Rules Classification of Offshore Units Operating in the Caspian Sea and Similar Areas

Effective from 1 January 2023

Part F

Additional Class Notations

GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

- (i) Rules for the Classification of Ships or other special units;
- (ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
- (iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
- (iv) Guides to carry out particular activities connected with Services;
- (v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
- (i) sets forth and develops Rules;
- (ii) publishes the Register of Ships;
- (iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various G overnments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatemen t. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
- (i) in the selection of its Surveyors
- (ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of th e specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as p art of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificati on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaw orthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.
These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.
In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.
In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.
Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.
With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any statutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.
Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of cl ass, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific propert y of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS OPERATING IN THE CASPIAN SEA AND SIMILAR AREAS

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Part F
Additional Class Notations

Chapter 6
ICE CLASS (ICE)

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 The following additional class notations are assigned in accordance with Pt A, Ch 1, Sec 2, [6.7] to ships strengthened for navigation in ice and complying with the relevant requirements of this Chapter :

- **ICE CLASS IA SUPER**
- **ICE CLASS IA**
- **ICE CLASS IB**
- **ICE CLASS IC**
- **ICE CLASS ID.**

1.1.2

Except for those applicable to ships with the additional class notation ICE CLASS ID, the ice strengthening requirements in this Chapter are equivalent to those stated in the "Finnish-Swedish Ice Class Rules, 2010", as adopted by the Finnish Transport Safety Agency (TRAF) on 23 November 2010", applicable to ships trading in the Northern Baltic Sea in winter.

1.1.3 For the purpose of this Chapter, the notations mentioned in [1.1.1] may be indicated using the following abbrevations:

- **IAS** for **ICE CLASS IA SUPER**
- **IA** for **ICE CLASS IA**
- **IB** for **ICE CLASS IB**
- **IC** for **ICE CLASS IC**
- **ID** for **ICE CLASS ID.**

1.2 Owner's responsibility

1.2.1 It is the responsibility of the Owner to decide which ice class notation is the most suitable in relation to the expected service conditions of the ship.

Nevertheless, it is to be noted that a ship assigned with the ice class notation **IAS** is not to be considered as a ship suitable for navigation in ice in any environmental condition, such as an icebreaker.

2 Ice class draughts and ice thickness

2.1 Definitions

2.1.1 Upper and lower ice waterlines

a) The upper ice waterline (UIWL) is to be the envelope of the highest points of the waterlines at which the ship is intended to operate in ice. The line may be a broken line.

b) The lower ice waterline (LIWL) is to be the envelope of the lowest points of the waterlines at which the ship is intended to operate in ice. The line may be a broken line.

2.1.2 Fore and aft draughts

The maximum and minimum ice class draughts at fore and aft perpendiculars are to be determined in accordance with the upper and lower ice waterlines.

2.1.3 Ice belt

The ice belt is that portion of the side shell which is to be strengthened; its vertical extension is equal to the required extension of strengthening.

2.2 Draught limitations

2.2.1 Maximum draught

The draught and trim limited by the UIWL are not to be exceeded when the ship is navigating in ice.

The salinity of the sea water along the intended route is to be taken into account when loading the ship.

2.2.2 Minimum draught

The ship is always to be loaded down to at least the LIWL when navigating in ice.

2.2.3 Minimum forward draught

In determining the LIWL, due regard is to be paid to the need to ensure a reasonable degree of ice going capability in ballast. The propeller is to be fully submerged, if possible entirely below the ice. The minimum forward draught is to be at least equal to the value T_{AV}, in m, given by the following formula:

$$T_{AV} = (2 + 0{,}00025\Delta_1)h_G$$

where:

Δ_1 : Displacement of the ship, in t, on the maximum ice class draught amidships, as defined in [2.2.1]

h_G : Ice thickness, in m, as defined in [2.3].

The draught T_{AV} need not, however, exceed 4 h_G.

2.2.4 Indication of maximum and minimum draughts

The maximum and minimum ice class draughts fore, amidships and aft are to be specified in the plans submitted for approval to the Society and stated on the Certificate of Classification.

Restrictions on draughts when operating in ice are to be documented and kept on board readily available for the Master.

2.2.5 Warning triangle

If the summer load line in fresh water is located at a higher level than the UIWL, the ship's sides are to be provided with a warning triangle and with an ice class draught mark at the maximum permissible ice class draught amidships (see Fig 1).

The purpose of the warning triangle is to provide information on the draught limitation of the vessel when it is sailing in ice for Masters of icebreakers and for inspection personnel in ports.

The upper edge of the warning triangle is to be located vertically above the "ICE" mark, 1000 mm higher than the summer load line in fresh water but in no case higher than the deck line. The sides of the triangle are to be 300 mm in length.

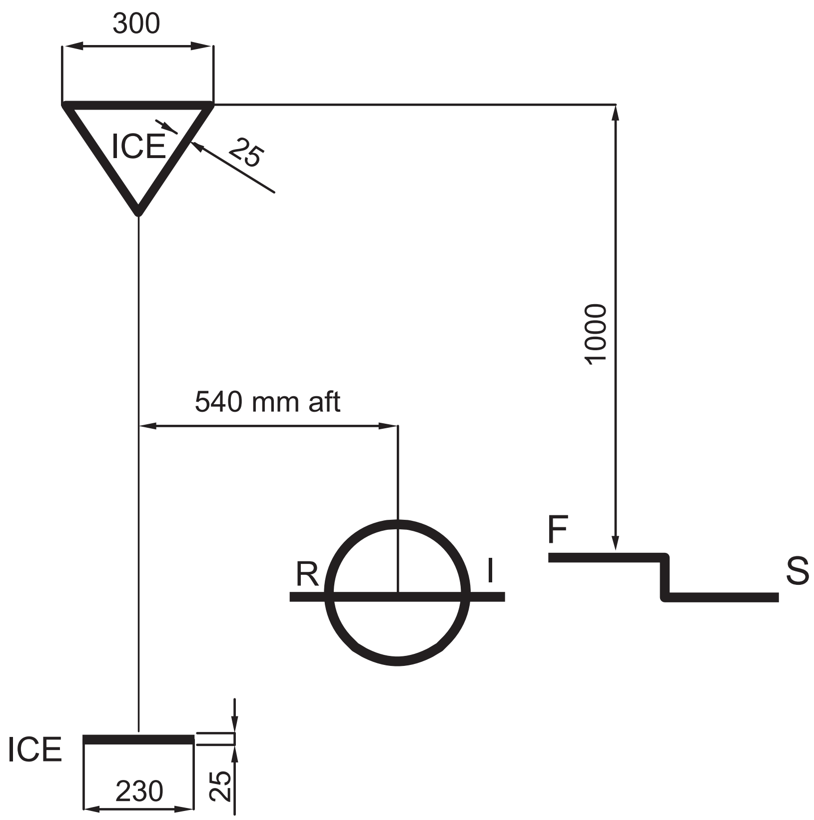
The ice class draught mark is to be located 540 mm abaft the centre of the load line ring or 540 mm abaft the vertical line of the timber load line mark, if applicable.

The marks and figures are to be cut out of 5 - 8 mm plate and then welded to the ship's side.

The marks and figures are to be painted in a red or yellow reflecting colour so that they are plainly visible even in ice conditions.

The dimensions of all figures are to be the same as those used in the load line mark.

Figure 1 : Warning triangle



2.3 Ice thickness

2.3.1

a) An ice strengthened ship is assumed to operate in open sea conditions corresponding to a level ice with a thickness not exceeding the value h_G.

b) The design height of the area actually under ice pressure at any time is, however, assumed to be only a fraction h, of the ice thickness h_G.

c) The values for h_G and h, in m, are given in Tab 1.

Table 1

Ice class notation	h_G (m)	h (m)
IAS	1,0	0,35
IA	0,8	0,30
IB	0,6	0,25
IC	0,4	0,22

3 Output of propulsion machinery

3.1 Required engine output

3.1.1 Definitions

The output P is the maximum output that the propulsion machinery can continuously deliver to the propeller.

If the output of the machinery is restricted by technical means or by any regulation applicable to the ship, P is to be taken as the restricted output.

The dimensions of the ship, defined below, are measured on the maximum ice class draught of the ship as defined in [2.2.1]. For the symbol definitions, see also Fig 2.

L : Length of the ship between the perpendiculars, in m

L_{BOW} : Length of the bow, in m

L_{PAR} : Length of the parallel midship body, in m

B : Maximum breadth of the ship, in m

T : Maximum ice class draught of the ship, in m, according to [2.2.1]

A_{wf} : Area of the waterline of the bow, in m²

α : Angle of the waterline at B/4, in deg

ϕ_1 : Rake of the stem at the centreline, in deg

ϕ_2 : Rake of the bow at B/4, in deg

ψ : Flare angle calculated as $\psi = \arctan(\tan\alpha / \sin\phi)$ using angles α and ϕ at each location, in deg. Within this Article [3] flare angle is to be calculated using $\phi = \phi_2$

D_P : Diameter of the propeller, in m

H_M : Thickness of the brash ice in mid-channel, in m

H_F : Thickness of the brash ice layer displaced by the bow, in m.

3.1.2 Minimum required power for IAS, IA, IB, IC

The power of the propulsion machinery is to be not less than the value P_{MIN}, in kW, determined by the following formula, but in no case less than 1000 kW for IA, IB, IC and not less than 2800 kW for IAS:

$$P_{MIN} = K_C \frac{\left(\frac{R_{CH}}{1000}\right)^{3/2}}{D_P}$$

where:

K_C : to be taken from Tab 2

R_{CH} : Resistance of the ship in a channel with brash ice and a consolidated layer, in N, equal to:

$$R_{CH} = C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 (B + C_\psi H_F) + $$
$$+ C_4 L_{PAR} H_F^{\ 2} + C_5 \left(\frac{LT}{B^2}\right)^3 (A_{wf}/L)$$

with:

H_F : $0,26 + (H_M B)^{0,5}$

H_M : 1,0 for IAS and IA; 0,8 for IB; 0,6 for IC

C_μ : $0,15 \cos\phi_2 + \sin\psi \sin\alpha$, to be taken equal to or greater than 0,45

C_ψ : $0,047\psi - 2,115$, to be taken as 0 if $\psi \le 45°$

C_1 : Coefficient taking into account a consolidated upper layer of the brash ice and to be taken:

- for ice class **IA**,**IB** and **IC**:
  $C_1 = 0$
- for ice class **IAS**:

$$C_1 = f_1 \frac{B L_{PAR}}{\frac{2T}{B} + 1} + (1 + 0,021\phi_1)(f_2 B + f_3 L_{BOW} + $$
$$+ f_4 B L_{BOW})$$

C_2 : Coefficient taking into account a consolidated upper layer of the brash ice and to be taken:

- for ice class **IA**,**IB** and **IC**:
  $C_2 = 0$
- for ice class **IAS**:

$$C_2 = (1 + 0,063\phi_1)(g_1 + g_2 B) + g_3\left(1 + 1,2\frac{T}{B}\right)\frac{B^2}{L^{0,5}}$$

where:

ϕ_1 : to be taken equal to 90° for ships with bulbous bow

f_1 : 23 N/m²

f_2 : 45,8 N/m²

f_3 : 14,7 N/m²

f_4 : 29 N/m²

g_1 : 1530 N

g_2 : 170 N/m

g_3 : 400 N/m²

C_3 : 845 kg/m²s²

C_4 : 42 kg/m²s²

C_5 : 825 kg/s²

ψ : $\arctan(\tan\phi_2 / \sin\alpha)$

$\left(\frac{LT}{B^2}\right)^3$ is not to be taken less than 5 and greater than 20.

Table 2 : Values of K_C

Number of propellers	CP propellers or electric or hydraulic propulsion machinery	FP propellers
1 propeller	2,03	2,26
2 propellers	1,44	1,60
3 propellers	1,18	1,31

3.1.3 Other methods of determining K_C or R_{CH}

The Society may for an individual ship, in lieu of the K_C or R_{CH} values defined above, approve the use of K_C values based on more exact calculations or R_{CH} values based on model tests. Such approval will be given on the understanding that it can be revoked if experience of the ship's performance in practice warrants this.

The design requirement for ice classes is a minimum speed of 5 knots in the following brash ice channels:

- IAS : H_M = 1,0 m and a 0,1 m thick consolidated layer of ice
- IA : H_M = 1,0 m
- IB : H_M = 0,8 m
- IC : H_M = 0,6 m

3.1.4 Minimum required power for class ID

The power of the propulsion machinery is to be not less than the value P, in kW, determined by the following formula:

$$P = 0,72 LB$$

3.1.5 Range of validity

The range of validity of the formulae for powering requirements in [3.1.2] is presented in Tab 3.

When calculating the parameter D_P/T, T is to be measured at UIWL.

If the ship parameter values are beyond the ranges defined in Tab 3, other methods for defining R_{CH} are to be used, as defined in [3.1.3].

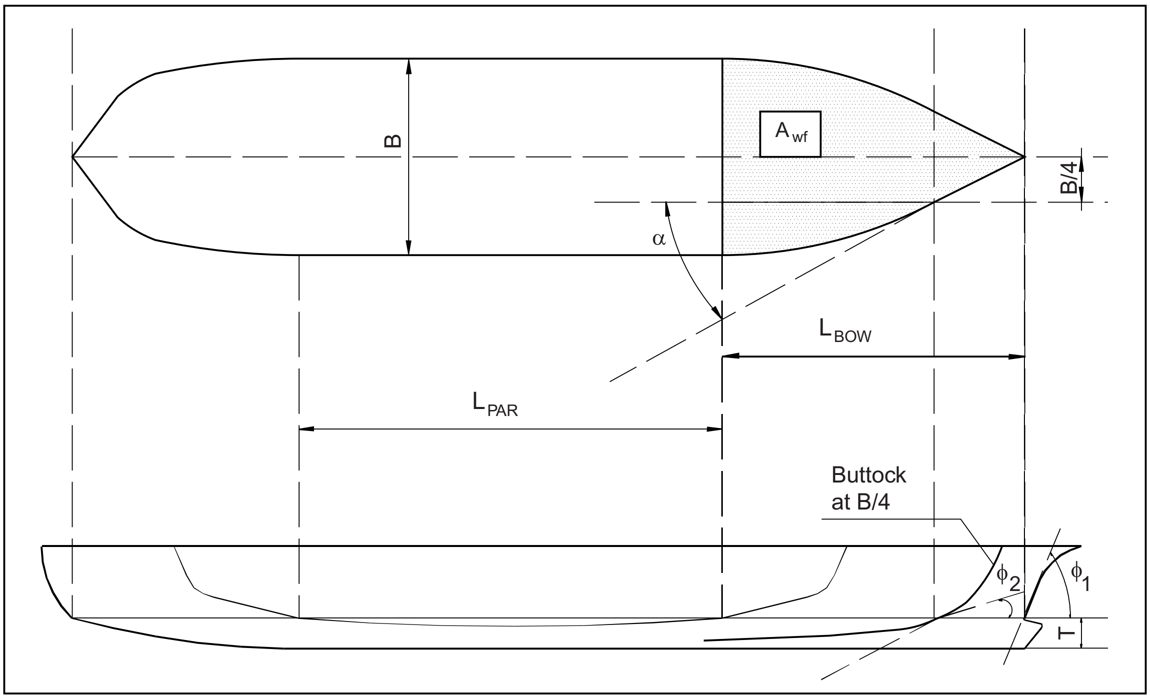
Table 3 : Range of parameters used for validation of the powering requirements

Parameter		Minimum	Maximum
α	[degrees]	15	55
ϕ_1	[degrees]	25	90
ϕ_2	[degrees]	10	90
L	[m]	65,0	250,0
B	[m]	11,0	40,0
T	[m]	4,0	15,0
L_{BOW} / L		0,15	0,40
L_{PAR} / L		0,25	0,75
D_P / T		0,45	0,75
Awf / (L * B)		0,09	0,27

3.1.6 Indication of minimum required power

The minimum required power is to be stated on the Certificate of Classification.

Figure 2



SECTION 2 HULL AND STABILITY

Symbols

UIWL : Load Waterline, defined in Sec 1, [2.1.2]

LIWL : Ballast Waterline, defined in Sec 1, [2.1.2]

s : Spacing, in m, of ordinary stiffeners or primary supporting members, as applicable

ℓ : Span, in m, of ordinary stiffeners or primary supporting members, as applicable

R_{eH} : Minimum yield stress, in N/mm², of the material as defined in Pt B, Ch 4, Sec 1, [2].

1 Definitions

1.1 Ice strengthened area

1.1.1 General

The vertical extension of the ice strengthened area (see Fig 1) is defined in:

- Tab 1 for plating
- Tab 2 for ordinary stiffeners and primary supporting members.

1.1.2 Fore foot

The fore foot is the area below the ice strengthened area defined in [1.1.1] extending from the stem to a position five ordinary stiffener spaces aft of the point where the bow profile departs from the keel line (see Fig 1).

1.1.3 Upper fore ice strengthened area

The upper fore is the area extending from the upper limit of the ice strengthened area defined in [1.1.1] to 2 m above and from the stem to a position at least 0,2L aft of the forward perpendicular (see Fig 1).

1.2 Regions

1.2.1 General

For the purpose of the assignment of the notations **ICE CLASS IA SUPER**, **ICE CLASS IA**, **ICE CLASS IB**, **ICE CLASS IC** and **ICE CLASS ID**, the ice strengthened area defined in [1.1.1] is divided into three regions defined in [1.2.2], [1.2.3], [1.2.4] and shown in Fig 1.

1.2.2 Fore region

The fore region is the region from the stem to a line parallel to and 0,04L aft of the forward borderline of the part of the hull where the waterlines run parallel to the centreline.

The overlap with the borderline need not exceed:

- 6 m for the notations **ICE CLASS IA SUPER** and **ICE CLASS IA**
- 5 m for the notations **ICE CLASS IB, ICE CLASS IC** and **ICE CLASS ID**.

Table 1 : Vertical extension of ice strengthened area for plating

<table>
<tr><th rowspan="2">Notgation</th><th rowspan="2">Region</th><th colspan="2">Vertical extension of ice strengthened area, in m</th></tr>
<tr><th>Above UIWL</th><th>Below LIWL</th></tr>
<tr><td rowspan="3">ICE CLASS IA SUPER</td><td>Fore region</td><td></td><td rowspan="2">1,20</td></tr>
<tr><td>Midship region</td><td>0,60</td></tr>
<tr><td>Aft region</td><td></td><td>1,0</td></tr>
<tr><td rowspan="3">ICE CLASS IA</td><td>Fore region</td><td></td><td>0,90</td></tr>
<tr><td>Midship region</td><td>0,50</td><td rowspan="2">0,75</td></tr>
<tr><td>Aft region</td><td></td></tr>
<tr><td rowspan="3">ICE CLASS IB
ICE CLASS IC</td><td>Fore region</td><td></td><td>0,70</td></tr>
<tr><td>Midship region</td><td>0,40</td><td rowspan="2">0,60</td></tr>
<tr><td>Aft region</td><td></td></tr>
<tr><td>ICE CLASS ID</td><td>Fore region</td><td>0,40</td><td>0,60</td></tr>
</table>

Figure 1 : Ice strengthened area and regions

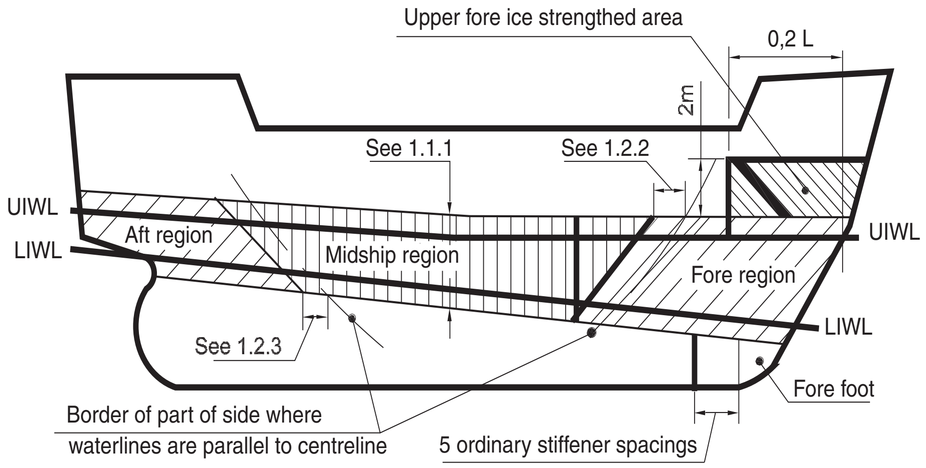


Table 2 : Vertical extension of ice strengthening for ordinary stiffeners and primary supporting members

Notation	Region	Vertical extension of ice strengthened area, in m,	
		above UIWL	below LIWL
ICE CLASS IA SUPER	Fore region	1,2	to double bottom or below top of floors
	Midship region		2,0
	Aft region		1,6
ICE CLASS IA **ICE CLASS IB** **ICE CLASS IC**	Fore region	1,0	1,6
	Midship region		1,3
	Aft region		1,0
ICE CLASS ID	Fore region	1,0	1,0

Note 1: Where an upper fore ice strengthened area is required (see [4.1.1]), the ice strengthened part of the ordinary stiffeners is to extend at least to the top of the ice strengthened area.
Note 2: Where the ice strengthened area extends beyond a deck or tank top by not more than 250 mm, it may be terminated at that deck or tank top.

1.2.3 Midship region

The midship region is the region from the aft boundary of the fore region to a line parallel to and 0,04L aft of the aft borderline of the part of the hull where the waterlines run parallel to the centreline.

The overlap with the borderline need not exceed:

- 6 m for the notations **ICE CLASS IA SUPER** and **ICE CLASS IA**
- 5 m for the notations **ICE CLASS IB** and **ICE CLASS IC**.

1.2.4 Aft region

The aft region is the region from the aft boundary of the midship region to the stern.

2 Structure design principles

2.1 General framing arrangement

2.1.1 Within the ice strengthened area defined in [1.1.1], all ordinary stiffeners are to be attached to the supporting structure by means of brackets having the same thickness as the frame web.

Ordinary stiffeners are to be connected to the structure of primary supporting members on both sides (i.e. a free edge of a scallop is to be connected to the ordinary stiffener by collar plates, as shown in Fig 2).

2.1.2

For the following regions of ice strengthened area:

- all regions of ships with the notation **ICE CLASS IA SUPER**
- fore and midship regions of ships with the notation **ICE CLASS IA**
- fore region of ships with the notations **ICE CLASS IB, ICE CLASS IC** or **ICE CLASS ID**,

the requirements which follow are to be complied with:

- ordinary stiffeners which are not at a right angle to the shell or with unsymmetrical profile and which have span exceeding 4000 mm are to be supported to prevent tripping by means of brackets, intercostals, stringers or similar at a distance not exceeding 1300 mm

If the span is less than 4000 mm, the support against tripping is required for ordinary stiffeners which are not at a right angle to the shell and with unsymmetrical profile.

- ordinary stiffeners are to be attached to the shell by double continuous welds; no scalloping is allowed (except when crossing shell plate butts)
- the web thickness t_w of ordinary stiffeners is to be at least as much as the greatest of the values obtained from the following formulae, in mm:

$$t_w = \frac{h_w \sqrt{R_{eH}}}{C}$$

$t_w = 25s$ for transverse framing

$t_w = 0,5t_p$

$t_w = 9$

h_w : web height of the ordinary stiffener, in mm

C : coefficient depending on the type of profile, to be taken as:

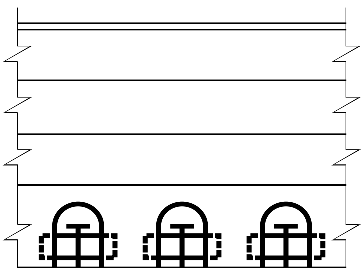
C = 282 for flat bars

C = 805 in other cases

t_p : shell plate thickness, to be calculated in accordance with [4.1.2] using R_{eH} of the ordinary stiffeners

Where there is a deck, tank top or bulkhead in lieu of an ordinary stiffener, the plate thickness is to be complied with to a depth corresponding to the height of adjacent ordinary stiffeners.

Figure 2 : End connection of ordinary stiffener Two collar plates



2.2 Longitudinal framing arrangement

2.2.1 Spacing of longitudinal ordinary stiffeners

The actual spacing of longitudinal ordinary stiffeners may not be greater than:

- 0,35 m for the notations **ICE CLASS IA SUPER** and **ICE CLASS IA**,
- 0,45 m for the notations **ICE CLASS IB**, **ICE CLASS IC** and **ICE CLASS ID**.

2.3 Transverse framing arrangement

2.3.1 Upper end of transverse framing

The upper end of the strengthened part of a main ordinary stiffener and intermediate ice ordinary stiffener is to be attached to a deck or an ice side girder as required in [4.3.1] and [4.3.2].

Where an intermediate ordinary stiffener terminates above a deck or an ice side girder which is situated at or above the upper limit of the ice strengthened area, the part above the deck or side girder may have the scantlings required for an unstrengthened ship and the upper end may be connected to the adjacent main ordinary stiffeners by a horizontal member of the same scantlings as the main ordinary stiffener.

2.3.2 Lower end of transverse framing

The lower end of the strengthened part of a main ordinary stiffener and intermediate ice ordinary stiffener is to be attached to a deck, a tank top or an ice side girder as required in [4.3.1] and [4.3.2].

Where an intermediate ordinary stiffener terminates below a deck, a tank top or an ice side girder which is situated at or below the lower limit of the ice strengthened area, the lower end may be connected to the adjacent main ordinary stiffeners by a horizontal member of the same scantlings as the ordinary stiffeners.

2.4 Bilge keels

2.4.1 The connection of bilge keels to the hull is to be so designed that the risk of damage to the hull, in the event of a bilge keel being ripped off, is minimised.

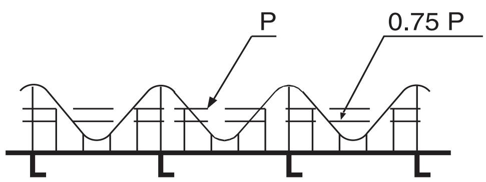
For this purpose, it is recommended that bilge keels are cut up into several shorter independent lengths.

3 Design loads

3.1 General

3.1.1 Because of the different flexural stiffness of plating, ordinary stiffeners and primary supporting members, the ice load distribution is to be assumed to be as shown in Fig 3.

Figure 3 : Ice load distribution on ship side



3.1.2 Use of direct analysis

The formulae and values given in this Section may be substituted by direct analysis if they are deemed by the Society to be invalid or inapplicable for a given structural arrangement or detail, on a case-by-case basis.

Otherwise, direct analysis is not to be utilised as an alternative to the analytical procedures prescribed by explicit requirements in [4].

3.1.3 Requirements for direct analysis

Direct analyses are to be carried out using the load patch defined in [3.2] (p, h and l_a). The pressure to be used is 1,8p where p is determined according to [3.2.2]. The load patch is to be applied at locations where the capacity of the structure under the combined effects of bending and shear is minimised. In particular, the structure is to be checked with load centred at the UIWL, $0,5h_G$ below the LIWL, h_G being defined in Sec 1, [2.3.1], and positioned at several vertical locations in between. Several horizontal locations are also to be checked, especially the locations centred at the mid-span or -spacing. Further, if the load length l_a, as defined in [3.2.2] cannot be determined directly from the arrangement of the structure, several values of la are to be checked using corresponding values for c_a.

The acceptance criterion for designs is that the combined stresses from bending and shear, using the Von Mises yield criterion, are lower than the yield point R_{eH}. When the direct calculation is using beam theory, the allowable shear stress is not to be larger than $0,9 R_{eH} / \sqrt{3}$.

If scantlings obtained from the requirements of this Section are less than those required for the unstrengthened ship, the latter are to be used.

3.2 Ice loads

3.2.1 Height of load area

The height of the area under ice pressure at any particular point of time is to be obtained, in m, from Tab 3 depending on the additional class notation assigned to the ship.

Table 3 : Height of load area

Notation	h, in m
ICE CLASS IA SUPER	0,35
ICE CLASS IA	0,30
ICE CLASS IB	0,25
ICE CLASS IC **ICE CLASS ID**	0,22

3.2.2 Design ice pressure

The value of the design ice pressure p, in N/mm², to be considered for the scantling check, is obtained from the following formula:

$$p = c_d c_p c_a p_o$$

where:

c_d : Coefficient taking account of the influence of the size and engine output of the ship, to be obtained from the following formula and not to be taken greater than 1:

$$c_d = \frac{a\ f + b}{1000}$$

a, b : Coefficients defined in Tab 4

Table 4 : Coefficients a, b

Region (see [1.2])	Condition	a	b
Fore region	f ≤ 12	30	230
	f > 12	6	518
Midship and aft regions	f ≤ 12	8	214
	f > 12	2	286

f : Coefficient to be obtained from the following formula:

$$f = \frac{\sqrt{\Delta\ P}}{1000}$$

Δ : Displacement, in t, at the maximum ice class draught (see Sec 1, [2.1.1])

P : Actual continuous output of propulsion machinery, in kW (see Sec 1, [3])

c_p : Coefficient taking account of the probability of the design ice pressure occurring in a particular region of the hull for the additional class notation considered, defined in Tab 5

c_a : Coefficient taking account of the probability that the full length of the area under consideration will be under pressure at the same time, to be obtained from the following formula:

$$c_a = \sqrt{\frac{\ell_0}{\ell_a}}$$

without being taken less than 0,35 or greater than 1,0 with $\ell_0 = 0,6$ m

ℓ_a : Distance, in m, defined in Tab 6

p_o : Nominal ice pressure, in N/mm², to be taken equal to 5,6.

4 Hull scantlings

4.1 Plating

4.1.1 General

The plating thickness is to be strengthened according to [4.1.2] within the strengthened area for plating defined in [1.1.1].

In addition, the plating thickness is to be strengthened in the following cases:

- For the notation **ICE CLASS IA SUPER**, the thickness within the fore foot is to be not less than that required for the ice strengthened area in the midship region
- For the notations **ICE CLASS IA SUPER** or **ICE CLASS IA**, on ships with an open water service speed equal to or exceeding 18 knots, the thickness of plating within the upper fore ice strengthened area is to be not less than that required for the ice strengthened area in the midship region.

A similar strengthening of the bow region is recommended also for a ship with a lower service speed, when it is evident, e.g. on the basis of model tests, that the ship will have a high bow wave.

4.1.2 Plating thickness in the ice strengthened area

The thickness of the shell plating is to be not less than the value obtained, in mm, from the following formulae:

- for transverse framing:

$$t = 667s\sqrt{\frac{F_1 p_{PL}}{R_{eH}}} + t_c$$

- for longitudinal framing:

$$t = 667s\sqrt{\frac{p}{F_2 R_{eH}}} + t_c$$

Table 5 : Coefficient c_p

Region (see [1.2])	Notation				
	ICE CLASS IA SUPER	**ICE CLASS IA**	**ICE CLASS IB**	**ICE CLASS IC**	**ICE CLASS ID**
Fore region	1,0	1,0	1,0	1,0	1,0
Midship region	1,0	0,85	0,70	0,50	not applicable
Aft region	0,75	0,65	0,45	0,25	not applicable

Table 6 : Distance ℓ_a

Structure	Type of framing	ℓ_a
Shell plating	Transverse	Spacing of ordinary stiffeners
	Longitudinal	1,7 times the spacing of ordinary stiffeners
Ordinary stiffeners	Transverse	Spacing of ordinary stiffeners
	Longitudinal	Span of ordinary stiffeners
Vertical primary supporting members		Two spaces of vertical primary supporting members
Ice side girders		Span of side girders

where:

p_{PL} : Ice pressure on the shell plating to be obtained, in N/mm², from the following formula:

$$p_{PL} = 0{,}75p$$

p : Design ice pressure, in N/mm², defined in [3.2.2]

F_1 : Coefficient to be obtained from the following formula:

$$F_1 = 1{,}3 - \frac{4{,}2}{\left[\frac{h}{s} + 1{,}8\right]^2}$$

without being taken greater than 1,0

F_2 : Coefficient to be obtained from the following formulae:

- for $h/s \le 1{,}0$:

$$F_2 = 0{,}6 + 0{,}4\frac{s}{h}$$

- for $1{,}0 < h/s < 1{,}8$:

$$F_2 = 1{,}4 - 0{,}4\frac{h}{s}$$

h : Height, in m, of load area defined in [3.2.1]

t_c : Abrasion and corrosion addition, in mm, to be taken equal to 2 mm; where a special surface coating, shown by experience to be capable of withstanding the abrasion of ice, is applied, a lower value may be accepted by the Society on a case-by-case basis.

4.2 Ordinary stiffeners

4.2.1 General

Ordinary stiffeners are to be strengthened according to [4.2.2] within the strengthened area for ordinary stiffeners defined in [1.1.1].

Where less than 15% of the ordinary stiffener span is located within the ice strengthened area defined in [1.1.1], it is not necessary to increase the scantlings of ordinary stiffeners.

4.2.2 Scantlings of transverse ordinary stiffeners

The section modulus of transverse ordinary stiffeners is to be not less than the value obtained, in cm³, from the following formula:

$$w = \frac{7 - 5(h/\ell)}{7m_0}\,\frac{psh\ell}{R_{eH}}\,10^6$$

$$A_{Sh} = \frac{0{,}87F_{3t}psh}{R_{eH}}10^4$$

where:

p : Design ice pressure, in N/mm², defined in [3.2.2]

h : Height, in m, of load area defined in [3.2.1]

m_0 : Coefficient defined in Tab 7.

4.2.3 Scantlings of longitudinal ordinary stiffeners

The section modulus w, in cm³ and the shear area A_{Sh}, in cm², of longitudinal ordinary stiffeners are to be not less than the values obtained from the following formulae:

$$w = \frac{F_3 ps\ell^2}{m_1 R_{eH}}10^6$$

$$A_{Sh} = \frac{0{,}87F_3F_4ps\ell}{R_{eH}}10^4$$

where:

F_3 : Coefficient, taking account of the load distribution on adjacent ordinary stiffeners, to be obtained from the following formula:

$$F_3 = \left(1 - 0{,}2\frac{h}{s}\right)\frac{h}{s}$$

h : Height, in m, of load area defined in [3.2.1]

F_4 : Coefficient taking account of the maximum shear force versus load location and the shear force distribution, to be taken equal to 2,16.

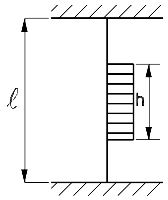
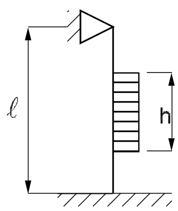
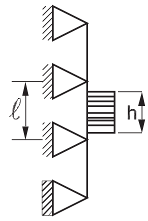
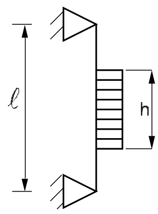
p : Design ice pressure, in N/mm², defined in [3.2.2]

m_1 : Boundary condition coefficient for the ordinary stiffener considered, to be taken equal to 13,3 for a continuous beam.

Where boundary conditions deviate significantly from those of a continuous beam, e.g. in an end field, a smaller value is to be adopted.

The spacing s is not to exceed 0,35 m for the notations **ICE CLASS IA SUPER** or **ICE CLASS IA**. In no case is s to exceed 0,45 m.

Table 7 : Coefficient m_0

Boundary condition	Example	m_0
Type 1 	Frames in a bulk carrier with top wing tanks	7,0
Type 2 	Ordinary stiffeners extending from the tank top to a single deck	6,0
Type 3 	Continuous ordinary stiffeners between several decks or side girders	5,7
Type 4 	Ordinary stiffeners extending between two decks only	5,0
Note 1: The boundary conditions are those for main and intermediate ordinary stiffeners. **Note 2:**Load is applied at mid-span.		

4.3 Primary supporting members

4.3.1 Ice side girders within the ice strengthened area

The section modulus w, in cm³ and the section area A_{Sh}, in cm², of a side girder located within the ice strengthened area defined in [1.1.1] are to be not less than the values obtained from the following formulae:

$$w = \frac{F_5 F_7 p h \ell^2}{m_S R_{eH}} 10'$$

$$A_{Sh} = \frac{0,87 F_5 F_7 F_8 p h \ell}{R_{eH}} 1($$

where:

p : Design ice pressure, in N/mm², defined in [3.2.2]

h : Height, in m, of load area defined in [3.2.1], without the product ph being taken less than 0,15

m_S : Boundary condition coefficient for the ordinary stiffener considered, to be taken equal to 13,3 for a continuous beam

F_5 : Coefficient taking account of the distribution of load to the transverse ordinary stiffeners, to be taken equal to 0,9.

F_7 : Safety factor of ice side girders, to be taken equal to 1,8.

F_8 : Coefficient taking into account the maximum shear force versus load location and the shear stress distribution, to be taken equal to 1,2.

4.3.2 Ice side girders outside the ice strengthened area

The section modulus w, in cm^3 and the section area A_{Sh}, in cm^2, of a side girder located outside the ice strengthened area, defined in [1.1.1], but supporting ice strengthened ordinary stiffeners are to be not less than the values obtained from the following formulae:

$$w = \frac{F_6 F_7 p h \ell^2}{m_S R_{eH}} \left(1 - \frac{h_S}{\ell_S}\right) 10^6$$

$$A_{Sh} = \frac{0{,}87 F_6 F_7 F_8 p h \ell}{R_{eH}} \left(1 - \frac{h_S}{\ell_S}\right) 10^4$$

where:

p : Design ice pressure, in N/mm^2, defined in [3.2.2]

h : Height, in m, of load area defined in [3.2.1], without the product ph being taken less than 0,15

m_S : Coefficient defined in [4.3.1]

F_6 : Coefficient taking account of the load distribution to transverse side girders, to be taken equal to 0,80

F_7, F_8 : Coefficients defined in [4.3.1]

h_S : Distance to the ice strengthened area, in m

ℓ_S : Distance to the adjacent ice side girder, in m.

4.3.3 Vertical primary supporting member checked through simplified model

For vertical primary supporting members which may be represented by the structure model represented in Fig 4, the section modulus w, in cm^3, and the shear area A_{Sh}, in cm^2, are to be not less than the values obtained from the following formulae:

$$w = \frac{0,193 F \ell}{R_{eH}} \left(\frac{1}{1-(\upsilon / A_a)^2}\right)^{\frac{1}{2}} 10^3$$

$$A_{Sh} = \frac{17,3 \alpha F_9 F}{R_{eH}}$$

where:

- F_9 : Coefficient taking into account the shear force distribution, to be taken equal to 1,1
- F : Load transferred to a vertical primary supporting member from a side girder or from longitudinal ordinary stiffeners, to be obtained, in kN, from the following formula:

  $F_{10} = phs\ 10^3$
- F_{10} : Safety factor of vertical primary supporting members, to be taken equal to 1,8
- p : Design ice pressure, in N/mm^2, defined in [3.2.2], where the value of c_a is to be calculated assuming ℓ_a equal to 2s
- h : Height, in m, of load area defined in [3.2.1], without the product ph being taken less than 0,3
- ν : Coefficient defined in Tab 8
- A_a : Actual cross-sectional area of the vertical primary supporting member
- α : Coefficient defined in Tab 8
- ℓ_F : Distance, in m, as indicated in Fig 4; for the lower part of the vertical primary supporting member the smallest ℓ_F within the ice strengthened area is to be used and for the upper part of the vertical primary supporting member the largest ℓ_F within the ice strengthened area is to be used.

5 Other structures

5.1 Application

5.1.1 The requirements in [5.3] and [5.4] do not apply to the notation ICE CLASS ID.

5.2 Fore part

5.2.1 Stem

The stem may be made of rolled, cast or forged steel or of shaped steel plates, as shown in Fig 5.

The plate thickness of a shaped plate stem and, in the case of a blunt bow, any part of the shell where α ≥ 30° and ψ ≥ 75° (α and ψ defined in Sec 1, [3.1.1]) of 30° is to be not less than that calculated in [4.1.2] assuming that:

- s is the spacing of elements supporting the plate, in m
- p_{PL} , in N/mm^2, is taken equal to p, defined in [3.2.2], with ℓ_a being the spacing of vertical supporting elements, in m.

Figure 4 : Reference structure model

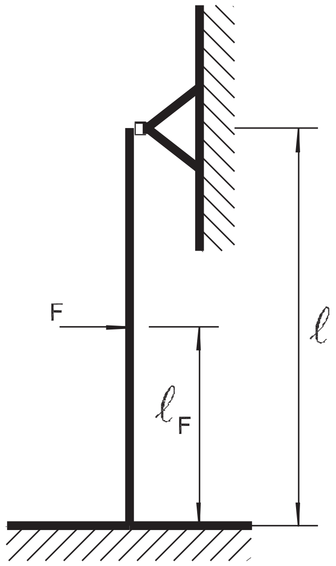
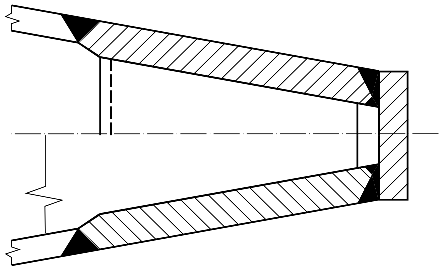


Table 8 : Coefficients α,ν

A_F/A_W	α	ν
0,0	1,50	0,0
0,20	1,23	0,44
0,40	1,16	0,62
0,60	1,11	0,71
0,80	1,09	0,76
1,00	1,07	0,80
1,20	1,06	0,83
1,40	1,05	0,85
1,60	1,05	0,87
1,80	1,04	0,88
2,00	1,04	0,89

Note 1:
A_F : Cross-sectional area of the face plate,
A_W : Cross-sectional area of the web.

Figure 5 : Example of suitable stems



The stem and the part of a blunt bow defined above are to be supported by floors or brackets spaced not more than 600 mm apart and having a thickness at least half that of the plate.

The reinforcement of the stem is to be extended from the keel to a point 0,75 m above the UIWL or, where an upper fore ice strengthened area is required (see [1.1.1]), to the upper limit of the latter.

5.2.2 Arrangements for towing

A mooring pipe with an opening not less than 250 mm by 300 mm, a length of at least 150 mm and an inner surface radius of at least 100 mm is to be fitted in the bow bulwark on the centreline.

A bitt or other means of securing a towline, dimensioned to withstand the breaking strength of the ship's towline, is to be fitted.

On ships with a displacement less than 30000 t, the part of the bow extending to a height of at least 5 m above the UIWL and at least 3 m back from the stem is to be strengthened to withstand the stresses caused by fork towing. For this purpose, intermediate ordinary stiffeners are be fitted and the framing is to be supported by stringers or decks.

Note 1: It is to be noted that for ships of moderate size (displacement less than 30000 t), fork towing is, in many situations, the most efficient way of assisting in ice. Ships with a bulb protruding more than 2,5 m forward of the forward perpendicular are often difficult to tow in this way.

5.3 Aft part

5.3.1

The minimum distance between propeller(s) and hull (including stern frame) is not to be less than h_G as defined in Sec 1, [2.3.1].

5.3.2 On twin and triple screw ships, the ice strengthening of the shell and framing is to be extended to the double bottom for at least 1,5 m forward and aft of the side propellers.

5.3.3 Shafting and sterntubes of side propellers are generally to be enclosed within plated bossings. If detached struts are used, their design, strength and attachment to the hull are to be examined by the Society on a case-by-case basis.

5.3.4 A wide transom stern extending below the UIWL seriously impedes the capability of the ship to run astern in ice, which is of paramount importance.

Consequently, a transom stern is not normally to be extended below the UIWL. Where this cannot be avoided, the part of the transom below the UIWL is to be kept as narrow as possible.

The part of a transom stern situated within the ice strengthened area is to be strengthened as required for the midship region.

5.4 Deck strips and hatch covers

5.4.1

Narrow deck strips abreast of hatches and serving as ice side girders are to comply with the section modulus and shear area calculated in [4.3.1] and [4.3.2], respectively. In the case of very long hatches, the product ph is to be taken less than 0,15 but in no case less than 0,10.

Special attention is to be paid when designing weather deck hatch covers and their fittings to the deflection of the ship sides due to ice pressure in way of very long hatch openings.

5.5 Sidescuttles and freeing ports

5.5.1 Sidescuttles are not to be located in the ice strengthened area.

Special consideration is to be given to the design of freeing ports.

6 Hull outfitting

6.1 Rudders and steering arrangements

6.1.1

The scantlings of the rudder post, rudder stock, pintles, steering gear, etc. as well as the capacity of the steering gear are to be determined according to Pt B, Ch 10, Sec 1, taking the coefficient r_2, defined in Pt B, Ch 10, Sec 1, [2.1.2], equal to 1,10 irrespective of the rudder profile type.

However, the maximum ahead service speed of the ship to be used in these calculations is not to be taken less than that stated in Tab 9.

Where the actual maximum ahead service speed of the ship is higher than that stated in Tab 9, the higher speed is to be used.

The local scantlings of rudders are to be determined assuming that the whole rudder belongs to the ice strengthened area. Further, the rudder plating and frames are to be designed using the ice pressure p for the plating and frames in the midship region.

Table 9 : Maximum ahead service speed

Notation	Maximum ahead service speed (knots)
ICE CLASS IA SUPER	20
ICE CLASS IA	18
ICE CLASS IB	16
ICE CLASS IC **ICE CLASS ID**	14

6.1.2
For the notations **ICE CLASS IA SUPER** or **ICE CLASS IA**, the rudder stock and the upper edge of the rudder are to be protected from direct contact with intact ice by an ice knife or equivalent means that extends below the LIWL, if practicable (or equivalent means). Special consideration is to be given to the design of flap-type rudders.

6.1.3
For the notations **ICE CLASS IA SUPER** or **ICE CLASS IA** suitable arrangements such as rudder stoppers are to be fitted to absorb large loads that arise when the rudder is forced out of the midship position while going astern in ice or into ice ridges.

6.2 Bulwarks

6.2.1 If the weather deck in any part of the ship is situated below the upper limit of the ice strengthened area (e.g. in way of the well of a raised quarter deck), the bulwark is to be reinforced at least to the standard required for the shell in the ice strengthened area.

SECTION 3 MACHINERY

1 Propulsion

1.1 Propulsion machinery performance

1.1.1 The engine output P is the maximum output that the propulsion machinery can continuously deliver. If the output of the machinery is restricted by technical means or by any regulations applicable to the ship, P is to be taken as the restricted output. In no case may P be less than the values calculated in accordance with Sec 1, [3.1.2] or Sec 1, [3.1.4], as applicable.

2 Class notations IAS, IA, IB and IC

2.1 Propulsion machinery

2.1.1 Scope

These requirements apply to propulsion machinery covering open- and ducted-type propellers with controllable pitch or fixed pitch design for the ice classes IAS, IA, IB and IC. The given loads are the expected ice loads throughout the ship's service life under normal operational conditions, including loads resulting from the changing rotational direction of FP propellers. However, these loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice. The regulations also apply to azimuthing and fixed thrusters for main propulsion, considering loads resulting from propeller-ice interaction. However, the load models of the regulations do not include propeller/ice interaction loads when ice enters the propeller of a turned azimuthing thruster from the side (radially) or the load case when an ice block hits the propeller hub of a pulling propeller. Ice loads resulting from ice impacts on the body of thrusters are to be estimated, but ice load formulae are not available.

2.2 Symbols

2.2.1 The symbols used in the formulae of this Section have the meaning indicated hereinafter. The loads considered are defined as following:

c : chord length of blade section, in m;

$c_{0,7}$: chord length of blade section at 0,7R propeller radius, in m

CP : controllable pitch

D : propeller diameter, in m

d : external diameter of propeller hub (at propeller plane), in m

D_{limit} : limit value for propeller diameter, in m

EAR : expanded blade area ratio;

F_b : maximum backward blade force for the ship's service life, in kN;

F_{ex} : ultimate blade load resulting from blade loss through plastic bending, in kN

F_f : maximum forward blade force for the ship's service life, in kN

F_{ice} : ice load, in kN

$(F_{ice})_{max}$: maximum ice load for the ship's service life, in kN

FP : fixed pitch

h_0 : depth of the propeller centreline from lower ice waterline, in m

h_{ice} : thickness of maximum design ice block entering propeller, in m

I : equivalent mass moment of inertia of all parts on engine side of component under consideration, in kgm^2

I_t : equivalent mass moment of inertia of the whole propulsion system, in kgm^2

k : shape parameter for Weibull distribution

LIWL : lower ice waterline, in m

m : slope for S-N curve in log/log scale, in kNm

M_{BL} : blade bending moment

MCR : maximum continuous rating

n : propeller rotational speed, in rev./s

n_n : nominal propeller rotational speed at MCR in free running condition, in rev./s

N_{class} : reference number of impacts per propeller rotational speed per ice class

N_{ice} : total number of ice loads on propeller blade for the ship's service life

N_R : reference number of load for equivalent fatigue stress (10^8 cycles)

N_Q : number of propeller revolutions during a milling sequence

$P_{0,7}$: propeller pitch at 0,7R radius, in m

$P_{0,7n}$: propeller pitch at 0,7R radius at MCR in free running condition, in m

$P_{0,7b}$: propeller pitch at 0,7R radius at MCR in bollard condition, in m

Q : torque, in kNm

Q_{emax} : maximum engine torque, in kNm

Q_{max} : maximum torque on the propeller resulting from propeller-ice interaction, in kNm

Q_{motor} : electric motor peak torque, in kNm

Q_n : nominal torque at MCR in free running condition, in kNm

Q_r : maximum response torque along the propeller shaft line, in kNm

Q_{smax} : maximum spindle torque of the blade for the ship's service life, in kNm

R : propeller radius, in m

r : blade section radius, in m

T : propeller thrust, in kN

T_b : maximum backward propeller ice thrust for the ship's service life, in kN

T_f : maximum forward propeller ice thrust for the ship's service life, in kN

T_n : propeller thrust at MCR in free running condition, in kN;

T_r : maximum response thrust along the shaft line, in kN

t : maximum blade section thickness, in m

Z : number of propeller blades

α_i : duration of propeller blade/ice interaction expressed in rotation angle, in [deg]

γ_e : the reduction factor for fatigue; scatter and test specimen size effect

γ_v : the reduction factor for fatigue; variable amplitude loading effect

γ_m : the reduction factor for fatigue; mean stress effect

ρ : a reduction factor for fatigue correlating the maximum stress amplitude to the equivalent fatigue stress for 10^8 stress cycles

$\sigma_{0,2}$: proof yield strength of blade material, in MPa

σ_{exp} : mean fatigue strength of blade material at 10^8 cycles to failure in sea water, in MPa

σ_{fat} : equivalent fatigue ice load stress amplitude for 10^8 stress cycles, in MPa

σ_{fl} : characteristic fatigue strength for blade material, in MPa

σ_{ref} : reference stress $\sigma_{ref} = 0,6 \cdot \sigma_{0,2} + 0,4 \cdot \sigma_u$, in MPa

σ_{ref2} : reference stress, in MPa $\sigma_{ref2} = 0,6 \cdot \sigma_u$ or $\sigma_{ref2} = 0,6 \cdot \sigma_{0,2} + 0,4 \cdot \sigma_u$ whichever is the lesser

σ_{st} : maximum stress resulting from F_b or F_f, in MPa

σ_u : ultimate tensile strength of blade material, in MPa

$(\sigma_{ice})_{bmax}$: principal stress caused by the maximum backward propeller ice load, in MPa

$(\sigma_{ice})_{fmax}$: principal stress caused by the maximum forward propeller ice load, in MPa

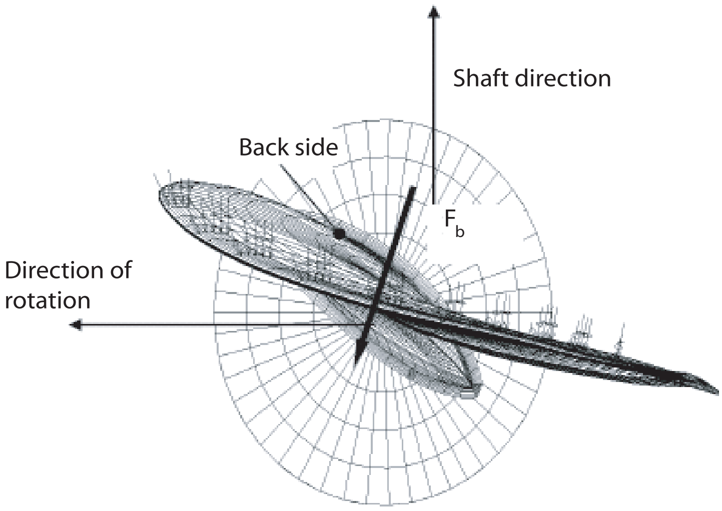
$(\sigma_{ice})_{max}$: maximum ice load stress amplitude, in MPa

Table 1 : Definition of loads

	Definition	Use of the load in design process
F_b	The maximum lifetime backward force on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7R chord line. See Fig 1.	Design force for strength calculation of the propeller blade.
F_f	The maximum lifetime forward force on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7R chord line.	Design force for calculation of strength of the propeller blade.
Q_{smax}	The maximum lifetime spindle torque on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade.	In designing the propeller strength, the spindle torque is automatically taken into account because the propeller load is acting on the blade as distributed pressure on the leading edge or tip area.
T_b	The maximum lifetime thrust on propeller (all blades) resulting from propeller/ice interaction. The direction of the thrust is the propeller shaft direction and the force is opposite to the hydrodynamic thrust.	Is used for estimation of the response thrust T_r. T_b can be used as an estimate of excitation for axial vibration calculations. However, axial vibration calculations are not required in the Rules.
T_f	The maximum lifetime thrust on propeller (all blades) resulting from propeller/ice interaction. The direction of the thrust is the propeller shaft direction acting in the direction of hydrodynamic thrust.	Is used for estimation of the response thrust T_r. T_f can be used as an estimate of excitation for axial vibration calculations. However, axial vibration calculations are not required in the Rules.
Q_{max}	The maximum ice-induced torque resulting from propeller/ice interaction on one propeller blade, including hydrodynamic loads on that blade.	Is used for estimation of the response torque (Q_r) along the propulsion shaft line and as excitation for torsional vibration calculations.

