambient Environmental Considerations

This addresses the habitability and occupational health characteristics related to human whole-body vibration, noise, indoor climate and lighting. Substandard physical working conditions undermine effective performance of duties, causing stress and fatigue. Examples of poor working conditions include poor voice communications due to high noise workplaces or physical exhaustion induced by high temperatures. Ambient environmental considerations also include appropriate design of living spaces that assist in avoidance of, and recovery from, fatigue.

c) Considerations Related to Human Capabilities and Limitations

Personnel readiness and fitness-for-duty are essential for vessel safety. This is particularly so as tasks and equipment increase in complexity, requiring ever-greater vigilance, skills, competency and experience. The following factors should be considered when selecting personnel for a task:

- Knowledge, skills, and abilities that stem from an individual's basic knowledge, general training, and experience
- Maritime-specific or craft-specific training and abilities (certifications and licenses) and vessel specific skills and abilities
- Bodily dimensions and characteristics of personnel such as stature, shoulder breadth, eye height, functional reach, overhead reach, weight, and strength
- Physical stamina; capabilities, and limitations, such as resistance to and freedom from fatigue; visual acuity; physical fitness and endurance; acute or chronic illness; and substance dependency
- Psychological characteristics, such as individual tendencies for risk taking, risk tolerance, and resistance to psychological stress.

d) Management and Organizational Considerations

This factor considers management and organizational considerations that impact safety throughout a system lifecycle. The effective implementation of a well-designed safety policy, that includes ergonomics, creates an environment that minimizes risks. Commitment of top management is essential if a safety policy is to succeed. Management's commitment can be demonstrated by:

- Uniformly enforced management rules for employee conduct
- Easy-to-read and clear management policies
- Allocation of sufficient funds in the owner/operator’s budget for operations and for safety programs, including ergonomics, to be properly integrated and implemented
- Work schedules arranged to minimize employee fatigue
- Creation of a high-level management safety position which includes the authority to enforce a safety policy that includes ergonomics
- Positive reinforcement of employees who follow company safety regulations
- Company commitment to vessel installation maintenance.

Section 3 - Rationale for considering the Human Element in the design of lighting, ventilation, vibration, noise, access and egress arrangements

3.1 General

3.1.1 The design of the on board working environment for the ship's crew should consider environmental factors such as lighting, ventilation, vibration and noise. Insufficient attention paid to the physical working conditions can have an effect on task performance, health and safety and well-being.

3.1.2 The design of stairs, vertical ladders, ramps, walkways and work platforms used for permanent means of access should facilitate safe movement within or among working or habitability areas. Insufficient attention paid to access arrangements can have an effect on task performance and safety. Insufficient attention paid to egress arrangements can have an effect on safe evacuation during an emergency.

3.1.3 The following headings are applied to each of the criteria addressed in this recommendation to give the rationale for what needs to be considered from a human element perspective;

- Task requirements
- Ergonomic design principles
- Conditions
- Implications for structures

3.2 Lighting

3.2.1 Task requirements

- The lighting of crew spaces should facilitate visual task performance as well as the movement of crew members within or between working or habitability areas. It should also aid in the creation of an appropriate aesthetic visual environment. Lighting design involves integrating these aspects to provide adequate illumination for the safety and well-being of crew as well as affording suitable task performance.

- In order to facilitate operation, inspection, and maintenance tasks in normally occupied spaces and inspection, survey and maintenance tasks in closed spaces, the design of lighting should promote;

- task performance, by providing adequate illumination for the performance of the range of tasks associated with the space
- safety, by allowing people enough light to detect hazards or potential hazards
- visual comfort and freedom from eye strain.

3.2.2 Ergonomic design principles

- In order to facilitate the task requirements identified above, the following design principles are identified as needing to be achieved for lighting design. These design principles are based on good ergonomic practice and will form the basis for the development of the structural arrangement recommendations.

- The design of lighting should;

- provide adequate illumination for the performance of the range of tasks associated with the space

- be suitable for normal conditions and any additional emergency conditions
- provide uniform illumination as far as practicable
- avoid glare and reflections
- avoid bright spots and shadows
- be free of perceived flicker
- be easily maintained and operated
- be durable under the expected area of deployment

3.2.3 Conditions

- The provision of adequate lighting is dependent on several factors which need to be taken into account. These include;

- Time of day and external light characteristics
- Differing proximity to deadlights, windows, doors

3.2.4 Implications for structures

- In order to address the design principles outlined above, there are several implications for the structural arrangements. These implications with regard to structures will address;

- Positioning of luminaires
- Overhead arrangements (stringers, pipes and ductwork, cable trays)
- Positioning of switches and controls
- Provision and position of windows providing natural light
- Control of natural and artificial sources of glare
- Supply of power
- Constrained space lighting (permanent or intrinsically safe portable lighting)

3.3 Ventilation

3.3.1 Task requirements

- In order to facilitate operation, inspection and maintenance tasks in manned spaces, the ventilation system is to be suitable to maintain operator vigilance, comfort, provide thermal protection (from heat and cold) and to aid safe and efficient operations.

- In order to facilitate periodic inspections, survey and maintenance in tanks or closed spaces the means of ventilation is to ensure the safety of personnel in enclosed spaces from poor or dangerous air quality.

3.3.2 Ergonomic design principles

- In order to facilitate the task requirements identified above, the following design principles are identified as needing to be achieved for ventilation / indoor climate design. These design principles are based on accepted ergonomic practice and will form the basis for the development of the structural arrangement recommendations.

- Indoor climate should be designed to;

- provide adequate heating and/or cooling for onboard personnel
- provide uniform temperatures (gradients)
- maintain comfortable zones of relative humidity
- provide fresh air (air exchange) as part of heated or cooled return air

- provide clean filtered air, free of fumes, particles or airborne pathogens
- monitor gas concentration (CO, CO_2, O_2 etc.)
- be easily adjustable by onboard personnel
- minimise contribution of ventilation noise to living and work spaces
- provide sufficient velocity to maintain exchange rates whilst not being noisy or annoying
- provide means to use natural ventilation
- provide/assess safe air quality while working in enclosed spaces

• Additionally, the design of the ventilation system should give consideration to keep the structural integrity for purposes of fire insulation

3.3.3 Conditions

• Ventilation provisions should accommodate and take into account the following factors;

- extremes of external environmental conditions (highs and lows of temperature and humidity)
- expected human occupancy of work and living spaces
- operating components that contribute heat to a living or working space
- entry into confined spaces for the purpose of inspection

3.3.4 Implications for structures

• In order to address the design principles outlined above, there are several implications for the structural arrangements. These implications with regard to structures will include;

- exterior ambient conditions (sizing the HVAC system)
- indoor air quality (particulate, smoke, O_2, CO_2, other gases)
- Ventilation capacity and air flow
- Water stagnation
- Bio-organisms and toxins
- Pipe and ductwork condensate
- Inspection access, maintenance access
- Noise and vibration control
- Energy efficiency

3.4 Vibration

3.4.1 Task requirements

• In order to facilitate operation, inspection and maintenance tasks in manned spaces, the level of vibration is to be such that it does not introduce injury or health risks to shipboard personnel.

• Additionally, consideration will be made for the impact of vessel motion on human comfort.

• These considerations extend to living and work tasks occurring in habitability and work spaces as well as infrequently occupied spaces such as tanks and small holds entered for the purpose of maintenance or inspection.

3.4.2 Ergonomic design principles

- In order to facilitate the task requirements identified above, the following design principles were identified as needing to be considered in vibration control. Vessel design should;

- protect onboard personnel from harmful levels of vibration
- protect onboard personnel from levels of vibration impairing job performance
- protect onboard personnel from levels of vibration that interferes with sleep or comfort
- provide protection from both continuous exposure and shock (high peak values)

3.4.3 Conditions

- Vibration control provisions should accommodate and take into account the following factors;

- Continuous service output of prime mover(s)
- Equipment operation (such as thrusters, air compressors and auxiliary generators)
- Course, speed and water depth
- Rudder conditions
- Sea conditions
- Loading conditions

3.4.4 Implications for structures

- In order to meet the design principles outlined above, there are several implications for the structural arrangements to reduce vibration. The implications with regard to structures will address;

- Machinery excitation (main mover)
- Rotating components (turbines)
- Pumps
- Refrigeration
- Air compressors
- Shafting excitation
- Propeller blade tip/hull separation
- Cavitation
- Thrusters and azipods
- Hull and structure response to vibration.
- Resonance of structures
- Location of safety rails, hand holds, seating devices, means to secure loose stock or rolling stock in relation to ship motion

3.5 Noise

3.5.1 Task requirements

- Depending on the level and other considerations, noise can contribute to hearing loss, interfere with speech communications, mask audio signals, interfere with thought processes, disrupt sleep, distract from productive task performance, and induce or increase human fatigue.

- In order to facilitate operation, inspection and maintenance tasks in manned spaces, the level of noise should to be such that it;

- does not impair hearing either permanently or temporarily,
- is not at levels which interfere with verbal communication

- is not at levels which interfere with the hearing of alarms and signals
- is not at levels that will cause stress, distract from task performance or increase the risk of errors
- does not interfere with the ability to sleep
- does not increase or induce fatigue
- does not reduce habitability or sense of comfort

3.5.2 Ergonomic design principles

- Noise control provisions should accommodate and take into account the following conditions. Vessel design should;

- ensure that onboard personnel are protected from harmful levels of noise (health hazards, hearing loss, cochlear damage)
- ensure that onboard personnel are protected from levels of noise impairing job performance
- ensure that onboard personnel are protected from levels of noise impairing verbal communication and the hearing of signals (such as alarms, bells, whistles, etc.)
- ensure that onboard personnel are protected from levels of noise that interfere with sleep or comfort

3.5.3 Conditions

- The development of provisions to reduce noise is dependent on several factors which need to be taken into account. These include;

- Equipment Operation
- Sea Conditions
- Loading Conditions and cargo operations
- Performance of maintenance or inspection tasks, including infrequently accessed areas.

3.5.4 Implications for structures

- In order to meet the design principles outlined above, there are implications for the structural arrangements to reduce noise, these include;

- Machinery excitation (main mover)
- Hull protrusions
- Rotating components (turbines)
- Pumps
- Refrigeration
- Air compressors, fans, ventilation ductwork, exhaust systems
- Shafting excitation
- Propeller blade tip/hull separation
- Cavitation
- Thrusters and azipods
- Noise abatement / shielding

3.6 Access & Egress

3.6.1 Task requirements

- The design of accesses and access structures of crew spaces should facilitate the safe movement of crew members within or among working or habitability areas. These

include access structures such as passageways, ladders, ramps, stairs, work platforms, hatches, and doors. Also included are handrails, guard rails, and fall protection devices.

- In order to facilitate operation, inspection, and maintenance tasks in normally occupied spaces and inspection, survey and maintenance tasks in closed spaces, the design of accesses and access structures should promote;

- task performance, by providing adequate configurations and dimensions facilitating human access.
- safety, by providing barriers to falls or other types of injury.

3.6.2 Ergonomic design principles

- In order to facilitate the task requirements identified above, the following design principles are identified as needing to be achieved for access design. These design principles are based on good ergonomic practice and will form the basis for the development of the structural arrangement recommendations.

- The design of access and egress arrangements should;

- provide adequate access for the performance of the range of tasks associated (general access, accommodations access, maintenance and other work access) with the space
- be suitable for normal and emergency conditions
- be sized according to the access (or related) task required
- be sized according to the expected user population
- be easily maintained and operated
- be durable under the expected area of deployment
- accommodate ship motions

3.6.3 Conditions

- The identification of access requirements is dependent on several factors which need to be taken into account when developing recommendations. These include;

- Expected extent of vessel motion and potential interference with walking, standing, or climbing due to instability
- Exposure to external areas that may experience rain, snow, ice, spray, wind or other environmental conditions that may influence the usability and safety of accesses or access aids
- Potential for slips, trips, or falls and provision and design of accesses and access aids preventing their occurrence.

3.6.4 Implications for structures

- In order to address the design principles outlined above, there are several implications for the structural arrangements. These implications with regard to structures will address;

- Provision and size of access structures (based on frequency of use and numbers of crew)
- Locations of accesses
- Exposure to the external elements
- Safety in access to, and use of, access structures

Section 4 - Ergonomic Structural Arrangement Recommendations

4.1 General

4.1.1 The guidance presented in this section provides detailed structural arrangement recommendations for each of the criteria – lighting, ventilation, vibration, noise, access and egress arrangements.

4.2 Lighting Design

4.2.1 Aims

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to facilitate the provision of adequate lighting in spaces normally occupied or manned by shipboard personnel should be considered.

- A space may be considered as being ‘normally occupied’ or ‘manned’ when it is routinely occupied for a period of 20 minutes or more.

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to facilitate the provision of adequate lighting in areas infrequently manned such tanks or closed spaces for periodic inspections, survey and maintenance should be considered.

4.2.2 Application

- The recommendations presented in this section are applicable to vessels covered in SOLAS Regulation II-1/3-10.

4.2.3 Locations

- Locations for lighting in manned spaces should be provided permanently and include the following;

- Living quarters (accommodation, recreation, offices, dining)
- Work Areas (control rooms, bridge, machinery spaces, workshops, offices, and spaces entered on a daily basis)
- Access Areas (corridors, stairways, ramps and the like)

- Lighting in infrequently manned spaces may be temporary and include the following;

- Tanks, small holds, infrequently occupied closed spaces

4.2.4 Structural Arrangements

Allowance should be made for the following ergonomic recommendations during structural design and construction as appropriate.

A) Positioning of Lighting

- Natural lighting through the use of windows and doors should be provided as far as practicable.

- Lights should be positioned, as far as practicable, in the same horizontal plane and arranged symmetrically to produce a uniform level of illumination.

- Lights should be positioned taking account of air conditioning vents or fans, fire detectors, water sprinklers etc. so the lighting is not blocked by these items.
- Lights should be positioned so as to reduce as far as possible bright spots and shadows.
- Fluorescent tubes should be positioned at right angles to an operator's line of sight while the operator is located at their typical duty station as far as practicable.
- Any physical hazards that provide a risk to operator safety should be appropriately illuminated.
- Lights should be positioned to consider the transfer of heat to adjacent surfaces.
- Lights should not to be positioned in locations which would result in a significant reduction in illumination.
- Lights should not to be positioned in locations that are difficult to reach for bulb replacement or maintenance.

B) Illuminance distribution

- Illumination of the operator task area should be adequate for the type of task, i.e. it should consider the variation in the working plane.
- Sharp contrasts in illumination across an operator task area or working plane should be reduced, as far as possible.
- Sharp contrasts in illumination between an operator task area and the immediate surround and general background should be reduced, as far as possible.
- Where necessary for operational tasks, local illumination should be provided in addition to general lighting.
- Lights should not flicker or produce stroboscopic effects.

C) Obstruction and glare

- Lights should be positioned so as to reduce as far as possible glare or high brightness reflections from working and display surfaces.
- Where necessary, suitable blinds and shading devices may be used to prevent glare.
- Lighting should not to be obstructed by structures such as beams and columns.
- The placement of controls, displays and indicators should consider the position of the lights relative to the operator in their normal working position, with respect to reflections and evenness of lighting.
- Surfaces should have a non-reflective or matt finish in order to reduce the likelihood of indirect glare.

D) Location and installation of lighting controls

- Light switches should be fitted in convenient and safe positions for operators.

- The mounting height of switches should be such that personnel can reach switches with ease.

E) Location and installation of electrical outlets

- Outlets should be installed where local lighting is provided, for e.g. in accommodation areas, work spaces and internal and external walkways.

- Provision is to be made for temporary lighting where necessary for inspection, survey and maintenance.

4.3 Ventilation Design

4.3.1 Aims

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to facilitate the provision of adequate ventilation in spaces normally occupied or manned by shipboard personnel should be considered.

- A space may be considered as being ‘normally occupied’ or ‘manned’ when it is routinely occupied for a period of 20 minutes or more.

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to facilitate the provision of adequate ventilation in areas infrequently manned such tanks or closed spaces for periodic inspections, survey and maintenance should be considered.

4.3.2 Application

- The recommendations presented in this section are applicable to vessels covered in SOLAS Regulation II-1/3-10.

4.3.3 Locations

- Locations for ventilation in manned spaces should be provided permanently and include the following;

- Living quarters (accommodation, recreation, offices, dining)
- Work Areas (control rooms, bridge, machinery spaces, offices, spaces and voids entered)

- Locations for ventilation in infrequently manned spaces should be temporary and include the following;

- Tanks, small holds, infrequently occupied closed/enclosed spaces

4.3.4 Structural Arrangements

Allowance should be made for the following ergonomic recommendations during structural design and construction as appropriate.

A) Ship ventilation design

- Natural ventilation design should be established by consideration of compartment layouts and specifications. Typical natural ventilation devices include mushroom ventilators, gooseneck ventilators, ventilators with weather proof covers etc.

- In general, HVAC (heating, ventilation and air conditioning) systems should be provided in spaces normally occupied during operation.

- For areas infrequently occupied (such as tanks or holds) means of air quality sampling (such as portable CO_2 densitometer) should be provided.

- Means to ventilate prior to entry of infrequently visited places should be provided.

- Adequate ventilation should be provided for inspection, survey, maintenance and repair within the voids of double-bottom and double-sided hulls.

B) Location and installation of ventilation

- The design of air ducts should facilitate reduced wind resistance and noise. Ductwork (particularly elbows and vents) should not contribute excess noise to a work or living space.

- Ductwork should not to interfere with the use of means of access such as stairs, ladders, walkways or platforms.

- Ductwork and vents should not be positioned to discharge directly on people occupying the room in their nominal working or living locations, for example, directed at a berth, work console, or work bench.

- Manholes and other accesses should be provided for accessibility and ventilation to points within.

- Fire dampers should be applied to contain the spread of fire, per statutory requirements.

- Ventilation penetrations through watertight subdivision bulkheads are not recommended unless accepted per statutory requirements. Ventilation dampers are to be visible (via inspection ports or other means).

- Ventilation fans for cargo spaces should have feeders separate from those for accommodations and machinery spaces.

- It is recommended that air Intakes for ventilation systems are located to minimise the introduction of contaminated air from sources such as for example, exhaust pipes and incinerators.

- Extractor grilles should be located to avoid short-circuits between inlets and outlets and to support even distribution of air throughout a work space.

4.4 Vibration Design

4.4.1 Aims

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to minimize vibration in spaces normally occupied or manned by shipboard personnel should be considered.

- A space may be considered as being ‘normally occupied’ or ‘manned’ when it is routinely occupied for a period of 20 minutes or more.

4.4.2 Application

- The recommendations presented in this section are applicable to vessels covered in SOLAS Regulation II-1/3-10.

4.4.3 Locations

- Locations in which vibration should be minimized include the following;

- Living quarters (accommodation, recreation, offices, dining)
- Work Areas (such as control rooms, bridge, machinery spaces, offices, spaces and voids entered)

4.4.4 Structural Arrangements

Allowance should be made for the following ergonomic recommendations during structural design and construction as appropriate.

A) General

- Vibration levels should be at or below the acceptable ergonomic standards for spaces normally occupied by the crew. In general, ISO 6954:2000 may be used as a guideline to evaluate the vibration performance in the spaces normally occupied by the crew.

- Generally, many alternative measures are applicable to reduce vibration, including but not limited to:

  1 Resonance avoidance with a combination of appropriate selection of main engine and its revolution, number of propeller blades and structural natural frequencies;

  2 To avoid resonance, addition of mass or reduction in scantlings to achieve lower structural natural frequencies. Or conversely, reduction of mass or structural reinforcement to increase natural frequencies;

  3 Reduction of exciting force by for e.g. application of various kinds of dampers, compensators and balancers; and

  4 Structural reinforcement to increase rigidity and reduce structural response, or conversely, where structural rigidity is reduced specifically to reduce structural responses.

- Due to the variety of effective measures that can be taken and the complex nature of vibration phenomena, it is not possible to apply simple prescriptive formulae for scantling calculation.

- Structural measures are mainly prescribed in the following sections, but other measures as stated in 1-4 above may be considered as effective alternatives.

B) Vibration reduction design

- Vibration level in the spaces normally occupied during operation should be estimated by an appropriate method, such as estimation based on empirical statistics and/or

application of analytical tools. When a vibration level exceeding the acceptable ergonomic standards is envisaged, suitable countermeasures should be taken.

- In general, natural frequencies should be calculated using theoretical formulae in way of local panels and stiffeners in the spaces close to the main exciting sources, i.e. propeller and main engine. These local scantlings should be decided so that the estimated natural frequencies are apart from the exciting frequencies adequately to avoid resonance.

- For heavy equipment or machinery in the spaces close to the main exciting sources, suitable measures should be taken at the deck structure underneath the equipment or machinery to reduce vibration.

C) Anti-vibration design in structural arrangements

- Vibration should be controlled at the source as far as possible.

- To prevent hull girder vibration, the following measures are recommended for consideration;

    - selection of hull forms, girders and other ship structures with consideration to vibration control;
    - selection of main machinery with inertia force and moment balanced;
    - adjusting natural frequency (the natural frequency of hull girder increases as the number of bulkheads increases).

- To prevent vibration of the local structure, the following measures are recommended for consideration;

    - line (mainly the ship tail shape) and propeller design modification;
    - adjustment of general arrangements, such as cabin arrangement, weight distribution, location of main machinery;
    - adjustment and modification of local structures, such as superstructure, aft structures, bottom frame structure in engine room;
    - other damping measures, such as vibration isolators, nozzle propeller.

D) Anti-vibration design of engine room, engine, propeller and thrusters

- Consideration should be paid to the vibration response of main machinery base and shafting.

- Consideration of control of vibration from the engine room should include installing bracings at the top and front of diesel engines and increasing the stiffness and natural frequency of the machine base to reduce the vibration of the base.

- Bow thruster induced vibration should be minimized by following good acoustic design practices relative to the design of the propeller and the location and placement of the thruster itself. Supply of resilient supported tunnels (tunnel within a tunnel), bubbly air injectors, and tunnels coated with a decoupling material can be considered.

- Propeller induced vibration should be minimized by following good acoustic design practices relative to the design of the propeller and the location and placement in relation to the hull.

Stern shape should be optimized and considered through theoretical calculation and model testing so as to improve the wake. The gap between the shell and the propeller should be appropriate to reduce the exciting force. Damping treatments can be applied to shell plates with severe vibration.

E) Anti-vibration design of superstructure

- Preventing vibration along the longitudinal area of the superstructure should be considered by increasing the shear and strut stiffness of the superstructure. To achieve this, the following measures are recommended;

    - Superstructure side wall can be vertically aligned,
    - The internal longitudinal bulkhead can be set up with more than four (4) tiers of superstructure,
    - Strong girders or other strong elements can be provided under the main deck,
    - The transverse bulkhead and the front bulkhead of superstructure can be vertically aligned as much as possible, otherwise large connection brackets should be provided,
    - The superstructure aft bulkhead of each superstructure deck can be aligned vertically with the main hull transverse bulkheads as far as possible, otherwise strong beams under the main deck should be provided.
    - To control vibration of outfitting, dimensions and the means of fixing and strengthening at the point of mounting can be considered.
    - To prevent vibration of high web girder, the following should be considered;

        - Increase dimension of longitudinals and face plate,
        - Increase the stiffness of face plate stiffeners,
        - Add horizontal stiffener.

F) Anti-vibration installation design

- Sources of vibration (engines, fans, rotating equipment), to the extent possible, should be isolated from work and living spaces (use of isolation mounts or other means can be considered).

- Hull borne vibration in living and work areas can be attenuated by the provision of vibration absorbing deck coverings or by other means.

4.5 Noise Design

4.5.1 Aims

- Following a review of IMO Res. MSC.337(91) Code on Noise Levels On Board Ships, the structural arrangements to minimize noise in spaces normally occupied or manned by shipboard personnel should be considered.

- A space may be considered as being ‘normally occupied’ or ‘manned’ when it is routinely occupied for a period of 20 minutes or more.

4.5.2 Application

- The recommendations presented in this section are applicable to vessels covered by SOLAS Regulation II-1/3-10.

4.5.3 Locations

- Locations in which noise should be minimized include the following;

- Living quarters (accommodation, recreation, offices, dining)
- Work Areas (such as control rooms, bridge, machinery spaces, living quarters and offices)

4.5.4 Structural Arrangements

Allowance should be made for the following ergonomic recommendations during structural design and construction as appropriate.

A) General

- Sources of noise (engines, fans, rotating equipment), to the extent possible, should be isolated and located away from work and living spaces (through use of isolation mounts or other means).

- If necessary hull borne noise transmitted through the steel structure may be attenuated by the provision of noise absorbing deck coverings.

- Noise for typical underway conditions should be specified for the following areas:

    - In living quarters
    - In open engineering and mechanical spaces
    - In offices, the bridge, engineering offices

- Noise on the hull from the propeller tips, athwart thrusters, or azipods should be designed to minimize structure borne noise to accommodations and work areas.

- Specific noise levels are to be obtained from the revised IMO Code on Noise Aboard ships (Resolution MSC.337(91)).

- To reduce noise transmitted to accommodation cabins, the crew accommodations areas are usually arranged in the middle or rear of the superstructure or on the poop deck and above.

B) Noise sources and propagation

- Ship noise can be divided into airborne noise and structure borne noise according to the nature of the sound source. It consists of main machinery noise, auxiliary machinery noise, propeller noise, hull vibration noise and ventilation system noise.

- There are three main routes of transmission of ship noise;

    - airborne noise radiated directly to the air by main or auxiliary machinery system;
    - structure borne noise spread along the hull structure through mechanical vibration and radiated outward;
    - fan noise and air-flow noise transmitted through the pipeline of the ventilation system.

C) Mechanical vibration induced noise control

- Mechanical vibrations are the largest source of noise. Methods relating to anti-vibration design in the structural arrangements are also useful for vibration induced noise control, including the following;

- Reducing the noise level of the various noise sources;
- Using vibration isolator for main and auxiliary machinery to reduce the noise;
- Improving the machine's static and dynamic balance;
- Installing soundproof cover with sound-absorbing lining for machines.

D) Noise control of ventilation system

- Fans with relative low pressure may be used to reduce noise when the flow resistance of ventilation ducts is low. Low flow resistance can be achieved by rational division of the ventilation system, reasonable determination of ability of ventilation and the ducts layout, adoption of reasonable duct type and provision of suitable materials.

- Fans and central air conditioners may be installed in a separate acoustic room or the damper elastomeric gasket or silencer box.

- Ventilation ducts can be encased in damping material if necessary. Penetration of compartments with a low-noise requirement by main air tubes may be avoided.

- Ventilation inlet, outlet, and diffuser elements can be provided that are designed for noise abatement to reduce ventilation terminal noise.

- If needed, an appropriate muffler can be used based on the estimated frequency range of the noise.

E) Noise Prevention/Mitigation

- The statements that follow should be considered in the context of the prevention and mitigation of human whole body vibration, which also have a noise reducing effect.

- Different treatments may be needed to reduce airborne sources, structureborne sources, airborne paths, structureborne paths, HVAC induced noise, etc. Each treatment type depends on an understanding of the prevailing airborne or structureborne noise components (e.g., low frequency or high frequency). A thorough understanding of the source, amount of noise, the noise’s components, and the noise’s path(s) is essential for cost effective noise abatement/treatment. Listed below, are summarized some of the more common noise control treatment methods,

    - Selection of equipment that by its design or quality are lower noise and/or vibration.
    - Reduction of vibration by mechanically isolating machinery from supporting structure.
    - Use of two layers of vibration isolation mounts under machinery with seismic based mounts between the machinery and the ship’s structure.
    - Reduce vibration energy in structures. Pumpable material used as ballast can also be used as damping in voids and tanks.
    - An air bubble curtain can be considered to shield the vessel’s hull from water borne noise.
    - A decoupling material can be applied to the exterior (wet side) plating in order to reduce the radiation efficiency of the structure.

- The airborne source level and airborne path are the most critical factors affecting noise within a machinery space itself and in the compartments directly adjacent to the machinery space. Structureborne sources and the structureborne path carry acoustical energy everywhere else on the vessel.

- Depending on the level of treatment, secondary structureborne noise (a combination of the airborne source level and the response of the structure inside the machinery space itself) may also be important in spaces remote from the machinery itself.

F) Noise modelling

- A technique becoming more common among designers is noise or acoustical modelling. In these models, it is essential that the factors related to the source-path receiver be very well understood.

- Noise/acoustical models should include the following components:

    - Source, acoustic path, and receiver space description
    - Sources - machinery source descriptions (e.g., noise and vibration levels, size and mass, location, and foundation parameters)
    - Sources - propulsor source description (e.g., number of propellers (impellers), number of blades, RPM, clearance between hull and tips of propeller, vessel design speed)
    - Sources – HVAC source description (e.g., fan parameters (flow rate, power, and pressure), duct parameter, louver geometry, and receiver room sound absorption quality)
    - Path - Essential parameters for sound path description include hull structure sizes and materials, (damping) loss factors, insulation and joiner panel parameters.
    - Receiver - Receiver space modelling is characterized by the hull structure forming the compartment of interest, insulation/coatings, and joiner panels.

4.6 Access & Egress Design

4.6.1 Aims

- Following a review of IMO Resolution MSC.296(87), the design of stairs, vertical ladders, ramps, walkways and work platforms used for permanent means of access and/or for inspection and maintenance operations should be considered.

- Following a review of IMO Resolution MSC.296(87), the structural arrangements to facilitate emergency egress of inspection personnel or ships' crew from tanks, holds, voids etc. is to be considered.

4.6.2 Application

- The recommendations presented in this section are applicable to vessels covered in SOLAS Regulation II-1/3-10.

4.6.3 Locations

- Locations for provision of access aids in manned spaces should be provided permanently and include the following;

- Living quarters (accommodation, recreation, offices, dining)

- Work Areas (control rooms, bridge, machinery spaces, offices, spaces and voids entered)
- Access to deck areas, muster stations, work platforms associated to periodic inspection, operation, or maintenance
- Locations for access in infrequently manned spaces may be temporary and include the following;
    - Tanks, small holds, infrequently occupied closed spaces

4.6.4 Structural Arrangements

A) Stairs

General Principles

The following are general recommendations to consider for stairs design:

- Stairs are appropriate means for changing from one walking surface to another when the change in vertical elevation is greater than 600 mm (23.5 in.).
- Stairs should be provided in lieu of ladders or ramps in accommodations spaces, office spaces, or to the navigation bridge.
- The angle of inclination should be sufficient to provide the riser height and tread depth that follows, a minimum angle of 38 degrees and maximum angle of 45 degrees is recommended.
- Stairs exposed to the elements should have additional slip resistance due to potential exposure to water and ice.
- Stairs should be used in living quarters instead of inclined ladders.
- No impediments or tripping hazards should intrude into the climbing spaces of stairs (for example, electrical boxes, valves, actuators, or piping).
- No impediments or tripping hazards should impede access to stair landings (for example, piping runs over the landing or coamings/retention barriers).
- Stairs running fore and aft in a ship are preferable but athwartship stairs are allowed.

Stair Landings

The following are recommendations to consider during the design of stair landings:

- A clear landing at least as wide as the tread width and a minimum of 915 mm (36 in.) long should be provided at the top and bottom of each stairway.
- An intermediate landing should be provided at each deck level serviced by a stair, or a maximum of every 3500 mm (140 in.) of vertical travel for stairs with a vertical rise of 6100 mm (240 in.).
- Any change of direction in a stairway should be accomplished by means of an intermediate landing at least as wide as the tread width and a minimum of 915 mm (36 in.) long.
- Stairways should have a maximum angle of inclination from the horizontal of 45 degrees.
- Where stairs change directions, intermediate landings along paths for evacuating personnel on stretchers should be 1525 mm (60 in.) or greater in length to accommodate rotating the stretcher.

Stair Risers and Treads

The following are recommendations to consider during the design of stair risers and treads:

- A riser height should be no more than 230 mm (9 in.) and a tread depth of 280 mm (11 in.), including a 25 mm (1 in.) tread nosing (step overhang).
- For stairs the depth of the tread and the height of riser should be consistent
- Minimum tread width on one-way (where there is expected to be only one person transiting, ascending ***or*** descending stairway) stairs should be at least 700 mm (27.5 in.)
- Minimum tread width on two-way (where there may be two persons, ascending ***and*** descending, or passing in opposite directions) stairs should be at least 900 mm (35.5 in.)
- Once a minimum tread width has been established at any deck in that stair run, it should not decrease in the direction of egress
- Nosings should have a non-slip/skid surface that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.

Headroom

- Clear headroom (free height) maintained in all stairs is recommended to be at least 2130 mm (84 in.).

Design Load

- It is recommended that stairways should be built to carry five times the normal anticipated live load, but less than a 544-kg (1000-lb) moving concentrated load.

Stair Handrails

The following are recommendations to consider during the design of stair risers and treads:

- Stairs with three or more steps should be provided with handrails.
- A single-tier handrail to maintain balance while going up or down the stairs should be installed on the bulkhead side(s) of stairs.
- A two-tier handrail to maintain balance and prevent falls from stairs should be installed on non-enclosed sides of stairs.
- Handrails should be constructed with a circular cross section with a diameter of 40 mm (1.5 in.) to 50 mm (2.0 in.).
- Square or rectangular handrails should not be fitted to stairs.
- The height of single tier handrails should be 915 mm (36 in.) to 1000 mm (39 in.) from the top of the top rail to the surface of the tread.
- Two-tier handrails should be two equally-spaced courses of rail with the vertical height of the top of the top rail 915 mm (36 in.) to 1000 mm (39 in.) above the tread at its nosing.
- A minimum clearance of 75 mm (3 in.) should be provided between the handrail and bulkhead or other obstruction.

B) Walkways and Ramps

General Principles

The following are general recommendations to consider for walkways and ramps:

- Guard rails should be provided at the exposed side of any walking or standing surface that is 600 mm (23.5 in.) or higher above the adjacent surface and where a person could fall from the upper to the lower surface.
- Ramps should be used with changes in vertical elevations of less than 600 mm (23.5 in.).

- Ramps should be provided with a non-skid surface that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.
- Headroom in all walkways should be ≥ 2130 mm (84 in.).
- Toeboards should be provided on elevated walkways, platforms, and ramps. No impediments or tripping hazards should intrude into the transit space (for example, electrical boxes, valves, actuators, or piping).
- No impediments or tripping hazards should impede use of a walkway or ramp (for example, piping runs, hatch covers, deck impediments (e.g., through bolts) or combings/retention barriers).
- The maximum opening in a walkway grating under which the presence of persons is expected should be less than 22 mm (0.9 in.).
- The maximum opening in a walkway grating under which the presence of persons is not expected should be less than 35 mm (1.7 in.).
- Toeboards should have a height of 100 mm (4.0 in.) and have no more than a 6 mm (0.25 in.) clearance between the bottom edge of the toeboard and the walking surface.

C) Vertical Ladders

General Principles

The following are general recommendations to consider for the design of vertical ladders:

- Vertical ladders should be provided whenever operators or maintainers must change elevation abruptly by more than 300 mm (12.0 in.).
- Vertical ladders should not be located within 1.83 m (6 ft.) of other nearby potential fall points (including the deck edge, cargo holds and lower decks) without additional fall protection, such as guardrails.
- Vertical ladders should be provided with skid/slip resistant on the rungs that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.
- The angle of inclination for vertical ladders should be 80 to 90 degrees.
- Permanent vertical ladders should be attached to a permanent structure.
- The maximum distance from the ladder’s centreline to any object that must be reached by personnel from the ladder should not exceed 965 mm (38.0 in.).
- Vertical ladders should be located so as not to interfere with the opening and closing of hatches, doors, gratings, or other types of access.
- No impediments should intrude into the climbing space (for examples, electrical boxes, valves, actuators, or piping).
- Overhead clearance above vertical ladder platforms should be a minimum of 2130 mm (84.0 in.)
- There should be at least 750 mm (29.5 in.) clearance in front of the ladder (climbing space).
- There should be between 175 mm (7.0 in.) to 200 mm (8.0 in.) clearance behind the ladder (toe space).
- A means of access to a cellular cargo space should be provided using staggered lengths of ladder. No single length is to exceed 6.0 m (91.5 ft) in length.

Rung Design

- Rungs should be equally spaced along the entire height of the ladder.
- If square bar is used for the rung, it should be fitted to form a horizontal step with the edges pointing upward.
- Rungs should also be carried through the side stringers and attached by double continuous welding.
- Ladder rungs should be arranged so a rung is aligned with any platform or deck that an operator or maintainer will be stepping to or from.

- Ladder rungs should be slip resistant or of grid/mesh construction.

Provision of Platforms

- When the height of a vertical ladder exceeds 6.0 m (19.5 ft), an intermediate or linking platform should be used.
- If a work task requires the use of two hands, working from a vertical ladder is not appropriate. The work area should be provided with a work platform that provides a flat, stable standing surface.

Vertical ladders as Means of Access

- Where vertical ladders lead to manholes or passageways, horizontal or vertical handles or grab bars should be provided. Handrails or grab bars should extend at least 1070 mm (42.0 in.) above the landing platform or access/egress level served by the ladder.

Safety Cages

- Safety cages should be used on vertical ladders over 4.5 m (15.0 ft) in height.
- Climber safety rails or cables should be used on vertical ladders in excess of 6.1 m (20.0 ft).

D) Work Platforms

General Principles

- Work platforms should be provided at locations where personnel must perform tasks that cannot be easily accomplished by reaching from an existing standing surface.
- Work platforms exposed to the elements should have additional slip resistance due to potential exposure to water and ice.
- Work platforms more than 600 mm (23.5 in.) above the surrounding surface should be provided with guard rails and hand rails.
    - Work platforms should be of sufficient size to accommodate the task and allow for placement of any required tools, spare parts or equipment.

E) Egress

- Doors, hatches, or scuttles used as a means of escape should be capable of being operated by one person, from either side, in both light and dark conditions. Doors should be designed to prevent opening and closing due to vessel motion and should be operable with one hand.
- Doors (other than emergency exit) used solely by crew members should have a clear opening width of at least 710 mm (28 in.) The distance from the deck to the top of the door should be at least 1980 mm (78 in.).
- The method of opening a means of escape should not require the use of keys or tools. Doors in accommodation spaces (with the exception of staterooms), stairways, stair towers, passageways, or control spaces, should open in the direction of escape or exit.
- The means of escape should be marked from both the inside and outside.
- Deck scuttles that serve as a means of escape should be fitted with a release mechanism that does not require use of a key or a tool, and should have a holdback device to hold the scuttle in an open position.
  Deck scuttles that serve as a means of escape should have the following dimensions:
  i) Round – 670 mm (26.5 in.) or greater in diameter
  ii) Rectangular – 670 mm (26.5 in.) by 330 mm (13 in.) or greater

Annex A - Recommended Measurement Values

1.1 General

The recommendations in the following section outline measurement values for lighting, ventilation, vibration and access from a best practice ergonomics perspective. The information provided can assist designers when applying structural arrangement guidance.

See the IMO Code on Noise Aboard ships (IMO Resolution MSC.337(91)) for recommended shipboard noise levels guidance.

1.2 Lighting

The following tables give details of recommended illuminance levels in Lux which support task performance, safety and visual comfort for the operator. Emergency lighting is covered in SOLAS and IMO Resolutions and has not been considered in the below table. Lighting measurements should be made with the probe approximately 800 mm (32 inches).

Table 1 - Lighting for Crew Accommodations Spaces

Space	*Illuminance Level in Lux*	*Space*	*Illuminance Level in Lux*
Entrances and Passageways			
Interior Walkways, Passageways, Stairways and Access Ways	100	Exterior Walkways, Passageways, Stairways and Access Ways (night)	100
Corridors in Living quarters and work areas	100	Stairs, escalators	150
		Muster Area	200
Cabins, Staterooms, Berthing and Sanitary Spaces*			
General Lighting	150	Bath/Showers (General Lighting)	200
Reading and Writing (Desk or Bunk Light)	500	All other Areas within Sanitary Space (e.g., Toilets)	200
Mirrors (Personal Grooming)	500	Light during sleep periods	<30
Dining Spaces			
Mess Room and Cafeteria	300	Snack or Coffee Area	150
Recreation Spaces			
Lounges	200	Gymnasiums	300
Library	500	Bulletin Boards/Display Areas	150
Multimedia Resource Centre	300	All other Recreation Spaces (e.g., Game Rooms)	200
TV Room	150	Training/Transit Room Office/Meeting rooms	500
Medical, Dental and First Aid Centre			
Dispensary Hospital/ward	500	Wards - General Lighting - Critical Examination - Reading Hospital/ward	 150 500 300 500
Medical and Dental Treatment/ Examination Room Hospital/ward	500		
Medical Waiting Areas	200		
Laboratories	500	Other Medical & Dental Spaces	300
*Note: If there is any opportunity for light to enter cabins or staterooms at the times of day or night when people sleep (e.g., portlights, transoms, etc.), the maximum lighting levels should be 30 Lux.			

Table 2 - Lighting for Navigation and Control Spaces

Space	*Illuminance Level in Lux*	*Space*	*Illuminance Level in Lux*
Wheelhouse, Pilothouse, Bridge	300	Offices - General Lighting - Computer Work - Service Counters	300 300 300
Chart Room - General Lighting - On Chart Table	150 500		
Other Control Rooms (e.g., Cargo Transfer etc.) - General Lighting - Computer Work Central Control Room	300 300 500	Control Stations - General Lighting - Control Consoles and Boards, Panels, Instruments - Switchboards - Log Desk Local Instrument room	300 300 500 500 400
Radar Room	200		
Radio Room	300	Gyro Room	200

Table 3 - Lighting for Service Spaces

Space	*Illuminance Level in Lux*	*Space*	*Illuminance Level in Lux*
Food Preparation - General Lighting - Galley - Pantry - Butcher Shop - Thaw Room - Working Surfaces, Food Preparation Counter and Range Tops - Food Serving Lines - Scullery (Dishwashing) - Extract Hood Store rooms Package handling/cutting	500 500 300 500 300 750 300 300 500 100 300	Laundries - General Lighting - Machine, Pressing, Finishing and Sorting	300 300
		Chemical Storage	300
		Storerooms - Large Parts - Small Parts - Issue Counters	200 300 300
		Elevators	150
		Food Storage - Non-refrigerated - Refrigerated	200 100
Mail Sorting	500		

Table 4 - Lighting for Operating and Maintenance Spaces/Areas

Space	*Illuminance Level in Lux*	*Space*	*Illuminance Level in Lux*
Machinery Spaces (General) Unmanned Machinery spaces	200 200	Cargo Holds (Portable Lighting) - General Lighting - During Cargo Handling - Passageways and Trunks	 30 300 80
Engine Room	300		
Generator and Switchboard Room Switchboard, transformer room Main generator room/switch gear	300 500 200		
Fan Room HVAC room	200 200	Inspection and Repair Tasks - Rough - Medium - Fine - Extra Fine	 300 500 750 1000
Motor Room	300		
Motor-Generator Room (Cargo Handling)	150		
Pump Room, Fire pump room Steering Gear Room Windlass Rooms Battery Room Emergency Generator Room Boiler Rooms	200 200 200 200 200 100	Workshops Paint Shop Workshop office Mechanical workshop Inst/Electrical Workshop	300 750 500 500 500
Bilge/Void Spaces	75		
Muster/Embarkation Area	200	Unmanned Machinery Room	200
		Shaft Alley	100
Cargo Handling (Weather Decks) Lay Down Area General Process and Utility area Loading ramps/bays	200 200 200 200	Escape Trunks	50
		Crane Cabin	400
Cargo Storage and Manoeuvring areas	350	Hand signalling areas between crane shack and ship deck	300

Table 5 - Lighting for Red or Low-level White Illuminance

Area	***Illuminance Level in Lux***
Where seeing is essential for charts and instruments	1 to 20
Interiors or Spaces	5 to 20
Bridge Areas (including chart tables, obstacles and adjacent corridors and spaces)	0 to 20 (Continuously Variable)
Stairways	5 to 20
Corridors	5 to 20
Repair Work (with smaller to larger size detail)	5 to 55

Brightness (Adopted from DOT/FAA/CT-96/1 - Human Factors Design Guide).

The following table recommends the brightness ratio between the lightest and darkest areas or between a task area and its surroundings.

Table 6 - Recommended Maximum Brightness Ratios

	Environmental Classification		
Comparison	A	B	C
Between lighter surfaces and darker surfaces within the task	5 to 1	5 to 1	5 to 1
Between tasks and adjacent darker surroundings	3 to 1	3 to 1	5 to 1
Between tasks and adjacent lighter surroundings	1 to 3	1 to 3	1 to 5
Between tasks and more remote darker surfaces	10 to 1	20 to 1	b
Between tasks and more remote lighter surfaces	1 to 10	1 to 20	b
Between luminaries and adjacent surfaces	20 to 1	b	b
Between the immediate work area and the rest of the environment	40 to 1	b	b

Environmental Classification Notes:

A Interior areas where reflectances of entire space can be controlled for optimum visual conditions.

B Areas where reflectances of nearby work can be controlled, but there is only limited control over remote surroundings.

C Areas (indoor and outdoor) where it is completely impractical to control reflectances and difficult to alter environmental conditions.

b Brightness ratio control is not practical.

1.3 Ventilation

- Thermal comfort varies among individuals as it is determined by individual differences. Individually, perception of thermal comfort is largely determined by the interaction of thermal environmental factors such as air temperature, air velocity, relative humidity, and factors related to activity and clothing.

- The Heating, Ventilation and Air-Conditioning (HVAC) systems onboard a vessel should be designed to effectively control the indoor thermal environmental factors to facilitate the comfort of the crew.

- The following are a set of ergonomic recommendations that aim to achieve operator satisfaction from a thermal comfort perspective.

A) Recommended Air temperature

- A Heating, Ventilation, and Air Conditioning (HVAC) system should be adjustable, and temperatures should be maintained by a temperature controller. The preferred means would be for each manned space to have its own individual thermostat for temperature regulation and dehumidification purpose.

- International Standards recommend different bands for a HVAC system, but there is little difference in the minimum and maximum values they stipulate. A band width between 18°C (64°F) and 27°C (80°F) accommodates the optimum temperature range for indoor thermal comfort.

B) Recommended Relative humidity

- A HVAC system should be capable of providing and maintaining a relative humidity within a range from 30% minimum to 70% maximum with 40 to 45% preferred.

C) Enclosed space vertical gradient recommendation

- The difference in temperature at 100 mm (4 in.) above the deck and 1700 mm (67 in.) above the deck should be maintained with 3°C (6°F).

D) Recommended Air velocity

- Air velocities should not exceed 30 metres-per-minute or 100 feet-per-minute (0.5 m/s or 1.7 ft/s) at the measurement position in the space.

E) Berthing Horizontal Temperature Gradient

- In berthing areas, the difference between the inside bulkhead surface temperature adjacent to the berthing and the average air temperature within the space should be less than 10°C (18°F).

F) Air exchange rate

- The rate of air exchange for enclosed spaces should be at least six (6) complete changes-per-hour.

