Rules for the Classification of Ships

Effective from 1 January 2023

Part B
Hull and Stability

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GENERAL CONDITIONS OF THE RULES *effective from 1/1/2021*

Definitions:

"Rules" in these General Conditions means the documents below issued by the Society:
- Rules for the Classification of Ships or other special units;
- Complementary Rules containing the requirements for certification of products, plants, systems and other or containing the requirements for the assignment of additional class notations;
- Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
- Guides to carry out particular activities connected with Services;
- 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.

"*Society*" or *"RINA"* means RINA Services S.p.A. and/or all the companies in the RINA Group which provide the Services.

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

"*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.

"*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.

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

"Client" means the Interested Party and any other party who requires 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.

The Society:
- sets forth and develops Rules;
- publishes the Register of Ships;
- 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 Governments.

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, though committed, also through its research and development services, to continuous updating, does not guarantee they 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 reinstatement. 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.rina.org.

2.3. - The Society exercises due care and skill:
- in the selection of its Surveyors
- 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 each component of the Ship or of the items subject to certification. The surveys and checks made by the Society, either on board ships or with remote techniques, do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks to qualified service suppliers, who will carry out these duties under their responsibility. 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, reflect the discretionary 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 the 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 part 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, are governed by the Rules of the Society, who is the sole subject entitled to make such authentic 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 certification 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 seaworthiness, 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 including, without limitation, 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, and within the limits of liability under art. 5 below, 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, where these are attributable to the Interested Party.

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 and costs, 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 2% shall be paid.

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.

The Society may withhold, suspend or withdraw any certificate, report or service in the event of non-payment of fees due to any member of the RINA Group by the Client in relation to the entire business relationship between any member of the RINA Group and the Client or by any other companies belonging to the same group as the Client. This also applies when the obligation to pay rests with a builder or with the Ship's previous Owner.

For every case of termination or suspension of the contract, the fees for the activities performed until the time of the termination or of the suspension 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 or of the suspension.

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, subject to what 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 one hundred thousand Euro. 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 1 million Euro. 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: THREE MONTHS from the date on which the Services were performed or THREE 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. - 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, will be determined in accordance with Italian Law and settled through arbitration assigned to a board of three arbitrators who will proceed in compliance with the Rules of the Chamber of National and International Arbitration of Milan. Arbitration will take place in Genoa, Italy.

6.2. - However, 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 judicial Court, the Society shall also have the right 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, conditions of class, 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 clients accept that the Society will 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 property 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, certificates, 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 to 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 have 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. – RINA shall not be obliged to perform any obligation towards the Client (including, without limitation, obligation to (a) perform, deliver, accept, sell, purchase, pay or receive money to, from or through a person or entity, or (b) engage in any other act) if this would be in violation of, inconsistent with or expose RINA to punitive measures under any United Nations resolutions and/or under any laws, regulations, decrees, ordinances, orders, demands, requests, rules or requirements of EU, United Kingdom, and/or United States of America and which relate to foreign trade controls, export controls, embargoes or international boycotts (applying, without limitation, to the financing, payment, insurance, transportation, delivery or storage of product and/or services) hereinafter referred to as "Trade Sanctions".

Recurring the above circumstances during the performance of the contract, RINA shall be entitled at its sole and absolute discretion:

I) to immediately suspend payment or performance of the Services which are the object of the contract until such time as the Trading Sanctions are in force; and/or

II) to a full disengagement from the obligation affected by the Trading Sanctions, in the event that the inability to fulfill the said obligation persists until the term provided for the fulfilment hereunder, provided that where the relevant obligation relates to payments for activities and/or Services which have already been delivered, the affected payment obligation shall remain only suspended until such time as the Trading Sanctions no longer apply to the payment ; and/or

III) to terminate the contract, without prejudice of the RINA's rights pursuant to article 4.3.

Article 9

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

Article 10

10.1. – When the Society provides its Services to a consumer - i.e. a natural person who does not act within the scope of his business or professional activity - the following provisions do not apply: art. 3.2. (as far as the Society is solely entitled to the authentic interpretation of the Rules); art. 4.2., (as far as the payment of the fees is also due for services not concluded due to causes not attributable to the Interested Party); art. 5.1. (as far as the exclusion of liability is concerned); art. 5.2.; art. 5.3.; and art. 6.1. (as far as the jurisdiction of a Board of Arbitrators based in Genoa is concerned).