	Definition	Use of the load in design process
F_{ex}	Ultimate blade load resulting from blade loss through plastic bending. The force that is needed to cause total failure of the blade so that plastic hinge is caused to the root area. The force is acting on 0,8R. Spindle arm is to be taken as 2/3 of the distance between the axis of blade rotation and leading/trailing edge (whichever is the greater) at the 0,8R radius.	Blade failure load is used to dimension the blade bolts, pitch control mechanism, propeller shaft, propeller shaft bearing and thrust bearing. The objective is to guarantee that total propeller blade failure will not cause damage to other components.
Q_r	Maximum response torque along the propeller shaft line, taking into account the dynamic behaviour of the shaft line for ice excitation (torsional vibration) and hydrodynamic mean torque on the propeller.	Design torque for propeller shaft line components.
T_r	Maximum response thrust along shaft line, taking into account the dynamic behaviour of the shaft line for ice excitation (axial vibration) and hydrodynamic mean thrust on the propeller.	Design thrust for propeller shaft line components.

Figure 1 : Direction of the backward blade force resultant taken perpendicular to chord line at radius 0,7R. Ice contact pressure at leading edge is shown with small arrows



2.3 Design ice conditions

2.3.1 In estimating the ice loads of the propeller for ice classes, different types of operation as given in Tab 2 are taken into account. For the estimation of design ice loads, a maximum ice block size is determined. The maximum design ice block entering the propeller is a rectangular ice block with the dimensions Hice 2Hice 3Hice. The thickness of the ice block (Hice) is given in Tab 3.

Table 2

Ice class	Operation of the ship
IA Super	Operation in ice channels and in level ice The ship may proceed by ramming
IA, IB, IC	Operation in ice channels

Table 3

	IA Super	IA	IB	IC
Thickness of the design maximum ice block entering the propeller (H_{ice})	1,75 m	1,5 m	1,2 m	1,0 m

2.4 Materials

2.4.1 Materials exposed to sea water

Materials of components exposed to sea water, such as propeller blades, propeller hubs, and thruster body, are to have an elongation of not less than 15% on a test specimen, the gauge length of which is five times the diameter. A Charpy V impact test is to be carried out for materials other than bronze and austenitic steel. An average impact energy value of 20 J taken from three tests is to be obtained at minus 10ºC.

2.4.2 Materials exposed to sea water temperature

Components exposed to sea water temperature are to be of ductile material. An average impact energy value of 20 J taken from three tests is to be obtained at minus 10 ºC for materials other than bronze and austenitic steel. This requirement applies to blade bolts, CP mechanisms, shaft bolts, strut-pod connecting bolts etc. This does not apply to surface-hardened components, such as bearings and gear teeth.

2.5 Design loads

2.5.1 The given loads are intended for component strength calculations only and are total loads including ice-induced loads and hydrodynamic loads during propeller/ice interaction.

The values of the parameters in the formulae in this section are to be given in the units shown in the symbol list.

If the propeller is not fully submerged when the ship is in ballast condition, the propulsion system is to be designed according to ice class IA for ice classes IB and IC.

2.5.2 Design loads on propeller blades

F_b is the maximum force experienced during the lifetime of the ship that bends a propeller blade backwards when the propeller mills an ice block while rotating ahead. F_f is the maximum force experienced during the lifetime of the ship that bends a propeller blade forwards when the propeller mills an ice block while rotating ahead. F_b and F_f originate from different propeller/ice interaction phenomena, not acting simultaneously. Hence they are to be applied to one blade separately.

a) Maximum backward blade force F_b for open propellers

$$F_b = 27 \cdot [n \cdot D]^{0,7} \cdot \left[\frac{EAR}{Z}\right]^{0,3} \cdot D^2 [kN] \text{ , when } D \le D_{limit}$$

$$F_b = 23 \cdot [n \cdot D]^{0,7} \cdot \left[\frac{EAR}{Z}\right]^{0,3} \cdot D \cdot H_{ice}^{1,4} [kN] \text{ , when } D > D_{limit}$$

where:

$D_{limit} = 0,85 \cdot H_{ice}^{1,4}$ [m]

n = is the nominal rotational speed (at MCR in free running condition) for a CP propeller and 85% of the nominal rotational speed (at MCR in free running condition) for an FP propeller.

b) Maximum forward blade force F_f for open propellers

$$F_f = 250 \cdot \left[\frac{EAR}{Z}\right] \cdot D^2 [kN] \text{ , when } D \le D_{limit}$$

where:

$$D_{limit} = \frac{2}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} [m]$$

$$F_f = 500 \cdot \left[\frac{EAR}{Z}\right] \cdot D \cdot \frac{1}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} [kN] \text{ , when } D > D_{limit}$$

c) Loaded area on the blade for open propellers

Load cases 1-4 are to be covered, as given in Tab 4 below, for CP and FP propellers. In order to obtain blade ice loads for a reversing propeller, load case 5 is also to be covered for FP propellers.

d) Maximum backward blade ice force F_b for ducted propellers

$$F_b = 9,5 \cdot [n \cdot D]^{0,7} \cdot \left[\frac{EAR}{Z}\right]^{0,3} \cdot D^2 [kN] \text{ , when } D \le D_{limit}$$

$$F_b = 66 [n \cdot D]^{0,7} \left[\frac{EAR}{Z}\right]^{0,3} \cdot D^{0,6} \cdot H_{ice}^{1,4} [kN] \text{ , when } D > D_{limit}$$

where:

$D_{limit} = 4 \cdot H_{ice}$ [m]

n = is the nominal rotational speed (at MCR in free running condition) for a CP propeller and 85% of the nominal rotational speed (at MCR in free running condition) for an FP propeller.

e) Maximum forward blade ice force F_f for ducted propellers

$$F_f = 250 \cdot \left[\frac{EAR}{Z}\right] \cdot D^2 [kN] \text{ , when } D \le D_{limit}$$

$$F_f = 500 \cdot \left[\frac{EAR}{Z}\right] \cdot D \cdot \frac{1}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} [kN] \text{ , when } D > D_{limit}$$

where:

$$D_{limit} = \frac{2}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} [m]$$

f) Loaded area on the blade for ducted propellers

Load cases 1 and 3 are to be covered as given in Tab 5 for all propellers, and an additional load case (load case 5) is to be considered for an FP propeller, to cover ice loads when the propeller is reversed.

g) Maximum blade spindle torque Q_{smax} for open and ducted propellers

The spindle torque Q_{smax} around the axis of the blade fitting is to be determined both for the maximum backward blade force b_F and forward blade force f_F, which are applied as in Tab 4 and Tab 5.

If the above method gives a value which is less than the default value given by the formula below, the default value is to be used.

Default value $Q_{smax} = 0{,}25 \cdot F \cdot c_{0.7}$ [kNm]

where $c_{0,7}$ is the length of the blade section at 0,7R radius and F is either F_b or F_f, whichever has the greater absolute value.

Table 4 : Load cases for open propellers

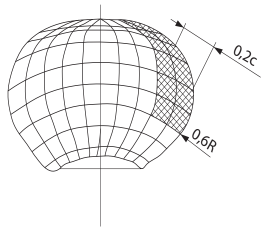
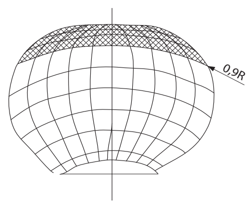
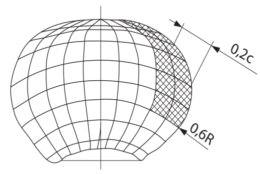
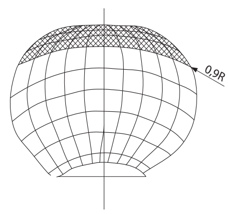
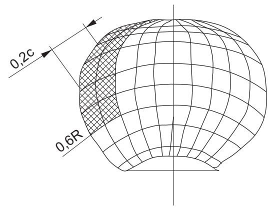
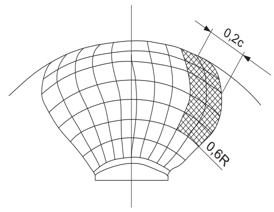
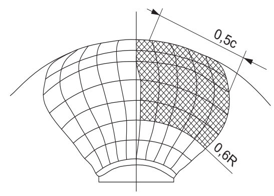
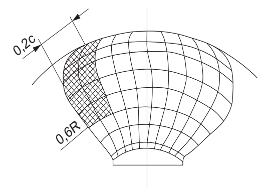
	Force	Loaded area	Right handed propeller blade seen from behind
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	50% of F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0,9R radius	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 4	50% of F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside of 0,9R radius	
Load case 5	60 % of F_f or F_b, whichever is the greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

Table 5 : Load cases for ducted propellers

	Force	Loaded area	Right handed propeller blade seen from behind
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,5 times the chord length	
Load case 5	60 % of F_f or F_b, whichever is the greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

h) Load distributions for blade loads

The Weibull-type distribution (probability that F_{ice} exceeds $(F_{ice})_{max}$), as given in Fig 2, is used for the fatigue design of the blade.

$$P\left(\frac{F_{ice}}{(F_{ice})_{max}} \geq \frac{F}{(F_{ice})_{max}}\right) = e^{\left(-\left(\frac{F}{(F_{ice})_{max}}\right)^k \cdot \ln(N_{ice})\right)}$$

where k is the shape parameter of the spectrum, N_{ice} is the number of load cycles in the spectrum, and F_{ice} is the random variable for ice loads on the blade, $0 \leq F_{ice} \leq (F_{ice})_{max}$. The shape parameter k=0,75 is to be used for the ice force distribution of an open propeller and the shape parameter k=1,0 for that of a ducted propeller blade.

i) Number of ice loads

The number of load cycles per propeller blade in the load spectrum is to be determined according to the formula:

$N_{ice} = k_1\ k_2\ k_3\ k_4\ N_{class}\ n$

where:

Reference number of loads for ice classes N_{class}, see Tab 6.

Propeller location factor k_1, see Tab 7.

Propeller type factor k_2, see Tab 8.

Propulsion type factor k_3, see Tab 9.

Table 6

Class	IA Super	IA	IB	IC
impacts in life/n	$9 \cdot 10^6$	$6 \cdot 10^6$	$3,4 \cdot 10^6$	$2,1 \cdot 10^6$

Table 7

Centre propeller		Wing propeller
k_1	1	1,35

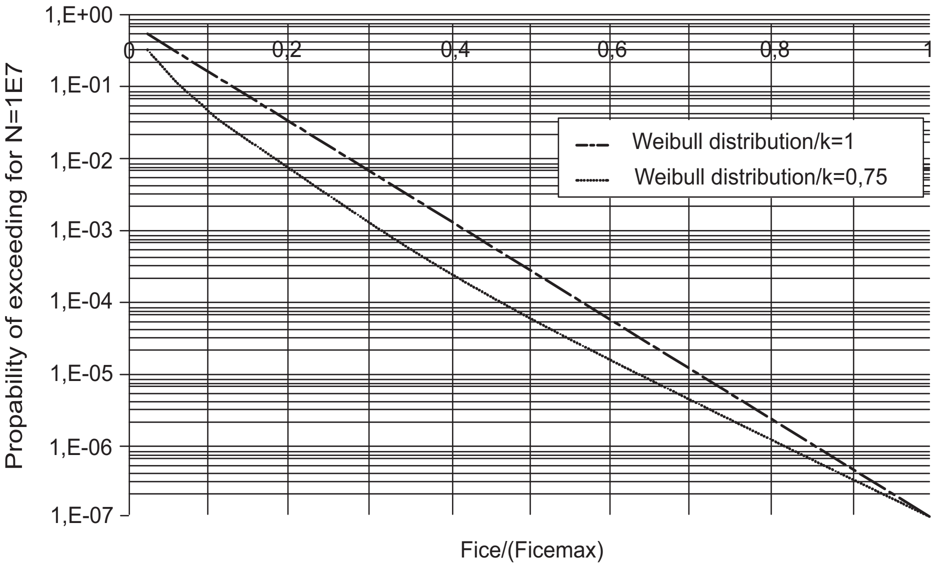
Table 8

type	open	ducted
k_2	1	1,1

Table 9

type	fixed	azimuthing
k_3	1	1,2

Figure 2 : The weibull-type distribution (probability that fice exceeds (fice)max) that is used for fatigue design



The submersion factor k_4 is determined from the equation:

k_4 = 0,8 - f when f < 0

= 0,8 - 0,4 · f when 0 ≤ f ≤ 1

= 0,6 - 0,2 · f when 1 < f ≤ 2,5

= 0,1 when f > 2,5

where the immersion function f is:

$$f = \frac{h_0 - H_{ice}}{D/2} - 1$$

where h_0 is the depth of the propeller centreline at the lower ice waterline (LIWL) of the ship.

For components that are subject to loads resulting from propeller/ice interaction with all the propeller blades, the number of load cycles (N_{ice}) is to be multiplied by the number of propeller blades (Z).

2.5.3 Axial design loads for open and ducted propellers

a) Maximum ice thrust on propeller T_f and T_b for open and ducted propellers

The maximum forward and backward ice thrusts are:

$T_f = 1,1 \cdot F_f$ [kN]

$T_b = 1,1 \cdot F_b$ [kN]

b) Design thrust along the propulsion shaft line for open and ducted propellers

The design thrust along the propeller shaft line is to be calculated with the formulae below. The greater value of the forward and backward direction loads is to be taken as the design load for both directions. The factors 2,2 and 1,5 take into account the dynamic magnification resulting from axial vibration.

In a forward direction:

$T_r = T + 2,2 \cdot T_f$ [kN]

In a backward direction:

$T_r = 1,5 \cdot T_b$ [kN]

If the hydrodynamic bollard thrust, T, is not known, T is to be taken as indicated in Tab 10.

Table 10

Propeller type	T
CP propellers (open)	1,25 T_n
CP propellers (ducted)	1,1 T_n
FP propellers driven by turbine or electric motor	T_n
FP propellers driven by diesel engine (open)	0,85 T_n
FP propellers driven by diesel engine (ducted)	0,75 T_n

Here, T_n is the nominal propeller thrust at MCR in free running open water condition.

2.5.4 Torsional design loads

a) Design ice torque on propeller Q_{max} for open propellers

Q_{max} is the maximum torque on a propeller resulting from ice/propeller interaction.

$$Q_{max} = 10,9\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3 [kNm]$$

when $D \le D_{limit}$

$$Q_{max} = 20,7\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H^{1,1}_{ice} [kNm]$$

when $D > D_{limit}$

where

$D_{limit} = 1,8 \cdot H_{ice}$ [m]

n is the rotational propeller speed in bollard condition. If not known, n is to be taken as indicated in Tab 11.

Table 11

Propeller type	Rotational speed n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	0,85 n_n

Here, n_n is the nominal rotational speed at MCR in free running condition.

For CP propellers, the propeller pitch $P_{0,7}$ is to correspond to MCR in bollard condition. If not known, $P_{0,7}$ is to be taken as 0,7 · $P_{0,7n}$, where $P_{0,7n}$ is the propeller pitch at MCR in free running condition.

b) Design ice torque on propeller Q_{max} for ducted propellers

Q_{max} is the maximum torque on a propeller resulting from ice/propeller interaction.

$$Q_{max} = 7,7\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3[kNm]$$

when $D \leq D_{limit}$

$$Q_{max} = 14,6\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H^{1,1}_{ice}[kNm]$$

when $D > D_{limit}$

where:

D_{limit} = 1,8 · H_{ice} [m]

n is the rotational propeller speed in bollard condition. If not known, n is to be taken as indicated in Tab 12.

Table 12

Propeller type	Rotational speed n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	0,85 n_n

Here, n_n is the nominal rotational speed at MCR in free running condition.

For CP propellers, the propeller pitch $P_{0,7}$ is to correspond to MCR in bollard condition. If not known, $P_{0,7}$ is to be taken as 0,7 · $P_{0,7n}$, where $P_{0,7n}$ is the propeller pitch at MCR in free running condition.

c) Ice torque excitation for open and ducted propellers

The propeller ice torque excitation for shaft line transient torsional vibration analysis is to be described by a sequence of blade impacts which are of a half sine shape (see Fig 3, which applies to propellers with 4 blades).

The torque resulting from a single blade ice impact as a function of the propeller rotation angle is then:

$Q(\varphi) = C_q \cdot Q_{max} \cdot \sin(\varphi(180/\alpha_i))$, when $\varphi = 0...\alpha_i$

$Q(\varphi) = 0$, when $\varphi = \alpha_i...360$

where the C_q and α_i parameters are given in Tab 13 and α_i is the duration of propeller blade/ice interaction expressed in propeller rotation angle.

Table 13

Torque excitation	Propelled/ice interaction	C_q	α_i
Case 1	Single ice block	0,75	90
Case 2	Single ice block	1,0	135
Case 3	Two ice block (phase shift 360/2/Z deg.)	0,5	45

The total ice torque is obtained by summing the torque of single blades, taking into account the phase shift 360deg./Z. In addition, at the beginning and end of the milling sequence, a linear ramp function for 270 degrees of rotation angle is to be used.

The number of propeller revolutions during a milling sequence is to be obtained with the formula:

$N_Q = 2 \cdot H_{ice}$

The number of impacts is Z · N_Q for blade order excitation.

d) Design torque along propeller shaft line

If there is not any relevant first blade order torsional resonance within the designed operating rotational speed range extended 20% above the maximum and 20% below the minimum operating speeds, the following estimation of the maximum torque can be used.

$Q_r = Q_{emax} + Q_{max} \cdot I / I_t$ [kNm],

where I is the equivalent mass moment of inertia of all parts on the engine side of the component under consideration and It is the equivalent mass moment of inertia of the whole propulsion system.

All the torques and the inertia moments are to be reduced to the rotation speed of the component being examined.

If the maximum torque, Q_{emax} , is not known, it is to be taken as indicated in Tab 14.

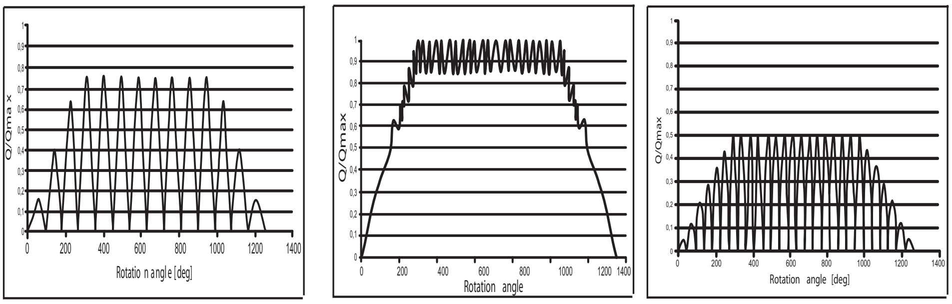
Table 14

Propeller type	Q_{emax}
Propellers driven by electric motor	Q_{motor}
CP propellers not driven by electric motor	Q_n
FP propellers driven by turbine	Q_n
FP propellers driven by diesel engine	0,75 Q_n

Here, Q_{motor} is the electric motor peak torque.

If there is a first blade order torsional resonance within the designed operating rotational speed range extended 20% above the maximum and 20% below the minimum operating speeds, the design torque (Q_r) of the shaft component is to be determined by means of torsional vibration analysis of the propulsion line.

Figure 3 : The shape of the propeller ice torque excitation for 90 and 135 degree single-blade impact sequences and 45 degree double blade impact sequence. (Figures apply to propellers with 4 blades)



2.5.5 Blade failure load

The ultimate load resulting from blade failure as a result of plastic bending around the blade root is to be calculated with the formula below. The ultimate load is acting on the blade at the 0,8R radius in the weakest direction of the blade. For calculation of the extreme spindle torque, the spindle arm is to be taken as 2/3 of the distance between the axis of blade rotation and the leading/trailing edge (whichever is the greater) at the 0,8R radius.

$$F_{ex} = \frac{300 \cdot c \cdot t^2 \cdot \sigma_{ref}}{0,8 \cdot D - 2 \cdot r} \quad [kN]$$

where

$\sigma_{ref} = 0,6 \cdot \sigma_{0,2} + 0,4 \cdot \sigma_u$

c, t, and r are, respectively, the length, thickness, and radius of the cylindrical root section of the blade at the weakest section outside the root filet.

2.6 Design

2.6.1 Design principle

The strength of the propulsion line is to be designed according to the pyramid strength principle.

This means that the loss of the propeller blade is not to cause any significant damage to other propeller shaft line components.

2.6.2 Propeller blade

a) Calculation of blade stresses

The blade stresses are to be calculated for the design loads given in [2.5.2]. Finite element analysis is to be used for stress analysis for final approval for all propellers. When this analysis is carried out by the Designer, it is to be submitted to the Society. The following simplified formulae can be used in estimating the blade stresses for all propellers at the root area (r/R < 0,5). The root area dimensions based on the following formula can be accepted even if the FEM analysis would show greater stresses at the root area.

$$\sigma_{st} = C_1 \frac{M_{BL}}{100 \cdot ct^2} \quad [MPa]$$

where

constant C_1 is the $\dfrac{\text{acutal stress}}{\text{stress obtained with beam equation}}$

If the actual value is not available, C_1 is to be taken as 1,6.

$M_{BL} = (0,75 - r/R) \cdot R \cdot F$, for relative radius r/R < 0,5

F is the maximum of F_b and F_f, whichever is greater.

b) Acceptability criterion

The following criterion for calculated blade stresses is to be fulfilled.

$(\sigma_{ref2} / \sigma_{st}) \geq 1,5$

where:

σ_{st} is the calculated stress for the design loads. If FEM analysis is used in estimating the stresses, von Mises stresses are to be used.

σ_{ref2} is the reference stress, defined as:

$\sigma_{ref2} = 0,7 \cdot \sigma_u$ or

$\sigma_{ref2} = 0,6 \cdot \sigma_{0,2} + 0,4 \cdot \sigma_u$, whichever is the lesser.

c) Fatigue design of propeller blade

The fatigue design of the propeller blade is based on an estimated load distribution for the service life of the ship and the S-N curve for the blade material. An equivalent stress that produces the same fatigue damage as the expected load distribution is to be calculated and the acceptability criterion for fatigue is to be fulfilled as given in this section. The equivalent stress is normalised for 100 million cycles.

If the following criterion is fulfilled, fatigue calculations according to this chapter are not required.

$\sigma_{exp} \geq B_1 \cdot \sigma_{ref2}^{B_2} \cdot \log (N_{ice})^{B_3}$

where B_1, B_2 and B_3 coefficients for open and ducted propellers are given in Tab 15.

>

	Open propeller	Ducted propeller
B_1	0,00270	0,00184
B_2	1,007	1,007
B_3	2,101	2,470

For calculation of equivalent stress, two types of S-N curves are available.

1) Two-slope S-N curve (slopes 4.5 and 10) (see Fig 4).
2) One-slope S-N curve(the slope can be chosen) (see Fig 5).

The type of the S-N curve is to be selected to correspond to the material properties of the blade. If the S-N curve is not known, the two-slope S-N curve is to be used.

Figure 4 : Two-slope S-N curve

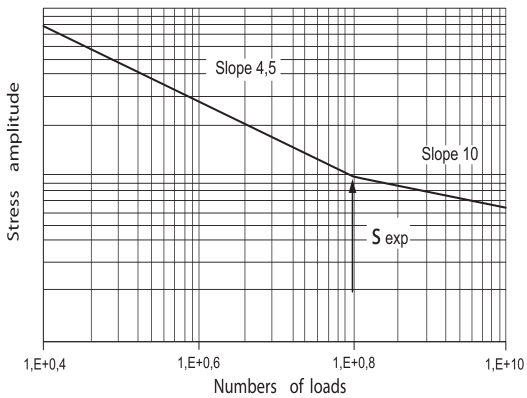
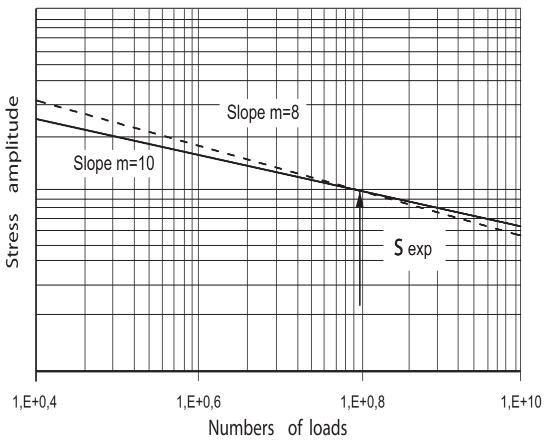


Figure 5 : Constant-slope S-N curve



Equivalent fatigue stress:

the equivalent fatigue stress for 100 million stress cycles which produces the same fatigue damage as the load distribution is:

$\sigma_{fat} = \rho \cdot (\sigma_{ice})_{max}$

where:

$(\sigma_{ice})_{max} = 0,5\ ((\sigma_{ice})_{f\ max} - (\sigma_{ice})_{b\ max})$

$(\sigma_{ice})_{max}$ is the mean value of the principal stress amplitudes resulting from design forward and backward blade forces at the location being studied

$(\sigma_{ice})_{f\ max}$ is the principal stress resulting from forward load

$(\sigma_{ice})_{b\ max}$ is the principal stress resulting from backward load.

In calculation of $(\sigma_{ice})_{max}$, case 1 and case 3 (or case 2 and case 4) are considered as a pair for $(\sigma_{ice})_{f\ max}$, and $(\sigma_{ice})_{b\ max}$ calculations. Case 5 is excluded from the fatigue analysis.

Calculation of ρ parameter for two-slope S-N curve:

The parameter ρ relates the maximum ice load to the distribution of ice loads according to the regression formulae.

$\rho = C_1 \cdot (\sigma_{ice})_{max}^{\ C_2} \cdot \ \sigma_{fl}^{\ C_3} \cdot \log(N_{ice})^{C_4}$

where:

$\sigma_{fl} = \gamma_\varepsilon \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$

where:

γ_ε is the reduction factor for scatter and test specimen size effect

γ_v is the reduction factor for variable amplitude loading

γ_m is the reduction factor for mean stress

σ_{exp} is the mean fatigue strength of the blade material at 10^8 cycles to failure in sea water.

The following values are to be used for the reduction factors if actual values are not available:

$\gamma_\varepsilon = 0,67$, $\gamma_v = 0,75$, and $\gamma_m = 0,75$.

The coefficients C_1, C_2 , C_3 , and C_4 are given in Tab 16.

Table 15

	Open propeller	Ducted propeller
C_1	0,000711	0,000509
C_2	0,0645	0,0533
C_3	-0,0565	-0,0459
C_4	2,22	2,584

Calculation of ρ parameter for constant-slope S-N curve:

for materials with a constant-slope S-N curve - see Fig 5 - the ρ factor is to be calculated with the following formula:

$$\rho = \left(G\frac{N_{ice}}{N_R}\right)^{1/m} \quad (\ln(N_{ice}))^{-1/k}$$

where:

k is the shape parameter of the Weibull distribution k = 1,0 for ducted propellers and k = 0,75 for open propellers. N_R is the reference number of load cycles (=100 million).

Values for the G parameter are given in Tab 17. Linear interpolation may be used to calculate the G value for other m/k ratios than those given in Tab 17.

Table 16 : Value for the G parameter for different m/k ratios

m/k	G	m/k	G	m/k	G
3	6	5,5	287,9	8	40320
3,5	11,6	6	720	8,5	119292
4	24	6,5	1871	9	362880
4,5	52,3	7	5040	9,5	1,133E6
5	120	7,5	14034	10	3,623E6

d) Acceptability criterion for fatigue

The equivalent fatigue stress at all locations on the blade is to fulfil the following acceptability criterion:

$(\sigma_{fl} \ / \ \sigma_{fat}) > 1,5$

where

$\sigma_{fl} = \gamma_{\varepsilon} \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$

γ_{ε} is the reduction factor for scatter and test specimen size effect

γ_v is the reduction factor for variable amplitude loading

γ_m is the reduction factor for mean stress

σ_{exp} is the mean fatigue strength of the blade material at 10^8 cycles to failure in sea water.

The following values are to be used for the reduction factors if actual values are not available:

$\gamma_{\varepsilon} = 0,67$, $\gamma_v = 0,75$, and $\gamma_m = 0,75$.

2.6.3 Propeller bossing and CP mechanism

The blade bolts, the CP mechanism, the propeller boss, and the fitting of the propeller to the propeller shaft are to be designed to withstand the maximum and fatigue design loads, as defined in [2.5]. The safety factor against yielding is to be greater than 1,3 and that against fatigue greater than 1,5. In addition, the safety factor for loads resulting from loss of the propeller blade through plastic bending as defined in [2.5.5] is to be greater than 1,0 against yielding.

2.6.4 Propulsion shaft line

a) General

The shafts and shafting components, such as the thrust and sterntube bearings, couplings, flanges and sealings, are to be designed to withstand the propeller/ice interaction loads as given in [2.5]. The safety factor is to be at least 1,3.

b) Shafts and shafting components

The ultimate load resulting from total blade failure as defined in [2.5.5] is not to cause yielding in shafts and shaft components. The loading is to consist of the combined axial, bending and torsion loads, wherever this is significant. The minimum safety factor against yielding is to be 1,0 for bending and torsional stresses.

2.6.5 Azimuthing main propulsors

In addition to the above requirements, special consideration is to be given to those loading cases which are extraordinary for propulsion units when compared with conventional propellers. The estimation of loading cases is to reflect the way of operation of the ship and the thrusters. In this respect, for example, the loads caused by the impacts of ice blocks on the propeller hub of a pulling propeller are to be considered. Furthermore, loads resulting from the thrusters operating at an oblique angle to the flow are to be considered. The steering mechanism, the fitting of the unit, and the body of the thruster are to be designed to withstand the loss of a blade without damage. The loss of a blade is to be considered for the propeller blade orientation which causes the maximum load on the component being studied. Typically, top-down blade orientation places the maximum bending loads on the thruster body.

Azimuth thrusters are also to be designed for estimated loads caused by thruster body/ice interaction. The thruster body is to stand the loads obtained when the maximum ice blocks, which are given in [2.3], strike the thruster body when the ship is at a typical ice operating speed. In addition, the design situation in which an ice sheet glides along the ship's hull and presses against the thruster body is to be considered. The thickness of the sheet is to be taken as the thickness of the maximum ice block entering the propeller, as defined in [2.3].

2.6.6 Vibrations

The propulsion system is to be designed in such a way that the complete dynamic system is free from harmful torsional, axial, and bending resonances at a 1-order blade frequency within the designed running speed range, extended by 20 per cent above and below the maximum and minimum operating rotational speeds. If this condition cannot be fulfilled, a detailed vibration analysis is to be carried out in order to determine that the acceptable strength of the components can be achieved.

2.7 Alternative design procedure

2.7.1 Scope

As an alternative to [2.5] and [2.6], a comprehensive design study may be carried out to the satisfaction of the Society. The study is to be based on ice conditions given for the different ice classes in [2.3]. It is to include both fatigue and maximum load design calculations and fulfil the pyramid strength principle, as given in [2.6.1].

2.7.2 Loading

Loads on the propeller blade and propulsion system are to be based on an acceptable estimation of hydrodynamic and ice loads.

2.7.3 Design levels

The analysis is to indicate that all components transmitting random (occasional) forces, excluding the propeller blade, are not subjected to stress levels in excess of the yield stress of the component material, with a reasonable safety margin.

Cumulative fatigue damage calculations are to indicate a reasonable safety factor. Due account is to be taken of material properties, stress raisers, and fatigue enhancements.

Vibration analysis is to be carried out and is to indicate that the complete dynamic system is free from harmful torsional resonances resulting from propeller/ice interaction.

2.8 Starting arrangements for propulsion machinery

2.8.1 In addition to complying with the provisions of Pt C, Ch 1, Sec 8 [17.3], ships with the ice class notation IAS are to have air starting compressors capable of charging the air receivers in half an hour, where their propulsion engines need to be reversed in order to go astern.

3 Class notation ID

3.1 Ice torque

3.1.1 For the scantlings of propellers, shafting and reverse and/or reduction gearing, the effect of the impact of the propeller blades against ice is also to be taken into account.

The ensuing torque, hereafter defined as ice torque, is to be taken equal to the value M_G, in N m, calculated by the following formula:

$M_G = 11000\ D^2$

where:

D is the propeller diameter, in m.

3.2 Propellers

3.2.1 Material

Materials of propellers are to have an elongation of not less than 15% on a test specimen, the gauge length of which is five times the diameter. A Charpy V impact test is to be carried out for materials other than bronze and austenitic steel. An average impact energy value of 20 J taken from three tests is to be obtained at minus 10 ºC.

3.2.2 Scantlings

The width l and the maximum thickness t of the cylindrical sections of the propeller blades are to be such as to satisfy the conditions stated in a), b) and c) below.

a) Cylindrical sections at the radius of 0,125D, for fixed pitch propellers

$$1 \cdot t^2 \geq \frac{26,5}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,24 M_G\right)$$

b) Cylindrical sections at the radius of 0,175D for controllable pitch propellers

$$1 \cdot t^2 \geq \frac{21,1}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,35 M_G\right)$$

c) Cylindrical sections at the radius of 0,3D both for fixed and controllable pitch propellers

$$1 \cdot t^2 \geq \frac{9,3}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,86 M_G\right)$$

where:

- ℓ : width of the expanded cylindrical section of the blade at the radius in question, in cm;
- t : corresponding maximum blade thickness, in cm;
- ρ : D/H;
- D : propeller diameter, in m;
- H : blade pitch of propeller, in m, to be taken equal to:
  - the pitch at the radius considered, for fixed pitch propellers,
  - 70% of the nominal pitch, for controllable pitch propellers;
- P : maximum continuous power of propulsion machinery for which the class notation has been requested, in kW;
- n : speed of rotation of propeller, in rev/min, corresponding to the power P;
- t : value, in Nm, of torque corresponding to the above power P and speed n, calculated as follows:

  $M_T = 9550 \cdot P/N$
- z : number of propeller blades;
- M_G : value, in Nm, of the ice torque, calculated according to the formula given in [3.1.1];
- R_m : value, in N/mm^2, of the minimum tensile strength of the blade material.;

3.2.3 Minimum thickness of blades

When the blade thicknesses, calculated by the formulae given in Pt C, Ch 6, Sec 8, [2.3.1] and Pt C, Ch 6, Sec 8, [2.4.1], are higher than those calculated on the basis of the formulae given in [3.2.2], the higher values are to be taken as Rule blade thickness.

3.2.4 Minimum thickness at top of blade

The blade tip thickness at the radius 0,5 D is not to be less than the value t_1, in mm, obtained by the following formula:

$t_1 = (15 + 2D) \cdot (490 / R_m)^{0,5}$

In the formula above, D and R_m have the same meaning as specified in [3.2.2].

3.2.5 Blade thickness at intermediate sections

The thickness of the other sections of the blade is to be determined by means of a smooth curve connecting the points defined by the blade thicknesses calculated by the formulae given in [3.2.2] and [3.2.4].

3.2.6 Thickness of blade edge

The thickness of the whole blade edge, measured at a distance from the edge itself equal to 1,25 t_1 (t_1 being the blade thickness as calculated by the appropriate formula given in [3.2.4]), is to be not less than 0,5 t_1.

For controllable pitch propellers, this requirement is applicable to the leading edge only.

3.2.7 Controllable pitch propeller actuating mechanism

The strength of the blade-actuating mechanism located inside the controllable pitch propeller hub is to be not less than 1,5 times that of the blade when a force is applied at the radius 0,45 D in the weakest direction of the blade.

3.3 Shafting

3.3.1 Propeller shafts

a) Propeller shafts are to be of steel having impact strength as specified in Pt D, Ch 2, Sec 3, [3.6.4]

b) The diameter of the propeller shaft at its aft bearing is not to be less than the value calculated according to Pt C, Ch 1, Sec 5, [2.2.3] increased by 5%.

3.3.2 Intermediate shafts

No Rule diameter increase of intermediate and thrust shafts is generally required.

4 Miscellaneous requirements

4.1 Sea inlets and cooling water systems of machinery

4.1.1

a) The cooling water system is to be designed to ensure the supply of cooling water also when navigating in ice.

b) For this purpose, for ships with the notation IAS, IA, IB or IC, at least one sea water inlet chest is to be arranged and constructed as indicated hereafter:

   1) The sea inlet is to be situated near the centreline of the ship and as aft as possible.

   2) As guidance for design, the volume of the chest is to be about one cubic metre for every 750 kW of the aggregate output of the engines installed on board, for both main propulsion and essential auxiliary services.

   3) The chest is to be sufficiently high to allow ice to accumulate above the inlet pipe.

   4) A pipe for discharging the cooling water, having the same diameter as the main overboard discharge line, is to be connected to the inlet chest.

   5) The area of the strum holes is to be not less than 4 times the inlet pipe sectional area.

   For ships with the notation ID, at least one of the largest sea water inlet chests is to be connected with the cooling water discharge by a pipe having the same diameter as the overboard discharge line. In addition, the arrangement of a bottom sea water inlet, situated as aft as possible, is recommended.

c) Where there are difficulties in satisfying the requirements of b) 2) and b) 3) above, two smaller chests may be arranged for alternating intake and discharge of cooling water.

d) Heating coils may be installed in the upper part of the chests.

e) Arrangements for using ballast water for cooling purposes may be accepted as a reserve in ballast conditions but are not acceptable as a substitute for the sea inlet chests as described above.

4.2 Systems to prevent ballast water from freezing

4.2.1

Any ballast tank situated above the LIWL, as defined in Sec 1, [2.1.1] b), and needed to load down the ship to this waterline is to be equipped with devices to prevent the water from freezing.

4.3 Steering gear

4.3.1

a) In the case of ships with the ice class notations IAS and IA, due regard is to be paid to the excessive loads caused by the rudder being forced out of the centreline position when backing into an ice ridge.

b) Effective relief valves are to be provided to protect the steering gear against hydraulic overpressure.

c) The scantlings of steering gear components are to be such as to withstand the yield torque of the rudder stock.

d) Where possible, rudder stoppers working on the blade or rudder head are to be fitted.

4.4 Fire pumps

4.4.1 The suction of at least one fire pump is to be connected to a sea inlet protected against icing.

Part F
Additional Class Notations

Chapter 7
POLAR CLASS (POLAR)

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 The following additional class notations are assigned in accordance with Pt A, Ch 1, Sec 2, [6.8] to ships constructed of steel and intended for navigation in ice-infested polar waters, except icebreakers:

- **POLAR CLASS PC1**
- **POLAR CLASS PC2**
- **POLAR CLASS PC3**
- **POLAR CLASS PC4**
- **POLAR CLASS PC5**
- **POLAR CLASS PC6**
- **POLAR CLASS PC7**

1.1.2 For the purpose of this Chapter, the notations mentioned in [1.1.1] are indicated using the following abbreviations:

- **PC1** for **POLAR CLASS PC1**
- **PC2** for **POLAR CLASS PC2**
- **PC3** for **POLAR CLASS PC3**
- **PC4** for **POLAR CLASS PC4**
- **PC5** for **POLAR CLASS PC5**
- **PC6** for **POLAR CLASS PC6**
- **PC7** for **POLAR CLASS PC7**

Ships that comply with Sec 2 and Sec 3 are assigned one of the additional class notations **POLAR CLASS** as listed in Tab 1.

The provisions of Sec 2 and Sec 3 are in addition to other applicable requirements of the Rules.

If the hull and machinery are constructed such as to comply with the requirements of different **POLAR CLASS** notations, then both the hull and machinery are to be assigned the lower of these classes on the Certificate of Classification. Compliance of the hull or machinery with the requirements of a higher **POLAR CLASS** is also to be indicated on the Certificate of Classification or an appendix thereto.

1.1.3 "Icebreaker" refers to any ship with an operational profile that includes escort or ice management functions, having powering and dimensions that allow it to undertake aggressive operations in ice-covered waters.

1.1.4 The POLAR CLASS (PC) notations and descriptions are given in Tab 1. It is the responsibility of the Owner to select an appropriate Polar Class.

2 Ice waterlines

2.1 Definitions

2.1.1 Upper ice waterline

The upper ice waterline (UIWL) is defined by the maximum draughts fore, amidships and aft.

2.1.2 Lower ice waterline

The lower ice waterline (LIWL) is defined by the minimum draughts fore, amidships and aft.

The lower ice waterline is to be determined with due regard to the ship's ice-going capability in the ballast loading conditions (e.g. propeller submergence).

Table 1 : Polar Class description

Polar Class	Ice description (based on WMO **(1)** Sea Ice Nomenclature)
PC1	Year-round operation in all Polar waters
PC2	Year-round operation in moderate multi-year ice conditions
PC3	Year-round operation in second-year ice which may include multi-year ice inclusions
PC4	Year-round operation in thick first-year ice which may include old ice inclusions
PC5	Year-round operation in medium first-year ice which may include old ice inclusions
PC6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC7	Summer/autumn operation in thin first-year ice which may include old ice inclusions
(1) WMO: World Meteorological Organisation	

2.2 Indication of upper and lower ice waterlines

2.2.1 The upper and lower ice waterlines upon which the design of the ship is based are to be specified by the Designer in the plans submitted for approval to the Society and are to be stated on the Certificate of Classification.

SECTION 2 HULL

1 General

1.1 Hull areas

1.1.1 The hull of all Polar Class ships is divided into areas reflecting the magnitude of the loads that are expected to act upon them. In the longitudinal direction, there are four regions:

- Bow,
- Bow Intermediate,
- Midbody,
- Stern.

The Bow Intermediate, Midbody and Stern regions are further divided in the vertical direction into the following regions:

- Bottom,
- Lower,
- Icebelt.

The extent of each hull area is indicated in Fig 1, where x, in m, measured at the aft end of the Bow region, in m, is to be taken as:

- 1,5 for **PC1** to **PC4**
- 1,0 for **PC5** to **PC7**

The upper ice waterline (UIWL) and lower ice waterline (LIWL) are as defined in Sec 1.

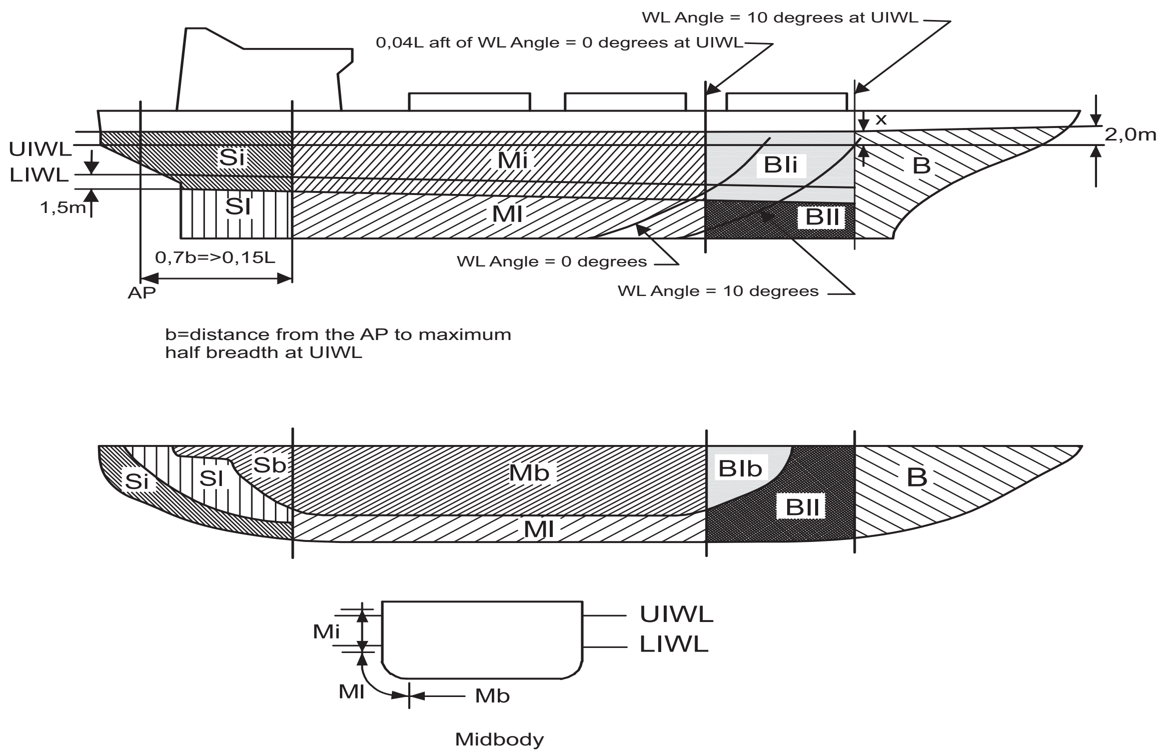
1.1.2 Fig 1 notwithstanding, at no time is the boundary between the Bow and Bow Intermediate regions to be forward of the intersection point of the line of the stem and the ship baseline.

1.1.3 Fig 1 notwithstanding, the aft boundary of the Bow region need not be more than 0,45 L aft of the forward perpendicular (FP).

1.1.4 The boundary between the bottom and lower regions is to be taken at the point where the shell is inclined 7 deg from horizontal.

1.1.5 If a ship is intended to operate astern in ice regions, the aft section of the vessel is to be designed using the Bow and Bow Intermediate hull area requirements.

Figure 1 : Extent of hull areas



1.2 Direct calculations

1.2.1 Direct calculations are not to be utilised as an alternative to the analytical methods prescribed in this Section for the determination of ice loads.

1.2.2 Where direct calculation is used to check the strength of structural systems, the load patch defined in [4] is to be applied.

2 Materials and welding

2.1 Material classes and grades

2.1.1 Plating materials for hull structures are to be not less than those given in Tab 2 and Tab 3 based on the as-built thickness of the material, the POLAR CLASS notation assigned to the ship and the material class of structural members given in Tab 1.

2.1.2 Material classes specified in Pt B, Ch 4, Sec 1, [2.4] are applicable to ships having an additional class notation POLAR CLASS regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed plating are given in Tab 1. Where the material classes in Tab 1 differ from those in Pt B, Ch 4, Sec 1, Tab 3, the higher material class is to be applied.

2.1.3 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0,3 m below the lower waterline, as shown in Fig 2, are to be obtained from Pt B, Ch 4, Sec 1, Tab 6 based on the material class for structural members in Tab 1 above, regardless of the POLAR CLASS assigned.

2.1.4 Steel grades for all weather exposed plating of hull structures and appendages situated above the level of 0,3 m below the lower ice waterline, as shown in Fig 2, are to be not less than given in Tab 2.

Table 1 : Material Classes for Structural Members of Polar Ships

Structural Members	Material Class
Shell plating within the bow and bow intermediate icebelt hull areas (B, B_{Ii})	II
All weather and sea exposed SECONDARY and PRIMARY structural members outside 0,4 L amidships, as defined in Pt B, Ch 4, Sec 1, Tab 3	I
Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	II
All inboard framing members attached to the weather and sea exposed plating, including any contiguous inboard member within 600 mm of the plating	I
Weather exposed plating and attached framing in cargo holds of ships which, by nature of their trade, have their cargo hold hatches open during cold weather operations	I
All weather and sea exposed SPECIAL structural members within 0,2 L from FP, as defined in Pt B, Ch 4, Sec 1, Tab 3	II

Figure 2 : Steel Grade Requirements for Submerged and Weather Exposed Shell Plating

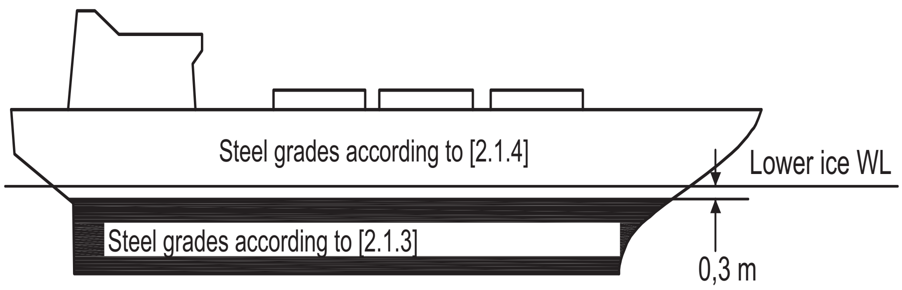


Table 2 : Steel grades for weather exposed plating (1) (3)

As built thickness t, in mm	Material Class I				Material Class II				Material Class III					
	PC1-5		PC6 and 7		PC1-5		PC6 and 7		PC1-3		PC4 and 5		PC6 and 7	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤10	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
10<t ≤15	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
15< t ≤20	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
20< t ≤25	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
25<t ≤30	D	DH	B	AH	E	EH **(2)**	D	DH	E	EH	E	EH	E	EH
30<t ≤35	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
35<t ≤40	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
40<t ≤45	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
45<t ≤50	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

(1) Includes weather exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0,3 m below the lowest ice waterline.
(2) Grades D and DH are allowed for a single strake of side shell plating not more than 1,8 m wide from 0,3 m below the lowest ice waterline.
(3) “NSS” and “HSS” mean, respectively:
“Normal Strength Steel” and “Higher Strength Steel”.

Table 3 : Steel grades for inboard framing members attached to weather exposed plating

As built thickness t, in mm	PC1 to PC5		PC6 and PC7	
	NSS	HSS	NSS	HSS
t ≤ 20	B	AH	B	AH
20 <t ≤ 35	D	DH	B	AH
35 <t ≤45	D	DH	D	DH
45 <t ≤50	E	EH	D	DH

2.1.5 Steel grades for all inboard framing members attached to weather exposed plating are to be not less than given in Tab 3. This applies to all inboard framing members as well as to other contiguous inboard members (e.g. bulkheads, decks) within 600 mm of the exposed plating.