Summary of Indoor Climate Recommendations

Item	*Recommendation or Criterion*
Air Temperature	18 to 27°C (68 to 77°F)
Relative Humidity	The HVAC system should be capable of providing and maintaining a relative humidity within a range from 30% minimum to 70% maximum
Vertical Gradient	The acceptable range is 0 – 3°C (0 – 6°F)
Air Velocity	Not exceed 30 meters-per-minute or 100 feet-per-minute
Horizontal Gradient (Berthing areas)	The horizontal temperature gradient in berthing areas should be <10°C (18°F)
Air Exchange Rate	The rate of air change for enclosed spaces should be at least six (6) complete changes-per-hour

1.4 Vibration

- Vibration comfort varies among individuals as it is determined by individual differences. Individually, perception of vibration comfort is determined by the magnitudes and frequencies of those vibrations.

- The following are recommendations aiming to control levels of whole body vibration exposure that are generally not considered to be uncomfortable, and these are based on the recommendations of ISO 6954 (2000).

- The following levels of whole body vibrations should not be exceeded when measured in three axes (x, y, and z) using the w weighting scale (whole body, as discussed in ISO 6954:2000) with a band limitation in all axes limited from 1 to 80 hz.

Maximum RMS vibration levels	
Accommodations Areas	Workspaces
180 mm/second^2 (5 mm/s)	215 mm/second^2 (6 mm/s)

1.5 Access

- The following provide further ergonomic guidance on access arrangements to support the recommendations given in Section 4.6 Access & Egress Design, with a view to covering wider scope than those covered by the mandatory requirements such as SOLAS Regulation II-1/3-6 and BCS- I SC191.

- The measurements hereunder are based on one of recognised practices for ergonomic design with a view to providing general guidance to cover not only means of access for inspections but also means of access for operation. Therefore, they are not necessarily identical to those specified in the mandatory requirements.

Stair Handrail

In addition to the recommendations for Stair Handrails presented in Section 4.6 Access & Egress Design, the following recommended dimensions relating to the design of Stair Handrails are presented in the following table. Stairs with three or more steps should be provided with handrails.

Stair Handrail Arrangements

Arrangement	***Handrail Recommendation***
1120 mm (44 in.) or wider stair with bulkhead on both sides	Single tier handrail on both sides
Less than 1120 mm (44 in.) stair width with bulkhead on both sides	Single tier handrail on one side, preferably on the right side descending
1120 mm (44 in.) or wider stair, one side exposed, one with bulkhead	Two tier handrail on exposed side, single tier on bulkhead side
Less than 1120 mm (44 in.) stair width, one side exposed, one with bulkhead	Two tier handrail on exposed side
All widths, both sides of stairs exposed	Two tier handrail on both sides

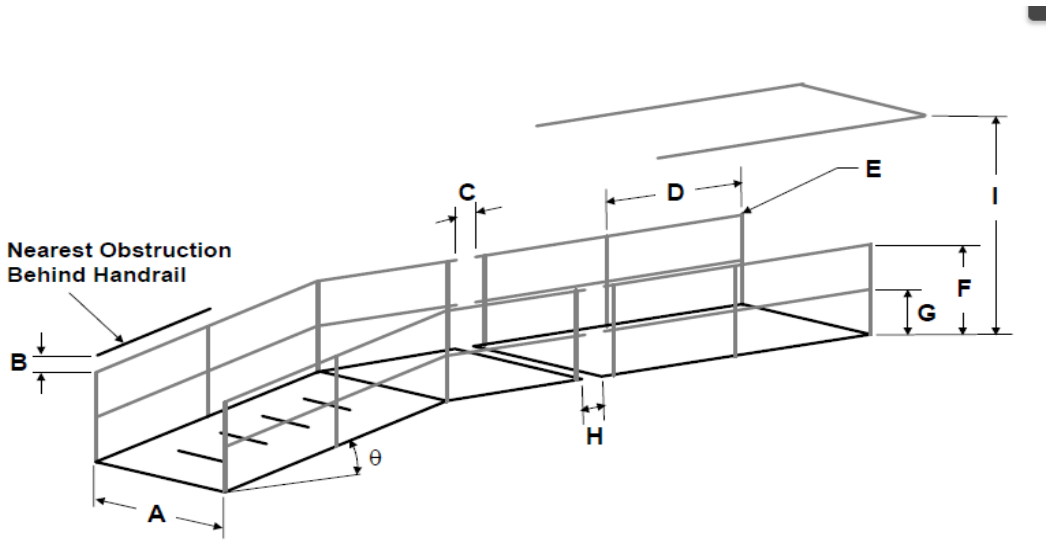
Walkway and Ramp Design

In addition to the recommendations for Walkway Design presented in Section 4.6 Access & Egress Design, the following recommended dimensions relating to the design of walkways and ramps are presented in Figure 1 'Walkway and Ramp Design'.

Figure 1 Walkway and Ramp Design

Dimension		*Recommendations*
A	Walkway width – one person[2]	≥ 710 mm (28 in.)
	Walkway width – two-way passage, or means of access or egress to an entrance	≥ 915 mm (36 in.)
	Walkway width – emergency egress, unobstructed width	≥ 1120 mm (44 in.)
B	Distance behind handrail and any obstruction	≥ 75 mm (3.0 in.)
C	Gaps between two handrail sections or other structural members	≤ 50 mm (2.0 in.)
D	Span between two handrail stanchions	≤ 2.4 m (8 ft)
E	Outside diameter of handrail	≥ 40 mm (1.5 in.) ≤ 50 mm (2.0 in.)
F	Height of handrail	1070 mm (42.0 in.)
G	Height of intermediate rail	500 mm (19.5 in.)
H	Maximum distance between the adjacent stanchions across handrail gaps	≤ 350 mm (14.0 in.)
I	Distance below any covered overhead structure or obstruction	≥ 2130 mm (84 in.)
Θ	Ramp angle of inclination – unaided materials handling	≤ 5 degrees
	Ramp angle of inclination – personnel walkway	≤ 15 degrees

Notes:
1 Toeboard omitted for clarity
2 The walkway width may be diminished to ≥ 500 mm around a walkway structure web frames



Vertical Ladder Design and Dimensions

In addition to the recommendations for Vertical Ladders presented in Section 4.6 Access & Egress Design, the following recommended dimensions relating to the design of Ladders are presented in Figure 2 to Figure 5.

- Figure 2 – Vertical Ladders (General Criteria)
- Figure 3 – Staggered Vertical Ladders
- Figure 4 – Vertical Ladders to Landings (Side Mount)
- Figure 5 – Vertical Ladders to Landings (Ladder through Platform)

Figure 2 Vertical Ladders (General Criteria)

Dimension		***Recommendation***
A	Overhead Clearance	2130 mm (84.0 in.)
B	Ladder distance (gap accommodating toe space) from surface (at 90 degrees)	≥ 175 mm (7.0 in.) ≤ 200 mm (8.0 in.)
C	Horizontal Clearance (from ladder face and obstacles)	≥ 750 mm (29.5 in.) or ≥ 600 mm (23.5 in.) (in way of openings)
D	Distance between ladder attachments / securing devices	≤ 2.5 m (8.0 ft)
E	Ladder angle of inclination from the horizontal	80 to 90 degrees
F	Rung Design – (Can be round or square bar; where square bar is fitted, orientation should be edge up)	Square bar 25 mm (1.0 in.) x 25 mm (1.0 in.) Round bar 25 mm (1.0 in.) diameter
G	Distance between ladder rungs (rungs evenly spaced throughout the full run of the ladder)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
H	Skew angle	≤ 2 degrees
I	Stringer separation	400 to 450 mm (16.0 to 18.0 in.)
J	Ladder height: Ladders over 6 m (19.7 ft) require intermediate/linking platforms)	≤ 6.0 m (19.5 ft)

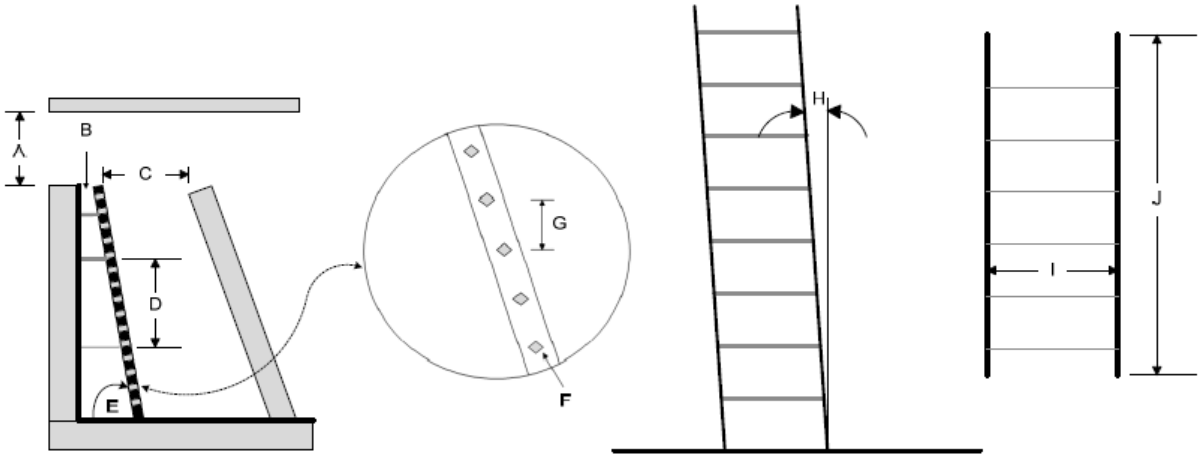


Figure 3 Staggered Vertical Ladders

Dimension		*Recommendation*
A	Stringer separation	400 to 450 mm (16.0 to 18.0 in.)
B	Horizontal separation between two vertical ladders, stringer to stringer	≥ 225 mm (9 in.) ≤ 450 mm (18 in.)
C	Distance between ladder rungs (rungs evenly spaced throughout the full run of the ladder)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
D	Stringer height above landing or intermediate platform	≥ 1350 mm (53.0 in.)
E	Rung design – (Can be round or square bar; where square bar is fitted, orientation should be edge up)	Square bar 22 mm (0.9 in.) x 22 mm (0.9 in.) Round bar 25 mm (1.0 in.) diameter
F	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) ≤ 300 mm (12.0 in.)
G	Landing or intermediate platform width	≥ 925 mm (36.5 in.)
H	Platform ladder to Platform ledge	≥ 75 mm (3.0 in.) ≤ 150 mm (6.0 in.)

*Note: Left side guardrail of platform omitted for clarity.

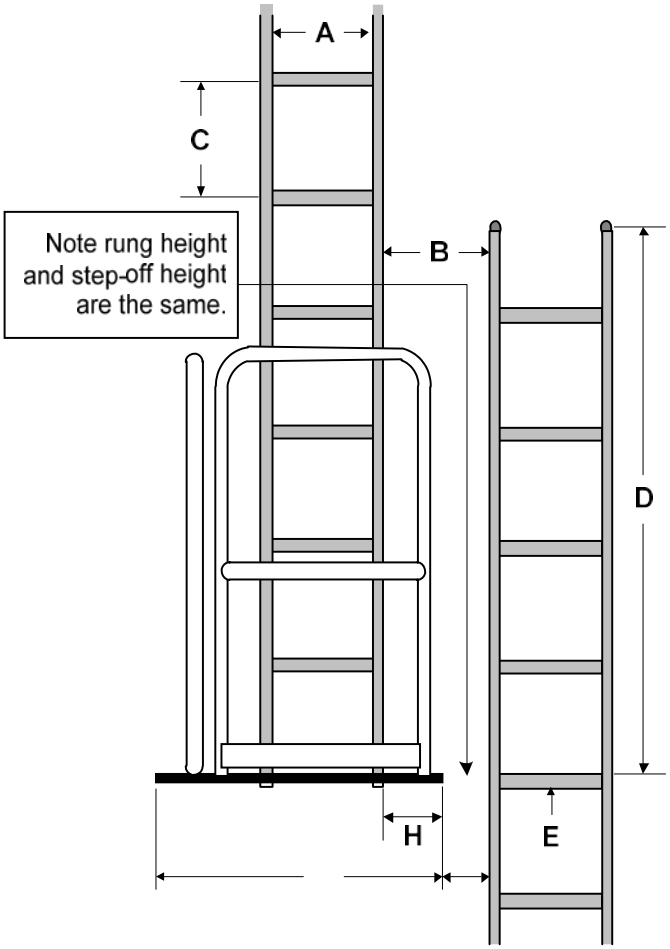


Figure 4 Vertical Ladders to Landings (Side Mount)*

Dimension		*Recommendation*
A	Platform depth	≥ 750 mm (29.5 in.)
B	Platform width	≥ 925 mm (36.5 in.)
C	Ladder distance from surface	≥ 175 mm (7.0 in.)
D	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) and ≤ 300 mm (12.0 in.)

* Notes: Top view. Guardrails/Handrails not shown.

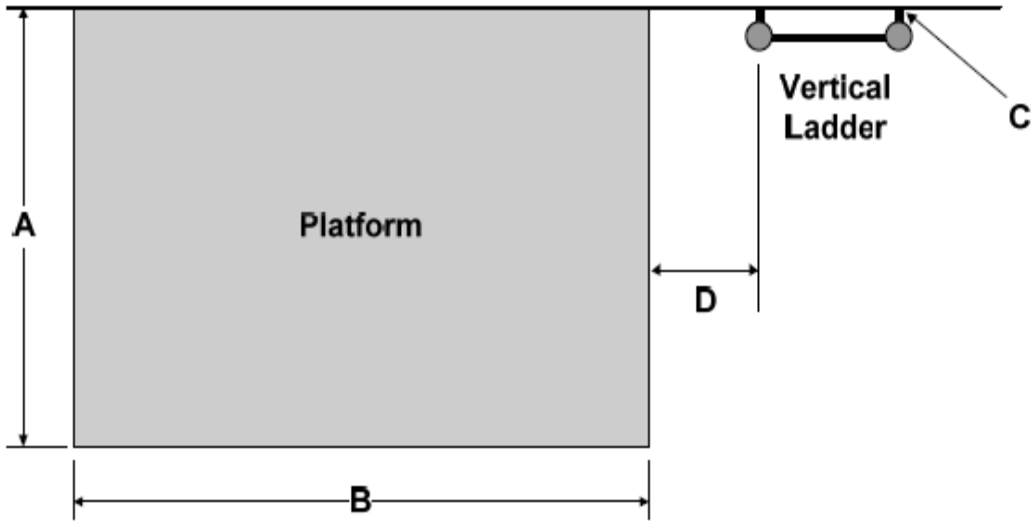
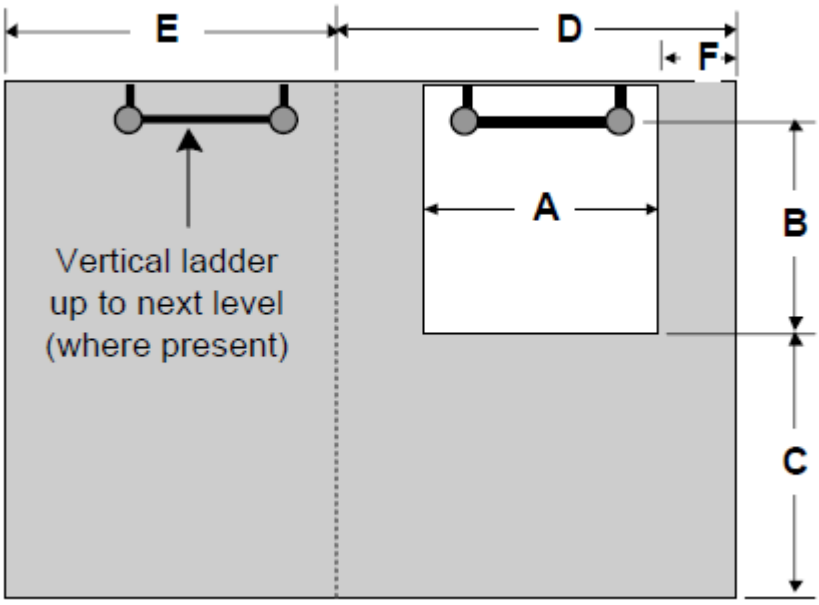


Figure 5 Vertical Ladders to Landings (Ladder through Platform)*

Dimension		*Recommendation*
A	Vertical ladder opening	≥ 750 mm (29.5 in.)
B	Distance from front of vertical ladder to back of platform opening	≥ 750 mm (29.5 in.)
C	Minimum clear standing area in front of ladder opening – Depth	≥ 750 mm (29.5 in.)
D	Minimum clear standing area in front of ladder opening – Width	≥ 925 mm (36.5 in.)
E	Additional platform width for intermediate landing (where present)	≥ 925 mm (36.5 in.)
F	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) and ≤ 300 mm (12.0 in.)

*Notes: Top view. Guardrails/Handrails not shown.

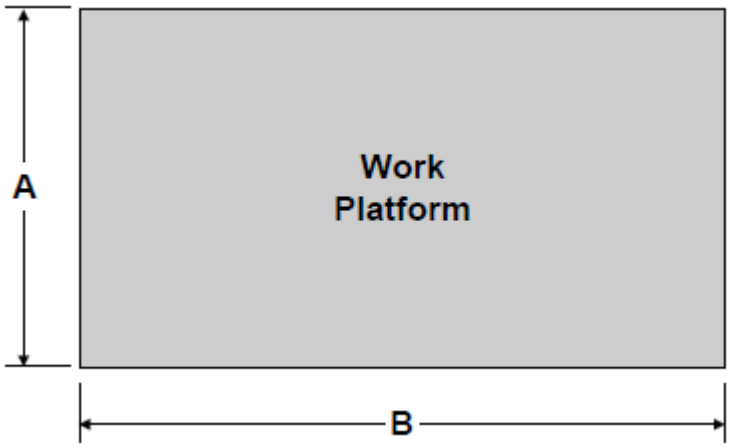


Work Platform

In addition to the recommendations for Work Platforms presented in Section 4.6 Access & Egress Design, the following recommended dimensions relating to the design of Work Platforms are presented in Figure 6 ‘Work Platform Dimensions’.

Figure 6 Work Platform Dimensions

Dimension		***Recommendation***
A	Work platform width	≥ 750 mm (29.5 in.)
	Work platform width (if used for standing only)	≥ 380 mm (15.0 in.)
B	Work platform length	≥ 925 mm (37.0 in.)
	Work platform length (if used for standing only)	≥ 450 mm (18.0 in.)



Annex B - Relevant Standards, Guidelines and Practices

This Annex presents a list of standards and guidance documents used by industry in relation to lighting, ventilation, vibration, noise and access in the context of their effects on human working onboard ships.

2.1 Lighting

- ASTM F1166 2007 Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities
- IESNA RP-12-97, Recommended Practice for Marine Lighting
- ISO 8995:2000 (CIES 008/E), Lighting of indoor work places
- ILO Maritime Labour Convention
- JIS F 8041: Recommended Levels of illumination and Methods of illumination Measurement for Marine Use

2.2 Ventilation

- ANSI/ASHRAE (15) (2010). Practices for Measuring, Testing, Adjusting, and Balancing Shipboard HVAC&R Systems
- ANSI/ASHRAE 55a, (2010). Thermal environmental conditions for human occupancy
- ANSI/ASHRAE 62.1 (2010) Ventilation for Acceptable Indoor Air Quality
- ISO 7547:2008 Ships and marine technology – Air-conditioning and ventilation of accommodation spaces – Design conditions and basis of calculations
- ISO 7726 (E), (1998), Ergonomics of the thermal environment – Instruments for measuring physical quantities

2.3 Vibration

- ISO 2631-1:1997, Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration – Part 1: General Requirements
- ISO 2631-2:2003, Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration – Part 2: Vibration in Buildings.
- ISO 6954:2000, Mechanical Vibration and Shock – Guidelines for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and Merchant Ships.
- ISO 8041:2005, Human response to vibration – Measuring instrumentation.

2.4 Noise

- IMO Resolution MSC.337(91), Code on Noise Levels on Board Ships
- IMO Resolution A.468(XII), Code on Noise Levels on Board Ships

2.5 Access

- American Society for Testing and Materials (ASTM) F1166 2007 Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities
- BCS- G 78 – Safe Use of Portable Ladders for Close-up Surveys
- BCS- G 90 – Ship Structure Access Manual
- BCS- G 91 – Guidance for Approval/Acceptance of Alternative Means of Access
- BCS- I SC191 for the application of amended SOLAS regulation II-1/3-6 (IMO Resolution MSC.151 (78)) and revised Technical provisions for means of access for inspections (IMO Resolution MSC.158 (78))
- IMO Maritime Safety Committee Resolution MSC.133 (76) Adoption of Amendments to the Technical Provisions for Means of Access for Inspections
- IMO Maritime Safety Committee Resolution MSC.134 (76) Adoption of Amendments to the International Convention for the Safety of Life At Sea
- IMO Maritime Safety Committee Resolution MSC.158 (78) (adopted 20 May 2004), Amendments to the Technical Provisions for Means of Access for Inspections

BCS-G 133 Guidelines for Pilot Schemes of Extended Interval between Surveys in Dry-Dock - Extended Dry-docking (EDD) Scheme

1 Introduction

The intervals between inspections of the outside of the ship's bottom are specified in SOLAS and BCS Rules and require a minimum of two inspections to be carried out during the 5 year validity period of the Safety Construction
Certificate/Special Survey period. SOLAS Regulation I/10(v) only requires a minimum of two inspections of the outside of the ship's bottom and does not specify a ship must be dry-docked out of the water.

IMO Resolution A.1053(27) as amended, "Survey guidelines for the harmonized system of survey and certification", requires that inspections of the outside of the ship's bottom should normally be carried out with the ship in a dry-dock. However, it also provides that Administrations may give consideration to alternate inspections being carried out with the ship afloat. This document recommends the acceptance procedure for pilot schemes which extend the interval between surveys in dry-dock. Ships eligible for the Extended Dry-Docking (EDD) scheme should meet the provisions and conditions described in this document. Qualifying ships may be permitted to carry out two consecutive in-water surveys, subject to the conditions described in this document. A minimum of two inspections of the outside of the ships bottom should be carried out during the renewal period of five years and the intervals between any two inspections shall not exceed 36 months.

Pilot schemes which extend the interval between out of water dry-docking surveys are normally tripartite projects between the Owner, Flag Administration and BCS.

Acceptance into such a Pilot scheme is subject to the formal written agreement with the ship's Flag Administration including any additional specific Flag Administration requirements.

2 Application

Owners /Managers requesting a ship be considered for the EDD scheme , are to apply to BCS in writing confirming and describing compliance with the requirements and conditions specified in this document.

Upon the Owner's request, the extended interval for each ship will be considered on a case by case basis by BCS. BCS may assist in forwarding the Owner's application to the Flag Administration.

The following ships and ship types are not eligible for the extended dry-docking scheme described in these guidelines:

- Passenger Ships;
- Ships subject to the Enhanced Survey Program (ESP);
- Ships subject to the Hull Survey Requirements of BCS- R Z7.1;

- Ships fitted with propulsion thrusters;
- Ships where the propeller connection to the shaft is by means of a keyed taper;
- High Speed Craft(HSC).

The dry-docking scheme will operate based upon the ship's age when entering the scheme. For ships already in service, the extended dry-docking scheme may be implemented at any time until a ship reaches 10 years of age.

No extensions should be granted for the dry-docking required at the end of each extended dry docking period.

3 Information to be submitted by the Owner

Prior to acceptance into an EDD scheme, the owner is to submit the following information:

- Provisions for carrying out maintenance required on electric/electronic sensors e.g. Echo-sounder, Doppler-Log, Speedlog (propeller speedlog or backpressure speedlog), seawater temperature gauges, electronic draught reading, etc.;
- Provisions for maintaining the draft marks fore, aft and midships as well as Loadline marks (painted and welded figures) and all other required hull markings;
- Maintenance required of thrusters and stabilisers, if fitted, and provision for carrying out surveys or maintenance or as required by the surveyor;
- Service experience to-date with hull coating system covered by manufacturer's guarantee that the underwater coatings used are designed to last for the extended period since the coating is to remain effective for the extended dry docking period;
- Impressed cathodic protection system or provisions for renewal of external hull sacrificial anodes in the afloat condition.

4 Preparatory Reviews by BCS

BCS should carry out the following reviews prior to accepting a ship into an EDD scheme:

- Satisfactory review of the items submitted by the owner as required in Section 3 above;
- Review of ship's history with particular attention to any previous findings affecting the underwater body.

5 Arrangements

Prior to acceptance into an EDD scheme, ships enrolled an extended dry-docking interval scheme should comply with the following provisions:

- The ship should comply with the In-Water Survey provisions in accordance with the corresponding requirements of BCS.
- Protective coating in double bottom/double side ballast tanks, void spaces and all other spaces adjacent to the shell should be maintained in GOOD condition;

- The shafting arrangement should fulfil the applicable Society's requirements for Tailshaft Condition Monitoring Survey Arrangement;

- Hull maintenance scheme to be implemented in accordance with ISM requirements.

6 In-Water Survey Requirements

The In-Water Survey should be carried out in accordance with BCS- R Z3.

An in-water survey plan should be submitted to BCS for review in advance of the survey and should include the following:

- Scheduled time and location for survey;

- Name of approved diving company;

- Means for cleaning of the hull below waterline;

- Means of access for examination of sea chests, sea valves and box coolers;

- Provisions for determining the condition of anchoring equipment, ranging of anchor chain cables and examination of the chain lockers when due for survey and/or as required by the surveyor;

- Provisions for surveying and maintaining sea connections including thickness measurements of sea chests;

- Results of inspections by the Owner's personnel of double bottom/double side ballast tanks (during the last 3 years) and other spaces adjacent to the shell with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the protective coating;

- Conditions for internal examination of double bottom/double side ballast tanks (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.).

Prior to commencement of the in-water survey, a survey planning meeting is to be held between the attending surveyor(s), the owner's representative in attendance, the diving company and the master of the ship or an appropriate representative appointed by the owner for the purpose of ascertaining that all the arrangements envisaged in the survey plan are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

A comprehensive report of findings, gaugings, clearances and any work undertaken, including recordings of representative CCTV images, must be submitted by the ship owner to all involved parties.

7 Special Survey/Statutory Renewal Requirements

It should be noted that the periodicity of the ships's Special Survey and Statutory Renewal Surveys will not change, therefore provision must be made for carrying out all such surveys and any repairs afloat, where not dry-docking.

8 Survey Findings

If the In-Water Survey reveals damage, deterioration or other conditions that requires early attention, the surveyor may require that the ship be dry-docked in order that a detailed survey can be undertaken and necessary repairs carried out.

If temporary repairs carried out to any underwater parts are considered acceptable these must be made permanent within a due date decided by the surveyor.

The owner is to request BCS to perform a survey in dry-dock in any event or circumstance in the operation of the ship which could have led to underwater damages or
deterioration in the crew's knowledge or opinion.

If the coating condition in double bottom/double side ballast tanks, void spaces and dry spaces is found in less than GOOD condition, the owner is to restore the coating to GOOD.

9 Termination of Scheme

The dry-docking survey required for the Special Survey at 15 years of age shall be carried out in a dry-dock. All ships in an EDD scheme shall be dis-enrolled once the ship reaches 15 years of age.

The Extended Dry-docking Scheme will be terminated in cases of change of the ship's owner, management or Flag Administration.

BCS may dis-enrol a ship from an EDD scheme at any time should it be found that the conditions for maintaining this extended Dry-Dock scheme are not fulfilled anymore.

Once the conditions for the scheme are no longer present, the ship will return to the normal docking interval and any due dock survey shall be carried out by the due date.

BCS- G 134 Boat Transfers Safe Practice

CONTENTS

1. Introduction

2. Boat Transfer Safety Policy

3. Definitions

4. Boat Transfer Hazards and Exposures

5. Training Boat Transfer Procedures and Personal Protective Equipment (PPE)

6. Reference Document List

Annex 1: Required Boarding Arrangements for Pilot - In accordance with SOLAS Regulation V/23 and IMO Resolution A.1045(27)

1. Introduction

These recommendations are intended to provide BCS with reference information to be used in developing Boat Transfer procedures or technical instructions for its Surveyors, according to a common reference standard of good practice. The content applies to operations affecting Boat Transfers, and is intended to enhance the safety of the manner and conditions under which such transfers are carried out.

Additionally, these recommendations are intended to serve as a reference for the maritime industry to assist operators in adequately preparing the receiving ship or offshore unit so that the transfer can be carried out in a safe manner and under safe conditions.

The recommendations are structured in four (4) Sections:

- 3. Includes Definitions
- 4. Identifies the Boat Transfer hazards and exposure to risk by the Surveyor
- 5. Gives detailed guidance for the safe Boat Transfer operations, including Training Transfer Procedures and Personal Protective Equipment
- 6. Consists of a Reference Document List

2. Boat Transfer Safety Policy

Boat Transfers are considered a high-risk activity and BCS should adopt procedures that seek to reduce the risks faced by Surveyors during such transfers and to positively influence the overall safety performance of such operations through:

- Establishing effective control measures to mitigate the risks.
- Complying with applicable safety legislation.
- Providing adequate training to Surveyors.
- Providing adequate resources to allow tasks to be undertaken safely.
- Requiring that adequate resources are provided by Clients and other worksite controllers to allow work to be undertaken safely.
- Giving their Surveyors the right and responsibility to refuse to conduct work they consider to present an unacceptable risk until it is safe to do so.

3. Definitions

3.1 Boat Transfer

Boat Transfer of Surveyors includes transfers from shore to vessels / offshore units at anchorage or at sea, and vice-versa, which involves embarking or disembarking between a Transfer Boat and a vessel / an offshore unit, either by ladder or crane-basket.

3.2 Transfer Boat

Boats used for transfer include pilot boats, launches, tenders, workboats, crew boats and other craft used for the transfer of personnel. Any boat used for the transfer of Surveyors should comply with applicable national and legal requirements and port State regulations for its stated purpose and / or for transfer of personnel. They should be of a suitable construction, properly equipped (including equipment designed to aid the rapid recovery of an individual from the water), properly maintained, and suitably manned.

3.3 Responsible Persons

Responsible Persons are those under whose control personnel transfer takes place. The following are all considered Responsible Persons, as relevant and appropriate:

- Ships Agent/Owners/Managers
- Master of the ship
- Offshore Installation Manager (OIM) of the offshore unit
- Captain of the Transfer Boat

3.4 Surveyor

For the purpose of this Recommendation a Surveyor is any person employed or contracted by BCS undertaking a Boat Transfer on behalf of BCS.

3.5 Competent Harbour Authority

Competent Harbour Authority means any harbour authority which has statutory power in relation to the regulation of shipping movements and the safety of navigation within its harbour and whose harbour falls wholly or partly within an active pilotage district.

3.6 Deck Hand

A Deck Hand means a person on board the Transfer Boat who assists the Surveyor when embarking or disembarking.

4. Boat Transfer Hazards and Exposures

4.1 The general hazards associated with Boat Transfer are;

- Fall from a height, i.e. fall on hard surfaces and fall into water
- Drowning
- Impact or crushing injuries
- Impact with either the Transfer Boat or receiving vessel after a slip or fall
- Sprains, twists and/or pulls
- Cold water immersion
- Hazardous weather and/or sea conditions
- Other conditions inherent to the specific locality (e.g. Lack of visibility during foggy hours).

4.2 Hazards associated with defective embarkation arrangements

4.2.1 Pilot ladder

- Not against ship's hull
- Steps not of suitable material
- Badly placed retrieval line
- Steps damaged or broken / Steps dirty or slippery / Steps painted
- Spreader bars not fitted, wrongly fitted or in poor condition
- Steps not equally spaced
- Pilot ladder only for freeboard more than 9 meters
- Side ropes not of suitable material or wrongly arranged
- Pilot ladder located forward / aft, at shaped areas of the ship
- Bulwark ladder not available.

4.2.2 Defective Combination Arrangement (Pilot ladder/Accommodation ladder)

Nine (9) meters or more of freeboard requires a proper combination arrangement. Hazards include:

- Accommodation ladder not leading aft
- Lower platform stanchions/rail damaged, insufficiently fixed and/or loose
- Accommodation ladder too steep (>45 degrees)

- Pilot ladder not attached to accommodation ladder

- Lower platform not horizontal.

4.3 Hazards associated with defective Transfer Boat

- Unsuitable boat or boat exceeding its operating limitations

- Insufficient life-saving appliances

- Defective or insufficient means of communication

- Insufficient crew (at least one crewmember in addition to the helmsman)

- Inadequately trained crew.

For Boat Transfers during lightering ship or bunkering operations, the Transfer Boat inlet and outlet vents to the machinery spaces should be designed to prevent the ingress of flammable gases.

4.4 Hazards associated with safety equipment defects and defects in the receiving vessel or offshore unit

- Insufficient lighting at night (Note: Boat Transfer Operations in darkness should be discouraged.)

- No standby ladder rigged for immediate use

- No lifebuoy with self-igniting light

- No communication at the embarkation site between the bridge of the receiving vessel or unit and the Transfer Boat

- No heaving line available to board Surveyor’s equipment

- No Responsible officer or Deck Hand in attendance on the receiving vessel or unit

- Inadequately trained receiving vessel crew on deck at the embarkation site.

5. Training Boat Transfer Procedures and Personal Protective Equipment (PPE)

5.1 Training

5.1.1 Surveyors who may be involved in Boat Transfers should be periodically trained in safety practices for such activities according to the Society's internal procedures. This training should include but not be limited to:

5.1.1.1 Recognizing the hazards during Boat Transfers as mentioned in paragraph 4 above and managing the associated risks.

5.1.1.2 IACS, IMO, ILO and other recognized requirements for boarding arrangements, as applicable. BCSshould introduce references to applicable industry standards and regulations (e.g. IACS, IMO, ILO as listed in paragraph 6 below), at the time of developing their internal procedures.

5.1.1.3 Roles of the persons involved.

5.1.1.4 Safe embarking and disembarking procedures.

5.1.1.5 Arrangements and use of pilot ladders, accommodation ladders, or a combination of both and the use of personnel transfer devices.

5.1.1.6 Use and maintenance of personal flotation devices.

5.1.1.7 Emergency arrangements and procedures, as applicable.

5.2 Boat Transfer Procedures

5.2.1 BCS may promote and implement, within their service supplier approval program, their review, approval and certification of companies operating Transfer Boats that comply with
at least but not limited to the recommendations contained in paragraphs 5.2.2.2 through 5.2.2.10.

5.2.2 Before leaving the berth

5.2.2.1 When necessary, Surveyors should seek the support of the Competent Harbour Authority to verify that the Transfer Boat meets the relevant local regulations. The appropriate certificates confirming compliance with these requirements should be available on board the Transfer Boat for inspection.

5.2.2.2 The suitability, size and type of the Transfer Boat to be used for the personnel transfer should be carefully considered and should take into account the length of the voyage and the means of transfer from the Transfer Boat to the destination vessel. The Transfer Boat intended to be used should be appropriate for the area of operations including the prevailing sea and weather conditions.

5.2.2.3 The Transfer Boat should be equipped to respond to a man-overboard situation. The crew of the Transfer Boat should have been trained to handle a man-overboard situation and alert local authorities.

5.2.2.4 A Transfer Boat should be adequately manned for the size of vessel and intended voyage and duties during this transfer operation, and should, as a minimum in addition to the helmsman, include one crewmember deployed exclusively for assisting the transfer of personnel for the entire duration of this operation.

5.2.2.5 Boat Transfers should be planned to avoid transfer during the hours of darkness whenever possible. If Boat Transfers need to be done during darkness, the Transfer Boat should be suitably equipped, including an appropriate search lighting system. Special protective equipment should also be available when operating in cold water areas.

5.2.2.6 Before the commencement of any voyage, the master of the Transfer Boat should ensure that all persons on board are briefed, as a minimum, on the stowage location and use of personal safety equipment such as lifejackets, thermal protective aids and lifebuoys, and the procedures to be followed in cases of emergency. Lifebuoys should be located in an easily accessible position at the place of transfer in both the transport vessel and the ship.

5.2.2.7 When boarding the Transfer Boat, when underway in harbour or at sea, the Surveyor should immediately be made familiar with the position and stowage of the safety equipment fitted on the Transfer Boat.

5.2.2.8 The transfer deck and its approaches of the Transfer Boat should be clear of all unnecessary obstructions allowing clear passage and movement to the Surveyor. They should be non-slip, free of ice, snow etc.

5.2.2.9 Equipment and procedures should be in place to allow for the establishment of radio communication between the Transfer Boat and the receiving vessel or unit.

5.2.2.10 Safe transfer and emergency recovery procedures (including alerting of shore based authorities) should be available on the Transfer Boat and agreed with the vessel/offshore unit. The Surveyor should immediately be made familiar with these equipment and procedures.

5.2.2.11 Transfer Boat master should consider whether assisting crew members should be secured by means of a safety line, in consideration of the arrangement of the working vessel, the conditions of the transfer and the conditions of weather and wind.

5.2.2.12 The boat that is being used for the transfer of Surveyors should give priority to such transfer ahead of any other functions that may have been assigned to it.

5.2.3 On approaching the ship

5.2.3.1 The master of the Transfer Boat should establish the position of the vessel to be served.

5.2.3.2 The master of the Transfer Boat should contact and agree with the officer of the watch of the vessel to be served as to which side to rig the pilot ladder and/or accommodation ladder in order that the best lee conditions can be created for the approaching Transfer Boat. Due allowance should be made for the close proximity of other ships or units, their intentions and their expected wash effects. The decision as to which side the Surveyor will board should be communicated to the Surveyor as early as possible.

5.2.3.3 The required distance between the lowest step of the pilot ladder or accommodation ladder and the water needs to be transmitted to the vessel to be served together with the ideal speed required for the operation.

5.2.3.4 Care should be taken to ensure that the wash created by the Transfer Boat does not interfere with the safe boarding or landing operation. This may require the Transfer Boat to remain clear of the pilot ladder or accommodation ladder until the wash created has cleared down the vessel's side. The use of the searchlight at night to check for incoming wash is prudent.

5.2.3.5 Particular caution should be taken when serving a ship at anchor or a fixed offshore unit which is unable to manoeuver to make a lee, particularly at slack water. A ship may need to be underway and making way in order to provide a sufficiently good shelter before embarking or disembarking the Surveyor.

5.2.3.6 During the approach to the vessel, the Surveyor should remain in the cabin of the Transfer Boat until the boat is at reduced speed, in the lee of the vessel and settled. The Surveyor should not proceed from the cabin until permission is granted by the master of the Transfer Boat.

5.2.3.7 Although Boat Transfers in darkness should be discouraged, when deemed necessary, the Transfer Boat deck should be adequately illuminated before anyone goes on deck.

5.2.3.8 During final approach at night, the Transfer Boat searchlight should be turned on to illuminate the pilot ladder or accommodation ladder and forward deck of the Transfer Boat. Care needs to be taken not to dazzle personnel on deck, or adversely affect the night vision of persons on the bridge, or on the deck of the vessel to be served.

5.2.3.9 In adverse weather conditions, where risk to personnel as well as the launch may be significant, the decision whether or not to place the Transfer Boat alongside the vessel to be served should ultimately be the responsibility of the master of the Transfer Boat. However, the Surveyor has the final word on whether it is safe to proceed with the boarding or not.

5.2.4 Boarding Arrangements

5.2.4.1 After establishing contact with the Transfer Boat, the vessel or offshore unit should rig a pilot ladder or accommodation ladder or combination on the side or in the location that has been agreed. Boarding arrangements should be in accordance with the requirements of SOLAS Reg. V/23 (see Annex 1) and SOLAS Reg. II-1/3-9.

5.2.4.2 The pilot ladder should be rigged and secured at the appropriate pilot ladder boarding position on the vessel’s side. For ships this may be at the side door if fitted, and should be as near amidships as possible and on the parallel body of the ship, clear of all discharges which could cause flooding.

5.2.4.3 If the accommodation ladder is located at the shaped area of the receiving ship (e.g. accommodation is located aft), the use of the accommodation ladder should be given special consideration by the Surveyor, particularly if the Boat Transfer takes place when the receiving ship is in the light ballast condition such that the ladder may be rigged in a manner that axial movement cannot be avoided. In such circumstances Surveyors may insist on an alternative means of access being provided.

5.2.4.4 During Surveyor transfer, the supervising officer of the serviced vessel should be in direct contact with the vessel’s navigating bridge from the boarding position.

5.2.4.5 If a combination of pilot ladder and accommodation ladder is being used for boarding, the latter should be rigged sufficiently high to allow the Transfer Boat to lie alongside the pilot ladder section, with sufficient allowance for swell such that no part of the upper works of the Transfer Boat can contact the accommodation ladder. This distance may be specified by the master of the Transfer Boat.

5.2.5 Transfer by crane or basket

5.2.5.1 Transfer by personnel basket to or from a vessel or offshore structure can be undertaken using different devices. The three main devices used are:

1. Billy Pugh – the oldest personnel transfer basket design, in which personnel are transferred whilst holding onto the outside of the lifted structure.

2. Esvagt – a rigid framed construction with buoyancy ring and fenders, in which personnel stand inside the basket.

3. Personnel transfer capsule – a rigid framed device with buoyancy panels, in which personnel sit strapped in a bucket seat.

5.2.5.2 In some situations, basket transfer may be the only feasible means of transferring personnel at sea, for example, when there is a significant height difference between the respective decks of the Transfer Boat and the receiving unit. All basket transfers should be considered a high-risk operation at all times and they should only be undertaken when transfer is essential and cannot be undertaken by other means. It would not be appropriate to use personnel baskets for routine transfers in open waters when other more appropriate methods of transfer are available, as described in the foregoing paragraphs.

5.2.5.3 Before basket transfer, it should be confirmed, by the master of the vessel or offshore unit to the Surveyor that:

1. The crane operator is competent for man-riding operations.

2. The crane is fully operational, properly maintained, certified and currently in compliance with its required inspections.

3. The transfer basket has been visually inspected for defects prior to starting the transfer.

4. Confirmation of readiness of the means for communication between banksmen[1] crane operator, receiving vessel master and the Transfer Boat are in place and working.

5. Environmental and vessel motion conditions are considered acceptable by all parties involved.

6. The relevant crane operator and banksmen confirm they have good visibility of the pick-up, transfer and landing area.

7. For transfers to offshore units, cranes should meet the applicable requirements for man-riding operation (e.g.: API Spec 2C; EN 13852-1).

5.2.5.4 The crane used in the transfer operation should be adequate and suitable for lifting persons and should be certified for man-riding (e.g.: for use in carrying personnel) under applicable regulations.

5.2.5.5 The transfer basket should be correctly rigged onto the crane's lifting apparatus prior to transfer and the crane hook pennant should be of sufficient length to keep the hook well clear of the personnel being transferred.

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[1] Banksmen: Competent person duly authorized to supervise the lowering and raising of persons or material in a conveyance at the bank and to give necessary signals.

5.2.5.6 The transfer basket should be marked with its safe working load. It should be appropriately certified with the current certificate of test and / or inspection available on board the vessel or unit.

5.2.5.7 The certification, security and integrity of the entire lifting system, including wire ropes, rigging, shackles, safety slings and hooks, should be confirmed by the master of the receiving ship or offshore unit, as appropriate for man-riding.

5.2.6 Surveyor boarding

5.2.6.1 In all cases the decision as to whether or not to board the ship or offshore unit should be the responsibility of the Surveyor involved.

5.2.6.2 The Surveyor should proceed to the ladder after agreeing with the captain of the Transfer Boat on the side of the receiving vessel to be used.

5.2.6.3 Before the Surveyor steps onto the ladder he or she should establish that it is properly secured by communicating directly with the officer at the top of the ladder. If the top of the embarking site is unattended the Surveyor should not attempt to embark.

5.2.6.4 The timing of stepping from the Transfer Boat to the ladder requires adequate care, for example using the top of the wave to step onto the ladder and the roll of the ship to aid the ascent.

5.2.6.5 Surveyor’s equipment and luggage needs to be transferred as a separate operation. Personnel should not carry luggage or other impediments during the transfer.

5.2.6.6 The Surveyor should wear buoyancy aids. Aids are to be of an approved type and worn in accordance with manufacturer’s instructions.

5.2.7 Surveyor disembarkation

5.2.7.1 The Transfer Boat Deck Hand should be at the bottom of the ladder to ensure that the ladder is rigged at the correct height and clear of the water and any obstructions.

5.2.7.2 Before stepping onto the ladder, the Surveyor should check that the Transfer Boat is lying alongside and has not fouled the ladder.

5.2.7.3 During the descent process the Surveyor should seek the advice of the Deck Hand as to how many steps further to go to the deck of the Transfer Boat. In adverse weather the stepping off point may not be the lowest step, therefore communication between the Deck Hand and Surveyor will be necessary. As the Surveyor is stepping from the ladder the Deck Hand is to be on hand to provide a timely warning of danger and to give physical assistance to the Surveyor if required.

5.2.7.4 Similarly to boarding, the Surveyor should wear buoyancy aids. Aids are to be of an approved type and worn in accordance with manufacturer’s instructions.

5.2.7.5 Once on board the Transfer Boat, the Surveyor should immediately make his or her way to the safety of the cabin.

5.2.7.6 The master of the Transfer Boat should not leave the lee of the ship until the Surveyor is safely in the cabin.

5.2.7.7 The decision as to whether or not to disembark from a ship to the Transfer Boat rests entirely with the Surveyor involved.

5.3 Personal Protective Equipment (PPE)

5.3.1 Surveyors on board a Transfer Boat and during the Boat Transfer process should have protective clothing appropriate to the prevailing air and sea temperatures.

5.3.2 When a vessel is operating in waters with a sea surface temperature of 5ºC or less, Surveyors should during the Boat Transfer process wear a dry suit or other efficient garment to reduce the likelihood of hypothermia should the Surveyor enter the sea. Sea temperature data may be found in sources such as the Admiralty Pilot for a given sea area and period.

5.3.3 During the Boat Transfer process, the Surveyor should use footwear having non-slip soles.

5.3.4 Surveyors should wear lifejackets or buoyancy aids (e.g. Personal Floatation Device, PFD) whilst outside of the Transfer Boat cabin.

5.3.5 Whilst aboard the Transfer Boat, the Surveyor should follow the instructions of the Transfer Boat crew. The Surveyor should carefully consider whether an automatic or manual PFD is preferable for the transfer procedure being undertaken. Consideration should be given to the level of hindrance to escape from flooded internal boat spaces should an automatic device inflate before escape.

6. Reference Document List

The International Maritime Organization (IMO)
SOLAS Chapter V, Regulation 23 – Pilot transfer arrangements
IMO Resolution A.1045(27)
SOLAS Chapter II-1, Regulation 3-9 – Means of embarkation and disembarkation from ships
IMO Circular MSC/Circ. 1331.