Article 11

11.1. – RINA and the Interested Party shall promote safety, protect human health and environment and create safe working conditions for their personnel.

11.2. – The Interested Party shall guarantee that the working environment in which RINA's Surveyor will be required to work is adequate, safe and in all respect compliant with the applicable legislation and Rules and shall adopt all necessary measures to mitigate and/or control any relevant risk.

11.3. – Furthermore, in accordance with the applicable legislation and Rules, the Interested Party shall provide RINA with complete and detailed information relevant to any actual or potential specific risk existing in the work areas where the Surveyor will be required to operate and relevant to the performance of the Services as well as with any specific safety measure that RINA Surveyor is requested to comply with.

11.4. – RINA reserves not to commence and/or to suspend the Services and/or to terminate the contract, claiming compensation for any damage occurred, if it considers that the safety requirements listed in this article are not satisfactorily met.

EXPLANATORY NOTE TO PART B

1. Reference edition

The reference edition for Part B is the RINA Rules 2000 edition, which is effective from 1 June 2000.

2. Amendments after the reference edition

2.1 RINA Rules 2000 has been completely rewritten and reorganised.

2.2 Except in particular cases, the Rules are updated and published annually.

3. Effective date of the requirements

3.1 All requirements in which new or amended provisions with respect to those contained in the reference edition have been introduced are followed by a date shown in brackets.

The date shown in brackets is the effective date of entry into force of the requirements as amended by the last updating. The effective date of all those requirements not followed by any date shown in brackets is that of the reference edition.

3.2 Item 6 below provides a summary of the technical changes from the preceding edition. In general, this list does not include those items to which only editorial changes have been made not affecting the effective date of the requirements contained therein.

4. Rule Variations and Corrigenda

Until the next edition of the Rules is published, Rule Variations and/or corrigenda, as necessary, will be published on the RINA web site (www.rina.org). Except in particular cases, paper copies of Rule Variations or corrigenda are not issued.

5. Rule subdivision and cross-references

5.1 Rule subdivision

The Rules are subdivided into six parts, from A to F.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Part D: Materials and Welding

Part E: Service Notations

Part F: Additional Class Notations

Each Part consists of:

- Chapters
- Sections and possible Appendices
- Articles
- Sub-articles
- Requirements

Figures (abbr. Fig) and Tables (abbr. Tab) are numbered in ascending order within each Section or Appendix.

5.2 Cross-references

Examples: Pt A, Ch 1, Sec 1, [3.2.1]or Pt A, Ch 1, App 1, [3.2.1]

- Pt A means Part A

The part is indicated when it is different from the part in which the cross-reference appears. Otherwise, it is not indicated.

- Ch 1 means Chapter 1

The Chapter is indicated when it is different from the chapter in which the cross-reference appears. Otherwise, it is not indicated.

- Sec 1 means Section 1 (or App 1 means Appendix 1)

The Section (or Appendix) is indicated when it is different from the Section (or Appendix) in which the cross-reference appears. Otherwise, it is not indicated.

- [3.2.1] refers to requirement 1, within sub-article 2 of article 3.

Cross-references to an entire Part or Chapter are not abbreviated as indicated in the following examples:

- Part A for a cross-reference to Part A
- Part A, Chapter 1 for a cross-reference to Chapter 1 of Part A.

6. Summary of amendments introduced in the edition effective from 1 January 2023

This edition of Part B contains amendments whose effective date is **1 Jnuary 2023**.

The date of entry into force of each new or amended item is shown in brackets after the number of the item concerned.