2.1.6 Castings are to have specified properties consistent with the expected service temperature for the cast component.

2.2 Welding

2.2.1 All weldings within ice-strengthened areas are to be of the double continuous type.

3 Corrosion/abrasion additions and steel renewal

3.1 Corrosion/abrasion addition

3.1.1 The value of corrosion/abrasion additions, tC, to be applied to shell plating is to be taken equal to the greater of the following values:

- t_C obtained from Pt B, Ch 4, Sec 2, [3.1]
- t_C obtained from Tab 4, subject to the fitting of effective protection against corrosion and ice-induced abrasion.

3.1.2 The value of corrosion/abrasion additions, tC, to be applied to all internal structures within the ice-strengthened hull areas, including plated members adjacent to the shell, as well as stiffeners, webs and flanges, is to be taken equal to the greater of the following values:

- t_C obtained from Pt B, Ch 4, Sec 2, [3.1]
- t_C = 1,0 mm.

3.2 Steel renewal

3.2.1 Steel renewal for ice-strengthened structures is required when the gauged thickness is less than tnet + 0,5 mm.

4 Design ice loads

4.1 General

4.1.1 For ships having an additional class notation POLAR CLASS, a glancing impact on the bow is the design scenario for determining the scantlings required to resist ice loads.

4.1.2 The design ice load is characterised by an average pressure (Pavg) uniformly distributed over a rectangular load patch of height (b) and width (w).

4.1.3 Within the bow area of all polar classes, and within the bow intermediate icebelt area of polar classes PC6 and PC7, the ice load parameters are functions of the actual bow shape. To determine the ice load parameters (Pavg, b and w), it is necessary to calculate the following ice load characteristics for sub-regions of the bow area;

- shape coefficient (f_{ai}),
- total glancing impact force (F_i),
- line load (Q_i)
- pressure (P_i).

4.1.4 In other ice strengthened areas, the ice load parameters (Pavg, bNonBow and wNonBow) are determined independently of the hull shape and based on a fixed load patch aspect ratio, AR = 3,6.

4.1.5 Design ice forces calculated according to [4.2] are only valid for vessels with icebreaking forms. Design ice forces for any other bow forms are to be specially considered by the Society.

4.1.6 Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship/ice interaction. These inertial loads, based on accelerations determined by the Society, are to be considered in the design of these structures.

Table 4 : Corrosion/Abrasion Additions for Shell Plating

Hull Area	t_c [mm]					
	With Effective Protection			Without Effective Protection		
	PC1 to PC3	PC4 and PC5	PC6 and PC7	PC1 to PC3	PC4 and PC5	PC6 and PC7
Bow; Bow Intermediate Icebelt	3,5	2,5	2,0	7,0	5,0	4,0
Bow Intermediate Lower; Midbody and Stern Icebelt	2,5	2,0	2,0	5,0	4,0	3,0
Midbody and Stern Lower; Bottom	2,0	2,0	2,0	4,0	3,0	2,5
Other Areas	2,0	2,0	2,0	3,5	2,5	2,0

4.2 Glancing impact load characteristics

4.2.1 The parameters defining the glancing impact load characteristics are reflected in the class factors listed in Tab 5.

Table 5 : Class Factors

Polar Class	Crushing Failure Class Factor (C_{FC})	Flexural Failure Class Factor(C_{FF})	Load Patch Dimensions Class Factor (C_{FD})	Displacement Class Factor (C_{FDIS})	Longitudinal Strength Class Factor (C_{FL})
PC1	17,69	68,60	2,01	250000	7,46
PC2	9,89	46,80	1,75	210000	5,46
PC3	6,06	21,17	1,53	180000	4,17
PC4	4,50	13,48	1,42	130000	3,15
PC5	3,10	9,00	1,31	70000	2,50
PC6	2,40	5,49	1,17	40000	2,37
PC7	1,80	4,06	1,11	22000	1,81

4.3 Bow area

4.3.1 General

In the bow area, the force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) associated with the glancing impact load scenario are functions of the hull angles measured at the upper ice waterline (UIWL). The influence of the hull angles is captured through calculation of a bow shape coefficient (fa). The hull angles are defined in Fig 3.

4.3.2 Sub-regions

The waterline length of the bow region is generally to be divided into 4 sub-regions of equal length. The force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) are to be calculated with respect to the mid-length position of each sub-region (each maximum of F, Q and P is to be used in the calculation of the ice load parameters P_{avg}, b and w).

The bow area load characteristics are determined as indicated in [4.3.3] to [4.3.7].

Figure 3 : Definition of Hull Angles

β' : normal frame angle at upper ice waterline [deg]

α : upper ice waterline angle [deg]

γ : buttock angle at upper ice waterline (angle of buttock line measured from horizontal) [deg]

$\tan(\beta)$: $\tan(\alpha) / \tan(\gamma)$

$\tan(\beta')$: $\tan(\beta) / \cos(\alpha)$

4.3.3 Shape coefficient

The shape coefficient, fa_i, is to be obtained from the following formula:

$fa_i = \min (fa_{i,1} \; ; fai_{,2} \; ; fa_{i,3})$

where:

$fa_{i,1}$: $[(0,097 - 0,68 (x/L - 0,15)^2] \; \alpha_i / (\beta'_i)^{0,5}$

$fa_{i,2}$: $99,81 \; CF_F \; / \; [\sin(\beta'_i) \; CF_C \; \Delta^{0,64}]$

$fa_{i,3}$: 0,60

i : sub-region considered

L : ship length as defined in Pt B, Ch 1, Sec 2 but measured on the upper ice waterline (UIWL), in m

x : distance from the forward perpendicular (FP) to the station under consideration, in m

α : waterline angle, in deg; see Fig 3

β' : normal frame angle in deg; see Fig 3

Δ : ship displacement, in t, to be taken not less than 5000 t

CF_C : crushing Failure Class Factor from Tab 5

CF_F : flexural Failure Class Factor from Tab 5.

4.3.4 Force

For each sub-region, the force F, in kN, is to be obtained from the following formula:

$F_i = 12,02 \; fa_i \; CF_C \; \Delta^{0,64}$

where:

i : sub-region considered

fa_i : shape coefficient of sub-region i

CF_C : crushing Failure Class Factor from Tab 5

Δ : ship displacement, in t, to be taken not less than 5000 t.

4.3.5 Load patch aspect ratio

For each sub-region, the load patch aspect ratio AR_i is to be obtained from the following formula:

$AR_i = 7,46 \sin(\beta'_i)$ to be taken not less than 1,3

where:

i : sub-region considered

β'_i : normal frame angle of sub-region i, in deg.

4.3.6 Line load

For each sub-region, the line load Q, in kN/m, is to be obtained from the following formula:

$Q_i = 14,79 \; F_i^{\,0,61} \; CF_D / AR_i^{\,0,35}$

where:

i : sub-region considered

F_i : force of sub-region i

CF_D : Load Patch Dimensions Class Factor from Tab 5

AR_i : load patch aspect ratio of sub-region i.

4.3.7 Pressure

For each sub-region, the pressure P, in kN/m², is to be obtained from the following formula:

$P_i = 218,78 \; F_i^{0,22} \; CF_D^2 \; AR_i^{0,3}$

where:

i : sub-region considered

F_i : force of sub-region i

CF_D : Load Patch Dimensions Class Factor from Tab 5

AR_i : load patch aspect ratio of sub-region i.

4.4 Hull areas other than the bow

4.4.1 General

In hull areas other than the bow, the force (F_{NonBow}) and line load (Q_{NonBow}) used in the determination of the load patch dimensions (b_{NonBow}, w_{NonBow}) and design pressure (P_{avg}) are determined as follows.

4.4.2 Force

The force F_{NonBow}, in kN, is to be obtained from the following formula:

- if $\Delta \le CF_{DIS}$

  $F_{NonBow} = 4,33 \; CF_C \; \Delta^{0,64}$

- if $\Delta > CF_{DIS}$

  $F_{NonBow} = 0,36 \; CF_C \; [12,02 \; CF_{DIS}^{0,64} + 0,10 \; (\Delta - CF_{DIS})]$

where:

CF_C : Crushing Force Class Factor from Tab 5

Δ : Ship displacement, in t, to be taken not less than 10000 t

CF_{DIS} : Displacement Class Factor from Tab 5.

4.4.3 Line Load

The line load Q_{NonBow}, in kN/m, is to be obtained from the following formula:

$Q_{NonBow} = 9,452 \; F_{NonBow}^{0,61} \; CF_D$

where:

CF_D : Load Patch Dimensions Class Factor from Tab 5.

4.5 Design load patch

4.5.1

In the Bow area, and the Bow Intermediate Icebelt area for ships with class notation PC6 and PC7, the dimensions (width, wBow, and height, bBow) in m, of the design load patch are to be obtained from the following formulae:

$w_{Bow} = F_{Bow} / Q_{Bow}$

$b_{Bow} = Q_{Bow} / P_{Bow}$

where:

F_{Bow} : maximum force F_i in the Bow area from the formula in [4.3.4], in kN

Q_{Bow} : maximum line load Q_i in the Bow area from the formula in [4.3.6], in kN/m

P_{Bow} : maximum pressure P_i in the Bow area from the formula in [4.3.7] , in kN/m².

4.5.2 In hull areas other than those covered by [4.5.1], the dimensions (width, wBow, and height, bBow) in m, of the design load patch are to be obtained from the following formulae:

$w_{NonBow} = F_{NonBow} \; / \; Q_{NonBow}$

b_{NonBow} = w_{NonBow} / 3,6

where F_{NonBow} and Q_{NonBow} are defined in [4.4.1] and [4.4.2].

4.6 Pressure within the design load patch

4.6.1 The average pressure Pavg, in kN/m2, within the design load patch is to be obtained from the following formula:

P_{avg} = F / (b w)

where:

F : F_{Bow} or F_{NonBow}, in kN, as appropriate for the hull area under consideration

b : b_{Bow} or b_{NonBow} as appropriate for the hull area under consideration

w : w_{Bow} or w_{NonBow} as appropriate for the hull area under consideration.

Areas of higher concentrated pressure exist within the load patch. In general, smaller areas have higher local pressures. Accordingly, the peak pressure factors listed in Tab 6 are used to account for the pressure concentration on localised structural members.

Table 6 : Peak pressure factors

Structural Member		Peak pressure factor (PPF_i)
Plating	Transversely framed	PPF_p = (1,8 - s) ≥ 1,2
	Longitudinally framed	PPF_p = (2,2 - 1,2 s) ≥ 1,5
Frames in transverse framing systems	With load distributing stringers	PPF_t = (1,6 - s) ≥ 1,0
	With no load distributing stringers	PPF_t = (1,8 - s) ≥ 1,2
Load-carrying stringers, side and bottom longitudinals, web frames		if S_w ≥ 0,5 w PPF_s = 1 if S_w < (0,5 w)PPF_s = 2,0 - 2,0 S_w w
where: s = frame or longitudinal spacing, in m. S_w = web frame spacing, in m w = ice load patch width, in m		

4.7 Hull area factors

4.7.1 Associated with each hull area is an area factor that reflects the relative magnitude of the load expected in that area. The area factor AF for each hull area is listed in Tab 7.

In the event that a structural member spans across the boundary of a hull area, the largest hull area factor is to be used in the scantling determination of the member.

Due to their increased manoeuvrability, ships having propulsion arrangements with azimuthing thruster(s) or "podded" propellers are to have specially considered Stern Icebelt (S_i) and Stern Lower (S_l) hull area factors.

Table 7 : Hull area factors (AF)

Hull area		Area	Polar Class						
			PC1	PC2	PC3	PC4	PC5	PC6	PC7
Bow (B)	All	B	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Bow Intermediate (BI)	Icebelt Lower Bottom	BI_i	0,90	0,85	0,85	0,80	0,80	1,00 **(1)**	1,00 **(1)**
	Lower	BI_l	0,70	0,65	0,65	0,60	0,55	0,55	0,50
	Bottom	BI_b	0,55	0,50	0,45	0,40	0,35	0,30	0,25
Midbody (M)	Icebelt	M_i	0,70	0,65	0,55	0,55	0,50	0,45	0,45
	Lower	M_l	0,50	0,45	0,40	0,35	0,30	0,25	0,25
	Bottom	M_b	0,30	0,30	0,25	**(2)**	**(2)**	**(2)**	**(2)**
Stern (S)	Icebelt	S_i	0,75	0,70	0,65	0,60	0,50	0,40	0,35
	Lower	S_l	0,45	0,40	0,35	0,30	0,25	0,25	0,25
	Bottom	S_b	0,35	0,30	0,30	0,25	0,15	**(2)**	**(2)**

(1) See [4.1.3]
(2) Indicates that strengthening for ice loads is not necessary.

5 Longitudinal strength

5.1 Application

5.1.1 Ice loads need only be combined with still water loads. The combined stresses are to be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local buckling strength is also to be verified.

5.2 Hull girder ice loads

5.2.1 Design vertical ice force at the bow

The design vertical ice force at the bow, FIB, in kN, is to be taken as:

$F_{IB} = \min (F_{IB,1}; F_{IB,2})$

where:

$F_{IB,1} = 1,505 \ K_I^{0,15} \ \sin^{0,2}(\gamma_{stem}) \ (\Delta \ K_h)^{0,5} \ CF_L$

$F_{IB,2} = 1200 \ CF_F$

K_I = indentation parameter = K_f / K_h, where K_f and K_h, in kN/m, are to be taken according to the following formulae:

$K_f = [2 \ C \ B^{1-e_b} / (1 + e_b)]^{0,9} \ \tan(\gamma_{stem})^{-0,9(1 + e_b)}$

$K_h = 10 \ A_{wp}$

CF_L = Longitudinal Strength Class Factor from Tab 5

e_b = bow shape exponent which best describes the water-plane (see Fig 4), to be taken as follows:

- e_b = 1,0 for a simple wedge bow form
- e_b = 0,4 to 0,6 for a spoon bow form
- e_b = 0 for a landing craft bow form

An approximate value of e_b determined by a simple fit is acceptable.

γ_{stem} : stem angle, in deg, to be measured between the horizontal axis and the stem tangent at the upper ice waterline (buttock angle as per Fig 3 measured on the centreline)

α_{stem} : waterline angle measured in way of the stem at the upper ice waterline (UIWL) (deg) (see Fig 4)

C : $1 / [2 (L_B / B)^{e_b}]$

B : ship's moulded breadth, in m

L_B : bow length, in m

y : $B / 2 \ (x/L_B)^{e_b}$, in m (see Fig 4 and Fig 5)

Δ : ship displacement, in t, to be taken not less than 10000 t

A_{wp} : ship waterplane area, in m^2

CF_F : Flexural Failure Class Factor from Tab 5.

Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.

Figure 4 : Bow Shape Definition

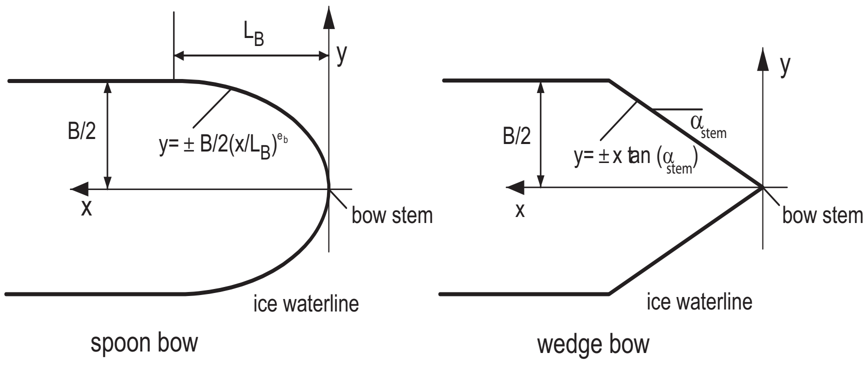
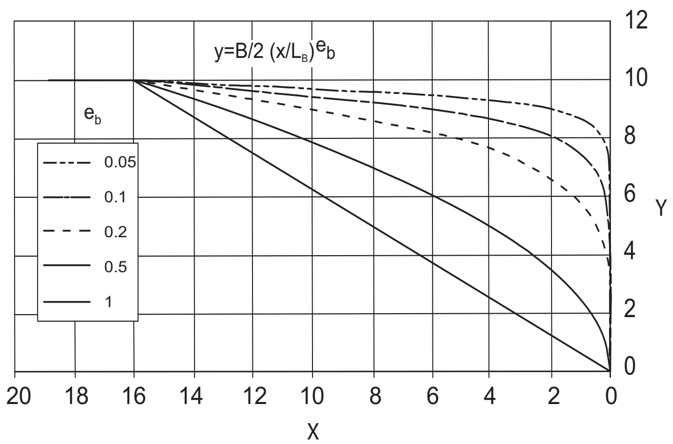


Figure 5 : Example of e_b effect on the bow shape for B = 20 and L_B =16



5.2.2 Design vertical ice bending moment

The design vertical ice bending moment M_I, in kN·m, along the hull girder is to be taken as:

$M_I = 0{,}1\ C_m\ L\ \sin^{-0{,}2}(\gamma_{stem})\ F_{IB}$

where:

- L : ship length as defined in Pt B, Ch 1, Sec 2 but measured on the upper ice waterline (UIWL), in m
- γ_{stem} : as given in [5.2.1]
- F_{IB} : design vertical ice force at the bow, in kN
- C_m : longitudinal distribution factor for the design vertical ice bending moment to be taken as follows:
  - C_m = 0,0 at the aft end of L
  - C_m = 1,0 between 0,5 L and 0,7 L from aft
  - C_m = 0,3 at 0,95 L from aft
  - C_m = 0,0 at the forward end of L

Intermediate values are to be determined by linear interpolation.

Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.

5.2.3 Design vertical ice shear force

The design vertical ice shear force F_I, in kN, along the hull girder is to be taken as:

$F_I = C_f\ \ F_{IB}$

where:

- C_f : longitudinal distribution factor to be taken as follows:

- For positive shear force:
  - C_f : 0,0 between the aft end of L and 0,6 L from aft
  - C_f : 1,0 between 0,9 L from aft and the forward end of L
- For negative shear force
  - C_f : 0,0 at the aft end of L
  - C_f : -0,5 between 0,2 L and 0,6L from aft
  - C_f : 0,0 between 0,8 L from aft and the forward end of L

  Intermediate values are to be determined by linear interpolation.

5.3 Longitudinal strength criteria

5.3.1 The strength criteria provided in Tab 8 are to be satisfied. The design stress is not to exceed the permissible stress.

where:

- σ_a : applied vertical bending stress, in N/mm²
- τ_a : applied vertical shear stress, in N/mm²
- σ_y : minimum upper yield stress of the material, in N/mm²
- σ_u : ultimate tensile strength of the material, in N/mm²
- σ_c : critical buckling stress in compression, according to Pt B, Ch 7, Sec 1, [5.3.1] in N/mm²
- τ_c : critical buckling stress in compression, according to Pt B, Ch 7, Sec 1, [5.3.1] in N/mm²
- η : 0,8

6 Shell plating

6.1 Definitions

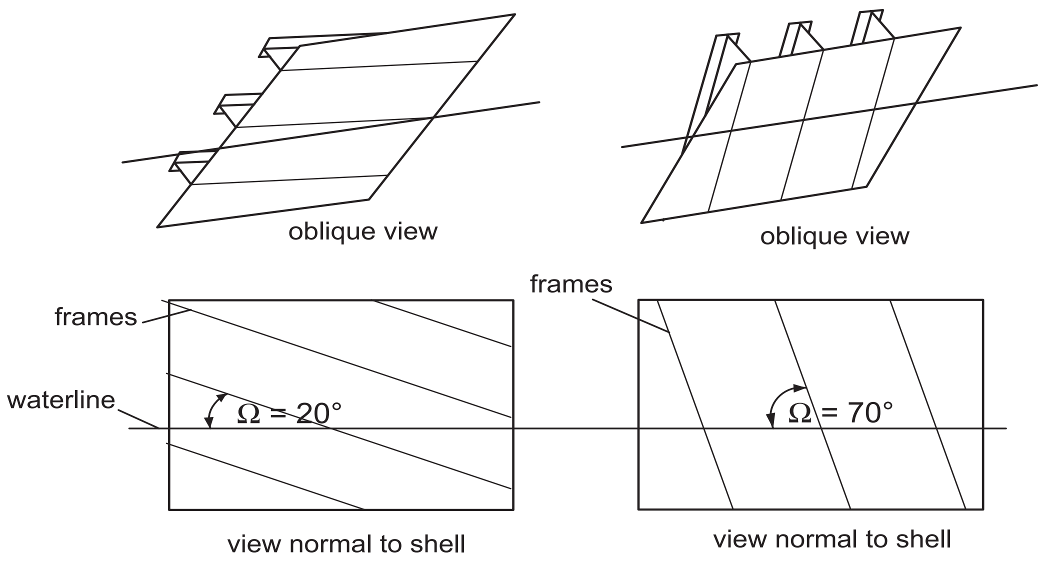
6.1.1

- Ω : smallest angle, in deg, between the chord of the waterline and the line of the first level framing as illustrated in Fig 6
- s : transverse frame spacing, in m, in transversely framed ships or longitudinal frame spacing in longitudinally framed ships
- AF : Hull Area Factor from Tab 7
- PPF_p : Peak Pressure Factor from Tab 6
- P_{avg} : average patch pressure, in kN/m², according to [4.6]
- σ_y : minimum upper yield stress of the material, in N/mm²
- b : height of design load patch, in m
- l : distance, in m, between frame supports, i.e. equal to the frame span as given in [7.1.4], but not reduced for any fitted end brackets. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support.

Table 8 : Longitudinal strength criteria

Failure Mode	Applied Stress	Permissible Stress when: $\sigma_y / \sigma_u \leq 0{,}7$	Permissible Stress when: $\sigma_y / \sigma_u > 0{,}7$
Tension	σ_a	$\eta\ \sigma_y$	$\eta\ 0{,}41\ (\sigma_u + \sigma_y)$
Shear	τ_a	$\eta\ \sigma_y / (3)^{0{,}5}$	$\eta\ 0{,}41\ (\sigma_u + \sigma_y) / (3)^{0{,}5}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners $\sigma_c / 1{,}1$ for stiffeners	
	τ_a	τ_c	

Figure 6 : Shell Framing Angle Ω



6.2 Required thickness

6.2.1 The required minimum shell plating thickness t, in mm, is not to be less than the value obtained from the following formula:

$t = t_{net} + t_c$

where:

t_{net} : plate thickness required to resist ice loads according to [6.3], in mm

t_c : corrosion and abrasion allowance according to [3.1], in mm.

6.2.2 The thickness of shell plating required to resist the design ice load, tnet, depends on the orientation of the framing.

6.3 Net thickness

6.3.1 Transversely framed plating

The net thickness t_{net}, in mm, for transversely framed plating (Ω = 70 deg), including all bottom plating, i.e. plating in hull areas B_{lb}, M_b and S_b, is to be obtained from the following formula:

$t_{net} = 15{,}8\ s\ [(AF\ PPF_p\ P_{avg}) / \sigma_y]^{0,5}\ /\ [1 + s / (2\ b)\ ]$

where b is to be taken not greater than *l* - s/4.

6.3.2 Longitudinally framed plating

The net thickness t_{net}, in mm, for longitudinally framed plating ($\Omega \leq 20$ deg) is to be obtained from the following formulae:

- when $b \geq s$:

  $t_{net} = 15{,}8\ s\ [(AF\ PPF_p\ P_{avg}) / \sigma_y]^{0,5}\ /\ [1 + s / (2\ l)]$

- when $b < s$:

  $t_{net} = 15{,}8\ s\ [(AF\ PPF_p\ P_{avg}) / \sigma_y]^{0,5}\ [2\ b/s - (b/s)^2]^{0,5}\ /\ [1+ + s / (2\ l)]$

6.3.3 Obliquely framed plating

The net thickness t_{net}, in mm, for obliquely framed plating (70° > Ω > 20°) is to be obtained by linear interpolation between the values obtained from [6.3.1] and [6.3.2].

7 Framing

7.1 General

7.1.1 The term "framing member" refers to transverse and longitudinal ordinary stiffeners, load-carrying stringers and web frames in the areas of the hull exposed to ice pressure. Where load-distributing stringers have been fitted, their arrangement is to be in accordance with the applicable requirements of Part B, Chapter 4 and their scantlings are to be such that the stresses are in accordance with the applicable checking criteria defined in Pt B, Ch 7, Sec 3.

7.1.2 The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support is to be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity is to be ensured at the support of any framing which terminates within an ice-strengthened area.

7.1.3 The details of framing member intersection with other framing members, including plated structures, as well as the details for securing the ends of framing members at supporting sections are to be in accordance with the applicable requirements of Part B, Chapter 4.

7.1.4 The span of a framing member is to be determined in accordance with Pt B, Ch 4, Sec 3, [3.2]. If brackets are fitted, the span may be taken at half-length of the brackets. Brackets are to be configured to ensure stability in the elastic and post-yield response regions.

7.1.5 When calculating the section modulus and shear area of a framing member, net thicknesses of the web, flange (if fitted) and attached shell plating are to be used.

The shear area of a framing member may include that material contained over the full depth of the member, i.e. web area including portion of flange, if fitted, but excluding attached plating.

7.2 Actual net effective shear area

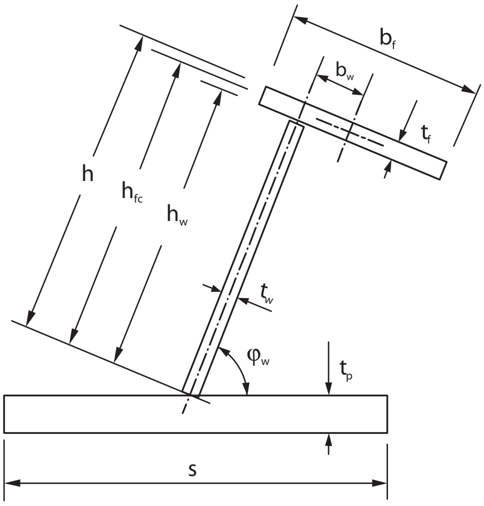
7.2.1 The actual net effective shear area, Aw, in cm2, of a framing member is given by:

$A_W = h\ \ t_{wn} \sin \varphi_w / 100$

where:

- h : height of stiffener, in mm; see Fig 7
- t_{wn} : net web thickness, in mm, given by: t_w - t_{c1}
- t_w : as-built web thickness, in mm; see Fig 7
- t_{c1} : corrosion addition as per relevant applicable Parts of the Rules but in any case not less than the value t_c indicated in [3.1],
- φ_w : smallest angle between shell plate and stiffener web, measured at the mid-span of the stiffener; see Fig 7. The angle φ_w may be taken as 90° provided the smallest angle is not less than 75°.

Figure 7 : Stiffener geometry



7.3 Actual net effective plastic section modulus

7.3.1

When the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus, Zp, in cm3, is given by:

$$Z_p = A_{pn} t_{pn} / 20 + \frac{h^2{}_w t_{wn} \sin \varphi_w}{2000} + A_{fn}(h_{fc} \sin \varphi_w - b_w \cos \varphi_w)/10$$

where:

h, t_{wn}, t_c, and φ_w are as given in [7.2] and s as given in [6.1]

- A_{pn} : net cross-sectional area, in cm^2 of the local frame
- t_{pn} : fitted net shell plate thickness, in mm (to comply with t_{net} as required by [6.1])
- h_w : height, in mm, of local frame web; see Fig 7
- A_{fn} : net cross-sectional area, in cm^2, of local frame flange
- h_{fc} : height, in mm, of local frame measured at mid-thickness of the flange; see Fig 7
- b_w : distance from mid-thickness plane of local frame web to the centre of the flange area; see Fig 7.

When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located at a distance z_{na}, in mm, above the attached shell plate, given by:

$$Z_{na} = (100 A_{fn} + h_w t_{wn} - 1000 t_{pn} s)/(2 t_{wn})$$

and the net effective plastic section modulus, Z_p, in cm^3, is given by:

$$Z_p = t_{pn} s z_{na} \sin \varphi_w + \left\{ \frac{[(h_w - z_{na})^2 + z^2{}_{na}] t_{wn} \sin \varphi_w}{2000} + \right.$$

$$\left. + A_{fn}[(h_{fc} \div z_{na}) \sin \varphi_w - b_w \cos \varphi_w]/10 \right\}$$

In the case of oblique framing arrangement (70° > Ω > 20°, where Ω is defined as given in [6.1]), linear interpolation is to be used.

7.4 Transverse ordinary stiffeners for side and bottom

7.4.1 Definitions

- LL : length of loaded portion of span, in m, to be taken as the lesser of a and b
- a : frame span, in m, as defined in [7.1.4]
- b : height, in m, of design ice load patch according to [4.5.1] or [4.5.2]
- s : transverse frame spacing, in m
- AF : Hull Area Factor from Tab 7
- PPF_t : Peak Pressure Factor from Tab 6
- P_{avg} : average pressure, in kN/m^2, within load patch according to [4.6]
- σ_y : minimum upper yield stress of the material, in N/mm^2.

7.4.2 The actual net effective shear area of transverse ordinary stiffeners, Aw, in cm2, as defined in [7.2], is to comply with the following condition:

$A_w \geq A_t$

where:

$A_t = 8{,}67\ \ LL\ \ s\ \ (AF\ \ PPF_t\ \ P_{avg}) / \sigma_y$.

7.4.3 The actual net effective plastic section modulus of the plate/stiffener combination Zp, in cm3, as defined in [7.3], is to comply with the following condition:

$Z_p \geq 250 \; LL \; (1 - 0,5 \; LL / a) \; s \; (AF \; PPF_t \; P_{avg}) \; a \; A_1/\sigma_y$

where A_1 is the greater of the following values:

- $A_{1A} = 1 / \{1 + j / 2 + k_w \, j/2 \; [(1 - a_1^2)^{0,5} - 1]\}$
- $A_{1B} = \{1 - 1 / [2a_1 \, (1 - 0,5 \, LL/a)]\} / (0,275 + 1,44 \, k_z^{0,7})$

where:

j = 1 for framing with one simple support outside the ice strengthened areas

j = 2 for framing without any simple supports

$a_1 = A_t / A_w$

A_t : minimum shear area of transverse frame as given in [7.4.2]

A_w : effective net shear area of transverse frame (calculated according to [7.2])

k_w : $1 / (1 + 2 \, A_{fn} / A_w)$ with A_{fn} as given in [7.3]

k_z : z_p / Z_p in general, to be assumed = 0 when the frame is arranged with end bracket

z_p : sum of individual plastic section moduli of flange and shell plate as fitted, in cm^3, to be obtained from the following formula:

$z_p = (b_f \; t^2 + b_{eff} \; t^2_{pn}) / 4000$

t_{fn} : net flange thickness, in mm, given by: $t_f - t_c$ (t_c as given in [7.2])

t_f : as-built flange thickness, in mm; see Fig 7

t_{pn} : fitted net shell plate thickness, in mm (not to be less than t_{net} as given in [6])

b_{eff} : effective width, in mm, of shell plate flange, to be assumed as 500 s

Z_p : net effective plastic section modulus, in cm^3, of transverse frame (calculated according to [7.3]).

7.4.4

The scantlings of transverse ordinary stiffeners are to meet the structural stability requirements of [7.7].

7.5 Longitudinal stiffeners

7.5.1 Definitions

AF : Hull Area Factor from Tab 7

PPF_s : Peak Pressure Factor from Tab 6

P_{avg} : average pressure, in kN/m^2, within load patch according to [7.4.1]

b : height, in m, of design ice load patch according to [4.5.1] and [4.5.2]

s : spacing of longitudinal frames, in m

a : longitudinal design span as given in [7.1.4], in m

σ_y : minimum upper yield stress of the material, in N/mm^2

b_1 : $k_o \; b_2$

k_o : $1 - 0,3 / b'$

b' : b / s

b_2 : to be taken in accordance with the following formulae:

- if $b' < 2$

  $b_2 = b \, (1 - 0,25 \, b')$
- if $b' \geq 2$

  $b_2 = s$.

7.5.2 Actual net effective shear area

The actual net effective shear area A_w, in cm^2, of longitudinal stiffeners, as defined in [7.2], is to comply with the following condition:

$A_w \geq A_t$

where:

$A_t = 8,67 \, (AF \; PPF_s \; P_{avg}) \; 0,5 \; b_1 \; a / \sigma_y$.

7.5.3 Actual net effective plastic section modulus

The actual net effective plastic section modulus, in cm^3, of the plate/stiffener combination, Z_p, as defined in [7.3], is to comply with the following condition:

$Z_p \geq Z_{pl}$

where:

$Z_{pl} = 125 \, (AF \; PPF_s \; P_{avg}) \; b_1 \; a^2 \; A_4 / \sigma_y$

A_4 : $1 / \{2 + k_{wl} \; [(1 - a_4^2)^{0,5} - 1]\}$

a_4 : A_L / A_w

A_L : minimum shear area for longitudinal as given in [7.5.2], in cm^2

A_w : net effective shear area of longitudinal (calculated according to [7.2.1]), in cm^2

k_{wl} : $1 / (1 + 2 \, A_{fn} / A_w)$ with A_{fn} as given in [7.3].

7.5.4 Actual net effective plastic section modulus

The scantlings of longitudinal stiffeners are to meet the structural stability requirements of [7.7].

7.6 Web frames and load-carrying stringers

7.6.1 Web frames and load-carrying stringers are to be designed to withstand the ice load patch as defined in [4]. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised.

7.6.2 Web frames and load-carrying stringers are to be dimensioned such that the combined effects of shear and bending do not exceed the limit state(s) defined Pt B, Ch 7, Sec 3. Where these members form part of a structural grillage system, appropriate methods of analysis are to be used. Where the structural configuration is such that members do not form part of a grillage system, the appropriate peak pressure factor (PPF) from Tab 6 is to be used. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

7.6.3 The scantlings of web frames and load-carrying stringers are to meet the structural stability requirements of [7.7].

7.7 Framing - Structural Stability

7.7.1 To prevent local buckling in the web, the ratio of web height (hw) to net web thickness (twn) of any framing member is not to exceed:

- For flat bar sections:

  $h_w / t_{wn} \leq 282 / (\sigma_y)^{0,5}$

- For bulb, tee and angle sections:

  $h_w / t_{wn} \leq 805 / (\sigma_y)^{0,5}$

where:

h_w : web height, in mm

t_{wn} : net web thickness, in mm

σ_y : minimum upper yield stress of the material, in N/mm^2.

7.7.2

Framing members for which it is not practicable to meet the requirements of [7.7.1] (e.g. load-carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners are to ensure the structural stability of the framing member. The minimum net web thickness, in mm, for these framing members is given by the following formula:

$$t_{wn} = 2,63 \cdot 10^{-3} \cdot c_1 \sqrt{\sigma_Y / (5,34 + 4 \cdot (c_1 / c_2)^2)}$$

where:

c_1 : h_w - 0,8 h, in mm

h_w : web height, in mm, of stringer / web frame (see Fig 8)

h : height, in mm, of framing member penetrating the member under consideration (equal to 0 if no such framing member) (see Fig 8)

c_2 : spacing, in mm, between supporting structure oriented perpendicular to the member under consideration (see Fig 8)

σ_y : minimum upper yield stress of the material, in N/mm^2.

7.7.3

In addition to [7.7.1] and [7.7.2], the following is to be satisfied:

$t_{wn} \geq 0,35\ t_{pn} (\sigma_y / 235)^{0,5}$

where:

σ_y : minimum upper yield stress of the shell plate in way of the framing member, in N/mm^2

t_{wn} : net thickness of the web, in mm

t_{pn} : net thickness of the shell plate in way of the framing member, in mm.

7.7.4 To prevent local flange buckling of welded profiles, the following conditions are to be satisfied:

$b'_f / t_{wn} \geq 5$

$b_{out} / t_{fn} = 155 / (\sigma_y)^{0,5}$

where:

b_{out} : width of the flange outstand, in mm

t_{fn} : net thickness of flange, in mm

σ_y : minimum upper yield stress of the material, in N/mm^2.

8 Plated Structures

8.1

8.1.1 Plated structures are those stiffened plate elements in contact with the hull and subject to ice loads. These requirements are applicable to an inboard extent which is the lesser of:

- the web height of the adjacent parallel web frame or stringer; or
- 2,5 times the depth of framing that intersects the plated structure.

8.2

8.2.1 The thickness of the plating and the scantlings of attached stiffeners are to be such that the degree of end fixity necessary for the shell framing is ensured.

8.3

8.3.1 The stability of the plated structure is to adequately withstand the ice loads defined in [4].

9 Stem and stern arrangement

9.1 Fore part

9.1.1 Stem

The stem may be made of rolled, cast or forged steel or of shaped steel plates.

A sharp edged stem (see Fig 9) improves the manoeuvrability of the ship in ice and is particularly recommended for smaller ships under 150 m in length.

Figure 8 : Parameter Definition for Web Stiffening

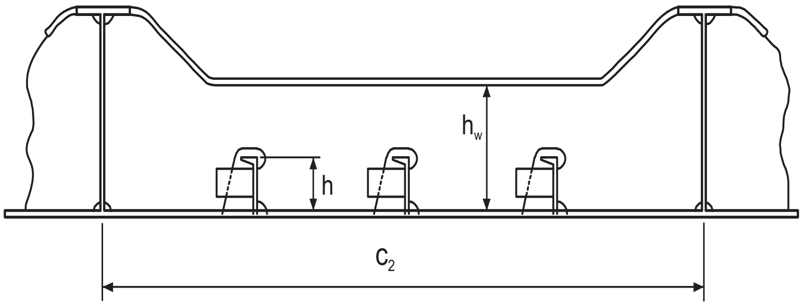
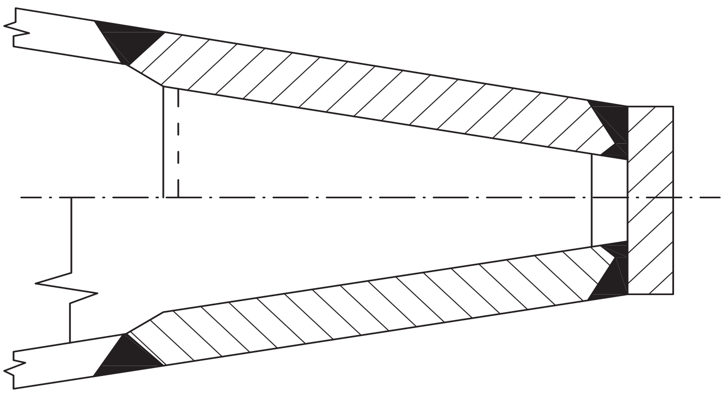


Figure 9



The plate thickness of a shaped plate stem and, in the case of a blunt bow, any part of the shell which forms an angle of 30° or more to the centreline in a horizontal plane, is to be not less than 1,3 times the thickness of the adjacent shell plating calculated according to [6].

The stem and the part of a blunt bow defined above are to be supported by floors or brackets spaced not more than 600 mm apart and having a thickness at least half that of the plate.

The reinforcement of the stem is to be extended from the keel to the upper level of the bow region.

9.2 Aft part

9.2.1 An extremely narrow clearance between the propeller blade tip and the sternframe is to be avoided so as not to generate very high loads on the blade tip.

9.2.2 On twin and triple screw ships, the ice strengthening of the shell and framing is to be extended to the double bottom for at least 1,5 m forward and aft of the side propellers.

9.2.3 Shafting and sterntubes of side propellers are generally to be enclosed within plated bossings. If detached struts are used, their design, strength and attachment to the hull are to be examined by the Society on a case-by-case basis.

9.2.4 A wide transom stern extending below the UIWL seriously impedes the capability of the ship to run astern in ice, which is of paramount importance.

Consequently, a transom stern is not normally to be extended below the UIWL. Where this cannot be avoided, the part of the transom below the UIWL is to be kept as narrow as possible.

The part of a transom stern situated within the ice-strengthened area is to be strengthened as required for the midship region.

10 Hull outfitting

10.1 Appendages

10.1.1 All appendages are to be designed to withstand forces appropriate for the location of their attachment to the hull structure or their position within a hull area.

10.2 Rudders and steering arrangements

10.2.1 The scantlings of the rudder post, rudder stock, pintles, steering gear, etc as well as the capacity of the steering gear are to be determined according to Pt B, Ch 10, Sec 1, taking the coefficient r2, defined in Pt B, Ch 10, Sec 1, [2.1.2], equal to 1,10 irrespective of the rudder profile type.

However, the maximum ahead service speed of the ship to be used in these calculations is not to be taken less than that stated in Tab 9. Where the actual maximum ahead service speed of the ship is greater than that stated in Tab 9, the higher speed is to be used.

Within the ice-strengthened zone, the thickness of rudder plating and diaphragms is to be not less than that required for the shell plating of the aft region.

10.2.2 The rudder stock and the upper edge of the rudder are to be protected against ice pressure by an ice knife or equivalent means.

10.3 Arrangements for towing

10.3.1 A mooring pipe with an opening not less than 250 mm by 300 mm, a length of at least 150 mm and an inner surface radius of at least 100 mm is to be fitted in the bow bulwark on the centreline.

10.3.2 A bitt or other means of securing a towline is to be fitted, dimensioned to withstand the breaking strength of the ship's towline.

10.3.3 On ships with a displacement less than 30000 t, the part of the bow extending to a height of at least 5 m above the UIWL and at least 3 m back from the stem is to be strengthened to withstand the stresses caused by fork towing. For this purpose, intermediate ordinary stiffeners are be fitted and the framing is to be supported by stringers or decks.

Table 9 : Maximum ahead service speed

Notation	Maximum ahead service speed (knots)
POLAR CLASS 1	26
POLAR CLASS 2	24
POLAR CLASS 3	23
POLAR CLASS 4	22
POLAR CLASS 5	21
POLAR CLASS 6	20
POLAR CLASS 7	18

SECTION 3 MACHINERY

1 General

1.1 Application

1.1.1 This Section applies to main propulsion, steering gear, emergency and essential auxiliary systems required for the safety of the ship and the survivability of the crew.

1.2 Drawings and particulars to be submitted

1.2.1 Details of the environmental conditions and the required polar class for the machinery, if different from the ship's polar class.

1.2.2 Detailed drawings of the main propulsion machinery. Description of the main propulsion, steering, and emergency and essential auxiliaries is to include operational limitations. Information on essential main propulsion load control functions.

1.2.3 Description detailing how main, emergency and auxiliary systems are located and protected to prevent problems from freezing, ice and snow, and evidence of their capability to operate in the intended environmental conditions.

1.2.4 Calculations and documentation indicating compliance with the requirements of this Section.

1.3 System Design

1.3.1 Machinery and supporting auxiliary systems are to be designed, constructed and maintained to comply with the requirements of "periodically unmanned machinery spaces" with respect to fire safety. Any automation plant (i.e. control, alarm, safety and indication systems) for essential systems installed is to be maintained to the same standard.

1.3.2 Systems subject to damage by freezing are to be drainable.

1.3.3 Single screw ships classed PC1 to PC5 inclusive are to have means provided to ensure sufficient vessel operation in the case of propeller damage including CP-mechanism.

2 Materials

2.1 Materials exposed to sea water

2.1.1 Materials exposed to sea water, such as propeller blades, propeller hub and blade bolts, are to have an elongation not less than 15% on a test piece the length of which is five times the diameter.

Charpy V impact tests are to be carried out for other than bronze and austenitic steel materials. Test pieces taken from the propeller castings are to be representative of the thickest section of the blade. An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at minus 10 ºC.

2.2 Materials exposed to sea water temperature

2.2.1 Materials exposed to sea water temperature are to be of steel or other approved ductile material.

An average impact energy value of 20 J taken from three tests is to be obtained at minus 10 ºC.

2.3 Material exposed to low air temperature

2.3.1 Materials of essential components exposed to low air temperature are to be of steel or other approved ductile material.

An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at 10 ºC below the lowest design temperature.

3 Ice interaction load

3.1 Propeller ice interaction

3.1.1 This Section covers open and ducted type propellers situated at the stern of a ship having controllable pitch or fixed pitch blades. Ice loads on bow propellers and pulling type propellers are to receive special consideration. The given loads are expected, single occurrence, maximum values for the whole ship's service life for normal operational conditions. These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice. This Section also applies to azimuthing (geared and podded) thrusters, considering loads due to propeller ice interaction. However, ice loads due to ice impacts on the body of azimuthing thrusters are not covered by this Section.

The loads given in this item [3] are total loads (unless otherwise stated) during ice interaction, are to be applied separately (unless otherwise stated) and are intended for component strength calculations only. The different loads given here are to be applied separately.

- F_b is a force bending a propeller blade backwards when the propeller mills an ice block while rotating ahead.
- F_f is a force bending a propeller blade forwards when the propeller interacts with an ice block while rotating ahead.

3.2 Ice Class factors

3.2.1 Tab 1 lists the design ice thickness and ice strength index to be used for estimation of the propeller ice loads.

Table 1

Polar Class	H_{ice} [m]	S_{ice} [-]	S_{gice} [-]
PC1	4,0	1,2	1,15
PC2	3,5	1,1	1,15
PC3	3,0	1,1	1,15
PC4	2,5	1,1	1,15
PC5	2,0	1,1	1,15
PC6	1,75	1	1
PC7	1,5	1	1

H_{ice} : Ice thickness for machinery strength design
S_{ice} : Ice strength index for blade ice force
S_{gice} : Ice strength index for blade ice torque.

3.3 Design ice loads for open propeller

3.3.1 Maximum backward blade force, F_b

The maximum backward blade force F_b, in KN, is equal to:

- when $D < D_{limit}$

$$F_b = -27 S_{ice} (nD)^{0,7} \left(\frac{EAR}{Z}\right)^{0,3} (D)^2$$

- when $D \geq D_{limit}$

$$F_b = -23 S_{ice} (nD)^{0,7} \left(\frac{EAR}{Z}\right)^{0,3} (H_{ice})^{1,4} (D)$$

where:

- $D_{limit} = 0,85\ (H_{ice})^{1.4}$, in m
- n is the nominal rotational speed (at MCR free running condition) for a CP propeller and 85% of the nominal rotational speed (at MCR free running condition) for a FP propeller (regardless of driving engine type)

F_b is to be applied as a uniform pressure distribution to an area on the back (suction) side of the blade for the following load cases:

a) Load case 1: from 0,6R to the tip and from the blade leading edge to a value of 0,2 chord length,
b) Load case 2: a load equal to 50 % of the F_b is to be applied on the propeller tip area outside of 0,9R
c) Load case 5: for reversible propellers a load equal to 60% of the F_b, is to be applied from 0,6R to the tip and from the blade trailing edge to a value of 0,2 chord length.

See load cases 1, 2 and 5 in Tab 3.

3.3.2 Maximum forward blade force, F_f

The maximum forward blade force, F_f , in KN, is equal to:

- when $D < D_{limit}$

$$F_f = 250 \left(\frac{EAR}{Z}\right) (D)^2$$

- when $D \geq D_{limit}$

$$F_f = 500 \left(\frac{1}{1 - \frac{d}{D}}\right) H_{ice} \left(\frac{EAR}{Z}\right) (D)$$

where:

$$D_{limit} = \left(\frac{2}{1 - \frac{d}{D}}\right) H_{ice}$$

- d = propeller hub diameter, in m
- D = propeller diameter, in m
- EAR = expanded blade area ratio
- Z = number of propeller blades.

F_f is to be applied as a uniform pressure distribution to an area on the face (pressure) side of the blade for the following load cases:

a) Load case 3: from 0,6R to the tip and from the blade leading edge to a value of 0,2 chord length
b) Load case 4: a load equal to 50 % of the F_f is to be applied on the propeller tip area outside of 0,9R
c) Load case 5: for reversible propellers a load equal to 60% F_f is to be applied from 0,6R to the tip and from the blade trailing edge to a value of 0,2 chord length,

See load cases 3, 4, and 5 in Tab 4.

3.3.3 Maximum blade spindle torque, Q_{smax}

Spindle torque Q_{smax} around the spindle axis of the blade fitting is to be calculated for the load cases described both in [3.3.1] for F_b and in [3.3.2] for F_f. If these spindle torque values are less than the default value, in kNm, given below, the default minimum value is to be used.

Default value $Q_{smax} = 0,25\ F\ c_{0,7}$

where:

$c_{0,7}$ = length, in m, of the blade chord at 0,7R radius

F is either F_b or F_f, whichever has the greater absolute value.

3.3.4 Maximum propeller ice torque applied to the propeller

The maximum propeller ice torque Q_{max}, in kNm, is equal to:

- when $D < D_{limit}$

$$Q_{max} = 105(1 - d/D)S_{qice}(P_{0,7}/D)^{0,16}(t_{0,7}/D)^{0,6}(nD)^{0,17}D^3$$

- when $D \geq D_{limit}$

$$Q_{max} = 202(1 - d/D)S_{qice}H_{ice}^{1,1}(P_{0,7}/D)^{0,16}(t_{0,7}/D)^{0,6}(nD)^{0,17}D^{1,9}$$

where:

$D_{limit} = 1,81\ H_{ice}$, in m

S_{qice} = Ice strength index for blade ice torque

$P_{0,7}$ = propeller pitch at 0,7R

$t_{0,7}$ = max thickness at 0,7 radius

n is the rotational propeller speed, in rpm, at bollard condition. If not known, n is to be taken as follows:

- n_n, for CP propellers
- n_n, for FP propellers driven by turbine or electric motor
- 0,85 n_n, for FP propellers driven by diesel engine,

where n_n is the nominal rotational speed at MCR free running condition. For CP propellers, propeller pitch $P_{0,7}$ is to correspond to MCR in bollard condition. If not known, $P_{0,7}$ is to be taken as $0,7P_{0,7n}$, where $P_{0,7n}$ is propeller pitch at MCR free running condition.

3.3.5 Maximum propeller ice thrust applied to the shaft

The maximum propeller ice thrust T_f and T_b, in kN, are equal to:

Forward:

$T_f = 1,1\ F_f$

Backwards:

$T_b = 1,1\ F_b$

3.4 Design ice loads for ducted propeller

3.4.1 Maximum backward blade force, F_b

The maximum backward blade force F_b, in kN, is equal to:

- when $D < D_{limit}$

$$F_b = -9,5S_{ice}\left(\frac{EAR}{Z}\right)^{0,3}[nD]^{0,7}D^2$$

- when $D \geq D_{limit}$

$$F_b = -66S_{ice}\left(\frac{EAR}{Z}\right)^{0,3}(nD)^{0,7}D^{0,6}(H_{ice})^{1,4}$$

where:

$D_{limit} = 4\ H_{ice}$, in m

n is to be taken as in [3.3.1].

F_b is to be applied as a uniform pressure distribution to an area on the back side for the following load cases (see Tab 2):

a) Load case 1: on the back of the blade from 0,6R to the tip and from the blade leading edge to a value of 0,2 chord length

b) Load case 5: for reversible rotation propellers a load equal to 60% of F_b is applied on the blade face from 0,6R to the tip and from the blade trailing edge to a value of 0,2 chord length.

3.4.2 Maximum forward blade force, F_f

The maximum forward blade force F_f, in kN, is equal to:

- when $D \leq D_{limit}$

$$F_f = 250\left(\frac{EAR}{Z}\right)D^2$$

- when $D > D_{limit}$

$$F_f = 500\left(\frac{EAR}{Z}\right)D\frac{1}{\left(1 - \frac{d}{D}\right)}H_{ice}$$

where:

$$D_{limit} = \frac{2}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} \quad \text{, in m}$$

F_f is to be applied as a uniform pressure distribution to an area on the face (pressure) side for the following load cases (see Tab 3):

a) Load case 3: on the blade face from 0,6R to the tip and from the blade leading edge to a value of 0,5 chord length

b) Load case 5: a load equal to 60% F_f is to be applied from 0,6R to the tip and from the blade leading edge to a value of 0,2 chord length.