The International Marine Contractors Association (IMCA)
IMCA SEL 025, IMCA M 202 – Guidance on the Transfer of Personnel to and from Offshore Vessels
IMCA S 004/M 189 – Marine inspection checklist for small workboats
IMCA SEL 36/04 – Personnel transfer by basket
IMCA SEL 019 – Guidelines of lifting operations

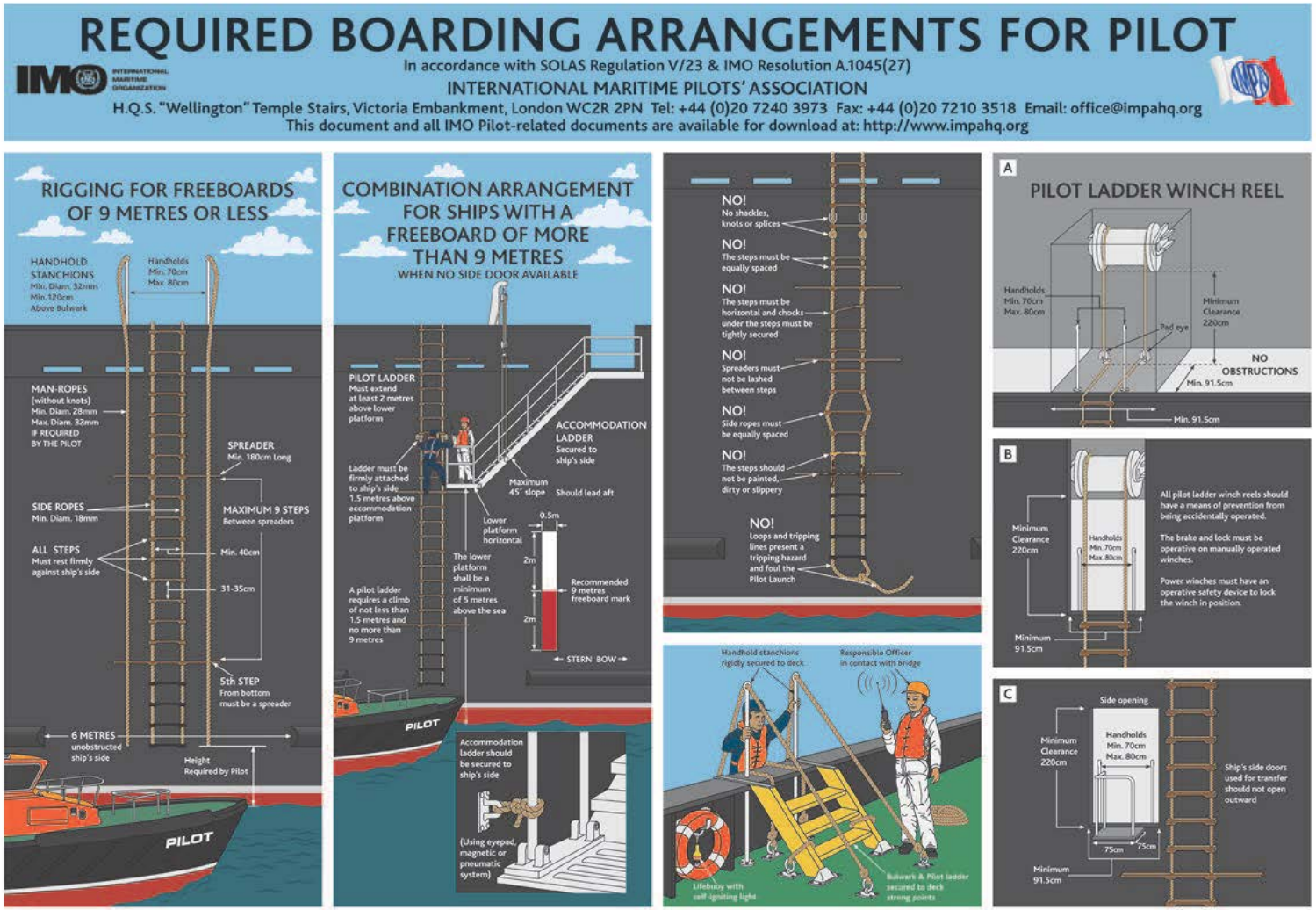
Marine/Pilotage Working Group of the British Ports Association (BPA) and the UK Major Ports Group (UKMPG) and the Technical & Training Committee of the United Kingdom Maritime Pilots Association (UKMPA)
The Embarkation and Disembarkation of Pilots Code of Safe Practice

Maritime and Coastguard Agency (MCA)
Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats – Alternative Construction Standards

International Maritime Pilots' Association (IMPA)
Poster - Required boarding arrangements for pilot prepared in accordance with SOLAS Regulation V/23 and IMO Resolution A.1045(27).

Annex 1 - Required Boarding Arrangements for Pilot

Prepared in accordance with SOLAS Regulation V/23 and IMO Resolution A.1045(27) by the International Maritime Pilots' Association



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BCS-G 136 Guidelines for Working at Height

A. Preamble

A1. This Recommendation has been developed to provide guidance to Classification Societies (hereinafter referred to as CS) when developing their own internal safety procedures and / or instructions relating to the hazards faced by survey personnel when working at height in the field (hereinafter referred to as WAH). Detailed calculations / testing of the equipment to be used when carrying out WAH activities are not required or intended under this Recommendation.

A2. The objective is to promote the safety of classification society personnel when required to work at height. Individual CS are encouraged to develop and / or modify their own internal procedures based on these and other similar references. All personnel, when WAH, should be familiar with, and conscientiously apply the applicable procedures / instructions, in the interest of their own safety.

A3. This Recommendation has been developed by drawing extensively on the latest versions of the references listed in Section B of this document, in addition to the existing procedures and practical experience of the member societies.

A4. The word ‘shall’ where used in any of the quoted references has been replaced in these Recommendations by the word ‘should’ reflecting the intended recommendatory guidance of this document. Specific wording taken from any of the quoted references may also have been amended, as necessary, to maintain consistency of presentation.

B. References

B1. UK Work At Height Regulations.

B2. UK HSE Information Sheets and Guidance on WAH.

B3. UK – MCA Marine Guidance Note MGN410 (M+F) on The Work at Height Regulations.

B4. Republic of Ireland - Guide to Safety, Health & Welfare at work (General Application) Regulations – Pt. 4.

B5. British Columbia OHS Regulations relating to WAH.

B6. US Department of Labour – OHSA Regulations (Standards – 29 CFR).

B7. British Petroleum’s HSE Directive 3 – Working at Heights.

B8. UK Construction workers union guideline on WAH.

B9. Singapore Government – Workplace Health & Safety Act.

B10. Singapore Government, Ministry of Manpower – Technical Advisories on WAH.

B11. BCS-G 91.

B12. BCS-G 78.

B13. BCS-G 72.

B14. European Commission – The Work at Height Directive – Directive 2001/45/EC on the protection of workers from the risks associated with WAH.

B15. European Commission – Non-binding guide to good practice for implementing Directive 2001/45/EC (Work at a height).

C. Scope

C1. This Recommendation relates to CS personnel when WAH, in the field.

C2. CS should have documented procedures and / or instructions addressing the requirements for their personnel when WAH, as necessary, depending upon the nature and extent of their services.

D. Introduction to Work at Height

D1. WAH is inherently hazardous and may expose personnel to injury and possible death. Research carried out by various agencies shows that falls from height usually occur as a result of poor management control and/or risky behaviours rather than because of equipment failure.

D2. Common factors include:

a. Failure to recognise the hazards and to assess the associated risk;

b. Failure to provide safe systems of work;

c. Failure to confirm that safe systems of work are followed;

d. Inadequate information, instruction, training or supervision;

e. Failure to use appropriate safety equipment, including Personal Protective Equipment (PPE), for example safety harnesses;

f. Failure to provide safe plant/equipment;

g. Failure to follow applicable procedures or instructions.

D3. In general, referenced regulations do not specify the height above which those requirements apply. Their focus is on the duty to prevent injuries, since a fall from a relatively low height may also cause serious injury. The WAH regulations require that the risk of a fall be mitigated wherever a fall is liable to cause personal injury. This means that measures should be taken for working at any height where there is a risk of a fall causing personal injury. This encompasses working:

a. from a ladder or on scaffolding, and other means of access;

b. alongside an open hatch or other opening in a ship’s structure;

c. in close proximity to, or supported from, a ship’s side;

d. in or entering or exiting spaces, such as ballast tanks, cargo holds, deep tanks, etc.;

e. on or from a permanent stairway, gangway, accommodation ladder or companionway in or on a ship;

f. in or on structures under fabrication, such as subassemblies, hull sections or hull blocks.

D4. In ship surveys and other marine inspections, WAH is often unavoidable. Therefore, adequate awareness, training and preparation on the part of all stake holders are essential to promote the safety of all involved personnel.

D5. Responsibility for the provision of the means of access, working platforms and related equipment lies with the shipyard / ship owner / crew / repairer / industrial unit or other party as applicable. Therefore, it is recommended that the CS include, in their procedures, means to make their specific procedural requirements known to the responsible party well in advance of the work to be carried out (e.g. in work planning meetings). The requirements provided should be considered by the surveyor during survey planning meetings and reviewed as changes occur.

D6. Various regulations, such as Quality Management System (QMS) standards, Safety Management System (SMS) standards and the IMO International Safety Management System (ISM) Code, may require employers to carry out a risk assessment and / or take appropriate measures to remove or mitigate the risks in work situations. Considering that most shipyards and industrial units have a certified QMS/SMS, and ships and ship owners and managers have certified safety management systems in accordance with the ISM Code in place, it is reasonable for CS's personnel to require and receive adequate support from them for WAH.

D7. National and international regulations usually also place an onus on personnel to protect their own safety. This is the main focus of this Recommendation. All CS's personnel should apply their own organisation's requirements and follow the relevant procedures when WAH. See also the relevant parts of BCS-R Z10 requirements for Access to Structures.

E. Definitions

E1. Work at Height

a. Work at height means work in any place where, if precautions are not taken, a person could fall and be injured. This includes working at or below ground level if a fall is still possible such as a fall from an edge or through an opening.

E2. Surveyor

a. For the purpose of this Recommendation, a surveyor is any person, employed or contracted by a CS, performing any survey-related services in the field on behalf of the CS.

E3. Competent person

a. A Competent Person means a person appointed by the facility's (ship / shipyard / workshop / factory) management, who has the required knowledge and experience to assess the risks associated with WAH and is responsible for approving the access arrangements for WAH.

E4. Responsible person

a. A Responsible Person means an authorized representative of the ship owner/manager or facility's management who is authorized to permit WAH.

E5. Work Restraint Equipment

a. Work restraint is a system that prevents persons from reaching a point where they can fall. Examples are: Guard rails, scaffolding, tower scaffolds, cherry pickers, scissor lifts.

E6. Work Positioning Equipment

a. Work positioning is a system that allows a person who has reached a point of work at height to secure themselves to allow work to take place without the risk of a fall.
b. A work positioning system is a personal fall protection system that enables a surveyor to work while supported in tension or suspension in such a way that a fall is prevented or restricted. An example would be a boatswain's chair.

E7. Fall Arrest Equipment

a. Fall arrest equipment is used in situations where a potential to fall cannot be avoided. Equipment used will both arrest the fall and absorb some energy of the fall. Examples would be the traditional harness plus lanyard incorporating energy absorbance, safety nets, air bags.

E8. Working Over Sea

a. Work over sea means work taking place outside permanent railings where there is a risk of a surveyor falling into the sea.

F. Training

F1. All surveyors who are expected to work at height should be trained in safety requirements for such activities according to CS's internal procedures.

F2. This training should include:

a. Recognising a WAH situation, including access to and exit from such locations.

b. Recognising, evaluating and managing the hazards and the risks associated with WAH.

c. Role of the Competent Person and Responsible Person.

d. Use of personal protective equipment for fall protection.

e. Emergency arrangements awareness.

F3. Competency in the areas covered by the training identified in F2 should be periodically assessed, either as a part of activity monitoring or some other suitable means. The maximum period between these assessments of competency should be 3 years. Assessment records should be maintained.

F4. CS should document in their internal procedures situations when these competency assessments are not held as required by this Recommendation and when surveyors do not pass these competency assessments.

G. General Guidelines for WAH

G1. WAH should only be undertaken when weather conditions are such that the health and safety of surveyors is not put at risk. The weather may not only affect surveyors WAH on an open deck, but may also adversely affect surveyors when WAH inside a vessel which is moving as a result of wind or wave action.

G2. When deciding which type of equipment is most suitable for a particular task, the following should be considered:

a. slopes or poor ground conditions;

b. obstructions, for example, steelwork or overhangs;

c. fragile surfaces;

d. floor loading;

e. job duration;

f. weather conditions.

G3. It is essential that a sensible and pragmatic approach is taken when addressing low falls. Precautions may only be needed when the scope and duration of the work presents a risk of injury. If the risk is minor and it is not reasonably practical to take other precautions, then no action may be needed provided proper training has been carried out.

G4. Personal protection equipment protects only the user/wearer and requires action by the individual, such as properly wearing and adjusting it, for it to work. Examples include work restraint equipment which prevents a fall and fall arrest equipment which minimises the consequences of a fall.

G5. Procedures for WAH are in place, are current and are being followed.

G6. Safety measures, including the following, should be taken by a responsible person prior to survey / inspection to the satisfaction of the attending surveyor:

a. The equipment's range of use should be agreed with the operator before using the equipment;

b. Permissible load and reach limitations should not be exceeded.

G7. The operation and training in the use of applicable equipment should be addressed by the Ship's Safety Management System / Shipyard's Occupational Health Management System and other facility's management systems (e.g. Vendors).

G8. Barriers, or other equivalent arrangements, should be in place to prevent objects falling from the work area which may harm any personnel in the vicinity below.

G9. Rescue facilities and procedures and support personnel should be readily available to permit evacuation in the event of imminent danger and / or to meet an emergency.

G10. When surveyors are working in the vicinity of flush manholes and other small openings of comparable size in the deck and other working surfaces, such openings should be suitably

covered or guarded, except where the use of such guards is made impracticable by the work actually in progress. In such situations use of appropriate signage should be considered.

G11. When surveyors are working around open hatches not protected by coamings or around other large openings, the edge of the opening should be guarded in the working area, except where the use of such guards is made impracticable by the work actually in progress. In such situations use of appropriate signage should be considered.

G12. When surveyors are exposed to unguarded edges of decks, platforms, flats, and similar flat surfaces more than 1.5 m above a solid surface, the edges should be guarded by adequate guardrails, unless the nature of the work in progress or the physical conditions prohibit the use or installation of such guardrails. In such situations, use of appropriate signage should be considered.

G13. When surveyors are working near the unguarded edges of decks of vessels afloat, or in situations where there is a danger of falling into water, they should be protected by personal flotation devices, in lieu of personal fall protection equipment.

G14. Sections of bilges from which floor plates or gratings have been removed should be guarded by guardrails except where they would interfere with work in progress. If these open sections are in a walkway, suitable planks should be put in place, side by side, or equivalent, should be laid across the opening to provide a safe walking surface.

G15. Gratings, walkways, and catwalks, from which sections or ladders have been removed, should be barricaded with adequate guardrails.

G16. Surveyors should be familiar with the procedures, preconditions, risks and safety precautions relating to the work.

G17. Equipment related to WAH is in compliance with relevant and applicable standards.

G18. Class rules normally require that Owners' / site managers' 'Responsible Person(s)' are responsible for providing means of access which are suitable and safe for the work to be carried out. The equipment, where applicable, should be operated/erected by qualified personnel. Evidence should be provided that the equipment has been properly maintained and inspected before each use; that formal inspections have been held annually, as a minimum; that re-inspections have been completed if any modifications from the original configuration have been carried out.

G19. It should be demonstrated by the Responsible Person that the equipment provided has been inspected, maintained and operated by trained and qualified persons. These should be demonstrated to the surveyors by the production of applicable documents, prior to the equipment being used.

G20. The records of training, inspections and maintenance should be established in accordance with the requirements of the ships Safety Management System or the facility's QMS/SMS, as applicable.

G21. Suitable and sufficient steps should be taken to ensure, so far as is practicable, that in the event of a fall by any person the fall arrest equipment does not itself cause injury to that person.

G22. The access and exit arrangements should be safe and clear of obstacles.

G23. Communication arrangements should be adequate.

G24. Lighting should be adequate to allow safe working. Lighting in a work area may be a temporary arrangement cabled into the area requiring additional protection against possible trip induced falls. Whenever possible, natural lighting should be provided in the work area during inspection.

G25. The tools and equipment used for WAH should be secured against falling.

G26. Effects of extreme temperature should be adequately considered. See guidelines in BCS-G 72, Guidelines for Safe Entry of Confined Spaces, Section 6.1

G27. Surveyors should verify that the necessary arrangements for WAH are suitable for the intended activity.

G28. No surveyor should carry out a survey from a 'one-man' lifting basket.

G29. No surveyor should perform survey using rope access, unless specifically trained, qualified and authorized.

H. Topic Specific Guidelines

H1. Emergency response arrangements

H1.a. For shipboard work, this aspect should be addressed in the Safety Management System manual of the ship as part of the risk assessment of 'shipboard operations', which is a requirement of the ISM Code.

H1.b. For work in shipyards and factories, this should be a part of their 'emergency preparedness planning' particularly when the shipyard / factory is certified for Occupational Health and Safety as per the international standard OHSAS18001.

H1.c. In the event that this is not addressed as stated above, then a situation specific plan should be prepared to the satisfaction of the surveyor.

H1.d. No surveyor should be part of a rescue team.

i. A rescue operation can only be performed by personnel trained for the task and having knowledge of emergency procedures and arrangements in place, agreed communication arrangements, escape routes, status of availability and readiness of the support team, etc. A surveyor does not meet this standard and should not be a formal part of any rescue team.

H2. Working over sea

H2.a. Work over sea may be permitted provided the ship is not being navigated and weather and sea conditions are satisfactory. As a guidance the following may be applied:

i. The weather and sea condition does not exceed Beaufort Sea State Scale 3 which corresponds to wind speed of 17 to 21 knots, moderate waves of height of about 2 m, many white caps and possible spray;

ii. Man over board (MOB) preparedness is in place;

iii. A rescue boat is operative and can be launched/retrieved in case a person falls into the sea;

iv. the visibility is good enough to perform the work and rescue any person that may fall into the sea.

H2.b. When working over sea, a safety guard should be present and monitor the surveyor's location over sea at all times. The safety guard should be familiar with and carry out tasks stated in the safety guard's duties in connection with work over sea.

H2.c. A life buoy with line and light should be readily available.

H2.d. Everyone working over open sea should wear a life vest and/or flotation device.

H2.e. Overboard discharges etc. should be secured, for example from fire water line.

H3. Fall arrest systems

H3.a. A fall arrest system should be fitted such that there is adequate clearance for it to deploy, and to prevent the surveyor from hitting an obstruction or the ground before the fall is stopped.

H3.b. Many recognized practices specify either a guardrail system, safety net system, or personal fall arrest system to protect the surveyor when exposed to a fall of 1.8 m or more from an unprotected side or edge. See also D3.

H3.c. Fall arrest procedures should provide for a rescue to be carried out if the surveyor is left suspended from the working place.

H3.d. Safety nets or airbags should be located as close as possible to the working level to enhance their effectiveness.

H3.e. Safety nets should be installed as close as practicable under the walking/working surface on which surveyors are working. As acceptable practice:

i. They should not be more than 9.1 m below such levels;

ii. The maximum size of each safety net mesh opening should not exceed 230 cm^2 nor be longer than 0.15 m on any side;

iii. The openings, measured centre-to-centre, of mesh ropes or webbing, should not exceed 0.15 m;

iv. All mesh crossings should be secured to prevent enlargement of the mesh opening;

v. Each safety net or section should have a border rope for webbing. Safety nets should be installed with sufficient clearance underneath to prevent contact with the surface or structure below.

H3.f. Safety nets should, as a good practice, extend outward from the outermost projection of the work surface as follows:

Vertical distance from working level to horizontal plane of net	Minimum required horizontal distance of outer edge of net from the edge of the working surface
Up to 1.5 m	2.4 m
More than 1.5 m up to 3 m	3 m
More than 3 m	3.9 m

H3.g. A fall arrest system should incorporate an integral shock absorbing device for limiting the forces applied to the surveyor's body.

H3.h. A fall arrest system should not be used in a manner:

i. which involves the risk of a line being cut;

ii. where its safe use requires a clear zone (allowing for any pendulum effect);

iii. which otherwise inhibits its performance or renders its use unsafe.

H3.i. Life-lines and anchorages should not be shared. As a good practice, harnesses with double lanyards should be used.

H3.j. Independent securing should be used for fixing all fall arrest equipment, man-riding belts or nets. They should not be attached to the scaffolding.

H3.k. When using fall arrest equipment, at least one person should be present in the area nearby at all times in order to alert and start basic rescue work in case of a fall.

H3.l. Prior to commencement of work, a realistic and safe rescue plan should be in place. The plan should take into consideration the time for a safe rescue in order to be able to rescue a person as quickly as possible to prevent consequential injuries (e.g. blood circulation injuries).

H3.m. There should be a site specific instruction on how required competent personnel are organized (for instance a rescue team).

H3.n. Surveyors should only use any work equipment or safety device provided to them for work at height by an employer, or by a person under whose control they work, in accordance with training or instructions received by them in the use of such equipment or device.

H3.o. Surveyors should always visually check their fall arrest system and anchor point. If there is any doubt regarding anchor points, defects in harnesses or harnesses that lack the inspection tag for approval, that harness should not be used.

H4. Personal fall protection system (PFPS)

H4.a. PFPS should be provided where applicable and appropriate.

H4.b. These consist of an anchorage, connectors, and a body belt or body harness and may include a deceleration device, lifeline, or suitable combinations.

H4.c. A personal fall protection system should be:

i. suitable and of sufficient strength for the purposes for which it is being used having regard to the work being carried out and any foreseeable loading;

ii. designed to minimise injury to the surveyor and, where necessary, be adjusted to prevent the surveyor falling or slipping from it, should a fall occur;

iii. so designed, installed and used as to prevent unplanned or uncontrolled movement of the surveyor;

iv. of correct size for the surveyor;

v. correctly worn;

vi. rigged so that the surveyor can neither free fall more than 1.8 m nor contact any lower level;

vii. fitted with a snap hook on a lanyard or lifeline which is self-locking. When in use, a carabineer or similar connecting hardware is to be secured to prevent inadvertent opening;

viii. able to effectively protect a vertical lifeline, lanyard, or safety strap at points of attachment and elsewhere, as necessary, to prevent chafing or abrasion caused by contact with sharp or rough edges.

H4.d. Safety harnesses should be used, as necessary, as a PFPS, for fall arrest.

H4.e. Body belts with lanyards should not be used as body support in a fall arrest system due to the possibility of death or injury from the following causes:

i. slipping out of a belt;

ii. abdominal injuries;

iii. back injuries; or,

iv. effects on the body of extended static suspension in a belt.

H4.f. PFPS should be inspected prior to each use for wear, damage, and other deterioration. Defective components should be removed from service.

H4.g. PFPS designed for use with an anchor should be securely attached to at least one anchor, and each anchor and the means of attachment thereto should be suitable and of sufficient strength and stability for the purpose of supporting any foreseeable loading.

H4.h. An anchor is “a secure point of attachment for a lifeline or lanyard.”

H4.i. Types of anchors under this definition include:

i. a device that has been purposefully manufactured and installed as an anchor to support a personal fall protection system;

ii. a substantial structure, such as a beam, column or similar substantial portion of the structure, selected as a point of anchorage where no dedicated anchor device is available.

H4.j. These points of anchorage generally require some supplemental rigging, such as a sling, to allow the anchorage connector of a personal fall protection system to connect to the anchorage.

H4.k. An anchor should be located so a lifeline attached to it is not deflected over a guardrail or other part of the structure which has insufficient strength to support the maximum potential load from a fall arrest.

H4.l. Equipment for PFPS should have appropriate marking. Normally, this is in accordance with the applicable PPE standards and regulations.

i. There are three categories of personal protective equipment (PPE) – most fall protection equipment is classed as PPE category III, “equipment for mortal danger”, for example harnesses.

H4.m. Marking does not necessarily mean that a piece of equipment is safe for the task.

H4.n. The manufacturer’s instructions should be checked, for example, to consider whether the particular piece of equipment is compatible with others being used. Some equipment may have a lifespan date given by the manufacturer and generally should be disposed of after this date.

H4.o. The surveyor should check for information related to:

a. use limitations and protection classes suitable for different levels of risk;

b. expiry date of PPE and of other related components.

H4.p. Any accessories or other equipment should also be checked to verify that they meet the above requirements.

H4.q. It is important to inspect personal fall protection equipment on an on-going basis to verify its suitability for continued use.

H4.r. As a minimum, this involves inspection before use on each work shift, and after each use to arrest a fall. It is also recommended to inspect equipment just before each use if not already covered by one of the other inspection scenarios. Such inspections are only one aspect of the overall review and monitoring of conditions and procedures.

H4.s. Inspections should be done in accordance with manufacturer instructions, if available, and in conformity with any standards which apply to the equipment.

H4.t. Inspections should cover at least the following items:

i. With harnesses, the following aspects should be checked:

a. integrity of stitching throughout the harness, on both outer and inner surfaces;

b. signs of deformation, bunching, or deterioration of pick points on the harness;

c. signs of contact with chemicals;

d. signs of any part of the harness being cut, stretched, frayed, or otherwise damaged;

e. integrity of shackles and straps on the harness;

f. signs of exposure to high temperatures.

ii. With other equipment such as shackles, carabineers, lines, and deceleration control devices, the examination of equipment should include the following:

a. all metal and other materials for any sign of deformation, wear, stretching, cracks, or kinking;

b. all metal and other materials for any signs of corrosion or other chemical deterioration;

c. all lines for wear on surfaces, and any potential or actual fraying, kinking, bird caging, heat fusion, or other damage;

d. moveable parts to verify proper action, and the capability of all locking and other immobilizing devices to perform their function.

H5. Scaffoldings

H5.a. Scaffolding should be suitably designed, constructed, inspected and maintained by competent personnel.

H5.b. Scaffolds should be built according to recognized standards or as a minimum:

i. be designed for the job/load;

ii. have scaffold poles made of metal and scaffold tubes linked by rigid angle couplers;

iii. be placed on a firm foundation;

iv. have good stability with a stable structure and be anchored with diagonal bracing at regular intervals;

v. have an adequate platform fully boarded with toe boards and guard rails fitted at all open ends;

vi. walkways with strong, continuous, clean, non-slippery platform boards;

vii. be free from loose materials objects/tools;

viii. be suspended scaffolds/staging to have minimum of 6 evenly spaced suspension points made of steel wire ropes or chains as near vertical as possible;

ix. have suspension points made of steel wire ropes or chains evenly spaced and as near vertical as possible;

x. be provided with safe access arrangement.

H5.c. The scaffolding should be approved by the Competent Person.

H5.d. A scaffold tagging system or equivalent method should be in place to record that the scaffolding or staging is fit for use.

H5.e. Barrels, boxes, cans, loose bricks, or other unstable objects should not be used as working platforms or for the support of planking intended as scaffolds or working platforms.

H5.f. Scaffoldings should have sufficient dimensions to allow safe passage, and wide enough to allow a person at shoulder width to pass along them easily. This width would normally be considered to be at least 0.6 m. Where this is impracticable, the situation should be specifically addressed by the surveyor prior to his or her use.

H5.g. Staging platforms should be fitted with fall prevention arrangements such as guardrails:

i. fixed or rigidly connected; top rail at least 0.95 m above the walking or working surface;

ii. have an intermediate rail not higher than 0.47 m above the surface;

iii. guardrail systems should be surfaced to protect surveyors from punctures or lacerations and to prevent clothing from snagging;

iv. the height of the toe board should be at least 0.15 m.

H5.h. Platforms should be arranged:

i. without gaps through which a person could fall or trip;

ii. to be non-slippery or non-tripping;

iii. so as to prevent any person getting caught between the system and the adjacent structure;

iv. so as to prevent inadvertent movement during work.

H6. Portable ladders and vertical/access ladders

H6.a. Portable ladders may be used for access to any structural members as a supplement to and/or additional to permanent means of access.

H6.b. Portable ladders should be designed based on a recognised International or National Standard. The rungs and steps of portable ladders should be designed to minimise slipping (e.g. corrugated, knurled, dimpled or coated with skid resistant material).

H6.c. The minimum clear distance between side rails for all portable ladders should be according to a recognized standard. *(For example ANSI A14.2 – Portable Metal Ladders; BS EN 131 Ladders (Specification for terms, types, functional sizes; Specification for requirements, testing, marking; User instructions; Single or multiple hinge-joint ladders)).*

H6.d. Portable ladders should be:

i. designed for the intended activity;

ii. not more than 5 m in length;

iii. rest on a stable, strong, suitably sized immobile footing;

iv. set at a suitable angle (approximately 75 degrees);

v. well maintained and free of oil, grease and slipping hazards;

vi. of sufficient length to extend above the exit platform to permit ease of exit/entry;

vii. equipped with feet prevented from slipping during use by securing the stiles at or near their upper and lower ends by any anti-slip device or by other arrangements of equivalent effectiveness;

viii. slip resistant feet should not be used as a substitute for the care in placing, lashing or holding a ladder upon a slippery surface;

ix. having another worker “foot” the ladder is not an effective means of securing the ladder and would only be suitable when other means are impracticable;

x. portable ladders should be used on top of bottom or deep stringer platforms so that the free falling height does not exceed 6 m; if it is necessary to exceed this height, there should be at least 3 m of water above the highest structural element in the bottom to provide a "cushion" or a safety harness is to be used; the free falling height above the water surface should not exceed 6 m.

H6.e. Surveyors should use fall protection equipment when accessing a height more than 4 m using a vertical ladder.

H6.f. Vertical ladders should be fixed both at top and bottom.

H6.g. Suspended ladders should be secured to prevent displacement or swinging.

H6.h. Portable ladders should have rubber caps at both ends and have no visual deformation.

H6.i. Hanging ladders and ladders more than 5 m long may only be utilized if fitted with a mechanical device to secure the upper end of the ladder.

H6.j. No interlocking or extension ladder should be used unless its sections are prevented from moving relative to each other while in use.

H6.k. When climbing ladders in tanks containing water, the surveying personnel should wear “flotation” aids. A flotation aid is a simple form of lifejacket which does not impede climbing or a self-inflatable lifejacket.

H6.l. Aluminium ladders may be used in cargo tanks, but cannot be stored in the cargo area or other gas dangerous spaces.

H6.m. As a guide, a ladder or stepladder should only be used:

i. where the work is of short duration – ladders are not suitable for work where they are in one position for 30 minutes or more; longer duration or regular jobs generally justify a better standard means of access (e.g. a tower scaffold, podium step or cherry picker) rather than a ladder or stepladder;

ii. where the risk is low, i.e. because the nature of the work makes a fall unlikely or, in the event of a fall, the nature of the fall would be unlikely to cause injury;

iii. for “light work” – ladders are not suitable for strenuous or heavy work;

iv. for work that does not involve carrying heavy or awkward tools or equipment;

v. where a handhold is available both for climbing the ladder and in the working position;

vi. where three points of contact (hands and feet) at the working position can be maintained. On a ladder where the surveyor cannot maintain a handhold, other than for a brief period of time, other measures will be needed to prevent a fall or reduce the consequences of the fall.

H6.n. New ladders should be marked in accordance with their conditions and class of use.

H6.o. Before using a ladder or stepladder, surveyors, should check for satisfactory condition of the ladder and confirm that it is marked in accordance with recognized standards*. (For example ANSI A14.2 – Portable Metal Ladders; BS EN 131 Ladders (Specification for terms, types, functional sizes; Specification for requirements, testing, marking; User instructions; Single or multiple hinge-joint ladders))*.

H6.p. Over reaching is a significant risk when working from a ladder. It may appear tempting to try to complete all the work without having to go down the ladder and move it. Over-reaching while working from a ladder is a major cause of falls, even for experienced surveyors.

H7. Mobile Elevating Work Platforms (MEWP)

H7.a. MEWP should be:

i. certified for use and applicable load;

ii. fitted with controls at the bottom able to override controls in the basket;

iii. provided with safety functions and limit switches as applicable;

iv. free of loose parts and have tools secured;

v. inspected and have controls and safety functions tested before each use;

vi. maintained in good condition, as per manufacturer's recommendation.

H7.b. The MEWP should be subjected to a thorough examination at least every six months.

H7.c. Vehicle-mounted elevating work platform or a self-propelled boom-supported elevating work platform should be subjected to annual inspection and certification.

H7.d. MEWP should be operated from within the basket, by a trained person.

i. MEWP operators should have attended a recognised operator training course and received a certificate, card or 'licence', listing the categories of MEWP the bearer is trained to operate;

ii. the training licence or card should be currently valid;

iii. in addition to formal training for the type of MEWP, operators should have familiarisation training on the controls and operation of the specific make and model of MEWP they are using.

H7.e. During operation, MEWP should be:

i. placed on a firm and level surface with spreaders used if applicable;

ii. moved for relocation only in the lowered position.

H7.f. Surveyors should wear fall arrest and restraint arrangements, secured to the basket.

H7.g. When working over water a personal floatation device should be worn instead of a harness.

H7.h. Hydraulic arm vehicles or aerial lifts (‘‘Cherry Picker’’) may be used to enable the examination of the cargo hold structure on bulk carriers not accessible by permanent ladders.

i. ‘cherry pickers’ may be accepted, for use up to 17 m above the tank top;

ii. the standing platform should be clean and fitted with anchor points for attaching fall arrest systems;

iii. the work platform should be fitted with effective guard rails and toe boards.

H7.i. For equipment provided with a self-levelling platform, care should be taken that the locking device is engaged after completion of manoeuvring to ensure that the platform is fixed.

H7.j. Lift controls, including safety devices should be serviceable and should be operated throughout the range prior to use.

H7.k. Potential crushing hazards (for example booming into the overhead, pinch point) should be considered.

H8. Crane-hoisted baskets

H8.a. Basket platform and lifting gear should be certified for applicable safe workload and certified for transportation of personnel.

H8.b. Crane-hook should have a safety latch and an extra safety wire between the hook and the basket.

H8.c. Crane hoisted appliances should not be used during adverse weather conditions.

H8.d. Crane operator should be trained and competent.

H8.e. The basket should be connected to a crane hoist line that is fully braked. No free fall rigs should be used. Hydraulic cranes should have “power-up” and “power-down”.

H8.f. Surveyors should be briefed about proper use of the basket prior to boarding a crane hoisted basket.

H8.g. Cranes, winches and other devices used for hoisting and lowering movable work platforms should:

i. be operated as slowly as practicable while supporting the work platform;

ii. be lowered under power, if the device is powered; and,

iii. not be equipped with a free running boom or hoisting winch controlled only by brakes.

H8.h. If a moveable work platform is suspended from a crane, winch or other device over a structure that cannot safely support its weight or if other hazards exist below the platform (e.g. water deep enough to present the hazard of drowning), lower limit travel devices compatible with the hoist system should be used to ensure the platform cannot be lowered beyond the safe lower limit of travel.

H8.i. If the lower limit travel devices required above are not practicable, the Responsible Person should ensure that work procedures that will minimize the risk of the platform going beyond the safe lower limit of travel are used.

H8.j. A trial lift for a work platform suspended from or attached to a crane or hoist or mounted on lift trucks should be performed at all work locations before the platform is occupied.

H8.k. High lift trucks should not be moved from location to location while a surveyor is on the work platform. Minor adjustments in horizontal positioning should only be carried out at the request of the surveyor on the work platform.

H8.l. Work platforms that can be elevated to a height of greater than 1.2 m should have a means of fall protection such as guardrails or a means for securing surveyors such as a body belt or lanyard.

i. the guardrail may be hinged, removable or consist of chains;

ii. fall protection should be selected and used in circumstances where a fall can occur;

iii. personal fall arrest equipment should be used.

I. Surveyors' Equipment for WAH

I.a. The following minimum set of Personal Protective Equipment should be made available to surveyors when WAH:

i. protective clothing;

ii. safety shoes/boots;

iii. safety helmet;

iv. work gloves;

v. protective glasses and/or goggles, if necessary;

vi. ear defenders and/or ear plugs, if necessary;

vii. strap provided flashlight, as necessary and optional head torch where appropriate;

viii. PFPS, as necessary.

I.b. The surveyor should use the necessary personal safety equipment according to the specific conditions and the survey being carried out.

BCS- G138 Recommendation for the FMEA process for diesel engine control systems

1 General

1.1 Introduction

BCS- R M44 defines the documents required for the approval of diesel engines. For engine control systems, the following item and respective footnote are listed in Table 1 of BCS- R M44:

25	FMEA (for engine control system)[5]

5. Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that single failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine. The FMEA reports required will not be explicitly approved by the classification society.

BCS- R M44 does not define requirements for the performance of an FMEA. It is therefore the purpose of this document to give guidance on FMEA for diesel engine control systems as required in BCS- R M44. It may also be applied to the control system of dual-fuel and gas engines.

1.2 Objectives

1.2.1 The primary objective of an FMEA for the diesel engine control system is to provide a comprehensive, systematic and documented analysis, which establishes the important failure conditions and assesses their significance with regard to acceptable safety and performance criteria. As stated in BCS- R M44, the FMEA should demonstrate that single failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine. Thereby, single failure is related to the consideration of only one component failure mode at a time, i.e. no combination of failure modes; however, it considers the possibility of common-cause failures.

1.2.2 General acceptable performance and safety criteria for the engine, as well as criteria specific to the engine application (see 2.1.1), should be stated in the FMEA report and all identified failure modes evaluated against these criteria. By doing so, the analysis recommended in this document is rather similar to a Failure Mode, Effects and Criticality Analysis (FMECA); however, the objective to demonstrate the compliance with acceptance criteria can efficiently be met this way.

1.2.3 This Recommendation focuses on the analysis and documentation requirements of an FMEA. The FMEA process and procedure is comprehensively documented in reference literature and recognized standards such as HSC-Code Annex 3 and Annex 4 and IMCA M 166.

1.3 System FMEA

1.3.1 The diesel engine control system FMEA should be performed as a system FMEA.

1.3.2 A system FMEA is carried out in a top-down manner, i.e. it starts from the overall system level and progresses to the next level down, or subsystem level, and further down to

the equipment item or component level. However, if it can be justifiably shown that at a certain level there is no further effect on the overall system if a failure occurs, then it is not necessary to continue to the next level down. In this case, it would not be necessary to continue to analyse all of the system levels down to component level.

1.3.3 The FMEA for diesel engine control systems should be based on a single-failure concept under which a subsystem or equipment item at various levels of the system's functional hierarchy is assumed to fail by one probable cause (initiating event) at a time. The effects of the postulated failure are analysed and classified according to their severity. Any failure mode which may cause an effect on the system beyond previously agreed acceptance criteria shall be mitigated by measures such as system or equipment redundancy. An exception is a “hidden failure” in which a second failure must occur in order to expose the “hidden failure”. A “hidden failure” is a special case because the failure effects are not apparent to the vessel operators under normal circumstances if the failure occurs on its own. One example would be a relief valve on a steam pipe.

1.3.4 A test programme of selected items should be drawn up to verify the assumptions and confirm the conclusions made in the FMEA.

1.4 Acronyms and definitions

For the purpose of this Recommendation, the acronyms and definitions listed in Table 1 apply.

Table 1: Acronyms and definitions

Term	Definition
CCF	Common Cause Failure. Failures of different items, resulting from a single event, where these failures are not consequences of each other.
Component	A constituent basic element or item of a system. In the context of diesel engine control systems e.g. a sensor, a processor, etc.
Design Intent	A detailed explanation of the ideas, concepts, and criteria that are defined by the designer to be important. Typically included • System requirements • Design conditions • System limitations
Essential Services	Equipment and systems necessary for the design intent and safe operation of the engine (e.g. fuel oil supply, cylinder lubrication, waste gate control, etc.)
Failure	Termination of the ability of an item or component to perform a required function under stated conditions.
Failure Effect	Immediate consequences of a failure on operation, function or functionality, or status of some item.
Failure Mode	The specific manner or way by which a failure occurs in terms of failure of the item (being a part or (sub) system) function under investigation; it may generally describe the way the failure occurs or the observed effect.
FMEA	Failure Mode and Effects Analysis. A systematic technique for failure analysis of the systems to whatever level of detail is required to identify the potential failure modes, their causes and effects on the performance of a system.
FMECA	Failure Mode, Effects and Criticality Analysis. An extension to the FMEA to include a means of ranking the severity of the failure modes to allow prioritization of countermeasures. This is done by combining the severity measure and frequency of occurrence to produce a metric called criticality.

Term	Definition
Function	A Function is what the system or equipment item is designed to do. Each function should be documented as a function statement that contains a verb describing the function, an object on which the function acts, and performance standard(s).
Interface	A point at which independent systems or components interact or communicate.
Redundancy	Redundancy is the duplication of critical components or functions of a system with the intention of increasing reliability of the system.
Reliability	Reliability is the ability of an item to perform a required function for a stated period of time under stated conditions.
Safety	This is freedom from unacceptable risk of physical injury or of damage to the health of people, either directly or indirectly as a result of damage to property or to the environment.
Severity	The magnitude of the consequence as a result of a failure mode occurring. Severity considers the worst potential consequence of a failure mode.
System	Set of interrelated or interacting elements. In the FMEA context, a system will have a) defined purposes expressed in terms of required functions; b) stated conditions of operation use; c) a defined boundary. The structure of a system is hierarchical.
System Boundary	The system boundary forms the physical and functional interface between the system and its environment, including other systems with which the analysed system interacts. The definition of the system boundary for the analysis should correspond to the boundary as defined for design and maintenance. This should apply to a system at any level. Systems and/or components outside the boundaries should explicitly be defined for exclusion.

2 FMEA process

The FMEA process can be divided into several steps as shown in Figure 1. These steps are further described in the following paragraphs, as referenced in Figure 1. The FMEA report shall describe all necessary information used as input for the FMEA process as well as the assumptions and results. The FMEA report is described in section 3.

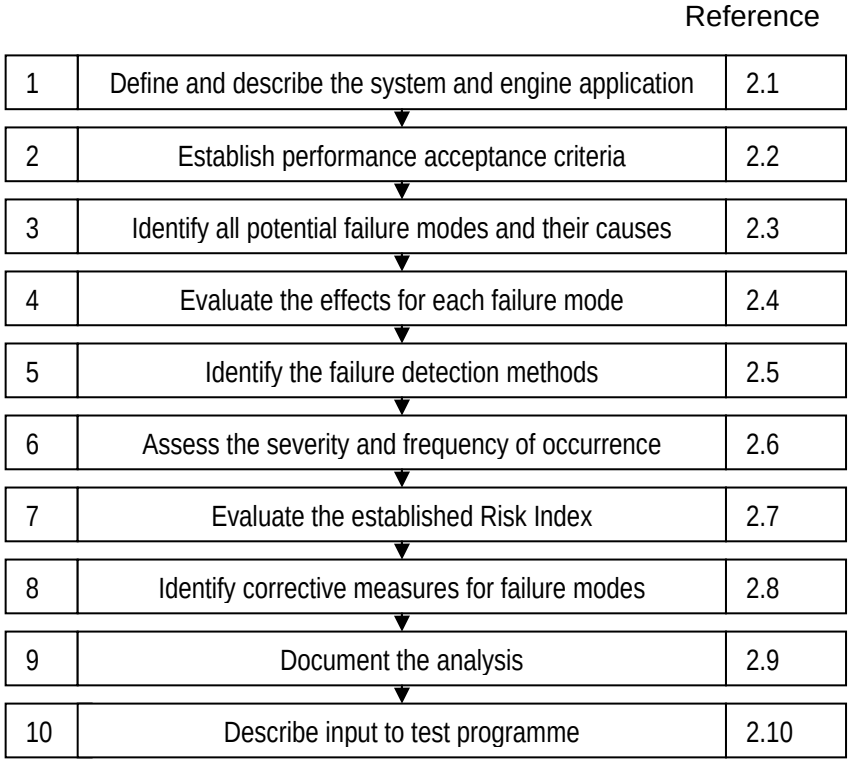

Figure 1: Diesel engine control system FMEA process

2.1 Define and describe the system and engine application

As a basis for the FMEA, the system to be analysed should be described through narrative text, use of drawings and reference to equipment manuals. The narrative description of the system, its operational modes, boundaries and functional requirements should address the following:

2.1.1 Description of the engine application (refer also to BCS- R M44, Appendix 3, “Design”), primarily defining:

- Single main engine propulsion (and limitations of application, e.g. controllable pitch propeller only)
- Multiple engines (diesel-electric and diesel-mechanic)
- Auxiliary engine
- Emergency engine

2.1.2 Functional description of system operation, structure and boundaries:

- Description of system boundaries (physical, e.g. diesel engine and control system elements considered in the analysis as well as operational boundaries, e.g. performance parameters):
  - I/O signal specification, sensors and actuators
  - Interface signal specification
  - Monitoring system, including human-machine-interfaces
  - Network connection, e.g. CAN bus, Ethernet
  - Protection, e.g. galvanic isolation
  - Hardwired safety circuits
  - Power supply arrangement
  - Definitions of interactions with engine external systems (e.g. ship alarm system, gear box, controllable pitch propeller automation, power management, gas detection, exhaust, ventilation, lube oil supply, fuel supply systems)
  - Definition of limiting performance parameters influenced by the control system, e.g. temperatures, pressures, power, speed
- Design intent(s) and system operational modes for the electronic control system
  - Description of manual operation
  - Description of local/remote mode
  - Alarms/warnings
- Any interface to the engine safety system, if applicable
- Illustration of the interrelationships of functional elements of the system by means of block diagram(s)

  The block diagram(s) should provide a graphical representation of the system and its components for the subsequent analysis. As a minimum, the block diagram should contain:
  - Breakdown of the system into major sub-systems or components
  - All appropriately labelled inputs and outputs and identification numbers by which each sub-system is referenced; and
  - All redundancies, alternative signal paths and other engineering features, which provide "fail-safe" measures

  It may be necessary to develop a different set of block diagrams for each operational mode.

2.1.3 Functional relationships among the system elements, including:

- Listing of all component units and components within the control system boundary (part list, names, functions)
- Redundancy level and nature of the redundancies, separation, independency
- Description of multiple CPU operation from a concept/system architecture perspective
- Distributed control system architecture

2.1.4 System requirements and function with acceptable functional performance limits of the system and its constituent elements in each of the typical operational modes

- Acceptance criteria for the electronic control - and safety system performance depending on engine application

2.1.5 System constraints

2.2 Establish safety and performance acceptance criteria

Performance acceptance criteria are to be established considering

- The pertinent class and statutory requirements
- The acceptable operating criteria set by the engine designer with respect to safety and availability
- The engine application (refer to BCS- R M44, Appendix 3, “Design”), e.g. a single engine propulsion application may have stricter acceptance criteria than a multiple engine propulsion application, for instance higher redundancy requirements and design for fault tolerance, meaning that the system can maintain safe operation in the presence of a certain number and certain types of failures

2.2.1 The acceptable performance criteria need to be stated in a manner, which enables the evaluation of each failure mode against these criteria. It is recommended to apply a risk matrix, using a severity index, reflecting the impact of a failure mode to the safety and to the engine performance, and a frequency index reflecting the frequency of occurrence of the event.

2.2.2 The assumptions made in the evaluation of the severity and frequency indices should be documented.

2.2.3 The following tables give **examples** of indices and the resulting risk matrix (Risk Index table). Depending on the specific analysis, a different scale or number of index steps may be used. The risk matrix can be divided into three areas: an area with an acceptable risk index (here lower left with indices 2 and 3), the area with not-acceptable risk indices (here upper right with indices 5, 6 and 7), and the area between the before mentioned two (here the diagonal with index 4), where the acceptance depends on further description of the event, for instance means of detection of the failure and the possibility of a manual mode of operation after a failure has occurred. In this area every effort should be made to make the risk as low as reasonably practicable.