RULES FOR THE CLASSIFICATION OF SHIPS

Part B
Hull and Stability

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OTHER STRUCTURES

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Section 6 Side Doors and Stern Doors

Section 7 Hatch Covers, Hatch Coamings and Closing Devices

Section 10 Helicopter Decks

CHAPTER 10
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Part B
Hull and Stability

Chapter 9
OTHER STRUCTURES

SECTION 1 FORE PART

Symbols

L_1, L_2 : Lengths, in m, defined in Ch 1, Sec 2, [2.1.1]

n : Navigation coefficient, defined in Ch 5, Sec 1, [2.6] or Ch 8, Sec 1, [1.5]

h_1 : Reference value of the ship relative motion, defined in Ch 5, Sec 3, [3.3] or Ch 8, Sec 1, [3.3]

a_{Z1} : Reference value of the vertical acceleration, defined in Ch 5, Sec 3, [3.4] or Ch 8, Sec 1, [3.3]

ρ_L : Density, in t/m^3, of the liquid carried

g : Gravity acceleration, in m/s^2:

$g = 9{,}81$ m/s^2

x, y, z : X, Y and Z co-ordinates, in m, of the calculation point with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [4]

p_S, p_W : Still water pressure and wave pressure defined in [2.3]

p_{BI} : Bottom impact pressure, defined in [3.2]

p_{FI} : Bow impact pressure, defined in [4.2]

k : Material factor, defined in Ch 4, Sec 1, [2.3]

R_y : Minimum yield stress, in N/mm^2, of the material, to be taken equal to 235/k, unless otherwise specified

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

c_a : Aspect ratio of the plate panel, equal to:

$$c_a = 1{,}21\sqrt{1+0{,}33\left(\frac{s}{\ell}\right)^2} - 0{,}69\frac{s}{\ell}$$

to be taken not greater than 1,0

c_r : Coefficient of curvature of the panel, equal to:

$$c_r = 1 - 0{,}5s/r$$

to be taken not less than 0,75

r : Radius of curvature, in m

β_b, β_s : Coefficients defined in Ch 7, Sec 2, [3.7.3]

λ_{bS}, λ_{bW}, λ_{sS}, λ_{sW}: Coefficients defined in Ch 7, Sec 2, [3.4.5]

c_E : Coefficient to be taken equal to:

$c_E = 1$ for $L \leq 65$ m

$c_E = 3 - L / 32{,}5$ for $65 \text{ m} < L < 90$ m

$c_E = 0$ for $L \geq 90$ m

c_F : Coefficient to be taken equal to:

$c_F = 0{,}9$ for forecastle sides

$c_F = 1{,}0$ in other cases.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the scantling of structures located forward of the collision bulkhead, i.e.:

- fore peak structures
- reinforcements of the flat bottom forward area
- reinforcements of the bow flare area
- stems.

1.1.2 Fore peak structures which form the boundary of spaces not intended to carry liquids, and which do not belong to the outer shell, are to be subjected to lateral pressure in flooding conditions. Their scantlings are to be determined according to the relevant criteria in Chapter 7 or Chapter 8, as applicable.

1.1.3 *(1/7/2003)*

For ships less than 65 m in length, the criteria in Ch 8, App 1 may be used for the strength check of plating and ordinary stiffeners as an alternative to those in [2.4.1], [2.5.1], [2.6.1], [2.7.1] and [2.8.1].

1.2 Connections of the fore part with structures located aft of the collision bulkhead

1.2.1 Tapering

Adequate tapering is to be ensured between the scantlings in the fore part and those aft of the collision bulkhead. The tapering is to be such that the scantling requirements for both areas are fulfilled.

1.2.2 Supports of fore peak structures

Aft of the collision bulkhead, side girders are to be fitted as specified in Ch 4, Sec 5, [2.2] or Ch 4, Sec 5, [3.2], as applicable.

1.3 Net scantlings

1.3.1 As specified in Ch 4, Sec 2, [1], all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.

Gross scantlings are obtained as specified in Ch 4, Sec 2.

2 Fore peak

2.1 Partial safety factors

2.1.1 The partial safety factors to be considered for checking fore peak structures are specified in Tab 1.

Table 1 : Fore peak structures - Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors			
	Symbol	Plating	Ordinary stiffeners	Primary supporting members
Still water pressure	γ_{S2}	1,00	1,00	1,00
Wave induced pressure	γ_{W2}	1,20	1,20	1,20
Material	γ_m	1,02	1,02	1,02
Resistance	γ_R	1,20	1,40	1,60

2.2 Load point

2.2.1 Unless otherwise specified, lateral pressure is to be calculated at:

- the lower edge of the elementary plate panel considered, for plating
- mid-span, for stiffeners.

2.3 Load model

2.3.1 General

The still water and wave lateral pressures in intact conditions are to be considered. They are to be calculated as specified in [2.3.2] for the elements of the outer shell and in [2.3.3] for the other elements.