3.4.3 Maximum propeller ice torque applied to the propeller

Q_{max} is the maximum torque, in kNm, on a propeller due to ice propeller interaction:

- when $D \leq D_{limit}$

$$Q_{max} = 74\left(1 - \frac{d}{D}\right)\left(\frac{P_{0,7}}{D}\right)^{0,16}\left(\frac{t_{0,7}}{D}\right)^{0,6}(nD)^{0,17}S_{qice}D^3$$

- when $D > D_{limit}$

$$Q_{max} = 141\left(1 - \frac{d}{D}\right)\left(\frac{P_{0,7}}{D}\right)^{0,16}\left(\frac{t_{0,7}}{D}\right)^{0,6}(nD)^{0,17}S_{qice}D^{1,9}H_{ice}^{1,1}$$

where $D_{limit} = 1,8\ H_{ice}$, in m

n is the rotational propeller speed, in rps, at bollard condition. If not known, n is to be taken as follows:

- n_n, for CP propellers
- n_n, for FP propellers driven by turbine or electric motor
- 0,85 n_n, for FP propellers driven by diesel engine,

where n_n is the nominal rotational speed at MCR free running condition.

For CP propellers, propeller pitch $P_{0,7}$ is to correspond to MCR in bollard condition. If not known, $P_{0,7}$ is to be taken as $0,7P_{0,7n}$, where $P_{0,7n}$ is propeller pitch at MCR free running condition.

3.4.4 Maximum blade spindle torque for CP-mechanism design, Q_{smax}

Spindle torque Q_{smax}, in kNm, around the spindle axis of the blade fitting is to be calculated for the load case described in [3.1.1]. If these spindle torque values are less than the default value given below, the latter value, in kNm, is to be used:

Default value $Q_{smax} = 0,25\ F\ c_{0,7}$

where:

- $c_{0,7}$ is the length of the blade section at 0,7R radius
- F is is either F_b or F_f, whichever has the greater absolute value.

3.4.5 Maximum propeller ice thrust (applied to the shaft at the location of the propeller)

The maximum propeller ice thrust T_f and T_b, in kN, are equal to:

$T_f = 1,1\ F_f$

$T_b = 1,1\ F_b$

3.5 Design loads on propulsion line

3.5.1 Torque

The propeller ice torque excitation for shaft line dynamic analysis is to be described by a sequence of blade impacts which are of half sine shape and occur at the blade frequency or at twice tb blade frequency (see Fig 1). The torque due to a single blade ice impact as a function of the propeller rotation angle is then:

- when $\varphi = 0...\alpha_i$

  $Q(\varphi) = Cq\ Q_{max} \sin[\varphi(180 / \alpha_i)]$

- when $\varphi = \alpha_i...360$

  $Q(\varphi) = 0$

  where C_q and α_i parameters are given in Tab 2.

Table 2 : Parameters C_q and α_i

Torque excitation	Propeller ice interaction	C_q	α_i
Case 1	Single ice block	0,5	45
Case 2	Single ice block	0,75	90
Case 3	Single ice block	1,0	135
Case 4	Two ice blocks with 45 degree phase in rotation angle	0,5	45

The total ice torque is obtained by summing the torque of single blades taking into account the phase shift 360°/Z. The number of propeller revolutions during a milling sequence is to be obtained with the formula:

$N_Q = 2\ H_{ice}$

The number of impacts is $Z\ N_Q$.

See Fig 1.

Milling torque sequence duration is not valid for pulling bow propellers, which are subject to special consideration.

The response torque at any shaft component is to be analysed considering excitation torque $Q_{(\varphi)}$ at the propeller, actual engine torque Q_e and mass elastic system.

Q_e = actual maximum engine torque at considered speed

The design torque (Q_r) of the shaft component is to be determined by means of torsional vibration analysis of the propulsion line. Calculations are to be carried out for all excitation cases given above and the response is to be applied on top of the mean hydrodynamic torque in bollard condition at the considered propeller rotational speed.

3.5.2 Maximum response thrust

Maximum thrust along the propeller shaft line is to be calculated with the formulae below. The factors 2,2 and 1,5 take into account the dynamic magnification due to axial vibration. Alternatively, the propeller thrust magnification factor may be calculated by dynamic analysis.

- Maximum shaft thrust forwards $T_r = T_n + 2,2T_f$
- Maximum shaft thrust backwards $T_r = 1,5\ T_b$

where:

T_n = propeller bollard thrust, in kN

T_f and T_b = maximum forward and backward propeller ice thrust, in kN

If hydrodynamic bollard thrust, T_n, is not known, T_n is to be taken as follows:

- 1,25 T, for CP propellers (open)
- 1,1 T, for CP propellers (ducted)
- T for FP propellers driven by turbine or electric motor
- 0,85 T, for FP propellers driven by diesel engine (open)
- 0,75 T, for FP propellers driven by diesel engine (ducted)

T = nominal propeller thrust at MCR at free running open water condition.

3.5.3 Blade failure load for both open and ducted propeller

The force is acting at 0,8R in the weakest direction of the blade and at a spindle arm of 2/3 of the distance of the axis of blade rotation of leading and trailing edge, whichever is the greater.

The blade failure load, in kN, is equal to:

$$F_{ex} = \frac{0,3 \cdot c \cdot t^2 \cdot \sigma_{ref}}{0,8 \cdot D - 2 \cdot r} \cdot 10^3$$

where $\sigma_{ref} = 0,6\ \sigma_{0,2} + 0,4\ \sigma_u$

and where σ_u and $\sigma_{0,2}$ are representative values for the blade material, in N/mm^2.

c, t and r are, in mm, respectively the actual chord length, thickness and radius of the cylindrical root section of the blade at the weakest section outside the root fillet and will typically be at the termination of the fillet into the blade profile.

4 Design

4.1 Design principle

4.1.1

The strength of the propulsion line is to be designed:

a) for maximum loads in [3]

b) such that the plastic bending of a propeller blade will not cause damage to other propulsion line components

c) with sufficient fatigue strength.

4.2 Azimuthing main propulsors

4.2.1 In addition to the above requirements, special consideration is to be given to the loading cases which are extraordinary for propulsion units when compared with conventional propellers. Estimation of the load cases is to reflect the operational realities of the ship and the thrusters. In this respect, for example, the loads caused by impacts of ice blocks on the propeller hub of a pulling propeller are to be considered. Also, loads due to thrusters operating in an oblique angle to the flow are to be considered. The steering mechanism, the fitting of the unit and the body of the thruster are to be designed to withstand the loss of a blade without damage. The plastic bending of a blade is to be considered in the propeller blade position which causes the maximum load on the studied component.

Azimuth thrusters are also to be designed for estimated loads due to thruster body / ice interaction.

4.3 Blade design

4.3.1 Maximum blade stresses

Blade stresses are to be calculated using the backward and forward loads given in [3.3] and [3.4]. The stresses are to be calculated with recognised and well documented FE-analysis or another acceptable alternative method. The stresses on the blade are not to exceed the allowable stresses σ_{all} for the blade material given below.

Calculated blade stress for maximum ice load is to comply with the following:.

$\sigma_{calc} < \sigma_{all}$

where $\sigma_{all} = \sigma_{ref} / S$

S = 1,5

σ_{ref} = reference stress, equal to the minimum of:

$\sigma_{ref} = 0,7\ \sigma_u$

$\sigma_{ref} = 0,6\ \sigma_{0,2} + 0,4\ \sigma_u$

where σ_u and $\sigma_{0,2}$ are representative values for the blade material.

4.3.2 Blade edge thickness

The blade edge thickness t_{ed} and tip thickness t_{tip} are to be greater than t_{edge}, in mm, given by the following formula:

$$t_{edge} \geq xS \cdot S_{ice} \sqrt{\frac{3p_{ice}}{\sigma_{ref}}}$$

x : distance from the blade edge, in mm, measured along the cylindrical sections from the edge; this is to be 2,5% of chord length, though need not be taken greater than 45 mm. In the tip area (above 0,975R radius) x is to be taken as 2,5% of 0,975R section length and is to be measured perpendicularly to the edge; however, it is not to be taken greater than 45 mm.

S : safety factor, to be taken equal to:

- trailing edges:
  S = 2,5
- leading edges:
  S = 3,5
- for tip:
  S = 5

S_{ice} : according to [3.2]

p_{ice} : ice pressure, to be taken equal to 16 Mpa for leading edge and tip thickness

σ_{ref} : according to [4.3.1].

The requirement for edge thickness is to be applied for the leading edge and in the case of reversible rotation open propellers also for the trailing edge. Tip thickness refers to the maximum measured thickness in the tip area above 0,975R radius. The edge thickness in the area between position of maximum tip thickness and edge thickness at 0,975 radius is to be interpolated between edge and tip thickness value and smoothly distributed.

4.4 Prime movers

4.4.1

The main engine is to be capable of being started and running the propeller with the CP in full pitch.

4.4.2 Provision is to be made for heating arrangements to ensure ready starting of the cold emergency power units at an ambient temperature applicable to the Polar Class of the ship.

4.4.3 Emergency power units are to be equipped with starting devices with a stored energy capability of at least three consecutive starts at the design temperature in [4.4.2]. The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy is to be provided for an additional three starts within 30 min, unless manual starting can be demonstrated to be effective.

5 Machinery fastening loading accelerations

5.1 General

5.1.1 Essential equipment and main propulsion machinery supports are to be suitable for the accelerations as indicated below. Accelerations are to be considered acting independently.

5.2 Accelerations

5.2.1 Longitudinal Impact Accelerations, a_l

Maximum longitudinal impact acceleration a_l at any point along the hull girder, in m/s², is equal to:

$a_l = (F_{IB} / \Delta) \{ [1,1 \tan (\gamma + \phi)] + (7H/L)\}$

where:

ϕ	:	maximum friction angle between steel and ice, in degrees, normally taken as 10°
γ	:	bow stem angle at waterline, in degrees
Δ	:	displacement, in t
L	:	length between perpendiculars, in m
H	:	distance in metres from the waterline to the point being considered, in m
F_{IB}	:	vertical impact force, defined in Sec 2, [5.2.1], in kN.

5.2.2 Vertical acceleration a_v

Combined vertical impact acceleration at any point along the hull girder, in [m/s²]

$a_v = 2,5 (F_{IB} / \Delta) F_x$

where:

F_x = 1,3 at FP

F_x = 0,2 amidships

F_x = 0,4 at AP

F_x = 1,3 at AP for ships conducting ice breaking astern.

Intermediate values of F_x are to be interpolated linearly.

5.2.3 Transverse impact acceleration a_t

Combined transverse impact acceleration at any point along the hull girder, in [m/s²]

$a_t = 3 F_i (F_x / \Delta)$

where:

F_x = 1,5 at FP

F_x = 0,25 amidships

F_x = 0,5 at AP

F_x = 1,5 at AP for ships conducting ice breaking astern.

Intermediate values of F_x are to be interpolated linearly.

F_i = total force normal to shell plating in the bow area due to oblique ice impact, defined in Sec 2, [4.3.4], in kN.

6 Auxiliary systems

6.1 General

6.1.1 Machinery is to be protected from the harmful effects of ingestion or accumulation of ice or snow. Where continuous operation is necessary, means are to be provided to purge the system of accumulated ice or snow.

6.1.2 Means are to be provided to prevent damage due to freezing, for tanks containing liquids.

6.1.3 Vent pipes, intake and discharge pipes and associated systems are to be designed to prevent blockage due to freezing or ice and snow accumulation.

7 Sea inlets and cooling water systems

7.1 General

7.1.1 Cooling water systems for machinery that is essential for the propulsion and safety of the ship, including sea chest inlets, are to be designed for the environmental conditions applicable for the additional class notation POLAR CLASS.

7.1.2 At least two sea chests are to be arranged as ice boxes for classes PC1 to PC5 inclusive. The calculated volume for each of the ice boxes is to be at least 1m3 for every 750 kW of the total installed power. For PC6 and PC7 there is to be at least one ice box located preferably near the centreline.

7.1.3 Ice boxes are to be designed for the effective separation of ice and venting of air.

7.1.4 Sea inlet valves are to be secured directly to the ice boxes. The valve is to be a full bore type.

7.1.5 Ice boxes and sea bays are to have vent pipes and are to have shut-off valves connected directly to the shell.

7.1.6 Means are to be provided to prevent freezing of sea bays, ice boxes, ship side valves and fittings above the load waterline.

7.1.7 Efficient means are to be provided to recirculate cooling seawater to the ice box. The total sectional area of the circulating pipes is not to be less than the area of the cooling water discharge pipe.

7.1.8 Detachable gratings or manholes are to be provided for ice boxes. Manholes are to be located above the deepest load line. Access is to be provided to the ice box from above.

7.1.9 Openings in ship sides for ice boxes are to be fitted with gratings, or holes or slots in shell plates. The net area through these openings is to be not less than 5 times the area of the inlet pipe. The diameter of holes or the width of slots in shell plating is to be not less than 20 mm. Gratings of ice boxes are to be provided with a means of clearing. Clearing pipes are to be provided with screw-down type non-return valves.

8 Ballast tanks

8.1 General

8.1.1 Efficient means are to be provided to prevent freezing in fore and after peak tanks and wing tanks located above the waterline and where otherwise found necessary.

9 Ventilation system

9.1 General

9.1.1 Air intakes for machinery and accommodation ventilation are to be located on both sides of the ship.

9.1.2 Accommodation ventilation air intakes are to be provided with means of heating.

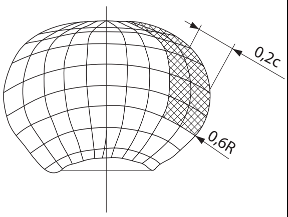
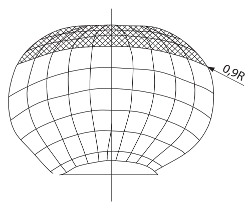
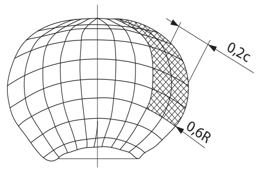
9.1.3 The temperature of inlet air provided to machinery from air intakes is to be suitable for safe operation of the machinery.

10 Alternative design

10.1 General

10.1.1 As an alternative, a comprehensive design study may be submitted with a request for validation by an agreed test program.

Table 3 : Load cases for open propeller

	Force	Loaded area	Right handed propeller blade seen from back
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	50% of F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0,9R radius	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	

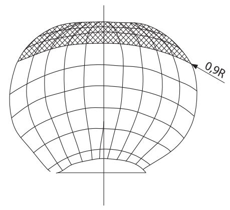
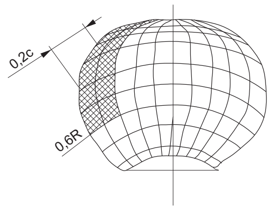
	Force	Loaded area	Right handed propeller blade seen from back
Load case 4	50% of F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside of 0,9R radius	
Load case 5	60 % of F_f or F_b, whichever is the greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

Table 4 : Load cases for ducted propeller

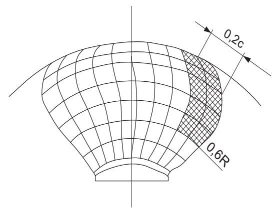
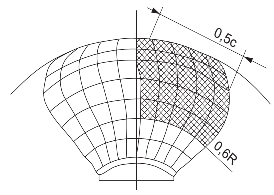
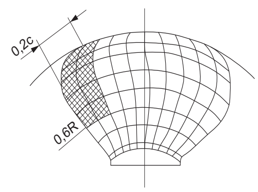
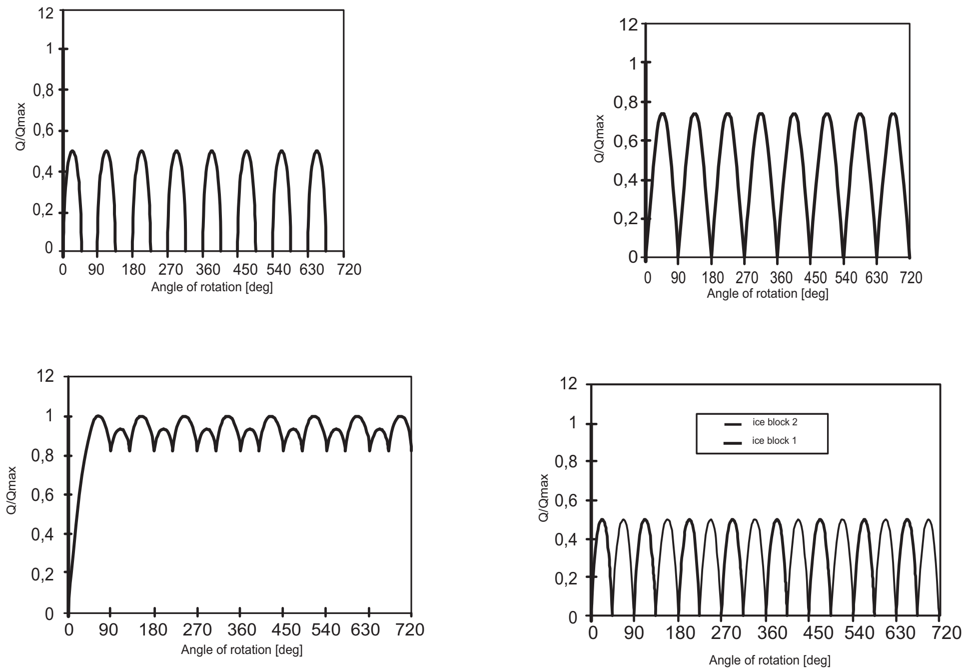
	Force	Loaded area	Right handed propeller blade seen from back
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,5 times the chord length	
Load case 5	60 % of F_f or F_b, whichever is the greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

Figure 1 : Shape of the propeller ice torque excitation for 45, 90, 135 degrees single blade impact sequences and 45 degrees double blade impact sequence (two ice pieces) on a four-bladed propeller



Part F
Additional Class Notations

Chapter 8
WINTERIZATION

SECTION 1 GENERAL

1 General

1.1 Purpose and applicatio

1.1.1 The additional class notation **WINTERIZATION** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.9.1], to ships intended to be operated in cold climate over long periods.

The value **temp** in brackets is the design temperature in °C taken as references.

2 Design temperature

2.1 Definitions

2.1.1

The design temperature **(temp)** is to be taken as the lowest mean daily average air temperature in the area of operation, where:

- Mean: Statistical mean over observation period (at least 20 years)
- Average: Average during one day and night
- Lowest: Lowest during one year.

Fig 1 illustrates the temperature definition.

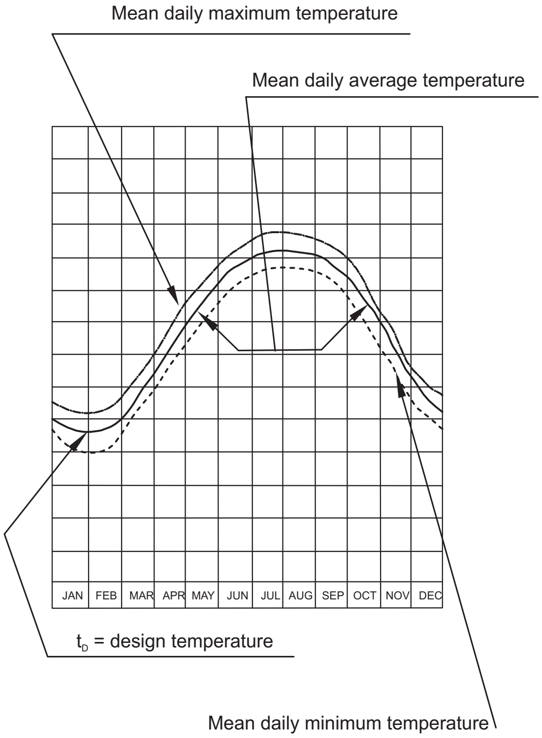
3 Required notations

3.1

3.1.1 In order for the **WINTERIZATION (temp)** notation to be granted, the ship is to be assigned the additional class notation **GREEN PLUS** or equivalent and one of the following class notations:

- **POLAR CLASS**
- **ICE CLASS IA SUPER**
- **ICE CLASS IA**
- **ICE CLASS IB**
- **ICE CLASS IC**

Figure 1 : Commonly used definitions of temperatures



4 Documentation to be submitted

4.1

4.1.1 Tab 1 lists the documents to be submitted for information or approval.

Table 1

No.	I/A **(1)**	Document
1	A	Distribution of steel qualities in structures exposed to low air temperatures
2	A	Trim and stability booklet with ice accretion effects
3	A	Damage stability calculations, when applicable, with ice accretion effects
(1) A : to be submitted for approval I : to be submitted for information.		

SECTION 2 HULL AND STABILITY

1 Structure Design Principles

1.1 Extention of inner hull

1.1.1 In addition to the requirements of the **GREEN PLUS** notation or equivalent, the inner hull in the cargo area, where fitted, is to be extended within the machinery space as much as possible.

1.2 Materials

1.2.1 The steel grades for structures exposed to low temperatures are to be suitable for the design temperature defined in Sec 1, [2].

Material used in external structures above the lower ice waterline (LIWL) is to be appropriate for the material design temperature.

External structure is defined as the plating with stiffening to a distance of 0.5 meter inwards from the shell plating, exposed decks and sides of superstructure and deckhouses. The requirement also applies to masts.

Steel grades are to be selected in accordance with Pt B, Ch 4, Sec 1, [2.5] or Pt F, Ch 7, Sec 2 for ship with the additional class notation POLAR.

1.3 Anchors

1.3.1 The housing arrangement for anchors is to be designed so that icing would not impede the anchor lowering.

The anchor windlass is to be located inside a covered space (deckhouse, or forecastle).

2 Stability

2.1 General

2.1.1 Ice accretion effects are to be taken into account in the evaluation of ship stability.

2.2 Intact stability

2.2.1 The stability check is to be carried out in accordance with Pt B, Ch 3, Sec 2, [6] where the values of ice allowances (refer to Pt B, Ch 3, Sec 2, [6.5.1]) are to be taken equal to:

- 140 kg per square metre on exposed weather decks and gangways
- 70 kg per square metre for the projected lateral area of each side of the ship above the water plane

2.3 Ships with DMS notation

2.3.1 For ships with the notation DMS the damage stability calculations are to be carried out in accordance with the applicable requirements of Ch 10, Sec 9 taking into account the ice allowances mentioned in [2.2].

2.4 Subdivision and arrangement

2.4.1 Heating system is to be provided to keep the scuppers free from ice.

SECTION 3 MACHINERY AND SYSTEMS

1 Ship arrangement

1.1

1.1.1 Life boats are to be located in deck-house recesses in superstructures or in separate semi-enclosures provided with protection from water spray. Free fall lifeboats are not accepted unless they have alternative means for lowering.

Anchor windlass are to be located inside a deckhouse, a semi-enclosure providing protection from water spray or inside a forecastle space.

The emergency towing arrangements are to be located inside a deckhouse, in a semi-enclosed space or in an under-deck space.

The cargo manifold, and manifold valves on tankers are to be located in a semi-enclosed space. If it is impracticable, alternative arrangements may be considered, e.g. hot water for de-icing in combination with heat tracing of valves and portable covers with heating.

The passageway to bow is to be in an under-deck or on-deck trunk.

Navigation bridge wings are to be fully enclosed.

A heated watchman's shelter is to be arranged at the gangway or at a location covering both the gangway and the loading manifold.

2 Equipment located in the machinery space

2.1

2.1.1 Emergency generators are to be so arranged and located that they are able to operate at the design temperature (temp).

The machinery is to be so located and arranged that the machinery is able to start from a black out after 30 minutes, taking realistic temperature drop in the machinery spaces at the design temperature into consideration. A procedure for start up after black out is to be approved and kept on board.

3 Heating of spaces

3.1

3.1.1 Heating of engine room and other areas containing important equipment, such as.

- emergency generator room
- steering gear room
- emergency fire pump room
- CO_2 rooms
- foam rooms
- battery rooms
- cargo pump rooms
- cargo compressor rooms
- bow thruster rooms

are to be provided. The heating of the room is not necessary if equipment and piping installations are designed and/ or heated in order to work at the lowest expected indoor temperature.

4 Electrical installation

4.1

4.1.1 Earth failure monitoring with automatic disconnection and alarm is to be provided to all circuits. A signal lamp is to be installed for each circuit in order to indicate energized circuits.

An ice search light are to be provided on the wheelhouse top capable of being remotely operated from the wheelhouse.

Electric cables exposed to the low temperature are to be comply with the relevant standard for impact test at -35°C and bending test at -40°C.

5 Fire fighting system

5.1

5.1.1 Water based full flooding fire extinguishing system for engine room is not accepted unless a system of heating of the area is provided in order to avoid temperature below 0°C at the outdoor temperature (temp).

The heat source is to be located outside engine room and the heating arrangements are not to be destroyed by heat of fire or by water extinguishing being released.

6 Testing

6.1

6.1.1 The following equipment is to be tested for operation at the design temperature:

- lifeboats and liferafts
- navigation equipment located outdoor
- communication equipment located outdoor.

SECTION 4 ANTI-ICING, DE-ICING, ANTI-FREEZING

1 General

1.1

1.1.1 In addition to the anti icing and de-icing arrangements of Pt C, Ch1, Sec 1, the following equipments are to be provided:

- anti-icing and/or de-icing of mooring equipment
- de-icing and/or anti icing of cranes for ship with service notation pontoon crane
- de-icing arrangements for anchor chain
- fire main and foam main, if applicable, are to be heat traced or located inside a heated passageway
- a heat tracing or a self draining arrangement is to be provided to water pipes on open decks and in no heated spaces
- hydraulic oil systems on open decks and in non-heated spaces are to be arranged with heating, alternatively special hydraulic oil for low temperatures is to be used
- horizontal surfaces of superstructure used as walkways are to be provided with heating to ease ice removal
- thermal protection suits including face masks, gloves and boots are to kept onboard in number sufficient for crew members
- "ballast tanks and fresh water tanks located partly or fully above ballast water line are to be provided with means for heating. These arrangements are not to be provided if the calculations prove that the tanks will not freeze at the material design temperature
- fuel oil storage tanks are to be provided with sufficient heating enabling transfer of fuel
- a heat tracing is to be provided to fuel oil transfer lines exposed to the low temperature environment.

The heating power capability for anti- icing and de-icing arrangements are to be not less than 450 W/m^2 for horizontal deck areas and/or outdoor passageways.

2 Special equipment

2.1

2.1.1 Immersion suits of insulated type are to be kept onboard.

SECTION 5 MATERIAL

1 General

1.1

1.1.1 All equipment exposed to the low temperature and being important for ship operations, such as the following, are to be made from materials suitable for the design temperature:

- anchor chain and chain stopper (e.g. shackle, end link, swivel, common link and kenter shackle of chain; lever, casing, shaft, shaft bearing, bush, roller of chain stopper; rod, casing, stopper bolt, bearing, bush, seat of anchor stopper)
- mooring equipment such as bollards, chocks, fairleads and roller pedestal (e.g. body and seat of fairleads and bollards; roller, pin, boss, bush, seat of deck stand rollers; body of sunken bits; chain wheel, gear wheel, shaft, casing, foundation bolt, drum, warping head of windlass/ mooring winches; mooring wires)
- lifeboats and/or rescue boat davits and winches
- rudderstock with flanges and bolts if flanged connection
- cargo oil piping, vents
- air pipes
- hatches for cargo holds and cargo tanks
- strongpoint for emergency towing
- hydraulic oil pipes for deck machinery or valve remote control unless heated and insulated
- hydraulic valve actuators
- control air pipes unless heated and insulated.

Windlass and mooring winches are to have foundation bolts and shaft bearing holding bolts made from low temperature steel. Grey cast iron is acceptable in no load bearing parts.

The anchor chain type is to be K2 in case of material design temperature upper to -20°C, in other case (temperature lower than -20°C) the anchor chain type is to be K3.

The steel grades of equipment or parts of equipment fabricated from plate material are to be in accordance with the requirements for primary structure (class II) (Pt B, Ch 4, Sec 1).

The steel grades of pipes are to be in accordance with Pt D, Ch2, Sec 2 or with the requirements for primary structure (class II) (Pt B, Ch 4, Sec 1).

2 Testing

2.1

2.1.1 Equipment or parts of equipment fabricated from forged or cast material are to be impact tested.

Test requirement: 27 J at the reference design temperature.

Part F
Additional Class Notations

Chapter 9

PLANNED MAINTENANCE SCHEME AND CONDITION BASED MAINTENANCE (PMS/CBM)

SECTION 1 PLANNED MAINTENANCE SCHEME

1 General

1.1 Application

1.1.1 The additional class notation PMS is assigned in accordance with Pt A, Ch 1, Sec 2, [6.10.2] to ships with an approved Planned Maintenance Scheme complying with the requirements of this Section.

1.1.2 A Planned Maintenance Scheme (hereafter referred to as PMS) is a survey system for machinery items which may be considered as an alternative to the Continuous Machinery Survey system (hereafter referred to as CMS), as described in Pt A, Ch 2, Sec 2, [4.3].

1.1.3 Surveys are to be carried out on the basis of intervals between overhauls recommended by Manufacturers, documented operator's experience and a condition monitoring system, where fitted.

1.1.4 This scheme is limited to components and systems covered by CMS.

1.1.5 Any items not covered by the PMS are to be surveyed and credited in the usual way.

1.1.6 This survey scheme is to be approved by the Society before being implemented.

1.1.7 When the PMS is applied, the scope and periodicity of the class renewal survey are tailored for each individual item of machinery and determined on the basis of recommended overhauls stipulated by the manufacturers, documented experience of the operators and, where applicable and fitted, condition based maintenance (CBM). For instance, within the scope of a PMS the following cases may occur:

- switchboard A is surveyed based on the regular expiry date of the class renewal survey
- lubricating oil pump B is surveyed based on CMS
- diesel engine C is surveyed based on running hours
- turbo pump D is surveyed based on CBM results.

1.2 Maintenance intervals

1.2.1 In general, the intervals for the PMS are not to exceed those specified for CMS. However, for components where the maintenance is based on running hours longer intervals may be accepted as long as the intervals are based on the Manufacturer's recommendations.

1.2.2 However, if an approved CBM is in effect, the machinery survey intervals based on the CMS cycle period may be extended.

1.2.3 When the CBM of machinery and components included in the approved PMS shows that their condition and performance are within the allowable limits, no overhaul is necessary, unless specified by the Manufacturer.

1.3 Shipboard responsability

1.3.1 On board the ship there is to be a person responsible for the management of the PMS for the purpose of which he is to possess the appropriate professional qualifications. This person is usually the Chief Engineer; however, another person designated by the Owner may be accepted by the Society provided that his qualifications are considered equivalent to those of the Chief Engineer.

The surveys of machinery items and components covered by the PMS may be carried out by personnel on board who have been issued a statement of authorisation, under the conditions and limits given in Pt A, Ch 2, App 1.

Items surveyed by the authorised person will be subject to the confirmatory survey as detailed in Pt A, Ch 2, App 1.

1.3.2 Documentation on overhauls of items covered by the PMS is to be recorded and signed by the person responsible for the management of the PMS.

1.3.3 Access to computerised systems for updating of the maintenance documentation and maintenance program is only to be permitted by the Chief Engineer or another authorized person.

2 Conditions and procedures for the approval of the system

2.1 General

2.1.1 The PMS is to be approved by the Society. To this end the Owner is to make a formal request to the Society and provide the documentation and information specified in [2.3], combined in a manual describing the proposed scheme and including sample copies of the different documents to be used during the implementation of the scheme.

2.2 System requirements

2.2.1 The PMS is to be programmed and maintained by a computerised system. However, this may not be applied to the current already approved schemes.

2.2.2 Computerised systems are to include back-up devices, which are to be updated at regular intervals.

2.3 Documentation and information

2.3.1 The documentation to be submitted is the manual mentioned above, which is to include:

a) a description of the scheme and its application on board, including documentation completion procedures, as well as the proposed organisation chart identifying the areas of responsibility and the people responsible for the PMS on board

b) the list of items of machinery and components to be considered for classification in the PMS, distinguishing for each the principle of survey periodicity used as indicated in [1.1.7]

c) the procedure for the identification of the items listed in b), which is to be compatible with the identification system adopted by the Society

d) the scope and time schedule of the maintenance procedures for each item listed in b), including acceptable limit conditions of the parameters to be monitored based on the manufacturers' recommendations or recognised standards and laid down in appropriate preventive maintenance sheets

e) the original baseline data, obtained on board, for machinery undergoing maintenance based on CBM

f) the list and specifications of the CBM equipment, including the maintenance and CBM methods to be used, the time intervals for maintenance and monitoring of each item and acceptable limit conditions

g) the baseline data of the machinery checked through CBM

h) the document flow and pertinent filing procedure.

2.3.2 As an alternative to the hard copy version of the manual, the Owner may grant the Society remote access to its computerised system (see [2.2.1]), which is to include the information requested in [2.3.1].

2.3.3 The following information is to be available on board:

a) all the documentation listed in [2.3.1], duly updated

b) the maintenance instructions for each item of machinery, as applicable (supplied by the manufacturer or by the shipyard)

c) the CBM data of the machinery, including all data since the last dismantling and the original reference data

d) reference documentation (trend investigation procedures etc.)

e) the records of maintenance performed, including conditions found, repairs carried out, spare parts fitted

f) the list of personnel on board in charge of the PMS management.

3 Implementation of the system and approval validity

3.1

3.1.1 When the documentation submitted has been approved, the additional class notation is issued.

3.1.2 An implementation survey is to be carried out to confirm the validity of the additional class notation (see [4.1.1]).

3.1.3 An annual report covering the year's service is to be reviewed by the Society. It is to include the following information:

- the list of items of machinery and components (item b) in [2.3.1]) and the procedure for their identification
- the preventive maintenance sheets
- the CBM data, including baseline data, all data since the last dismantling and the original reference data of the machinery checked through CBM
- any changes to the other documentation in [2.3.1]
- full trend analysis (including spectrum analysis for vibrations) of machinery displaying operating parameters exceeding acceptable tolerances. In such cases, the actions taken to restore the values of the parameters within the acceptable tolerances are also to be reported.

3.1.4 An annual survey is to be carried out to maintain the validity of the PMS (see [4.2]).

The issues listed in [3.1.3] may be examined in the annual survey.

3.1.5 The survey arrangement for machinery under the PMS can be cancelled by the Society if it is apparent that the PMS is not being satisfactorily carried out either from the maintenance records or the general condition of the machinery, or when the agreed intervals between overhauls are exceeded.

3.1.6 The case of sale or change of management of the ship or transfer of class is to cause the approval to be reconsidered.

3.1.7 The ship Owner may, at any time, cancel the survey arrangement for machinery under the PMS by informing the Society in writing and in this case the items which have been inspected under the PMS since the last annual survey can be credited for class at the discretion of the attending Surveyor.

4 Surveys

4.1 Implementation Survey

4.1.1 The Implementation Survey is to be carried out by the Society's Surveyor within one year from the date of approval.

4.1.2 The scope of this survey is to verify that:

- the PMS is implemented in accordance with the approved documentation and is suitable for the type and complexity of the components and systems on board

- the documentation required for the annual survey is produced by the PMS
- the requirements of surveys and testing for retention of class are complied with
- the shipboard personnel are familiar with the PMS procedures and the CBM, if applied
- the CBM data, including baseline data and all data since the last dismantling of the machinery checked through CBM, are stored and managed correctly.

4.1.3 When this survey is carried out and the implementation is found in order, a report describing the system is to be submitted to the Society and the system may be put into service.

4.2 Annual Survey of the PMS

4.2.1 An annual survey of the PMS is to be carried out by a Surveyor of the Society and preferably concurrently with the annual survey of machinery.

4.2.2 The Surveyor is to review the annual report (or verify that it has been reviewed by the Society) and to check that any change to the approved PMS is submitted to the Society for agreement and approval, and that the personnel on board in charge of the PMS have the appropriate authorisation (see Pt A, Ch 2, App 1).

4.2.3 The purpose of this survey is to verify that the scheme is being correctly operated, in particular that all items (to be surveyed in the relevant period) have actually been surveyed in due time, and that the machinery has been functioning satisfactorily since the previous survey. A general examination of the items concerned is to be carried out.

4.2.4 The performance and maintenance records are to be examined to verify that the machinery has functioned satisfactorily since the previous survey or action has been taken in response to machinery operating parameters exceeding acceptable tolerances and that the overhaul intervals have been maintained.

4.2.5 Written details of breakdown or malfunction are to be made available.

4.2.6 Description of repairs carried out is to be examined. Any machinery part which has been replaced by a spare due to damage is to be retained on board, where possible, until examined by a Surveyor of the Society.

4.2.7 At the discretion of the Surveyor, function tests, confirmatory surveys and random check readings, where condition monitoring equipment is in use, are to be carried out as far as practicable and reasonable.

4.2.8 Upon the satisfactory outcome of this survey, the Surveyor confirms the validity of the PMS and decides which items can be credited for class.

5 Damage and repairs

5.1

5.1.1 Damage to components or items of machinery is to be reported to the Society. The repairs of such damaged components or items of machinery are to be carried out to the satisfaction of the Surveyor.

5.1.2 Any repair and corrective action regarding machinery under the PMS is to be recorded in the PMS logbook and repair verified by the Surveyor at the annual survey.

5.1.3 *(1/1/2021)*

In the case of overdue outstanding conditions of class or records of unrepaired damage which would affect the PMS, the relevant items are to be kept out of the PMS until the conditions of class are fulfilled or the repairs carried out.

6 Machinery survey in accordance with a Condition Based Maintenance program

6.1 General on Condition Based Maintenance

6.1.1

Condition Based Maintenance (CBM) is the process of extracting prognostic information from machines to indicate their actual wear and degradation and the relevant rate of change (i.e. trend), on the basis of which the maintenance tasks can be adjusted flexibly in accordance to their actual status. The cost effectiveness of the CBM approach is related to the criticality of the monitored items, the reliability of the CBM techniques in providing valuable information and the ease of the interpretation of the results and their trends. In any case, especially for complex machine types, it cannot be expected that CBM can predict the failure mechanism of every component, and opening up will remain the only possible solution to check certain items.

The choice of the items to be included in the CBM program is up to the Owner.

The minimum parameters to be checked in order to monitor the conditions of the various machinery for which this type of maintenance is accepted are indicated in [6.3] and [6.4]. The frequency of the measurements can be increased according to the criticality of the equipment. In general, the CBM strategy and its extent, inclusive of the acceptability limits, are to be approved by the Manufacturer. CBM techniques not included in this Section may be accepted if they are proposed or established by the Manufacturer of a machine.

Guidance on CBM can be found in the Society "Guide for the Application of Condition Based Maintenance in the Planned Maintenance Scheme".

6.2 Roles and Responsibilities

6.2.1 Operator

At the time of the request for approval of the machinery Planned Maintenance Scheme, the Operator is to submit the CBM details as specified in [6.3] and [6.4], the techniques and the tools that will be employed; for onboard instrumentation, the operating manual and user's guide supplied by the Manufacturer are to be part of the ship's maintenance documentation.

The strategy for the items subjected to CBM is to be computer based and a minimum number of readings is to be taken during the period between annual surveys. CBM does not absolve the machinery personnel of the responsibility to perform visual inspections of the items.

The reading points are to be clearly marked and identified by Memory Identification Card.

The documentation is also to include the responsibility chart of the dedicated human resources for CBM, which may be internal (i.e. shipboard or shoreside staff) or external (professional engineering companies), and the relevant qualifications.

The CBM strategy, inclusive of the description of the tools to be used, dedicated personnel, measurements to be taken etc, is to be an integral part of the PMS survey and is to be included in a dedicated section of the PMS manual.

6.2.2 Society

The Planned Maintenance Scheme will be reviewed for approval with particular reference to the CBM proposals. The Society reserves the right to require the baseline measurements for a period of at least six months, according to the age and condition of the ship's machinery.

The Society's Surveyors retain the right to test or open up the machinery, irrespective of the presence of CBM, if deemed necessary.

6.2.3 Chief Engineer

The presence of a CBM does not absolve the Chief Engineer from his duties, including the responsibility for interventions on machines according to his experience and judgment. The Chief Engineer is to ensure that the CBM parameters are recorded at the agreed intervals. This is to include an initial or "baseline" set of readings, against which further data can be compared.

6.2.4 Annual survey

The requirements for an annual survey of the machinery maintenance and monitoring records are the same as those given in [4.2]. At the annual survey the Chief Engineer is to make available the following maintenance and monitoring records, in addition to those specified in [4.2]:

- CBM records for each item to be credited for class. The records are to indicate where acceptable limits have been exceeded and what actions were taken.
- Calibration certificates for instrumentation used to take measurements, if applicable.

The responsibilities of the Society's Surveyors at the annual survey, additional to those described in [4.2], are:

a) to examine the machinery and monitoring records in sufficient depth to ensure that the scheme has been operated correctly and that the machinery has functioned satisfactorily since the previous survey.

b) to examine the CBM records to verify that the parameters lie within the specified limits (or, in the case of a malfunction in a machine, to check the readings taken just before the malfunction for information to be used in the preparation of the relevant Damage Report). Baseline condition data are to be compared with subsequent readings to ascertain the trend characteristics. The Society's Surveyors may require confirmatory readings on available running machinery to be taken for comparison with the ship's records.

c) to check the calibration certificates for CBM instrumentation and probe the crew's ability to manage CBM tools and records.

6.3 CBM criteria for main machinery

6.3.1 Diesel engines for propulsion and main electrical generation

Tab 1 lists the minimum checks to be carried out according to the engine service.

Table 1

Parameters to be monitored	Diesel engine (single or dual fuel) for direct main propulsion		Diesel engine for electric power generation	
	Request	Minimum periodicity	Request	Minimum periodicity
Power output **(1)**	Yes	Weekly	Yes	Weekly
Running hours	Yes	Weekly	Yes	Weekly
Rotational speed	Yes	Weekly	Yes	Weekly
Indicated pressure diagram (where possible) or pressure-time curves	Yes	Weekly	Yes	Weekly
Fuel oil temperature and/or viscosity	Yes	Weekly	Yes	Weekly
Charge air pressure and temperature at receiver	Yes	Weekly	Yes	Weekly
Exhaust gas temperature for each cylinder	Yes	Weekly	No	-
Exhaust gas temperature before and after the turbochargers	Yes	Weekly	Yes	Weekly
Temperatures and pressure of engine cooling system	Yes	Weekly	Yes	Weekly
Temperatures and pressure of engine lube oil system	Yes	Weekly	Yes	Weekly
Rotational speed of turbochargers **(2)**	Yes	Weekly	Yes	Weekly
Bearing vibrations of turbochargers **(2)**	Yes	Monthly	Yes	Monthly
Results of lube oil analysis	Yes	3 months	Yes	6 months
Crankshaft deflection readings	Yes	6 months	Yes	6 months
Analysis of the fluid of crankshaft torsional vibration damper (if viscous type) according to maker's instructions	Yes	6 months or as per maker’s instruction	Yes	6 months or as per maker’s instruction
Temperature of main bearings and crankcase pressure	Yes	Weekly Where available	Yes	Weekly Where available
Fuel oil analysis (ISO 8217:2005)	Yes	At every bunkering	Yes	At every bunkering
Engine load (%)	No	-	Yes	Weekly
Alternator load (kW)	No	-	Yes	Weekly

(1) To be read by a torquemeter or other equivalent instrument, or through the governor output, or by taking the position of the rack

(2) Reading points of turbocharger's rotational speed and bearing vibrations are to be identified according to the Manufacturer's instructions

Note 1: If the Owner opts to monitor the turbocharger(s) independently of the diesel engine, the following measures are to be taken on a weekly basis as a minimum:

- Exhaust gas temperature before/after turbocharger
- Charge air pressure at receiver
- Turbocharger rotational speed and vibration.

Reading points are to be identified according to the Manufacturer's instructions.

Parameters to be monitored	Diesel engine (single or dual fuel) for direct main propulsion		Diesel engine for electric power generation	
	Request	Minimum periodicity	Request	Minimum periodicity
Inspection of bedplate structure/ chocks / down bolts	Yes	6 months	Yes	6 months
Vibration of bearings of diesel generator and alternator	No	-	Yes	4 months

(1) To be read by a torquemeter or other equivalent instrument, or through the governor output, or by taking the position of the rack

(2) Reading points of turbocharger's rotational speed and bearing vibrations are to be identified according to the Manufacturer's instructions

Note 1: If the Owner opts to monitor the turbocharger(s) independently of the diesel engine, the following measures are to be taken on a weekly basis as a minimum:

- Exhaust gas temperature before/after turbocharger
- Charge air pressure at receiver
- Turbocharger rotational speed and vibration.

Reading points are to be identified according to the Manufacturer's instructions.

6.3.2 Emergency diesel generator

The parameters to be checked are the following:

- calibration and test of fuel nozzles
- measurement of compression of cylinders
- fuel oil filter cleaning
- lube oil analysis.

The measures are to be taken at five-year intervals as a minimum.

6.3.3 Electric propulsion motor with associated frequency converter

Tab 2 lists the minimum checks to be carried out.

Table 2

Method	Requirement
Performance Monitoring	Propulsion Motor: Continuous or periodical monthly monitoring of: • Supplying current on main switchboard (phases and windings) • Converter current (phases and windings) • Feeding transformer highest winding temperature • Motor highest winding temperature • Rotational speed • Encoder for rotor position check • Bearing temperature at drive end (D.E.) • Bearing temperature at non-drive end (N.D.E.) • Cooling air in temperature • Cooling air out temperature • Highest cubicle temperature • Converter heat exchanger temperatures • Motor D.E. and N.D.E. oil leakage detection Propulsion system insulation resistance: every 12 months
Vibration Monitoring	Periodical monitoring of motor bearings. No less than one per month
Lubricant Analysis	Regular sampling, laboratory testing. No less than one sampling every 6 months
Oil Transformer analysis	Regular sampling, laboratory testing. No less than one sampling every 6 months

6.3.4 Pods with associated frequency converter

Ch 1, App 7, Tab 4Tab 3 lists the minimum checks to be carried out.

Table 3

Method	Requirement
Performance Monitoring	Propulsion Motor: Continuous or periodical monthly monitoring of: • Supplying current on main switchboard (phases & windings) • Converter current (phases & windings) • Feeding transformer highest winding temperature • Motor highest winding temperature • Rotational speed • Encoder for rotor position checking, including gears, if any • Pod propeller bearing temperature • Pod thrust bearing temperature • Cooling air in temperature • Cooling air out temperature • Highest cubicle temperature • Converter heat exchanger temperatures • Pod propeller end - thrust end bearings, oil/water contamination recorded value • Pod slewing sealing oil/grease leaking recorded value • Pod steering check of pump working pressure/current • Propulsion system insulation resistance (every 12 months)
Vibration Monitoring	Periodical or continuous monitoring of motor bearings. No less than one per month
Lubricant Analysis	Regular sampling, laboratory testing. No less than one sampling every 6 months. Alternatively, a fixed analyser allowing continuous oil debris monitoring can be fitted in the section from the oil return line to the filter, provided that it does not affect the oil flow in any way
Oil Transformer analysis	Regular sampling, laboratory testing. No less than one sampling every 6 months

6.3.5 Tailshaft

The requirements as per the additional class notation **MON-SHAFT** (Ch 3, Sec 2) apply. In addition, a visual inspection of flexible joints is to be carried out regularly, at the same periodicity set forth in Ch 3, Sec 2, [2.2.2], to check the following items:

- Static deformation
- Oxidation/ageing of the elastic rubber element
- Detachment of rubber/metal joining
- Surface cracks in the elastic rubber element.

6.3.6 Gearing

Tab 5 lists the minimum checks to be carried out.

Table 4

Method	Requirement
Condition Monitoring	Gear wheels, pinions, shafts, bearings, couplings, power clutch and driven pumps are to be inspected at every dismantling. The following checks are required: • gear backlash and pinion/shaft diametric clearance • shaft seal tightness. It may be accepted that gears and roller bearings are inspected without dismantling, as far as practicable, by means of non-invasive diagnostic techniques. Moreover, the following parameters are to be checked weekly: • bearing lubricating oil pressure • rotational speed.
Vibration Monitoring	Periodical or continuous monitoring of bearings. No less than once every 4 months
Lubricant Analysis	Regular sampling, laboratory testing. No less than one sampling every 6 months

6.3.7 Shaft generator

Periodical or continuous monitoring of bearings is requested, no less than once per month.

6.4 Miscellaneous systems and equipment

6.4.1 General

This item [6.4] summarises the minimum requirements for the most common machinery types that can be fitted on ships. In addition to the listed parameters to be checked, periodical visual inspections are to be scheduled.

6.4.2 Cooling system equipment: centrifugal pumps, electric motor driven

Periodical check of:

- rotational speed
- vibration monitoring with associated readings
- pressure at suction/delivery
- electric motor current.

Note 1: for engine driven pumps, vibration readings are always to be taken at the same engine speed (rpm).

Minimum frequency of checks:

- monthly: sea water cooling pumps, high and low temperature fresh water cooling pumps, general service low temperature pumps
- every four months: preheating high temperature cooling system pumps.

6.4.3 Lubrication oil system: worm/gear pumps, electric motor driven

Periodical check of:

- rotational speed
- vibration monitoring with associated readings
- pressure at suction/delivery
- electric motor current.

Note 1: for engine driven pumps, vibration readings are always to be taken at the same engine speed (rpm).

Minimum frequency of checks: monthly.

6.4.4 Fuel oil system: booster/supply gear pumps, electric motor driven

Periodical check of:

- rotational speed
- vibration monitoring with associated readings
- pressure at suction/delivery
- electric motor current.

Note 1: for engine driven pumps, vibration readings are always to be taken at the same engine speed (rpm).

Minimum frequency of checks: monthly.

6.4.5 Compressed air system

For the following machine types:

- starting air compressor, reciprocating, electric motor driven
- general service air compressor, piston/screw type, electric motor driven
- auxiliary blower electric motor driven,

periodical check of:

- rotational speed
- vibration monitoring with associated readings
- delivery pressure
- electric motor current,

are required.

Minimum frequency of checks: every three months.

6.4.6 Steering gear system: hydraulic pumps, electric motor driven

The following checks are required, on a monthly basis as a minimum:

- rotational speed
- vibration monitoring, (continuous or periodical readings)
- zero positioning check
- flexible hose check.

6.4.7 Purifying system : fuel oil and lube oil purifiers

The following checks are required:

a) on a monthly basis as a minimum:
   - vibration monitoring at reading point indicated by maker (vibration limits suggested by Manufacturer, because of high speed)
   - bowl rotational speed reading

b) every three months as a minimum:
   - vibration monitoring periodical readings and visual inspection of fuel oil or lube oil supply gear pumps.

6.4.8 Miscellaneous liquid transfer pumps

For the following equipment types, electric motor driven:

- fuel oil transfer pumps (worm, gears)
- fresh water transfer pumps (centrifugal)
- lube oil transfer pumps (worm, gears),

the following checks are required, at least every three months:

- vibration monitoring with associated readings
- suction/delivery pressure
- electric motor current
- rotational speed.

6.4.9 Ballast, fire and general service pumps

For the following equipment types, electric motor driven:

- ballast pumps (centrifugal)
- fire pumps (centrifugal)
- general service pumps (centrifugal),

the following checks are required, at least every three months and as far as possible in the same working conditions:

- vibration monitoring with associated readings
- suction/delivery pressure
- electric motor current
- rotational speed.

6.4.10 Bilge system

For the following equipment types, electric motor driven:

- centrifugal pumps
- reciprocating pumps,

the following checks are required, at least on a monthly basis and as far as possible in the same working conditions:

- vibration monitoring with associated readings
- suction/delivery pressure
- electric motor current
- rotational speed.

6.4.11 Manoeuvring equipment: bow and stern thrusters, electric motor driven

The following checks are required, at least every three months:

- vibration monitor readings of electric motor
- electric motor current to be recorded
- rotational speed
- vibration monitor readings and visual inspection of servo unit pumps of thrusters.

6.4.12 Steam system

For the following equipment type:

- main boiler feed water multistage centrifugal pumps, steam turbine driven,

the following checks are required, at least every three months:

- rotational speed,
- steam pressure/temperature at turbine inlet/outlet
- pump suction/delivery pressure
- lubricating oil analysis
- pump and turbine bearing vibration monitoring.