Table 2: Example of Severity Index (SI) table

SI	Description	Definition
3	High	Serious impact on safety, e.g. fatality and/or Serious impact on engine performance e.g. engine stop
2	Medium	Medium impact on safety, e.g. injury and/or Medium impact on engine performance e.g. engine de-rated
1	Low	Negligible to low impact on safety and/or Negligible to low impact on engine performance

Table 3: Example of Frequency Index (FI) table

FI	Description	Definition
4	High	1 or more events per year of engine operation
3	Medium	1 event in 10 to less than 1 event in 1 engines per year of engine operation
2	Low	1 event in 100 to less than 1 event in 10 engines per year of engine operation
1	Very Low	less than 1 event in 100 engines per year of engine operation

Table 4: Example of Risk Index (RI) table

	FI	**1**	**2**	**3**	**4**
SI		**Very Low**	**Low**	**Medium**	**High**
3	**High**	4	5	6	7
2	**Medium**	3	4	5	6
1	**Low**	2	3	4	5

2.3 Identify all potential failure modes and their causes

A failure mode is the specific effect by which a failure is observed. When used in conjunction with functional performance specifications governing the inputs and outputs on the system block diagram, all potential failure modes can be thus identified and described.

Each (sub-) system should be considered in a top-down approach. Starting from the system's functional output a failure should be assumed by one possible cause at a time. Since a failure mode may have more than one cause, all potential independent causes for each failure mode should be identified.

2.3.1 Identify all potential common cause failures: It is not sufficient to consider only random and independent failures. Some common-cause failures (CCF) can occur, that cause system performance degradation or failure through simultaneous deficiency in several system components, due to a single source, environmental stresses, or human error. CCFs are those failures, which defeat the fundamental assumption that the failure modes under consideration in the FMEA are independent. The CCF will cause more than one item to fail simultaneously, or within a sufficiently short period of time as to have the effect of simultaneous failures. Typically, sources of CCF include environmental influences, such as electrical interference, temperature cycling, vibration, as well as human factors like incorrect operating or maintenance actions.

2.4 Evaluate the effects for each failure mode

The consequence of a failure mode on the operation, function, or status of a component or a system is called a 'failure effect'. The failure effects are to be evaluated regarding safety and availability in two respects locally, i.e. related to the engine, considering effects to the engine safety system as well, if applicable; and globally, i.e. related to the engine application, e.g. single prime mover in a ship or multiple engine installation.

2.5 Identify failure detection methods

A failure detection method can be a visual or audible warning device, automatic sensing devices, sensing instrumentation, manual inspection or other unique indications. These are to be identified for every failure mode and its causes, as appropriate.

2.6 Assess the severity and frequency of occurrence against the safety and performance acceptance criteria

The severity of each failure effect, as well as the frequency of occurrence of each failure mode should be assessed, e.g. using elaborated index tables dependent on the acceptable performance and safety criteria as described in 2.2 above. Local and global effects on safety and availability should be considered when determining the severity index.

2.7 Evaluate the established Risk Index

The risk index for each failure mode is to be evaluated as described in 2.2.3 and the example in Table 4.

2.8 Identify corrective measures for failure modes

The response of any back-up equipment, or any corrective action (manual or automatic) initiated at a given system level to prevent or reduce the effect of the failure mode of a system element or component is to be identified and evaluated.

2.9 Document the analysis

It is helpful to perform FMEA on worksheets with a structure similar to the example below. The worksheet(s) should start with the highest system level and then proceed down through the system hierarchy.

Example FMEA worksheet

Name of system_____ References_____

Mode of operation_____ System block diagram_____

Sheet No_____ _____

Date_____ _____

FMEA participants_____ Drawings_____

Id. No.	Item description	Function	Failure mode	Failure effects		Severity Index of failure effect	Failure causes	Frequency Index of event	Risk Index	Detection method	Corrective action	Remark / Testing
				local	global							
	Ref to 2.1	Ref to 2.1.4	Ref to 2.3	Ref to 2.4	Ref to 2.4	Ref to 2.6	Ref to 2.3	Ref to 2.6	Ref to 2.7	Ref to 2.5	Ref to 2.8	Ref to 2.10

2.10 Describe input to test programme

A test program should be developed to support the conclusions from the FMEA analysis and to verify any assumptions made.

The FMEA should be an input to the development of test specifications in general and particularly for identification of relevant test to be done during Type Approval Test (TAT) and Factory Acceptance Test (FAT) respectively.

3 FMEA report

The FMEA report should include a description of the diesel engine control system, its subsystems and their functions and the proposed operating and environmental conditions for the failure modes, causes and effects to be understood. The analysis assumptions, system block diagrams, performance acceptance criteria, worksheets (ref. to 2.9), as well as the reference to a test programme and any other test reports should be included. The report should contain a summary of the main conclusions, such as the results of the evaluation against the acceptance criteria.

4 References

HSC Code 2000: International Code of Safety for High Speed Craft
Annex 3 - ***Use of probability concept***
Annex 4 - ***Procedures for failure mode and effects analysis***
International Maritime Organization, 2000

IEC 60812: Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA). International Electrotechnical Commission IEC, 2006

IMCA M 166: Guidance on Failure Modes & Effects Analyses (FMEAs). The International Marine Contractors Association (IMCA), 2002

BCS- G 140 Recommendation for safe precautions during Survey and Testing of Pressurized Systems

A. Preamble

A1. This Recommendation has been developed to assist BCS when developing its own internal procedures and / or instructions to safeguard their surveyors when dealing with systems under pressure or during pressure testing of ships' and offshore units' equipment, machinery, structures, piping systems.

A2. The objective is to promote the safety of the surveyor and associated personnel engaged in the above types of operations while carrying out inspections on such systems. BCS is encouraged to develop their own internal procedures based on these recommendations and other similar references. It is recommended that all personnel, when dealing with systems under pressure, thoroughly familiarise themselves with the applicable procedures and instructions in the interest of their own safety. They should also be encouraged to read the original documents referenced in this recommendation for a more thorough understanding of the hazards caused by the equipment and systems being pressurized and under pressure.

A3. This Recommendation has been developed by drawing extensively on the references listed in Section B of this document, using the latest version available.

The quoted text has been reworded, where considered necessary, to suit the context of this Recommendation and also to maintain consistency of presentation.

A4. This Recommendation is intended to give an overview of the procedures and associated hazards of pressure testing of ships' and offshore units' structural parts, pressure vessels, components, systems and equipment and of dealing with a system under pressure, whether these are permanent or temporary fixtures on board a ship or offshore unit. Individual government agencies may have additional health and safety requirements that should be taken into consideration. It is recommended that BCS identifies the applicable legal and other requirements and verify their compliance with local regulations when reviewing pressure testing procedures or witnessing pressure testing.

B. References

Below referenced documents were used in the development of this recommendation.

B1. UK HSE – Safety of Pressure Systems (Pressure System Safety Regulation 2000).

B2. UK HSE – Pressure Systems – A brief Guide to Safety.

B3. UK HSE - Written Schemes of Examination (Pressure System Safety Regulation 2000).

B4. ABSA (The Pressure Equipment Safety Authority) User Guide on Pressure Equipment Safety Regulation – AB- 516, Rev. 6. 09-01-2014.

B5. Pressure System Safety Guidance Notes – GN SC 38 Dec 2012 by Safe contractor.

B6. Health & Safety Authority - Guide to the Safety Health and Welfare at work (Regulation 2012) on Pressure System.

C. Scope

This Recommendation applies only to personnel of BCS when dealing with pressurized systems and/or during witnessing a pressure test.

This recommendation may not cover all health and safety aspects of cryogenic systems and ships using gas or other low flash point fuels.

BCS should document procedures and / or instructions, addressing the recommendations contained in this document, as necessary for their personnel when engaged in the above activities and as applicable to the nature and extent of the services provided.

D. Definition

Pressure means pressure relative to atmospheric pressure, i.e. gauge pressure and, as a consequence, a vacuum is designated by a negative value. The pressure units system (bar) has been used in this document, except in paragraph F5.9, referring to offshore industry data, where both, bar and psi, are used.
Uncontrolled or potential release of pressure may cause hazardous conditions.

Pressure Equipment means vessels, piping, protective devices and pressure accessories used with a relevant fluid or gas and, where applicable, pressure equipment includes attachments relevant to the integrity of the equipment.

Pressure System

A pressure system is defined as:

- any system comprising of one or more pressure vessels of rigid construction, their associated pipework and protective devices.

- the pipework with its protective devices to which a transportable pressure receptacle is, or is intended to be, connected.

- a pipeline and its protective devices which contain or are liable to contain a relevant fluid or gas, but does not cover transportable pressure receptacles.

Pressurized Tanks and Systems mean tanks and systems that are subjected to an applied pressure.

Medium means any fluid (liquid or gas).

Owner/User in relation to a pressurized system, means the “company” responsible for the technical operation of the ship / offshore unit.

Facility means units and locations where the tasks covered within this recommendation are carried out. Examples of facility are ships, offshore units, shipyards (new building and repair), machinery and equipment manufacturer plants.

Competent Person is a qualified person, having the appropriate knowledge, experience and independence, to identify the hazards and their control while work on a pressurized system is carried out and to undertake other functions required of them, including approval of ‘Written Scheme of Examination’ for the Pressure Systems. He/she may be a self-employed individual or a member of an in-house inspection department or from an organisation providing an independent inspection service.

Protective devices mean devices designed to protect pressurized equipment whenever the safe operating limits may be exceeded.

Remote location means a safe location, away from the applicable hazards and comprising of all necessary equipment to witness the pressure test and / or to observe the pressurized items in compliance with the applicable rules and regulations.

Safe Operating Limits mean the operating limits (incorporating a suitable margin of safety) beyond which system failure is liable to occur.

Surveyor for the purpose of this Recommendation is any person employed or contracted by BCS, performing services in the field on behalf of BCS.

Tests - Pressure Testing involves the application of a stored energy to a part or an assembly of parts in order to verify their strength / integrity (e.g. tightness) / functionality.

Common Types of Pressure Tests are described below:

a. **Burst Pressure Test** is a process to determine a pressure point at which a component such as a valve, hose or other pressure equipment will fail as a result of excess pressure. It may also determine the pressure immediately before which failure will occur, targeting for a pre-established pressure/or load named **burst pressure/ or breaking load**.

Thus Burst Pressure can be considered as the maximum pressure which a component can endure before a catastrophic failure occurs. It gives an indication of the “factor of safety” employed in the design, particularly when this cannot be easily determined by calculation.

b. **Proof Pressure Test** is similar to a burst pressure test. It is used to prove that a component or pressure equipment is capable of withstanding a pressure greater than the

standard Pressure Test without distortion or failure, based on an agreed (design) or defined (statutory) 'Factor of Safety'.

c. **Standard Pressure Test** is carried out initially after manufacture, subsequently after modification/repairs and also as a periodic test. The test medium may be hydraulic or pneumatic and test pressure is normally between 1.25 and 1.5 times the design pressure, depending upon the design code used and the age of the equipment or item being pressurized.
Standard Pressure test is also normally used to verify pressure relief systems.

d. **Leak (or Leak-proof-ness/Tightness) Test** as the name implies, is designed to check for leaks in systems, components or pressure retaining parts.

e. **Functional Test** is used to check operation of a system including tightness of isolating valves, mechanical joints and functioning of moving parts, if any.

f. **Safety Valve Testing:** Safety valves (pressure releasing devices) are tested at the shop floor, following their manufacture, after reassembly following routine maintenance and during surveys of ships in service. The safety valve is required to be checked for lift (popping up) pressure as well as reseat pressure.

g. **Flexible Hose Test** is used for prototype burst test to an international standard.

h. **Pressure Pulsation Test** is used as necessary for mechanical joints and it is defined in UR P2.

E. Training

E1. All surveyors who are expected to carry out inspections on Pressure Systems or participate in pressure testing should be trained in safety aspects and requirements for such activities, according to BCS's internal procedures and applicable regulations.

E2. This training should include:

a. Recognising pressure systems, their hazards and associated level of risks.

b. Recognising, evaluating and managing the hazards and the risks associated in dealing with pressure systems and pressure testing.

c. Pressure measuring equipment, its selection (suitable for appropriate pressure rates) and calibration, including remotely located instruments.

d. Role of the Owner/User and Competent Person.

e. Use of hazard control means, such as personal protective equipment, barriers, protective guards, isolated / remote location for witnessing of tests.

E3. Competency in the areas covered by the training identified in item E2 should be periodically assessed, either as a part of activity monitoring or some other suitable means. The maximum period between these assessments of competency should be 3 years. Assessment records should be maintained.

E4. BCS should document in accordance with their internal procedures, situations when these competency assessments are not held as addressed by this recommendation and when surveyors do not pass these competency assessments.

F. Pressure Testing

F1. Introduction

During the course of surveys and inspections, both on board ships or offshore units and at manufacturers' premises, Surveyors may be called upon to witness different types of Pressure Tests, generally known as Hydraulic Testing, Pneumatic Testing, Hydro – Pneumatic Testing and Leak Testing.

Such types of tests are required, by the Rules, Regulations and applicable Standards, to be carried out on pressurized tanks, pressure equipment and pressure systems. Such types of testing are normally required after manufacture (initial testing), at the time of fabrication of components, during construction of ships and after repairs or modifications. These tests are also required as part of a periodical inspection regime for compliance with Class or Statutory requirements, including testing of safety valves or other pressure relieving devices (PRDs).

Pressures encountered during such testing can range from a vacuum (testing of P/V valves and other pressure receptacles) up to in excess of 1500 bar for deepwater drilling applications.

F1.1 There are a number of different types of test that a Surveyor may be called upon to witness, each having its own characteristics, pressure ranges and procedures, and appropriate safety precautions.

F1.2 Different types of compartments are tested at time of attendance for tightness and/or structural integrity verification on board ships, during new construction and at the time of surveys after construction. In general, these types of tests are carried out on board the ships and fall within one of the definitions (Section D, a through f.) "Common Types of Pressure Tests".

Surveyors should familiarize themselves with specific issues, by studying the referenced guideline and applicable Rules and Procedures. Subject Rules should include applicable terminology and required items for use during these types of tests (e.g. use of U-Tube).

F1.3 Surveyors should take special care in cases where the manufacturer, fabrication facility or building facility proposes to substitute a type of testing using parameters (i.e. pressure rates, test medium) from another accepted method of testing. It is important to note that additional or undetermined hazards may exist when mixing applicable parameters from different types of testing. If, for example, a pneumatic test is to be carried out at low temperature conditions in place of a hydraulic test, then test pressure hazards and increased risks could result requiring additional precautions.

To further promote safety in such cases, surveyors should confirm that the test procedures and conditions have been reviewed and approved (e.g. "Pneumatic tests in Lieu of Hydrostatic tests"), by a competent person within the class society.

F2. Pressure Testing Procedure

Surveyors should not organize or conduct any form of pressure testing. The Surveyor should attend solely to witness the test and confirm that it meets regulatory and/or other requirements including any pre/post inspection pass/fail criteria. In this respect, the entity responsible for carrying out the pressure test should be in possession of and work in accordance with, suitable test procedures. These procedures should be developed by a competent person, based on a risk assessment of the intended operation, taking into account

relevant hazards, dangers and any local/national Health and Safety legislation pertaining to safety in the workplace.

Most manufacturers, shipyards, depots, test houses and specialist testing companies should be in possession of hydraulic or pneumatic test procedures as part of their established quality systems.

In these cases, it is responsibility of the attending Surveyor to confirm that the subject documented procedures comply with applicable Class, Statutory, and Legal and other requirements for the test. In the case of any perceived unsafe working conditions, noted by the surveyor, it should be resolved to the surveyor's satisfaction before the tests commence.

F3. Test Procedures

Test procedures can vary significantly: from the very basic, covering just one test operation, to quite comprehensive documents which may detail many different types of test under one cover. Whilst it is not expected that a Surveyor officially approve the applicable pressure test procedures, those procedures should be reviewed by the Surveyor for anticipated hazards and their controls. If such procedures appear deficient (e.g., fail to identify any hazards) the Surveyor should document his findings, comments or identified unsafe conditions and should seek changes and corrections to rectify deficiencies prior to witnessing the conduct of the test.

A typical procedure should contain reference to the following subjects as applicable:

1. Purpose
2. Scope
3. Responsibilities and qualification of key Personnel
    a. Test Supervisor
    b. Test Operator
    c. Class Surveyor
    d. Safety Director
    e. Others
4. Pressure Test Hazards and their controls
    a. Checklists
    b. Fittings
    c. Pressure Sources
    d. Test Area
    e. Barricades, cordoning and marking of test area and other appropriate means to restrict access at the time of pressurization, during the test process and depressurization.

5. Test Procedures

    a. Flow diagram and test equipment

    b. Position, specification of test gauges, safety valves and other means of pressure relieving (e.g. U-tube for certain air leak tests).

    c. Position of isolating valves and test medium supply line.

    d. Sequence of opening and closing vent valves (where multiple valves fitted).

    e. Test pressure, medium and time for the gradual pressurization / depressurization where applicable.

    f. Instrumentation to record timing, pressurization and depressurization when deemed necessary to carry out the test under remote presence of the Surveyor.

6. Pass/Fail Criteria

7. Reporting

8. Reference (other documents or information sources pertinent to the test, including temporary arrangements).

F4. Hydraulic versus Pneumatic Testing

In most cases pressure testing is carried out using water as the test medium, but there may be occasions where a liquid other than water (e.g. hydraulic oil, or kerosene) is used. All such testing is collectively known as hydraulic testing and although not without risk, depending on the pressure, it is safer than using a gas which, being compressible, has the ability to store more energy for any given test pressure compared to an equivalent volume of liquid.

However, there are cases of high pressure hydraulic test being applied mainly to Offshore Industry components and Gas Carrier Industry components and for those cases, careful consideration should be given to review, consider, apply and follow all relevant safety precautions.

There are occasions, on the other hand, where it may be necessary to resort to what is collectively termed pneumatic testing (e.g. using air, steam, nitrogen or other inert gas as the test medium), primarily where the interior of the pressure equipment may be contaminated by water or other liquid, or where the containment system or its supporting structure is not designed to withstand the weight of the volume of liquid required to carry out a hydraulic test. The Surveyor should therefore be aware of and understand the additional hazards involved in pneumatic testing and, in particular, the stored energy available in the event of a catastrophic failure of the pressurized item that could result in injury or death from blast waves, as well as pieces or portions of material that may become projectiles.

F5. Precautions related to Pressure Testing

General Precautions

Any pressurized equipment has the potential to cause serious injury or even death in the event of a catastrophic failure. In order to reduce the risk, appropriate risk assessment should be carried out considering the test items, equipment, medium, procedure and ambient conditions. Specifically, the following points should be taken into consideration.

F5.1 Where the surveyor is not protected by suitable barriers / screens, verify and confirm that the test procedure is followed, test equipment is in good condition, isolating valves are tight, test pressure gauges (at least 2 pcs) are calibrated and are of suitable range as per test pressure, that they are not isolated or bypassed, and that releasing mechanisms or safety valves are of adequate size/rating and correctly set. Pipe work, especially flexible piping, should be free from damage or leaking joints. Inlet, outlet and release arrangement for the test medium to or from the item being tested are properly fabricated and supported, including their appropriate dimensions (e.g. Smaller diameter for inlets and bigger diameter for outlets, as well as releasing means).

F5.2 Test pressure should be applied gradually to avoid shock loading of the item under test. Where items are tested together this should only be accepted where their test pressures are identical. Where a number of items are tested together, the test pressure should not exceed what is necessary to prove the weakest part but this pressure must meet the test pressure of all parts being tested. The temperature of the test medium should not be lower than that specified in the procedure to avoid the possibility of brittle fracture.

F5.3 Close visual inspection of the equipment should be conducted only when the pressure does not exceed the design pressure level for hydraulic pressure tests or pneumatic pressure test, the pressure should be reduced to the leak test level.

F5.4 Couplings and connections of flexible hoses subjected to the pressure should be adequately secured to prevent injury due to “flailing” in the event of failure. Adequate precautions should be in place to protect test personnel and observers, either by using a purpose built test enclosure (barricades or strong baskets) or by putting in place a safety zone. The sizes of the enclosure or the safety zone will depend on the type of test and pressures involved.

F5.5 Where leakage is detected in joints or fittings, whether on the item under test or on the test equipment itself, pressure should be reduced to atmospheric pressure prior to rectifying the leak. On no account should the test piece be subjected to a “hammer test” while under pressure and this includes the “peening” of welds to prevent seepage. Other means to attempt correction of leaks under pressure, especially welding, should be avoided.

F5.6 Necessary personal protective equipment, as applicable, should be worn by the surveyor working within the test area.

F5.7 Where safety valves are being tested (floated), the venting arrangements should lead away from the work/test area. In case of setting a boiler safety valve, drainage arrangements and escape piping should be particularly examined for blockages, appropriate support and damage.

F5.8 For higher pressure tests surveyors should witness the tests from a remote location. For these cases, provision of pressurization, depressurization and suitable time recording instruments may be required by the attending surveyors.

F5.9 The test procedure should specify precautions to safeguard against hazards resulting from the possible expansion of the test medium, during the test. If a pressure test is to be maintained for a period of time, during which the test medium in the system is subject to thermal expansion, precautions should be taken to avoid excessive pressure. Additional pressure relief devices, set at an appropriate percentage of the test pressure, are recommended, during the pressure test of these types of items/systems (e.g. Mud Line in the Offshore industry is tested to 15,000 – 20,000 psi) (1034.21 – 1378.95 bar).

F6. Precautions Specific to Hydraulic Testing

In addition to the general precautions cited above, the following points should be taken into consideration:

F6.1 When water is used as the test medium the temperature during the test should not be less than 7°C in order to avoid the possibility of ice damage. When a pressure test is carried out with water at an ambient temperature below 0°C it has to be confirmed that the test medium, test gauges and connecting lines cannot freeze.

F6.2 The item under test should be totally filled with the fluid to be used as the test medium and closed systems should be properly vented. Where, due to the design of the item under test, it is not possible to eliminate all air/gas pockets then the additional precautions noted below for pneumatic testing should be considered.

F6.3 The effect of the weight of the test medium on the item under test, and any supporting structure or foundation needs to be especially considered.

F6.4 If liquid other than water is used as a test medium, e.g. kerosene, then hazards specific to that medium should also be considered.

F7. Precautions Specific to Pneumatic Testing

In addition to the general precautions cited above the following points should be taken into consideration:

F7.1 Because of the potential for high levels of stored energy, the internal volume of any items to be pneumatically tested should be kept to a minimum by isolating certain sections or testing components individually. Alternatively, the use of non-compressible material should be considered.

F7.2 For large volumes under test, consideration needs to be given to the effects of blast waves and projectiles in the event of a catastrophic failure. The test procedure should specify a suitably sized restricted zone to protect human life and properties in such cases.

F7.3 Local chilling due to filling and emptying of the items under test needs to be controlled to avoid the possibility of local brittle fracture. This can be achieved by maintaining constant flow rates across inlets or exhaust nozzles. The internal pressure of the test medium should also be controlled to avoid any shock loading by using suitably sized reducing valves and flow control valves.

F7.4 Normally, class society Rules refers to the use of U-Tube for Air Leak test during testing of structural tanks and spaces for tightness. However rules may allow the use of a releasing mechanism, in place of a U-Tube. If a safety valve is selected, Surveyors should be aware that, in some cases, this approach has resulted in catastrophic failure of the space being tested. If a releasing mechanism is used in lieu of a U-tube the Surveyor should carefully review the safety precautions adopted for the test and evaluate the risks after taking into account necessary precautions and whether the design of the mechanism is similar to the U-tube principle (i.e. suitable to be lifted by the predetermined excessive pressure, and not subject to any kind of spring or restricting device) (See also G9.2).

F8. Precautions Specific to Hydro-Pneumatic Testing

There are also standards that accept the method of test that combines liquid and gas (normally water and air) as the test mediums. Where the subject method is applied, then the additional precautions noted above should be considered, as applicable for each medium.

F9. Pressure Piping Tests

F9.1 Pressure piping leak tests should be conducted using the hydrostatic method.

F9.2 A pressure piping system should not be tested at a temperature that is colder than its minimum design temperature.

F9.3 When conducting pressure tests, the ductile to brittle transition temperature and the possibility of brittle fracture should be considered by the competent person.

F9.4 Before testing any pressure piping system, the surveyor should obtain from the Owner/User or the facility management confirmation that the materials, construction and installation of the piping system is in accordance with applicable regulation and/or the approved design.

F9.5 When conducting tests or initial starts ups, applicable safety precautions should be observed and only essential personnel should be present during the test.

G. Pressure Systems

G1. Introduction

The failure of pressurized equipment or systems can result in fatalities and serious injuries and cause major damage to property.

G1.1 BCS's surveyors are also called upon to examine or witness tests of systems which are under operating working pressure (e.g. during steering system trial, windlass trial, trial of thrusters, jacking systems, drilling system, mud circulating system, cargo system).

G1.2 Examples of pressure systems and equipment include but are not limited to:

- boilers and steam heating systems
- pressurized process plant and piping
- compressed air systems (fixed and portable)
- hydraulic systems such as steering gear, Windlass, V/V actuating system
- fuel Oil circulating system
- liquid cargo loading/unloading system
- heat exchangers and refrigeration plant
- valves, steam traps and filters
- pipe work and hoses
- pressure gauges and level indicators

G2. Hazards of Pressure System

Pressure systems present particular hazards because pressure vessels can release large amounts of stored thermal and kinetic energy, following leaks or explosion of gases, liquids, vapours or steam.

G2.1 The main hazards while dealing with such systems are:

- impact from the blast of an explosion or release of compressed gas or liquid
- impact from parts of equipment that fail or any flying debris
- contact with the released liquid, gas or steam, including compressed air
- fire resulting from the escape of flammable liquids or gases

G2.2 Pressurized systems may fail at the point of connection of flexible hoses (e.g. Portable tools, causing the unsupported length of hose to whip or snake violently).

G3. Principal Causes of Incidents

Principal causes of incidents are:

- defective equipment and / or system design
- lack of maintenance of pressure equipment
- unsafe installed systems of work leading to release of pressure
- operator error, insufficient training / supervision
- unsafe / worn out installation
- inadequate repairs or modifications

G4. Level of Risk

The level of risk from the failure of pressure systems and equipment depend on a number of factors including but not limited to:

- the pressure in the system
- the type of media, liquid or gas, and its properties
- the suitability of the equipment and pipe work that contains it
- the age and condition of the equipment
- the complexity and control of its operation
- the prevailing conditions (e.g. a process carried out at high temperature)
- the skills and knowledge of the people who design, manufacture, install, maintain the system, carry out the test, and operate the pressure equipment and systems

G5. General Safety Requirements for Pressure Systems

G5.1 The objective is to control the hazards presented by a pressure system under test:

- by way of design, installation, maintenance and periodic examination
- by providing a robust regime for the management of pressure systems, including requirements for preliminary and periodic examinations of pressure systems

G5.2 The pressure system should be manufactured from material suitable for the substances it will contain.

G5.3 Owners/Users should know, by checking with designers, manufacturers or installers, the safe operating limits of the involved fluid of the system and of any equipment directly linked to it or affected by it.

G5.4 The Owner/User of the pressure system should:

- maintain an accurate inventory of its pressure equipment
- control and verify that its pressure equipment is inspected at the prescribed intervals
- maintain appropriate records of inspections

The above may be in the form of a written scheme of examination.

G5.5 Safety Legislation of certain countries may require Written Scheme of Examination as applicable to industrial facilities where surveyors may attend to witness pressure tests.

G6. Written Schemes of Examination:

A written scheme of examination is a document containing information about selected items of the plant or equipment which form a pressure system, operate under pressure and contain a 'relevant fluid'.

G6.1 A written Scheme of Examination is required to obtain the Statutory approval of the Pressure System in the case of an industrial application. A written Scheme of Examination normally covers all protective devices and should include every pressure vessel and those parts of pipelines and pipework which, if they fail, may give rise to danger. The written scheme should specify the nature and frequency of examinations and include any special measures that may be needed to prepare a system for a safe examination.

G6.2 The Owner/User is responsible for ensuring the suitability of the scope of the written scheme and that it covers all the pressure vessels, protective devices and pipework.

G6.3 Records are required to be maintained for inspections, repairs and testing as evidence of following the written scheme.

G6.4 The pressure system, together with records of examination by the Owner/User, should be examined in accordance with the written scheme by a Competent Person.

G6.5 For fired (heated) pressure systems, such as steam boilers, the written scheme should include an examination of the system when it is cold and stripped down and when it is running under normal conditions.

G7. What types of typical pressurised systems might require a written scheme of examination?

G7.1 The following pressurised systems are likely to require a written scheme of examination:

- a compressed air receiver and the associated pipework, where the product of the pressure in bars multiplied by the internal capacity in litres of the receiver is equal to or greater than 250 bar litres.
- a fixed high pressure fire-fighting system, using gas smothering media and associated pipework and protective devices.
- a steam boiler and associated pipework and protective devices.
- a gas loaded hydraulic accumulator.
- a vapour compression refrigeration system where the installed power exceeds 25 kW.
- the components of self-contained breathing apparatus sets (excluding the gas container).
- a fixed liquefied petroleum gas (LPG) storage system, supplying fuel for heating in a workplace.

G7.2 Various regulations, such as Quality Management System (QMS) standards, Safety Management System standards such as IMO International Safety Management System (ISM) Code, require Owners/Users to determine a documented system of maintenance, inspection and testing of all Pressure Systems as per maker's recommendations and other applicable requirement such as SOLAS, Flag administration regulations and class Rules.

G8. Precautions while dealing with Pressure System

Considering that the management of the industrial and shipbuilding units are responsible for maintaining a certified QMS/SMS, ship Owners/ Users generally have a certified safety management system in accordance with the ISM Code in place, as applicable for convention ships, it is reasonable for surveyors to require and receive adequate care and support while dealing with pressure systems.

G8.1 Knowledge of Operating Conditions:

Before working in the vicinity of a pressure system, the class surveyor should verify that the following checks have been performed by the Owner/User:

- is the gas or liquid toxic or flammable?
- what are the process pressures and temperatures?
- what are the safe operating limits?
- is there a set of operating instructions for all of the equipment?
- have the operators had suitable training on the operating instructions?
- have the protective devices been set correctly and in good operating condition?
- audible and visual warning devices are in satisfactory condition.
- do the fitted safety valves, bursting disc and other releasing systems discharge towards a safe place?

G8.2 Surveyors should confirm that the system under survey is generally in satisfactory condition and the Owner/User of pressure systems has a Written Scheme of Examination, if required by statutory regulations and maintenance of the system and has assigned a competent person.

G8.3 No part of the pressure system should be allowed to operate beyond the safe operating limits.

G8.4 To check and confirm that limits are not exceeded, protective devices should be correctly specified and, where applicable, adjusted to the correct setting.

G8.5 The Owner/User of a pressure system should keep control and verify that it is operated in accordance with the manufacturer’s recommendations or in accordance with the Written Scheme of Examination, if applicable.

G8.6 Instrumentation and measuring equipment are properly selected, maintained and calibrated.

G9. Class surveyors should consider also the following precautions before attending a pressurized system test:

G9.1 Overpressure Protection:

Applicable Industry Regulations require that all pressure equipment be provided with overpressure protection.

1. It is required that the Owner/User of the pressure equipment controls and verifies that it has been installed with an overpressure protection that is certified as:

    a. a pressure relief valve that meets the requirements of the applicable Code (e.g. ASME Code, Class Rules), or

b. other means of overpressure protection acceptable to the Administration / BCS.

2. The protection device is required to be set to open before the pressurized equipment exceeds the maximum allowable working pressure.

3. The Owner/User of the equipment under pressure controls and verifies that the overpressure protection system is designed and maintained so that the maximum pressure in the equipment does not exceed the prescribed limit allowed in the applicable code/standard.

G9.2 Pressure Relief Devices

1. Adjustable parts of the pressure relief device are required to be sealed at the time of servicing and remain sealed during operation. Seals are to be installed in a manner that prevents changing the adjustment of a pressure relief device without breaking the seal.

2. A pressure relief device is to be serviced at an interval acceptable to the regulating authority. A pressure relief valve is to be serviced, repaired, set and sealed only by a qualified/competent person.

3. Any change to the adjustable parts of the pressure relief devices are to be done on a controlled basis, as this can affect the system operation and safety. Adjustments are to be made by duly qualified and authorised persons only.

4. Safety Management System, under ISM Code, requires that all safety equipment and relieving devices, including alarms and measuring instruments are tested regularly to enhance their reliability. Records of this should be made available to the surveyor.

G10. Maintenance and modification of pressure systems

G10.1 Class Rules normally require that Owners/Users are responsible for controlling and verifying that all pressure systems and associated pipes and equipment are operated by qualified personnel. Evidence should be provided that the equipment has been properly maintained and inspected as per documented procedures.

G10.2 Prior to any modifications being carried out, Owners/Users should conduct a proper assessment to confirm that all the technical and safety aspects of the change have been considered. Modifications are to be reviewed/approved by BCS.

G10.3 Owners/Users should also carry out a risk assessment and take appropriate measures to remove or mitigate the risk of hazards while working with pressure systems on board a ship, offshore unit or in industrial workshops.

G10.4 Following modification or repair of any part of a system, the person carrying out such work is normally required, immediately after completion of the work, to supply to the Owner/User written information concerning the work carried out and the instructions for the safe operation of the system, including any newly issued instructions if appropriate.

G10. 5 When pressure systems are under repair, precautions need to be in place to prevent the system being accidently restarted before all the safety devices or systems have been restored.

G10.6 Whenever possible, systems should be depressurised before maintenance work is carried out, but for various reasons this may not be always achievable. In such cases it may

be possible to safely isolate the part of the system which requires attention. In certain circumstance work on a live system may be necessary.

G10.7 Protective measures for work on a pressure system may need to address “Permit to Work” arrangements, isolation procedures and methods.

H. Personal Protective Equipment (PPE) for pressure systems:

1. Eye protection - safety glasses / goggles
2. Ear protection, when required.
3. Hand Protection
4. Safety Shoes
5. Helmet
6. Body protection/apron, where required
7. Multi-gas meter, when required
8. Safety Torch
9. Safety Face Shields, where required
10. Additional special PPE, if and as required.

The surveyor should use the necessary personal safety equipment and Protective Equipment according to the specific conditions and the survey being carried out. Other PPE not listed above may be used by the surveyors, as found necessary and applicable.

BCS-G 141 Guidelines for the Assessment of Safety Aspects at Workplace

A. Preamble

A1. This Recommendation has been developed to provide guidance to Classification Societies (hereinafter referred to as CS) when developing their own internal safety procedures and / or instructions relating to the health and safety assessments of workplaces.

A2. The objective is to promote the health and safety culture in the maritime industry for the benefit of the same maritime industry and of the classification society personnel when required to work in the shipyards. Individual CSs are encouraged to develop and/or modify their own internal procedures based on these and other similar references.

A3. All CSs personnel, when working in shipyards, should be in compliance with, and conscientiously apply the applicable procedures / instructions, in the interest of their own health and safety and that of others.

A4. CS's personnel when working in shipyards, in addition to complying with their respective class society's health and safety policies, procedures and requirements, should be in compliance with local requirements and the subject shipyard's health and safety policies, procedures and instructions, as they may apply to them.
As a general rule, on similar matters, the more stringent requirements should prevail.

A5. This Recommendation has been developed by drawing extensively on the latest versions of the references listed in Section B of this document, in addition to the existing procedures and practical experience of the member societies.

B. References

B1. US Department of Labor - OSHA Regulations, 29 CFR – 1915, 1917 and 1918

B2. US Department of Labor - OSHA Regulations, 29 CFR – OSH Act of 1970; General Duty Clause

B.3 US Department of Labor - OSHA Regulations, 29 CFR – 1926 Subpart C; Safety and Health Program Management Guidelines; Issuance of Voluntary Guidelines (Summary)

B4. British Standards Institute (BSI) – OHSAS 18001

B5. BCS-PR 37, for Confined Space Safe Entry

B6. BCS-G 39 on Safe use of rafts or boats for survey

B7. BCS-G 72 for Confined Space Safe Practice

B8. BCS-G 78 on Safe Use of Portable Ladders for Close-up Surveys

B9. BCS-G 90 on Ship structure access manual

B10. BCS-G 91 on Guidelines for Approval / Acceptance of Alternative Means of Access

B11. BCS-G 36 on Working At Heights

B12. BCS-G 134 on Boat Transfers

B13. BCS-G 140 on Pressure Testing and Working with Pressure Systems

B14. BCS-R Z.7 on Hull Classification Surveys

B15. BCS-R Z.10.1 to 10.5 on Hull Survey of Oil Tankers / Bulk Carriers / Chemical Carriers / Double Hull Oil Tankers / Double Skin Bulk Carriers

B16. BCS-R Z.23 Hull Survey for New Construction

C. Scope

C1. This Recommendation relates to CS interaction with shipyards and relates to CS employees while attending projects at these shipyards.

C2. CS should have documented procedures and / or instructions addressing the requirements for their personnel when dealing with the shipyards and when working at the premises of these shipyards, depending upon the type of projects being worked out by the shipyard and the nature and extent of the CS services.

C3. This Recommendation refers specifically to health and safety aspects during all surveys carried out at the shipyards / repair yards and at the premises of their sub-contractors, where similar work conditions may exist, while building, repairing, or converting ships and/or other marine units or parts thereof.

D. Introduction

D1. There are inherently hazardous conditions at the shipyards (see definition, in the next section) and they may expose CS's personnel to injury and possible death. From experience it has been learnt that hazards may occur at the shipyards as a result of many factors, including poor health and safety management implementation, poor hazard-control and risky behaviours of other personnel working in shipyards as reported in section G2.

D2. Surveys for new construction, repair and conversion of ships and other marine structures are by their nature, inherently hazardous. Therefore, CSs should implement training programs for their personnel covering hazard awareness, identification and mitigation to promote a sound health and safety culture.

D3. At the time a CS initiates a project in a shipyard, an assessment of the subject shipyard's facilities and health and safety management system should be carried out, to verify the degree of the system implementation and to confirm how the health and safety culture has been instilled in the shipyard's personnel, managers, supervisors, workers and subcontractors, as applicable.

D4. Other programs that may supplement the health and safety management system of a shipyard should be taken into account, while assessing the shipyard. Good examples of these programs are "Hazards Identification, Risk Assessment and Job Safety Analysis" (JSA or similar); "Safety Steering Committees"; "Behaviour-Based Safety" (BBS).

E. Definitions

E1. Shipyard

- For the purpose of this recommendation, a shipyard is a facility, including the premises of its sub-contractors, or any other premises, where production works are carried out for building or repairing or converting ships and/or other maritime units.

- Shipyard: the definition should include workshops, not as subcontractors' premise, where repair and test are carried out, i.e. ship in service.

E2. Surveyor

- For the purpose of this Recommendation, a Surveyor is any person, employed or contracted by a CS, performing any survey/inspection/testing/audit-related services in the shipyard on behalf of the CS.

E3. Competent person

- A Competent Person means a person nominated by the shipyard’s management, who has the required knowledge and experience to assess the risks associated with the applicable hazards and is responsible for approving the arrangements for controlling the subject hazards.

E4. Responsible person

- A Responsible Person means an authorized representative of the shipyard’s management who is authorized to issue work permits, and to organise and co-ordinate surveys, as applicable.

E5. Hazard

- A hazard is a situation or condition that has the potential to cause harm to an individual or property.

E6. Severe health and safety incident

- For the use of this Recommendation, an incident may be categorized as severe when harm or damage affects CS’s persons or properties. Where an incident has occurred but no harm or damage has been caused then, the incident should not be categorised as severe.

Incidents may be defined as follows:

- Accident – event resulting in injury to people
- Near Miss – event which under slightly different circumstances would have resulted in an accident
- Safety Observation – an unsafe situation / object / practice with the potential to cause harm to people
- Occupational Health Issue – an unsafe situation / object / practice, prolonged exposure which can result in illness to people.(if we say “to which results” means if did and therefore is an accident)

F. Training

F1. All surveyors who are expected to work at shipyards should be trained in health and safety requirements, according to the CS's internal procedures.

F2. This training should include:

a. Recognising hazards, including those typical hazards that are faced in shipyards.

b. Recognising, evaluating and managing the hazards and the risks associated with them.

c. Specifically but not limited to, Confined Space Awareness (BCS-PR 37, BCS-G 72) and Working at Heights (BCS-G 136).

d. Role of the Competent Person and Responsible Person.

e. Use of personal protective equipment, including standard PPE and specific PPE.

f. Emergency arrangements awareness and degree of participation and enrolment.

g. Application of Stop Work Authority (SWA) when facing a situation in which the risk to health and safety is considered to be unacceptably high. Reference is made to the "BCS Joint Statement on Safety for Surveyors".

F3. Competency in the areas covered by the training identified in F2 should be periodically assessed, either as a part of activity monitoring or some other suitable means. The maximum period between these assessments of competency should be 3 years with records maintained of the most recent assessment.

F4. CS should document in their internal procedures situations when these competency assessments are not held as required by this Recommendation and when surveyors do not pass these competency assessments. In either of these cases, CS should take immediate corrective and preventive actions prior to CS personnel continuing in those duties which are affected by the situation.

G. General Health and Safety Related Guidelines for Working at Shipyards

G1. The following are many of the typical hazardous situations that may be faced in shipyards:

a. Physical Agents

i. Noise Heat stress/High temperature

ii. Low temperature

iii. Burn by heat

iv. Electrocution

v. Electrical disruption

b. Confined spaces and chemical agents

i. Oxygen deficiency

ii. Oxygen enrichment Toxic chemicals

1. Carbon monoxide/CO

2. Hydrogen sulphide/H2S

3. Others (e.g. Asbestos, Benzene, Hexavalent Chromium Compounds, Ozone, Nitrogen dioxide, etc.)

iii. Explosive atmospheres and fire substances

1. Hydrocarbon gases

2. Paint fumes

3. Solid combustibles

c. Ergonomic Conditions

i. Slip/Trip/Fall

ii. Access and egress

iii. Working at height

iv. Working over water

v. Movement of normal and heavy lift vehicles

vi. Heavy equipment, structures and their supporting systems

vii. Geographical spread of survey locations (long walks and climbs)

viii. Hygiene (Biological hazard)

d. Specific Shipyard's production works

i. Welding (Eye discomfort, Heat)

ii. Cutting and fairing (Oxygen enrichment; Heat; Explosive atmospheres)

iii. Hull pressure testing

iv. Non-destructive testing (radiation)

v. Dry-dock work

vi. Sea trials

e. Airborne matters

i. Sandblasting

ii. Dust

iii. Pressurised water washing

iv. Paints and solvents

v. Fibers (Asbestos, mineral wool, ceramic)

vi. Lead

f. Surrounding conditions

i. Poor housekeeping

ii. Lifting appliances / Lifted items

iii. Falling objects

iv. Others working aloft

g. Machinery, equipment and tools use

i. Aerial lifts

ii. Pressure systems and tests

iii. Machinery and systems running test, and dock and sea trials

iv. NDT(i.e. X-Ray)

G2. Common factors leading to an incident include:

a. Failure to recognise the hazards, to assess the associated risk and to control it

b. Failure to provide safe processes of work

c. Failure to confirm that safe processes of work are followed

d. Failure to provide safe machinery, equipment and tools

e. Failure to provide safe guards and protection

f. Inadequate information, instructions, training or supervision

g. Failure to follow applicable procedures or instructions, particularly those of manufacturers/suppliers of equipment

h. Failure to avoid situations where attention or reaction is inhibited (e.g. cell phone usage, lack of attention due to exhaustion, medication or personnel distractions)

i. Failure to use appropriate safety equipment, including Personal Protective Equipment (PPE), as applicable

j. Failure to ensure good communications

G3. In addition to the foregoing G1 and G2 listed hazards and common factors, the following aspects should be addressed by the Shipyard's Occupational, Health and Safety Management System:

a. Operation and training in the use of applicable machinery, equipment and tools

b. Barriers, or other equivalent arrangements, in place to prevent objects falling/flying from the work/test area, as well as machinery and equipment in service which may harm any personnel in the vicinity or below

c. Appropriate signage methods for working in the vicinity of dangerous or hazardous locations (i.e. Lifted/carried weights, temporary unprotected openings, radiation, during NDE)

d. Lock-out/Tag-out procedures

e. Segregation and marking of Pedestrian routes and movable equipment and machinery roads duly marked with applicable restrictions (EG: Speed limit, high limit, established preferences or right to cross the roads, construction works in progress, etc.)

f. Routes and roads permanently free from material, machinery, equipment, debris and tools

g. Rescue facilities, equipment, procedures and trained support personnel readily available to permit evacuation in the event of imminent danger and / or to meet an emergency

h. Effects of extreme ambient temperatures (high and low)

i. Protection of openings to prevent inadvertent fall – e.g. open manholes, sections of bilges from which floor plates or gratings have been removed. Provision of guards, anti-sliding boards and signage

j. Measures to avoid objects falling to lower levels or down on vessels

k. The on board access and exit arrangements – safe and clear of obstacles

l. Adequate lighting and ventilation and management of disruptions to allow safe access, visiting and working, as applicable

m. Adequate cleaning to allow safe access, visiting and exit of the full space being inspected

n. Procedures for handling of welding, cutting/fairing tools, equipment and hoses with particular attention when used in confined spaces

o. Procedures for management of fluid hoses, with particular attention to handling of them when they break

p. Procedure for testing the atmosphere of confined spaces, including:

   i. Provision of adequate ventilation

   ii. Safe entry permit process

iii. Hot work permit process

G4. Class rules require that Owners / Shipyard Management are responsible for providing means of access which are suitable and safe for the work to be carried out by the CS's personnel. The equipment, where applicable, should be operated by qualified personnel. Evidence should be provided that:

a. The equipment has been properly maintained and inspected before each use, and equipment operates properly and calibration is up to date

b. Formal inspections have been held periodically, as required

c. Re-inspections have been completed, after repair / overhaul

d. If any modifications from the original configuration have been carried out, they have been done as per manufacturer's acceptable specifications

G5. The records of training, inspections, calibration and maintenance should be established in accordance with the requirements of the shipyard's safety management system.

H. Topic Specific Guidelines

H1. Emergency response arrangements

H1.a. Emergency response arrangements should be a part of the shipyard's 'emergency preparedness planning'.

H1.b. Emergency preparedness planning should address situation specific plans covering as many hazards as possible. In particular, this should cover works in confined spaces, at heights, over water, with pressurized systems.

H1.c. Emergency preparedness planning should include periodical emergency drills, control of people and escape routes.

H1.d. No surveyor should be part of any rescue team. A rescue operation can only be performed by personnel trained for the task and having knowledge of emergency procedures and arrangements in place, agreed communication arrangements, escape routes, status of availability and readiness of the support team, etc.

I. Shipyard Safety Assessment

I1. CSs should develop procedures to carry out assessments of shipyards' safety arrangements as a part of their regular contracts.

I2. CSs should review shipyards' safety systems periodically and, particularly, when a major health and safety related incident occurs in the shipyard. The periodicity of these reviews should be determined by the individual CS having considered the regularity of contact and contracts with the shipyards concerned. Where no contract or involvement with the shipyard has taken place within a twelve month period such reviews should be performed prior to commencing any new surveys within the shipyard. Where the CS is continually present in the shipyard the periodicity of these reviews should not exceed three years.