Still water pressure (p_S) includes:

- the still water sea pressure, defined in Tab 2
- the still water internal pressure due to liquids or ballast, defined in Tab 4
- for decks, the still water internal pressure due to uniform loads, defined in Tab 5.

Wave pressure (p_W) includes:

- the wave pressure, defined in Tab 2
- the inertial internal pressure due to liquids or ballast, defined in Tab 4
- for decks, the inertial internal pressure due to uniform loads, defined in Tab 5.

2.3.2 Lateral pressures for the elements of the outer shell

The still water and wave lateral pressures are to be calculated considering separately:

- the still water and wave external sea pressures
- the still water and wave internal pressures, considering the compartment adjacent to the outer shell as being loaded.

If the compartment adjacent to the outer shell is not intended to carry liquids, only the external sea pressures are to be considered.

Table 2 : Still water and wave pressures

Location	Still water sea pressure p_S, in kN/m²	Wave pressure p_W, in kN/m²
Bottom and side below the waterline: $z \le T$	$\rho g(T-z)$	$\rho g h_1 e^{\frac{-2\pi(T-z)}{L}}$
Side above the waterline: $z > T$	0	$\rho g(T+h_1-z)$ without being taken less than 0,15L
Exposed deck	Pressure due to the load carried **(1)**	$19{,}6 n\varphi\sqrt{H}$

(1) The pressure due to the load carried is to be defined by the Designer and, in any case, it may not be taken less than 10φ kN/m², where φ is defined in Tab 3.
The Society may accept pressure values lower than 10φ kN/m² when considered appropriate on the basis of the intended use of the deck.

Note 1:

φ : Coefficient defined in Tab 3

$$H = \left[2{,}66\left(\frac{x}{L}-0{,}7\right)^2+0{,}14\right]\sqrt{\frac{VL}{C_B}}-(z-T)$$

without being taken less than 0,8

V : Maximum ahead service speed, in knots, to be taken not less than 13 knots.

Table 3 : Coefficient for pressure on exposed deck

Exposed deck location	φ
Freeboard deck	1
Superstructure deck	0,75
1st tier of deckhouse	0,56
2nd tier of deckhouse	0,42
3rd tier of deckhouse	0,32
4th tier of deckhouse and above	0,25

Table 4 : Still water and inertial internal pressures due to liquids

Still water pressure p_S in kN/m²	Inertial pressure p_W in kN/m²
$\rho_L g(z_L - z)$	$\rho_L a_{Z1}(z_{TOP} - z)$

Note 1:

z_{TOP} : Z co-ordinate, in m, of the highest point of the tank

z_L : Z co-ordinate, in m, of the highest point of the liquid:
$z_L = z_{TOP} + 0{,}5\,(z_{AP} - z_{TOP})$

z_{AP} : Z co-ordinate, in m, of the moulded deck line of the deck to which the air pipes extend, to be taken not less than z_{TOP}.

Table 5 : Still water and inertial internal pressures due to uniform loads

Still water pressure p_S, in kN/m²	Inertial pressure p_W, in kN/m²
The value of p_S is, in general, defined by the Designer; in any case it may not be taken less than 10 kN/m². When the value of p_S is not defined by the Designer, it may be taken, in kN/m², equal to 6,9 h_{TD}, where h_{TD} is the compartment 'tweendeck height at side, in m	$p_S\dfrac{a_{Z1}}{g}$

2.3.3 Lateral pressures for elements other than those of the outer shell

The still water and wave lateral pressures to be considered as acting on an element which separates two adjacent compartments are those obtained considering the two compartments individually loaded.

2.4 Longitudinally framed bottom

2.4.1 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than the values obtained from the formulae in Tab 6 and the minimum values in the same Table.

2.4.2 Floors

Floors are to be fitted at every four frame spacings and generally spaced no more than 2,5 m apart.

The floor dimensions and scantlings are to be not less than those specified in Tab 7.

In no case may the above scantlings be lower than those of the corresponding side transverses, as defined in [2.6.2].

2.4.3 Centre girder

Where no centreline bulkhead is to be fitted (see [2.10]), a centre bottom girder having the same dimensions and scantlings required in [2.4.2] for floors is to be provided.