For the following equipment types, electric motor driven:

- auxiliary boiler feed water, single stage or multistage centrifugal pumps
- exhaust boiler circulating centrifugal pumps
- fuel oil pumps of main and auxiliary boilers
- boiler forced draught ventilators, electric motor driven,

the following checks are required, at least every three months, as far as possible in the same working conditions:

- vibration monitoring with associated readings
- suction/delivery pressure
- electric motor current
- rotational speed.

For the following equipment type, electric motor driven:

- boiler forced draught ventilators, electric motor driven,

the following checks are required, at least every three months, as far as possible in the same working conditions:

- vibration monitoring with associated readings
- electric motor current.

6.4.13 Fresh water generator

For the following equipment type, electric motor driven:

- feed, cooling, injector sea water centrifugal pumps the following checks are required, at least on a monthly basis:

- vibration monitoring with associated readings
- rotational speed
- electric motor current
- suction/delivery pressure.

The above checks also apply for distillate and condensate centrifugal pumps, at least every three months.

6.4.14 Air conditioning and refrigeration system

For the following equipment type, electric motor driven:

- screw, piston or centrifugal compressor for HVAC, electric motor driven, direct or belt transmission,

the following checks are required, at least every three months:

- vibration monitoring with associated readings
- rotational speed
- electric motor current
- suction/delivery pressure.

6.4.15 Oil tanker systems

For centrifugal large size cargo pumps, electric motor or steam turbine driven, the following checks are required, at least every three months:

- vibration monitoring with associated readings
- rotational speed
- electric motor current
- suction/delivery pressure.

The ship loading conditions and draught are to be recorded.

Note 1: the instruments employed are to be intrinsically safe.

For inert gas blowers (radial, centrifugal or rotary), electric motor driven, the following checks are required, at least on a monthly basis:

- vibration monitoring with associated readings
- rotational speed
- electric motor current.

6.4.16 Ventilation system

For ventilators, the following checks are required, at least every three months:

- vibration monitoring with associated readings
- rotational speed
- electric motor current.

Note 1: the following equipment may be difficult to reach and may require remote installations with cables placed outside:

- HVAC units of accommodation systems
- ventilators of various type for engine rooms, pump room, stores, purifier room with ventilator on shaft
- ventilators for evacuating exhaust from ro-ro car spaces.

6.4.17 Refrigerated cargo ship systems

For compressors screw or piston type, electric motor driven, the following checks are required, at least every three months:

- vibration monitoring with associated readings
- electric motor current
- suction/delivery pressure.

6.4.18 Electrical switchboard

For low voltage panels and medium voltage panels (if practicable), a thermographic inspection is required at least yearly, in the conditions of maximum expected load. The same techniques may also be applied to cables, piping or even to machinery parts to extract information additional to the other CBM techniques.

SECTION 2 CONDITION BASED MAINTENANCE OF THE PROPULSION SYSTEM (PMS-CM(PROP))

1 General

1.1 Application

1.1.1 The additional class notation PMS-CM(PROP) is assigned to ships classed by the Society, eligible for the PMS additional class notation as per Sec 1 and complying with the requirements of this Section.

In the event that the ship undergoes modifications, refitting or repairs that may affect the machinery previously subject to Condition Based Maintenance (CBM), the retention of the notation is subject to the results of new measurements as deemed appropriate by the Society.

1.2 Scope of PMS-CM(PROP) Notation

1.2.1 The notation is assigned if CBM in accordance with the criteria laid down in Sec 1, [6] is applied to equipment that is essential for the continuous operation of the propulsion system. Such equipment is to include, as applicable, the main engine, coupling, and main shaft. Piping, pressure vessels and electrical cables can be surveyed in the usual way. The result of the survey is to be recorded and kept together with the CBM results.

1.3 Documentation for Approval

1.3.1 The documentation for the CBM is to be in accordance with the requirements of Sec 1, [6.2]; in particular, the scope of the application is to be clearly illustrated. The CBM criteria to follow for each piece of machinery are laid out in Sec 1, [6.3] and Sec 1, [6.4]. Equipment not included therein will be the subject of special consideration.

1.4 Implementation of the CBM

1.4.1 When the documentation submitted has been approved and the CBM has been implemented on board and used for a sufficient period (which is not to exceed one year) to allow the personnel to become familiar with it, a survey is to be carried out, in order to make the system officially operational, by a Surveyor of the Society or by another certified society.

1.4.2

Upon the successful outcome of this survey, the CBM is considered approved.

1.5 Surveys

1.5.1 The same requirements laid out in Sec 1, [5] and Sec 1, [6] are valid, as applicable.

SECTION 3 CONDITION BASED MAINTENANCE OF THE HEATING VENTILATION AND AIR CONDITIONING (PMS-CM(HVAC))

1 General

1.1 Application

1.1.1 The additional class notation **PMS-CM(HVAC)** is assigned to ships classed by the Society, eligible for the PMS additional class notation as per Sec 1 and complying with the requirements of this Section.

In the event that the ship undergoes modifications, refitting or repairs that may affect the machinery previously subject to Condition Based Maintenance (CBM), the retention of the notation is subject to the results of new measurements as deemed appropriate by the Society.

1.2 Scope and requirements of PMS-CM(HVAC) Notation

1.2.1 The notation is assigned if CBM in accordance with the criteria laid down in Sec 1, [6] is applied to equipment that is essential for the continuous operation of the HVAC system. Such equipment is to include HVAC compressors and ventilators comprising electric motors and transmission. Heat exchangers, piping, pressure vessels and valves can be surveyed in the usual way. The result of the survey is to be recorded and kept together with the CBM results.

1.3 Documentation for Approval

1.3.1 The documentation for the CBM is to be in accordance with the requirements of Sec 1, [6.2]; in particular, the scope of the application is to be clearly illustrated. The CBM criteria to follow for each piece of machinery are laid out in Sec 1, [6.3] and Sec 1, [6.4]. Equipment not included therein will be the subject of special consideration.

1.4 Implementation of the CBM

1.4.1 When the documentation submitted has been approved and the CBM has been implemented on board and used for a sufficient period (which is not to exceed one year) to allow the personnel to become familiar with it, a survey is to be carried out, in order to make the system officially operational, by a Surveyor of the Society or by another certified society.

1.4.2 Upon the successful outcome of this survey, the CBM is considered approved.

1.5 Surveys

1.5.1 The same requirements laid out in Sec 1, [5] and Sec 1, [6] are valid, as applicable.

SECTION 4 CONDITION BASED MAINTENANCE OF THE CARGO SYSTEM (PMS-CM(CARGO))

1 General

1.1 Application

1.1.1 The additional class notation **PMS-CM(CARGO)** is assigned to ships classed by the Society, eligible for the PMS additional class notation as per Sec 1 and complying with the requirements of this Section.

In the event that the ship undergoes modifications, refitting or repairs that may affect the machinery previously subject to Condition Based Maintenance (CBM), the retention of the notation is subject to the results of new measurements as deemed appropriate by the Society.

1.2 Scope and requirements of PMS-CM(CARGO) Notation

1.2.1 The notation is assigned if a CBM program i n accordance with the criteria laid down in Sec 1, [6] is applied to equipment that is essential for the operation of the cargo systems of tankers. Such equipment is to include as applicable, cargo pumps and their prime movers, power packs and remotely operated valves; the latter are to be tested periodically (at least every three months) to ascertain their functionality and tightness. Piping, pressure vessels and valves can be surveyed in the usual way. The result of the survey is to be recorded and kept together with the CBM results.

1.3 Documentation for Approval

1.3.1 The documentation for the CBM is to be in accordance with the requirements of Sec 1, [6.2]; in particular, the scope of the application is to be clearly illustrated. The CBM criteria to follow for each piece of machinery are laid out in Sec 1, [6.3] and Sec 1, [6.4]. Equipment not included therein will be the subject of special consideration.

1.4 Implementation of the CBM

1.4.1 When the documentation submitted has been approved and the CBM has been implemented on board and used for a sufficient period (which is not to exceed one year) to allow the personnel to become familiar with it, a survey is to be carried out, in order to make the system officially operational, by a Surveyor of the Society or by another certified society.

1.4.2 Upon the successful outcome of this survey, the CBM is considered approved.

1.5 Surveys

1.5.1 The same requirements laid out in Sec 1, [5] and Sec 1, [6] are valid, as applicable.

SECTION 5 CONDITION BASED MAINTENANCE OF THE ELECTRICAL SWITCHBOARDS (PMS-CM(ELE))

1 General

1.1 Application

1.1.1 The additional class notation **PMS-CM(ELE)** is assigned to ships classed by the Society, eligible for the PMS additional class notation as per Sec 1 and complying with the requirements of this Section.

In the event that the ship undergoes modifications, refitting or repairs that may affect the items previously subject to Condition Based Maintenance (CBM), the retention of the notation is subject to the results of new measurements as deemed appropriate by the Society.

1.2 Scope and requirements of CM(ELE) Notation

1.2.1 The notation is assigned if a CBM program in accordance to the criteria laid down in Sec 1, [6] is applied to electrical switchboards above 100 kW.

1.3 Documentation for Approval

1.3.1 The documentation for the CBM is to be in accordance with the requirements of Sec 1, [6.2]; in particular, the scope of the application is to be clearly illustrated. The CBM criteria to follow for each piece of machinery are laid out in Sec 1, [6.3] and Sec 1, [6.4]. Equipment not included therein will be the subject of special consideration.

1.4 Implementation of the CBM

1.4.1 When the documentation submitted has been approved and the CBM has been implemented on board and used for a sufficient period (which is not to exceed one year) to allow the personnel to become familiar with it, a survey is to be carried out, in order to make the system officially operational, by a Surveyor of the Society or by another certified society.

1.4.2 Upon the successful outcome of this survey, the CBM is considered approved.

1.5 Surveys

1.5.1 The same requirements laid out in Sec 1, [5] and Sec 1, [6] are valid, as applicable.

SECTION 6 CONDITION BASED MAINTENANCE OF THE FIRE DETECTION SYSTEM (PMS-CM(FDS))

1 General

1.1 Application

1.1.1 The additional class notation **PMS-CM(FDS)** is assigned to ships classed by the Society, eligible for the PMS additional class notation as per Section 1 and complying with the requirements of this Section.

In the event that the ship undergoes modifications, refitting or repairs that may affect the items previously kept subject to Condition Based Maintenance (CBM), the retention of the notation is subject to the results of new measurements as deemed appropriate by the Society.

1.2 Scope and requirements of PMS-CM(FDS) Notation

1.2.1 The notation is assigned if CBM is applied to fire control panels and fire sensors (FDS).

System faults in the control panels, their peripherals and the networking system (if any) and sensors are to be logged and reported.

In addition to the fault messages generated by the event, the FDS is to:

- log the performance and the response of the sensors at least [once a day] [every 6 hours],
- evaluate the drift of the sensor reading due to external factors (pollution),
- predict possible faults due to the environmental conditions.

The results of the CBM evaluations are to be stored in the CBM system itself and to generate automatically the lists of the predicted faulty units for maintenance purposes.

A full list of the system conditions, as well as statistical data about sensors, divided into groups (e.g. good conditions, close to fault, faulty due to..) are to be generated by the system in order to provide means for quick checking both by Surveyors and authorities.

1.3 Documentation for Approval

1.3.1 The documentation for the monitoring strategy is to be in accordance with the requirements of Sec 1, [6.2]; in particular, the scope of the application is to be clearly illustrated. The CBM criteria to follow for each piece of machinery are laid out in Sec 1, [6.3] and Sec 1, [6.4]. Equipment not included therein will be the subject of special consideration.

1.4 Implementation of the CBM

1.4.1 When the documentation submitted has been approved and the CBM has been implemented on board and used for a sufficient period (which is not to exceed one year) to allow the personnel to become familiar with it, a survey is to be carried out, in order to make the system officially operational, by a Surveyor of the Society or by another certified society.

1.4.2 Upon the successful outcome of this survey, the CBM is considered approved.

1.5 Surveys

1.5.1 The same requirements laid out in Sec 1, [5] and Sec 1, [6] are valid, as applicable.

Part F
Additional Class Notations

Chapter 10
OTHER ADDITIONAL CLASS NOTATIONS

SECTION 1 STRENGTHENED BOTTOM (STRENGTHBOTTOM)

1 General

1.1 Application

1.1.1 The additional class notation **STRENGTHBOTTOM** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.1], to ships built with specially strengthened bottom structures so as to be able to be loaded and/or unloaded when properly stranded and complying with the requirements of this Section.

2 Double bottom

2.1 Ships with L < 90 m and longitudinally framed double bottom

2.1.1 Plating

The net thickness of the bottom plating within 0,4 L amidship, obtained from the formulae in Pt B, Ch 7, Sec 1 or Pt B, Ch 8, Sec 3, as applicable, is to be increased by 20%, and, in no case is to be less than 8 mm.

2.1.2 Ordinary stiffeners

The net scantlings of bottom and bilge ordinary stiffeners are to be in accordance with Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as applicable, where the hull girder stress is to be taken equal to 195/k and the span is to be taken not less than 1,5 m.

2.1.3 Primary supporting members

Solid floors are to be spaced not more than the lesser of the values 0,025 L and 1,9 m.

A side girder is to be fitted on each side of the ship, in addition to those obtained by applying the requirements in Pt B, Ch 4, Sec 4, [4.1] for maximum spacing.

The number and size of holes on floors and girders are to be kept as small as possible, but are to be such as to allow complete inspection of double bottom structures.

2.2 Ships with L < 90 m and transversely framed double bottom

2.2.1 Plating

The net thickness of the bottom plating within 0,4 L amidship, obtained from the formulae in Pt B, Ch 7, Sec 1 or Pt B, Ch 8, Sec 3, as applicable, is to be increased by 20%. In any case, the net thckness is to be larger than 8 mm.

2.2.2 Ordinary stiffeners

Intercostal ordinary stiffeners are to be fitted for the whole flat bottom area when the actual spacing between girders is equal to or greater than two thirds of the maximum spacing specified in Pt B, Ch 4, Sec 4, [5.3]. Their scantlings are to be considered by the Society on a case by case basis.

2.2.3 Primary supporting members

Solid floors are to be fitted at every frame and are to be reinforced with vertical stiffeners spaced not more than 1,2 m.

A side girder is to be fitted on each side of the ship, in addition to those obtained by applying the requirements in Pt B, Ch 4, Sec 4, [5.3] for maximum spacing.

The number and size of holes on floors and girders are to be kept as small as possible, but are to be such as to allow complete inspection of double bottom structures.

2.3 Ships with L ≥ 90 m

2.3.1 Plating, ordinary stiffeners and primary supporting members

The net scantlings of plating, ordinary stiffeners and primary supporting members are to be considered by the Society on a case by case basis.

3 Single bottom

3.1 Scantlings

3.1.1 Plating, ordinary stiffeners and primary supporting members

The net scantlings of plating, ordinary stiffeners and primary supporting members are to be considered by the Society on a case by case basis.

SECTION 2 IN-WATER SURVEY ARRANGEMENTS (INWATERSURVEY)

1 General

1.1 Application

1.1.1 The additional class notation **INWATERSURVEY** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.2].

1.2 Documentation to be submitted

1.2.1 Plans

Detailed plans of the hull and hull attachments below the water line are to be submitted to the Society in triplicate for approval. These plans are to indicate the location and/or the general arrangement of:

- all shell openings
- stem
- rudder and fittings
- sternpost
- propeller, including the means used for identifying each blade
- anodes, including securing arrangements
- bilge keels
- welded seams and butts.

The plans are also to include the necessary instructions to facilitate the divers' work, especially for taking clearance measurements.

Moreover, a specific detailed plan showing the systems to be adopted in order to assess, when the ship is floating, the slack between pintles and gudgeons is to be submitted to the Society in triplicate for approval.

1.2.2 Photographs

As far as practicable, a photographic documentation, used as a reference during the in-water surveys, of the following hull parts is to be submitted for information, in duplicate, to the Society:

- propeller boss
- rudder pintles, where slack is measured
- typical connections to the sea
- directional propellers, if any
- other details, as deemed necessary by the Society on a case by case basis.

1.2.3 Documentation to be put on board

The Owner is to put on board of the ship the plans and documents given in [1.2.1] and [1.2.2], and they are to be made available to the Surveyor and the divers when an in-water survey is carried out.

2 Structure design principles

2.1

2.1.1 Marking

Identification marks and system are to be supplied to facilitate the in-water survey. In particular, the positions of transverse watertight bulkheads are to be marked on the hull.

2.1.2 Rudder arrangements

Rudder arrangements are to be such that rudder pintle clearances and fastening arrangements can be checked.

2.1.3 Tailshaft arrangements

Tailshaft arrangements are to be such that clearances (or wear down by poker gauge) can be checked.

SECTION 3 SINGLE POINT MOORING (SPM)

1 General

1.1 Application

1.1.1 The additional class notation **SPM** is assigned in accordance with Pt A, Ch 1, Sec 2, [6.11.3] to ships fitted forward with equipment for mooring at single point mooring or single buoy mooring terminals, using standardized equipment complying with the recommendations of the Oil Companies International Marine Forum (OCIMF), according to the requirements of this Section.

1.1.2 These requirements comply with and supplement the Recommendations for Equipment Employed in the Mooring of Ships at Single Point Moorings of the OCIMF (4th edition - 2007).

Note 1: Subject to Owner's agreement, applications for certification in compliance with the following previous editions of the OCIMF recommendations are examined by the Society on a case by case basis:

- 1st edition (1978): Standards for Equipment Employed in the Mooring of Ships at Single Point Moorings
- 2nd edition (1988): Recommendations for Equipment Employed in the Mooring of Ships at Single Point Moorings.

Note 2: The considered edition is specified in the Attestation relating to the SPM notation.

1.1.3 Some components of the equipment used for mooring at single point moorings may be common with the bow emergency towing arrangements specified in Pt B, Ch 10, Sec 4, [4], provided that requirements of this section and of Pt B, Ch 10, Sec 4, [4] are complied with.

2 Documentation

2.1 Documentation for approval

2.1.1 In addition to the documents in Pt B, Ch 1, Sec 3, the following documentation is to be submitted to the Society for approval:

- general layout of the forecastle arrangements and associated equipment
- construction drawing of the bow chain stoppers, bow fairleads and pedestal roller fairleads, together with material specifications and relevant calculations
- drawings of the local ship structures supporting the loads applied to chain stoppers, fairleads, roller pedestals and winches or capstans.

2.2 Documentation for information

2.2.1 The following documentation is to be submitted to the Society for information (see Pt B, Ch 1, Sec 3):

- specifications of winches or capstans giving the continuous duty pull and brake holding force
- DWT, in t, of the ship at summer load line defined in Pt B, Ch 1, Sec 2, [3.8.1].

3 General arrangement

3.1 General provision

3.1.1 For mooring at SPM's terminals ships are to be provided forward with equipment to allow for heaving on board a standardized chafing chain of 76 mm in diameter by means of a pick-up rope and to allow the chafing chain to be secured to a strongpoint.

3.1.2 The strongpoint is to be a chain cable stopper.

3.2 Typical layout

3.2.1 Fig 1 shows the forecastle schematic layout of the ship which may be used as reference.

3.3 Equipment

3.3.1 The components of the ship equipment required for mooring at single point moorings are the following:

- bow chain stopper, according to [5.1]
- bow fairlead, according to [5.2]
- pedestal roller fairlead, according to [5.3]
- winch or capstan, according to [5.4].

4 Number and safe working load of chain stoppers

4.1 General

4.1.1 The number of chain stoppers and their safe working load (SWL), in kN, depending on the DWT of the ship, are defined in Tab 1.

4.1.2 Although required safe working load (SWL) is generally agreed by SPM's terminal operators, Owners and Shipyards are advised that increased safe working load may be requested by terminal operators to take account of local environmental conditions.

In such a case the Society is to be duly informed of the special safe working load to be considered.

Figure 1 : Forecastle schematic layout

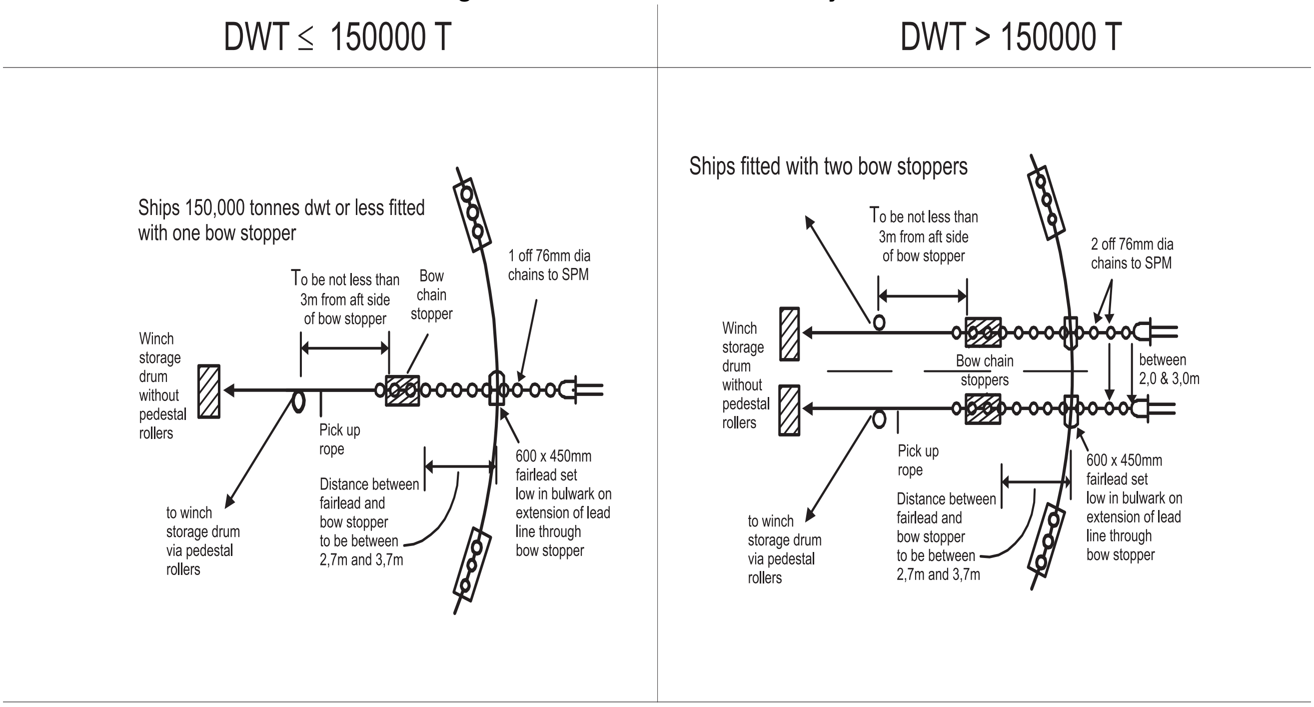


Table 1 : Number and SWL of chain stoppers

Deadweight, in t	Chain stoppers	
	Number	Safe working load (SWL), in kN
DWT ≤ 100000	1	2000
100000 < DWT ≤ 150000	2	2500
DWT > 150000	2	3500

5 Mooring components

5.1 Bow chain stopper

5.1.1 The ship is to be equipped with bow chain cable stoppers complying with the requirements in Tab 1 and designed to accept standard chafing chain of 76 mm in diameter.

5.1.2 The stoppers are to be capable to secure the 76 mm common stud links of the chain cable when the stopping device (chain engaging pawl or bar) is in the closed position and to freely pass the chain cable and its associated fittings when the stopping device is in the open position.

5.1.3 Chain stoppers may be of the hinged bar type or of pawl (tongue) type or of other equivalent design.

Typical arrangements of chain stoppers are shown in Fig 2.

5.1.4 The stopping device (chain engaging pawl or bar) of the chain stopper is to be arranged, when in the closed position, to prevent it from gradually working to the open position, which would release the chafing chain and allow it to pay out.

Stopping devices are to be easy and safe to operate and, in the open position, are to be properly secured.

5.1.5 Chain stoppers are to be located between 2,7 m and 3,7 m inboard from the bow fairleads (see Fig 1).

When positioning, due consideration is to be given to the correct alignment of the stopper relative to the direct lead between bow fairlead and pedestal roller.

5.1.6 Bow chain stopper support structures are to be trimmed to compensate for any camber and/or sheer of the deck. The leading edge of the bow chain stopper base plate is to be faired to allow for the unimpeded entry of the chafing chain.

Bow chain stoppers are to be type approved according to the requirements in [5.5].

A copy of the manufacturer's type-approval certificate for the bow chain stopper(s) is to be kept on board.

The strength of the bow chain stopper foundations and associated ship supporting structure is to be checked with detailed stress analysis based on the actual local structure arrangement and considering the allowable stresses of Pt B, Ch 10, Sec 4, [3.1.14].

Bow chain stoppers are to be permanently marked with the SWL and appropriate serial numbers.

Bow chain stopper Manufacturers are to provide basic operating, maintenance and inspection instructions which are to be taken on board. Where appropriate, Manufacturers are also to provide guidance on maximum component wear limits.

5.1.7 Where the chain stopper is bolted to a seating welded to the deck the bolts are to be relieved from shear force by efficient thrust chocks capable to withstand a horizontal force equal 1,3 times the required working strength and to meet, in this condition, the strength criteria specified in [7].

The steel quality of bolts is to be not less than grade 8.8 as defined by ISO standard No.898/1 (Grade 10.9 is recommended).

Bolts are to be pre-stressed in compliance with appropriate standards and their tightening is to be suitably checked.

5.1.8 The chain stopper is to be made of fabricated steel (see Pt D, Ch 2, Sec 1) or other ductile materials such as steel forging or steel casting complying with the requirements of Pt D, Ch 2, Sec 3 or Pt D, Ch 2, Sec 4 respectively.

5.1.9 Use of spheroidal graphite (SG) iron casting (see Pt D, Ch 2, Sec 5) may be accepted for the main framing of the chain stopper provided that:

- the part concerned is not intended to be a component part of a welded assembly
- the SG iron casting is of ferritic structure with an elongation not less than 12%
- the yield stress at 0,2% is to be measured and certified
- the internal structure of the component is to be inspected by means of non-destructive examinations.

5.1.10 The material used for the stopping device (pawl or hinged bar) of chain stoppers is to have mechanical properties similar to grade R3 chain cable defined in Tasneef "Rules for the construction and classification of mobile offshore drilling units and other similar units".

5.2 Bow fairleads

5.2.1 One bow fairlead is to be fitted for each bow chain stopper (see Fig 1).

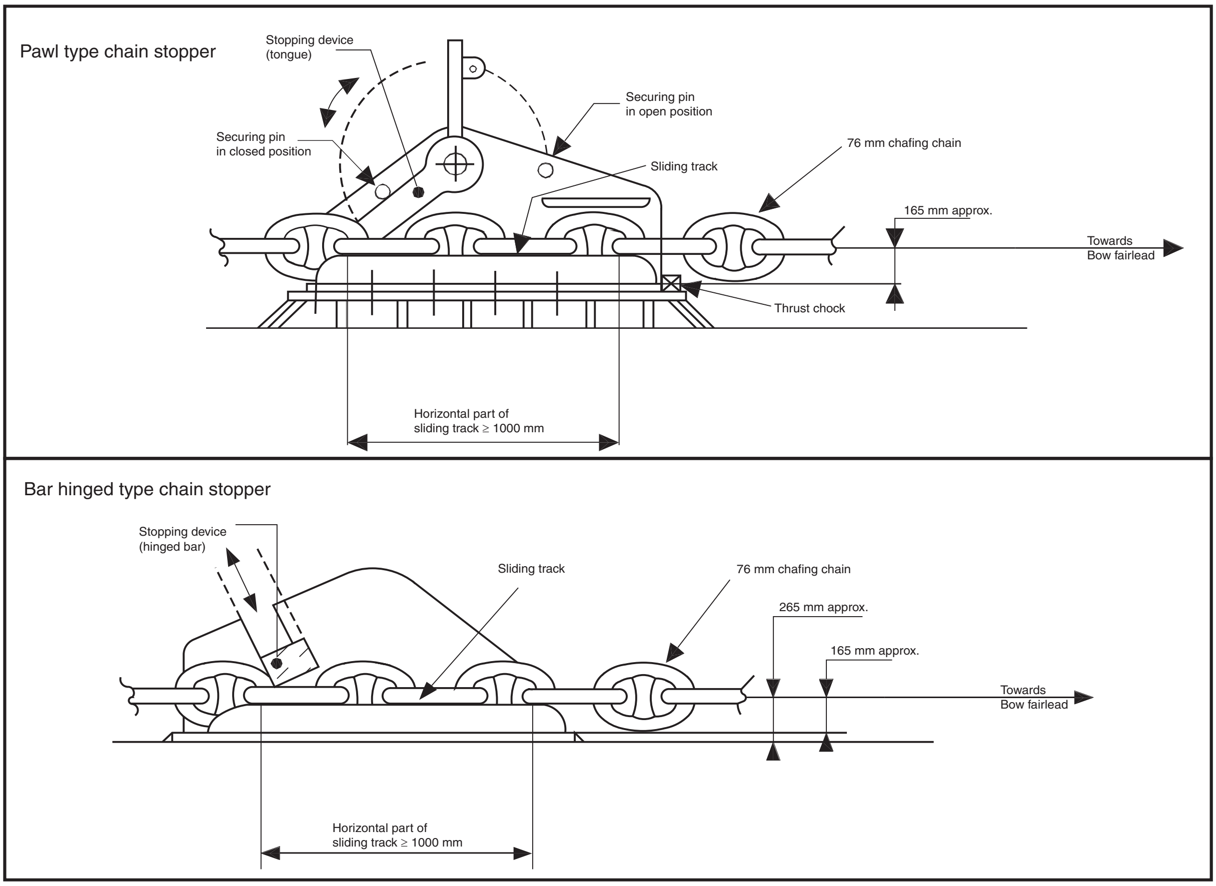
5.2.2 For ships of more than 150000 t DWT, where two bow fairleads are required, the fairleads are to be spaced 2,0 m centre to centre apart, if practicable, and in no case be more than 3,0 m apart.

For ships of 150000 t DWT or less for which only one bow fairlead is required (see Tab 1), it is in general to be fitted on the centreline.

5.2.3 Fairleads are normally of a closed type (as Panama chocks) and are to have an opening large enough to pass the largest portion of the chafing gear, pick-up rope and associated fittings.

For this purpose, the inner dimensions of the bow fairlead opening are to be at least 600 mm in width and 450 mm in height.

Figure 2 : Typical bow chain stoppers



5.2.4 Fairleads are to be oval or round in shape.

The lips of the fairleads are to be suitably faired in order to prevent the chafing chain from fouling on the lower lip when heaving inboard.

The bending ratio (bearing surface diameter of the fairlead to chafing chain diameter) is to be not less than 7 to 1.

5.2.5 The fairleads are to be located as close as possible to the deck and, in any case, in such a position that the chafing chain is approximately parallel to the deck when it is under strain between the chain stopper and the fairlead.

5.2.6 Fairleads are to be made of fabricated steel plates (see Pt D, Ch 2, Sec 1) or other ductile materials such as weldable steel forging or steel casting complying with the requirements of Pt D, Ch 2, Sec 3 and Pt D, Ch 2, Sec 4 respectively.

5.2.7 The SWL of bow fairleads is to be not less than the SWL of the bow chain stoppers that they serve.

The safety factor on yield of bow fairleads is to be not less than 2,0.

The load position is to be based on hawser angles up to 90 degrees from the ship's centreline, both starboard and port in the horizontal plane and to 30 degrees above and below horizontal in the vertical plane.

Bow fairleads are to be type approved according to the requirements in [5.5].

A copy of the Type Approval Certificate for the bow fairleads is to be kept on board.

The strength of the bow fairleads hull connections and associated ship supporting structure is to be checked with detailed stress analysis based on the actual local structure arrangement and considering the allowable stresses of Pt B, Ch 10, Sec 4, [3.1.14].

Bow fairleads are to be permanently marked with the SWL and appropriate serial numbers.

5.3 Pedestal roller fairleads

5.3.1 It is recommended that winch storage drums used to recover the pick-up ropes are positioned in a direct straight lead with the bow fairlead and bow chain stopper without the use of pedestal rollers.

If pedestal rollers are used, the number of pedestal rollers for each bow chain stopper is not to exceed two and the angle of change of direction of the pick-up rope lead is to be kept minimal.

It is recommended that remote operated winch storage drums are used.

If pedestal rollers are used, the requirements from [5.3.2] to [5.3.4] are to be applied.

5.3.2 Pedestal roller fairleads are to be positioned to enable a direct pull to be achieved on the continuation of the direct lead line between the bow fairlead and bow chain stopper (see Fig 1).

They are to be fitted not less than 4,5 m behind the bow chain stopper.

5.3.3 The pedestal roller fairleads are to be capable to withstand a horizontal force equal to the greater of the two values:

- 225 kN
- the resultant force due to an assumed pull of 225 kN in the pick-up rope.

Stresses generated by this horizontal force are to comply with the strength criteria indicated in [7].

5.3.4 It is advised that the fairlead roller is to have a diameter not less than 7 times the diameter of the pick-up rope. Where the diameter of the pick-up rope is unknown it is advised that the roller diameter be of 400 mm, at least.

5.4 Winches or capstans

5.4.1 Winches or capstans used to handle the mooring gear are to be capable of heaving inboard a load of 15 t at least. For this purpose winches or capstans are to be capable to exert a continuous duty pull of not less than 150 kN and to withstand a braking pull of not less than 225 kN.

5.4.2 If a winch storage drum is used to stow the pick-up rope, it is to be of sufficient size to accommodate 150 m of rope of 80 mm diameter.

Use of winch drum ends (warping ends) to handle pick-up ropes is not allowed.

5.5 Type approval

5.5.1 Procedure

Bow chain stoppers and fairleads are to be type approved according to the following procedure:

- the design is to comply with the requirements of this Section
- the bow chain stopper and fairlead are to be tested and their manufacturing is to be witnessed and certified by a Surveyor according to Tab 2.

5.5.2 Inspection and certification testing is to be carried out according to Tab 2.

Table 2 : Material and component certification status

	Material		Component	
	Certificate	Reference of applicable requirements	Certificate	Reference of applicable requirements
Chain stoppers	COI	[5.1.8]	COI	Recognised standards
Fairleads	CW	[5.2.6]	COI	[5.2]

(1) according to Part D, Chapter 1.
(2) to be type approved.
(3) the recognised standard is to specify SWL, yield strength and safety factors
Note 1:
COI: certificate of inspection
CW: works' certificate 3.1.B according to EN 10204

6 Supporting hull structures

6.1 General

6.1.1 The bulwark plating and stays are to be suitably reinforced in the region of the fairleads.

6.1.2 Deck structures in way of bow chain stoppers, including deck seatings and deck connections, are to be suitably reinforced to resist to a horizontal load equal to 1,3 times the required working strength and to meet, in this condition, the strength criteria specified in [7].

As a guidance, the local deck thickness is to be, at least, equal to:

- 15 mm for working strength 2 000 kN
- 18 mm for working strength 2 500 kN.

For deck bolted chain stoppers, reinforcements are to comply with [5.1.7].

6.1.3 The deck structures in way of the pedestal roller fairleads and in way of winches or capstans as well as the deck connections are to be reinforced to withstand, respectively, the horizontal force defined in [5.3.3] or the braking pull defined in [5.4.1] and to meet the strength criteria specified in [7].

6.1.4 Main welds of the bow chain stoppers with the hull structure are to be 100% inspected by means of non-destructive examinations.

7 Strength criteria

7.1 General

7.1.1 The equivalent stress σ_{VM} induced by the loads in the equipment components (see [3.3]), is to be in compliance with the following formula:

$\sigma_{VM} \leq \sigma_a$

where:

σ_a : Permissible stress, to be taken, in N/mm², as the minimum between 0,67 R_{eH} and 0,4 R_m

R_{eH} : Minimum yield stress, in N/mm², of the component material

R_m : Tensile strength, in N/mm², of the component material.

SECTION 4 DYNAMIC POSITIONING (DYNAPOS)

1 General

1.1 Application

1.1.1 The additional class notation **DYNAPOS** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.4], to ships fitted with dynamic positioning installations complying with the requirements of this Section.

This notation is completed by additional symbols defined in [1.4], according to the operational mode of the installation.

1.1.2 These requirements are additional to those applicable to the classification of the corresponding ships or mobile offshore units. Attention is drawn to the fact that dynamic positioning installations may have to comply with the existing national regulations.

1.1.3 The following requirements apply:

- Pt C, Ch 1, Sec 2 when the thruster is driven by an internal combustion engine
- Pt C, Ch 1, Sec 10 for azimuthal and transversal thrusters.

1.2 Definitions

1.2.1 Dynamically positioned vessel (DP-vessel): a unit or a vessel which automatically maintains its position (fixed location or predetermined track) exclusively by the action of its thrusters (including shaft-lines); the dynamic positioning system (DP-system) comprises all means necessary for this purpose.

1.2.2 Active failure concerns all failures which have an immediate effect either on the operation of the installations or on the monitoring circuits.

1.2.3 Passive failure has no immediate effect on the operating conditions of the installations and moreover is not detected by the monitoring circuits, which could lead, in certain conditions, to a failure of the system.

1.2.4 Position reference system: a system measuring the position and heading of the unit.

1.2.5 Position keeping: maintaining a desired position within the normal operating range of the control system and the environmental conditions.

Therefore, active compensation of the dynamic effects of environment (waves, wind, current) is considered.

1.2.6 Redundancy: the ability of a component or system to maintain or restore its function, when a single failure has occurred. Redundancy can be achieved for instance by installation of multiple components, systems or alternative means of performing a function.

1.2.7 Environment: environmental conditions include wind, current and waves. Ice loads are not taken into account.

1.2.8 Alarm devices: visual and audible signals enabling the operator to immediately identify any failure of the positioning system.

1.2.9 Computer based system: system of one or more computers, associated software, peripherals and interfaces, computer network with their protocol.

1.3 Dynamic positioning sub-systems

1.3.1 The installation necessary for dynamically positioning a vessel comprises the following sub-systems:

- Power system, i.e.: all components and systems necessary to supply the DP-system with power.
- Thruster system, i.e.: all components and systems necessary to supply the DP-system with thrust force and direction.
- DP-control system, i.e.: all control components and systems, hardware and software necessary to dynamically position the vessel.

1.3.2 The power system includes:

- prime movers with necessary auxiliary systems including piping
- generators
- switchboards, and
- distributing system (cabling and cable routing).

1.3.3 The thruster system includes:

- thrusters with drive units and necessary auxiliary systems including piping
- main propellers and rudders if these are under the control of the DP-system
- thruster control electronics
- manual thruster controls, and
- associated cabling and cable routing.

1.3.4 The DP-control system consists of the following:

- computer system / joystick system, sensor system
- display system (operator panels)
- autopilot
- position reference system, and
- associated cabling and cable routing.

1.4 Additional and optional class notation

1.4.1 Notation **DYNAPOS** is completed by one or more of the following optional additional symbols according to the operational mode of the installation:

a) **SAM** (semi-automatic mode). The operator's manual intervention is necessary for position keeping.
   - The control system of installations receiving notation **SAM** is to achieve automatic conversion of the instructions issued by the operator in thruster commands.
   - The control system is to indicate the position and heading of the unit to the operator. Control settings are to be displayed.
   - The control device handle is to have a well-defined neutral position (no thrust).
   - Any dynamic positioning installation provided with an automatic control is to be additionally fitted with a manual manoeuvring control complying with the requirements of **SAM** notation.

b) **AM** (automatic mode): position keeping is automatically achieved.

c) **AT** (automatic tracking): the unit is maintained along a predetermined path.

Note 1: the notation **AM/AT** used in the remaining part of this section corresponds to **AM** or **AT**.

1.4.2 Installations intended to be granted with the notation **DYNAPOS AM/AT** are to be provided with a calculation unit including, besides the computer, a reference clock and peripheral equipment for visualisation and printing.

The computer type and features are to comply with the requirements regarding performance in environmental conditions to the satisfaction of the Society.

Calculation cycle fulfilment is to be automatically monitored. Any failure of the computer is to activate a visual and audible alarm.

1.4.3 For **DYNAPOS AM/AT** notation, the ship is to be fitted with an automatic control and a stand-by manual control, the latter being equivalent to the control system required for **SAM** notation.

1.4.4 The optional additional notation **DYNAPOS AM/AT** can be completed by the following symbols:

- **R**, when the dynamic positioning is provided with redundancy means, as defined in [1.2.6]. In this case, class 2 equipment, as per [6] is to be used.
- **RS**, when in addition to symbol **R**, the redundancy is achieved by using two systems or alternative means of performing a function physically separated as defined in [4.8.6]. Equipment class 3, as per [3] is to be used for installations to be granted the **RS** symbol.

1.4.5 The above mentioned notations may be supplemented with an environmental station keeping number ESKI which indicates the station keeping capability of the vessel (as a percentage of time) under given environmental conditions.

1.4.6 Association of DP system with position mooring system

The present Rules do not cover the association of the dynamic positioning system together with a position mooring system, in that case a special examination of the installations is to be carried by the Society, technical consideration about this type of installation are given in [4.1.4] for information.

1.4.7 The practical choice of the dynamic positioning classification notation is governed by the following guidelines:

a) The notation **DYNAPOS SAM** is not granted to the following types of units:
   - diving support vessel
   - cable and pipe laying ship.

b) Supply vessels fitted with installations intended for position keeping alongside offshore work units may be granted the notations **DYNAPOS SAM** or **DYNAPOS AM/AT**.

1.5 Installation survey during construction

1.5.1 Installations built under special survey are subject to:

- document examination with consideration of those specified in [1.6]
- surveys during fabrication and component testing carried out at the supplier's works and at the yard
- dock and sea trials with a Society's surveyor in attendance.

1.6 List of documents to be submitted

1.6.1 In addition to the drawings and specifications required by the Rules and Regulations for the Classification of Ships and Offshore Platforms, the following documents shall be submitted .

1.6.2 For approval:

a) functional block diagram of the sensor and reference systems (position / environmental conditions)

b) functional block diagram of the control unit

c) one line diagram and specification of the cables between the different equipment unit (power, control, display)

d) balance of power

e) list of the equipment units with, for each of them, manufacturer's identification, type and model

f) type test reports of the sensors of the measurement systems, or equivalent

g) test report of the computer units; checking of the behaviour of the installation when submitted to the radiated and conducted electromagnetic interferences

h) estimation of reliability figures when required by the **DYNAPOS** classifications, specially for symbols **R** and **RS**, (see [2]). The document, to be submitted, is to demonstrate the reliability of the system. This is to be achieved with appropriate analysis such as:

   - a failure mode analysis describing the effects due to failures leading to the destruction of the automation system. In addition,this document is to show the consequences on other systems, if any. It is to be detailed up to a level which allows the society to evaluate the necessity of redundancy. This analysis is to be presented in accordance with the IEC standard 812, or any recognised standard
   - test report / life test
   - MTBF calculation
   - any other document which prove to the Society, the reliability of the system

i) for approval of propulsion, based on rotary azimuth thrusters:
   - layout drawings of thrust units, thrust shafts and blocks,
   - arrangement of hull passages
   - thrust curves of each propulsion unit

j) electrical power management layout drawings and specification if provided on board

k) internal communication system description

l) description of the control stations (onboard layout, descriptive diagrams of the display consoles)

m) alarm list and parameter values displayed on the consoles

n) program of tests alongside quay and at sea.

And, for **R** and **RS** symbols only:

- simulation report of the behaviour of the unit
- failure mode effect analysis using as far as possible the fault tree method
- study of possible interaction between thrusters.

1.6.3 For information:

a) diagram of the environmental limit conditions (foot print) for the conditions defined in the specification (wind speed, current and waves)

b) technical specification of the positioning system

c) operator manual of the positioning system including:
   - description of the equipment
   - maintenance guide
   - emergency procedures.

2 Performance analysis

2.1 General

2.1.1 A performance analysis of the dynamic positioning installation is normally required in order to justify design options and limiting allowable environmental conditions. This analysis is to consider the main features of DP installation:

- characteristics of control laws
- installed power
- sizing and location of thrusters,

with regard to the required station keeping stability and accuracy in the specified environmental conditions.

2.2 Condition of analysis

2.2.1 The environmental conditions to be taken into account in the analysis are normally defined by the Shipowner for the contemplated service of the unit. However, for symbol **R** assignment, the following situations are to be considered:

- Normal environmental conditions: those environmental conditions in which nominal position holding performances are attained, while the unit is in normal working situation
- Safety environmental conditions: environmental conditions such that any single failure of a thruster or generator unit occurring in service does not impair position keeping nor operational safety
- Limiting environmental conditions: those environmental conditions in which position keeping is possible with all thrusters running, installations essential for safety only being in service.

When symbol **R** assignment is not required, the analysis may be limited to normal environmental conditions, single failure of a generating set being however considered. The required analysis may be performed either:

- by a mathematical model of the behaviour of the unit, possibly associated with tank test results, or
- on the basis of previous operational experience gained upon similar installations.

2.3 Modelling and simulations

2.3.1 A simulation of the unit displacements in relation to applied environmental forces is normally required for symbol **R** assignment.

2.3.2 The simulation required in [2.3.1] is notably to include suitable modelling of the following:

- environmental forces, wind
- hyrodynamical behaviour of the unit
- dynamic action of thrusters
- control loop.

Simulation results are to include displacements of the unit as well as power determination for each case under consideration.

Note 1: The simulation is to take account of the response of the unit to oscillating forces of positive average (waves, wind, possible external links) likely to have a resonant action upon the dynamic system composed of the unit together with its DP-system.

2.4 Risk analysis

2.4.1 A qualitative risk analysis of the DP installation may be required for symbol **R** or **RS** assignment. Analysis is to be carried out according to the fault-tree method, the FMECA (failure mode effect critical analysis), the RBD (reliability block diagram) or a similar method.

2.4.2 The risk analysis required for symbol **R** and **RS** assignment is to take into account the frequency and duration of planned maintenance tasks.

2.4.3 The analysis is to show the level of redundancy of each sub-system as well as the consequences of possible common mode failures.

3 Equipment class

3.1 General

3.1.1 It is a provision of the present Rules that the DP-vessel is operated in such a way that the worst case failure, as determined in [3.2], can occur at any time without causing a significant loss of position.

3.1.2 Based on the single failure definitions in [3.2], the worst case failure is to be determined and used as the criterion for the consequence analysis, see [4.8.4].

3.1.3 When a DP-vessel is assigned an equipment class, this means that the DP-vessel is suitable for all types of DP-operations within the assigned and lower equipment classes.

3.2 Equipment class according to single failure

3.2.1 For **DYNAPOS AM/AT**, the equipment class 1 are required. In that case, loss of position may occur in the event of a single failure.

3.2.2 For **DYNAPOS AM/AT R**, the equipment class 2 are required. A loss of position is not to occur in the event of a single failure in any active component or system. Single failure criteria includes:

- any active component or system (generators, thrusters, switchboards, remote controlled valves, etc.)
- any normally static component (cables, pipes, manual valves, etc.) which is not properly documented with respect to protection and reliability.

3.2.3 For equipment **DYNAPOS AM/AT RS**, the equipment class 3 are required. A loss of position is not to occur in the event of a single failure in any active component or system., as above for class 2. In that case, a single failure includes:

- items listed above for class 2, and any normally static component is assumed to fail
- all components in any one watertight compartment, from fire or flooding
- all components in any one fire sub-division, from fire or flooding. For cables, see [6.1.3].

3.2.4 For equipment classes 2 and 3, a single inadvertent act is to be considered as a single failure if such an act is reasonably probable.

4 Functional requirements

4.1 General

4.1.1 All components in a DP-system are to comply with the relevant Rules and Regulations for the Classification of Ships or Offshore Platforms.

4.1.2 In order to meet the single failure criteria given in [3.2], redundancy of components will normally be necessary as follows:

- for equipment class 2 (for **R** symbol), redundancy of all active components
- for equipment class 3 (for **RS** symbol), redundancy of all components and physical separation of the components.

For equipment class 3, full redundancy may not always be possible (e.g., there may be a need for a single change-over system from the main computer system to the back-up computer system). Non-redundant connections between otherwise redundant and separated systems may be accepted provided that it is documented to give clear safety advantages, and that their reliability can be demonstrated and documented to the satisfaction of the Society. Such connections are to be kept to the absolute minimum and made to fail to the safest condition. Failure in one system is in no case to be transferred to the other redundant system.

4.1.3 Redundant components and system are to be immediately available and with such capacity that the DP operation can be continued for such a period that the work in progress can be terminated safely. The transfer to redundant component or system is to be automatic, as far as possible, and operator intervention is to be kept to a minimum. The transfer is to be smooth and within acceptable limitations of operation.

4.1.4 When associated with position mooring equipment and when this system is used to assist the main dynamic positioning in special circumstances of operation, for instance in the vicinity of an offshore platform, this system is to be designed in such a way to remote control the length and tension of individual anchor lines.

The analysis of the consequences of anchor line breaks or thruster failure, according to the operational situation, is to be carried out.

4.2 Power system

4.2.1 The electrical installations are to comply with applicable requirements of the Rules for the Classification of Ships, as well as those of the Rules for the Construction and Classification of Offshore Platforms, in particular for the following points:

- general conditions
- power supply systems
- rotating electrical machinery
- transformers
- switchboards
- electrical cables
- electrical batteries
- rectifiers
- electronic equipment
- electromagnetic clutches and brakes, with special consideration for the Rules applicable for electrical propulsion system, see Pt C, Ch 2, Sec 14.

4.2.2 The power system is to have an adequate response time to power demand changes.

4.2.3 For equipment class 1, the power system needs not to be redundant.

4.2.4 For equipment class 2, the power system (generators, main bus bars, etc.) is to be divisible into two or more systems such that, in the event of failure of one system, at least one other system will remain in operation. The power system may be run as one system during operation, but is to be arranged with bus-tie breakers to separate them automatically upon failures, to prevent the transfer of failure of one system to the other.

4.2.5 For equipment class 3, the power system (generators, main bus bars, etc.) is to be divisible into two or more systems such that in the event of failure of one system, at least one other system will remain in operation. The divided power system is to be located in different spaces separated by A-60 class division, or equivalent. Where the power systems are located below the operational waterline, the separation is also to be watertight. Bus-tie breakers are to be open during equipment class 3 operations.

4.2.6 For equipment classes 2 and 3, the following applies:

a) The power available for position keeping is to be sufficient to maintain the vessel in position after worst case failure to [3.2.1].The automatic management system is to be capable of:
   - enabling quick supply of active power to consumers in all operating conditions including generator failure or change of thruster configuration
   - monitoring power sources and informing the operator about desirable configuration changes such as starting or stopping of generators
   - providing automatic change-over of a generating set in case of detected failure
   - this required capability mainly applies to normal operating conditions. It is to be possible to maintain a proper balance between power demand and power generating configuration, in view of achieving efficient operation with sufficient reserve to avoid black-out
   - limitation of absorbed power, appropriate devices are to allow for automatic reduction of power demands in case of emergency.

b) For **R** or **RS** symbols an adequate redundancy or a suitable reliability of the power management system is to be provided.

c) In addition, the following provisions may be required:
   - assessment of priority criteria as regards load shedding
   - suitable automatic power limitations. For instance, gradation may be required to allow safe achievement of essential functions before circuit breaker opening. Proportional cut backs may be adequately implemented: static rectifiers tripping, thrust command limits, etc.
   - proportional limitation is to activate warning devices. Override arrangements are to be fitted at the operator's disposal
   - implementation of suitable delay in connecting load consumers so as to enable additional power source switching on or load shedding.

4.3 Monitoring of the electricity production and propulsion

4.3.1 As a general rule, the monitoring level of electrical generators, their prime movers and power supply equipment, main propulsion diesel engines, electrical propulsion is to be granted at least with the requirements of additional classification notation **AUT CCS**. For the installations granted with **DYNAPOS AM/AT RS** class notation, the requirements of **AUT UMS** or **AUT IMS** could be contemplated.