I3. BCS should promote these shipyard safety assessments for the benefit of the maritime industry health and safety conditions. CS's procedures should include, for these assessments, a system to control follow up actions which will facilitate regular revisits and reassessments of the findings and identified improvements. Records of such reviews should be maintained for a period of not less than five years.

I4. CSs should be proactive and co-operate among themselves for the improvement of health and safety conditions in either a shipyard or group of shipyards in an area or shipyards in a country or a common cultural area.

J. Surveyors' Protective Equipment for Working at Shipyards

J1. The choice of the required PPE relies on risk assessments, local legal requirements and the requirements from 3rd parties. PPE selected should not add to existing risks. Different types and combinations of PPE should be compatible and not undermine each other's effectiveness.

J2. The following Personal Protective Equipment and tools, as a minimum, should be made available by the respective CS to their surveyors when working at shipyards:

i. protective clothing

ii. safety shoes/boots

iii. hard hat

iv. work gloves

v. protective glasses and/or goggles, if necessary

vi. ear defenders and/or ear plugs, if necessary

vii. flashlight with strap, as necessary and optional head torch where appropriate

viii. personal multi-gas meter

ix. mask as appropriate for intended use

x. safety belt

J3. The surveyor should use the necessary personal protective safety equipment and tools, according to the specific conditions and locations of survey, always in conformance with the respective manufacturers' recommendations.

J4. If PPE provided by shipyards is to be used, for special and specific reasons, then the surveyor should ensure that the PPE is suitable for his task, size and is clean, not damaged and maintained and used in conformance with the manufacturers' recommendations.

BCS- G 142

LNG BUNKERING GUIDELINES

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Section 1 - Application

1.1 Introduction

LNG bunkering is developing worldwide in line with the increase of use of natural gas as a fuel compliant with environmental legislation.

This guideline provides recommendations for the responsibilities, procedures and equipment required for LNG bunkering operations and sets harmonised minimum baseline recommendations for bunkering risk assessment, equipment and operations.

These guidelines do not consider commercial aspects of the bunker transfer such as Bunker Delivery Notes and measurement of quantity or quality of LNG.

1.2 Purpose

The purpose of these guidelines is mainly to define and cover the additional risks associated with bunkering LNG and to propose a methodology to deal with those additional risks in order to provide a similar level of safety as is achieved for traditional oil fuel bunkering operations.

This document is designed to complement the requirements from the existing applicable guidelines and regulations, such as port and terminal checklists, operator's procedures, industry guidelines and local regulations. This guide provides guidance to clarify the gaps that have been identified in the existing guidance and regulations. In particular, the following items are covered:

- The responsibility of different parties involved in the LNG transfer,
- The LNG bunkering process,
- SIMOPS
- Safety distances,
- QRA and HAZID

1.3 LNG Bunkering process and guideline structure

LNG bunkering is the process of transferring LNG fuel to a ship from a bunkering facility.

The sequence for a bunkering operation carried out between two parties for the first time is described in the following diagram; the references identify the applicable sections of the guideline.

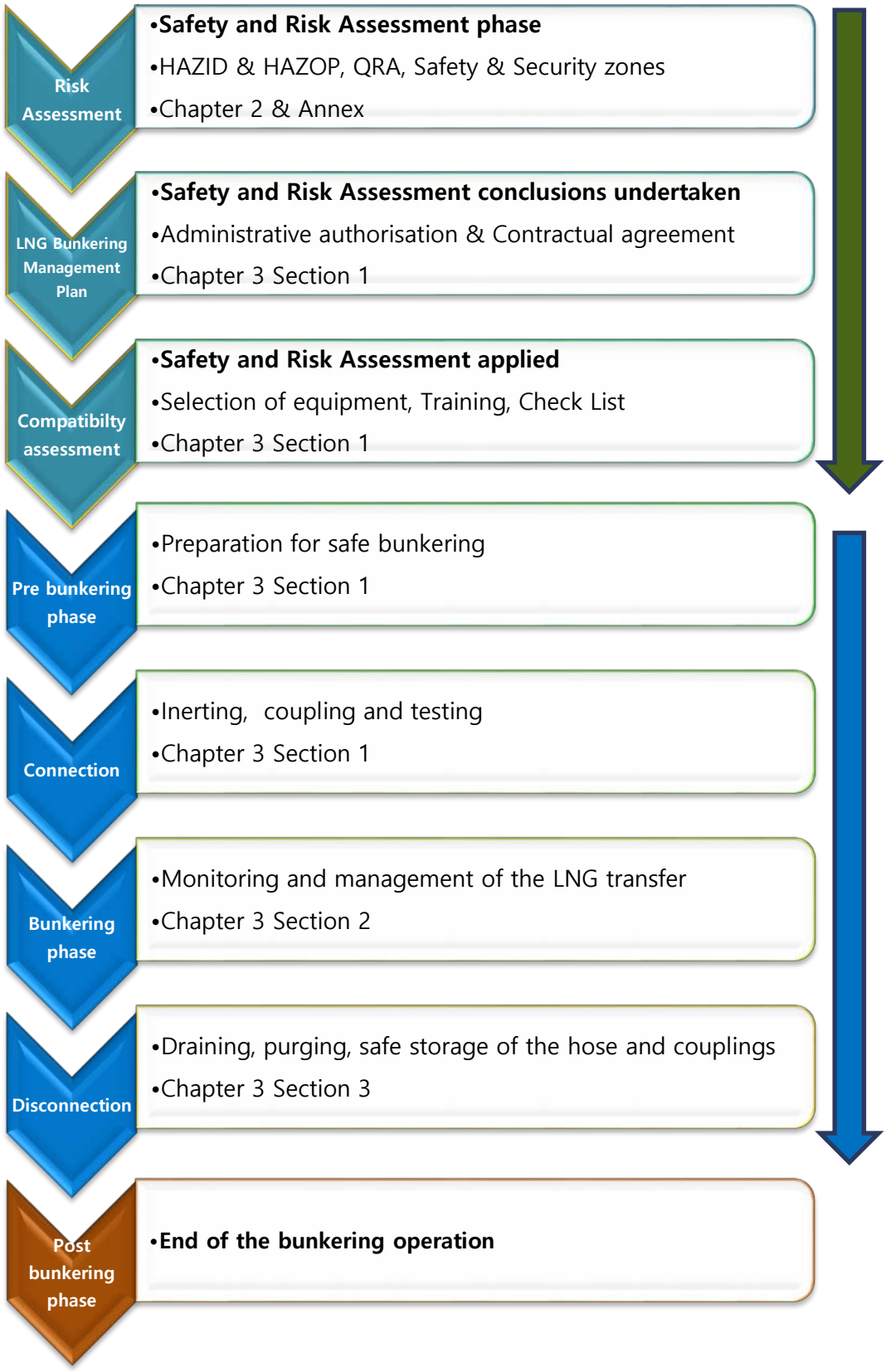


Figure 1: Bunkering process

1.4 Applicability

These guidelines are applicable to LNG bunkering operations for:

- Different methods,
- Different ship types, and
- Different locations (in port, off shore and terminal) worldwide.

1.5 LNG Bunker Management Plan (LNGBMP)

An LNG bunker management plan should be established in order for the involved parties to agree technically and commercially on methodology, flow rate, temperature, pressure of the delivery of LNG and receiving tank. This plan gathers together all the information, certificates, procedures, and checklist(s) necessary for an effective and safe LNG Bunkering operation.

The LNG Bunker Management Plan should be referenced as part of the safety management system of the RSO.

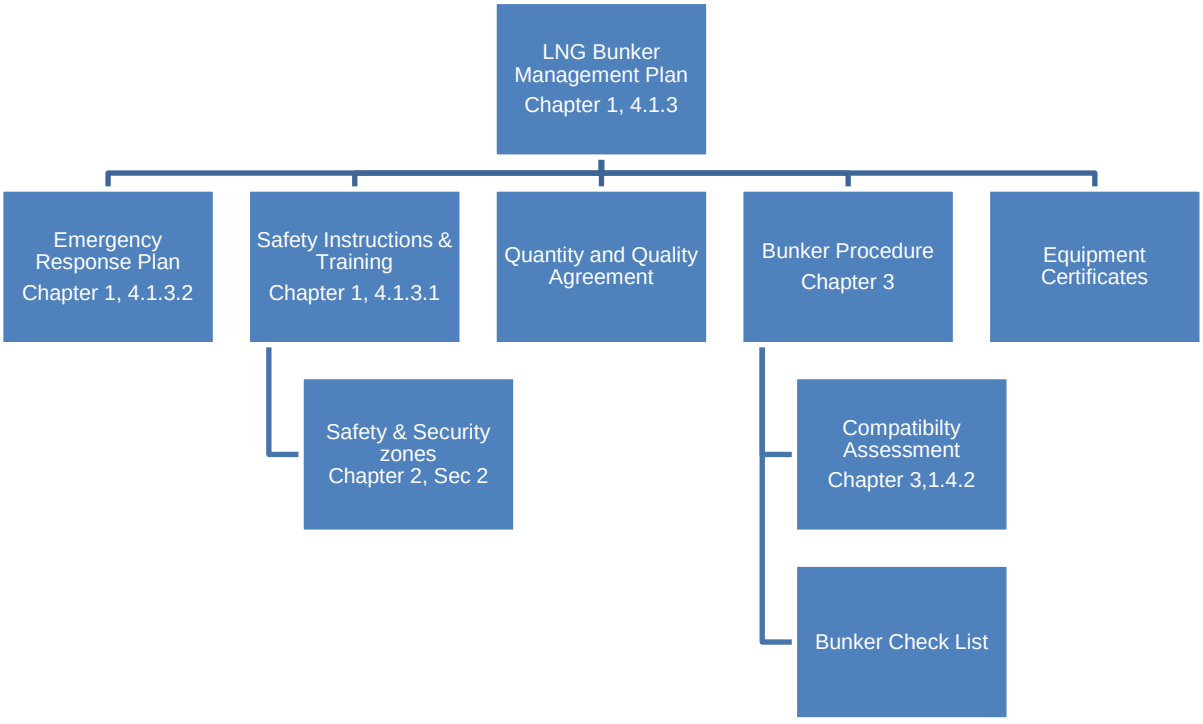


Figure 2: Breakdown of LNGBMP content showing related sections of this guide

Section 2 - Definitions, applicable standards and rules

2.1 Terms and definitions

2.1.1 Atmospheric tanks

Atmospheric tanks mean tanks of the types A or B or membrane tanks as defined in:

- IGC Code, regulations 4.21, 4.22 and 4.24; and
- IGF Code, regulations 6.4.15.1, 6.4.15.2 and 6.4.15.4.

2.1.2 Bunkering Facility Organisation (BFO)

This is the organisation in charge of the operation of the bunkering facility.

2.1.3 Breakaway Coupling (BRC)

A breakaway coupling is a safety coupling located in the LNG transfer system (at one end of the transfer system, either the receiving ship end or the bunkering facility end, or in the middle of the transfer system), which separates at a predetermined section at a determined break-load or relative separation distance each separated section containing a self-closing shut-off valve, which seals automatically.

2.1.4 Bunkering facility

A bunkering facility is normally composed of a LNG storage and a LNG transfer installation, a bunkering facility may be (a stationary shore-based installation or a mobile facility, i.e. a LNG bunker ship or barge or a tank truck).

A bunkering facility may be designed with a vapour return line and associated equipment to manage the returned vapour.

2.1.5 Dry disconnect

This applies when the transfer system between two vessels or a vessel and a port facility is disconnected as part of normal operations. The objective is that no LNG or natural gas should be released into the atmosphere. If this objective cannot be achieved, the amount released can be reduced to negligible amounts consistent with safety. Dry disconnect can be achieved by:

- Draining and inerting process before the disconnection; or
- Use of dry connect / disconnect coupling.

2.1.6 Emergency Shut-Down (ESD)

These are systems installed as part of the LNG transfer system that are designed to stop the flow of LNG and or prevent damage to the transfer system in an emergency. The ESD may consist of two parts, they are;

- ESD - stage 1, is a system that shuts the LNG transfer process down in a controlled manner when it receives inputs from one or more of the following; transfer personnel, high or low level LNG tank pressure alarms, cables or other means designed to detect excessive movement between transfer vessels or vessel and an LNG bunkering facility, or other alarms.

- ESD - stage 2, is a system that activates decoupling of the transfer system between the transfer vessels or between a vessel and an LNG bunkering facility. The decoupling mechanism contains quick acting valves designed to contain the contents of the LNG transfer line (dry break) during decoupling.

2.1.7 Emergency Release Coupling (ERC)

The ERC is normally linked to the ESD system where this may be referred to as ESD2 as per SIGTTO “ESD arrangements & linked ship/shore systems for liquefied gas carriers”.

An emergency release coupling is activated:

- By excessive forces applied to the predetermined section, or

- By manual or automated control, in case of emergency.

2.1.8 Emergency Release System (ERS)

A system that provides a positive means of quick release of the transfer system and safe isolation of receiving vessel from the supply source.

2.1.9 Flash Gas

Boil-off Gas instantly generated during LNG transfer due to the warmer temperature of the receiving ship tanks, sudden pressure drop or friction.

2.1.10 HAZOP

A structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. A HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team of experts during a set of meetings.

2.1.11 HAZID

Hazard identification exercise, there are a number of recognised methods for the formal identification of hazards. For example: a brainstorming exercise using checklists where the potential hazards in an operation are identified and gathered in a risk register these will then be assessed and managed as required.

2.1.12 Hazardous zones

Bunkering-related hazardous zone means any hazardous area zone 1 or zone 2 defined for:

- The receiving ship in accordance with IGF Code[1], regulation 12.5;

[1] The IGF Code adopted by Resolution MSC.391(95)

- The bunkering ship in accordance with IGC Code[2], regulation 1.2.24 and where gas may be present as a result of the bunkering operation; and

- The bunkering shore facility or truck tanker facility in accordance with IEC 60079-10-1.

2.1.13 IAPH

International Association of Ports and Harbours.

2.1.14 IGC Code

International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (Gas Carrier Code). The revised IGC Code was adopted by Resolution MSC.370(93). It will enter into force on 1 July 2016.

2.1.15 IGF Code

International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels. IGF Code refers to Resolution MSC.391(95). It will enter into force on 1 January 2017.

2.1.16 LNG Bunkering

The process of transferring LNG to be used as fuel on board the receiving ship.

2.1.17 Vapour return line

A vapour return line is a connection between the bunkering facility and the receiving ship to allow excess vapour generated during the bunkering operation to be returned to the bunkering facility and remove any need to vent to atmosphere. It is used to control the pressure in the receiving tank due to the liquid transfer, flash gas and boil-off gas generation.

2.1.18 LNG transfer system

A system consisting of all equipment contained between the manifold used to deliver LNG bunker (and to handle vapour return) and the manifold receiving the LNG (and delivering vapour return) including but not limited to:

- Loading arms and supporting structures,

- LNG articulated rigid piping,

- Hoses, swivels, valves, couplings,

- Emergency Release Coupling (ERC),

- Insulating flanges,

- Quick connect / disconnect couplings (QC/DC),

- Handling system and its control / monitoring system,

[2] The IGC Code adopted by Resolution MSC.370(93)

- Communication system,
- ESD Ship/Shore Link or Ship/Ship Link used to connect the supplying and receiving ESD systems.

It can also include the compressors or blowers intended for the boil-off gas handling system where provided depending on the design of the transfer system. However, liquefaction systems used to maintain pressure in the bunker vessel tanks are not to be considered as part of the LNG transfer system.

2.1.19 MARVS

Maximum Allowable Relief Valve Setting.

2.1.20 MSC

Maritime Safety Committee of the IMO.

2.1.21 Person in Charge (PIC)

The Person in Charge (PIC) is a person who is responsible for the overall management of the bunkering operation. The PIC may also be referred to as Person in Overall Advisory Control (POAC).

2.1.22 PPE

Personal Protective Equipment.

2.1.23 Qualitative Risk Assessment (Q_{ual}RA)

A risk assessment method using relative measure of risk value based on ranking or separation into descriptive categories such as low, medium, high; not important, important, very important; or on a scale, for example from 1 to 10 or 1 to 5.

2.1.24 Quantitative Risk Assessment (QRA)

This is a formalised statistical risk assessment method for calculating a numerical risk level for comparison with defined regulatory risk criteria.

2.1.25 Receiving Ship

Receiving ship is the ship that receives LNG fuel.

2.1.26 Receiving Ship Operator (RSO)

The receiving ship operator (RSO) is the company responsible for the operation of the receiving ship, in particular during the bunkering operations.

2.1.27 Risk

A combination of the likelihood of an event and the consequences if the event occurs.

2.1.28 Risk matrix

A risk matrix is a tool for displaying combinations of likelihood and consequence, used as the basis for risk determination. Multiple consequence categories can be included: impact on people, assets, environment and reputation. Plotting the intersection of the two considerations on the matrix provides an estimate of the risk. Acceptable levels of risk are normally shown by color coding the boxes.

2.1.29 Safety zone

The safety zone is a zone around the bunkering facility, the bunkering station of the receiving ship and the LNG transfer system.

The purpose of the zone is to set an area that is put in place during LNG bunkering and within which only essential authorised and qualified personnel are allowed and potential ignition sources are controlled.

2.1.30 Security zone

The Security Zone is the area around the bunkering facility and receiving ship where ship traffic and other activities are monitored (and controlled) to prevent entry and provide a ‘stand-off’ distance during the bunkering operation; this will be larger than the safety zone.

The security zone may also be referred to as the “exclusion zone”.

The security zone is site dependent and is often determined by the Port Authorities.

2.1.31 SIGTTO

Society of International Gas Tanker and Terminal Operators.

2.1.32 Simultaneous Operations (SIMOPS)

Carrying out LNG bunkering operations concurrently with any other transfers between ship and shore (or between ships if ship-to-ship bunkering method is used). This includes loading or unloading cargo operations, dangerous goods loading or unloading and any kind of other goods loading or unloading (i.e. stores and provisions), passenger embarkation/disembarkation, chemical and other low flash product handling, bunkering of fuels other than LNG, and any other activity that can impact or distract from bunkering operations (e.g. cargo movements on board, heli-ops, etc.).

Special attention is to be paid to any of the above activities occurring within the bunkering safety zone as well as any on board testing that may impact on the bunker operation.

2.1.33 STCW Code

IMO Code for Seafarers’ Training, Certification and Watchkeeping.

2.1.34 Independent Type A, B, C and Membrane tank

These tank types are defined in the IGC and IGF Code.

2.2 Standards and rules

The following tables provide an overview of existing standards related to LNG and risk assessment. The lists are not exhaustive.

2.2.1 Standards and rules for LNG

No.	Reference	Title
1	EN 1160	General characteristics of liquefied natural gas
2	EN 1473	Design of onshore installations
3	EN ISO 16904:2016	Design and testing of marine transfer systems. Design and testing of transfer arms
4	EN 1474-2	Design and testing of marine transfer systems. Design and testing of transfer hoses
5	EN 1474-3	Design and testing of marine transfer systems. Offshore transfer systems
6	EN 12308	Suitability testing of gaskets designed for flanged joints used on LNG piping
7	EN 12838	Suitability testing of LNG sampling systems
8	EN 13645	Design of onshore installations with a storage capacity between 5 t and 200 t
9	EN ISO 28460	Ship-to-shore interface and port operations
10	ISO 16903	Characteristics of LNG influencing design and material selection
11	ISO/TS 18683	Guidelines for systems and installations for supply of LNG as fuel to ships
12	CSA Z276	Standard for production, storage and handling of LNG in Canada

2.2.2 Draft Standards and rules for LNG

No.	Reference	Title
13	ISO 20519	Specification for bunkering of gas fuelled ships
14	CTAC	Recommendations for LNG Unmanned Barge Policy Letter

2.2.3 Standards for Risk Analysis

No.	Reference	Title
15	ISO/IEC Guide 73	Risk Management - Vocabulary
16	ISO/TS 16901	Guidance on performing risk assessments in the design of onshore LNG installations including the ship/shore interface
17	ISO 31000	Risk Management - Principles and Guidelines
18	ISO 31010	Risk Management - Guidelines on principles and implementation of risk management

2.2.4 Other standards & guidelines

No.	Reference	Title
19	SGMF	Gas as a marine fuel - Bunkering safety guidelines
20	IEC 60079	Explosive Atmosphere Standards
21	IEC 60092-502	Electrical installations in ships - Tankers - Special features
22	EN13463-1	Non electric equipment for use in potentially explosive atmospheres
23	SIGTTO	ESD arrangements & linked ship/shore systems for liquefied gas carriers
24	USCG (CG-OES) Policy Letter No. 01-15	Guidelines for Liquefied Natural Gas Fuel Transfer Operations and Training of Personnel on Vessels using Natural Gas as Fuel (19 Feb 2015)
25	USCG (CG-OES) Policy Letter No. 02-15	Guidelines Related to Vessels and Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations (19 Feb 2015)
26	USCG CG-521 Policy Letter 01-12	Equivalency Determination: Design Criteria for Natural Gas Fuel Systems
27	NFPA 52	Vehicular Gaseous Fuel Systems Code
28	NFPA 59A	Standard for the Production, Storage, and Handling of LNG
29	49 CFR 193	Liquefied Natural Gas Facilities: Federal Safety Standards (DOT)

Section 3 - Bunkering methods

3.1 Description of typical ship bunkering arrangements

Four methods of bunker supply are detailed in the following sections.

The duration of the bunkering will depend mainly on the transfer rate from the bunkering facility; different pump sizes or pressurised supply can be selected depending on the specific needs. Other parameters influencing the duration include the testing procedures, BOG and flash gas handling, purging and draining method and pre- and post-bunkering procedures.

3.1.1 Ship-to-ship LNG bunkering

LNG bunker ships are a common solution when there is a significant volume of LNG to be transferred. Current capacities of LNG bunker ships, in operation and under construction, are in the range of a few hundred to several thousand cubic meters.

The bunker ship is loaded either in a purpose-built, small-scale terminal, a standard LNG terminal adapted for small scale LNG carriers or ship-to-ship bunkering from a larger LNG carrier.

3.1.2 Truck-to-ship LNG bunkering

LNG bunkering operations are carried out from standardised LNG trucks (typically about 40 cubic meter capacity). More than one truck may be required to bunker a single ship, depending on the required bunker volume.

The LNG bunkering operation duration is dependent on the transfer capacity of the truck which is relatively small. Depending on the shore side arrangement it may be possible to increase the bunker rate to some extent by simultaneous bunkering from multiple trucks via a common manifold or using a permanently installed buffer station on the quay side.

This LNG bunkering method is recognised to be flexible as it offers the possibility for many different ships to be bunkered in different port locations. Depending on the port arrangement it may be possible to park the trucks close to the bunker station on the receiving ship allowing short hoses to be used, this potentially reduces the heat flux into the LNG, minimises the pressure drop and also reduces the size of a potential spill if the hose is damaged.

This method is recognised as most suitable where the amount of LNG to be transferred is less than 200 cubic meters and when the commercial operation of the ship allows a sufficient duration for bunkering.

In some cases, LNG trucks may bunker Ro-Ro ferries directly from the ship’s main open cargo deck to the bunker station. This bunkering method derives from normal practices of oil fuel bunkering methods used in Ro-Ro ferries.

3.1.3 Terminal (or shore-based facility) to ship LNG bunkering

A permanent bunkering facility may be used by ships such as short sea shipping ferries, ro-ro ships, OSV and IWW vessels.
LNG bunkering takes place through a rigid cryogenic pipe and a flexible hose or loading arm for final connection with the ship. The tanks for the storage of the LNG should generally be as close as possible to the bunkering terminal.

It is expected that this type of facility will be manned such that there will be shore side personnel able to manually activate the ESD and stop the bunker transfer in case of an emergency.

3.1.4 Containerised LNG tanks used as fuel tanks

This bunkering method may also be referred to as using portable tanks (see IGF code 18.4.6.3 and 18.4.6.4).

Instead of transferring LNG into the receiving ship's tanks pre-loaded LNG containers are lifted on board the vessel as a complete fuelling package. Each container is connected to three different piping systems: the LNG fuelling line to the engines, piping to the vent mast for the pressure relief valves (PRV) of each container and the inert gas system.

In case of use of ISO containerised LNG tanks used on board some small container carriers (feeders), the LNG tanks are provided in standard container sizes and consist of a Type C LNG tank, similar to a road tanker, inside a container shaped steel frame. The connection system for the LNG tank is also located within the frame.

For trailer tanks, used on-board some ferries, they are parked in specific location, usually IMDG areas, where they are fixed to the deck and connected through adequate hoses for the LNG fuelling in navigation. The specific LNG trailers (and its connecting equipment) used as portable LNG fuel tanks on board should be approved according to IGF code in addition to approval according to national, regional or international standards, e.g. ADR, Transport Canada or US DOT.

3.2 Examples of ship bunkering arrangements

Possible ship bunkering options are given in Table 1 below with corresponding arrangements (Figures 3 to 7).

Table 1: Bunkering options and arrangements

		Bunkering facility				
		Type C tank			Atmospheric tank	
		Bunker ship	Tank truck	Shore-based facility	Bunker ship	Shore-based facility
Receiving ship	Type C tank	Fig.3	Fig.6	(*)	(*)	Fig.7
	Atmospheric tank	Fig.4	(*)	(*)	Fig.5	(*)

(*) This arrangement is possible but not shown.

Note: For small scale bunker supply using Type C tanks, the LNG supply pressure may be generated by pump (as shown in the figures below) or by a Pressure Built Up unit.

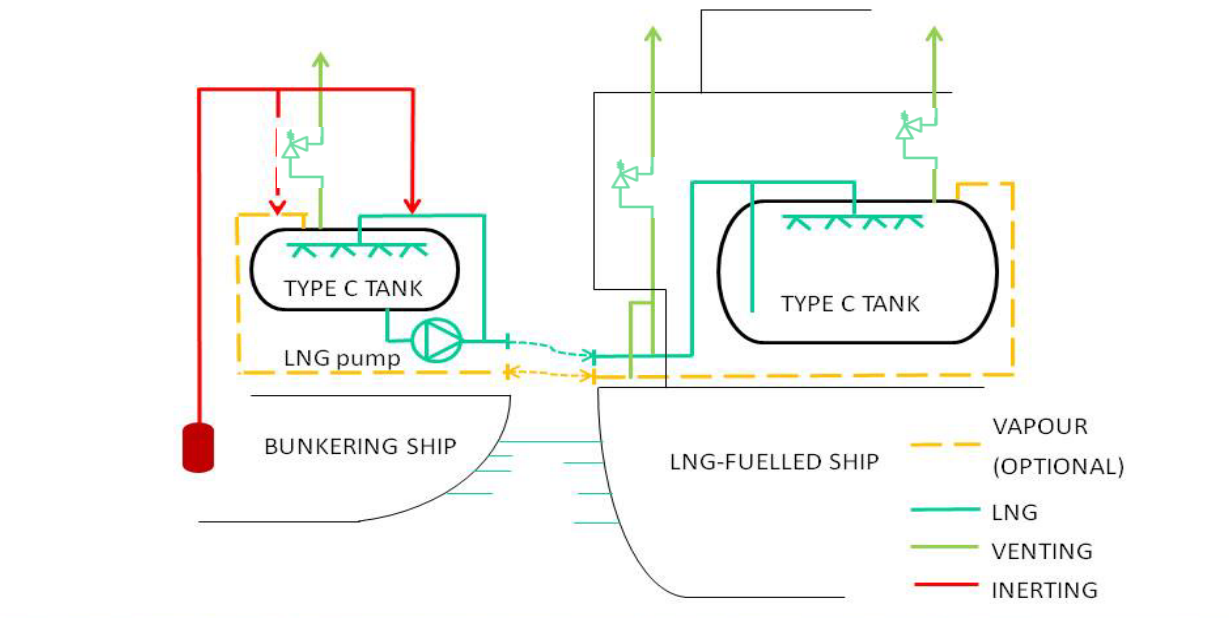


Figure 3: Ship-to-ship bunkering - typical arrangement of bunkering ship and LNG fuelled ship with type C tank

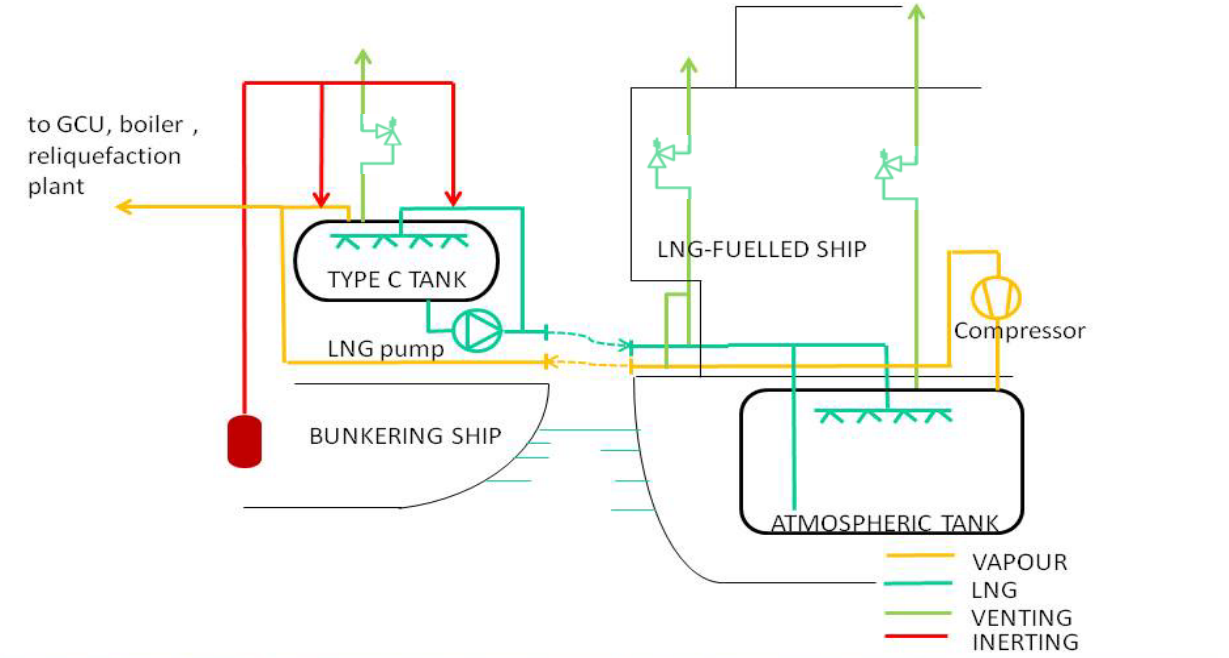


Figure 4: Ship-to-ship bunkering - typical arrangement of bunkering ship with type C tank and LNG fuelled ship with atmospheric tank

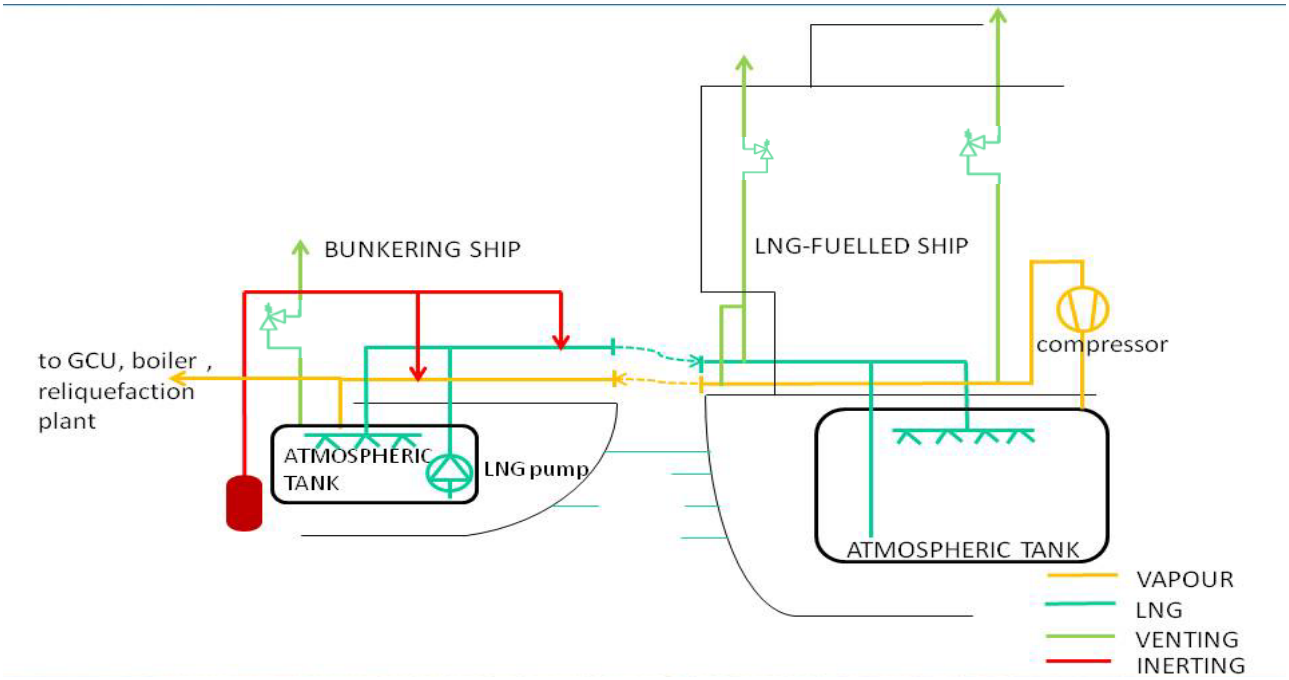


Figure 5: Ship-to-ship bunkering - typical arrangement of bunkering ship and LNG fuelled ship with atmospheric tank

* Compressor is optional, only necessary if free flow is not possible. Normally there is no need for a compressor if the bunker ship uses atmospheric tanks or uses type C tanks operated at very low pressure (using discharge pump and not PBU). It is only required in cases where there is likely to be large quantities of flash gas generated during bunkering and the pressure gradient between the bunker ship and receiving ship does not allow free flow of vapour.

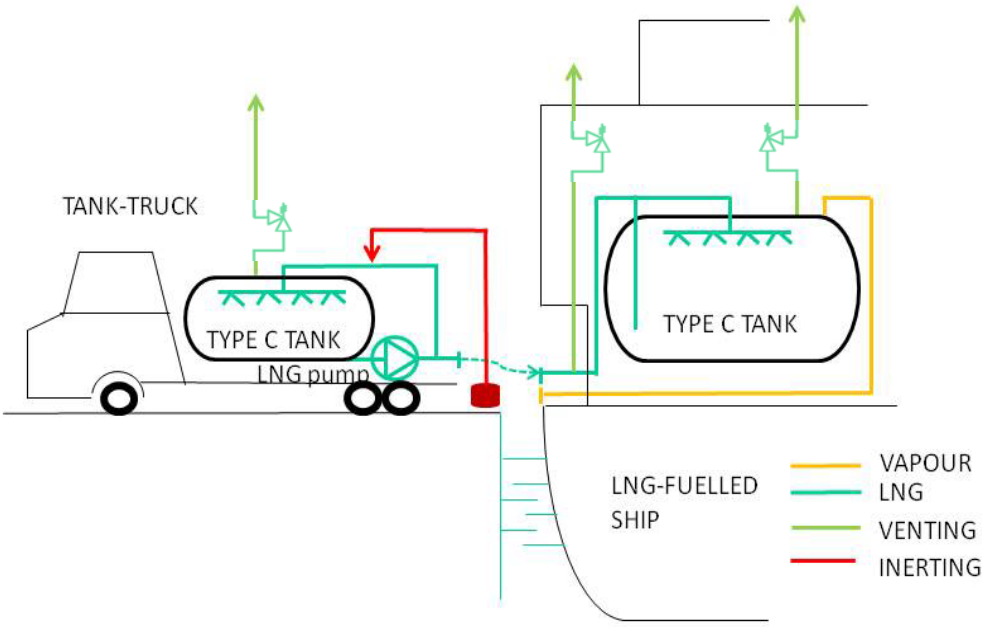


Figure 6: Truck-to-ship bunkering - typical arrangement of LNG fuelled ship with type C tank

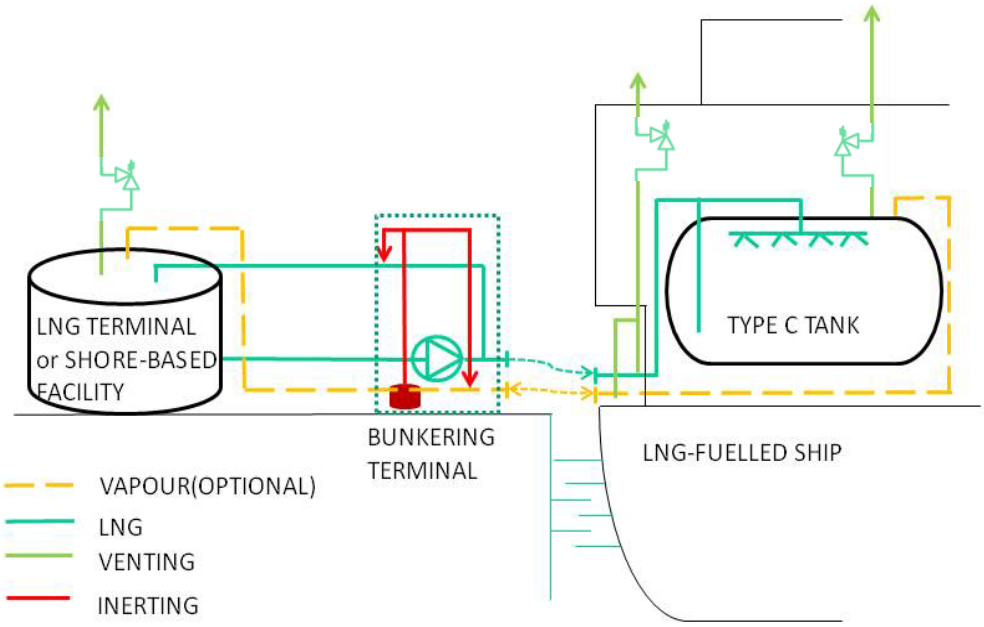


Figure 7: Terminal to ship bunkering - typical arrangement of LNG fuelled ship with type C tank

Section 4 - Responsibilities during LNG bunkering

4.1 Responsibilities during planning stage

The involvement of port or other authorities, LNG supplier and receiving ship in the planning of a bunkering operation are detailed below.

4.1.1 Port, National Authority and Flag Administration responsibilities

Decisions and requirements for LNG bunkering should be based on a risk analysis carried out in advance of any bunkering operation. The Port authority and/or national or other authority with jurisdiction should consider:

- Approval of the risk acceptance criteria,
- Overall responsibility for the good governance and framework for LNG bunker operations in the port,
- Applicability of an accreditation scheme for LNG bunker operators in the ports under their authority,
- Acceptability of the location of bunkering facilities, (bunkering may be limited to specific locations within the port/anchorage),
- Restrictions on bunkering operations such as simultaneous operations,
- Shore side contingency plans, emergency response systems,
- General procedures for traffic control and restrictions,
- Whether additional requirements should be applied.

4.1.2 Receiving ship operator (RSO) and bunkering facility organisation (BFO) responsibilities

Before setting up a ship bunkering operation, the receiving ship operator (RSO) and bunkering facility organisation (BFO) should perform the actions listed below.

Table 2: Receiving ship operator (RSO) and bunkering facility organisation (BFO) responsibilities

No.	Actions	to be performed by:		Observations
		RSO	BFO	
1	Review the applicable International, National and Local Regulations, Port by-laws, industry guidelines, standards, checklists, and Classification Societies Rules and Guidelines.	X	X	Prior to the operation.
2	Identify all documents, information, analysis, procedures, licences, accreditations, etc. required by Authorities.	X	X	Prior to the operation.
3	Check that the bunkering equipment is certified by the relevant Classification Society (on-board equipment) or by relevant Authorities (on-shore equipment).		X	Prior to the operation.
4	Check that the receiving ship and the bunkering facility are compatible.	X	X	This action should be carried out jointly by RSO and BFO.
5	Develop a specific LNG bunkering procedure for the concerned ship and bunkering facility based on preselected LNG bunkering guideline.	X	X	The LNG bunkering procedure should take into account any instructions and check-lists issued by the Port. This procedure should be developed jointly by RSO and BFO.
6	Perform the bunkering risk assessment (as part of an initial in-depth study).	X	X	Normally required by the Port Authorities and Flag authorities. Bunkering risk assessment study should involve RSO and BFO.
7	Develop an emergency response plan and bunkering safety instructions.	X	X	This action should be carried out jointly by RSO and BFO with local authorities, fire brigade and hospital premises involvement.
8	Ensure that all bunkering personnel are adequately trained.	X	X	
9	Develop bunkering plans and procedures reflecting the status of the facility.		X	
10	Prepare, compile and share the LNG bunkering management plan with stakeholders.	X		

4.1.3 LNG Bunker Management Plan (LNGBMP)

A bunker management plan should be compiled to allow for easy availability of all relevant documentation for communication between the receiving vessel and the BFO and if applicable the terminal and/or third parties.

The Bunker Management plan should be stored and maintained by both RSO and BFO. For onboard bunkering this may not be the best scenario and should include the following aspects:

- Description of LNG, its handling hazards as a liquid or as a gas, including frostbite and asphyxiation, necessary safety equipment, personal protection equipment (PPE) and description of first aid measures
- Description of the dangers of asphyxiation from inert gas on the ship
- Bunkering safety instructions and emergency response plan
- Description of the bunker facility LNG tank measurement and instrumentation system for level, pressure, and temperature control
- Definition of the operating envelope for which safe LNG bunkering operations can be undertaken in reference to temperature, pressure, maximum flow, weather and mooring restrictions etc.
- A procedure for the avoidance of stratification and potential rollover, including comparison of the relative temperature and density of the remaining LNG in the receiving tank and that in the bunker provider tank and action to be taken to promote mixing during bunkering
- The description of all risk mitigation measures to comply with during an LNG bunkering
- The description of the hazardous areas, safety zone, and security zone and a description of the requirements in the zones to be complied with by the receiving vessel, the bunkering facilities, and if applicable the terminal and third parties
- Descriptions and diagrams of the bunker facility LNG bunkering system, including, but not limited to, the following as applicable:
    - Recirculating and vapour return line system
    - LNG fuel tank cooling down procedure
    - Procedure for collapsing the pressure of the receiving tank before and during bunkering
    - LNG fuel tank pressure relief valve
    - Ventilation and inlet/outlet location
    - Inerting system and components
    - Boil-off gas compressor or reliquefaction system
    - Gas detection system including locations of detectors and alarms
    - List of alarms or safety indication systems linked to the gas fuel installation
    - LNG transfer line and connectors
    - Emergency Shutdown System description
    - Communication systems and controls protocol

In addition to the above list of description and schematic drawings, the LNGBMP should include:

- Documents/reports on periodic inspections of the BFO LNG installation (components), and safety equipment.
- A checklist to verify that the ship's crew have received proper training for bunkering LNG.
- Bunkering safety instructions and safety management plan, (see below).

4.1.3.1 Bunkering safety instructions

RSO and BFO specific safety instructions should be prepared by both parties based on the conclusions and outputs of the LNG Bunkering Operations Risk Assessment (see Chapter 2 Sec 1 and Annex).
The specific LNG Bunkering safety instructions should cover at least:

- Sudden change of ambient / sea conditions,
- Breaching of safety and security zones,
- Loss of power (receiving ship or bunkering facility),
- Loss of monitoring / control / safety systems (ESD),
- Loss of communication, and
- Abnormal operating parameters.

In addition, the safety instructions for LNG bunkering may contain technical, RSO and BFO company-internal and operational regulations. The safety instructions should identify conditions under which bunkering will be stopped and in each case the actions required/conditions to be reinstated before the bunkering operation can be restarted

4.1.3.2 Emergency Response Plan

An Emergency Response Plan should be prepared to address cryogenic hazards, potential cold burn injuries to personnel and firefighting techniques for controlling, mitigating and elimination of a gas cloud fire, jet fire and/or a LNG pool fire.

The Emergency Response Plan should cover all emergency situations identified in the LNG Bunkering Operations Risk Assessment and may designate responsibilities for local authorities, hospitals, local fire brigades, PIC, Master and selected personnel from the bunkering facility. As a minimum, the following situations should be covered where appropriate:

- LNG leakage and spill on the receiving ship, on the bunkering facility or from the LNG transfer system
- Gas detection
- Fire in the bunkering area
- Unexpected movement of the vessel due to failure or loosening of mooring lines
- Unexpected moving of the truck tanker

- Unexpected venting on the receiving ship or on the bunkering facility
- Loss of power

4.2 Responsibilities during bunkering operations

The involvement of port, national and/or other LNG supplier, receiving ship and specific individuals in the different phases of LNG bunkering are indicated below. In some situations there may be no port authority with direct responsibility for oversight of the bunkering operation (for example when the port/terminal is owned and managed by the BFO or RSO) in those cases the responsibilities listed in 4.1.1 and 4.2.1 should be adopted by either the BFO or the RSO.

4.2.1 Port Authorities general responsibilities

Port Authority regulations and procedures may impose requirements or criteria for:

- Accreditation of the BFO,
- Qualification of the PIC,
- Mooring of the receiving ship and bunker facility, industry standards may be referenced (e.g. OCIMF Effective Mooring 3rd Edition 2010),
- Immobilisation / braking of the tank truck,
- Establishment of a Safety zone / Security zone in way of the bunkering area,
- Simultaneous operations,
- Spatial planning and approval of bunker locations,
- Enforcement,
- Use of checklists,
- Environmental protection (Releases of NG, purging),
- Approval of safety and emergency response plans,
- Bunkering risk assessment, and
- Conditions in which LNG bunkering operations are allowed: weather conditions, sea state, wind speed and visibility.

4.2.2 LNG Bunkering facilities organisation (BFO) responsibilities

The LNG bunkering facilities organisation should be responsible for the operation of the LNG bunkering installations including:

- Planning of the specific operation (liaising with the RSO),
- Operation of the facility in line with plans and procedures; and
- Maintenance of the bunkering equipment.

4.2.3 Receiving ship operator (RSO)

Receiving ship operator has responsibilities for bunkering operation including:

- Informing the BFO and the Port Authority in advance for necessary preparation of the bunkering operation; and
- Attending the pre-bunkering meeting to ensure: compatibility with local requirements for equipment, quantity and flow rate of LNG to be bunkered, and coordination of crew and safety communication systems and procedures.

4.2.4 Master

The master of the receiving ship retains overall control for the safe operation of the ship throughout the bunkering operation. If the bunkering operation deviates from the planned and agreed process the master retains the right to terminate the process.

The master has overall responsibility for the following aspects of the bunkering operation. However, these tasks may be delegated to the PIC or other responsible crew member but the overall responsibility should be retained by the master:

- Approving the quantity of LNG to be bunkered
- Approving the composition, temperature and delivery pressure of LNG that is available from the bunkering facility operator. (Aspects of this may have been agreed prior to the bunkering operation as part of the LNG supply contract)
- Ensuring that the approved safe bunkering process is followed including compliance with any environmental protection requirements required by international, national or local port regulations
- Agreeing in writing the transfer procedure, including cooling down and if necessary, gassing up; the maximum transfer rate at all stages and volume to be transferred
- Completing and signing the bunkering checklist

4.2.5 Person in Charge (PIC)

A person in charge of the bunkering operation (PIC) should be agreed by the receiving ship and the bunkering facility. It is noted that in case of ship-to-ship transfer the role of PIC should be undertaken by either the Master or Chief Engineer of the receiving ship, or the Master of the bunker ship, for other bunker transfer methods a person of equivalent authority should be selected. In the case of distinct Master and PIC, the division of responsibilities between the two parties should be agreed before commencing bunkering operations.

The PIC should have an appropriate level of competence and be accepted to operate in the bunkering location. This may require authorisation or certification to act as PIC for bunkering operations, issued by the Port Authority or other Authority with jurisdiction over the bunkering location. The PIC should have adequate education, training and authorisation to ensure safe bunkering operations.

The PIC should be responsible for the bunkering operation and for the personnel involved, in all aspects of the bunkering operation, in particular safety, until completion.

The PIC should ensure that:

- Relevant approved procedures are properly applied; and
- Safety standards are complied with, in particular within the hazardous zone and safety zone.

To achieve this, the PIC should be responsible for:

- Ensuring that company specific operating procedures are followed, and that the operation is conducted in compliance with all applicable port regulatory requirements;
- Ensuring that all required reports are made to the appropriate Authorities;
- Conducting a pre-operation safety meeting with the responsible officers of both the bunkering facility and the receiving ship;
- Ensuring that all bunkering documentation is completed (checklists, bunker delivery note, etc.);
- Agreeing the mooring arrangement and where applicable nominated Mooring Master during the operation;
- Ensuring all safeguards and risk prevention measures are in place prior to initiating the fuel flow;
- Being familiar with the results of the location risk assessment and ensuring that all specific risk mitigation means are in place and operating (water curtain, fire protection, etc.);
- The activation of Emergency Procedures related to the bunkering system operation;
- Ensuring operation will remain within the accepted environmental window for the duration of bunkering;
- Ensuring safe procedures are followed and the connection of liquid and vapour transfer hoses and associated ERS is successfully completed;
- Ensuring the safe procedures are followed and purging and leak testing of the bunkering system prior to transfer is successfully completed;
- Monitoring fuel transfer and discharge rates including vapour management;
- Monitoring climatic conditions throughout operation;
- Monitoring mooring arrangement integrity (in communication with mooring master);
- Monitoring communications throughout the operation;
- Ensuring the safe procedures are followed for drainage and purging of the bunkering system prior to disconnection;
- Supervising disconnection of liquid and vapour hoses/pipes;

- Supervising unmooring and separation of ships or in the case of truck bunkering, departure of the truck; and

- Supervising deployment/return of fenders and/or additional support utility to the bunker ship.

4.3 Crew and Personnel Training and LNG awareness

4.3.1 General LNG bunkering operational training

The RSO is responsible for ensuring that the personnel on board the receiving ship involved in the bunkering operation should be suitably trained and certified by a recognised organisation, to fulfil requirements according to STCW.7/Circ.23 “Interim guidance on training for seafarers on board ships using gases or other low flashpoint fuels”.

Reference is also made to Resolution MSC.396(95) – (adopted on 11 June 2015) on AMENDMENTS TO THE INTERNATIONAL CONVENTION ON STANDARDS OF TRAINING, CERTIFICATION AND WATCHKEEPING FOR SEAFARERS (STCW), 1978, AS AMENDED and corresponding sections to Parts A and B of the 1978 STCW Convention containing training and qualifications of personnel that work on ships subject to the IGF Code.

The BFO is responsible for ensuring that all bunkering facility personnel involved with the bunkering operations are suitably trained and certified as required by the regulations governing the bunkering method.

- For ship-to-ship bunkering these are the requirements of STCW Regulation V/1-2 – “Mandatory minimum requirements for the training and qualifications of masters, officers and ratings on liquefied gas tankers” and equivalent requirements as provided by the governing authority for the inland waterway where the vessel is operating.

- For truck-to-ship or shore based terminal-to-ship bunkering these are the requirements of the local authorities governing activities within the port area. The personnel to be trained include but are not limited to personnel involved in LNG bunkering, personnel from authorities and emergency response services.

The person in charge (PIC) is to be trained in all aspects involving LNG. For the introduction of LNG bunkering operations within Port, sufficient training courses should be introduced in order to provide adequate competency to the role of PIC. This is especially the case with the development of novel bunkering systems or methods. The responsibility for verifying that the PIC is adequately trained falls on the RSO and BFO, the responsibility for certifying the PIC may be taken by the port authority.

4.3.2 Specific LNG bunkering safety training

Each bunkering method introduces different hazards. Specific training should be developed, based on the different possible failure scenarios and external events identified during the risk assessment study. Specific safety instructions as defined in 4.1.3.1 should be prepared based on the conclusions and outputs of the LNG Bunkering Risk Assessment.

The specific LNG Bunkering safety training should cover at least:

- Sudden change of ambient / sea conditions,

- Loss of power (receiving ship or bunkering facility),
- Loss of monitoring / control / safety systems (ESD),
- Loss of communication,
- Abnormal operating parameters, and
- Rapid situation assessment technique with focus of restabilising unstable situations.

Section 5 - Technical requirements for bunkering systems

5.1 General

The LNG / vapour transfer system should be designed and the bunkering procedure carried out so as to avoid the release of LNG or natural gas. The transfer system should be designed such that leakage from the system cannot cause danger to personnel, the receiving ship, the bunkering facility or the environment when the system is well maintained and properly used. Where any spillage of LNG can occur provisions should be taken protect personnel, ship's structure and equipment from cryogenic hazards. The consequences of other natural gas fuel related hazards (such as flammability) should be limited to a minimum through the arrangement of the transfer system and the corresponding equipment.

Specific means should be provided to purge the lines efficiently without release of natural gas with all purged gasses either retained by the receiving ship or returned to the bunkering facility.

Accidental leakage from the LNG / vapour transfer systems including the connections with the receiving ship bunkering manifold and with the bunkering facility should be detected by appropriate means.

5.2 Loading arms and hoses arrangements

5.2.1 Transfer installation

Arrangements should be made for:

- Purging and inerting the bunkering lines (or between designated ESD valves for systems with long LNG transfer lines) prior to the LNG transfer,
- Draining, purging and inerting the transfer system after completion of the LNG transfer.

LNG and vapour transfer systems (loading arm and/or flexible hose) should be fit for marine LNG bunkering operations. Design should be according to Tables 1 and 2 in ISO/TS 18683. The hoses and loading arms should be specially designed and constructed for the transfer products (LNG and Nitrogen) with a minimum temperature of -196°C.

Pressure relief devices should be provided so that the hose or loading arm is not over-pressurised in the event that liquid is trapped between its isolating valves (for example if the ERS is activated).

Hoses, loading arms and parts of the ship manifold should be designed for loads which may be experienced during operation such as self-weight (including fully loaded), loads due to relative motion between receiving ship and bunker supplier, and loads due to any lifting equipment used to handle the hose. The loading arms and parts of the ships manifold may also need to be designed to support the weight of an emergency release coupling.

Care should be taken when choosing the transfer system particularly with regards to:

- Potential movements between the receiving ship and the bunkering facility,

- Operating envelope of transfer system,
- Minimum bending radius allowed for hoses,
- ESD system functionality,
- Means of purging and draining the transfer lines,
- Material selection and structural support,
- Type of connectors,
- Electrical insulation,
- Continuity of earthing system,
- System design to address potential surge pressures developed during an ESD,
- Flash gas handling system, and
- Arrangements for pressure relief.

5.2.2 Hoses

Hoses should comply with appropriate recognized standards such as EN 1474-2, EN 12434 or BS 4089.
Transfer hose manufacturer's instructions, regarding testing and number of temperature and pressure operating cycles before removal from service, should be strictly followed.

Depending on which party owns the bunkering hose, a document should be included in the LNG Bunker management plan and a copy kept by the receiving ship containing the following information as applicable:

- Hose identification number
- Date of initial entry into service
- Initial test certificate and all subsequent test reports and certificates

The cryogenic hose should be subjected to hydrostatic testing once a year, if any defects appears during this inspection, the hose should be replaced. In addition the manufacturer of these hoses may lay down requirements relating to service life, inspection and maintenance. The manufacturer's instructions should be followed.

5.2.3 Lifting and supporting devices

The lifting devices, where fitted, should be of suitable capacity to handle the LNG transfer hoses and associated equipment.
Hoses should be suitably supported in such a way that the allowable bending radius is satisfied. They should normally not lie directly on the ground and should be arranged with enough slack to allow for all possible movements between the receiving ship and the bunkering facility.

Lifting and supporting devices should be suitably electrically insulated and should not impair the operation of any emergency release coupling or other safety devices.

5.3 Couplings and connecting flanges

5.3.1 General

The use of dry disconnect couplings is recommended for day-to-day bunkering operations using small hose diameters that will require several connections and disconnections.

5.3.2 Standard

An ISO standard for LNG bunkering connections is currently under development within TC8 WG8. In the meantime, couplings used for LNG Bunkering operation should be designed according to the requirements in ISO EN 16904:2016 and 1474-3 or any other applicable standards.

5.3.3 Isolation flange

The bunker transfer system should contain an isolation flange/of a non-electrically conductive material to prevent stray currents between the bunkering facility and the receiving ship. The isolation flange is generally fitted at the receiving ship end of the transfer system.

5.3.4 Spool piece

When spool pieces are used to connect to different sizes and geometries of connectors, they should be installed and tested as part of the preparation for bunkering. The leak testing would be applicable to ensure that the arrangement including spool piece is fully inerted and gas tight before transfer.

5.4 Leakage detection

As a minimum, in an enclosed or semi enclosed bunker station (on the receiving ship) or discharging station (of the bunker facility), the following safety devices should be in place:

- Gas detector(s), in suitable location(s) taking into consideration the rate of dispersion of cold vapour in the space, or temperature detection sensor(s), installed in the drip trays, or any combination to immediately detect leakage.

- CCTV is recommended to observe the bunkering operation from the bridge or operation control room. The CCTV should provide images of the bunker connection and also if possible the bunker hose such that movement of transfer system during bunkering are visible. CCTV is particularly recommended for enclosed bunker stations. Where CCTV is not provided, a permanent watch should be maintained from a safe location.

Gas detectors should be connected to the ESD system for monitoring leakage detection on the receiving ship.

Consideration may be given to the use of thermal imaging equipment or other suitable technology for leakage detection, especially in semi-enclosed bunkering stations.

A gas dispersion analysis will aid in identifying the critical locations and the extent of the LEL range where gas detectors should be fitted to enable early detection of any leakage.

5.5 ESD systems

The bunkering facility and receiving ship should be fitted with a linked ESD system such that any activation of the ESD systems should be implemented simultaneously on both bunkering facility and receiving ship. Any pumps and vapour return compressors should be designed with consideration to surge pressure in the event of ESD activation.
The bunkering line should be designed and arranged to withstand the surge pressure that may result from the activation of the emergency release coupling and quick closing of ESD valves.

On ESD activation, manifold valves on the receiving ship and bunkering facility and any pump or compressor associated with the bunkering operation are to be shut down except where this would result in a more hazardous situation (see Table 3).

An ESD activation should not lead to LNG being trapped in a pipe between closed valves. An automatic pressure relief system is to be provided that is designed to release the natural gas to a safe location without release to the environment.

If not demonstrated to be required at a higher value due to pressure surge considerations, a suitably selected closing time up to 5 seconds should be selected, depending on the pipe size and bunkering rate from the trigger of the alarm to full closure of the ESD valves, in accordance with the IGF Code.

The emergency shutdown system ESD should be suitable for the capacity of the installation. The minimum alarms and safety actions required for the transfer system are given in Table 3 below:

Table 3: Alarms and safety actions required for the transfer system

Parameter/ Alarm trigger	**Alarm**	**Action[1]**
Low pressure in the supply tank	X	X
Sudden pressure drop at the transfer pump discharge	X	X
High level in the receiving tank[2]	X	X
High pressure in the receiving tank	X	X
LNG leakage in bunker station (gas detection/low temperature detection)	X	X
Gas detection in the ducting around the bunkering lines (if applicable)	20% of LEL	Alert at 20% LEL ESD activation at 40% of LEL
Manual activation of shutdown from either the ship to be bunkered or the bunkering installation (ESD1)	X	X
Manual activation of the emergency release coupling from either the ship to be bunkered or the bunkering installation (ESD2)	X	X
Safe working envelope of the loading arm exceeded	X	X
Fire detection (any fire detection on receiving ship or bunker facility)	X	X
Electrical power failure (supplied by independent source of energy, e.g. battery)	X	X

Notes:

1. Alert is to be made at both the delivery and receiving ends of the transfer system to clearly identify the reasons for the ESD activation.

X = Audible/visual alert to be made at bunker station/discharging station and ESD system to be activated.

2. Where the parameter that triggers the ESD is such that closure of vapour connection valves and shut down of vapour return compressors would increase the potential hazard (for example a receiving tank high level alarm) these are to remain open/active where appropriate.

The manual activation position for the ESD system should be outside the bunker station and should have a clear view of the manifold area (the 'clear view' may be provided via CCTV).

LNG bunker transfer should not be resumed until the transfer system and associated safety systems (fire detection, etc.) are returned to normal operation condition.
All electrical components of the emergency release coupling actuator and of the ESD systems that are considered as provided by the ship side should be type approved/certified by the classification society. When the ESD hardware and components are part of the onshore facility they should be designed and tested according to the industry standards.

5.6 Emergency Release Coupling (ERC)

5.6.1 General

Transfer arms and hoses should be fitted with an emergency release coupling (ERC) designed to minimize the release of LNG on emergency disconnection. The emergency release coupling may be designed for:

- Manual or automatic activation, and
- Activation as a result of excessive forces i.e. automatic disconnection in case the safe working envelope of the transfer system is exceeded.

The breakaway coupling (BRC) should be subjected to a type test to confirm the values of axial and shear forces at which it automatically separates. For an emergency release coupling (ERC), the tightness of the self-closing shut-off valves after separation should be checked.

The ERC coupling should be designed and installed so that, in the worst allowable conditions for current, waves and wind declared in the bunkering conditions, it will not be subjected to excessive axial and shear forces likely to result in the loss of tightness or opening of the coupling. When the Safe working envelope of the transfer system is exceeded, the ERC system should be triggered.

Means should be provided in order to avoid a pressure surge in the bunker hose after release of the ERC when the connecting end of the hose is fitted with a dry disconnect coupling type.
Full operating instructions, testing and inspection schedules, necessary records and any limitations of all emergency release systems should be detailed in the ship's operating manuals.

5.6.2 ERC Activation

Where manual activation type ERC is fitted, the means of remotely operating the ERC should be positioned in a suitability protected area both on bunkering facility and receiving ship allowing visual monitoring of the bunkering system operation. A physical ESD link should bond the two parties. This does not apply to a dry breakaway coupling as this is a passive component which cannot be remotely activated.

5.6.3 Hose Handling after ERC Release

An integrated hose/support handling system should be in place, capable of handling and controlling the bunker transfer hoses after release of the ERC. In addition, it should be capable of absorbing all shock loadings imposed by the release of ERC during maximum capacity transfer conditions.

The system should ensure that, as far as practicable, upon release the hoses, couplings and supports do not contact the metal structure of the ship and bunkering facility, thereby reducing the risk of sparking at the contact point, injury to personnel or mechanical damage.

5.7 Communication systems

A communication system with back-up should be provided between the bunkering facility and the receiving ship.

The components of the communication system located in hazardous and safety zones should be type approved according to IEC 60079.

5.8 Bunkering transfer rate

The maximum LNG transfer rate from the BFO should be adjusted, taking into consideration:

- Maximum allowable flow rate of the bunker station manifold,
- Maximum allowable cooling down rate acceptable regarding induced thermal stresses in the LNG receiving ship piping and tank,
- Management of the flash gas generated during bunkering,
- Temperature of the LNG supplied from the bunkering facility,
- Temperature of the LNG remaining in the receiving ship tank, and
- Pressure in both bunkering facility tank and receiving ship tank.

Adequate provisions should be made for the management of the flash gas generated during the bunkering operation, without release to the atmosphere. This may be done by:

- Considering the capacity of the available vapour spaces and allowable pressure build-up of both ships, or
- Burning additional volumes in boilers, gas combustion units or gas engines, or
- Cooling the vapour space to control the pressure by using LNG spray in the receiving tank, or
- Reliquefaction.

The LNG velocity in the piping system should not exceed 12.0 m/sec under the rated equipment capacity in order to avoid the generation of static electricity, additional heat, and consecutive boil off gas due to nonlinear flow.

5.9 Vapour return line

Vapour return line(s) may be used in order to control the pressure in the receiving tank or to reduce the time required for bunkering (refer to 2.4.6 of Chapter 3). This is particularly applicable to atmospheric pressure fuel storage tanks (type A, prismatic type B or membrane tanks). The most relevant factors that will affect the amount of flash gas generation in a typical bunkering operation are as follows:

- Cool down of the transfer system
- Difference in the conditions prevailing between the bunkering facility tanks and the receiving tanks (particularly the temperature of the receiving tank)
- Transfer rates (ramp up, full flow, ramp down/topping up)
- Heat gain in pipe line between bunkering facility tank and receiving ship tank
- Pumping energy

5.10 Lighting

Lighting should illuminate the bunker station area, and if installed in a hazardous area should be compliant with applicable hazardous area equipment requirements. Lighting should adequately illuminate the bunkering operation work area especially:

- LNG bunker hose(s),
- Connection and couplings on both receiving ship and bunkering facility,
- ESD system call points,
- Communication systems,
- Fire-fighting equipment,
- Passage ways / gangways intended to be used by the personnel in charge of the bunkering operation, and
- Vent mast(s).

Chapter 2 - Risk Assessment

Section 1 LNG Bunkering operations risk assessment

Section 2 Safety and security zones

Section 1 - LNG Bunkering operations risk assessment

1.1 General

A bunkering operations risk assessment should be undertaken in accordance with ISO/TS 18683. This technical specification is specific to the supply of LNG as fuel to ships and refers to recognised standards that provide detailed guidance on the use and application of risk assessment. The objectives of the bunkering operations risk assessment are to:

- Demonstrate that risks to people and the environment have been eliminated where possible, and if not, mitigated as necessary, and
- Provide insight and information to help set the required safety zone and security zone around the bunkering operation.

In order to meet these objectives, as a minimum, the bunkering operations risk assessment should cover the following operations:

- Preparations before and on ship's arrival, approach and mooring
- Preparation, testing and connection of equipment
- LNG transfer and boil-off gas (BOG) management
- Completion of bunker transfer and disconnection of equipment
- Simultaneous operations (SIMOPS) as noted in 1.3.3

1.2 Risk assessment approach

1.2.1 Qualitative Risk Assessment (Q_{ual}RA)

A Qualitative Risk Assessment (Q_{ual}RA) should be undertaken prior to introduction of a new bunkering operation procedure that follows the guidance in this document and the guidance given in ISO/TS 18683 guidelines.

Provided the bunkering operation is one of the three standard bunkering scenarios below, and guidance in this document and ISO/TS 18683 is followed, i.e. there are no deviations from the functional requirements, , then the qualitative approach (i.e. Q_{ual}RA) is sufficient to meet the objectives of the bunkering operations risk assessment.

Standard bunkering is characterised by three bunkering scenarios, as noted in ISO/TS 18683:

1. Shore-to-ship (that is, LNG transfer from an onshore facility to a gas fuelled ship)
2. Truck-to-ship (that is, LNG transfer from a road truck to a gas fuelled ship)
3. Ship-to-ship (that is, LNG transfer from a ship, such as a bunker barge, to a gas fuelled ship)

1.2.2 Quantitative Risk Assessment (QRA)

As a supplement to the Q_{ual}RA, a Quantitative Risk Assessment (QRA) may be required where:

1. bunkering is not of a standard type (as described above);

2. design, arrangements and operations differ from the guidance given in this document; and

3. bunkering is undertaken alongside other transfer operations (SIMOPS), see 1.3.3.

A QRA is also appropriate where further insight is required to: judge the overall level of risk (since this is not typically provided by a Q_{ual}RA); appraise design options and mitigation alternatives; and/or to support a reduced safety zone and/or security zone.

The requirement for a QRA (in addition to a Q_{ual}RA) is normally determined by the Administration or Port Authority based on the conclusions and outcomes of the Q_{ual}RA and accepted by the concerned parties.

1.2.3 Risk Assessment Minimum Scope for LNG bunkering

Whether only a Q_{ual}RA is required or both a Q_{ual}RA and QRA are required, as a minimum the risk assessment should detail:

a. How the bunkering operation could potentially cause harm. That is, systematic identification of potential accidents/incidents that could result in fatality or injury or damage to the environment;

b. The potential severity of harm. That is, the worst case consequences of the accidents/incidents identified in ‘a’, in terms of single and multiple fatalities and environmental damage caused;

c. The likelihood of harm. That is, the probability or frequency with which the worst case consequences might occur;

d. A measure of risk, where risk is a combination of (b) and (c); and

e. How the functional requirements are met.

In addition, the risk assessment should help identify the scenarios to be used to determine the safety zone; and as a minimum, consider SIMOPS within the safety zone.

A typical approach to Q_{ual}RA and QRA is described in ISO/TS 18683. These approaches or similarly established approaches should be used provided they cover items (a) to (e) above.

Regardless of the approach used, the risk assessment should be carried out by a team of suitably qualified and experienced individuals with collective knowledge of, and expertise in: risk assessment application; engineering design; emergency response, and bunkering operations.

1.3 Risk criteria

Examples of qualitative and quantitative risk criteria are outlined in ISO/TS 18683. In addition, guidance on selection of appropriate criteria may be given by government organisations. Furthermore, many industry organisations, such as the international oil companies, have specific risk criteria extensively used to demonstrate safe onshore and offshore operations to governments and regulators.

Although criteria from different sources may appear similar, it is important to note that there are no universally agreed risk criteria: there are differences between governments, regulators and organisations. Therefore, prior to the commencement of the risk assessment, risk criteria should be agreed with appropriate stakeholders, in particular the port and regulatory authorities, the Administration and the ship operator.

1.3.1 Risk Levels in Qualitative Risk Assessment ($Q_{ual}RA$)

Risk levels in qualitative risk assessments are commonly incorporated within a risk matrix and indicate a level of risk associated with a specific combination of consequence and likelihood. For example, the risk may be:

1. Sufficiently 'low' that it need not be reduced further,

2. At a level where mitigation should be considered and implemented if practicable, or

3. At a 'high' level where mitigation is required to reduce it.

An important point to note is that the risk level is indicative of one or more but not all potential accidents/incidents. That is, the assessment does not provide a collective or overall indication of the risk level from all potential accidents/incidents; rather it provides a relative ranking of the accidents/incidents considered. If the overall risk level is required then this can be determined using QRA.

1.3.2 Risk Criteria in Quantitative Risk Assessment (QRA)

Risk criteria in quantitative risk assessments commonly refer to individual risk and societal risk (or group risk), and these are related to fatality or some other measure of harm. Where a significant number of people are exposed to the bunkering operations then both should be assessed. This is because the risk to any individual may be 'low' but the risk of harming many people in a single accident/incident might be sufficient to warrant risk reduction. Stakeholders should consider what constitutes a significant number of people to require assessment of societal risk. Dependent upon specifics this might be exposure of ten or more people.

It is important to note that the criteria are typically expressed on a per annum basis (i.e. per year). For hazards that are present for a relatively short time (over a year) the per annum criteria may not be appropriate. This is because the risk is not spread uniformly across the year but peaks intermittently, and for long periods of time it does not exist. As such, if this is not recognised then proposed risk mitigation may not offer the protection envisaged. As a guide, per annum criteria may not be appropriate for a hazard present less than a third of the year.

1.3.3 Risk assessment for simultaneous operations (SIMOPS)

Where it is proposed to carry out bunkering operations concurrently with other operations that may impact or be impacted by the bunkering then further risk assessment should be carried out to demonstrate that the required level of safety can be maintained.
Note: Risk assessment for simultaneous operations should be considered when the following operations are intended to be carried out simultaneously with the bunkering operations:

- Cargo handling
- Ballasting operations
- Passenger embarking / disembarking
- Dangerous goods loading / unloading and any kind of other goods loading or unloading (i.e. stores and provisions)
- Chemical products handling
- Other low-flash point products handling
- Bunkering of fuels other than LNG

Simultaneous operations should be investigated for any of the above activities occurring within the safety zone calculated as described in 2.3.

Any simultaneous shipboard technical operations such as testing systems that might affect the stability of the receiving ship, for example, changes to the mooring situation, testing of power generations systems or fire-fighting systems, are not to be carried out during LNG bunkering operations.

1.4 Guidance on a typical Risk Assessment for LNG bunkering operations

The scale of risk assessment required for the bunkering process will depend on the bunkering method and equipment used with additional, more detailed, levels of risk assessment potentially required where novel procedures and/or equipment are selected.

It is generally expected that the risk assessment activities will be broken into two main parts, a higher level HAZID activity followed by a more detailed HAZOP activity. It is recommended that both of these activities are conducted with professional guidance to ensure an appropriately detailed risk assessment outcome is achieved.

Where designs or operational methods are modified after the risk assessment(s) have been conducted this may result in the risk assessments needing to be revised accordingly.

1.4.1 HAZID

The hazard identification process should provide sufficient detail for an operator to fully understand the nature of each hazard and to identify the controls necessary for the management of each hazard. The outcomes of the HAZID include risk rankings and recommendations for additional safeguards and analysis.

As a minimum, the HAZID should include the scope as described in the ISO/TS 18683.

Guidance for conducting a HAZID for LNG bunkering operation is detailed in the Annex of this guideline.

1.4.2 HAZOP

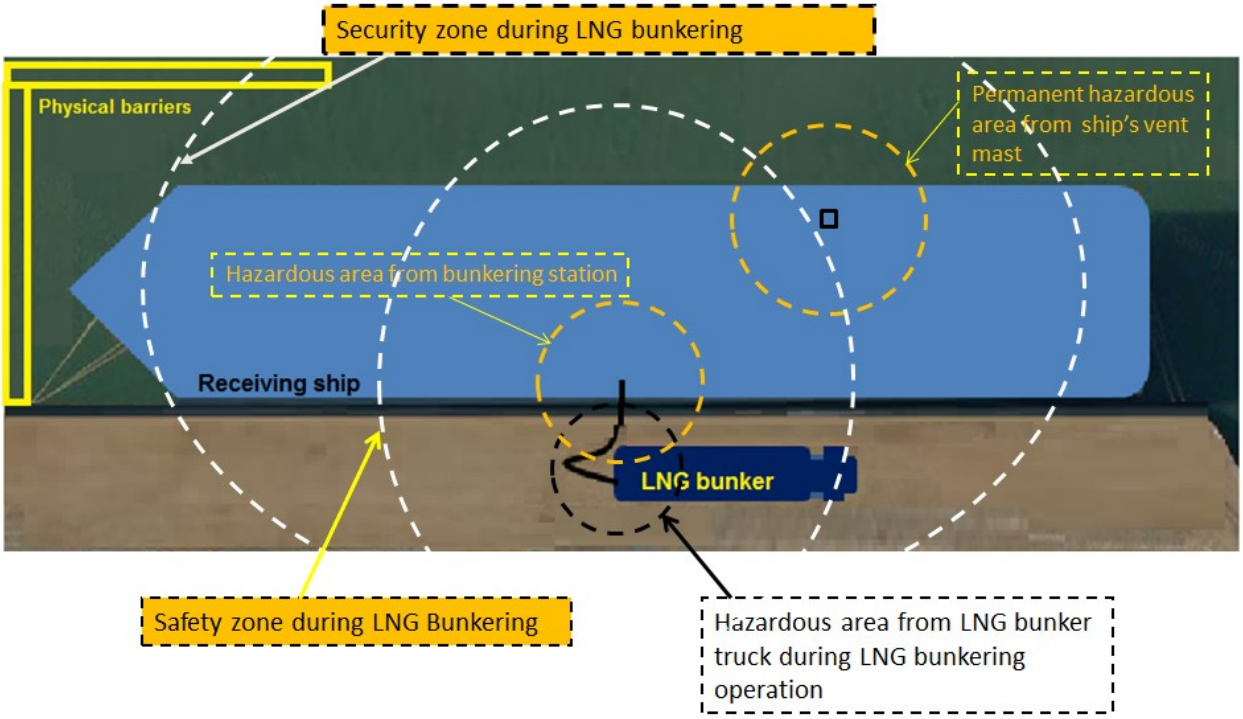
The HAZOP study is a structured and methodical examination of a planned process or operation in order to identify causes and consequences from a deviation to ensure the ability of equipment to perform in accordance with the design intent. It aims to ensure that appropriate safeguards are in place to help prevent accidents. Guidewords are used in combination with process conditions to systematically consider all credible deviations from normal conditions.

Guidance for conducting a HAZOP for LNG bunkering operation is detailed in the Annex of this guideline.

Section 2 - Safety and security zones

2.1 General

A safety zone and a security zone should be established around the bunkering operation in accordance with ISO/TS 18683. These zones are in addition to the established practice of setting hazardous area classification zones that will be required around areas with potential for explosive atmospheres such as the bunkering connections. A pictorial example of these zones is illustrated below.



Both the safety and security zones should be enforced and monitored at all times during bunkering, at all other times these zones are not enforced.

The purpose of the safety zone is to set an area within which only essential personnel are allowed and potential ignition sources are controlled. Essential personnel are those required to monitor and control the bunkering operation. Similarly, the purpose of the security zone is to set an area within which ship/port traffic is monitored and controlled.

Together, the safety and security zones help further minimise the low likelihood of a fuel release and its possible ignition, and help protect individuals and property via physical separation.

2.2 Hazardous area classification

Bunkering-related hazardous areas means any hazardous area zone 1 and zone 2 defined for:

- The receiving ship in accordance with IGF Code, regulation 12.5,
- The bunkering ship in accordance with IGC Code, regulation 1.2.24, and

Example minimum hazardous zone sizes include:

- Areas on open deck, or semi-enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet, bunker / supply manifold valve, other gas valve, gas pipe flange and gas tank openings for pressure release,
- Areas on the open deck within spillage coamings surrounding gas bunker / supply manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck,
- Semi-enclosed bunkering stations, and
- Areas within 1.5 m surrounding spaces listed above.

The bunkering-related hazardous area also includes areas around the truck, LNG bunker vessel or shore-based bunkering facility. Depending on the outcomes of the risk assessment and the specific details of the bunkering process (equipment and transfer flow rates and pressures) the size of these areas may be increased.

In the hazardous area, only electrical equipment certified in accordance with IEC 60079 is permitted. Other electrical equipment should be de-energised prior to the bunkering operations. Attention is drawn to the following equipment, which is not intrinsically safe and should therefore be disabled, except if otherwise justified:

- The radar equipment, which may emit high power densities,
- Other electrical equipment of the ship, such as radio equipment and satellite communication equipment, when they may cause arcing.

2.3 Safety zones

In the safety zone, the following restrictions normally apply during the bunkering operations, except if otherwise justified by the safety analysis or agreed by the Local Port Authorities or National Administration:

- Smoking is not permitted.
- Naked lights, mobile phones, cameras and other non-certified portable electrical equipment are strictly prohibited.
- Cranes and other lifting appliances not essential to the bunkering operation are not to be operated.
- No vehicle (except the tank truck) should be present in the safety zone.
- No ship or craft should normally enter the safety zone, except if duly authorised by the Port Authorities.
- Other possible sources of ignition should be eliminated.
- Access to the safety zone is restricted to the authorised staff, provided they are fitted with personal protective equipment (PPE) with anti-static properties and portable gas detector.

2.3.1 Determination of the safety zone distance

There are two different approaches which are outlined in the following paragraphs.

2.3.1.1 Deterministic approach

The safety zone should be set based upon the flammable extent of a maximum credible release scenario. In ISO/TS 18683 this approach to setting the safety zone is referred to as the ‘deterministic approach’. Specific requirements for the determination of the safety zone may be set by national and local authorities.

The flammable extent is the distance at which the lower flammable limit (LFL) is reached as the vapour/gas (from the released fuel) disperses in the atmosphere. For LNG, the LFL is approximately 5% of natural gas in air.

As a minimum, the following information should be taken into account in the maximum credible release scenario:

- The physical properties of the released fuel.
- Weather conditions at the bunkering location; wind speed, humidity, air temperature and the temperature of the surface upon which the fuel leaks. The chosen conditions should reflect the worst-case conditions that result in the greatest distance to LFL.
- Roughness of the surface over which the vapour/gas disperses, (i.e. land or water).
- Structures and physical features that that could significantly increase or decrease dispersion distances.

- Release rate, release orientation, available inventory and rate of vapour generation.

In addition, release height is to be considered as this can significantly affect the extent of the calculated safety zone. The vertical extent of the safety zone may require special consideration, especially in cases where persons can be at elevated positions, such as located in cabins many metres above the bunker station.

Large objects, such as buildings and ships, and topography, such as cliffs and sloping ground, can constrain or direct dispersion. This should be recognised in setting the safety zone. Failure to do this can result in inappropriate safety zones that include areas that would not be affected by any release of natural gas or exclude areas that would be affected if there was a release. In certain cases, advanced modelling techniques, such as computational fluid dynamics (CFD) might be required to justify the zone's shape and extent.

Regardless of the technique(s) used in setting the safety zone it should be applied by a suitably qualified and experienced individual.

ISO/TS 18683 provides two examples of a maximum credible release scenario, where the one resulting in the greatest LFL extent is used to set the safety zone:

a. A release of the 'trapped inventory' between emergency shutdown valves in the liquid bunkering line (i.e. bunker hose), and

b. A 'continuous release' from an instrument connection where emergency valves do not close to isolate the release and delivery pressure is maintained.

To set the safety zone either:

- The ISO/TS 18683 release cases as described above should be used (i.e. 'a' and 'b'), or

- A maximum credible release scenario should be used that has been identified and justified using the risk assessment method described in ISO/TS 18683. This option allows for consideration of mitigation measures and other factors specific to the bunkering operation.

2.3.1.2 Probabilistic approach

An alternative approach to setting the safety zone should use quantitative risk assessment (QRA) whereby consideration is given within a predefined scenario to a representative set of potential releases and the likelihood with which they occur. This approach is often referred to as the "probabilistic" or "risk based" approach.

In theory, this approach could lead to a safety zone of less than the hazardous area or even 0 metres. This is not acceptable. The Safety Zone should at least extend beyond the hazardous areas and/or the minimum distance defined by the authorities from any part of the bunkering installation.

A key feature of QRA is that it accounts for both the consequence and likelihood of releases and can consider the location of people, the probability of ignition, and the effectiveness of mitigation measures and other emergency actions. As such, it can provide increased understanding of those releases that contribute most to the risk, and this can be useful in identifying and testing the suitability of mitigation measures, and optimizing zone extent. If this approach is selected then it is important that appropriate risk criteria are used.

2.4 Security zones

A security zone should be set based upon ship/port operations. In setting the zone consideration should be given to activities and installations that could endanger the bunkering operation or exacerbate an emergency situation. For example, consideration of the following is required when setting the security zone:

- Other ship/ship movements
- Surrounding road traffic, industrial plants, factories and public facilities
- Crane and other loading/unloading operations
- Construction and maintenance works
- Utilities and telecommunication activities and infrastructure

Many of the above are considered in the risk assessment described in this document. Therefore, to help inform setting of the zone, reference should be made to this risk assessment.

Chapter 3 - Functional and General Requirements for LNG Bunkering Operation

Section 1 **Pre-bunkering phase**

Section 2 **Bunkering phase**

Section 3 **Bunkering completion phase**

Section 1 - Pre-bunkering phase

1.1 Definition

The pre-bunkering phase starts from the first communication between receiving ship and bunkering facility for ordering a bunker of LNG, and ends with the physical connection of the bunker line to the bunker station.

1.2 Goal

The goal of the pre-bunkering phase is the preparation and the completion of a safe connection between the transfer systems of the bunkering facility and the receiving ship.

1.3 Functional requirements

The following functional requirements should be considered during the pre-bunkering phase:

- The risk assessment has been conducted and the findings have been implemented.
- An LNG Bunker Management Plan has been established and is applicable to the ship.
- A compatibility check demonstrates that the safety and bunkering systems of the bunkering facility and the ship to be bunkered match.
- The necessary authorities have been informed regarding the LNG bunkering operation.
- The permission for the transfer operation is available from the relevant authority.
- The boundary conditions such as transfer rate, boil-off handling and loading limit have been agreed between the supplier and the ship to be bunkered.
- Initial checks of the bunkering and safety system are conducted to ensure a safe transfer of LNG during the bunkering phase.

1.4 General requirements

1.4.1 Personnel on duty

During the transfer operation, personnel in the safety zone should be limited to essential staff only. All staff engaged in duties or working in the vicinity of the operations should wear appropriate personal protective equipment (PPE) and an individual portable gas detector as required by the LNG Bunker Management Plan.

1.4.2 Compatibility assessment (prior to confirming the bunkering operation)

A compatibility assessment of the bunkering facility and receiving ship should be undertaken prior to confirming the bunkering operation to identify any aspects that require particular management.

The compatibility assessment should be undertaken with the assistance of an appropriate Checklist to be completed and agreed by Master(s) and PIC prior to engaging in the bunkering operation.

As a minimum, compatibility of the following equipment and installation should be checked prior to engaging further in any LNG bunkering operation:

- Communication system (hardware, software if any and language) between the PIC, ship's crew and BFO personnel
- ESD system
- Bunker connection
- Emergency release system (ERS) or coupling (ERC)
- Vapour return line when appropriate
- Nitrogen lines availability and connection
- Mooring equipment
- Bunker Station location
- Transfer system sizing and loading on manifold
- Location of ERS
- Closure speed of valves
- HAZOP results as applicable

1.5 Preparation for bunker transfer

1.5.1 Environmental conditions

The environmental conditions (weather (especially lightening), sea state, temperature, and visibility limitation such as fog or mist) should be acceptable in terms of safety for all the parties involved.

1.5.2 Mooring

1.5.2.1 Mooring condition of receiving ship

The ship should be securely moored to the bunker supplier to prevent excessive relative movement during the bunkering operation.

1.5.2.2 Mooring condition of bunker ship

For ship-to-ship bunkering the bunker ship should be securely moored according to the result of the compatibility check, so that excessive movements and overstressing of the bunkering connections can be avoided. Refer to 1.7.3 below. For the mooring of the bunker ship the limiting conditions should be considered such as weather, tide, strong wind and waves.

1.5.2.3 Parking condition of truck LNG tanker(s)

The truck LNG tanker(s) should be securely parked, to prevent unintended movements.

All ignition sources linked to the truck are to be managed in accordance with the bunkering management plan/procedure taking into account Hazardous areas and Safety Zones. Any situation whereby this requirement cannot be met, special consideration must be provided (i.e. non-standard) to ensure the risk of ignition is managed to ALARP.

In any case, the truck engine should not be running during connection and disconnection of the transfer system.

1.5.3 Communication

Communication should be satisfactorily established between the bunkering facility and the receiving ship prior to any transfer operation. If they are to be used, visible signals should be agreed by and clear to all the personnel involved in the LNG bunkering operation.

In case of communication failure, bunkering operations should be stopped and not resumed until communication is re-established.

1.5.4 Agreement of the transfer conditions

The following should be agreed before commencing the bunker transfer:

- Transfer time, temperature and pressure of the delivered LNG, pressure inside the receiving ship tank, delivery line measurement, vapour return line measurement (if any) should be agreed and checked prior to engaging in any LNG Bunkering Operation.

- The maximum LNG temperature that the receiving ship can handle should be stated by the receiving ship in order to avoid excessive boil-off generation.

- Liquid levels, temperature and pressure for the LNG bunker tanks of the receiving ship should be checked and noted on the bunkering checklist.

- The maximum loading level and transfer rate, including cool down and topping up should be agreed upon. This includes the pressure capacity of pumps and relieving devices in the connected transfer system. The filling limit of the receiving tank depends on MARVS (as per IGC / IGF codes) and accounts for the possible expansion of cold LNG.

The agreed transfer conditions should be included in the LNG Bunker Management Plan.

1.5.5 Individual safety equipment in place (PPE)

All personnel involved in the LNG bunkering operation should properly wear adequate Personal Protective Equipment (PPE). It should be ensured that all the PPEs have been checked for compliance and are ready and suitable for use.

1.5.6 Protection of the hull plate, shell side and ship structure

Protection from cryogenic brittle fracture of the receiving ship deck and structure caused by leakage of LNG should be fitted as per IGF code requirements.

When appropriate one or more of the following protective measures may be utilised:

- A water curtain may be installed to protect the ship’s hull.

- A cover of suitable material grade to withstand LNG temperatures may be installed underneath the transfer hose to protect deck plating.

- A drip tray of suitable material grade to withstand LNG temperatures may be fitted below the pipe coupling to collect LNG spill.

It is recommended that spill protection is also provided for the BFO equipment, this may be governed by local regulations for truck-to-ship bunkering and shore based facilities.

1.5.7 Safety zone requirements and mark out

- The boundaries of the safety zone associated with bunker station and BFO connection should be clearly marked out.

- Any non-EX equipment installed in hazardous areas and/or in safety zone, such as the bunker station, should be electrically isolated before the bunkering operation commences and throughout the bunkering process until such time as the area is free of any gas leak hazard. Any such arrangement where there is non-Ex rated equipment installed in a hazardous zone should be subject to special consideration by the classification society.

- Radio communications equipment not needed during bunkering and cell phones should be switched off as appropriate.

1.5.8 Electric isolation

A single isolation flange should be provided, in each arm or hose of the transfer system, between the receiving ship manifold and the bunker pipeline. The installation should not permit shorting out of this insulation for example by, leaving the flange resting in stainless steel drip tray. This flange prevents galvanic current flow between the receiving ship and the bunkering facility. Steel to steel contact between receiving ship and bunkering facility e.g. via mooring lines, ladders, gangways, chains for fender support etc. should be avoided through the use of insulation. Bunker hoses/pipes should be supported and isolated to prevent electrical contact with the receiving ship.

When bunkering from trucks, the truck should be grounded to an earthing point at the quay to prevent static electricity build up. Where approval has been given for the bunkering truck to be parked on the deck of the ship then the truck should be grounded to the receiving ship.

Ship-shore bonding cables/straps should not be used unless required by national or local regulations.

If national or local regulations require a bonding cable/strap to be used, the circuit continuity should be made via a ‘certified safe’ switch (e.g. one housed inside a flame proof enclosure) and the connection on board the receiving ship should be in a location remote safe area from the hazardous area. The switch should not be closed until the bonding cable/strap has been connected, and it should be opened prior to disconnection of the bonding strap.

1.5.9 ERS

Simulated testing of all types of coupling having the function of ERC within the ERS should be performed according to a recognised standard. Testing records should be retained with the bunkering operator or organisation responsible for such equipment ready for immediate inspection by authorities. Any transfer /support system should be proved operational (if

necessary by inspection of marine loading arm or supported hose) and be confirmed as part of the pre-transfer checklist.

Testing of the system prior to each bunkering operation should prove all components are satisfactory, with the exception of actually releasing the ERC. The system used to link the ERS system with the ships' ESD1 trip circuit should be tested and proved operational.

1.5.10 Emergency Release Coupling (Break away coupling)

The disconnection can be triggered manually or automatically. In either case, activation of the ERS system should trigger activation of the ESD (ESD1) before release of the ERC (ESD2).

Where applicable, step-by-step operating instructions should be permanently affixed to the ERC equipment and all personnel involved in its operations should be trained and made familiar with its correct use. Additionally, clear procedures should be in place identifying the process for authorisation to remotely activate the ERC.

In the event of ESD2 activation, i.e. breakaway coupling sudden release triggered due to emergency event or overstress on the transfer line induced by ship movement, the backlashing hoses can damage hull structure and injure personnel in the absence of an appropriate supporting arrangement. This supporting arrangement, if fitted, should not prevent the correct operation of the breakaway coupling, any relative motion between the receiving ship and the bunkering facility should act directly on the ERC to ensure its correct operation if the event of vessel drift or unexpected truck movement.

Routine inspection and testing of the release equipment is required, responsibility for this testing will depend on agreements between the BFO and RSO.

1.5.11 ESD testing

The bunkering facility and receiving ship should both test their emergency shutdown systems not more than 24 hours before bunkering operations commence. The PIC should then be advised of the successful completion of these tests. These tests should be documented in accordance with the bunkering procedure.

1.5.12 Visual inspection of bunker hose or arm before physical connection

Bunker hoses and connecting systems should be visually examined for wear and tear, physical damage and cleanliness. If any defects are found during this inspection, the bunkering operation is cancelled until the transfer hose is replaced.

1.5.13 Liquid and gas leakage detection systems activated

The gas detection system as described in Chapter 1, 5.4 should be activated. Temperature sensor(s) should be installed in the bunker station below the drip tray and their temperature calibration(s) should be checked. Their function should also be tested.

1.5.14 Preparation of the transfer system

The piping at the bunkering facility should be inerted and cooled down (as far as practicable) prior to the connection with the ship to be bunkered. If this operation may cause any specific hazards when connecting to the transfer line it should be carried out after the connection has been carried out. The specific cooling down procedure for the transfer system in terms of cooling down rate should be observed with special care regarding the potential for induced

thermal stresses and damage and leaks that may occur. Connections to the bunkering facility and the receiving ship should be visually checked and if necessary retightened. During this operation there should be no release of any LNG or natural gas.

1.6 Pre-bunkering checklist

The LNG Bunker Management Plan should include a checklist to be used during LNG bunkering operation by all involved personnel. This checklist should be elaborated once the full agreement on: procedures to apply, equipment to be used, quantity and quality of LNG to bunker, and training is obtained by all involved parties.

At the time of writing this guideline a LNG bunkering operation checklist is under development within ISO and IMO. In the meantime the LNG Bunkering operation specific checklist should be therefore adapted from the examples checklists for truck-to-ship, shore-to-ship and ship-to-ship LNG bunkering that have been elaborated by WPCI and IAPH. These can be downloaded from: www.lngbunkering.org.

1.7 Connection of the transfer system

1.7.1 Connecting

Equipment utilised with the transfer system such as couplings and hoses should be approved and tested both before and after installation. For emergency release coupling requirements (ERC), see Chapter 1, 5.6.

The transfer system should be connected such that all the forces acting during the transfer operation are within the operating range.

1.7.2 Condition of flange and sealing surfaces prior to connection

During connecting of the transfer system, humidity at the flange mating surfaces should be avoided and it should be ensured that all mating surfaces are clean. When necessary, compressed air should be used for cleaning the contact surface of flanges and seals before physical connection and clamping of the couplings. Heating of the connections to dry them prior to connecting may be considered in some circumstances.

1.7.3 Minimum bending radius of the hose

Hoses should be suitably supported in a manner that the minimum acceptable bending radius according to the qualification standard of the hose is not exceeded. Equipment utilised with the transfer system such as hose rests, saddles, and guidance systems (as applicable) should be approved and tested.
A LNG transfer hose should normally not lie directly on the deck plate and should be isolated thermally from the deck. As a minimum, suitable protection such as wooden boards should also be provided to avoid damage from friction on the quay.

The hose arrangement should be so designed with enough slack to allow for all possible movements between the receiving ship and the bunkering facility.