Table 1 : System configuration for main power supply and propulsion systems

Equipment class	No requirement	1	2	3
Class Notation **DYNAPOS**	**SAM**	**AM/AT**	**AM/AT R**	**AM/AT RS**
Distribution system	non redundant	non redundant	redundant	redundant in separate rooms
Electrical generators	minimum number of generators see **(1)**	minimum number of generators see **(1)**	redundant	redundant in separate rooms
Main switchboard	1	1	1 with bus tie 2 circuits equally distributed	2 bus bars circuit breakers normally open located in separate rooms
Electrical propulsion	at least 1 azimuthal thruster driven by 1 electrical motor	at least 1 thruster driven by 1 electrical motor	redundant	redundant in separate rooms
Thruster driven by diesel engines	at least one thruster	at least one thruster	redundant	redundant in separate rooms
Power management system	non redundant	non redundant	redundant	redundant in separate rooms
(1) Concerning the electrical production for the minimum number of generators, it is to be considered that a spare generator is to be provided in order to maintain the electrical supply continuity in case of failure of the generator on duty.				

4.3.2 A possibility to integrate the dynamic positioning system and the automation system could be considered, the computerized system configuration used in that case is to be submitted to the Society. In addition, the consequences of a failure of the communication network and programmable controller units included in the systems is to be documented and included in the FMEA analysis.

4.4 Thruster system

4.4.1 The thruster design and construction is to comply with the applicable requirements of the Rules for the Construction and Classification of Steel Vessels or Offshore Platforms.

4.4.2 The provisions of this section apply to fixed axis or orirentable thrusters using fixed or orientable pitch propeller installed below the hull and tunnel thrusters. The use of other thruster types (cycloidal propeller for example) is subject to a special examination.

4.4.3 The electrical motors driving the thrusters are to be approved. The use of other types of thruster prime mover such as direct coupling to diesel engines or hydraulic motors is specially examined by the Society.

4.4.4 Electrical propulsion installations are to comply with the requirements of Pt C, Ch 2, Sec 14.

4.4.5 For symbol **R** assigment, attention is drawn to the requirements stated in [3.2.2].

4.4.6 Uninterruptible power supply (U.P.S.)

For **DYNAPOS SAM** and **DYNAPOS AM/AT**, an U.P.S. is to be provided for the control of power and propulsion system defined above. Concerning the system granted with **R** and **RS** symbols, the number of U.P.S. is to be in accordance with the result of the FMEA analysis. Unless otherwise justified, 2 U.P.S. are to be provided for **R** symbol. For **RS** symbol, 2 U.P.S. are to be installed, one being located in a separate room.

4.5 Thruster control

4.5.1 General

The following requirements apply to the thruster control.

4.5.2 Closed loop command of thruster pitch, azimuth and RPM is to be provided from the controller. Feedback signals are to be provided by independent sensors connected to the controlled device.

4.5.3 Controllers are to incorporate features for avoiding commands likely to overload mechanical gearing or prime movers. Control is preferably to be performed using active power measurements.

4.5.4 Thrusters are to be capable of being easily stopped.

4.6 Thruster monitoring and protection

4.6.1 Thruster monitoring is to be provided by the controller unit. Thruster monitoring is to enable:

- detection of equipment failures
- monitoring of the correlation between set and achieved values of control parameters.

The following parameters are to be regularly monitored:

- status of thrusters (on-line / off-line)
- pitch, RPM, azimuth
- thruster load level
- electrical motor stator winding temperature
- temperature of main bearings (except roller type)
- lube oil and hydraulic fluid pressure and temperature.

4.6.2 Failure of thruster system including pitch, azimuth or speed control is to trigger an alarm, and must not make the thruster rotate or go to uncontrolled full pitch and speed.

4.6.3 Provisions for automatic stop of a thruster are to be restricted to circumstances liable to bring about immediate plant damage and are to be submitted for approval.

4.7 DP Control system

4.7.1 In general, the DP-control system is to be arranged in a DP-control station where the operator has a good view of the vessel's exterior limits and the surrounding area.

4.7.2 The DP-control station is to display information from the power system, thruster system, and DP-control system to ensure that these systems are functioning correctly. Information necessary to operate the DP-system safely is to be visible at all times. Other information is to be available upon operator request.

4.7.3 Display systems, and the DP-control station in particular, are to be based on sound ergonometric principles. The DP-control system is to provided for easy selection of control mode, i.e. manual, joystick, or computer control of thrusters, and the active mode is to be clearly displayed. The following principles apply to display system:

- segregation of redundant equipment to reduce the possibility of common mode failure occurrence
- ease of access for maintenance purposes
- protection against adverse effects from environment and from electric and electromagnetic disturbances.

4.7.4 For equipment classes 2 and 3, operator controls are to be designed so that no single inadvertent act on the operator's panel can lead to a critical condition.

4.7.5 Alarms and warnings for failures in systems interfaced to and/or controlled by the DP-control system are to be audible and visual. A permanent record of their occurrence and of status changes is to be provided together with any necessary explanations. The alarm list is given for information in Tab 3.

4.7.6 The DP-control system is to prevent failures being transferred from one system to another. The redundant components are to be so arranged that a failure of one component should be isolated, and the other component activated.

4.7.7 It must be possible to control the thrusters manually, by individual joysticks and by a common joystick, in the event of failure of the DP-control system.

4.7.8 The software is to be produced in accordance with an appropriate international quality standard recognised by the Society.

4.7.9 Regarding control stations, the following requirements are to be met:

- Where several control stations are provided, control is to be possible from one station only at the same time, adequate interlocking devices are to be fitted, and indication of the station in control is to be displayed at each control station.
- Alarm and control systems concerning a same function are to be grouped together (position reference system, propulsion, power generation).
- Where inadvertent activation of commands may jeopardise the unit's safety, these commands are to be protected (light cover, double triggering or other equivalent devices or procedures).
- A two-way voice communication facility, independent of the unit general system, is to be provided between the main control station and the following spaces: navigating bridge, engine room and engine control station, other control stations, responsible officer's accommodation, other control locations specific to the task of the unit.

4.8 Computers

4.8.1 For equipment class 1, the DP-control system needs not be redundant.

4.8.2 For equipment class 2 (symbol **R**), the DP-control system is to consist of at least two independent computer systems. Common facilities such as self-checking routines, data transfer arrangements, and plant interfaces are not to be capable of causing the failure of both / all systems.

4.8.3 For equipment class 3 (symbol **RS**), the DP-control system is to consist of at least two independent computer systems with self-checking and alignment facilities. Common facilities such as self-checking routines, data transfer arrangements and plant interfaces are not to be capable of causing failure at both/all systems. In addition, one back-up DP-control system should be arranged. An alarm should be initiated if any computer fails or is not ready to take control.

4.8.4 For equipment classes 2 (symbol **R**) and 3 (symbol **RS**), the DP-control system is to include a software function, normally known as "consequence analysis", which continuously verifies that the vessel will remain in position even if the worst case failure occurs. This analysis is to verify that the thrusters remaining in operation after the worst case failure can generate the same resultant thruster force and moment as required before the failure. The consequence analysis is to provide an alarm if the occurrence of a worst case failure would lead to a loss of position due to insufficient thrust for the prevailing environmental conditions. For operations which will take a long time to safely terminate, the consequence analysis is to include a function which simulates the thrust and power remaining after the worst case failure, based on manual input of weather trend.

4.8.5 Redundant computer systems are to be arranged with automatic transfer of control after a detected failure in one of the computer systems. The automatic transfer of control from one computer system to another is to be smooth, and within the acceptable limitations of the operation.

4.8.6 For equipment class 3 (symbol **RS**), the back-up DP-control system is to be in a room, separated by A-60 class division from the main DP-control station. During DP-operation, this back-up control system is to be continuously updated by input from the sensors, position reference system, thruster feedback, etc., and be ready to take over control. The switch-over of control to the back-up system is to be manual, and can be operated either from the main or back-up systems. This occurs when the main system is affected by failure, fire or explosion at the main DP-control system.

4.8.7 An uninterruptable power supply (U.P.S.) is to be provided for each DP-computer system to ensure that any power failure will not affect more than one computer. U.P.S. battery capacity is to provide a minimum of 30 minutes operation following a main supply failure.

4.8.8 For dynamic positioning control system based on computer, it must be demonstrated that the control systems work properly in the environmental conditions prevailing on board ships and offshore platforms. To this purpose, the DP-control systems are to be submitted to the environmental tests defined in Pt C, Ch 3, Sec 6, with a special consideration for E.M.I. (Electromagnetic interferences).

5 Position reference system

5.1 General

5.1.1 As a general rule, a dynamic positioning installation is to include at least two independent reference systems.

- For **SAM** notation assignment, one reference system is required.
- For equipment classes 2 and 3, at least three position reference systems are to be installed and simultaneously available to the DP-control system during operation.
- Position reference systems are to be selected with due consideration to operational requirements, both with regard to restrictions caused by the manner of deployment and expected performance in working situation.
- When two or more position reference systems are required, they are not all to be of the same type, but based on different principles and suitable for the operating conditions.

5.1.2 As a general rule, the system is to allow for smoothing and mutual adjustment of the inputs originating from various position reference systems and transfer between reference is to be bumpless. Other arrangement is subject to special examination by the Society. Change over is preferably to take place automatically in case of failure of the reference system in use.

5.1.3 Meteorological reports, suitable for the operation of the unit are to be made available to the personel onboard.

5.2 Arrangement and performance of reference systems

5.2.1 The position reference systems are to produce data with adequate accuracy for the intended DP-operation.

5.2.2 Visual and audible alarms are to be activated when the unit deviates from the set heading or from the working area determined by the operator. The performance of position reference system is to be monitored and warnings provided when the signals from the position reference systems are either incorrect or substantially degraded.

5.2.3 Indication of the reference system in operation is given to the operator.

5.2.4 For equipment class 3, at least one of the position reference system is to be connected directly to the back up control system and separated by A-60 class division from other position reference system.

5.3 Type of position reference systems

5.3.1 When acoustical reference systems are used, hydrophone is to be chosen for minimising influence of mechanical and acoustical disturbance on the transmission channels, such as propeller noise, spurious reflection on the hull, interference of riser, bubble or mud cluster on the acoustic path.

The directivity of transponders and hydrophones is to be compatible with the availability of the transmission channels in all foreseeable operational conditions. It is to be possible to select the frequency range and the rate of interrogation according to prevailing acoustical conditions, including other acoustical system possibly in service in the area.

5.3.2 When taut wire system is used, materials used for wire rope, tensioning and auxiliary equipment are to be appropriate for marine service. The anchor weight is to be designed to avoid dragging on the sea floor and is not to induce, on recovery, a wire tension exceeding 60% of its breaking strength, and the capacity of the tensioner is to be adapted to the expected movement amplitude of the unit.

5.3.3 When the signals from position reference system are likely to be altered by the movement of the unit (rolling, pitching), a correction of the position is to be made. For this purpose, a vertical reference unit of appropriate characteristics with regard to the expected accuracy of position measurement is to be provided. The VRS is to be duplicated for symbol **R** assignment.

5.4 Other reference systems

5.4.1 Other reference systems such as short to medium range radio positioning system, global positioning system may be used. Whatever the chosen principle (for example, hyperbolic or polar determination), the accuracy of the position measurement is to be satisfactory in the whole operational area.

5.4.2 The list of the reference systems is not exhaustive. It is possible to interface the DP-system with Syledis, Arthemis, Loran, GPS, DGPS etc.

5.4.3 When a GPS or DGPS is used, it is reminded that this equipment is to be designed in accordance with the following resolutions IMO A525 (13), A 694 (17), A 813 (19). This equipment is to be approved, at least by a national competent authority, and the relevant certificate is to be submitted to the Society. For other reference systems the same procedure shall be applied when the system is covered by an IMO resolution, this document is to be considered.

5.4.4 System needing periodical updating such as those based upon inertial navigation, Doppler effect, deep tautwire with riser angle detection are to be integrated with an other reference system giving continuous output without appreciable offset. These systems are subject to a special examination by the Society, and are normally not taken into consideration for complying with [5.1.1], unless otherwise justified.

5.4.5 Location of the receiving equipment is to be chosen so as to minimise as far as practicable masking effects and interferences.

5.5 Vessel sensors

5.5.1 Vessel sensors are to be at least measure of vessel heading, vessel motion, wind speed and direction.

5.5.2 Arrangement of sensors and monitoring

Sensors are to be as far as possible provided with failure monitors (overheating, power loss).

- Inputs from sensors are to be monitored in order to detect possible faults, notably relative to temporal evolution of the signal. Concerning the analogue sensors, an alarm is to be triggered in case of connecting line wire break, short-circuit or low insulation.
- Inputs from simultaneously in use sensors are to be compared in order to detect significant discrepancy between them.
- Any failure of automatic change-over between sensors are to activate visual and audible alarms at the control room.

- Sensors for class 2 and 3 equipment,sensors used for the same purpose, connected to redundant systems are to be arranged independently so that failure of one does not affect the others.
- For equipment class 3 (symbol **RS**), one of each type of sensors is to be connected directly to the back-up control system and separated by A-60 class division from the other sensors.
- When an equipment class 2 or 3 (for **R** and **RS** symbols), DP-control system is fully dependent on correct signals from vessel sensors, then these signals are to be based on three systems serving the same purpose (i.e., this will result in at least three gyrocompasses being installed).

5.5.3 For equipment class 3 (symbol **RS**), one of each type of sensors is to be connected directly to the back up control system and separated by A-60 class division from the other sensors.

5.5.4 When an equipment class 2 or 3 (for **R** and **RS** symbols), DP-control system is fully dependent on correct signals from vessel sensors, then these signals are to be based on three systems serving the same purpose (i.e., this will result in at least three gyrocompasses being installed).

5.5.5 Heading

For **DYNAPOS SAM**, one gyrocompass or another heading measurement unit of equivalent accuracy is to be provided. For the assignment of notation **DYNAPOS AM/AT**, two gyrocompasses or other sensors of equivalent accuracy are required. For **DYNAPOS AM/AT R** or **RS**, see [5.5.4] and Tab 2.

5.5.6 Wind speed and direction are to be recorded by suitably located wind sensors, due consideration being given to superstructure influence.

5.5.7 The alarms to be triggered and indication to be displayed are detailed in Tab 3. This list is given for information and can be completed taking into consideration of the installation configuration. This list does not include the alarms which are required by the automated notation granted to the unit.

6 Installation requirements

6.1 Cables and piping systems

6.1.1 The following requirements are to be applied to hydraulic pneumatic and electrical circuits.

6.1.2 For equipment class 2, the piping systems for fuel, lubrication, hydraulic oil, cooling water, pneumatic circuits and the cabling of the electrical circuits essential for a proper running of the DP-system are to be located with due regard to fire hazards and mechanical damages.

6.1.3 For equipment class 3:

- Redundant piping system (i.e., piping for fuel, cooling water, lubrication oil, hydraulic oil, pneumatic circuits etc.) are not to be routed together through the same compartments. Where this is unavoidable, such pipes could run together in ducts of A-60 class.
- Cables for redundant equipment or systems are not to be routed together through the same compartments. Where this is unavoidable such cables may run together in cable ducts of A-60 class. Cable connection boxes are not allowed in such ducts.

6.1.4 For equipment classes 2 and 3, systems not directly part of the DP-system but which, in the event of failure, could cause failure of the DP-system (common fire suppression systems, engine ventilation systems, shut-down systems, etc.) are also to comply with relevant requirements of these Rules.

6.2 Thruster location

6.2.1 The thruster location, operational modes and design are to comply with the following requirements.

Table 2 : Configuration for reference systems, vessel sensors and computers

Equipment class	No requirement	1	2	3
DYNAPOS class notations	**SAM**	**AM/AT**	**AM/AT R**	**AM/AT RS**
Number of control computers	1	1	2	3, 1 of them connected to back up control station
Manual control joystick with automatic heading	may be fitted	Yes	**(1)**	**(1)**
One man operating the DP system	Yes	Yes	Yes	Yes
Position reference system	1	2	3	3, 1 of them connected to back up control station
Vertical reference system	1	2	2	2, 1 of them connected to back up control station
Wind sensor	1	2	2	2, 1 of them connected to back up control station
Gyro	1	2	2	3, 1 of them connected to back up control station

(1) Not required.

6.2.2 The thruster location and operational modes are to be chosen so as to minimise interference between thrusters as well as disturbance brought to proper operation of sensor systems or specific equipment the unit is provided with.

6.2.3 Thrusters intake depth is to be sufficient to reduce the probability of ingesting floating debris and of vortex formation.

Table 3 : Alarm and warning system

Parameters and equipment	Alarms or group of alarms	Signalling
Ship coodinates and desired position		x
Actual position		x
Maximum deviation required		x
Deviation from the desired operating area out of the a.m. limits	x	
Thruster availability ready for operation		x
Thruster in operation		x
Thruster in failure	x	
Vectorial thrust ouput out of limit	x	
Total output of all thrusters		x for class 2 and class 3 equipment
Thrust limitation by available power	x	
Power supply failure	for group of alarms x	
Power management failure	x for class 2 and class 3 equipment	
Desired heading		x
Actual heading		x
Deviation from desired heading out of limit	x	
Status of heading reference system connected or not		x
Failure of any heading reference system	x	
Automatic switching to stand by heading reference system	x	
Failure of the vertical reference sensor measuring the pitching and rolling of the unit	x	
Operational status of each vertical reference sensor		x
Automatic switching to vertical stand by reference sensor	x	
Indication of wind speed and direction sensor		x
Operational status of wind sensors, speed and direction		x
Wind sensor failure, speed and direction	x	
Automatic switching of wind speed and direction sensor	x	
Computer failures	for group of alarms x	
Automatic switching to stand by computer	x	
Abnormal input signals to the computer, analogue input failures	x	
Number of generators available		x
Sea state conditions		x for class 2 and class 3 equipment

Note 1: Depending upon the DP classification notation required, the above mentioned list could be simplified.
Note 2: Instead of individual alarm, when it is possible to discriminate the cause of the alarm on the unit which is concerned, it is possible to display an alarm group

6.2.4 The integrity of the hull is not to be adversely affected by thruster installation, particularly where retractable or tunnel thruster are provided.

6.2.5 Bow thrusters are to be located aft of the collision bulkhead.

6.2.6 The thruster system is to provide adequate thust in longitudinal and lateral directions and provid yawing moment for heading control.

6.2.7 As regard **AM/AT** notation, transverse fixed axis thrusters, if used, are to be capable of providing sufficient thrust in the contemplated range of speed of the unit.

6.2.8 The values of the thruster forces used in the consequence analysis (see [4.8.4]) are to be corrected for interference between thrusters and other effects which will reduce the effective force.

6.2.9 For equipment classes 2 and 3, the thruster system is to be connected to the power system in such way that the requirement stated in [6.2.6] can be complied with, even after failure of one of the constituent power systems and one of the thrusters connectected to that system.

7 Operational requirements

7.1 General

7.1.1 The following operation conditions are to be fulfilled.

7.1.2 Before every DP-operation, the DP-system is to be checked according to a vessel specific "location" checklist to make sure that the DP-system is functioning correctly and that the system has been set up for the appropriate equipment class.

7.1.3 During DP-operations, the system should be checked at regular intervals according to a vessel specific watch-keeping checklist.

7.1.4 DP-operations necessitating equipment class 2 or 3 should be terminated when the environmental conditions are such that the DP-vessel will no longer be able to keep position if the single failure criterion applicable to the equipment class occured. In this context, deterioration of environmental conditions and the necessary time to safely terminate the operation is also be taken into consideration. This should be checked by way of environmental envelopes if operating in equipment class 1 and by way of an automatic consequence analysis if operating with equipment class 2 or 3. The necessary operating instructions, etc., are to be placed on board as far as practicable.

7.1.5 The following checklist, test procedures and instructions are to be incorporated into the DP-operating manuals for the vessel:

- location checklist, see [7.1.2]
- watch-keeping checklist, see [7.1.3]
- DP-operation instructions, see [7.1.4]
- initial and periodical (5-year) tests and procedures, see [8]
- annual tests and procedures, see [8]
- example of tests and procedures after modifications and non-conformities, see [8].

7.1.6 Reports of tests and record of modification or equivalent are to be kept on board and made available during periodical inspections.

8 Test and trials

8.1 Inspection at works

8.1.1 Inspection at work of items subject to classification are to be carried out at the attending surveyor's satisfaction, in accordance with a programme previously agreed.

8.1.2 Thruster and electrical installation tests are to be conducted in accordance with the requirements for electrical propulsion of Pt C, Ch 2, Sec 14.

8.2 Trials

8.2.1 Before a new installation is put into service and after modification of an existing installation, port and sea trials are to be carried out to check the DP-system proper functioning and performances.

8.2.2 The programme of these trials is to be previously submitted to the Society.

8.2.3 Such trials are to verify:

- functioning of equipment
- shielding efficiency of sources of electrical and electromagnetic interferences
- functioning of alarms
- functioning of change-over arrangements.

8.2.4 Tests are to be performed in order to assess the appropriate function of the system in case of single failure (controller, position reference system, gyrocompass, alternator, thruster, etc) and in case of worst case failure.

8.2.5 Sea trials are to be of sufficient duration to confirm satisfactory operation.

8.2.6 Final report of dock and sea trials is to be submitted for information.

9 Environmental station keeping index ESKI

9.1 Definition

9.1.1 An environmental station keeping index (ESKI) may be associated with each of the class notation defined in [1.4.2] and [1.4.4].

9.1.2 This ESKI indicates the station keeping capability of the vessel (as a percentage of time) under given environmental conditions.

9.2 Environmental conditions

9.2.1 The ESKI is based on environmental conditions consistent with the geographical area of vessel operation.

9.2.2 For unlimited service, a set of standard North Sea Environmental Conditions is to be used.

9.2.3 For restricted service, a long term distribution of environmental conditions prevailing where the vessel is in operation is to be considered.

9.3 Condition of ESKI estimation

9.3.1 The ESKI indicates the allowable environmental conditions for three system configurations:

- with all thrusters operating
- with one single failure
- with most critical single failure.

9.3.2 The ESKI reflects the capability to maintain position with the most unfavourable heading.

9.3.3 Environmental forces (wind, wave drift and current loads) and thrust shall be evaluated through tunnel and tank model tests or other recognised methods.

9.4 Documentation to be submitted

9.4.1 The following documentation are to be submitted in order to derive ESKI:

- General arrangement (including deck superstructure)
- Line plan
- Design environmental conditions
- Documentation of environmental conditions long term distribution (restricted service)
- Basin and tunnel test results
- Details of waves drift loads on ship or unit
- Details of current load on ship or unit
- Details of thruster layout
- Details of thrust power (including polar distribution of thrust as a function of heading for both intact and one thruster failure mode). This should take into consideration the interaction between thrusters, thrusters and hull, thrusters and current
- Thruster management logic.

SECTION 5 VAPOUR CONTROL SYSTEM (VCS)

1 General

1.1 Application

1.1.1 The additional class notation **VCS** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.5], to ships fitted with systems for control of vapour emission from cargo tanks both in way of midship cargo crossovers and in way of stern cargo manifolds, complying with the requirements of this Section.

The notation **MIDSHIP** is added to the notation **VCS** where the ship is equipped with cargo vapour control systems only in way of cargo midship crossovers.

The notation **TRANSFER** is added to the notation **VCS** for ships fitted with systems for control of vapour emission from cargo tanks to another ship and viceversa. Additional requirements for **TRANSFER** additional notation are given in article [6].

1.1.2 As a rule, this notation is applicable to ships which are assigned the class notation **oil tanker**.

1.2 Definitions

1.2.1 Diluted

A flammable gas or mixture is defined diluted when its concentration in air is less than 50% of its lower explosive limit.

1.2.2 Flammable cargoes

Flammable cargoes are crude oils, petroleum products and chemicals having a flashpoint not exceeding 60 °C (closed cup tests) and other substances having equivalent fire risk.

1.2.3 Inerted

Inerted is the condition in which the oxygen content in a flammable gas/air mixture is 8% or less by volume.

1.2.4 Independent

Two electrical systems are considered independent when anyone system may continue to operate with a failure of any part of the other system, except power source and electrical feeder panels.

1.2.5 Lightering operation

Lighting operation is the operation of transferring liquid cargo from one ship to one service ship.

1.2.6 Maximum allowable transfer rate

Maximum allowable transfer rate is the maximum volumetric rate at which a ship may receive cargo or ballast.

1.2.7 Service ship

Service ship is a ship which receives and transports liquid cargoes between a facility and another ship and viceversa.

1.2.8 Ship vapour connection

The ship vapour connection is the point of interface between the ship's fixed vapour collection system and the collection system of a facility or another ship. Hoses or loading arms on board, carried for the purpose of these rules, are considered part of the vapour control system of the ship.

1.2.9 Terminal vapour connection

The terminal vapour connection is that point at which the terminal vapour collection system is connected to a vapour collection hose or arm.

1.2.10 Topping-off operation

Topping-off is the operation of transfer of liquid cargo from a service ship to another ship in order to load the receiving ship at a deeper draft.

1.2.11 Vapour balancing

Vapour balancing is the transfer of vapour displaced by incoming cargo from the tank of a ship receiving cargo into a tank of a facility delivering cargo via a vapour collection system.

1.2.12 Vapour collection system

The vapour collection system is an arrangement of piping and hoses used to collect vapour emitted from a ship's cargo tank and to transport the vapour to a vapour processing unit.

1.2.13 Vapour processing unit

Vapour processing unit is that component of a vapour control system that recovers, destroys or disperds vapour collected from a ship.

1.3 Documentation to be submitted

1.3.1 Tab 1 lists the documents which are to be submitted.

Table 1

No.	A/I **(1)**	Document
1	A	Diagrammatic plan of the vapour piping system including: • material specifications • dimensions, scantlings and sizes • ratings (temperature / pressure) • joining details • fittings and standards used • etc.
2	A	Diagrammatic drawing of the gauging system and overfill protection including: • manufacturer and type of the instruments • plan of hazardous area locations • location of electrical equipment in gas dangerous spaces and safe certificates of the electric instruments intended to be used in hazardous locations • electrical schemes concerning the alarm system supply • electrical schemes concerning the intrinsically safe circuits • etc.
3	A	Diagrammatic drawings of the venting system, including necessary data for verifying the venting capacity of the pressure/vacuum valves
4	I	Pressure drop calculations comparing cargo transfer rates versus pressure drops from the farthest tanks to the vapour connection, included any possible hoses
5	I	Calculations showing the time available between alarm setting and overfill at maximum loading rate for each tank
6	A	Instruction manual
7	I	Information on the antidetonation devices, including manufacturer and type of the device employed as well as documentation on any acceptance test carried out, only for ships for which the notation **TRANSFER** is requested
(1) A = to be submitted for approval in quadruplicate I = to be submitted for information in duplicate		

2 Vapour system

2.1 General

2.1.1 Installation of vapour collection system

Each ship is to have vapour collection piping permanently installed, with the tanker vapour connection located as close as practical to the loading manifolds.

2.1.2 Incompatible cargoes

If a tanker simultaneously collects vapour from incompatible cargoes, it is to keep these incompatible vapours separate throughout the entire vapour collection system.

2.1.3 Liquid condensate disposal

Means are to be provided to eliminate liquid condensate which may collect in the system.

2.1.4 Electrical bonding

Vapour collection piping is to be electrically bonded to the hull and is to be electrically continuous.

2.1.5 Inert gas supply isolation

When inert gas distribution piping is used for vapour collection piping, means to isolate the inert gas supply from the vapour collection system are to be provided. The inert gas main isolating valve required in Part C, Chapter 4 may be used to satisfy this requirement.

2.1.6 Prevention of interference between vapour collection and inert gas systems

The vapour collection system is not to interfere with the proper operation of the cargo tank venting system. However, a vapour collection piping may be partly common with the vent piping and/or the inert gas system piping.

2.1.7 Flanges

a) Bolt hole arrangement of vapour connection flanges to the terminal is to be in accordance with Tab 2.

b) Each vapour connection flange is to have permanently attached 12,7 mm diameter studs protruding out of the flange face for at least 25,4 mm.

c) The studs are to be located at the top of the flange, midway between bolt holes and in line with bolt hole patterns.

Table 2 : Bolting arrangement of connecting flanges

Pipe nominal diameter (mm)	Outside diameter of flange (mm)	Bolt circle diameter (mm)	Bolt holes diameter (mm)	Bolt diameter (mm)	Number of bolts
≤ 12.70	88.90	60.45	15.75	12.70	4
≤19.05	98.55	69.85	15.75	12.70	4
≤25.40	107.95	79.25	15.75	12.70	4
≤31.75	117.35	88.90	15.75	12.70	4
≤38.10	127.00	98.55	15.75	12.70	4
≤50.80	152.40	120.65	19.05	15.87	4
≤63.50	177.80	139.70	19.05	15.87	4
≤76.20	190.50	152.40	19.05	15.87	4
≤88.90	215.90	177.80	19.05	15.87	8
≤101.60	228.60	190.50	19.05	15.87	8
≤127.00	254.00	215.90	22.35	19.05	8
≤152.40	279.40	241.30	22.35	19.05	8
≤203.20	342.90	298.45	22.35	19.05	8
≤254.00	406.40	361.95	25.40	22.22	12
≤304.80	482.60	431.80	25.40	22.22	12
≤355.60	533.40	476.25	28.45	25.40	12
≤406.40	596.90	539.75	28.45	25.40	16
≤457.20	635.00	577.85	31.75	28.54	16
≤508.00	698.50	635.00	31.75	28.57	20
≤609.60	749.3	749.30	35.05	31.75	20

2.2 Vapour manifold

2.2.1 Isolation valve

a) An isolation valve capable of manual operation is to be provided at the ship vapour connection.

b) The valve is to have an indictor to show clearly whether the valve is in the open or closed position, unless the valve position can be readily determined from the valve handle or valve stem.

2.2.2 Labelling

The vapour manifold is to be:

- for the last 1 m painted red/yellow/red, with the red bands 0,1 m wide and the yellow band 0,8 m wide;
- labelled “VAPOUR” in black letters at least 50 mm high.

2.3 Vapour hoses

2.3.1 Hoses

Each hose used for transferring vapour is to have:

- a design burst pressure of at least 0,175 MPa;
- a maximum working pressure of at least 0,035 MPa;
- the capability of withstanding at least 0,014 MPa vacuum without collapsing or constricting;
- electrical continuity with a maximum resistance of 10000 Ω;
- resistance to abrasion and kinking;
- the last 1 m of each end of the hose marked in accordance with [2.2.2];
- for hose flanges see [2.1.7].

2.3.2 Handling equipment

Vapour hose handling equipment are to be provided with hose saddles which provide adequate support to prevent kinking or collapse of hoses.

2.4 Vapour overpressure and vacuum protection

2.4.1 General

The cargo tank venting system is:

a) to be capable of discharging cargo vapour at 1.25 times the maximum transfer rate in such a way that the pressure in the vapour space of each tank connected to the vapour collection system does not exceed:

   1) the maximum working pressure of the tank;

   2) the operating pressure of a safety valve or rupture disk, if fitted;

b) not to relieve at a pressure corresponding to a pressure in the cargo tank vapour space of less than 0,007 MPa;

c) to prevent a vacuum in the cargo tank vapour space, that exceeds the maximum design vacuum for any tank which is connected to the vapour collecting system, when the tank is discharged at the maximum rate;

d) not to relieve at a vacuum corresponding to a vacuum in the cargo tank vapour space less than 0,0035 MPa below the atmospheric pressure.

2.4.2 Pressure/vacuum safety valves

a) Pressure/vacuum safety valves are to be fitted with means to check that the device operates freely and does not remain in the open position.

b) Pressure relief valves are to be fitted with a flame screen at their outlets, unless the valves are designed in such a way as to ensure a vapour discharge velocity of not less than 30 m/second.

3 Instrumentation

3.1 Cargo tank gauging equipment

3.1.1 Each cargo tank that is connected to a vapour collection system is to be equipped with a cargo gauging device which:

- provides a closed gauging arrangement which does not require opening the tank to the atmosphere during cargo transfer;
- allows the operator to determine the liquid level in the tank for the full range of liquid levels in the tank;
- indicates the liquid level in the tank, at the location where cargo transfer is located;
- if portable, is installed on tank during the entire transfer operation.

3.2 Cargo tank high level alarms

3.2.1 General

a) Each cargo tank that is connected to a vapour collection system is to be equipped with an intrinsically safe high level alarm system which alarms before the tank overfill alarm, but not lower than 95% of the tank capacity.

b) The high level alarm is to be identified with the legend "HIGH LEVEL ALARM" and have audible and visible alarm indications that can be seen and heard where the cargo transfer is controlled.

3.2.2 Alarm characteristics

The high level alarm is:

- to be independent of the overfill alarm;
- to alarm in the event of loss of power to the alarm system or failure of the electrical circuits to the tank level sensors.
- to be able to be checked at the tank for proper operation prior to each transfer or contain an electronic self-testing feature which monitors the condition of the alarm circuits and sensors.

3.3 Cargo tank overfill alarms

3.3.1 General

a) Each cargo tank that is connected to a vapour collection system is to be equipped with an intrinsically safe overfill alarm which alarms early enough to allow the person in charge of transfer operation to stop the transfer operation before the cargo tank overflows.

b) The overfill alarm is to be identified with the legend "OVERFILL ALARM" and have audible and visible alarm indications that can be seen and heard where the cargo transfer is controlled and in the deck cargo area.

3.3.2 Alarm characteristics

The overfill alarm is:

- to be independent of both the high level alarm (see [3.2.1]) and the cargo gauging system (see [3.1]);
- to alarm in the event of loss of power to the alarm system or failure of the electrical circuits to the tank level sensors.
- to be able to be checked at the tank for proper operation prior to each transfer or contain an electronic self-testing feature which monitors the condition of the alarm circuits and sensors.

3.4 High and low vapour pressure alarms

3.4.1 Pressure alarms

Each vapour collection system is to be fitted with one or more pressure sensing devices that sense the pressure in the main collection line, which:

- have a pressure indicator located where the cargo transfer is controlled;
- alarm the high pressure of not more than 90% of the lowest relief valve setting in the tank venting system;
- alarm at a low pressure of not less than 0,98 kPa for an inerted tank, or the lowest vacuum relief valve setting in the cargo venting system for a non-inerted tank.

3.4.2 Equivalence

Pressure sensors fitted in each cargo tank are acceptable as equivalent to pressure sensors fitted in each main vapour collection line.

4 Instruction manual

4.1 General

4.1.1

a) Each ship utilising a vapour emission control system is to be provided with written operational instructions covering the specific system installed on the ship.

b) Instructions are to encompass the purpose and principles of operation of the vapour emission control system and provide an understanding of the equipment involved and associated hazards. In addition, the instructions are to provide an understanding of the operating procedures, piping connection sequence, start-up procedures, normal operations and emergency procedures.

4.2 Content

4.2.1 The instruction are to contain:

a) a line diagram of the tanker's vapour collection piping including the location of each valve, control device, pressure-vacuum safety valve, pressure indicator, flame arresters and detonation arresters, if fitted;

b) the maximum allowable transfer rate for each group of cargo tanks having the same venting line, determined as the lowest of the following:

1) 80% of the total venting capacity of the pressure relief valves in the cargo tank venting systems;

2) the total vacuum relieving capacity of the vacuum relief valves in the cargo tank venting system;

3) the rate based on pressure drop calculations at which, for a given pressure at the facility vapour connection, or, if lightering, at the vapour connection of the service ship, the pressure in any cargo tank connected to the vapour collection system exceeds 80% of the setting of any pressure relief valve in the cargo tank venting system;

c) the initial loading rate for each cargo tank, to be determined in such a way as to minimise the development of a static electrical charge, when applicable;

d) tables or graphs of transfer rates and corresponding vapour collection system pressure drops including the vapour hoses, if foreseen) determined, from the most remote cargo tanks to the ship vapour connection, as follow:

1) for each cargo handled by the vapour collection system at the a maximum transfer rate and at the lesser transfer rates;

2) based on 50% cargo vapour and air mixture, and a vapour growth rate appropriate for the cargo being loaded;

e) the safety valve setting at each pressure-vacuum safety valve.

5 Testing and trials

5.1

5.1.1 General

Machinery and equipment which are part of the vapour collecting system are to be tested in compliance with the applicable requirements of the various Sections of the Rules.

5.1.2 Hydrostatic tests

Pressure parts are to be subjected to hydrostatic tests in accordance with the applicable requirements.

5.1.3 Pressure/vacuum valves

Pressure/vacuum valves are to be tested for venting capacity. The test is to be carried out with the flame screen installed if contemplated in accordance with [2.4.2].

5.2 On board trials

5.2.1 Upon completion of construction, in addition to conventional sea trials, specific tests may be required at the Society's discretion in relation to the characteristics of the plant fitted on board.

6 Additional requirements for "TRANSFER" notation

6.1 Application

6.1.1 These requirements are applicable to service ships.

6.2 Equipment

6.2.1 Ships with inerted cargo tanks

If the cargo tanks on a ship discharging cargo and a ship receiving cargo are inerted, the service ship is to have means to inert the vapour transfer hose prior to transferring cargo vapour and an oxygen analyser with a sensor or sampling connection fitted within 3 m of the ship vapour connection which:

- activates an audible and visible alarm at a location on the service ship where cargo transfer is controlled when the oxygen content in the vapour collection system exceeds 8% by volume;
- has an oxygen concentration indicator located on the service ship where the cargo transfer is controlled;
- has a connection for injecting a span gas of known concentration for calibration and testing of the oxygen analyser.

6.2.2 Ships with cargo tanks not inerted

If the cargo tanks on a ship discharging cargo are not inerted, the vapour collection line on the service ship is to be fitted with a detonation arrester located within 3 m of the ship vapour connection.

6.2.3 Electrical insulating flange

An electrical insulating flange or one length of non-electrically conductive hose is to be provided between the vapour connection of the service ship and the vapour connection on the ship being lightered.

SECTION 6 COFFERDAM VENTILATION (COVENT)

1 General

1.1 Application

1.1.1 The additional class notation COVENT is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.6], to ships having all cofferdams (including ballast tanks) in cargo area which are provided with fixed ventilation systems or having movable components included in the ship equipment complying with the requirements of this Section.

1.1.2 For the purpose of this Section cargo area is that portion of the ship included between the forward bulkhead of the machinery space and the collision bulkhead.

In the case of ships with machinery spaces located amidships, the cargo area is also to include that portion of the ship between the aft bulkhead of the engine space and the after peak bulkhead, excluding the shafting tunnel.

1.2 Documents to be submitted

1.2.1 The documents listed in Tab 1 are to be sent to Society for approval.

The Society reserves the right to require additional plans or information in relation to the specific characteristics of the installations.

2 Design and construction

2.1 Arrangement

2.1.1 Number of air changes

a) The ventilation system is be capable to supply at least 4 complete air changes per hours, based on the cofferdam gross volume.

b) For cofferdams adjacent to spaces where dangerous mixtures may be present, such as, for instance cargo tanks of oil carriers, the minimum number of air changes per hour is to be increased to 8.

2.1.2 Avoidance of stagnation zones

In order to avoid air stagnation zones, air exhaust ports inside the cofferdam are to be adequately distributed.

Particular attention is to be paid to the arrangement of the inlet and outlet ducts in the cofferdams surrounding the cargo tanks of the double hull tankers, where, due to the particular shape of the cofferdams and the presence of stiffening inside it is easy the formation of stagnant zones.

2.1.3 Cofferdams that may be used as ballast tanks

Provisions are to be taken to blank the inlet and outlet ventilation ducts, when the cofferdams are used for carriage of ballast.

2.2 Other technical requirements

2.2.1 Ventilation inlets and outlets

Ventilation inlets and outlets leading to the open air from cofferdam adjacent to dangerous spaces are to be fitted with protective screens recognized as suitable by the Society. The spacing between them and from ignition sources, openings into spaces where ignition sources are present, openings into cargo tanks and air inlets and outlets of different spaces is to be not less than 3m.

2.2.2 Fans

a) Ventilation fans are to be of non-sparking construction in accordance with the requirements of Part C, Chapter 4.

b) In the case the ventilated cofferdams are adjacent to a dangerous space, the electric motors driving the ventilation fans are not to be located in the ventilation ducts.

Table 1

No.	A/I **(1)**	Item
1	I	Schematic drawing of the installations
2	A	Calculation of number of air changes per hour for each cofferdam in cargo area
3	A	Line diagram of power supply circuits of control and monitoring systems, including circuit table
4	A	List and type of equipment and in particular type of fans and their arrangements in ducts
5	I	Plan of the location and arrangements of the control station, if any
6	A	List of remote control devices, if any
7	A	List of alarms
(1) A = to be submitted for approval in quadruplicate I = to be submitted for information in duplicate		

2.2.3 Lighting

In the case the cofferdams are provided with electric light appliances, the ventilation system is to be interlocked with the lighting, such that ventilation is to be in operation to energise the lighting.

2.2.4 Alarms

An audible and visible alarm is to be activated in case of failure of the ventilation.

3 Inspections and testings

3.1 Equipment and systems

3.1.1 Equipment and systems are to be inspected and tested in accordance with the applicable requirements of the Rules relative at each piece of equipment or system used for the ventilation of the cofferdams.

3.2 Testing on board

3.2.1 Following installation on board, the ventilation systems are to be subjected to operational tests in the presence of the Surveyor.

SECTION 7 CENTRALISED CARGO AND BALLAST WATER HANDLING INSTALLATIONS (CARGOCONTROL)

1 General

1.1 Application

1.1.1 The additional class notation **CARGOCONTROL** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.7], to ships carrying liquid cargo in bulk fitted with a centralised system for handling cargo and ballast liquids and complying with the requirements of this Section.

1.1.2 Compliance with these Rules does not exempt the Owner from the obligation of fulfilling any additional requirements issued by the Administration of the State whose flag the ship is entitled to fly.

1.2 Documents to be submitted

1.2.1 The documents listed in Tab 1 are to be sent to Society for approval.

The Society reserves the right to require additional plans or information in relation to the specific characteristics of the installations.

2 Design and construction requirements

2.1 Control station

2.1.1 Location of control station

a) The control station is to be located such as to allow visibility of the cargo tanks deck area, and in particular of the cargo loading and unloading ramps.

b) The station is preferably to be situated in the accommodation area; should this be impracticable, the control station is to be bounded by A-60 Class fire-resisting bulkheads and provided with two escapes.

2.1.2 Communications

It is be possible from the control station to convey orders to crew members on deck and to communicate with the navigating bridge, with cargo handling spaces, with the engine room and with the propulsion control room, where the latter is foreseen.

2.1.3 Safety equipment

Where the control station is located in the cargo area, two complete sets of protective clothing in order to protect the skin from the heat radiating from the fire are always to be readily available together with three breathing apparatuses.

2.2 Remote control, indication and alarm systems

2.2.1 Remote control system

It is to be possible to carry out the following operations from the control station

a) opening and closing of valves normally required to be operated for loading, unloading and transfer of cargo and ballast (however, the opening and closing of valves is not required for the ends of cargo loading and unloading arrangements);

b) starting and stopping of cargo pumps, stripping pumps and ballast pumps (alternative solutions may be considered in the case of pumps powered by turbines);

c) regulation, if foreseen, of the number of revolutions of cargo pumps, stripping pumps and ballast pumps.

Table 1

No.	A/I **(1)**	Item
1	I	Schematic drawing of the installations
2	I	Plan of the location and arrangements of the control station
3	A	List of remote control devices
4	A	List of alarms
5	I	List of the equipment (sensors, transducers, etc.) and automation systems (alarm systems, etc.) envisaged with indication of the manufacturer and of the type of equipment or system
6	A	Line diagram of power supply circuits of control and monitoring systems, including • circuit table, in the case of electrical power supply • specification of service pressures, diameter and thickness of piping, materials used, etc. in the case of hydraulic or pneumatic power supply

(1) A = to be submitted for approval in quadruplicate
I = to be submitted for information in duplicate

2.2.2 Indication system

The control station is to be fitted with indicators showing:

- (open/closed) position of valves operated by remote control;
- state (off/on) of cargo pumps, stripping pumps and ballast pumps;
- number of revolutions of cargo pumps, stripping pumps and ballast pumps where they may be operated at adjustable speeds;
- delivery pressure of the hydraulic plant for the operation of cargo pumps, stripping pumps and ballast pumps;
- delivery and suction pressure of cargo pumps, stripping pumps and ballast pumps;
- pressure of the ends of cargo loading and unloading arrangements;
- oxygen level, temperature and pressure of the inert gas, where the operation of the inert gas system is required or envisaged at the same time as loading/unloading;
- level in cargo and ballast tanks (relaxation of this requirement may be permitted for double bottom ballast tanks of reduced capacity and limited depth);
- temperature in cargo tanks provided with heating or refrigeration.

2.2.3 Alarm systems

The cargo control station is to be fitted with visual and audible alarms signalling the following:

- high level, and where requested very high level, in cargo tanks;
- high pressure in cargo tanks, if required by the Rules;
- low delivery pressure of the hydraulic plant for the operation of pumps and valves;
- high vacuum in cargo tanks, if required by the Rules;
- high pressure in the cargo and ballast lines;
- high and low temperature for cargo tanks fitted with heating and refrigerating systems;
- high oxygen level, high temperature, high and low pressure of inert gas, if foreseen;
- high level in a bilge well in cargo and ballast pump rooms;
- high concentration of explosive vapours (exceeding 30% of the lower flammable limit) in spaces where cargo is handled;
- high temperature of gas tight seals with oil glands for runs of shafts, where these are foreseen through bulkheads or decks, for the operation of cargo and ballast pumps.

3 Inspections and testings

3.1 Equipment and systems

3.1.1 Equipment an systems are to be inspected and tested in accordance with the applicable requirements of the Rules relative at each piece of equipment or system used for the centralised control.

3.2 Testing on board

3.2.1 Following installation on board, remote control, indication and alarm systems are to be subjected to operational tests in the presence of the Surveyor.

SECTION 8 SHIP MANOEUVRABILITY (MANOVR)

1 General

1.1 Application

1.1.1 The additional class notation **MANOVR** is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.8], to ships whose manoeuvring capability standards are complying with the requirements of this Section.

1.1.2

The requirements of this Section reproduce the provisions of the IMO Resolution MSC 137(76) "Standards for Ship Manoeuvrability"and are applicable to ships of all rudder and propulsion types, of 100 m in length and over.

Note 1: Reference is also to be made to IMO MSC/Circ. 1053 on Explanatory notes to the Standards for ship manoeuvrability.

1.2 Manoeuvres evaluation

1.2.1 Conventional trials

The requirements in this section are based on the understanding that the manoeuvrability of ships can be evaluated from the characteristics of conventional trial manoeuvres.

1.2.2 Compliance with the requirements

The following two methods can be used to demonstrate compliance with these requirements:

a) Scale model tests and/or predictions using computer programs with mathematical model can be performed to predict compliance at the design stage.

   Results of the model test and/or computer simulations will be confirmed by full scale trials, as necessary.

b) The compliance with these requirements can be demonstrated based on the results of the full scale trials conducted in accordance with such requirements.

2 Definitions

2.1 Geometry of the ship

2.1.1 Length (L)

Length (L) is the length measured between the aft and forward perpendiculars.

2.1.2 Midship point

Midhip point is the point on the centreline of a ship midway between the aft and forward perpendiculars.

2.1.3 Draught T_A

The draught T_A is the draught at the aft perpendicular.

2.1.4 Draught T_F

The draught T_F is the draught at the forward perpendicular.

2.1.5 Mean draught T_M

The mean draught T_M is defined as $T_M = (T_A + T_F)/2$.

2.1.6 Trim T

The trim (T) is defined as $T = (T_A - T_F)$.

2.1.7 Displacement Δ

The displacement Δ is the full load displacement of the ship (in tonnes).

2.2 Standard manoeuvres and associated terminology

2.2.1 Test speed

The test speed (V) used in the requirements is a speed of at least 90% of the ship's speed corresponding to 85% of the maximum engine output.

2.2.2 Turning circle manoeuvre

The turning circle manoeuvre is the manoeuvre to be performed to both starboard and port with 35° rudder angle or the maximum rudder angle permissible at the test speed, following a steady approach with zero yaw rate.

2.2.3 Advance

Advance is the distance travelled in the direction of the original course by the midship point of a ship from the position at which the rudder order is given to the position at which the heading has changed 90° from the original course.

2.2.4 Tactical diameter

Tactical diameter is the distance travelled by the midship point of a ship from the position at which the rudder order is given to the position at which the heading has changed 180° from the original course. It is measured in a direction perpendicular to the original heading of the ship.

2.2.5 Zig-zag test

Zig-zag test is the manoeuvre where a known amount of helm is applied alternately to either side when a known heading deviation from the original heading is reached.

2.2.6 10°/10° zig-zag test

10°/10° zig-zag test is performed by turning the rudder alternately by 10° either side following a heading deviation of 10° from the original heading accordance with the following procedure.

a) after a steady approach with zero yaw rate, the rudder is put over 10° to starboard/port (first execute);

b) when the heading has changed to 10° off the original heading, the rudder is reversed to 10° to port/starboard (second execute);

c) after the rudder has been turned to port/starboard, the ship will continue turning in the original direction with decreasing turning rate. In response to the rudder, the ship is then to turn to port/starboard. When the ship has reached a heading of 10° to port/starboard of the original course, the rudder is again reversed to 10° to starboard/port (third execute).

2.2.7 First overshoot angle

The first overshoot angle is the additional heading deviation experienced in the zig-zag test following the second execute.

2.2.8 Second overshoot angle

The second overshoot angle is the additional heading deviation experienced in the zig-zag test following the third execute

2.2.9 20°/20° zig-zag test

20°/20° zig-zag test is performed using the same procedure given in [2.2.6] above using 20° rudder angle and 20° change of heading, instead of 10° rudder angles and 10° change of heading, respectively.

2.2.10 Full astern stopping test

Full astern stopping test determines the track reach of ship from the time an order for full astern is given until the ship stops in water.

2.2.11 Track reach

Track reach is the distance along the path described by the midship point of a ship measured from the position at which an order for full astern is given to the position at which the ship stops in the water.

3 Requirements

3.1 Foreword

3.1.1 The standard manoeuvres are to be performed without the use of any manoeuvring aids, which are not continuously and readily available in normal operations.

3.2 Conditions at which the requirements apply

3.2.1 In order to evaluate the performance of a ship, manoeuvring trials are to be conducted to both port and starboard and at conditions specified below:

a) deep, unrestricted water
b) calm environment
c) full load (summer load line draught), even keel condition
d) steady approach at test speed.

3.3 Criteria for manoeuvrability evaluation

3.3.1 Turning ability

The advance is not to exceed 4,5 ship lengths (L) and the tactical diameter is not to exceed 5 ship lengths in the turning circle manoeuvre.

3.3.2 Initial turning ability

With the application of 10° rudder angle to port/starboard, the ship is not to have travelled more than 2,5 ship lengths by the time the heading has changed by 10° from the original heading.

3.3.3 Yaw checking and course keeping ability

a) The value of the first overshoot angle in the 10°° zig-zag test is not to exceed:

   1) 10°, if L/V is less than 10 seconds;
   2) 20°, if L/V is 30 seconds or more; and
   3) (5 + 1/2 (L/V)) degrees, if L/V is 10 seconds or more, but less than 30seconds.

   where L and V are expressed in m and m/second respectively.

b) The value of the second overshoot angle in the 10°/10° zig-zag test is not to exceed:

   1) 25°, if L/V is less than 10 seconds;
   2) 40°, if L/V is 30 seconds or more; and
   3) (17,5 + 0,75 (L/V)) degrees, if L/V is 10 seconds or more, but less than 30 seconds.

c) The value of the first overshoot angle in the 20°/20° zig-zag test is not to exceed 25°.

3.3.4 Stopping ability

The track reach in the full astern stopping test is not to exceed 15 ship lengths. However, this value may be increased after judgement of the Society for large ships, but in no case is it to exceed 20 ship lengths.

3.3.5 Non-conventional steering and propulsion systems

For ships with non-conventional steering and propulsion systems, the Society may permit the use of comparative steering angles to the rudder angles specified in this Section.