1.7.4 Transfer line purging

After connection of the transfer system it should be purged to ensure that no oxygen or humidity remains in the transfer system. Nitrogen should be used for purging of any parts of the system that will be cooled to cryogenic temperatures during the bunkering operation.

Attention is drawn to quantity of the inert gas used for purging / inerting, which may result in high inert gas content in the LNG tank of the receiving ship, which may affect the proper operation of engines. A typical purging sequence of the transfer line involves the injection of five (5) times the volume of the bunker line. The volume of inert gas required may be minimised by the design of the transfer system (i.e. using shorter lengths of hose).

1.7.5 Transfer line pressure testing

During inerting of the transfer system the leak test according to the bunkering procedure should be carried out. As a minimum, a leak test of the connection points and flanges in the system from the bunkering facility up to the ESD valve on the receiving ship should be performed prior to any transfer operation.

Section 2 - Bunkering phase

2.1 Definition

The bunkering phase begins after the physical connection between the bunkering facility and the receiving ship's bunker station has been safely completed with the opening of the LNG transfer valve from the bunker ship, the truck tanker or the onshore bunkering facility.

It continues with the cooling down of the transfer line followed by the LNG bunker transfer and ends at the end of the topping up phase and the closure of the LNG valve from the bunkering facility.

2.2 Goal

Transfer of the required quantity of LNG without release of LNG and/or natural gas to the surrounding environment in a safe and efficient operation.

2.3 Functional requirements

- During the whole transfer process a suitable ESD and ERS system should be provided for the transfer system.
- After connection of the transfer system a suitable cooling down procedure should be carried out in accordance with the specification of the transfer system and the receiving tank supplier requirements.
- Flash gas or boil-off gas will not be released to atmosphere during normal transfer operations.
- Bunker lines, transfer system and tank condition should be continuously monitored for the duration of the transfer operation.

2.4 General requirements

2.4.1 ERS

The ERS control signals and actuators should be checked and tested and should be ready for use.

The mechanical release mechanism of the ERS system should be proven operational and ready for use before fuel bunkering operation commences.

2.4.2 ESD connection testing

It should be ensured that a linked ESD system connected, tested and ready for use is available. There are two phases of testing Warm ESD testing and Cold ESD testing.

2.4.2.1 Warm ESD Testing

The ESD system should be tested following completion of manifold connection & ESD link. The testing should take place between the receiving ship and the bunkering facility prior to commencement of operation (warm ESD1) to confirm that the systems are compatible and correctly connected. The initiation of the warm ESD1 signal should be done from either one of the receiving ship or the bunkering facility.

2.4.3 Cool down of transfer system

As far as practicable, cooling down of the transfer lines should be carried out according to the requirements of the transfer system and according to the bunkering procedure with special care regarding the potential leaks that may occur as components shrink as they are cooled. Connections to the bunkering facility and the receiving ship should be monitored and, if necessary, tightened.

If a pump is used to deliver the required pressure for the tank to be filled, it is necessary to cool it to operating temperature before starting. This is done by filling the pump circuit with liquid from the tank.

2.4.3.1 Cold ESD Testing

Following the successful completion of cool down operation the cold test should be carried out as far as practicable to ensure that the ESD valves operate correctly in cold conditions before initiating the main LNG bunker transfer.

2.4.4 Main bunker transfer

After proper cooling down of the transfer system and a stable condition of the system the transfer rate can be increased to the agreed amount according to the bunkering procedure. The transfer process should be continuously monitored with regard to the operating limits of the system.

If there are any deviations from the operation limits of the system the transfer of LNG should be immediately stopped.

2.4.5 Monitoring pressure and temperature

Receiving tank pressure and temperature should be monitored and controlled during the bunkering process to prevent over pressurisation and subsequent release of natural gas or liquid natural gas through the tank pressure relief valve and the vent mast.

2.4.6 Vapour management

The vapour management methodology will vary depending on tank type, system type and system condition, but should be agreed on during the compatibility check.
For atmospheric tanks a vapour return line may be used but also other systems like reliquefaction units or pressurised auxiliary systems can also be used to regulate the pressure of the return vapour.

If the receiving tank is a Type C tank, the above remains valid. An alternative practise of LNG bunkering widely used, especially in a truck-to-ship bunkering situation or when no vapour return line is available, is to spray LNG into the top of the receiving tank through diffusers in order to cool the vapour space. As a result the tank pressure will be reduced and

therefore the pressure increase due to flash gas can be contained and managed for the duration of the LNG bunkering.

2.4.7 Topping up of the tank

The topping up of the tank should be carefully surveyed by the Person in Charge and/or the Chief Engineer surveying the filling up of the LNG tank(s). The LNG fuel transfer flow rate should be slowed with an appropriate declining value when the receiving tank LNG level approaches the agreed loading limit. The loading limit of the tank and the tank pressure should be paid special attention by the PIC during this operational step. The opening of the tank's Pressure Relief Valve (PRV) due to overpressure in tank, for example following overfilling, should be avoided.

2.4.8 Selection of measurement equipment

The impact on the safety of the transfer system by any equipment used for the measurement of LNG quantity during the bunkering operation should be considered. The measurement method selected, and the equipment used (flow meters, etc.), should minimise disruption to the flow of LNG to prevent pressure surge, excess flash gas generation, or pressure losses in the transfer system.

Section 3 - Bunkering completion phase

3.1 Definition

The post bunkering phase begins once the bunker transfer (final topping up phase) has been completed and the bunkering facility LNG delivering valve has been closed. It ends once the receiving ship and bunkering facility have safely separated and all required documentation has been completed.

3.2 Goal

This phase should secure a safe separation of the transfer systems of the receiving ship and bunkering facility without release of LNG or excess vapour to the surrounding environment.

3.3 Functional requirements

The following functional requirements should be considered during the Post Bunkering Phase:

- The draining, purging and inerting sequences as described in 3.4 below for the different bunkering cases are fulfilled without release of excess natural gas to the atmosphere.
- The securing and safe storage of transfer system equipment is ensured.
- The unmooring operation and separation of ship(s) is completed safely.

3.4 Draining, purging and inerting sequence

This part of the process is intended to ensure that the transfer system is in a safe condition before separation, the couplings should not be separated unless there is an inert atmosphere on both sides of the coupling.

The details of this process will be design dependent but should include the following steps:

- Shut down of the supply.
- Safe isolation of the supply.
- Draining of any remaining LNG out of the transfer system.
- Purging of natural gas from the transfer system.
- Safe separation of the transfer system coupling(s).
- Safe storage of the transfer system equipment in a manner that the introduction of moisture or oxygen into the system.

3.4.1 LNG Bunkering from Truck LNG Tank

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the receiving ship tank.

3.4.2 LNG Bunkering from Bunker ship

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the bunker ship tank.

3.4.3 LNG Bunkering from shore based terminal

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the shore facility.

3.4.4 LNG Bunkering using portable tanks

The method for safe disconnection of portable tanks will vary depending on the specific design of the system. The general principles remain the same:

- All pipe connections to be isolated at the delivery and receiving ends.
- The connecting hose(s) should be purged and inerted to below the lower flammable limit to prevent risk of ignition and minimise release of natural gas during disconnection.
- Hoses and connections should be securely blanked or otherwise protected to avoid introduction of moisture and oxygen into the system.

3.5 Post-bunkering documentation

Upon completion of bunkering operations the checklist in the LNG bunkering management plan (as described in the pre-bunkering section above) should be completed to document that the operation has been concluded in accordance with the agreed safe procedure. The vessel PIC should receive and sign a Bunker Delivery Note for the fuel delivered, the details of the bunker delivery note are specified in the annex to part C-1 of IGF Code.

Annex: Guidance on HAZID and HAZOP for LNG bunkering operations

This annex presents the minimum scope for Risk Analysis related to LNG Bunkering.

Section 1 - HAZID for LNG bunkering

1.1 Objectives

The principal objectives of the HAZID should identify:

- Hazards and how they can be realised (i.e. the accident scenarios);
- The consequences that may result;
- Existing measures/safeguards that minimise leaks, ignition and potential consequences, and maximise spill containment; and
- Recommendations to eliminate or minimise risks.

1.2 Scope

As a minimum the HAZID should include the scope as described in Chapter 2. It may be complemented with an HAZOP (Hazard and Operability) assessment after all safeguards have been implemented.

1.3 Process

The HAZID process should be carried out in accordance with a recognised process using appropriately experienced subject matter experts. It is recommended that professional guidance is sought to ensure that the process is carried out to an adequate and appropriate level of detail.

The outcomes of the HAZID include hazard rankings and recommendations for additional safeguards and analysis. This may include detailed analysis or studies to establish that the measure in place meet the acceptance criteria agreed by the Administration.

1.4 Technique

To facilitate the HAZID process, the bunkering process may be divided into smaller steps each of which are then addressed systematically.

It is recommended that the following list is used to structure the HAZID exercise for LNG bunkering:

- Preparation (compatibility, testing, mooring)
- Connection
- Inerting of relevant pipe sections
- Cooling down

- Transfer start
- Transfer at nominal flow
- Transfer stop including topping-up
- Draining & purging
- Inerting
- Disconnection
- Commissioning
- Security

1.5 Guidewords

To guide and help the HAZID workshop process, the following guidewords may be used:

- Leakage
- Rupture
- Corrosion
- Impact
- Fire/Explosion
- Structural integrity
- Mechanical failure
- Control/electrical failure
- Human error
- Manufacturing defects
- Material selection
- Flange or connector failure
- BOG management during bunkering
- Control failure
- ESD valves control failure
- ERC actuator failure
- ERC spring failure causing not closing
- Loss of containment (piping, valves)
- Cryogenic leaks (minor, major)
- Hose damage
- Hose rupture
- Major structural damage
- Gas leak
- Gas dispersion
- Gas in air intake
- Potential fire & explosion
- Cooling down operation wrong
- Excessive transfer rate
- Hydraulic Power Unit failure
- Communication failure
- Black out
- Relative motions of vessels
- SIMOPS
- Unexpected venting
- Harsh weather

Section 2 - HAZOP for LNG bunkering operations

2.1 Definition

The HAZOP study is a structured and methodical examination of a planned process or operation in order to identify causes and consequences from a deviation to ensure the ability of equipment to perform in accordance with the design intent. It aims to ensure that appropriate safeguards are in place to help prevent accidents. Guidewords are used in combination with process conditions to systematically consider all credible deviations from normal conditions.

2.2 Process

The HAZOP should be realised with a focus on the LNG bunkering, storage and delivery to the engines. The operational modes for the receiving ship to be considered are:

- Start-up
- Normal Operations
- Normal Shutdown, and
- Emergency Shutdown

2.3 Scope

The HAZOP should review the following cases but not limited to:

- Joining together of the emergency shutdown systems of the Bunkering Facility, Receiving Ship and transfer system
- Emergency procedures in the event of abnormal operations
- Leakage from hoses
- Overpressure of the containment system
- Emergency unmooring
- Emergency venting of LNG or vapour
- Additional protection for the ship’s hull in case of fuel leakage in way of the manifolds
- Emergency shut down and quick release protocol
- Requirements for outside assistance such as tugs
- Loss of power

The following should be analysed:

- Connection
- Inerting of relevant pipe sections
- Cooling down
- Transfer start
- Transfer at nominal flow
- Transfer stop including topping-up
- Draining
- Inerting
- Disconnection
- Fatigue, stress and human errors

It is recommended that emergency disconnection at the receiving ship's manifold should be addressed by the bunkering operations risk assessment in order for any potential impact of the system within the receiving ship's bunker station lay-out to be identified and additional mitigation or support utilities to be incorporated as appropriate.

Both HAZID and HAZOP processes will produce a list of recommendations and an action plan. These action plans will address each recommendation developed and provides a means for tracking the hazards for assessment and implementation.

BCS- G 143 Recommended procedure for the determination of contents of metals and other contaminants in a closed fresh water system lubricated stern tube

1. General

As provided by paragraph 1.2.15 of BCS- R Z21, a sample test of lubricating fresh water should be carried out at the required intervals.

The documentation on lubricating fresh water analysis is to be available on board. Each analysis, to be performed by an appropriate method, should include the minimum parameters as listed:

- Metal contents as applicable (with the material of the shaft and liners used), refer to Section 3 and 4.

- Corrosion inhibitors in fresh water (pH or equivalent alkalinity indicators) indicating the degree of passivation of the system against corrosion, refer to Section 5.

- Salinity indicators or equivalent indicators i.e. total conductivity, refer to Section 3 and 6.

- Contents of bearing particles, refer to Section 7.

Analysis result records should also include the extent of make-up water in the system.

2. Sampling procedure

One lubricating fresh water sample should be taken:

- The fresh water sample should be taken under service conditions, i.e. with a rotating shaft and the system at service temperature.

- The sample is to be drawn from the same agreed position in the system which should be positively identified. The sample should be representative of the water circulating within the stern tube.

- The sample, unless supervised by a Surveyor, is to be collected under the direct supervision of the Chief Engineer.

3. Contaminants determination

The presence of the following contaminants should be determined:

- In connection with presence of wear metals and corrosion products (shaft and/or liners):

  Iron

  Chromium

  Nickel

  Copper

  Silicon

- In connection with the presence of sea water:

  Sodium

  Chlorides

4. Metal content values

The metal content values should be considered taking into account the chemical composition of the shaft and liner materials.

Suggested upper limits are given below for guidance only:

Metal	**Limit value**
Iron	25ppm
Chromium	5ppm
Nickel	5ppm
Copper	40ppm
Silicon	30ppm

These limits should be considered versus the elapsed time.

It is important to have results of a number of sequential analyses in order to observe any trends taking place.

In case of shafts provided with a corrosion protection system the possible presence of further metal contaminants should be evaluated in accordance to the indications of the shaft/system manufacturer.

5. Corrosion inhibitors

The fresh water used for shaft lubrication may be treated, according to the provisions of the system manufacturer, by means of corrosion inhibitors that limit the risk of oxidation of the shaft and/or liners. The characteristics and contents of such inhibitors may vary, hence no recommended value is listed.

However a significant indicator that may be used as guidance is the pH value of the sample or an equivalent indicator of alkalinity. The lower limit of the pH value of the water that may be assumed as guidance is 11.

6. Salinity indicators

In order to evaluate the possible contamination of the fresh water with salt water (e.g. leakages from the outboard seals) the following indicators should be considered:

Chloride contents

Sodium

Suggested upper limits are given below for guidance only:

Chloride contents	60ppm
Sodium	70ppm

7. Presence of bearing particles

The bearings used in fresh water lubricated propulsion shaft are made of synthetic material and could have composite structure consisting of specifically selected polymers and additives having mineral or synthetic origin.
The possible presence of synthetic material in the fresh water sample may indicate the deterioration of the bearing or onset of bearing failure.

Mechanical filtering of the water sample, e.g. by means of a paper micro-filter, may allow a first quantitative analysis of the content of macro parts. This shall be taken before the filters if any fitted in the system.

Microscopic analysis of the particles may be recommended to identify the non-metallic bearing material in the sample.

BCS-G 146 Risk assessment as required by the IGF Code

1.1 General

To help eliminate or mitigate risks a risk assessment is required by the IGF Code[1]. In this regard it requires that the risk assessment is undertaken using acceptable and recognised techniques, and the risks and their mitigation are documented to the satisfaction of the Administration.

It is recognised that there are many acceptable and recognised techniques and means to document a risk assessment. As such, it is not the intent of this document to limit a risk assessment to a particular technique or means of documentation. This document does, however, describe recommended practice and examples to help satisfy the IGF Code.

1.2 Risk assessment - Objective

The objective or goal of the risk assessment, as noted in the IGF Code, is to help *"eliminate or mitigate any adverse effect to the persons on board, the environment or the ship"*[2]. That is, to eliminate or mitigate unwanted events related to the use of low-flashpoint fuels that could harm individuals, the environment or the ship.

1.3 Risk assessment - Scope

The IGF Code requires the risk assessment to cover the use of low-flashpoint fuel[3]. This is taken to mean assessment of the supply of such fuel to consumers and covers:

- equipment installed on board to receive, store, condition as necessary and transfer fuel to one or more engines, boilers or other fuel consumers;
  Such equipment includes manifolds, valves, pipes/lines, tanks, pumps/compressors, heat exchangers and process instrumentation from the bunker manifold(s) to delivery of fuel to the consumers.

- equipment to control the operation;
  For example, pressure and temperature regulators and monitors, flow controllers, signal processors and control panels.

- equipment to detect, alarm and initiate safety actions;
  For example, detectors to identify fuel releases and subsequent fires, and to initiate shutdown of the fuel supply to consumers.

- equipment to vent, contain or handle operations outside of that intended (i.e. outside of process norms);
  For example, vent lines, masts and valves, overflow tanks, secondary containment, and ventilation arrangements.

- fire-fighting appliances and arrangements to protect surfaces from fire, fuel contact and escalation of fire;
  For example, water sprays, water curtains and fire dampers.

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1. International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) - as adopted at MSC 95 (June 2015).
2. IGF Code (ref 1 of this document), Part A, Chapter 4.1.
3. IGF Code (ref 1 of this document), Part A, Chapter 4.2, Paragraph 4.2.1.

- equipment to purge and inert fuel lines;
  For example, equipment to store and supply nitrogen for the purposes of purging/inerting bunker lines, and equipment used for the safe transfer/disposal of fuel.

- structures and constructions to house equipment;
  For example, fuel storage hold spaces, tank connection spaces and fuel preparation rooms.

In agreement with stakeholders (e.g. the Administration) the scope can exclude items that have been previously subjected to a risk assessment, provided there are no changes to 'context of use' and mitigation measures taken as a result of previous risk assessment are to be included. This can help reduce assessment time and effort.

The term 'context of use' (used above) refers to differences, such as differences in design or arrangement, installed location, mode of operation, use of surrounding spaces, and the number and type of persons exposed. For example, if an item is located on a cargo ship on-deck, it is a change to the 'context of use' if the same item is then installed below deck on a passenger ship. In addressing 'context of use' it is important to recognise that these 'differences' can significantly decrease or increase risk resulting in the need for fewer, more, changed or alternative means to eliminate or mitigate the risks.

With regards to liquefied natural gas (LNG), the IGF Code states that risk assessment "need only be conducted where explicitly required by paragraphs 5.10.5, 5.12.3, 6.4.1.1, 6.4.15.4.7.2, 8.3.1.1, 13.4.1, 13.7 and 15.8.1.10 as well as by paragraphs 4.4 and 6.8 of the annex". Hence, the IGF Code allows the scope of the risk assessment to be limited to these paragraphs. It is important to note that there are differences of opinion on the scope of risk assessment required by these paragraphs. Therefore, the views of stakeholders and approval by the Administration should be sought when finalising the scope of the risk assessment.

The risk assessment includes consideration of bunkering equipment installed on board but does not cover the bunkering operation of: ship arrival, approach and mooring, preparation, testing and connection, fuel transfer, and completion and disconnection. Bunkering of fuel is the subject of separate assessment as per ISO/TC18683 and reference should be made to appropriate and specific guidance.

The IGF Code requires that consideration is given to physical layout, operation and maintenance. Typically, the risks associated with maintenance are controlled by job specific risk assessments before the activity is undertaken. Therefore, consideration of maintenance is taken to mean high-level consideration of design and arrangements to facilitate a safe and appropriate working environment. This requires consideration of, for example, equipment isolation, ventilation of spaces, emergency evacuation, heating and lighting, and access to equipment. The purpose of this is to minimise the likelihood of unwanted events resulting in harm during maintenance. In addition, the purpose is to minimise the likelihood of unwanted events after maintenance, as a result of deficient work where a contributory cause was 'a poor working environment'.

The assessment should also appreciate potential systems integration issues such as equipment control and connection compatibility. This is particularly important where a number of stakeholders are involved in separate elements of design, supply, construction and installation.

4. IGF Code (ref 1 of this document), Part A-1, Chapter 4.2, Paragraph 4.2.2.

Occupational risks can be excluded from the risk assessment. They are an important safety consideration and are expected to be covered by the safety management system of the ship.

The scope should obviously cover the design and arrangement as installed on board. Therefore, where the risk assessment is undertaken prior to finalising the design, it may require revision to ensure that the risks remain 'mitigated as necessary'.

The IGF Code makes no reference to periodic update of the risk assessment. This should be undertaken where changes to the design/arrangement and/or its operation have been made, and in response to changes in performance of equipment and controls. This helps ensure the risks are 'mitigated as necessary' through-out the life of the fuel system.

The final scope of the risk assessment should be agreed with appropriate stakeholders (e.g. the Administration) and guided by applicable **BCS** rules and the IGF Code.

1.4 Risk assessment - Approach

IMO has published guidance on formal safety assessment (FSA) and this provides useful information on risk assessment approaches and criteria[5]. The purpose of the guidance is to help evaluate new regulations on maritime safety and protection of the environment. In this regard, assessment is focused on risk quantification and cost benefit analysis to inform decision-making. As such, it is a useful reference to IMO's views on risk assessment and criteria. However, the IGF Code does not require a quantitative measure of risk to people, the environment or assets from the use of fuel. The risk assessment is simply required to provide information to help determine if further measures are needed to 'eliminate' risks or to ensure they are 'mitigated as necessary'. Therefore, a qualitative or semi-quantitative approach to the risk assessment is appropriate (i.e. Qualitative Risk Assessment, QualRA[6]). That is not to say that a fully quantitative approach is inappropriate or that circumstances might not favour its use (i.e. Quantitative Risk Assessment, QRA). What is important is that the risk assessment is of sufficient depth to help demonstrate that risks have been 'eliminated' or 'mitigated as necessary'.

As a minimum, the risk assessment should detail:

A. how the low-flashpoint fuel could potentially cause harm – Hazard identification;
That is, systematic identification of unwanted events that could result in, for example, major injuries or fatality, damage to the environment, and/or loss of structural strength or integrity of the ship.

B. the potential severity of harm – Consequence analysis;
That is, the potential severity of harm (i.e. consequences) expressed in terms of, for example, major injuries, single and multiple fatalities, adverse environmental impact, and structural/ship damage sufficient to compromise safe operations.

C. the likelihood of harm – Likelihood analysis;
That is, the probability or frequency with which harm might occur.

D. a measure of risk – Risk analysis;
That is, a combination of consequence (B) and likelihood (C).

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5. Revised Guidelines for formal safety assessment for use in the IMO rule-making process. MSC-MEPC.2/Circ.12, 8th July 2013.
6. Where some form of quantification occurs, then the approach is semi-quantitative. However, such approaches are often referred to as qualitative and this term is used throughout this document.

E. judgements on risk acceptance – Risk assessment.
The measure of risk (D) should be compared against criteria to judge if the risk has been 'mitigated as necessary'.

Acceptable and recognised techniques to address the requirements noted above (i.e. A-D) are described in, for example, ISO 31010[7], ISO 17776[8], ISO 16901[9], NORSOK Z-013[10], CPR 12E[11], and publications by CCPS[12] and HSE[13], etc.

The following sub-section, A1.4.1, outlines an approach to meeting the above requirements.

1.4.1 An approach to satisfying the IGF Code requirements - Qualitative Risk Assessment (QualRA)

A. Hazard identification

1. Divide the fuel system into discrete parts with respects to equipment function and location.
This promotes systematic consideration of each part of the system and helps identify specific causes of unwanted events related to a particular item, activity or section. A typical division of the system might be, for example: (a) the bunker station and fuel lines to the storage tank; (b) the fuel storage hold space; (c) the tank connection space; (d) the fuel preparation room; and (e) the fuel lines and valves 'regulating' fuel delivery to the engine.

2. Develop a set of guidewords/phrases and example causes that could result in unwanted events (e.g. a release of fuel or fuel system failure resulting in loss of power).
The guidewords/phrases and example causes are used as prompts. A typical, but not exhaustive list of prompts is given in Appendix 1.

3. By reference to design and arrangement information, location plans, process flow diagrams, mitigation measures and planned emergency actions use the prompts to identify potential causes of unwanted events (e.g. fuel releases and loss of power).
The prompts are used to stimulate discussion and ideas within a workshop led by a facilitator and attended by subject matter experts (SMEs).

4. Record the potential causes of unwanted events and mitigation measures
An example of a record sheet or worksheet is given in Appendix 2. This worksheet is also used to record steps B to E below, and forms part of the overall documentation of the risk assessment.

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7. Risk management: Risk assessment techniques. IEC/ISO 31010:2009.
8. Petroleum and natural gas industries - Offshore production installations - Guidelines on tools and techniques for hazard identification and risk assessment. EN ISO 17776:2002.
9. Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface. ISO/TS 16901:2015.
10. Risk and emergency preparedness assessment. NORSOK Standard Z-013, Edition 3, October 2010.
11. Methods for determining and processing probabilities. CPR 12E, 1997/2005.
12. e.g. Guidelines for chemical process quantitative risk analysis. Centre for Chemical Process Safety, American Institute of Chemical Engineers, Second Edition, 2000.
13. e.g. Marine risk assessment. Health & Safety Executive, 2001.

B. Consequence analysis

5. For each identified cause, estimate the potential consequences in terms of, for example, major injuries, single and multiple fatalities, adverse environmental impact and damage sufficient to compromise safe operations.
The potential consequences can be estimated by the SMEs using judgement and reference to: (a) the fuel's properties/hazards; (b) the release location; (c) dispersion/leak pathways; (d) location and 'strength' of ignition sources; (e) proximity of vulnerable receptors; (f) generic or (if commissioned) specific fire and explosion modelling; and (f) expected effectiveness of existing/planned mitigation measures. The properties and hazards of liquefied natural gas (LNG) noted in (a) are summarised in Appendix 3.

6. Categorise the consequence estimates.
The consequences can be categorised by the SMEs to provide an indication of severity. For example, categories for harm to persons can distinguish between major injury, single fatality and multiple fatalities. Example consequence categories are given in Appendix 4.

C. Likelihood analysis

7. Estimate the annual likelihood of occurrence of 'cause and consequence'.
Likelihood can be estimated by the SMEs (or a suitably qualified individual) for each 'cause-consequence' pair or a grouping of causes with the same consequence. The estimation can be informed by reference to accident and near-miss reports, accident and equipment release data, analogy to accidents in similar or other industries and consideration of the reliability and effectiveness of mitigation measures. It is not always apparent if the likelihood of a 'cause-consequence' combination is credible (i.e. reasonably foreseeable). As a guide, an unwanted event may be considered credible if: (a) it has happened before and it could happen again; (b) it has not happened but is considered possible with an annual likelihood of 1 in a million or more; and (c) it is planned for, that is, emergency actions cover such a situation or maintenance is undertaken to prevent it. A guide to the likelihood of releases relevant to LNG equipment and operations is given in Appendix 5.

8. Categorise the likelihood estimates.
Likelihood can be categorised by the SMEs (or a suitably qualified individual) to provide an indication of accident/incident occurrence or other unwanted event occurrence. Example likelihood categories are given in Appendix 4.

D. Risk analysis

9. Estimate the risk.
Risk can be estimated by the SMEs (or a suitably qualified individual) by combining the consequence and likelihood categories to provide a risk rating. For example, if a 'cause-consequence' pair is categorised as, say 'A', and associated 'likelihood' as, say '1', then the risk rating is 'A1'. An example of a risk rating scheme is given in Appendix 4.

E. Risk assessment

10. Judge if the risk has been 'mitigated as necessary'.
The estimated risk can be compared against risk criteria embedded within a risk matrix. The matrix shows the risk rating (with respects to consequence and likelihood) and the criteria illustrate whether the risk has been 'mitigated as necessary'. An example of a risk rating scheme and its associated risk criteria are given in Appendix 4.

With respects to D and E above, it is important to note that there are no universally agreed risk rating schemes or risk criteria: there are differences between governments, regulators and organisations. Therefore, prior to the commencement of the risk assessment, risk rating/criteria should be agreed with appropriate stakeholders (e.g. the Administration).

It should also be recognised that the risk rating of individual or grouped 'cause-consequence' pairs does not provide an indication of the collective (overall) risk from all potential 'cause-consequence' pairs. If the overall risk level is required then this can be determined using QRA.

Practically, the risk rating is an indication that additional or alternative mitigation measures:

- must be provided; or
- must be considered and implemented if practical and cost effective; or
- need not be considered further, beyond accepted good practice of reducing risk where practicable.

In each of the steps above many assumptions are made and there is uncertainty. Therefore, it is good practice for SMEs to list assumptions and 'test' the sensitivity of results to changes in any of these steps. For example, a change to an assigned consequence or likelihood category could alter the risk rating and the judgement on whether a risk is 'mitigated as necessary'.

1.4.1.1 Mitigated as necessary

The phrase 'mitigated as necessary' is used in the IGF Code and is akin to the phrase 'As Low As Reasonably Practicable', commonly referred to as ALARP. Essentially, a risk is considered ALARP if all reasonably practicable mitigation measures have been implemented. This means that additional or alternative measures have been identified and implemented unless they are demonstrated as impractical or the cost of implementation is disproportionate to the reduction in risk. This concept of ALARP is established practice in many industries and recognised as best practice by IMO[14].

Where 'mitigated as necessary' is not proven then the SMEs should consider additional and/or alternative mitigation measures[15] and re-evaluate the risk. **The risk cannot be 'accepted' until 'mitigated as necessary' is achieved**. In this regard, additional study can be undertaken to help the SMEs decide if existing, additional or alternative measures can provide 'mitigated as necessary'.

14. Revised Guidelines for formal safety assessment for use in the IMO rule-making process. MSC-MEPC.2/Circ.12, 8th July 2013.

15. Within the IGF Code, measures to reduce likelihood and measures to reduce consequences are both understood to be mitigation measures (i.e. they mitigate the risk). To align with the IGF Code this understanding is maintained within this document. It is recognised that in many other industries it is common to use the terms 'prevention measures' and 'mitigation measures', where the former reduces likelihood and the latter reduces consequences. Prevention and mitigation measures are often referred to as 'safeguards' or 'barriers'.

When considering mitigation measures the following **hierarchy of mitigation** is considered best practice:

- firstly, measures to prevent an unwanted event;
  That is, to ensure the unwanted event cannot occur or its likelihood of occurrence is greatly reduced;

- secondly, measures to protect against harm given an unwanted event.
  That is, to reduce the consequences after the unwanted event has occurred.

In addition, when considering mitigation measures it is good practice to consider **engineering solutions in preference to procedural controls**. This helps promote an inherently safer design. Furthermore, it is good practice to consider **passive measures in preference to active measures**. For example, a passive measure is one where no manual or automated action is required for it to function on demand and as intended. Whereas, an active measure requires some means of activation for it to operate. Both passive and active measures may be required to demonstrate that the risk has been mitigated as necessary. Examples of mitigation measures are listed in Appendix 6.

To help judge if mitigation measures are effective it can be useful to illustrate or map the pathway from 'cause' to 'consequence' and review the effectiveness of the mitigation measures. An example of such mapping and review is given in Appendix 7.

Whether a single mitigation measure or a collection of mitigation measures is practical and cost-effective is in some respects relative to the resources and skills available. If the SMEs cannot decide then the use of cost benefit analysis can be helpful. In any case, a documented justification for not implementing a mitigation measure should be made where SMEs judge the measure to be practical and cost-effective.

1.5 Risk assessment - Team

The team conducting the risk assessment should comprise of subject matter experts (SMEs) who are, collectively, suitably qualified and experienced. For the QualRA noted above, this means the workshop team includes individuals who are degree qualified and/or chartered/professional engineers, have operational ship experience and are experienced in risk assessment. Such qualifications and experience should be in relevant disciplines to cover engineering design and safe use of the fuel.

It is unlikely that one SME can satisfy the above team requirements. In any case, to ensure investigative discussion, generation of ideas, challenge and coverage of, for example, mechanical, process, electrical and operational aspects, a typical number of SMEs might be four to eight.

In addition to the SMEs, the team should be led by a facilitator (also referred to as the chair or chairman). The facilitator should be impartial with no vested interests in the fuel system, and experienced in leading such risk assessments. The facilitator may be supported by a scribe (also referred to as a secretary) to aid reporting.

The time expended by the team depends upon the agreed scope and the designs' 'complexity'. For example, a QualRA workshop for a new design might require two or three working days, whereas, a minor variation to a previously assessed and approved design might require only half a day.

1.6 Risk assessment - Reporting

1.6.1 Main report

A written report documenting the risk assessment should be produced. This needs to be sufficiently detailed to support results, conclusions, recommendations and any actions taken. This is because the assessment will inform important design and operational decisions. Furthermore, the report is a record in helping to demonstrate 'mitigated as necessary'. A report only consisting of a completed worksheet is insufficient.

The specific contents of the report and its structure are dependent upon design and assessment specifics, and reporting preferences. However, for a QualRA, the report should provide:

- an overview of the design and arrangement;
  This is a simple explanation of the design and arrangement with respects to its intended operation and process conditions. Technical appendices should include process flow diagrams, general arrangement plans and all information used during the assessment. Where this is too cumbersome to include in the report in full, reference to this material is sufficient provided it remains accessible.

- an explanation of the risk assessment process;
  This is a description of the risk assessment method and includes how the design was divided into parts for assessment, how hazard identification was undertaken, and the selection of consequence and likelihood categories and risk criteria.

- information on the relevant qualifications and expertise of the team;
  This can be a table listing the names, job titles, relevant qualifications, expertise and experience of all team members (including the facilitator and scribe). It is not sufficient to simply list names and job titles.

- the time taken to complete the assessment and whether SMEs were present to provide their expert input;
  For a workshop, this can be a table listing the schedule/duration and attendance of each SME (i.e. full-time or part-time, and if part-time the 'parts' for which the person was absent). The purpose of this is to indicate if sufficient time was taken to assess the design/arrangement, and to highlight any SME absences that could be detrimental to results, conclusions and actions. For any SME absences, a note should be made by the facilitator as to whether this impacted adversely upon the assumptions and judgements made.

- risk results and conclusions;
  This is a listing or discussion of the results and a judgement on whether or not the risk has been 'mitigated as necessary'.

- recommendations and actions.
  This can include requests for modelling and analysis (e.g. gas dispersion or thermal radiation extent, etc.) and will most likely include additional and alternative mitigation measures to be investigated and/or implemented, who is responsible for these and, if known, an expected completion date. It is important that these recommendations and actions are suitably documented because they are likely to be used to plan a response and monitor progress until the recommendations/actions have been addressed.

An example report contents is given in Appendix 8.

1.6.2 Terms of reference (ToR)

Prior to the workshop it is good practice for the facilitator to issue relevant information to the team. This is sometimes referred to as a terms of reference (ToR). This helps the team familiarise with the design and intended approach before the workshop. It also provides time for clarifications and agreement with the proposed consequence and likelihood categories and risk criteria. Importantly, it provides time to confirm the suitability of the proposed schedule and team. The ToR can form an appendix to the main report.

Typically, a ToR includes:

- objectives and scope of the assessment;
  This is to ensure all team members understand the objective and what equipment and operations are to be covered in the assessment.

- technical description of the proposed design and arrangements;
  This can include copies of process flow diagrams (PFDs) or schematics detailing process conditions of equipment and pipework, and a scaled layout drawing illustrating equipment and pipework arrangements, size and location.

- overview of the potential consequences of a fuel release;
  For LNG, this could refer to Appendix 3 of this document.

- technique to be used;
  This includes proposed consequence and likelihood categories and risk criteria.

- intended workshop schedule;
  This highlights the time to be given to the workshop and when SME input is required.

- team details.
  This includes the name and job title, relevant qualifications, expertise and experience of each SME and team member/workshop attendee.

Appendix 1
Prompts - guidewords and phrases

Example prompts for use in QualRA

Failure of fuel containing equipment* – a hole/crack leading to release of fuel	
Wear and tear	*vibration, loading, cycling, prolonged use*
Erosion	*fuel contaminants, high stream velocity, prolonged use*
Stress and strain	*vibration, loading, cycling, ship movement, prolonged use*
Fatigue	*vibration, loading, cycling, ship movement, prolonged use*
Corrosion	*exposure to weather, exposure to sea water, humidity, loss of dry air supply, contact with corrosive materials*
Collision	*ship collides with another vessel, ship hits rocks, ship strikes the harbour wall or jetty*
Grounding	*ship runs aground*
Impact	*dropped object (e.g. during maintenance or cargo loading), collapse of supporting structure, maloperation during loading/maintenance*
Fire	*ignition of flammable materials, fire in adjacent spaces/areas*
** plus equipment containing gases or other substances that could release into spaces resulting in harm (e.g. asphyxiation, burns)*	
Failure of process control – operation outside of design conditions leading to subsequent release of fuel	
Temperature high	*loss of insulation, instrument failure, software failure, actuator failure, maloperation by operator, external fire, exposure to extreme weather, decomposition*
Temperature low	*loss of heating medium circulation, heating medium contamination, instrument failure, software failure, actuator failure, maloperation by operator, exposure to extreme weather*
Pressure high	*maloperation by operator (e.g. closed valve), loss of utilities (e.g. instrument air), external fire, loss of power supply, rollover, excess generation of boil-off gas, actuator failure*
Pressure low (vacuum)	*maloperation by operator, loss of utilities (e.g. instrument air), loss of power supply (electricity), actuator failure*
Flow high	*instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions*
Flow low	*instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions*
Flow reversed	*instrument failure, software failure, maloperation by operator (e.g. closed valve), exposure to extreme sea conditions*
No Flow	*instrument failure, software failure, maloperation by operator (e.g. closed valve), actuator failure*
Level high	*instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions*
Level low	*instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions*
Fuel left in pipe/line	*maloperation by operator, closed valves, no inert/purge supply, limited inert/purge supply*
No fuel in pipe/line	*instrument failure, software failure, maloperation by operator, closed valves*
Loss of power	*loss of electrical signals, blackout, loss of instrument air, loss of hydraulic fluid*

Note: Poor manufacturing, installation and commissioning of equipment can increase the likelihood and/or consequences of fuel releases. If these aspects are not covered and controlled by, for example, class rules, then they should be included in the risk assessment. The assessment should cover intended operation, shutdown and start-up.

Appendix 2
Record sheet / Worksheet

Worksheet Example

Worksheet for [project title]											
Part or Section [title]											
						Category & Rating					
Item / Activity	Guideword / Phrase	Causes (accident / incident)	Consequences	Mitigation (existing safeguards)	Additional / Alternative Mitigation (safeguards)	Consequence	Likelihood	Risk	Mitigated as necessary	Recommendations Comments / Actions	Action by / date

Note: The worksheet can be used to record risk ratings before and after consideration of additional/alternative safeguards by using one row for ‘existing safeguards’ and one row for ‘additional/alternative safeguards’. If preferred, the ‘Additional/Alternative Mitigation (safeguards)’ column can be moved after the ‘Category & Rating’ columns followed by additional ‘Category & Rating’ columns.

Appendix 3
Properties & hazards of liquefied natural gas

3.1 LNG Properties

Liquefied natural gas (LNG) is a cryogenic liquid. It consists of methane with small amounts of ethane, propane and inert nitrogen. When used as a fuel, typically 94% or more is methane. Stored at ambient or near ambient pressure, its temperature approximates minus 162 deg.C and its specific gravity is about 0.42. Hence, if released onto the sea LNG floats (and can rapidly 'boil' – refer to 3.2.7). When stored at pressures of up to 10 bar the temperature typically remains below minus 130 deg.C with a specific gravity of approximately 0.4.

Released into atmospheric conditions, LNG rapidly boils forming a colourless, odourless and non-toxic gas. Although colourless, due to its very low temperature, water vapour in the air condenses forming a visible mist or cloud. The cold gas is initially heavier than air and it remains negatively buoyant until its temperature rises to about minus 100 deg.C. At this stage the gas becomes lighter than air, and in an open environment it is thought that this coincides with a gas concentration of less than 5%. At this temperature and concentration the gas is still within the visible cloud. As the gas continues to warm to ambient conditions its volume is approximately 600 times that of the liquid with a relative vapour density of about 0.55, and so the gas is much lighter than air (air = 1).

As the gas disperses, its concentration reduces. At a concentration in air of between 5% and 15% the mix is flammable and can ignite in the presence of ignition sources or in contact with hot sources at or above a temperature of approximately 595 deg.C (referred to as the auto-ignition temperature). Once below a concentration of 5% the mix is no longer flammable and cannot be ignited (and this is the case if the concentration remains above 15%). The 15% and 5% concentrations of LNG in air are commonly known as the upper and lower flammability limits, respectively. More recently, the limits are referred to as the upper and lower explosion limits, although ignition may not necessarily result in explosion.

3.2 LNG Hazards

3.2.1 Cryogenic burns

Owing to its very low liquid temperature, in contact with the skin LNG causes burns. In addition, breathing the cold gas as it 'boils' can damage the lungs. The severity of burns and lung damage is directly related to the surface area contacted by the liquid/gas and duration of exposure.

3.2.2 Low temperature embrittlement

In contact with low temperature LNG, many materials lose ductility and become brittle. This includes carbon and low alloy steels typically used in ship structures and decking. Such low temperature embrittlement can result in material fracture, such that existing stresses in the contacted material cause cracking and failure even without additional impact, pressure or use. For LNG duty, materials resistant to low temperature embrittlement are used. These materials include stainless steel, aluminium, and alloy steels with a high-nickel content.

3.2.3 Asphyxiation

LNG is non-toxic and is not a known carcinogen. However, as it boils to gas it can cause asphyxiation as it displaces and then mixes with the surrounding air. The likelihood of asphyxiation is related to the concentration of gas in air and duration of exposure.

3.2.4 Expansion and pressure

Released into the atmosphere LNG will rapidly boil with the volume of gas produced being hundreds of times that of the liquid (approximately 600 times at ambient conditions). Hence, if confined and unrelieved, the pressure will increase and this can damage surrounding structures and equipment.

3.2.5 Fire

3.2.5.1 Pool fire

A ‘small’ release of LNG will rapidly boil and ‘flash’ to gas (i.e. evaporate). However, given a ‘large’ and sudden release, a cold pool of LNG will form with gas boiling from the pool and mixing and dispersing with the surrounding air. If this mix is within the flammable range (i.e. 5% to 15% with air) and contacts an ignition source or a heated surface above the auto-ignition temperature (595 deg.C) it will ignite and the resultant flame will ‘travel back’ to the pool resulting in a pool fire.

3.2.5.2 Jet fire

If stored under pressure then a release of LNG may discharge as a jet of liquid, entraining, vapourising and mixing with air. If the mix disperses and reaches an ignition source or a heated surface (above the auto-ignition temperature) whilst in the flammable range it will ignite. The resultant flame will ‘travel back’ and may result in a pressurised jet fire from the release source. Similarly, where contained LNG has been heated to form gas, a pressurised release of this gas could ignite and result in a jet fire.

3.2.5.3 Flash fire

Release of LNG to atmosphere and ignition within a few tens of seconds is likely to result in a pool fire or jet fire (as noted above) with no damaging overpressure. This is because the flammable part of the cloud is likely to be relatively small and close to the release point upon ignition. However, if ignition is delayed, the gas cloud will be larger and may have travelled further from the release point. Ignition will then result in a flash fire as the flammable part of the cloud is rapidly consumed within a few seconds. This ignition is likely to be violent and audible, and is often mistaken for an explosion, although there is little appreciable overpressure.

3.2.5.4 Thermal radiation from a pool fire, jet fire and flash fire

Harm to people and damage to structures and equipment from fire is dependent upon the size of the fire, distance from the fire, and exposure duration. Within a metre of the fire, thermal radiation may approximate 170 kW/m^2 but this rapidly falls with distance from the fire.

As a rough guide:

- 6 kW/m^2 or more and escape routes are impaired and persons only have a few minutes or less to avoid injury or fatality[16];
- 35 kW/m^2 results in immediate fatality[16];
- 37.5 kW/m^2 has long been considered as the onset of damage to industrial equipment and structures exposed to a steady state fire[17];
- industrial equipment and structures within a flash fire are unlikely to be significantly damaged; and
- persons within a pool, jet or flash fire are likely to be fatally injured.

An LNG fire on a ship could result in fatalities and damage to equipment and structures (including the hull).

3.2.6 Explosion

Release of LNG to atmosphere and delayed ignition of the resultant flammable cloud beyond a few tens of seconds can result in an explosion. This is because the cloud may have dispersed in and around equipment and structures causing a degree of confinement and increased surface area over which to increase flame speed as it travels (i.e. burns) through the flammable mixture. The resultant overpressure may be sufficient to harm individuals, and damage structures and equipment. Such an explosion is most likely to be a deflagration (rather than a detonation), categorised by high-speed subsonic combustion (i.e. the rate at which the flame travels through the flammable cloud).

3.2.6.1 Overpressure from an explosion

Harm to people and damage to structures and equipment from an explosion is dependent upon the magnitude of overpressure generated and the rate at which the overpressure is delivered (known as impulse). In addition, harm is often a result of falling or being thrown against hard surfaces or being struck by objects and debris as a result of the blast. As a rough guide:

- the probability of fatality from exposure to an explosion of 0.25 bar and 1 bar is about 1% and 50%, respectively[18];
- less than 0.25 bar could throw an individual against a hard surface resulting in injury or fatality[18]; and
- 0.3 bar is typically the limit of damage to structures and industrial equipment[18].

---

16. There are many quoted values from many sources and with inconsistencies. Thermal dose might be alternatively used. The values quoted here are based on: Health & Safety Executive, Indicative human vulnerability to the hazardous agents present offshore for application in risk assessment of major accidents, SPC/Tech/OSD/30, 2011, and supporting document: Methods of approximation and determination of human vulnerability for offshore major accident hazard assessment, http://www.hse.gov.uk/foi/internalops/hid_circs/technical_osd/spc_tech_osd_30/spctecosd30.pdf
17. Risk Analysis of Six Potentially Hazardous Industrial Objects in the Rijnmond Area, A Pilot Study. (1982). D. Reidel Publishing Company, The Netherlands.
18. There are many quoted values from many sources and with inconsistencies. Impulse might be alternatively used. The values quoted here for fatality and damage are based on Ref 16 and Methods for the determination of possible damage to people and objects resulting from releases of hazardous materials, CPR 16E, Labour Inspectorate, The Netherlands.

An explosion of vapourised LNG on a ship could result in fatalities and damage to equipment and structures (including the hull).

3.2.7 Rapid phase transition

Upon release, LNG rapidly boils due to heat from the surrounds, be this from the air, water/sea, steel or ground. However, this rapid and sometimes violent boiling is not rapid phase transition (RPT); RPT is an explosive vaporisation of the liquid, that is, a near instantaneous transition from liquid to gas. This is a more violent event than rapid boiling and it can result in liquid ejection and damaging overpressure[19]. The phenomenon is well known in the steel industry, where accidental contact between molten metal and water can result in RPT.

3.2.8 Rollover

Slowly, stored refrigerated LNG evaporates (i.e. 'boils-off') as heat from the surrounds gradually 'leaks' into the tank. Essentially, liquid in contact with the wall of the tank warms, becomes less dense and rises to the top. This top-layer then begins to evaporate (i.e. boil-off) increasing the liquid layer's density. Liquid further away from the walls also warms but at a slower rate and because of this a less dense layer below the top layer forms. Owing to the hydrostatic head, the saturation condition of this layer changes and although it heats-up, it does not evaporate but remains in the liquid state and becomes 'superheated'. As the heating continues, the trapped layer's density reduces; this is an unstable state and when the density of this layer is similar to the top layer the two layers rapidly mix and the superheated lower layer vaporises. This rapid mixing and vaporisation is known as rollover and can cause damaging over-pressure and release of gas if not appropriately controlled.