4 Additional considerations

4.1 Trials in different conditions

4.1.1 In the case where the standard trials are conducted in conditions different from those specified in [3.2.1] c), the corrections deemed necessary, at judgement of the Society, is to be made in each particular instance.

4.2 Dynamic instability

4.2.1 Where standard manoeuvres indicate dynamic instability the Society may require additional tests to be conducted to define the degree of instability, such as spiral tests or the pull out manoeuvre.

SECTION 9 DAMAGE STABILITY (DMS)

1 General

1.1

1.1.1 The additional class notation DMS is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.9], to ships complying with the damage stability requirements given in this Section.

1.2 Documents to be submitted

1.2.1 The stability documentation to be submitted for approval is as follows:

- damage stability calculations,
- damage control documentation.

1.2.2 A copy of the documentation as per [1.2.1] is to be available on board for the attention of the Master.

2 Requirements applicable to all type of ships

2.1 Approaches to be followed for damage stability investigation

2.1.1 General

Damage stability calculations are required in order to achieve a minimum degree of safety after flooding.

In order to assess the behaviour of the ship after damage, the requirements contained in Chapter II-1 of Solas'74 as amended are to be complied with if not otherwise stated in item [3], depending on the ship type.

2.1.2 Damage stability calculations

The damage stability calculations are to include:

- list of the characteristics (volume, centre of gravity, permeability) of each compartment which can be damaged
- a table of openings in bulkheads, decks and side shell reporting all the information about:
  - identification of the opening
  - vertical, transverse and horizontal location
  - type of closure: sliding, hinged or rolling for doors
  - type of tightness: watertight, weathertight, semi-watertight or unprotected
  - operating system: remote control, local operation, indicators on the bridge, television surveillance, water leakage detection, audible alarm, as applicable
  - foreseen utilisation: open at sea, normally closed at sea, kept closed at sea
- list of all damage cases corresponding to the applicable requirements
- detailed results of damage stability calculations for all the loading conditions foreseen in the applicable requirements
- the limiting GM/KG curve, if foreseen in the applicable requirements
- capacity plan
- arrangement of cross-flooding, pipes showing location of remote controls for valves, or special mechanical means to correct list due to flooding, if any
- watertight and weathertight door plan.

As a supplement to the approved damage stability documentation, a loading instrument, approved by the Society, may be used to facilitate the damage stability calculations mentioned in this Section.

The procedure to be followed, as well as the list of technical details to be sent in order to obtain loading instrument approval, are given in Pt B, Ch 11, Sec 2, [4.8].

2.1.3 Damage control documentation

The damage control documentation is to include a damage control plan which is intended to provide ship's officers with clear information on the ship's watertight compartments and equipment related to maintaining the boundaries and effectiveness of the watertight compartments so that, in the event of damage causing flooding, proper precautions can be taken to prevent progressive flooding through openings therein and effective action can be taken quickly to mitigate and, where possible, recover the ship's loss of stability.

The damage control documentation is to be clear and easy to understand. It is not to include information which is not directly relevant to damage control, and is to be provided in the language or languages of the ship's officers. If the languages used in the preparation of the documentation are not English or French, a translation into one of these languages is to be included.

The use of a loading instrument performing damage stability calculations may be accepted as a supplement to the damage control documentation. This instrument is to be approved by the Society according to the requirements of Pt B, Ch 11, Sec 2, [4.8].

The damage control plan is required for the following ships:

- Ships carrying passengers
- Dry cargo ships corresponding to Part E, Chapter 7.

Note 1: Dry cargo ship is intended to mean a cargo ship which has not been designed to carry liquid cargo in bulk; furthermore, the following ship types are not to be considered as dry cargo ships:

- tugs, as defined in Part E, Chapter 3
- supply vessels, as defined in Part E, Chapter 4
- fire-fighting ships, as defined in Part E, Chapter 5
- oil recovery ships, as defined in Part E, Chapter 6.

2.1.4 Progressive flooding

a) Definition

Progressive flooding is the additional flooding of spaces which were not previously assumed to be damaged. Such additional flooding may occur through openings or pipes as indicated in b) and c).

b) Openings

The openings may be listed in the following categories, depending on their means of closure:

- Unprotected

  Unprotected openings may lead to progressive flooding if they are situated within the range of the positive righting lever curve or if they are located below the waterline after damage (at any stage of flooding). Unprotected openings are openings which are not fitted with at least weathertight means of closure.

- Weathertight

  Openings fitted with weathertight means of closure are not able to sustain a constant head of water, but they can be intermittently immersed within the positive range of stability.

  Weathertight openings may lead to progressive flooding if they are located below the waterline after damage (at any stage of flooding).

- Semi-watertight

  Internal openings fitted with semi-watertight means of closure are able to sustain a constant head of water corresponding to the immersion relevant to the highest waterline after damage at the equilibrium of the intermediate stages of flooding.

  Semi-watertight openings may lead to progressive flooding if they are located below the final equilibrium waterline after damage.

- Watertight

  Internal openings fitted with watertight means of closure are able to sustain a constant head of water corresponding to the distance between the lowest edge of this opening and the bulkhead/freeboard deck.

  Air pipe closing devices complying with Pt C, Ch 1, Sec 8, [9.1.6] may not be considered watertight, unless additional arrangements are fitted in order to demonstrate that such closing devices are effectively watertight.

  The pressure/vacuum valves (PV valves) currently installed on tankers do not theoretically provide complete watertightness.

  Manhole covers may be considered watertight provided the cover is fitted with bolts located such that the distance between their axes is less than five times the bolt's diameter.

  Access hatch covers leading to tanks may be considered watertight.

  Watertight openings do not lead to progressive flooding.

c) Pipes

Progressive flooding through pipes may occur when:

- the pipes and connected valves are located within the assumed damage, and no valves are fitted outside the damage
- the pipes, even if located outside the damage, satisfy all of the following conditions:
  - the pipe connects a damaged space to one or more spaces located outside the damage,
  - the highest vertical position of the pipe is below the waterline, and
  - no valves are fitted.

The possibility of progressive flooding through ballast piping passing through the assumed extent of damage, where positive action valves are not fitted to the ballast system at the open ends of the pipes in the tanks served, is to be considered. Where remote control systems are fitted to ballast valves and these controls pass through the assumed extent of damage, then the effect of damage to the system is to be considered to ensure that the valves would remain closed in that event.

If pipes, ducts or tunnels are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Society may permit minor progressive flooding if it is demonstrated that the additional flooding of those compartments cannot lead to the capsizing or the sinking of the ship.

Requirements relative to the prevention of progressive flooding are specified in Pt C, Ch 1, Sec 8, [5.5].

3 Additional requirements applicable to specific type of ships

3.1 Alternative requirements to those given in this Section

3.1.1 Taking into account the ship dimensions, service and navigation, alternative requirements to those given in this Section may be accepted by the Society on a case-by-case basis

SECTION 10 PROTECTIVE COATINGS IN WATER BALLAST TANKS (COAT-WBT)

1 General

1.1 Application

1.1.1 This Section provides the criteria for the assignment of the additional class notation COAT-WBT, in accordance with Pt A, Ch 1, Sec 2, [6.11.10], to ships of new construction whose water ballast tanks have been provided with protective coatings complying with the requirements of this Section.

The criteria for retaining the additional class notation **COAT-WBT**, which is subject to the coating system being maintained in or restored to GOOD condition, according to the definition given in Pt A, Ch 2, Sec 2, [2.2.11], during intermediate or class renewal surveys, are dealt with in Pt A, Ch 5, Sec 8, [8].

1.1.2

The criteria for the selection, application and maintenance of protective coatings in water ballast tanks, provided in this Section, are based on the following international regulations and standard:

a) Regulation 3-2 of Part A-1, Chapter II-1 of SOLAS Convention 1974, which compulsorily applies to oil tankers and bulk carriers constructed on or after 1 July 1998, stating that "All dedicated seawater ballast tanks shall have an efficient corrosion prevention system, such as hard coating or equivalent. The coating is to preferably be of light colour. The scheme for the selection, application and maintenance of the system shall be approved by the Administration, based on guidelines adopted by the Organisation. Where appropriate, sacrificial anodes shall also be used";

b) IMO Resolution A.798(19) "Guidelines for the selection, application and maintenance of corrosion protection systems of dedicated seawater ballast tanks", referred to in the above-mentioned SOLAS regulation;

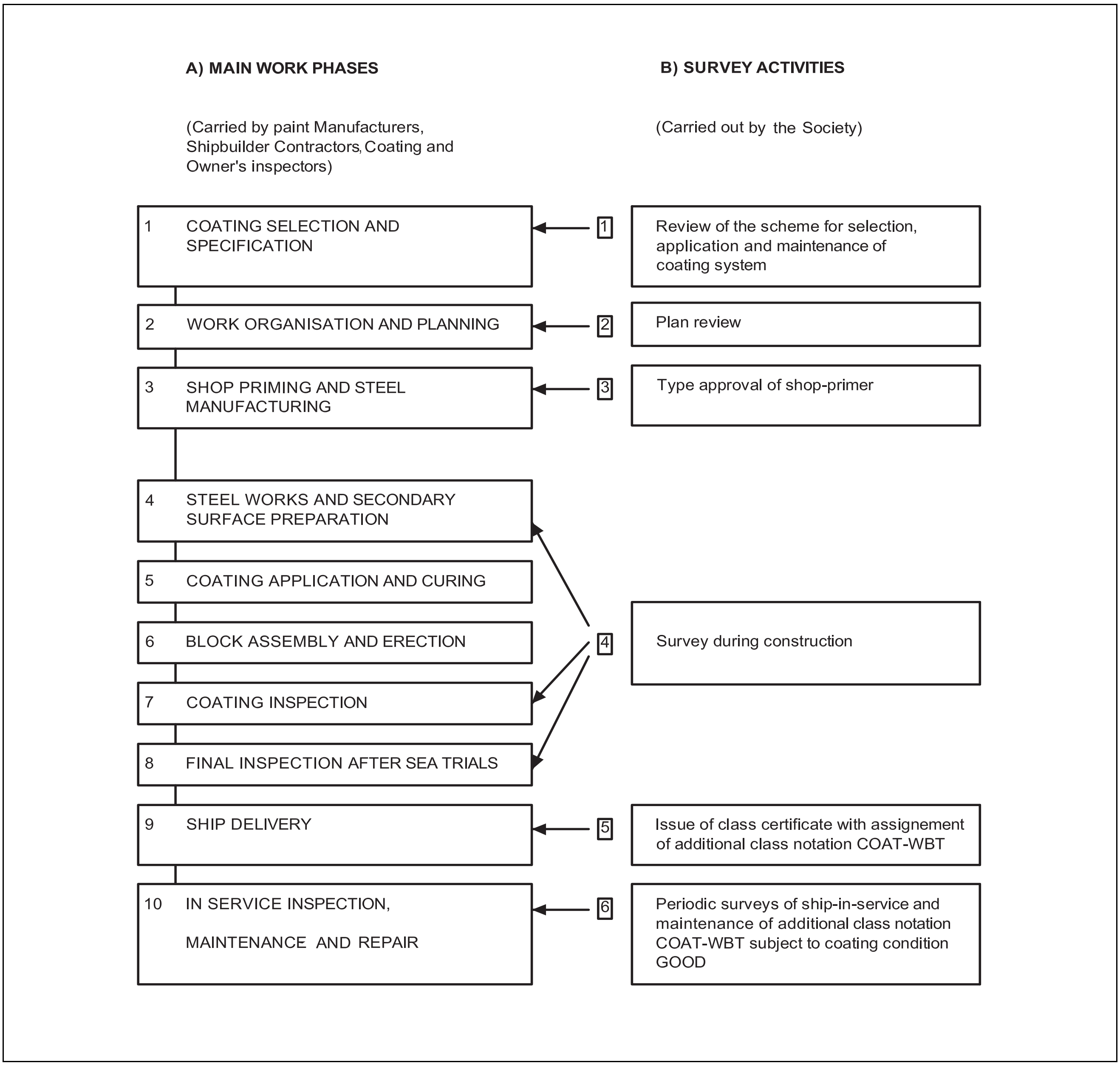
The reference "coating performance standard" for the assignment of the notation is the "Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers", approved by IMO at MSC 81 for adoption at MSC 82 and entry into force on 1 July 2008. The basic coating system requirements are indicated in Tab 2.

A different "coating performance standard", which may have been chosen in the agreement between the shipyard and the Owner, may be accepted as a reference standard provided that the Society deems it at least equivalent to the above-mentioned standard.

The reference "coating performance standard" will be appended as an enclosure to the Certificate of Classification of those ships to which the notation is assigned.

1.1.3 The assignment of the notation COAT-WBT is subject to the verification of the "main work phases" indicated in Tab 1, schedule A) by means of the "survey activities" identified at the milestones indicated in Tab 1, schedule B), as described in [3].

Table 1 : Main work phases and survey activities for the assignment of the notation COAT-WBT



1.2 Definitions

1.2.1 For the purpose of this Section the following definitions apply:

a) **Ballast spaces:** are spaces that can be used for storing ballast water. They normally include, but are not limited to, ballast tanks as defined in Resolution A.798(19) and Resolution A.744(18) and tanks which, according to the ship's loading manual, can be used for both cargo and ballast;

b) **Cathodic protection:** is a technique to prevent corrosion of a metal surface by making an electrochemical contact between the substrate and a metal easier to be corroded, i.e. zinc, magnesium, which in this case is sacrificed to preserve the less noble metal such as steel;

c) **Curing:** is a complex of chemical phenomena which cause the polymerisation of the binder of the paint with formation of a three-dimensional molecular structure insoluble in the original solvents of the binder;

d) **Curing time:** is the time required by a coating to reach its complete properties and mechanical characteristic;

e) **Dew point:** is the temperature at which air is saturated with moisture;

f) **Dust:** is loose particle matter present on a surface prepared for painting arising from blast-cleaning or other surface preparation processes, or resulting from the action of the environment;

g) **Edge grinding:** is the treatment of edges before secondary surface preparation;

h) **Hard coating:** is a coating that chemically converts during its curing process or a non-convertible air drying coating which may be used for maintenance purposes. It can be either inorganic or organic;

i) **NDFT:** is the nominal dry film thickness of coating. 90/10 practice means that 90% of all thickness measurements are to be greater than or equal to NDFT and none of the remaining 10% measurements is to be below 0,9 x NDFT;

j) **Primer coat:** is the first coating applied in the shipyard (to differentiate it from shop primer);

k) **Shop primer:** is the prefabrication primer coating applied to steel plates and profiles in thin film, often in an automatic painting shop;

l) **Solvent:** is a volatile liquid capable of completely dissolving a given binder;

m) **Stripe coating:** is an application, normally by brush or roller, of one or more coating layers on locations where it is not easy to achieve the final total dry film coating thickness with the simple spray application;

n) **Target useful life:** is the target value, in years, of the durability for which the coating system is designed. It is noted that the design of a coating system includes criteria for selection of the coating and for its proper application;

o) **Technical Data Sheet:** is the paint Manufacturer's Product Data Sheet, which contains detailed technical instructions and information relevant to the coating and its application;

p) **Thinner:** is a volatile liquid that does not necessarily dissolve the binder, but which is capable of reducing the viscosity of the binder solution (vehicle), for example by reducing the viscosity of a paint spraying consistency.

2 Coating selection and specification

2.1 General Principles

2.1.1 The ability of the coating system to reach its target useful life depends on the selected type of coating system, steel preparation, application and coating inspection and maintenance. All these aspects contribute to the good performance of the coating system.

2.1.2 Inspections of surface preparation and coating processes are to be agreed upon between the Owner, the shipyard and the coating Manufacturer and submitted to the Society for review, prior to the commencement of the shipbuilding process, in order to check that they contain at least the information shown in Tab 7 and that it complies with the basic coating system requirements shown in Tab 2. Clear evidence of these inspections is to be reported and be included in the Coating Technical File (see [2.2]).

2.1.3 The following aspects are to be taken into account for achieving the required coating performance:

a) it is essential that the agreed technical specifications, procedures and various different steps in the coating application process (including but not limited to surface preparation) are strictly followed by the shipbuilder, in order to prevent premature decay and/or deterioration of the coating system;

b) the effectiveness of these Rule requirements can be improved by adopting measures at the ship design stage such as reducing scallops, using rolled profiles, avoiding complex geometric configurations and ensuring that the structural configuration permits easy access for tools and to facilitate cleaning, drainage and drying of the space to be coated;

c) these Rule requirements are based on experience from Manufacturers, shipyards and ship operators and are not intended to exclude suitable alternative systems or innovative approaches that might be developed and applied in the future, provided that they demonstrate a level of performance at least equivalent to that specified in this Section. Acceptance criteria for alternative systems are given in [2.8].

2.2 Coating Technical File

2.2.1 Specification of the coating system applied to the seawater ballast tanks, records of the shipyard's and Owner's coating work, and detailed criteria for coating selection, job specifications, inspection, maintenance and repair are to be documented in the Coating Technical File, which is to be reviewed by the Society.

2.2.2 The Coating Technical File is to contain at least the following items relating to this standard and is to be delivered by the shipyard at new ship construction stage:

a) copy of Statement of Compliance or Type Approval Certificate;

b) copy of Technical Data Sheet, including:

- product name and identification mark and/or number;
- materials, components and composition of the coating system, colours;
- minimum and maximum dry film thickness;
- application methods, tools and/or machines;
- condition of surface to be coated (de-rusting grade, cleanness, profile, etc.); and
- environmental limitations (temperature and humidity);

c) shipyard work records of coating application, including:
   - applied actual space and area (in square metres) of each compartment;
   - applied coating system;
   - time of coating, thickness, number of layers, etc.;
   - ambient condition during coating; and
   - method of surface preparation;

d) procedures for inspection and repair of coating system during ship construction;

e) coating log issued by the coating inspector - stating that the coating was applied in accordance with the specifications to the satisfaction of the coating supplier representative and specifying deviations from the specifications (examples of a Daily Log and Non-conformity Report are given in Tab 4 and Tab 5, respectively);

f) shipyard's verified inspection report, including:
   - completion date of inspection;
   - result of inspection;
   - remarks (if given); and
   - inspector's signature; and

g) procedures for in-service maintenance and repair of coating system.

2.2.3 Maintenance, repair and partial re-coating activities are to be recorded in the Coating Technical File. For coating maintenance and repair, reference is to be made to IACS Recommendation 87 "Guidelines for Coating Maintenance and Repair for Ballast tanks and Combined Cargo/Ballast tanks on Oil Tankers".

2.2.4 If full re-coating is carried out, the items specified in [2.2.2] are to be recorded in the Coating Technical File.

2.2.5 The Coating Technical File is to be kept on board and maintained throughout the life of the ship.

2.3 Health and safety

2.3.1 The shipyard is responsible for implementation of national regulations to ensure the health and safety of individuals and to minimise the risk of fire and explosion.

2.4 Coating Standard

2.4.1 Performance Standard

This coating performance standard is based on specifications and requirements which intend to provide a target useful life of 15 years, which is considered to be the time period, from initial application, over which the coating system is intended to remain in "GOOD" condition. The actual useful life will vary, depending on numerous variables including actual conditions encountered in service.

2.4.2 Permanent means of access

It is recommended that this standard is to be applied, to the extent possible, to those portions of permanent means of access provided for inspection, not integral to the vessel structure, such as rails, independent platforms, ladders, etc. Other equivalent methods of providing corrosion protection for the non-integral items may also be used provided they do not impair the performance of the coatings of the surrounding structure. Access arrangements that are integral to the vessel structure, such as increased stiffener depths for walkways, stringers, etc., are to fully comply with this standard.

2.4.3 Other items within ballast tanks

It is also recommended that supports for piping, measuring devices, etc., should be coated in accordance with the non-integral items indicated in [2.4.2].

2.4.4 Basic coating requirements

The requirements for protective coating systems to be applied at ship construction for water ballast tanks meeting the performance standard specified in [2.4.1] are listed in Tab 2.

Coating Manufacturers are to provide a specification of the protective coating system to satisfy the requirements of Tab 2.

The Society will verify the Technical Data Sheet and Statement of Compliance or Type Approval Certificate for the protective coating system.

The shipyard is to apply the protective coating in accordance with the verified Technical Data Sheet and its own verified application procedures.

Table 2 : Basic coating system requirements for the notation COAT-WBT

Item	Requirement	Reference standard
1 - Design of coating system		
a) Selection of the coating system	The selection of the coating system is to be considered by the parties involved with respect to the service conditions and planned maintenance. The following aspects, among other things, should be considered: (i) location of space relative to heated surfaces; (ii) frequency of ballasting and deballasting operations; (iii) required surface conditions; (iv) required surface cleanliness and dryness; (v) supplementary cathodic protections, if any (where coating is supplemented by cathodic protection, the coating is to be compatible with the cathodic protection system). Coating Manufacturers are to have products with documented satisfactory performance records and technical data sheets. The Manufacturers are also to be capable of rendering adequate technical assistance. Performance records, technical data sheets and technical assistance (if given) are to be recorded in the Coating Technical File. Coatings for application underneath sun-heated decks or on bulkheads forming boundaries of heated spaces are to be able to withstand repeated heating and/or cooling without becoming brittle.	
b) Coating type	Epoxy based systems Other coating systems are to have performance according to the test procedure in App 1. A multi-coat system with each coat of contrasting colour is recommended. The top coat is to be of a light colour in order to facilitate in-service inspection.	
c) Coating pre-qualification test	Epoxy based systems tested in a laboratory prior to the date of entry into force of this standard, by a method corresponding to the test procedure in App 1 or equivalent, meeting at least the requirements for rusting and blistering, or which have documented field exposure for 5 years with a final coating condition of not less than "GOOD", may also be accepted. For all other systems, testing according to the procedure in App 1, or equivalent, is required.	
Job specification	There are to be a minimum of two stripe coats and two spray coats, except that the second stripe coat, by way of welded seams only, may be reduced in scope where it is proven that the NDFT can be met by the coats applied in order to avoid unnecessary over thickness. Any reduction in scope of the second stripe coat is to be fully detailed in the Coating Technical File. Stripe coats are to be applied by brush or roller. A roller is to be used for scallops, ratholes, etc. only. Each main coating layer is to be appropriately cured before application of the next coat, in accordance with the coating Manufacturer's recommendations. Surface contaminants such as rust, grease, dust, salt, oil, etc. are to be removed prior to painting with a proper method according to the paint Manufacturer's recommendation. Abrasive inclusions embedded in the coating are to be removed. Job specifications are to include the dry-to-recoat times and walk-on time given by the Manufacturer.	

Item	Requirement	Reference standard
NDFT (nominal total dry film thickness)	NDFT 320 μm with 90/10 rule for epoxy based coatings, other systems to coating Manufacturer's specifications. Maximum total dry film thickness according to Manufacturer's detailed specifications. Care is to be taken to avoid increasing the thickness in an exaggerated way. Wet film thickness is to be regularly checked during application. Thinner is to be limited to those types and quantities recommended by the Manufacturer.	Type of gauge and calibration in accordance with SSPC-PA2
2. Primary surface preparation		
a) Blasting and profile	Sa 2½, with profiles between 30-75 μm Blasting is not to be carried out when: (i) the relative humidity is above 85%; or (ii) the surface temperature of steel is less than 3°C above the dew point. Checking of the steel surface cleanliness and roughness profile is to be carried out at the end of the surface preparation and before the application of the primer, in accordance with the Manufacturer's recommendations.	ISO 8501-1 ISO 8503-1/3
b) Water soluble salt limit equivalent to NaCl	≤ 50 mg/ m² of sodium chloride (NaCl)	ISO 8502-6 Extraction Conductivity measured in accordance with ISO 8502-9
c) Shop primer	Zinc containing inhibitor free zinc silicate based or equivalent. Compatibility with main coating system is to be confirmed by the coating Manufacturer.	
3. Secondary surface preparation		
a) Steel condition	The steel surface is to be prepared so that the coating selected can achieve an even distribution at the required NDFT and have an adequate adhesion by removing sharp edges, grinding weld beads and removing weld spatter and any other surface contaminant in accordance with ISO 8501-3 grade P2. Edges are to be treated to a rounded radius of minimum 2 mm, or subjected to three pass grinding or at least equivalent process before painting.	ISO 8501-3
b) Surface treatment	Sa 2½ on damaged shop primer and welds. Sa 2 removing at least 70% of intact shop primer which has not passed a pre-qualification certified by test procedures specified in 1.c) of this Table. If the complete coating system comprising epoxy based main coating and shop primer has passed a pre-qualification certified by test procedures specified in 1.c) of this Table, intact shop primer may be retained provided the same epoxy coating system is used. The retained shop primer is to be cleaned by sweep blasting, high-pressure water washing or equivalent method. If a zinc silicate shop primer has passed the pre-qualification test specified in 1.c) of this Table, as part of an epoxy coating system, it may be used in combination with other epoxy coatings certified under the same test, provided that the compatibility has been confirmed by the Manufacturer by the test in accordance with App 1.	ISO 8501-1

Item	Requirement	Reference standard
c) Surface treatment after erection	Butts St 3 or better or Sa 2½ where practicable. Small damage up to 2% of total area: St 3. Contiguous damage over 25 m^2 or over 2% of the total area of the tank, Sa 2½ is to be applied. Coating in overlap to be feathered.	ISO 8501-1
d) Profile requirements	In the case of full or partial blasting 30-75 µm, otherwise as recommended by the coating Manufacturer.	ISO 8501-1/3
e) Dust	Dust quantity rating "1" for dust size class "3", "4" or "5". Lower dust size classes are to be removed if visible on the surface to be coated without magnification.	ISO 8502-3
f) Water soluble salts limit equivalent to NaCl after blasting/grinding	≤ 50 mg/ m^2 of sodium chloride (NaCl)	ISO 8502-6 Extraction Conductivity measured in accordance with ISO 8502-9
g) Oil contamination	No oil contamination.	
4. Miscellaneous		
a) Ventilation	Adequate ventilation is necessary for the proper drying and curing of coating. Ventilation is to be maintained throughout the application process and for a period after application is completed, as recommended by the coating Manufacturer.	
b) Environmental conditions	Coating is to be applied under controlled humidity and surface conditions, in accordance with the Manufacturer's specifications. In addition, coating is not to be applied when: (i) the relative humidity is above 85%; or (ii) the surface temperature is less than 3°C above the dew point.	
c) Testing of coating	Destructive testing is to be avoided. Dry film thickness is to be measured after each coat for quality control purposes and the total dry film thickness is to be confirmed after completion of final coat, using appropriate thickness gauges.	ISO 19840 Annex 3
d) Repair	Any defective areas, e.g. pin-holes, bubbles, voids, etc,. are to be marked up and appropriate repairs effected. All such repairs are to be re-checked and documented.	

2.5 Coating system approval

2.5.1 Results from prequalification tests of the coating system (see 1.c) of Tab 2) are to be documented, and a Statement of Compliance or Type Approval Certificate is to be issued if found satisfactory by a third party, independent of the coating Manufacturer.

2.6 Coating inspection requirements

2.6.1 Inspector qualification

The inspections indicated in the following paragraphs are to be carried out by qualified coating inspectors certified to NACE Level II or FROSIO level Red, or equivalent as verified by the Society.

2.6.2 Records of inspections

Results from the inspections indicated in [2.6.3] are to be recorded by the inspector, made available to the Interested Parties, including the attending Surveyor of the Society. and included in the Coating Technical File (refer to Tab 4 - Example of Daily Log and Tab 5 - Non-conformity Report).

2.6.3 Inspection items

Coating inspectors are to inspect surface preparation and coating application during the coating process by carrying out, as a minimum, those inspection items listed in Tab 3. Emphasis is to be placed on initiation of each stage of surface preparation and coating application, as improper work is extremely difficult to correct later in the coating progress. Representative structural members are to be non-destructively examined for coating thickness. The inspector is to verify that appropriate collective measures have been carried out.

2.7 Verification requirements

2.7.1 Prior to reviewing the Coating Technical File for the particular ship under construction, the Society is to carry out the following:

a) check that the Technical Data Sheet and Statement of Compliance or Type Approval Certificate comply with the requirements of this Section;

b) check that the coating identification on representative containers is consistent with the coating identified in the Technical Data Sheet and Statement of Compliance or Type Approval Certificate;

c) check that the inspector is qualified in accordance with the qualification standards, as indicated in [2.6.1];

d) check that the inspector's reports of surface preparation and the coating's application indicate compliance with the Manufacturer's Technical Data Sheet and Statement of Compliance or Type Approval Certificate; and

e) monitor implementation of the coating inspection requirements.

2.8 Alternative systems

2.8.1 All systems that are not an epoxy based system applied according to Tab 2 are defined as an alternative system.

2.8.2 The requirements of this Section are based on recognised and commonly used coating systems. It is not meant to exclude other, alternative, systems with proven equivalent performance, for example non-epoxy based systems.

2.8.3 Acceptance of alternative systems will be subject to documented evidence that they ensure a corrosion prevention performance at least equivalent to that indicated in this Section.

2.8.4 As a minimum, the documented evidence is to consist of satisfactory performance corresponding to that of a coating system, which conforms to the requirements, indicated in [2.4], a target useful life of 15 years in either actual field exposure for 5 years with final coating condition not less than "GOOD" or laboratory testing. Laboratory test is to be conducted in accordance with the test procedure given in App 1.

Table 3 : Inspection items to be carried out during ship construction

Construction stage	Inspection items
Primary surface preparation	a) The surface temperature of steel, the relative humidity and the dew point are to be measured and recorded before the blasting process starts and at times of sudden changes in weather. b) The surface of steel plates is to be tested for soluble salt and checked for oil, grease and other contamination. c) The cleanliness of the steel surface is to be monitored in the shop primer application process. d) The shop primer material is to be confirmed as meeting the requirements of 2.c of Tab 2.
Thickness	If compatibility with the main coating system has been declared, then the thickness and curing of the zinc silicate shop primer are to be confirmed as conforming to the specified values.
Block assembly	a) After completing construction of the block and before secondary surface preparation starts, a visual inspection for steel surface treatment, including edge treatment, is to be carried out. Any oil, grease or other visible contamination is to be removed. b) After blasting/grinding/cleaning and prior to coating, a visual inspection of the prepared surface is to be carried out. On completion of blasting and cleaning and prior to the application of the first coat of the system, the steel surface is to be tested for levels of remaining soluble salts in at least one location per block. c) The surface temperature, the relative humidity and the dew point are to be monitored and recorded during the coating application and curing. d) Inspection is to be performed of the steps in the coating application process mentioned in Tab 2. e) DFT measurements are to be taken to prove that the coating has been applied to the thickness as specified and outlined in Tab 6.
Erection	a) Visual inspection for steel surface condition, surface preparation and verification of conformance to other requirements in Tab 2 and the agreed specification is to be performed. b) The surface temperature, the relative humidity and the dew point are to be measured and recorded before coating starts and regularly during the coating process. c) Inspection is to be performed of the steps in the coating application process mentioned in Tab 2.

Table 4 : Example of a Daily Log

<table>
<tr><td colspan="5">DAILY LOG</td><td colspan="4">Sheet No:</td></tr>
<tr><td colspan="3">Hull no.:</td><td colspan="3">Tank/Hold no.:</td><td colspan="3">Database:</td></tr>
<tr><td colspan="9">Part of structure:</td></tr>
<tr><td colspan="9">SURFACE PREPARATION</td></tr>
<tr><td colspan="5">Method:</td><td colspan="4">Rounding of edges:</td></tr>
<tr><td colspan="5">Abrasive:</td><td colspan="4">Area (m^2):</td></tr>
<tr><td colspan="5">Surface temperature:</td><td colspan="4">Grain size:</td></tr>
<tr><td colspan="5">Relative humidity (max):</td><td colspan="4">Air temperature:</td></tr>
<tr><td colspan="5">Standard achieved:</td><td colspan="4">Dew point</td></tr>
<tr><td colspan="9">COMMENTS:</td></tr>
<tr><td colspan="3">Job no.:</td><td colspan="2">Date:</td><td colspan="4">Signature:</td></tr>
<tr><td colspan="9">COATING APPLICATION
Method:</td></tr>
<tr><td>Coat no.</td><td>System</td><td>Batch no.</td><td>Date</td><td>Air temp.</td><td>Surface temp.</td><td>RH%</td><td>Dew point</td><td>DFT meas. (1)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">(1) Measured minimum and maximum WFT (Wet Film Thickness) and DFT readings to be attached to Daily Log.</td></tr>
<tr><td colspan="9">COMMENTS:</td></tr>
<tr><td colspan="3">Job no.:</td><td colspan="2">Date:</td><td colspan="4">Signature:</td></tr>
</table>

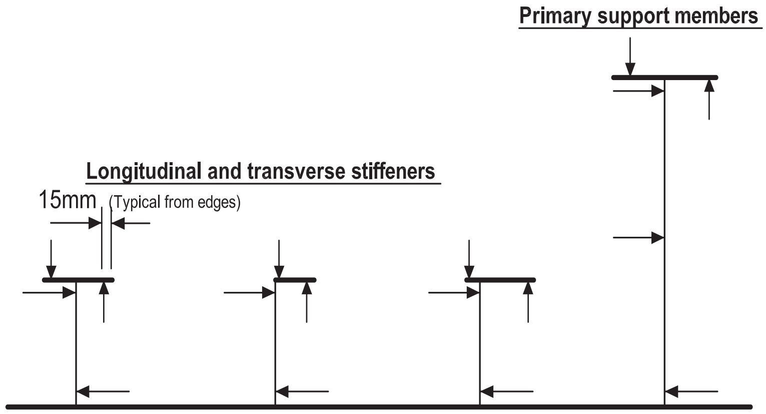
Table 5 : Example of Non-conformity Report

NON-CONFORMITY REPORT		**Sheet No:**
Hull no.:	**Tank/Hold no.:**	**Database:**
Part of structure:		
DESCRIPTION OF THE INSPECTION FINDINGS		
Description of findings		
Reference document (daily log):		
Action taken:		
Job no.:	**Date:**	**Signature:**

Table 6 : Dry Film Thickness measurements

The following verification checkpoints of DFT are to be taken:	
(i)	one gauge reading per 5 m^2 of flat surface areas;
(ii)	one gauge reading at 2 to 3 metre intervals and as close as possible to tank boundaries, but not further than 15 mm from edges of tank boundaries;
(iii)	longitudinal and transverse stiffening members: one set of gauge readings as shown in Fig 1, taken at 2 to 3 metres run and not less than two sets between primary support members;
(iv)	three gauge readings for each set of primary support members and 2 gauge readings for each set of other members as indicated by the arrows in Fig 1;
(v)	for primary support members (girders and transverses) one set of gauge readings for 2 to 3 metres run as shown in Fig 1, but not less than three sets;
(vi)	around openings one gauge reading from each side of the opening;
(vii)	five gauge readings per square metre (m^2) but not less than three gauge readings taken at complex areas (i.e. large brackets of primary support members); and
(viii)	additional spot checks to be taken to verify coating thickness for any area considered necessary by the coating inspector.

Figure 1



Note: Arrows of diagram indicate critical areas and are to be understood to mean indication for both sides.

Table 7 : Documentation to be included in the "Coating Selection, Application and Maintenance Scheme"

1. GENERAL
1.1 Evidence of explicit agreement between Owner, shipyard and paint Manufacturer on the scheme and its contents
1.2 Manufacturer's evidence of product quality and ability to meet the agreed coating requirements
1.3 Evidence of shipyard's and /or its subcontractor's experience in coating application
2. TANKS TO BE COATED
2.1 List of seawater ballast tanks to be coated identifying the coating system for each tank, including colour
2.2 Identification of tanks whose surfaces to be coated are underneath sun-heated decks or are part of bulkheads forming boundaries of heated cargo or heated bunker spaces
2.3 Identification of tanks where a cathodic protection system is foreseen in addition to a coating system
3. COATING SELECTION
3.1. Paint Manufacturer's technical product data sheet for each product (hard coating or equivalent)
3.2 Paint Manufacturer's documentation of satisfactory service performance
3.3 Paint Manufacturer's data on laboratory tests carried out, and related standard adopted, to verify the suitability for the intended product
3.4 Paint Manufacturer declaration that the coating is able to withstand repeated heating (for tanks listed under 2.2 above)
3.5 Paint Manufacturer's declaration of coating compatibility with the cathodic protection system (for tanks listed under 2.3 above)
4. COATING APPLICATION
4.1 Surface preparation procedures and standards, selected in accordance with paint Manufacturer's recommendations and including inspection points and methods
4.2 Procedures for coating application, including inspection points and methods
4.3 Range of humidity, surface temperature and ventilation conditions during and after coating application
4.4 Number of coats and minimum/maximum limits in dry film thickness (DFT) of each coat; DFT measuring method
4.5 Over-coating time at different temperatures
4.6 Criteria agreed upon for inspection and acceptance of surface preparation and coating application. Agreed format for the inspection reports
4.7 Paint Manufacturer's Material Safety Data Sheet (MSDS) for each selected product.
4.8 Owner's, paint Manufacturer's and shipyard's explicit agreement to take all safety precautions to reduce health and other safety risks
5. MAINTENANCE OF THE COATING SYSTEM
5.1 Maintenance scheme for the coating system
5.2 Indications on replacement of the sacrificial anodes and the inspection of coating around anodes (only when the coating is supplemented with cathodic protection)

3 Survey activities

3.1 Review of the scheme for selection and application of coating system

3.1.1 The selection of a coating system on water ballast tanks is to take into consideration several factors affecting corrosion of steel structures, including frequency of ballasting/deballasting, partial or complete filling, temperature of cargo in adjacent cargo tanks, etc. All these factors, separately or in combination, can considerably affect the effectiveness of the corrosion protection system during ship life.

3.1.2 The coating selection is to take into account that:

a) epoxy (or other equivalent hard coating) is only to be used for ballast tanks of new buildings;

b) multi-coat layers of contrasting colour are recommended (the top coat layer is to be of a light colour in order to facilitate in-service inspection).

3.1.3 To comply with the requirements of this Section, the following aspects are to be taken into due account:

a) the contractual coating specifications and the procedures and related working steps for its application as well as the paint Manufacturer's recommendations are to be agreed between the shipyard and Owner taking account of the reference standard and any changes thereto coming from the construction procedures and standards of the shipyard. The above-mentioned aspects will be dealt with during a pre-job meeting, to which the Society is to be invited as an observer;

b) the coating specifications are to be made known to all Interested Parties, including the Society;

c) all work is to be performed by skilled operators in a safe and workmanlike manner, in accordance with the agreed specifications;

d) the coating inspections during the ship's construction are to be performed by qualified coating inspectors, who are to verify that the reference standard agreed between shipyard and Owner is complied with;

e) coating damage, if any, during ship construction is to be properly repaired in order to avoid premature decay and deterioration of the coating system.

3.2 Plan review

3.2.1 The Shipbuilder is to provide the Society with additional drawings of the internal water ballast tank structures showing compliance with the following aspects:

a) internal structures, stiffeners and piping are to be designed to avoid, as far as possible, any entrapped areas not subject to coating application, inspection and maintenance;

b) burrs and sharp edges are to be rounded off, in accordance with the basic coating system requirements (e.g. three pass edge grinding of sharp edges) and any steel defects removed as listed in Tab 2;

c) hollow components which are not accessible are to be sealed off completely and permanently, e.g. by welding them closed and leaving them filled with inert material (plastic foam or similar);

d) if a cathodic protection system is installed, the number and position of sacrificial anodes are to be consistent with the specifications in the agreed scheme for coating selection, application and maintenance;

e) the structural configuration of internal spaces is to be such as to permit easy access with tools for cleaning, drainage, ventilation and drying of the tanks necessary for coating inspection and repair during the ship life.

3.3 Type approval of shop primer

3.3.1 Shop primers applied to steel plates and profiles are to be approved by the Society or another recognised organisation, in accordance with the requirements in Pt D, Ch 5, Sec 3.

3.3.2 The shipyard is to provide the Society with information confirming that all parameters of shop primer application are consistent with the paint Manufacturer's recommendations.

3.4 Inspection and testing

3.4.1 The shipyard is to provide the Society with daily reports containing the results of the inspections carried out by representatives of the shipyard, Owner and paint Manufacturer during surface preparation and coating application.

3.4.2 At any time during construction the attending Surveyor is to be allowed to take samples of the coating material used for coating the ballast tanks, which may be analysed for verifying conformity with agreed coating specifications.

3.5 Surface preparation survey

3.5.1 At any time during construction the attending Surveyor is to be allowed to carry out an inspection of surface preparation (e.g. blasting and grinding profiles) in order to verify on the spot compliance with the requirements given in Tab 2.

This survey may be carried out by the attending Surveyor concurrently with the inspection carried out by the shipyard, Owner or paint Manufacturer Inspectors, or with the survey carried out on the fabricated blocks to check their correspondence to the approved plans, or on any other appropriate occasion.

3.6 Coating application survey

3.6.1 After the completion of coating application in a compartment and before staging has been removed, the attending Surveyor is to be allowed to carry out spot checks of the coating application (e.g. after spray and stripe coats) to verify on the spot that it complies with the requirements given in Tab 2.

This survey may be carried out by the attending Surveyor concurrently with the inspection carried out by the shipyard, Owner or paint Manufacturer Inspectors, or with the survey carried out on the assembled blocks to check their correspondence to the approved plans, or on any other appropriate occasion.

3.6.2 After the staging has been removed, the attending Surveyor is to be allowed to carry out a visual inspection to check that there is no damage caused by mechanical and/or welding work. Any damage found to the coating is to be repaired in accordance with the technical coating specifications and paint Manufacturer's recommendations.

3.6.3 After the repairs have been completed, a final space inspection is to be carried out for acceptance. If the result is satisfactory, the space is to be closed immediately afterwards.

3.7 Final inspection after sea trials

3.7.1 The attending Surveyor is to be allowed to carry out a final inspection of the ballast tanks emptied after sea trials. Should any damage to coating be found, appropriate repairs are to be performed in accordance with the technical coating specifications and paint Manufacturer's recommendations before the ship is delivered. This survey may be concurrent with the final acceptance inspection carried out by shipyard, Owner and paint Manufacturer's Inspectors.

SECTION 11 CREW ACCOMMODATION AND RECREATIONAL FACILITIES ACCORDING TO THE MARINE LABOUR CONVENTION, 2006 (MLCDESIGN)

1 General

1.1 Applications

1.1.1 The additional class notation MLCDESIGN is assigned, in accordance with Pt A, Ch 1, Sec 2, [6.11.14], to ships having crew accommodation and recreational facilities complying with the Marine Labour Convention, 2006 - Title 3 and with the requirements of this Section.

1.2 Documentation to be submitted for approval

1.2.1 Plans

Detailed plans of the on board crew accommodation and recreational facilities are to be submitted to the Society in triplicate for approval. These plans are to indicate the general arrangements and dimensions of:

- Rooms and other accommodation spaces;
- Heating and ventilation;
- Noise and vibration and other ambient factors;
- Sanitary facilities;
- Lighting;
- Hospital accommodation.

1.2.2 Documentation to be put on board

The Owner is to put on board the ship the plans given in [1.2.1], and they are to be available to the Surveyor when a shipboard inspection is carried out.

2 Design requirements

2.1 Basic Standard Requirements to obtain the additional class notation MLCDESIGN

2.1.1 The minimum standards for shipboard accommodation and recreational facilities are set out in paragraphs 6 to 17 of the Marine Labour Convention, 2006 - Title 3 as summarised in Tab 1.

A plan approval and shipboard inspection is to be carried out when the accommodation has been substantially altered and the **MLCDESIGN** additional class notation is to be re-issued.

Table 1 : Basic Standard Requirements with reference to paragraphs 6 to 17 of the Marine Labour Convention, 2006 - Title 3

Accommodation and recreational facilities	Standard
General Insulation	6(a) minimum permitted headroom: 203 cm 6(b) the accommodation is to be adequately insulated 6(c) in ships sleeping rooms are, in general. to be situated above the load line amidships or aft 6(d) there are to be no direct openings into sleeping rooms from cargo and machinery spaces or from galleys, storerooms, drying rooms or communal sanitary areas; that part of a bulkhead separating such places from sleeping rooms and external bulkheads is to be efficiently constructed of steel or other approved substance and to be watertight and gas-tight
Ventilation and heating	7(a) sleeping rooms and mess rooms are to be adequately ventilated 7(b) except for those regularly engaged in temperate climates, ships are to be equipped with air conditioning for seafarer accommodation, for any separate radio room and for any centralised machinery control room 7(c) all sanitary spaces are to have ventilation to the open air, independently of any other part of the accommodation 7(d) an appropriate heating system is to be provided, except in ships engaged exclusively on voyages in tropical climates
Lighting	8) Sleeping rooms and mess rooms are to be lit by natural light and provided with adequate artificial light

Accommodation and recreational facilities	Standard
Sleeping rooms	9(a) In ships, an individual sleeping room is to be provided for each seafarer (exemptions may be granted for ships of less than 3000 gt or special purpose ships) 9(b) separate sleeping rooms are to be provided for men and women 9(d) a separate berth is to be provided for each seafarer in all circumstances 9(e) berth's minimum inside dimensions: 198 cm by 80 cm 9(f) floor area of single berth seafarers' sleeping rooms (reduced areas may be permitted in special circumstances): • 4,5 m^2 (gt<3000) • 5,5 m^2 (3000<gt<10000) • 7 m^2 (gt>10000) 9(k) floor area of sleeping room in ships other than special purpose ships for seafarers who perform the duty of ship officers: • 7,5 m^2 per person (gt<3000) • 8,5 m^2 per person (3000<gt<10000) • 10 m^2 per person (gt>10000) 9(i) floor area of sleeping rooms in special purpose ships for seafarers not performing the duty of ship officers: • 7,5 m^2 rooms accommodating 2 persons • 11,5 m^2 rooms accommodating 3 persons • 14,5 m^2 rooms accommodating 4 persons 9(l) floor area of sleeping rooms in special purpose ships for seafarers performing the duty of ship officers: • 7,5 m^2 per person for junior officers (operational level) • 8,5 m^2 per person for senior officers (management level) 9(n) for each occupant, the furniture is to include a clothes locker (minimum 475 litres) and a drawer (minimum 56 litres) 9(o) each sleeping room is to be provided with a table or desk
Mess rooms	10(a) located apart from sleeping rooms and as close as practicable to the galley (exemptions may be granted for ships of less than 3000 gt)
Sanitary facilities	11(a) separate for men and for women 11(b) easy access from the navigating bridge and the machinery space or near the engine room control centre (exemptions may be granted for ships of less than 3000 gt) 11(c) a minimum of one toilet, one washbasin and one tub or shower or both for every six persons who do not have personal facilities 11(d) one washbasin with hot and cold fresh running water in each sleeping room 11(e) hot and cold fresh running water in all wash places
Hospital	12) Ships carrying 15 or more seafarers and engaged on a voyage of more than three days' duration are to provide separate hospital accommodation to be used exclusively for medical purposes
Laundry facilities	13) Appropriately situated laundry facilities are to be provided
Open space	14) All ships are to have a space or spaces on open deck to which the seafarers can have access when off duty, which are of adequate area having regard to the size of the ship and the number of seafarers on board
Office(s)	15) All ships are to be provided with separate offices or a common ship's office for use by deck and engine departments (exemptions may be granted to ships of less than 3000 gt)
Recreational facilities	16) Ship regularly trading in mosquito-infested ports are be fitted with appropriate devices 17) Appropriate seafarers' recreational facilities, amenities and services, as adapted to meet the special needs of seafarers who must live and work on ships, are to be provided on board for the benefit of all seafarers.

SECTION 12 DIVING SUPPORT SHIPS (DIVINGSUPPORT)

1 General

1.1 Applications

1.1.1 This Section provides the criteria for the assignment of the additional class notation DIVINGSUPPORT in accordance with Pt A, Ch 1, Sec 2, [6.11.15], to ships equipped with a diving system certified by Tasneef according to the "Rules for the classification of underwater units" (or certified by another QSCS Classification Society, see Pt A, Ch 1, Sec 1, [1.2.1]) and complying with the requirements of this Section.

The diving system is intended as the whole system and equipment as indicated in Pt E, Ch 2, Sec 3 of the "Rules for the classification of underwater units".

The additional class notation covers the following issues:

a) the ship's ability to maintain its position during diving operations,

b) the ship's stability during handling of diving equipment (such as lowering of diving bells into the sea),

c) the hull structural arrangements related to the diving system, such as moonpool (launching and recovery well for bell) and lifting appliances,

d) the electrical system to support the diving operations.

1.2 Documents to be submitted

1.2.1 The documents listed in Tab 1 are to be submitted in addition to the documentation requested for the assignment of the additional class notation DYNAPOS AM/AT R and by the "Rules for loading and unloading arrangements and for other lifting appliances on board ships" for cranes and other lifting appliances for diving bell handling systems.

1.3 Position keeping

1.3.1 The ship is to be able to maintain its position safely during diving operations. The ship is to be equipped with a dynamic positioning system complying with the requirements for the additional class notation DYNAPOS AM/AT R or other equivalent arrangement.

1.4 Stability criteria

1.4.1 Intact stability criteria during lifting of diving equipment

The following intact stability criteria are to be complied with:

- $\theta_c \leq 15°$
- $GZ_C \leq 0,6\ GZ_{MAX}$
- $A_1 \geq 0,4\ A_{TOT}$

where:

θ_c : Heeling angle of equilibrium, corresponding to the first intersection between heeling and righting arms (see Fig 1)

GZ_C, GZ_{MAX} : Defined in Fig 1

A_1 : Area, in m·rad, contained between the righting lever and the heeling arm curves, measured from the heeling angle θ_c to the heeling angle equal to the lesser of:

- heeling angle θ_R of loss of stability, corresponding to the second intersection between heeling and righting arms (see Fig 1)
- heeling angle θ_F, corresponding to flooding of unprotected openings as defined in Sec 11, [2.1.4] (see Fig 1)

A_{TOT} : Total area, in m rad, below the righting lever curve.

In the above formula, the heeling arm, corresponding to equipment lifting, is to be obtained, in m, from the following formula:

$b = (P_d - Z_z) / \Delta$

where:

P : Equipment lifting mass, in t

d : Transverse distance, in m, from diving equipment to the longitudinal plane (see Fig 1)

Z : Mass, in t, of ballast used to right the ship, if applicable (see Fig 1)

z : Transverse distance, in m, of the centre of gravity of Z to the longitudinal plane (see Fig 1)

Δ : Displacement, in t, in the loading condition considered.

The above check is to be carried out considering the most unfavourable situations of equipment lifting combined with the lesser initial metacentric height GM, corrected according to the requirements in Pt B, Ch 3, Sec 2, [4].

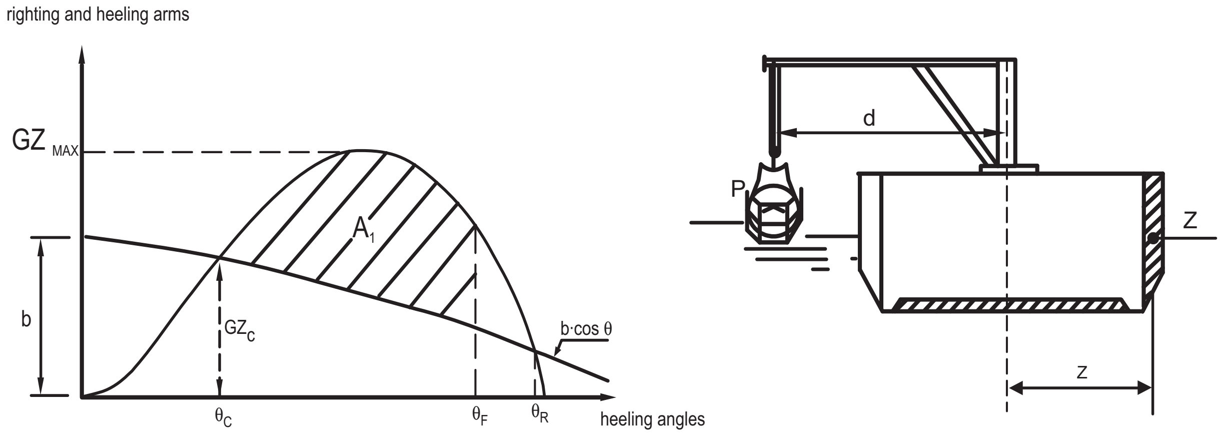
The residual freeboard of the ship during lifting operations in the most unfavourable stability condition is to be not less than 0,30 m. However, the heeling of the unit is not to produce in the lifting devices higher loads than those envisaged by the Manufacturer, generally expected to be 5° in the boom plane and 2° transversally in the case of a crane.

The vertical position of the centre of gravity of diving equipment is to be assumed in correspondence with the suspension point.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document
1	I	General arrangement of the diving system
2	A	Hull structures related to the arrangement of the diving system
3	A	Electrical load analysis of main and emergency source, showing diving system related loads
4	I	Plans showing electrical equipment arrangement
5	A	Single line diagrams of communication systems
(1) A = to be submitted for approval, in quadruplicate I = to be submitted for information, in duplicate		

Figure 1 : Diving equipment lifting



1.5 Hull structural arrangements related to the diving system

1.5.1 General

The hull structures related to the arrangement of the diving system on the ship are to be designed with adequate strength and stiffness to sustain the loads induced by the system during rest and operation, in accordance with the general load and strength criteria in Pt B, Ch 7, App 1.

Pedestals and foundations also concern the ship's hull and are to comply with the above structural strength requirements.

1.5.2 Lifting appliances

Cranes and other lifting appliances for diving bell handling systems are to be certified according to the Tasneef "Rules for loading and unloading arrangements and for other lifting appliances on board ships", as far as applicable.

1.6 Arrangement and installation of the diving system

1.6.1 General

The diving system is not to be located in spaces containing other machinery or in spaces where explosive gas-air mixtures may be present.

1.7 Electrical systems

1.7.1 Essential services

In addition to the primary and secondary essential services defined in Part C, Chapter 2, those services that need to be in continuous operation to:

- sustain the safety, health and environment in a hyperbaric environment
- monitor the divers by the crew
- support divers in the water, in a bell, in the decompression chambers are to be considered essential.

1.7.2 Emergency services

In addition to the emergency services defined in Part C, Chapter 2, those services that are essential for safety in an emergency condition are to be considered emergency services as well.

Examples of these services include:

a) condition monitoring of emergency batteries

b) launch and recovery system

c) diving system emergency lighting

d) diving system communication systems

e) diving system life support systems including environmental monitoring equipment

f) diving system heating systems

g) alarm systems for the above services.

1.7.3 Main source and emergency source

The main source is to be capable of maintaining the essential services mentioned above for the period required to safely terminate the diving operation, including time for decompression of the divers.

The electrical installations essential to the safe completion of the mission are to be supplied from both main and emergency sources of electrical power.

The emergency source of electrical power is to be capable of supplying all connected loads and in particular the emergency users mentioned above, for the duration specified hereafter:

a) all services supporting divers in the water, for at least 20 minutes (minimum time required to ensure that the divers are safely recovered in the bell or brought to the surface),

b) all services supporting divers in a bell, for at least 24 hours (minimum time required to ensure that the divers are safely recovered in the decompression chambers or brought to the surface),

c) all services supporting divers in the decompression chambers, at least for the required life-support time,

unless the diving system is provided with an emergency source complying with the above.

1.7.4 Distribution systems

Only insulated (IT) electrical distribution systems are permitted to supply a diving system. Being insulated, they are to be provided with a device capable of automatic insulation monitoring and, in the case of insulation failure, actuating switch-off and giving an alarm.

Alarm only may be used if a sudden switch-off of the equipment may cause danger to the divers.

Systems using double insulated apparatus or earth fault circuit-breakers will be considered on a case-by-case basis.

It is to be possible to disconnect power from each chamber or bell separately.

When the main power to the diving system is supplied via a distribution board, this board is to be supplied by two separate feeders from different sections of the main switchboard.

When the emergency power to the diving system is supplied by the ship, the supply is to be from the ship's emergency switchboard.

1.7.5 Installation

Tensile loads are not to be applied to electrical cables or wiring.

1.7.6 Communication systems

A communication system is to be arranged for direct two-way communication between the ship's control position and the following as applicable:

- diver in water,
- bell
- chamber (each compartment)
- diving system
- diving system handling position and emergency control station
- dynamic positioning room, navigation bridge.

An emergency means of communication between the control position and the diving system is to be available.

For diving bells, this may be a self-contained, through water communication system.

For diving bells, this may be a self-contained, through water communication system.

When means (e.g. TV) are arranged for visual observation of the divers in the bells and in the chamber compartments (or in general the persons in the diving system), a suitable connection to the relevant ship's control position is to be provided.

Means are to be available in the ship's control position to record communications with the diving system.

1.7.7 Instrumentation

Indication and operation of all essential life support conditions to and from the diving system are to be arranged at the appropriate control position.

SECTION 13 HELICOPTER FACILITIES (HELIDECK)

1 General

1.1 Application

1.1.1 This Section provides the criteria for the assignment of the additional class notations HELIDECK and HELIDECK-H, in accordance with Pt A, Ch 1, Sec 2, [6.11.17], to ships fitted with helicopter facilities (i.e. platforms specifically built for the landing of helicopters or areas of open decks intended for the same purpose)..

1.1.2 The requirements set out in this Section are applied by the Society for the purposes of the class notations in [1.1.1]. Compliance with these requirements does not absolve the Interested Parties from obligations regarding different and/or more stringent regulations issued by the flag Administration, international organisations or other concerned Parties, if applicable.

1.1.3 Notwithstanding the requirements of this Section, the notation HELIDECK may also be assigned to ships fitted with helicopter facilities in compliance with relevant national or international regulations. In this case, a specific annotation concerning the applied regulations will be introduced in the Certificate of Classification.

1.2 Documents to be submitted

1.2.1 The documents listed in Tab 1 are to be submitted to the Society.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document **(2)**
1	I	General arrangement plan
2	I	Main characteristics of helicopter intended to use the helideck (main dimensions and weight)
3	A	General plan showing the markings to be fitted on the helideck
4	A	Structural plans of the helideck also showing the connection of the helideck with the unit's hull
5	A	Diagram of the fuel supply system
6	A	Structural fire protection, showing the purpose of the various spaces, adjacent helideck & helideck facilities and the fire rating of relevant bulkheads and decks
7	A	Natural and mechanical ventilation systems of helideck facilities (including ventilation systems serving hazardous spaces) showing: • position of vent inlets and outlets; • penetrations on "A" class divisions; • location of dampers; • means of closing; • arrangements of air conditioning rooms; • location of fan controls; • air changes per hour (where requirements for air changes per hour are set)
8	A	Automatic fire detection systems

(1) A : to be submitted for approval, in four copies
I : to be submitted for information, in duplicate.

(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification, such as:
- structural scantling
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems

All or part of the information may be provided, instead of on the above plans, in suitable operating manuals or in specifications of the systems.

No.	I/A **(1)**	Document **(2)**
9	A	Fire pumps and fire main including pump head and capacity, hydrant and hose locations
10	A	Arrangement of fixed fire-extinguishing systems
11	A	Fire-fighting equipment and firemen's outfits (or fire control plans)
12	A	Electrical diagram of the fixed gas fire-extinguishing systems
13	A	Plan of hazardous areas relevant to hangar and refuelling installations
14	A	Documents giving details of types of cables and safety characteristics of the equipment installed in the hazardous areas mentioned in 13 above

(1) A : to be submitted for approval, in four copies
I : to be submitted for information, in duplicate.
(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification, such as:
- structural scantling
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems

All or part of the information may be provided, instead of on the above plans, in suitable operating manuals or in specifications of the systems.

2 Helideck lay-out

2.1 General

2.1.1 The construction of the helidecks is to be of steel or other equivalent metallic materials, i.e. any non-combustible metallic material which, by itself or due to insulation provided (e.g. aluminium alloy with appropriate insulation), has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (see Note 1). Where the Society permits aluminium or other low melting point metal construction, items [4.2.1] a) to c) are also to be taken into account.

Note 1: Refer to the "International Code for Application of Fire Test Procedures" (FTP Code), as adopted by the Maritime Safety Committee of IMO by Resolution MSC.61 (67), as may be amended by IMO.

2.2 Definitions

2.2.1

a) "Helicopter landing area" means an area on a ship designed for emergency landing of helicopters.

b) "Diameter (d)" means the overall length of the helicopter with the rotors turning. The maximum value of "d" will depend on the type and size of the helicopter. This is to be agreed by the Society taking into account the particulars of the ship and its area of operation.

2.3 Landing area

2.3.1 Positioning of landing area

Helicopter landing areas are to be located on a weather deck or on a platform permanently connected to the hull structure. The landing areas are to consist of an outer manoeuvring zone and a clear zone. Whenever possible, the clear zone is to be close to the ship's side.

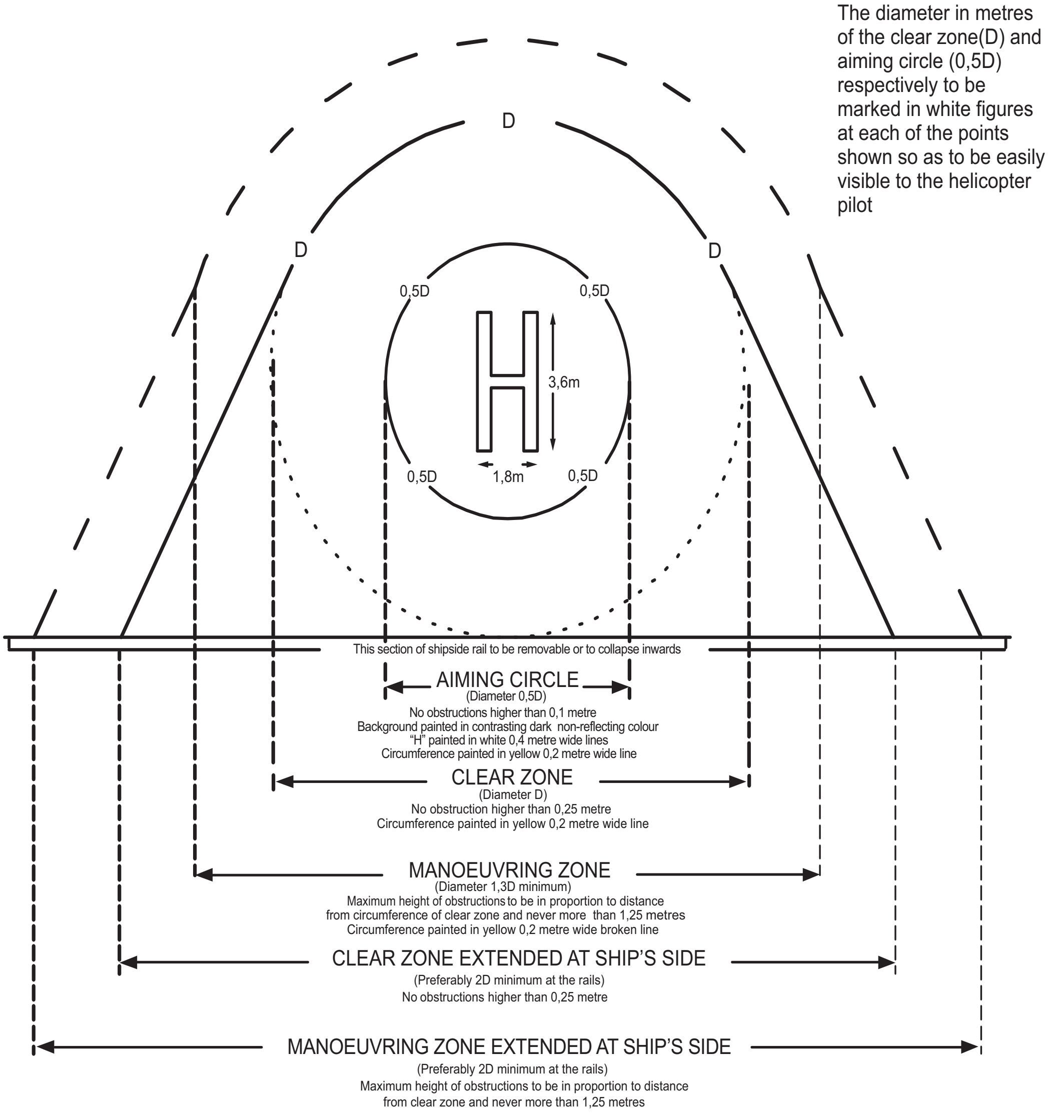
2.3.2 Landing area at ship's side

The landing area is to be as large as possible and set out to provide safe access for helicopters from the ship's side. Due account must be taken of possible helicopter slippage and wind and ship movement. Where the boundary of the clear zone is close to or in line with the ship's side, and where the height of fixed obstructions so permits (see item [2.3.8]), helicopter safety is to be improved by extending the clear and manoeuvring zones to the ship's side symmetrically, thereby widening the approach to the landing area (see Fig 1).

2.3.3 Landing area without unobstructed access from ship's side

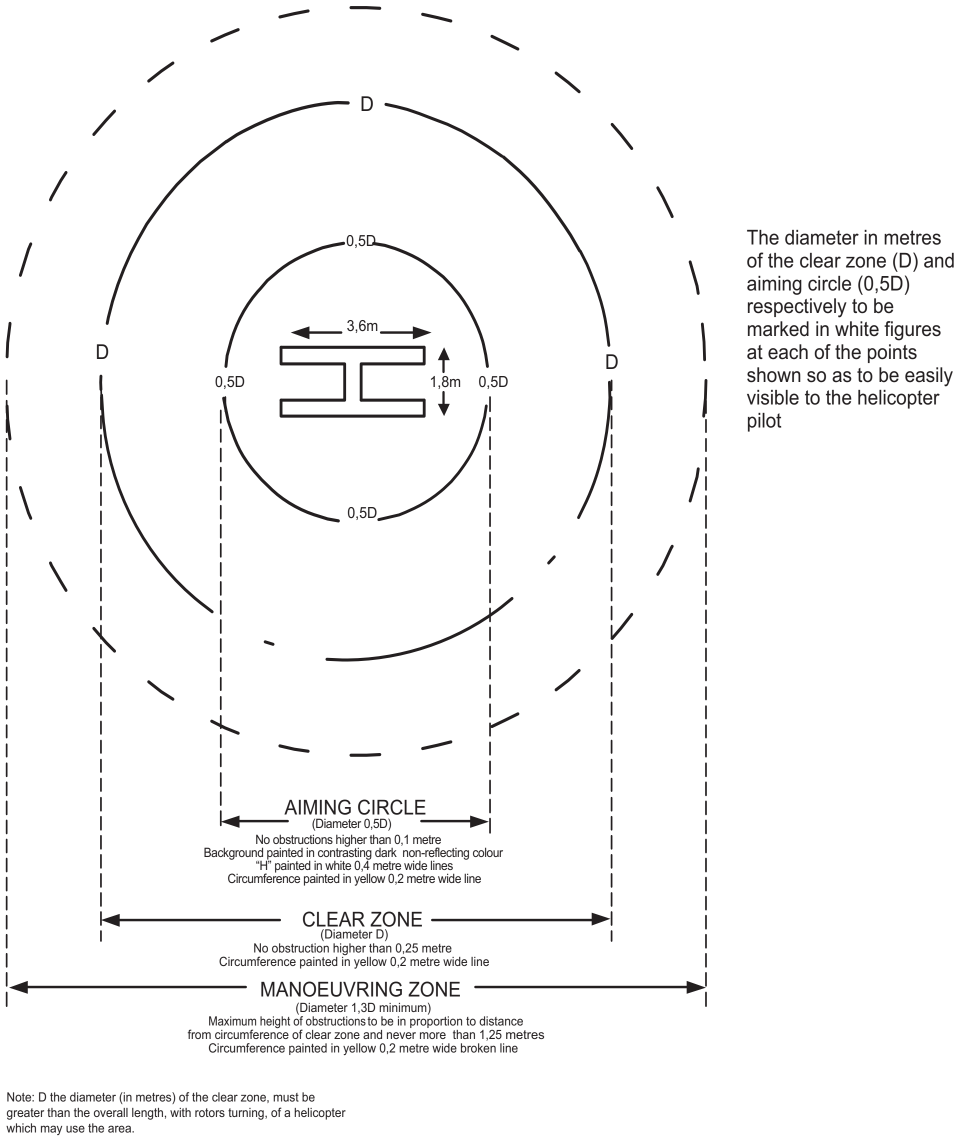
Where it is not possible to provide an operating area with clear access from the ship's side, the landing area is be set out as shown in Fig 2 and, if practicable, placed on the ship's centreline.

Figure 1 : Landing area at the ship's side



Note: D the diameter (in metres) of the clear zone, must be greater than the overall length, with rotors turning, of a helicopter which may use the area.

Figure 2 : Landing area without unobstructed access from ship's side



2.3.4 Dimension of the landing area

In establishing a landing area, it is essential to ensure a safe correlation between:

- the dimensions of the aiming circle, clear zone and manoeuvring zone and the maximum permitted height of obstructions in these zones; and
- the sizes of helicopters expected to use the facility.

The dimensions of the landing area are to be in proportion to the diameter of the clear zone, as illustrated in Fig 1 and Fig 2 (see [2.3.6]).

2.3.5 Aiming circle (touchdown zone)

The aiming circle is an area concentric to the centre of the clear zone and has a diameter half that of the clear zone itself. The circle is to accommodate with safety the landing gear of helicopters for which it is intended and, if possible, be completely obstruction-free. If there are unavoidable obstructions, they are to have rounded edges capable of being traversed without damaging the landing gear of a helicopter, and are to be no higher than 0,1 m.

The aiming circle is to be completely covered with a matt anti-slip surface painted in a dark non-reflecting colour which contrasts with the other deck surfaces. Its circumference is to be marked with a yellow line 0,2 m wide, with the diameter in metres of the aiming circle clearly indicated in white figures at four points in the circumference line as shown in Fig 1 and Fig 2.

The letter 'H' is to be painted at the centre of the aiming circle in 0,4 m wide white lines forming a letter of dimensions 3,6 x 1,8 m.

2.3.6 Clear zone

The diameter of the clear zone will depend upon the available landing area. The clear zone is however to be as large as practicable recognizing that its diameter D is to be greater than the overall length, with rotors turning, of a helicopter able to use the landing area (d). Where the landing area is at the ship's side safe helicopter access will be enhanced by widening, where possible, the boundaries of the obstacle free clear zone at the ship's side to a dimension of at least 1,5D (see Fig 1).

The circumference of the clear zone is to be marked by a yellow line of 0,2 m width, with the diameter D in metres indicated in white figures at points in the circumference line as shown in Fig 1 and Fig 2.

There are to be no fixed obstructions in the clear zone higher than 0,25 m.

2.3.7 Manoeuvring zone

The maneuvering zone of the landing area extends the area in which a helicopter may maneuver with safety by enlarging, to a diameter of at least 1,3D, the area over which the rotors of the helicopter may overhang without danger from high obstructions. When the landing area is at the ship's side, safe helicopter access will be enhanced by widening, where possible, the boundaries of the obstruction-free maneuvering zone at the ship's side to a dimension of at least 2D (see Fig 1).

If it is impossible to remove all obstructions from the manoeuvring zone, a graduated increase in the permitted height of obstructions, from 0,25 m at the circumference of the clear zone to a maximum of 1,25 m at the circumference of the manoeuvring zone, is acceptable. However, such height above 0,25 m is not to exceed a ratio of one to two in relation to the horizontal distance of the obstruction from the edge of the clear zone (see Fig 3). So, for example, an obstruction of 1 m in height (0,75 m more than the maximum obstruction height in the clear zone) is to be at least 1,5 m outside the circumference of the clear zone. All obstructions in the manoeuvring zone are to be clearly marked in contrasting colours.

To assist the helicopter pilot in his positioning, the circumference of the manoeuvring zone is to be indicated by a broken yellow line of 0,2 m width (see Fig 1 and Fig 2).

2.3.8 Use of landing area for other purposes

It is considered that helicopter landing areas may be used for other purposes in normal circumstances. In the event of need, it is to be possible to clear this area readily.

2.3.9 Night operations: Lighting

The following general remarks apply in all cases:

a) lighting is to be arranged so as to illuminate the operating area and is not to be directed towards the helicopter; and

b) a wind pennant or flag is to be illuminated.

For a helideck located on an ad hoc platform, a safety net is to be provided at the sides of the platform. The requirements of this item [2.3.9] may be not met if the position and arrangement of the helicopter platform facilities are such that, in the opinion of the Society, they provide an equivalent standard of safety.

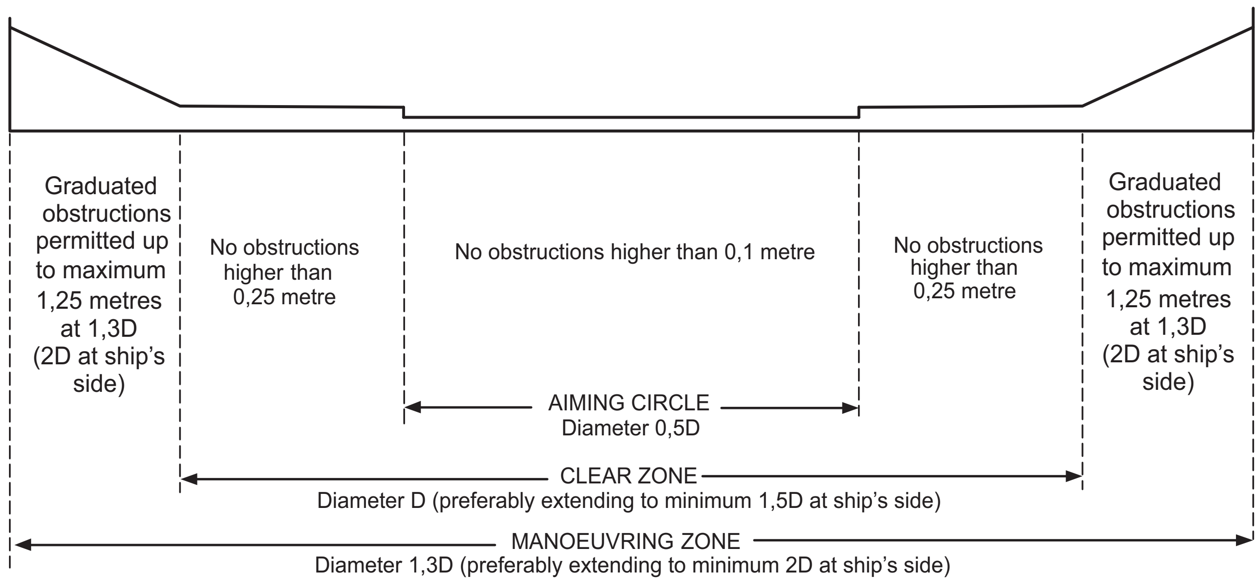
2.3.10 Drainage system

Gutter-ways of adequate height and a drainage system are to be provided on the periphery of the helideck.

Drainage facilities are to be constructed of steel, lead directly overboard independent of any other system and are to be designed so that drainage does not fall onto any part of the ship.

The requirements of this item [2.3.10] may be not met if the position and arrangement of the helicopter facilities are such that, in the opinion of the Society, they provide an equivalent standard of safety.

Figure 3 : Landing area - permitted height of obstructions (elevation)



3 Structural design and scantling

3.1 General and symbols

3.1.1 General

Local deck strengthening is to be fitted at the connection of diagonals and pillars supporting the platform where an ad hoc platform is fitted for the helideck.

3.1.2 Symbols

W_H : Maximum weight of the helicopter, in t

g : Gravity acceleration, in m/s^2

Ry : Minimum yield stress, in N/mm^2, of the material, to be taken equal to 235/k N/mm^2, unless otherwise specified

k : material factor for steel, defined in Pt B, Ch 4, Sec 1, [2.3].

3.2 Design loads

3.2.1 Landing area located on a weather deck

The following loads are to be considered for the scantlings of the helicopter deck:

- landing load defined in [3.4],
- garage load, if any, defined in [3.5],
- loads due to ship accelerations and wind defined in [3.6].

3.2.2 Landing area located on a platform

The loads defined in [3.2.1], and in addition the sea pressure defined in [3.3], are to be considered for the scantlings of the helicopter deck.

3.2.3 Helicopter having landing devices other than wheels

In the case of a deck or a platform intended for the landing of helicopters having landing devices other than wheels (e.g. skates), the landing load, the emergency landing load and the garage load, if any, will be examined by the Society on a case-by-case basis.

3.3 Sea pressure

3.3.1 The sea pressure acting on a landing platform is to be obtained according to Pt B, Ch 5, Sec 5, [2.1.2].

3.4 Landing load

3.4.1 The landing load transmitted through one tyre to the deck or the platform is to be obtained, in kN, from the following formula:

$F_{CR} = 0{,}75 g W_H$

3.4.2 Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are quarters, the bridge, control room or other normally manned service spaces, the value of the landing load defined in [3.4.1] is to be multiplied by 1,15.

3.5 Garage load

3.5.1 Where a garage zone is fitted in addition to the landing area, the still water and inertial forces transmitted through the tyres to the deck or the platform in the garage zone are to be obtained, in kN, as specified in Pt B, Ch 5, Sec 6, [6.1.2], where M is to be taken equal to 0,5 WH.

3.6 Forces due to ship accelerations and wind

3.6.1 The still water and inertial forces applied to the deck or the platform are to be determined on the basis of the forces obtained, in kN, as specified in Tab 2.

3.7 Net scantling

3.7.1 As specified in Pt B, Ch 4, Sec 2, [1], all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Pt B, Ch 4, Sec 2, [1].

3.8 Plating

3.8.1 Load model for landing area located on a weather deck

The following loads transmitted by tyre prints are to be considered:

- landing load, as defined in [3.4],
- garage load, if any, as defined in [3.5].

3.8.2 Load model for landing area located on a platform

The following loads are to be considered independently:

- sea pressure, as defined in [3.3],
- loads transmitted by tyre prints,
- landing load, as defined in [3.4],
- garage load, if any, as defined in [3.5].

3.8.3 Plating subjected to sea pressure

The net thickness of the landing area plating subjected to sea pressure is to be not less than that obtained from the formulae in Pt B, Ch 7, Sec 1, [3].

3.8.4 Plating subjected to landing load or garage load

The net thickness of the landing area plating subjected to landing load or garage load, if any, transmitted by tyre prints, is to be not less than that obtained from the formulae in Pt B, Ch 7, Sec 1, [4.3], considering the wheeled load as being calculated according to [3.8.1] or [3.8.2], as applicable.

Where the print area is not specified by the Designer, a 300x300 mm print area is to be taken into account.

Table 2 : Still water and inertial forces

Ship condition	Load case	Still water force F_S and inertial force F_W, in kN
Still water condition		$F_S = (W_H + W_P)g$
Upright condition	"a"	No inertial force
	"b"	$F_{W,X} = (W_H + W_F)\ a_{X1} + 1,2\ A_{HX}$ in x direction $F_{W,Z} = (W_H + W_P)\ a_{Z1}$ in z direction
Inclined condition (negative roll angle)	"c"	$F_{W,Y} = C_{FA}(W_H + W_P)\ a_{Y2} + 1,2\ A_{HY}$ in y direction
	"d"	$F_{W,Z} = C_{FA}(W_H + W_P)\ a_{Z2}$ in z direction

Note 1:

- W_P : structural weight of the platform, in t, to be evenly distributed, and to be taken not less than the value obtained from the following formula:
  $W_P = 0,2\ A_H$
- A_H : area, in m², to be obtained projecting on A horizontal plane parallel to the summer load waterline the entire landing area considering also possible helideck supporting structures outside the landing area
- a_{x1}, a_{z1} : accelerations, in m/s², determined at the helicopter centre of gravity for the upright ship condition, and defined in Ch 5, Sec 3, [3.4]
- a_{Y2}, a_{Z2} : accelerations, in m/s², determined at the helicopter centre of gravity for the inclined ship condition, and defined in Ch 5, Sec 3, [3.4]
- A_{HX} : area, in m², to be obtained projecting on a transversal plane perpendicular to the summer load waterline the helideck supporting structures (including the helideck platform)
- A_{HY} : area, in m², to be obtained projecting on a longitudinal plane parallel to the centreline plane of the ship the helideck supporting structures (including the helideck platform)
- C_{FA} : Combination factor, to be taken equal to:
  - C_{FA} = 0,7 for load case "c"
  - C_{FA} = 1,0 for load case "d"

3.9 Ordinary stiffeners

3.9.1 Load model for landing area located on a weather deck

The following loads are to be considered independently:

- landing load defined in [3.4],
- garage load, if any, defined in [3.5],
- loads due to ship accelerations and wind defined in [3.6].

3.9.2 Load model for landing area located on a platform

The following loads are to be considered independently:

- sea pressure, as defined in [3.3],
- loads transmitted by tyre prints,
- landing load defined in [3.4],
- garage load, if any, as defined in [3.5],
- loads due to ship accelerations and wind defined in [3.6].

3.9.3 Normal and shear stresses

Normal and shear stresses induced by loads and pressures in an ordinary stiffener are to be obtained according to:

- Pt B, Ch 7, Sec 2, [3.4] for an ordinary stiffener subjected to sea pressure,
- Pt B, Ch 7, Sec 2, [3.5] for an ordinary stiffener subjected to loads transmitted by tyre prints.

3.9.4 Checking criteria

It is to be checked that the normal stress σ and the shear stress τ calculated according to [3.9.3], are in compliance with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0,5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

where:

- γ_m : partial safety factor covering uncertainties on the material, to be taken equal to 1,02
- γ_R : partial safety factor covering uncertainties on the resistance:
  - γ_R = 1,3 for landing area located above accommodation spaces,
  - γ_R = 1,05 for landing area located outside a zone covering accommodation spaces,
  - γ_R = 1,0 for emergency condition.

3.10 Primary supporting members

3.10.1 Load model for landing area located on a weather deck

The following loads are to be considered independently:

- loads transmitted by tyre prints,
- landing load defined in [3.4],

- garage load, if any, defined in [3.5],
- loads due to ship accelerations and wind defined in [3.6].

3.10.2 Load model for landing area located on a platform

The following loads are to be considered independently:

- sea pressure, as defined in [3.3],
- loads transmitted by tyre prints,
- landing load defined in [3.4],
- garage load, if any, defined in [3.5],
- loads due to ship accelerations and wind defined in [3.6].

3.10.3 Normal and shear stresses

Normal and shear stresses induced by loads and pressures in a primary supporting member are to be obtained according to Pt B, Ch 7, App 1, [5], considering:

- $\sigma = \max(\sigma_1, \sigma_2)$ and $\tau = \tau_{12}$, for analyses based on finite element models,
- $\sigma = \sigma_1$ and $\tau = \tau_{12}$, for analyses based on beam models.

3.10.4 Checking criteria

It is to be checked that the normal stress σ and the shear stress τ calculated according to [3.9.3], are in compliance with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0,5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

where:

γ_m : partial safety factor covering uncertainties on the material, to be taken equal to 1,02

γ_R : partial safety factor covering uncertainties on the resistance:

- γ_R = 1,3 for landing area located above accommodation spaces,
- γ_R = 1,05 for landing area located outside a zone covering accommodation spaces,
- γ_R = 1,0 for emergency condition.

4 Specific requirements for the assignment of the Helideck-H notation

4.1 Refuelling and hangar facilities

4.1.1 Storage of fuel

a) A designated area is to be provided for the storage of fuel tanks which is to be:
   - as remote as is practicable from accommodation spaces, escape routes and embarkation stations; and
   - isolated from areas containing a source of vapour ignition.

b) The fuel storage area is to be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

c) "NO SMOKING" signs are to be displayed at appropriate locations.

d) Tanks and associated equipment are to be protected against physical damage and from a fire in an adjacent space or area.

e) Where portable fuel storage tanks are used, special attention is to be given to:
   - design of the tank for its intended purpose;
   - mounting and securing arrangements;
   - electric bonding; and;
   - inspection procedures.

f) Storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fuelling system is installed, equivalent closing arrangements are to be provided to isolate the fuel source.

g) The fuel pumping unit is to be connected to one tank at a time. The piping between the tank and the pumping unit is to be of steel or equivalent material, as short as possible, and protected against damage.

h) Electrical fuel pumping units and associated control equipment are to be of a type suitable for the location and potential hazards.

i) Fuel pumping units are to incorporate a device which will prevent overpressurisation of the delivery or filling hose.

j) Equipment used in refuelling operations is to be electrically bonded.

k) Electrical equipment and wiring in an enclosed hangar or enclosed spaces containing refuelling installations are to comply with the following:
   1) electrical equipment and wiring are to be of a type suitable for use in an explosive petrol and air mixture (see Note 1);
   2) electrical equipment and wiring, if installed in an exhaust ventilation duct, are to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition; and
   3) other equipment which may constitute a source of ignition of flammable vapours is not permitted.

Note 1: Refer to the recommendations of the International Electrotechnical Commission, in particular publication 60079.

4.2 Fire protection

4.2.1 Fire integrity of bulkheads and decks

a) If the Society permits aluminium or other low melting point metal construction that is not made equivalent to steel, the following provisions in [4.2.2] and [4.2.3], as pertinent, are to be satisfied.

b) If the platform is cantilevered over the side of the ship, after each fire on the ship or on the platform, the latter is to undergo a structural analysis to determine its suitability for further use; and

c) if the platform is located above the ship's deckhouse or similar structure, the following conditions are to be satisfied:

   1) the deckhouse top and bulkheads under the platform are to have no openings;

   2) windows under the platform are to be provided with steel shutters; and

   3) after each fire on the platform or in close proximity, the platform is to undergo a structural analysis to determine its suitability for further use.

d) If the helideck forms the deckhead of a deckhouse or superstructure, it is to be insulated to "A-60" class standard.

e) Hangar, refuelling and maintenance facilities are to be treated as category 'A' machinery spaces with regard to structural fire protection requirements. For the determination of the structural fire protection of these spaces with respect to adjacent spaces, SOLAS regulations II-2/9.2.2.3, 9.2.2.4, 9.2.3.3 or 9.2.4.2 apply on the basis of the type of ship under consideration (i.e. passenger ship, cargo ship or tanker).

4.2.2 Ventilation

a) Enclosed hangar facilities or enclosed spaces containing refuelling installations are to be provided with mechanical ventilation complying with these requirements.

b) The system is to be capable of:

- providing 6 air changes per hour;
- preventing air stratification and the formation of air pockets;
- being controlled from a position outside the spaces served.

c) Ventilation fans are to be of non-sparking type and are normally to be run continuously whenever helicopters are on board. Where this is impracticable, they are to be operated for a limited period daily as weather permits and in any case for a reasonable period prior to discharge, after which period the hangar facilities or enclosed spaces containing refuelling installations are to be proved gas-free. At least one portable combustible gas detecting instrument is to be carried for this purpose.

d) Means are to be provided on the navigation bridge to indicate any loss of the required ventilating capacity.

e) Ventilation ducts, including dampers, are to be made of steel and are to be capable of being effectively sealed for each space served.

f) Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation ducts and openings from outside of the space served in case of fire, taking into account the weather and sea conditions.

4.2.3 Fire-fighting appliances and rescue equipment

The following fire-fighting appliances are to be provided and stored in close proximity to and near the means of access to the helideck:

a) at least two dry powder extinguishers having a total capacity of not less than 45 kg;

b) carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent;

c) a suitable foam application system consisting of monitors or foam making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system is to be capable of delivering a discharge rate as required in Tab 3 for at least five minutes;

d) a principal agent suitable for use with salt water and conforming to performance standards not inferior to those acceptable to the Society (see Note 1):

e) at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck;

f) two sets of fire-fighter's outfits, additional to those required elsewhere; and

g) at least the following equipment, stored in a manner that provides for immediate use and protection from the elements:

   - 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; and
   - harness knife complete with sheath.

Note 1: Refer to the International Civil Aviation Organization Airport Services Manual, Part 1 - Rescue and Fire Fighting, Chapter 8-Extinguishing Agent Characteristics, Paragraph 8.1.5 - Foam Specifications Table 8-1, Level 'B'.

4.2.4 Fire-fighting appliances for hangars, refuelling and maintenance facilities

Hangars, refuelling and maintenance facilities are to be provided with:

a) a fixed fire-extinguishing system complying with Chapter 5, 6 or 7 of the Fire Safety System Code;

b) a fire detection and alarm system complying with Chapter 9 of the Fire Safety System Code;

c) one portable foam applicator unit of capacity of 20 l with a spare charge;

d) foam-type fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed onto any part of the space;

e) a sufficient number of portable foam extinguishers or equivalent, which are to be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space.

4.2.5 Means of escape

A helideck is to be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel. These are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

5 Specific requirements for the assignment of the Helideck notation

5.1 Fire protection

5.1.1 The requirements of items a) to d) of [4.2.1] apply.

5.2 Fire-fighting appliances and rescue equipment

5.2.1 Fire-fighting equipment fitted on board

Fire-fighting equipment fitted on board may be used, to the Society's satisfaction. This equipment is to be made readily available in close proximity to the landing or winching areas during helicopter operations.

5.3 Means of escape

5.3.1 The requirements of item [4.2.5] apply.

Table 3 : Foam discharge rates

Category	Helicopter overall length	Foam solution discharge rate
H1	Less than 15 m	250
H2	At least 15 m but less than 24 m	500
H3	At least 24 m but less than 35 m	800

APPENDIX 1 TEST PROCEDURES FOR COATING QUALIFICATION FOR WATER BALLAST TANKS OF ALL TYPES OF SHIPS

1 Scope

1.1

1.1.1 This Appendix provides details of the test procedures referred to in Sec 10, Tab 2 and Sec 10, [2.8.4].

2 Definitions

2.1

2.1.1 Coating specification: means the specification of coating systems, which includes the type of coating system, steel preparation, surface preparation, surface cleanliness, environmental conditions, application procedure, acceptance criteria and inspection.

3 Testing

3.1

3.1.1 Coating specification is to be verified by the following tests. The tests are to be carried out according to the procedures described in [4] - Test on simulated ballast tank conditions (see Fig 2) and [5] - Condensation chamber tests (see Fig 3).

3.1.2 Protective coatings for dedicated seawater ballast tanks are to comply with the requirements given in [4] and [5].

3.1.3 Protective coatings for double-side spaces of bulk carriers of 150 m in length and upwards, other than dedicated seawater ballast tanks, are to comply with the requirements given in [5].

4 Test on simulated ballast tank conditions

4.1 Test condition

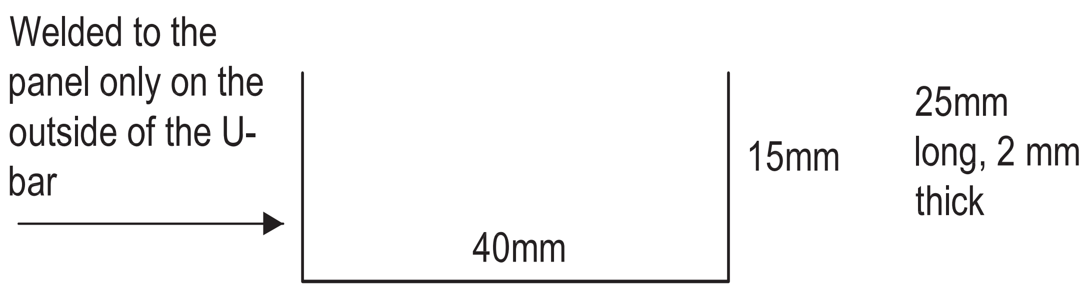
4.1.1 The test on simulated ballast tank conditions is to satisfy each of the following conditions:

a) The test is to be carried out for 180 days.

b) There are to be 5 test panels.

c) The size of each test panel is 200 mm x 400 mm x 3 mm. Two of the panels (Panel 3 and 4 below) have a U-bar Fig 1 welded on. The U-bar is welded to the panel at a distance of 120 mm from one of the short sides and 80 mm from each of the long sides.

Figure 1



The panels are to be treated according to Sec 10, Tab 2, and the coating system applied according to items 1.d) and 1.e) of Sec 10, Tab 2. The shop primer is to be weathered for at least 2 months and cleaned by low pressure washing or other mild method. Blast sweep or high pressure washing or other primer removal methods are not to be used. The weathering method and extent are to take into consideration that the primer is to be the foundation for a 15-year target life system. To facilitate innovation, alternative preparation, coating systems and dry film thicknesses may be used when clearly defined.

d) The reverse side of the test piece is to be painted appropriately, in order not to affect the test results.

e) As simulating the condition of the actual ballast tank, the test cycle runs for two weeks with natural or artificial seawater and one week empty. The temperature of the seawater is to be kept at about 35°C.

f) Test Panel 1 is to be heated for 12 hours at 50°C and cooled for 12 hours at 20°C in order to simulate upper deck condition. The test panel is cyclically splashed with natural or artificial seawater in order to simulate a ship's pitching and rolling motion. The interval of splashing is 3 seconds or faster. The panel has a scribe line down to bare steel across width.

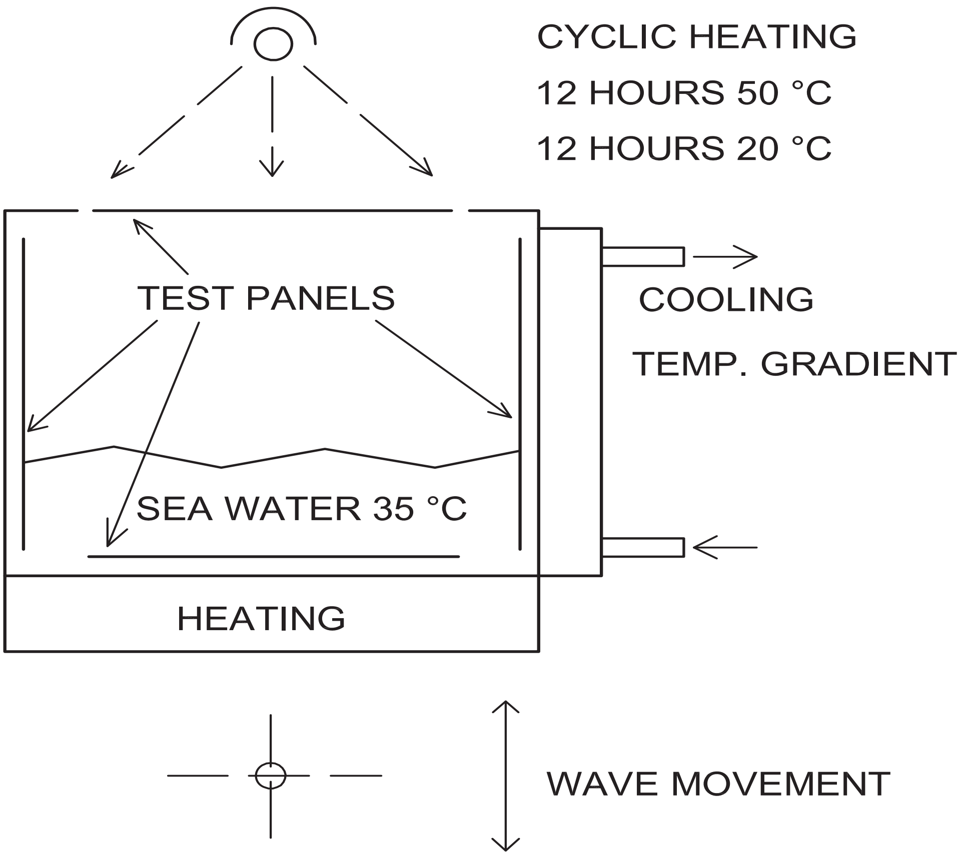
g) Test Panel 2 has a fixed sacrificial zinc anode in order to evaluate the effect of cathodic protection. A circular 8 mm artificial holiday down to bare steel is introduced on the test panel 100 mm from the anode in order to evaluate the effect of the cathodic protection. The test panel is cyclically immersed with natural or artificial seawater.

h) Test Panel 3 is to be cooled on the reverse side, so as to give a temperature gradient in order to simulate a cooled bulkhead in a ballast wing tank, and splashed with natural or artificial seawater in order to simulate a ship's pitching and rolling motion. The gradient of temperature is approximately 20°C, and the interval of splashing is 3 seconds or faster. The panel has a scribe line down to bare steel across width.

i) Test Panel 4 is to be cyclically splashed with natural or artificial seawater in order to simulate a ship's pitching and rolling motion. The interval of splashing is 3 seconds or faster. The panel has a scribe line down to bare steel across width.

j) Test Panel 5 is to be exposed to dry heat for 180 days at 70°C to simulate boundary plating between heated bunker tank and ballast tank in double bottom.

Figure 2 : Wave tank for testing of water ballast tank coating



4.2 Test results

4.2.1 Prior to the testing, the following measured data of the coating system is to be reported:

a) infrared (IR) identification of the base and hardener components of the coating;

b) specific gravity, according to ISO 2811-74, of the base and hardener components of the paint; and

c) number of pinholes, low voltage detector at 90 Volt.

4.2.2 After the testing, the following measured data is to be reported:

a) blisters and rust according to ISO 4628/2 and ISO 4628/3;

b) dry film thickness (DFT) (use of a template) (see Sec 10, Tab 6);

c) adhesion value according to ISO 4624;

d) flexibility according to ASTM D4145, modified according to panel thickness (3 mm steel, 300 μm coating, 150 mm cylindrical mandrel gives 2% elongation) for information only;

e) cathodic protection weight loss/current demand/disbondment from artificial holiday;

f) undercutting from scribe. The undercutting along both sides of the scribe is measured and the maximum undercutting determined on each panel. The average of the three maximum records is used for the acceptance.

4.3 Acceptance criteria

4.3.1 The test results based on [4.2] are to satisfy the acceptance criteria indicated in Tab 1.

4.3.2 Epoxy based systems tested prior to the date of entry into force of Sec 10 are to satisfy only the criteria for blistering and rust in the table above.

4.3.3 Epoxy based systems tested when applied according to Sec 10, Tab 2 are to satisfy the criteria for epoxy based systems as indicated in the table above.

4.3.4 Alternative systems not necessarily epoxy based and/or not necessarily applied according to Sec 10, Tab 2 are to satisfy the criteria for alternative systems as indicated in the table above.

Table 1 : Acceptance criteria of the results of test on simulated ballast tank conditions

Item	Acceptance criteria for epoxy based systems applied according to Table 2 of Section 10	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)
Number of pinholes	0	0
Adhesive failure	> 3.5 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas	> 5.0 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas
Cohesive failure	> 3.0 MPa Cohesive failure in coating for 40% or more of the area	> 5.0 MPa Cohesive failure in coating for 40% or more of the area
Cathodic protection current demand calculated from weight loss	< 5 mA/m^2	< 5 mA/m^2
Cathodic protection; disbondment from artificial holiday	< 8 mm	< 5 mm
Undercutting from scribe	< 8 mm	< 5 mm
U-beam	Any defects, cracking or detachment at the angle or weld will lead to system being failed.	Any defects, cracking or detachment at the angle or weld will lead to system being failed.

4.4 Test report

4.4.1 The test report is to include the following information:

a) name of the Manufacturer;

b) date of tests;

c) product name/identification of both paint and primer;

d) batch number;

e) data of surface preparation on steel panels, including the following:

- surface treatment;
- water soluble salts limit;
- dust; and
- abrasive inclusions;

f) application data of coating system, including the following:

- shop primed;
- number of coats;
- recoat interval (see Note 1);
- dry film thickness (DFT) prior to testing (see Note 1);
- thinner (see Note 1);
- humidity (see Note 1);
- air temperature (see Note 1); and
- steel temperature;

g) test results according to [4.2]; and

h) judgment according to [4.3].

Note 1: Both actual specimen data and Manufacturer's requirement/recommendation.

5 Condensation chamber test

5.1 Test condition

5.1.1 The condensation chamber test is to be conducted in accordance with ISO 6270. The conditions are the following:

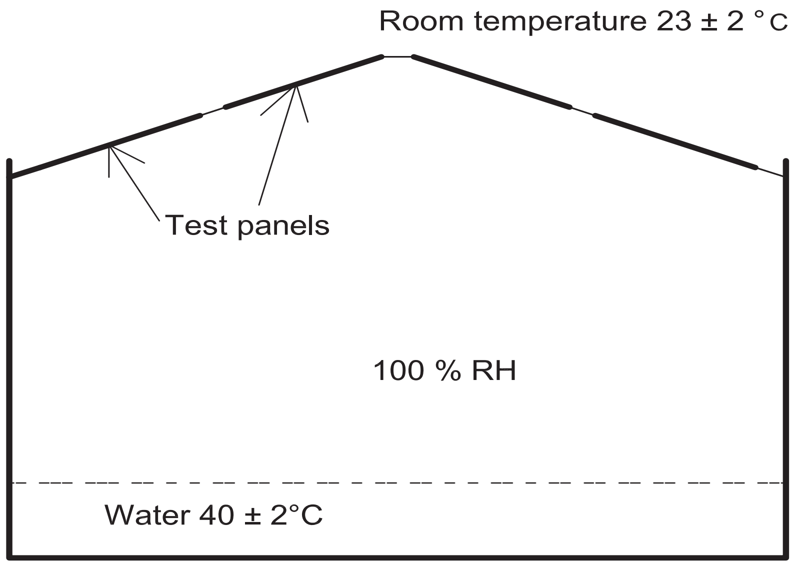
a) The exposure time is 180 days.

b) There are to be 2 test panels.

c) The size of each test panel is 150 mm x 150 mm x 3 mm. The panels are to be treated according to Sec 10, Tab 2, and the coating system applied according to items 1.d) and 1.e) of Sec 10, Tab 2. The shop primer is to be weathered for at least 2 months and cleaned by low pressure washing or other mild method. Blast sweep or high pressure washing or other primer removal methods are not to be used. The weathering method and extent are to take into consideration that the primer is to be the foundation for a 15-year target life system. To facilitate innovation, alternative preparation, coating systems and dry film thicknesses may be used when clearly defined.

d) The reverse side of the test piece is to be painted appropriately, in order not to affect the test results.

Figure 3 : Condensation chamber



5.2 Test results

5.2.1 Prior to the testing, the following measured data of the coating system is to be reported:

a) infrared (IR) identification of the base and hardener components of the coating;

b) specific gravity, according to ISO 2811-74, of the base and hardener components of the paint; and

c) number of pinholes, low voltage detector at 90 Volt.

5.2.2 After the testing, the following measured data is to be reported:

a) blisters and rust according to ISO 4628/2 and ISO 4628/3;

b) dry film thickness (DFT) (use of a template) (see Sec 10, Tab 6);

c) adhesion value according to ISO 4624;

d) flexibility according to ASTM D4145, modified according to panel thickness (3 mm steel, 300 μm coating, 150 mm cylindrical mandrel gives 2% elongation) for information only.

5.3 Acceptance criteria

5.3.1 The test results based on [5.2] are to satisfy the acceptance criteria indicated in Tab 2.

5.3.2 Epoxy based systems tested prior to the date of entry into force of Sec 10 are to satisfy only the criteria for blistering and rust in the table above.

5.3.3 Epoxy based systems tested when applied according to Sec 10, Tab 2 are to satisfy the criteria for epoxy based systems as indicated in the table above.

5.3.4 Alternative systems not necessarily epoxy based and/or not necessarily applied according to Sec 10, Tab 2 are to satisfy the criteria for alternative systems as indicated in the table above.

5.4 Test report

5.4.1 The test report is to include the same information required in [4.4] for the test report of the test on simulated ballast tank conditions.

Table 2 : Acceptance criteria of the results of condensation chamber test

Item	Acceptance criteria for epoxy based systems applied according to Table 2 of Section 10	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)
Number of pinholes	0	0
Adhesive failure	> 3,5 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas	> 5 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas
Cohesive failure	> 3,0 MPa Cohesive failure in coating for 40% or more of the area	> 5,0 MPa Cohesive failure in coating for 40% or more of the area