The heating mechanism described above can result in a number of differing layers and is referred to as stratification. It is a phenomenon that is well known and is safely managed through venting, mixing and temperature control.

The above phenomenon is hastened by, or can directly occur when differing densities of LNG are bunkered.

3.3 References

The information and facts given in this appendix are well known and have been recorded in numerous papers and reports on LNG. However, original sources are not always readily available (or known) and so the information given in this section was cross-checked by reference to:

1. Chamberlain, G. (2006). Management of Large LNG Hazards. 23rd World Gas Conference, Amsterdam.

2. International Maritime Organization, Marine Safety Committee. (2007). FSA - Liquefied Natural Gas (LNG) Carriers, Details of the Formal Safety Assessment. MSC 83/INF.3.

3. Bull, D. and Strachan, D. (1992). Liquefied natural gas safety research.

19. Chamberlain, G. (2006). Management of Large LNG Hazards. 23rd World Gas Conference, Amsterdam.

4. Sheats, D. & Capers, M. (1999). Density Stratification in LNG Storage. Cold Facts, 15/2.

5. Bashiri, A. & Fatehnejad, L. (2006). Modeling and Simulation of Rollover in LNG Storage Tanks. 23rd World Gas Conference, Amsterdam.

Reference can also be made to ISGOTT (International Safety Guide for Oil Tankers and Terminals) Publication (2009) - Report on the Effects of Fire on LNG Carrier Containment Systems.

Comparison of the Hazards of LNG and Fuel Oil

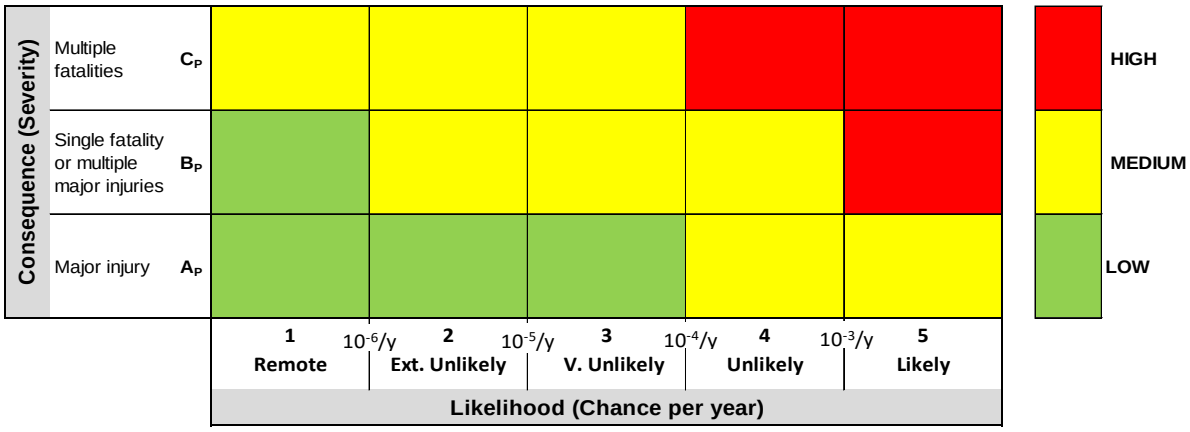
Hazards		LNG	Fuel Oil[1]
1.	**Cryogenic Burns** Liquid contact with skin will cause burns and can result in fatality. Inhalation of gas can cause burns to the lungs and lead to fatal injury.	✓	X
2.	**Low Temperature Embrittlement** Equipment/structures can fail on contact with liquid.	✓	X
3.	**Rapid Phase Transition (RPT)** Released onto the sea a near instantaneous 'explosive' transition from liquid to gas can occur. This can result in structural damage to the hull.	✓	X
4.	**Gas Expansion** A liquid pool rapidly boils, and as the gas warms and expands it requires a volume 600 times that of the liquid. This can result in equipment damage.	✓	X
5.	**Asphyxiation** In a confined space, displacement and mixing of the gas in the air will reduce oxygen content and can cause asphyxiation.	✓	✓
6.	**Pool Fire** Gas/vapour above the pool can ignite resulting in a pool fire. The intensity of the radiation can cause fatal injury and fail structure and critical equipment.	✓	✓
7.	**Flash Fire** Gas/vapour can disperse away from the pool and ignite resulting in a flash fire. The short-duration and intense radiation can instigate secondary fires, and cause fatal injuries to those within the fire and to critical equipment. Most probably the fire will burn back to the pool and result in a pool fire.	✓	X[2]
8.	**Explosion** Gas/vapour can disperse and collect in confined areas and ignite resulting in an explosion. The explosion can cause fatal injuries, instigate secondary fires, and fail structure and critical equipment. Most probably the explosion will burn back to the pool/gas source and result in a pool fire or jet fire.	✓	X[2]
9.	**Rollover** Stored liquid can stratify, that is different layers can have different densities and temperatures. This can cause the layers to 'rollover' resulting in significant gas/vapour generation that must be contained. If released, this can result in flash fire or explosion.	✓	X
10.	**Boil-off Gas (BoG)** LNG continually boils and must be re-liquefied or burnt-off. A release of BoG can ignite and result in a jet fire (given sufficient release pressure), flash fire or explosion.	✓	X

Note:

1. Fuel oil – heavy fuel oil (HFO) (ISO 8217).
2. If a fuel oil is 'sprayed' as an aerosol resulting in fine air-borne droplets, ignition can result in flash fire or explosion.

Appendix 4
Risk Matrix

Risk Matrix Example – persons on board



Consequence Category Examples

A_P Major injury - *long-term disability / health effect*
B_P Single fatality or multiple major injuries - *one death or multiple individuals suffering long-term disability / health effects*
C_P Multiple fatalities - *two or more deaths*

Likelihood Category Examples

1. Remote - *1 in a million or less per year*
2. Extremely Unlikely - *between 1 in a million and 1 in 100,000 per year*
3. Very Unlikely - *between 1 in 100,000 and 1 in 10,000 per year*
4. Unlikely - *between 1 in 10,000 and 1 in 1,000 per year*
5. Likely - *between 1 in 1,000 and 1 in 100 per year*

The likelihood categories can be related to a ship life. For example, assuming a ship lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the ship's lifetime is 1 in 40,000 (i.e. $1/(10^{-6} \times 25)$).

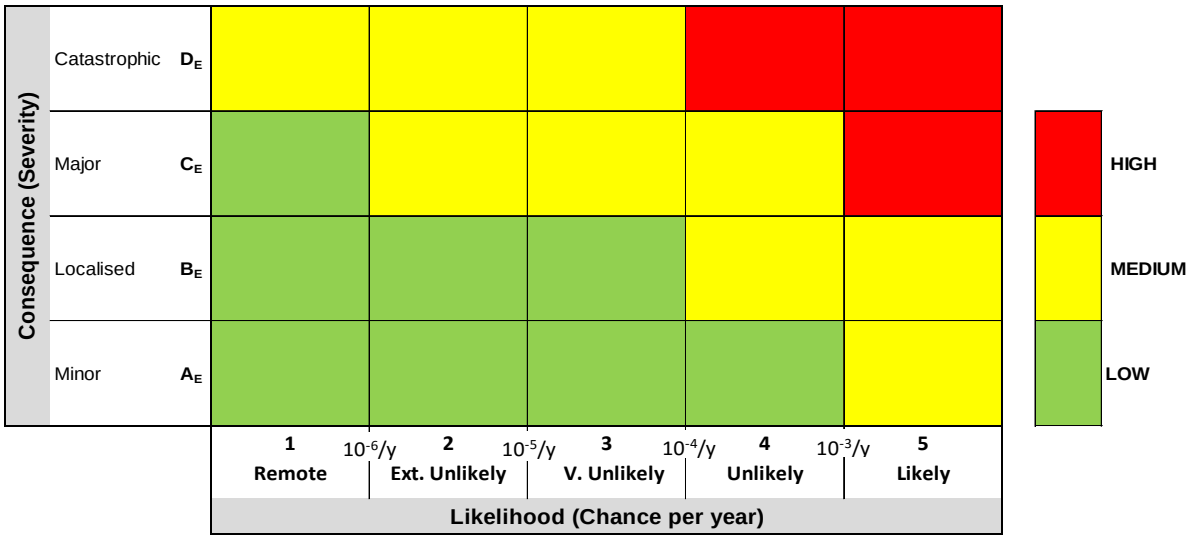
Risk Rating and Risk Criteria Examples

Low Risk – A_P1, A_P2, A_P3 & B_P1
The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk.

Medium Risk – A_P4, A_P5, B_P2, B_P3, B_P4, C_P1, C_P2 & C_P3
The risk is tolerable and considered 'mitigated as necessary'. This assumes that all reasonably practicable mitigation measures have been implemented. That is, additional or alternative mitigation measures have been identified and implemented unless judged impractical or the cost of implementation would be disproportionate to the reduction in risk.

High Risk – B_P5, C_P4 & C_P5
The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Risk Matrix Example – environment



Consequence Category Examples

A_E Minor - *limited and reversible damage to sensitive areas/species in the immediate vicinity*
B_E Localised - *significant but reversible damage to sensitive areas/species in the immediate vicinity*
C_E Major - *extensive or persistent damage to sensitive areas/species*
D_E Catastrophic - *irreversible or chronic damage to sensitive areas/species*

Likelihood Category Examples

1. Remote - *1 in a million or less per year*
2. Extremely Unlikely - *between 1 in a million and 1 in 100,000 per year*
3. Very Unlikely - *between 1 in 100,000 and 1 in 10,000 per year*
4. Unlikely - *between 1 in 10,000 and 1 in 1,000 per year*
5. Likely - *between 1 in 1,000 and 1 in 100 per year*

The likelihood categories can be related to a ship life. For example, assuming a ship lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the ship's lifetime is 1 in 40,000 (i.e. $1/(10^{-6} \times 25)$).

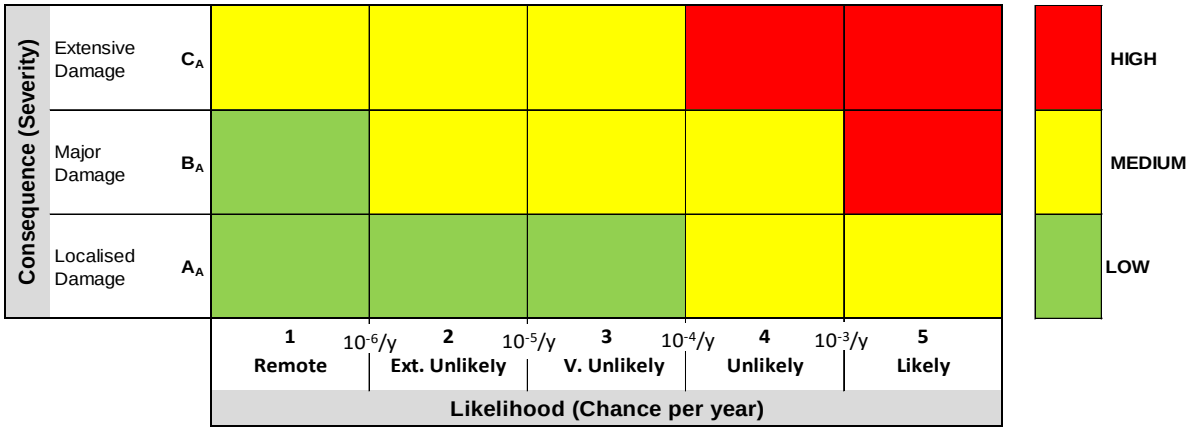
Risk Rating and Risk Criteria Examples

Low Risk – A_E1, A_E2, A_E3, A_E4, B_E1, B_E2, B_E3 & C_E1
The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk.

Medium Risk – A_E5, B_E4, B_E5, C_E2, C_E3, C_E4, D_E1, D_E2 & D_E3
The risk is tolerable and considered 'mitigated as necessary'. This assumes that all reasonably practicable mitigation measures have been implemented. That is, additional or alternative mitigation measures have been identified and implemented unless judged impractical or the cost of implementation would be disproportionate to the reduction in risk.

High Risk – C_E5, D_E4 & D_E5
The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Risk Matrix Example – ship assets (equipment, spaces and structure)



Consequence Category Examples

A_A Localised damage - *an event halting operations for more than x days*
B_A Major damage - *an event halting operations for more than y days*
C_A Extensive damage - *loss of ship, an event halting operations for more than z days*

Likelihood Category Examples

1. Remote - *1 in a million or less per year*
2. Extremely Unlikely - *between 1 in a million and 1 in 100,000 per year*
3. Very Unlikely - *between 1 in 100,000 and 1 in 10,000 per year*
4. Unlikely - *between 1 in 10,000 and 1 in 1,000 per year*
5. Likely - *between 1 in 1,000 and 1 in 100 per year*

The likelihood categories can be related to a ship life. For example, assuming a ship lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the ship's lifetime is 1 in 40,000 (i.e. $1/(10^{-6} \times 25)$).

Risk Rating and Risk Criteria Examples

Low Risk – A_A1, A_A2, A_A3 & B_A1
The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk.

Medium Risk – A_A4, A_A5, B_A2, B_A3, B_A4, C_A1, C_A2 & C_A3
The risk is tolerable and considered 'mitigated as necessary'. This assumes that all reasonably practicable mitigation measures have been implemented. That is, additional or alternative mitigation measures have been identified and implemented unless judged impractical or the cost of implementation would be disproportionate to the reduction in risk.

High Risk – B_A5, C_A4 & C_A5
The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Appendix 5
Likelihood of releases

Indicative likelihood categories

The following table provides indicative likelihood categories as follows: (a) named equipment item fails and releases fuel[20], and (b) collisions and groundings[21].

Likelihood values differ dependent upon source, assumptions made and the inclusion/ exclusion of causes, etc. Therefore, it is important to refer to the original data sources to ensure the indicative likelihood category remains valid for specific cases of interest.

Indicative Likelihood Values by Likelihood Category

1. Remote - 1 in a million or less per year (10^{-6}/y or less)			
Type C Fuel Tank	$<1 \times 10^{-6}$		
2. Extremely Unlikely - *between 1 in a million and 1 in 100,000 per year (10^{-6}/y to 10^{-5}/y)*			
Leak ≥ 10 mm Ø	**50 mm or less Ø**	**51-150 mm Ø**	**151-300 mm Ø**
Pipework / per metre	7×10^{-6}	3×10^{-6}	3×10^{-6}
Flange	4×10^{-6}	5×10^{-6}	7×10^{-6}
Manual Valve	---	7×10^{-6}	9×10^{-6}
3. Very Unlikely - *between 1 in 100,000 and 1 in 10,000 per year (10^{-5}/y to 10^{-4}/y)*			
	50 mm or less Ø	**51-150 mm Ø**	**151-300 mm Ø**
Pipework / per metre	8×10^{-5}	4×10^{-5}	3×10^{-5}
Flange	4×10^{-5}	5×10^{-5}	8×10^{-5}
Manual Valve	3×10^{-5}	5×10^{-5}	7×10^{-5}
4. Unlikely - *between 1 in 10,000 and 1 in 1,000 per year (10^{-4}/y to 10^{-3}/y)*			
	50 mm or less Ø	**51-150 mm Ø**	**151-300 mm Ø**
Actuated Valve	3×10^{-4}	3×10^{-4}	3×10^{-4}
Instrument Connection	3×10^{-4} includes flange		
Process Vessel	7×10^{-4} pressurised vessel		
5. Likely - *between 1 in 1,000 and 1 in 100 per year (10^{-3}/y to 10^{-2}/y)*			
		50-150 mm Ø	**>151 mm Ø**
Heat Exchanger / Evaporator / Heater		2×10^{-3}	2×10^{-3}
Pumps (centrifugal or reciprocating)		5×10^{-3}	1×10^{-3}
Ro-Pax	1×10^{-2} collision / 1×10^{-2} grounding		
Cruise Ship	5×10^{-3} collision / 1×10^{-2} grounding		
Container Ship	2×10^{-2} collision / 7×10^{-3} grounding (data refers to wrecked/stranded)		

The likelihood values include all collisions and groundings. For collisions this means all collisions where the ship is 'struck' and where the ship is the 'striking ship'. The likelihood of interest might be less than the values above when consideration is given to ship, route and incident specifics. For example, assuming a release requires a Ro-Pax ship to be 'struck' and the collision to be 'serious' then the likelihood value approximates 5×10^{-4} (i.e. category 4 'Unlikely' where 'struck/striking' is assumed 50/50 and about 10% of collisions are 'serious'[21]).

20. Indicative values are based on (a) and (b) and summarised in (c): (a) International Association of Oil & Gas Producers. (1 March 2010). Risk Assessment Data Directory – Process Release Frequencies, Report No. 434 – 1; (b) Health and Safety Executive. (1992-2006). Hydrocarbon Releases (HCR) System. https://www.hse.gov.uk/hcr3/; (c) LNG as a Marine Fuel - Likelihood of LNG Releases. Journal of Marine Engineering & Technology (JMET), Vol. 12, Issue 3, September 2013.

21. Formal Safety Assessment (FSA): FSA Container Vessels, MSC 83/21/2 (Table 3), 3 July 2007; FSA Cruise Ships, MSC 85/17/1 (Table 1), 21 July 2008; and FSA RoPax Ships, MSC 85/17/2 (Table 1), 21 July 2008.

Appendix 6
Mitigation measures

Example mitigation measures

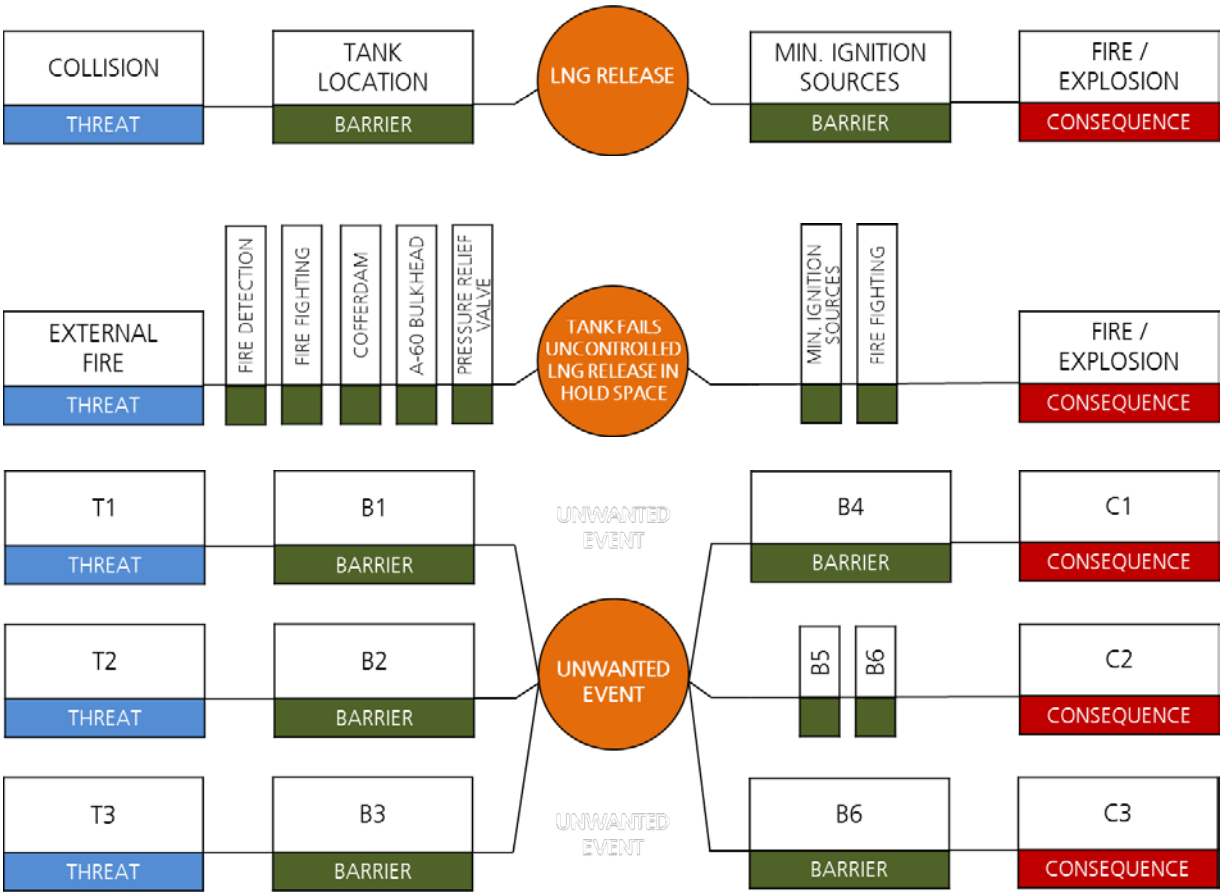
Engineering Mitigation Measures
Protection from mechanical impact damage
Protection from vibration / vibration monitoring
Protection from wind, waves and weather
Pressure relief, venting
Increased separation or increased physical protection from collision / grounding
Secondary containment (e.g. double-walled pipework)
Welded connections in preference to flanged connections
Alarmed and self-closing doors
Bulkhead separation / cofferdam
Drip tray capacity, liquid detection
Spray shield coverage
Protection of structure from cryogenic temperatures and pressure from evolved vapour / gas
Independent bilge
Fire and gas detection, monitoring, audible / visual alarm and shutdown
Pressure and temperature detection, audible / visual monitoring, alarm and shutdown
Level detection
Forced / natural ventilation - airlock
Minimisation of ignition sources - Ex proof electrical equipment
Fire-fighting fire and cooling appliances - foam, water spray
Fire dampers
Separation of spaces
Access arrangements
Physical shielding
Mooring tension monitoring / alarm
Strain monitoring of supports
Buffer / overflow tank - Fuel recycling
Independent safety critical controls to IEC 61508
Radar monitoring
Service fluid - level / gas detection, alarm and shutdown
Flame arrestor
Procedural Mitigation Measures
Increased frequency of inspection (and maintenance)
Reduced parts replacement frequency
Specific training for low-flashpoint fuels
Restricted access
Monitoring
Note:
1. The mitigation measures above are largely generic and in no particular order. They are listed as a simple *aide memoir* when considering mitigation.
2. Within the IGF Code, measures to reduce likelihood and measures to reduce consequences are both understood to be mitigation measures (i.e. they mitigate the risk). To align with the IGF Code this understanding is maintained within this document. It is recognised that in many other industries it is common to use the terms ‘prevention measures’ and ‘mitigation measures’, where the former reduces likelihood and the latter reduces consequences. Prevention and mitigation measures are often referred to as ‘safeguards’ or ‘barriers’.

Appendix 7
Cause to Consequence Mapping

An established means to illustrate or map the pathway from 'cause' to 'consequence' is known as Bowtie. There are a number of variations on this theme and differing terminologies but essentially the Bowtie helps to visualise: threats or causes of an unwanted event; the barriers or mitigation measures to prevent the unwanted event; and the barriers to mitigate the consequences.

Bowtie examples

Threat – *A cause that can potentially lead to the unwanted event.*
Barrier – *A mitigation measure that can potentially prevent the unwanted event or its consequences.*
Unwanted Event – *A situation to be avoided e.g. a release of fuel or a loss of ship propulsion.*
Consequence – *An outcome of a threat and an unwanted event not being mitigated by the barriers.*



In respect of 'mitigation measures' (i.e. barriers) those prior to the unwanted event are often referred to as preventative barriers or prevention measures.

Appendix 8
Report Contents

Example report contents

Executive summary
An overview of the assessment and main results and conclusions.
1. Introduction
A brief statement on the purpose of the assessment and the parties involved.
2. Objective and Scope
The principal objective is, for example, to demonstrate that the safety-risk is, or can be made acceptable/tolerable for Class approval. The scope is, for example, limited to the design/arrangement, the specific environment/location and the intended modes of operation.
3. Description
A simple explanation of the design and arrangement with respects to its intended operation and process conditions.
4. Approach
Overview of the risk assessment technique/method. This includes how the design was divided into sections for assessment, how hazard identification was undertaken, the selection of risk criteria, and the mechanism of risk rating and recording. In addition, a note on the actual workshop schedule illustrating the time expended on each section.
5. Team
The names, job titles, relevant qualifications, expertise and experience of the facilitator and SMEs. This can be recorded in a table, together with a record of workshop attendance. If this information is particularly large and would detract from the approach and results, the information can be included as an appendix.
6. Results
Discussion of the main findings and issues.
7. Conclusions
A summary judgement on whether the risks are ‘mitigated as necessary’.
8. Actions
A listing of additional/alternative safeguards, including who is responsible and expected completion date.
Appendices
A. Worksheets (as recorded in the workshop, including guidewords and phrases i.e. prompts).
B. Drawings, Process Information and Reference Documents (including the Terms of Reference).

BCS-G 148 Survey of liquefied gas fuel containment systems

The International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code), MSC Res.391(95) paragraph 6.4.1.8 states:

An inspection/survey plan for the liquefied gas fuel containment system shall be developed and approved by the Administration. The inspection/survey plan shall identify aspects to be examined and/or validated during surveys throughout the liquefied gas fuel containment system's life and, in particular, any necessary in-service survey, maintenance and testing that was assumed when selecting liquefied gas fuel containment system design parameters. The inspection/survey plan may include specific critical locations as per 6.4.12.2.8 or 6.4.12.2.9.

1. In developing the inspection/survey plan, the requirements for the survey of liquefied gas fuel containment systems are to be in accordance with the requirements of Unified Requirement Z16, Section 2.2 except as noted below:

1.1. The tank insulation and tank support arrangements should be visually examined. Non-destructive testing may be required if conditions raise doubt to the structural integrity.

1.2. Vacuum insulated independent fuel storage tanks of type C without access openings need not be examined internally. Where fitted, the vacuum monitoring system should be examined and records should be reviewed.

2. For vessels which need not comply with the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code), MSC Res.391(95), as amended, even though an inspection/survey plan is not required, the survey for liquefied gas fuel containment systems should be in accordance with paragraph 1.

BCS- G 149

Guidance for applying the requirements of 15.4.1.2 and 15.4.1.3 of the IGC Code (on ships constructed on or after 1 July 2016)

The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) as amended by Res. MSC.370(93), 15.4 states:

> *15.4 Determination of increased filling limit*
>
> *15.4.1 A filling limit greater than the limit of 98% specified in 15.3 may be permitted under the trim and list conditions specified in 8.2.17, providing:*
>
> *.1 no isolated vapour pockets are created within the cargo tank;*
>
> *.2 the PRV inlet arrangement shall remain in the vapour space; and*
>
> *.3 allowances need to be provided for:*
>
> > *.1 volumetric expansion of the liquid cargo due to the pressure increase from the MARVS to full flow relieving pressure in accordance with 8.4.1;*
> >
> > *.2 an operational margin of minimum 0.1% of tank volume; and*
> >
> > *.3 tolerances of instrumentation such as level and temperature gauges.*
>
> *15.4.2 In no case shall a filling limit exceeding 99.5% at reference temperature be permitted.*

1. Determining PRV inlet remains in vapour space (15.4.1.2)

The PRV inlet shall remain in the vapour space at a minimum distance of 40% of the diameter of the suction funnel measured at the centre of the funnel above the liquid level under conditions of 15° list and 0.015L trim.

2. Calculation of Allowances (15.4.1.3)

The following method may be used to determine the allowance. BCS may accept other methods to determine the allowance provided the method meets an equivalent level of safety.

The parameters specified under 15.4.1.3 may be expressed by the expansion factors α_1 through α_4 as follows:

α_1 = relative increase in liquid volume due to tolerance of level gauges

α_2 = relative increase in liquid volume due to the tolerance of temperature gauges

α_3 = expansion of cargo volume due to pressure rise when pressure relief valves are relieving at maximum flow rate

α_4 = operational margin of 0.1%

The factors α_1 through α_4 are to be determined as follows:

$$\alpha_1 = \frac{dV}{dh} \cdot \frac{\Delta h}{V} \cdot 100(\%)$$

where:

$\frac{dV}{dh}$ = variation of tank volume per metre filling height at the filling height h (m^3/m)

h = filling height (m) at the filling limit FL to be investigated (FL > 98%)

V = accepted total tank volume (m^3)

Δh = max. total tolerance of level gauges (m)

$$\alpha_2 = \beta \cdot \Delta T(\%)$$

where:

β = volumetric thermal expansion coefficient at reference temperature (%/ºK)

ΔT = max. tolerance of temperature gauge (ºK)

$\alpha_3 = \left(\frac{\rho_{PRV}}{\rho_{PRV \cdot 1.2}} - 1 \right) \cdot 100(\%)$ expansion due to pressure rise when relieving at full capacity

ρ_{PRV} = ρ_R cargo density at reference conditions, i.e. corresponding to the temperature of the cargo at set opening pressure of the pressure relief valve (PRV)

$\rho_{PRV \cdot 1.2}$ = cargo density corresponding to the temperature of the cargo at 1.2 times the set opening pressure of the pressure relief valve (PRV)

α_4 = 0.1% operational margin

Based on the factors α_1 through α_4 the following total expansion factor α_t is to be determined

$$\alpha_t = \sqrt{\alpha_1^2 + \alpha_2^2} + \alpha_3 + \alpha_4(\%)$$

BCS-G 150 Vapour pockets not in communication with cargo tank vapour / liquid domes on liquefied gas carriers

The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) as amended by Res. MSC.370(93), 8.2.17 states:

> *PRVs shall be connected to the highest part of the cargo tank above deck level. PRVs shall be positioned on the cargo tank so that they will remain in the vapour phase at the filling limit (FL) as defined in chapter 15, under conditions of 15° list and 0.015L trim, where L is defined in 1.2.31.*

Under normal operating conditions, the vapour space is continuous and in communication with the vapour/liquid domes where the vapour line and cargo tank pressure relief valves (PRVs) are located. However, due to the geometry of the tank there may be times when a vapour pocket can be formed in a cargo tank on a liquefied gas carrier which is not in communication with the vapour/liquid domes. The vast majority of these conditions occur in a dynamic condition and are dissipated by the motion of the ship. However, there can be situations where the pocket exists in a static condition, for instance, due to damage to the ship caused by an accident such as grounding or collision. Even though the IGC Code states that the PRVs should be in the vapour phase under conditions of 15° list and 0.015L trim and presumes that no isolated vapour pockets are formed within this range in principle, this scenario can occur at other trim and list values based upon the filling level of the tank since the ship is designed to survive a damage condition up to 30° of list.

In this condition, there is the potential for liquid build-up in the vapour/liquid domes caused by a pressure differential between the isolated vapour pocket and the vapour/liquid domes resulting in a possible overflow of cargo liquid into the vapour line or into the tank PRVs.

Even though the likelihood of this situation occurring may be minimal, the consequences could be quite severe and lead up to the loss of the ship. Owners/operators of liquefied gas carriers, in consultation with the cargo containment system/cargo handling system designers, are recommended to develop emergency procedures to mitigate the risks to the vessel caused by isolated vapour pockets. These procedures should identify the condition when isolated vapour pockets can be present and contain measures to reduce or eliminate them and/or mitigate their consequences such as cargo jettisoning, transfer of cargo between tanks, and cargo vapourization/utilization based upon different scenarios following the accident, including, but not limited to, loss of power, limited ability to reduce angle of heel or trim.

These emergency procedures are not a substitute for requirement 15.4.1.1 when determining the increased filling limits.

BCS-G. 167 Guidelines for the Identification of Vibration Issues and Recommended Remedial Measures on Ships

1. Introduction

The most efficient way to meet vibration criteria is to undertake a vibration analysis and apply appropriate controls during the design stage. After the vessel is built there are less options readily available to rectify vibration problems in hull structures and the cost of fixing such problems is much more expensive in-service than if incorporated into the design from the preliminary design stage. Therefore, careful consideration should be given to incorporating vibration reduction elements during the design stage by either using experience with satisfactory service history or by employing analytical methods.

Having mentioned the above, this guidance is limited to identifying vibration problems in hull structures on newly built or in-service vessels and lists a few common remedial actions to make improvements to address those problems. It is recommended that consideration be given to employing experts in the measurement, evaluation and resolution of issues should vibration problems in hull structures be present.

This document is an BCS Recommendation which is a guideline and not necessarily a direct matter of class, but which BCS considers would be helpful to offer some advice to the marine industry. Further, this Recommendation may be utilized to supplement the IMO GBS requirements, i.e. SOLAS II-1/Reg. 3-10, the functional requirement 3.2.1.11 in Resolution MSC.296(87) GBS verification guidelines, and BCS CSR Part 1 Ch 10 Sec 2 [3. 1.1]. As these guidelines are recommendations they are not mandatorily applied.

2. Terminology

Damping: The dissipation of energy with time or distance. In this document, damping generally refers to dissipation of vibrating energy in structures.

Hard Mounting: Rigid attachment of a machine to its sub-base or foundation.

Isolation: The coupling of a vibrating structure (e.g., machine) to another structure (e.g., foundation or hull) by means of resilient or compliant supports that prevent the transmission of the vibration from the vibrating structure to the coupled structure.

Resonance: (1) The phenomenon of amplification of a free wave or oscillation of a system by a forced wave or oscillation of exactly equal period. The forced wave may arise from an impressed force upon the system or from a boundary condition. The growth of the resonant amplitude is characteristically linear in time. (2) Of a system in forced oscillation, the condition that exists when any change, however small, in the frequency of excitation causes a decrease in the response of the system.

Vibration: The variation with time of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value. Also referred to as structure-borne noise.

Vibration Level: Measure of the amplitude of vibration. Most commonly given as acceleration in mm/s^2 or velocity in mm/s.

3. Sources of Vibration

The most basic forces of interest are those generated by engines, propellers, and shafts. Other common sources of vibration include: gears, screws, thrusters, fans, compressors, pumps, pipes, and valves. Flow generated vibrations may also occur.

3.1 Machinery Excitation – Unbalanced or misaligned machinery, particularly propulsion machinery such as the main propulsion engines, is the major source of excessive vibration and can develop excitation forces in the frequency range of interest for both the equipment and structure in the vicinity of the machinery. These frequencies of excitation match either the rotation rate, or twice the rotation rate.

3.1.1 Diesel Engines – Diesel engines, whether low, medium or high speed – two or four stroke, generate significant force and moment coupled vibration excitation. The diesel firing forces, which depend on rotation rate and the number of cylinders, are impulsive in nature, which causes components of vibration at many harmonics of the firing frequency. Low-speed propulsion diesel engines are typically more of a concern than high-speed diesel engines because their low excitation frequencies are more likely to lie in the range of a hull natural frequency. As a result, diesel engines, and other reciprocating machinery, may develop forces and moments, which are sufficient to create excessive ship vibration. These forces/moments may excite the machinery itself, the ship foundation on which it is attached, the hull girder, or other structures within the vessel.

The excitation of a reciprocating engine can be divided into two parts:

- Unbalanced inertial forces
- Firing forces/moments

The unbalanced inertial forces are associated with the rotating or reciprocal masses. The frequencies of resulting forces are multiples of shaft rotation rate.

A 4- stroke engine has twice as many ‘firing’ harmonics as a 2- stroke engine. Analytical calculations of diesel engine generated forces are not easily undertaken and should be left to the diesel engine vendor.

3.2 Propulsion and Shafting Excitation – The basic design purpose of the propulsor is to generate steady thrust to the vessel. In addition, this propulsor generates undesired fluctuating dynamic forces and moments due to its operation in a non-uniform wake and due to passage of the blades close to hull and appendages.

3.2.1 Hull Pressure vs. Bearing Forces – Propellers generate two types of fluctuating forces. These are hull pressure forces and bearing forces. The hull pressure originates from the hydro-acoustic pressure variations caused by the passage of a propeller through non-uniform inflow or wake. These hull pressure forces are affected by propeller-hull clearance in the vertical and horizontal directions, by blade loading, and by changes in the local pressure field around the blades.

Bearing forces are caused by fluctuating forces on the blade during a propeller rotation which generate both vertical and horizontal forces on the shaft. These vertical and horizontal forces produce lateral and axial forces and moments on the support bearings and thrust bearing. The frequencies of these forces and moments are the same as for the hull pressure, shaft rate, blade rate, and multiples.

The thrust bearing forces provide an excitation to the propulsion system in the longitudinal direction; the fluctuating torque produces shaft torsional vibration. The blade frequency vertical bearing force, when combined with same frequency vertical hull pressures, provides the overall vertical excitation of the hull in the vertical direction. Similarly, the combined horizontal forces excite the hull in the horizontal direction. Dynamic unbalance of any component of the system (propeller, shaft, coupling, gear, and engine) will increase the resulting hull vibration levels.

3.2.2 Cavitation – Where there is the occurrence of cavitation, (the sudden formation and collapse of low-pressure bubbles in liquids by means of mechanical forces, such as those resulting from rotation of a propeller), there is a significant increase in the hull pressure forces. Again, the frequencies of these propeller impacts are shaft rate, blade rate, and 2× and 3× multiples of the blade rate.

3.2.3 Thrusters – Another significant vibration source may be the bow or stern thruster(s). These units can be located relatively close to accommodations and can cause high vibration. As discussed above for the prime propulsor, inflow and propeller design control the induced vibration levels.

4. Structural Response

Generally, it is important to ensure that the natural frequencies of the fundamental hull girder vibration modes do not coincide with the excitation frequencies from any of the major excitation sources (propellers/main engines). This is normally ensured by global vibration calculations during design stage. However, increased vibration levels caused by hull girder modes excited by machinery or propellers can sometimes be experienced during sea trial or operation. The natural frequencies of the hull girder modes are influenced by the draft, trim and load distribution along the hull girder.

Substructures, like decks, machinery platforms, or the deckhouse, of sufficient mass and flexibility also need to be considered in a vibration-related survey. These substructures have their own natural frequencies, which should not coincide with primary excitation frequencies. The natural frequencies of these substructures are usually higher than that of the whole hull. However local structural elements like plates, bulkheads, parts of the deck, rudders, and machinery platforms may have natural frequencies which are close to the excitation frequencies. Massive equipment installed on platforms may have a large influence on the resulting natural frequency.

5. Vibration Assessment

If observations regarding vibration are made, it is helpful to remember that vibration levels experienced as “uncomfortable” are normally well below vibration levels necessary to create structural problems.

If found necessary based on vibrations experienced by the surveyor or personnel during the vessel trials or operation, vibration measurements should be considered. Changes in the text plan might be necessary or a test plan should be developed which includes evaluation of relevant measurement locations and vessel operating conditions. This may include measurement positions suitable for describing global vibration behavior of hull girder and deck house, as well as local positions in accommodation and machinery areas. Locations should include the potentially ‘worst locations’ (e.g., closest to sources or places expected to have maximum vibration).

Vibrations can in all cases be expected during maneuvering or during operation far outside of normal operation range for the vessel. Such temporarily experienced vibrations are normal and should not be considered problematic.

There are several international standards which address vibration, measurement procedures and evaluation. It is recommended to use the following standards, although not limited to them, as guidelines:

- ISO 20283-5:2016, Mechanical Vibration – Measurement of Vibration on Ships – Part 5: Guidelines for Measurement, Evaluation and Reporting of Vibration with Regard to Habitability on Passenger and Merchant Ships
- ISO 8041:2005, Human Response to Vibration – Measuring Instrumentation
- ISO 5348:1998, Mechanical Vibration and Shock – Mechanical Mounting of Accelerometers
- ISO 20283-2:2008, Mechanical Vibration – Measurement of Vibration on Ships – Part 2: Measurement of Structural Vibration

6. Measurements

The following summarizes some typical measurement types that may be relevant in case of severe vibrations. For all vibration related issues where measurements are considered, it is important that a proper measurement procedure is established by personnel with vibration expertise.

6.1 Global Structures – If vibrations are of a global nature, e.g. longitudinal vibrations in the deck house, it may be relevant to carry out measurements to establish the vibration behavior of the hull girder or deck house. Reference is made to ISO 20283-2.

6.2 Local Structures – Local structure includes plates and stiffened panels in deck or bulkheads. For local deck areas in the accommodation vibrations are normally only a problem for human comfort. This is further discussed in BCS-G 132. Reference is also made to ISO 20283-5 . Vibrations in plates or panels in way of bulkheads, e.g. tank boundaries, can be a cause of structural damage.

If severe or critical local vibration exists, vertical, transverse, and/or longitudinal measurements are taken at the suspect location in order to determine the need for corrective measures. If the problem is established as highly localized resonant vibration of plating panels, piping, etc., then the vibration survey likely needs to go no further. It is usually obvious in such cases how natural frequency changes, through local stiffening, can be effectively accomplished to eliminate the local resonant conditions.

6.3 Semi-global structure – If vibrations are of a semi global nature, e.g. including an entire deck or coupling between decks, vertical and transverse vibration bending shape measurements can be taken using a significant number of points necessary to determine the mode shapes at low frequencies while avoiding local resonances. These types of measurements are made by use of a reference transducer at the stern along with a portable transducer. Torsional modes may require phased deck-edge measurements.

6.4 Vibration source measurements – Some of the following measurements may be relevant investigating the source of any excessive structural vibrations in hull or accommodation areas. Often measurements of machinery vibration or propeller pressure pulses are taken simultaneously with measurements of relevant structural positions. In cases

with variable rpm on relevant machinery or propellers, such measurements are normally carried out as a run-up.

6.4.1 Local Machinery and Equipment – Vertical, transverse and/or longitudinal measurements are taken on non-rotating parts of the machinery where there is evidence of large vibration amplitudes. Types of machinery and equipment include diesel generator, electric motors, air compressors, ballast pumps, etc. Vibration measurements are normally taken at the bearing position and /or foundation.

6.4.2 Shell Near Propeller – If necessary, the measurements of hull surface pressure are taken in order to confirm design estimates, to obtain design data or to investigate hull pressure forces or potential cavitation problems.

To minimize the effect of plate vibration, all transducers in the hull plating are located as close as possible to adjacent frames or partial bulkheads.

6.4.3 Main Engine and Thrust Bearing –, Vertical, transverse, and longitudinal measurements are taken in order to determine the need for corrective measures. In some cases, measurements to establish an operational deflection shape (ODS) of the engine can be relevant. ODS measurements are carried out either with simultaneous measurement with numerous fixed sensors or more commonly with one fixed sensor and one or more roaming sensors. Such measurements are time consuming and with high demand to equipment and postprocessing tools. However, they may be a helpful tool for troubleshooting cases.

6.4.4 Lateral Shaft Vibration – If this measurement is conducted, vertical and transverse vibration measurements are made on the shaft. Additional measurement points may be taken. These measurements are made throughout the normal operational range of the ship.

In order to eliminate possible error, shaft run-out is checked by rotating the shaft by the turning gear and recording the first-order signal. This signal is phased, and the shaft vibration measurement corrected accordingly.

6.4.5 Torsional Shaft Vibration – If this measurement is conducted, torsional vibration measurements are taken either at the free end of the propulsion machinery, using a suitable torsional vibration transducer, and/or on the main shafting, using strain gauges. Alternatively, depending on the system characteristics, a mechanical torsiograph, driven from a suitable position along the shafting or free end, may be used for this purpose.

7. Remedial Measures

A foundation for critical vibration sources (e.g., large reciprocating machinery) typically is fitted with a thick foundation top plate, stiff floors, and local gussets between these two members in way of attachment points in order to provide damping of the vibratory forces. This is true whether the machinery is isolation mounted or not.

7.1 General Approach – The test report should describe the operating conditions for measurements, including weather, sea state, speed, rpm, water depth under keel, and other pertinent data. The report should show the locations of measurements and overall rms value in mm/s or mm/s^2. For additional information the spectrum and/or single peak level with corresponding frequency could also be recorded. As the vibration control treatment designs evolve, drawings and other design information should be reviewed by one familiar with the design of treatments to verify that the treatment design adequately reflects vibrational considerations mentioned in the report.

Just as in developing a vibration-sufficient ship design, there exist three possibilities for correcting a vibration-deficient one in normal practice:

i) Reduce vibratory excitation

ii) Change natural frequencies to avoid resonance

iii) Change exciting frequencies to avoid resonance.

Most of the excessive diesel engine excited hull vibration can usually be corrected by the following provisions:

i) Mechanical or electrical moment compensators against engine external moments, or

ii) Engine lateral stays of weld, hydraulic or friction type against engine lateral vibration, or

iii) Axial damper against crank shaft vibration, or

iv) Dynamic absorber against fore-and-aft vibration of deckhouse.

The detail information necessary for the installations of above provisions is typically provided by engine or equipment manufacturers.

7.2 Structural Modifications – The most cost-effective approach for eliminating structural resonances is usually to shift natural frequencies through structural modifications such as adding panel stiffeners.

7.3 Propeller or wake modifications – For cases where the pressure pulses or shaft forces from the propellers are the source of excessive vibrations, it may be a solution to modify the propeller design or to manipulate the wake in order to reduce the excitation forces.

7.4 Machinery modifications – For vibration caused by unbalanced or misaligned machinery, the 'treatment' in these cases is to correct the mechanical problem. This represents another basic design function often carried out by the equipment vendor, who usually takes responsibility for the proper selection of vibration dampers, torsional couplings, and flexible shaft couplings.

7.4.1 Top stays - For vibration caused by e.g. main engine H-moment, the solution may be to add (or in some cases remove) top stays. Active top-stays can in some special cases be relevant.

7.4.2 Moment compensator – The excitation by main engine forces can in many cases be limited by installation of a moment compensator. This can be a solution for both 1st order, 2nd order, H-moment and X-moment excitation.

7.4.3 Resilient Mounts – If there is no inherent mechanical problem, resilient mounts may provide some abatement. However, isolation mounting provides no vibration reduction below the systems natural frequency and may amplify the vibration in the vicinity of the system resonance. Resilient mounts need careful design for two reasons. Vibration levels of the machinery itself are actually higher on resilient mounts than that if the machinery is hard mounted. Another concern is that the excitation frequencies of the machinery should not coincide with isolation system's natural frequencies. To avoid such a coincidence, the selection of the resilient mounts should be made with consultation of experts or the equipment manufacturer accompanied with calculations of natural frequencies of a 'machinery-resilient mount' system (six degrees of freedom calculations). The lower the

natural frequency (softer resilient mounts), the lower the vibratory effect will be on the foundation and adjacent structures.

7.4.4 Foundation – Designing a stiff foundation structure is the most important approach to prevent excessive machinery induced vibration. The incorporation of a stiff egg-crate like framing and flooring system is preferable and should be a relatively light system of floors in either the longitudinal or transverse direction only. Transverse plating of a foundation should be a continuation of rigid floors; longitudinal plating should be incorporated into longitudinal stiff girders. The structure of thrust bearing foundations is also important, especially for systems with a Cardan shaft (universal joint).

8. Verification of Countermeasures

It is important that proper verifications are carried out to determine the effectiveness of the vibration treatment measures. This can include re-measurement of affected areas and/or calculations or documentation of the effect of the modifications carried out. The extent of necessary follow-up needs to be evaluated from case by case. The performance of vibration control treatments is ultimately dependent on the quality of the implementation. Seemingly trivial deviations from the detailed design, or inadvertent errors due to unfamiliarity with vibration control treatment materials and constructions, may compromise vibrational performance. Hence re-measurements will often be requested.