The centre bottom girder is to be connected to the collision bulkhead by means of a large end bracket.

2.4.4 Side girders

Side girders, having the same dimensions and scantlings required in [2.4.2] for floors, are generally to be fitted every two longitudinals, in line with bottom longitudinals located aft of the collision bulkhead. Their extension is to be compatible in each case with the shape of the bottom.

2.5 Transversely framed bottom

2.5.1 Plating

The net scantling of plating is to be not less than the value obtained from the formulae in Tab 6 and the minimum values in the same table.

2.5.2 Floors

Solid floors are to be fitted at every frame spacing.

The solid floor dimensions and scantlings are to be not less than those specified in Tab 8.

2.5.3 Centre girder

Where no centreline bulkhead is to be fitted (see [2.10]), a centre bottom girder is to be fitted according to [2.4.3].

2.6 Longitudinally framed side

2.6.1 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than the values obtained from the formulae in Tab 9 and the minimum values in the same table.

2.6.2 Side transverses

Side transverses are to be located in way of bottom transverse and are to extend to the upper deck. Their ends are to be amply faired in way of bottom and deck transverses.

Their net section modulus w, in cm³, and net shear sectional area A_{Sh}, in cm², are to be not less than the values obtained from the following formulae:

$$w = \gamma_R\gamma_m\beta_b\frac{\gamma_{S2}\lambda_{bS}p_S+\gamma_{W2}\lambda_{bW}p_W}{8R_y}s\ell^2 10^3$$

$$A_{Sh} = 10\gamma_R\gamma_m\beta_s\frac{\gamma_{S2}\lambda_{sS}p_S+\gamma_{W2}\lambda_{sW}p_W}{R_y}s\ell$$

Table 6 : Scantling of bottom plating and ordinary stiffeners *(1/7/2002)*

Element	Formula	Minimum value
Plating	Net thickness, in mm: • in general: $t = 14{,}9c_ac_rs\sqrt{\gamma_R\gamma_m\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}}$ • for inner bottom: $t = 14{,}9c_ac_rs\sqrt{\gamma_R\gamma_m\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}}$	Net minimum thickness, in mm: • in general: $t = c_F(0{,}038L+7{,}0)(sk)^{1/2}-c_E$ • for inner bottom: $t = 2+0{,}017Lk^{1/2}+4{,}5s$
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R\gamma_m\beta_b\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{8R_y}\left(1-\frac{s}{2\ell}\right)s\ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5L_2^{1/3}k^{1/6}$ • the thickness of the attached plating.
	Net shear sectional area, in cm²: $A_{Sh} = 10\gamma_R\gamma_m\beta_s\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}\left(1-\frac{s}{2\ell}\right)s\ell$	

Table 7 : Longitudinally framed bottom Floor dimensions and scantlings

Dimension or scantling	Specified value
Web height, in m	h_M = 0,085 D + 0,15
Web net thickness, in mm	To be not less than that required for double bottom floors aft of the collision bulkhead; in any case, it may be taken not greater than 10 mm.
Floor face plate net sectional area, in cm²	A_P = 3,15 D
Floor face plate net thickness, in mm	t_P = 0,4 D + 5 May be assumed not greater than 14 mm.

Table 8 : Transversely framed bottom Floor dimensions and scantlings

Dimension or scantling	Specified value
Web height, in m	h_M = 0,085 D + 0,15
Web net thickness, in mm	To be not less than that required for double bottom floors aft of the collision bulkhead; in any case, it may be taken not greater than 10 mm.
Floor face plate net sectional area, in cm²	A_P = 1,67 D

2.7 Transversely framed side

2.7.1 Plating and ordinary stiffeners (side frames)

Side frames fitted at every frame space are to have the same vertical extension as the collision bulkhead.

The net scantlings of plating and side frames are to be not less than the values obtained from the formulae in Tab 9 and the minimum values in the table.

The value of the side frame section modulus is generally to be maintained for the full extension of the side frame.

2.7.2 Side girders

Depending on the hull body shape and structure aft of the collision bulkhead, one or more adequately spaced side girders per side are to be fitted.

Their net section modulus w, in cm³, and net shear sectional area A_{Sh}, in cm², are to be not less than the values obtained from the following formulae:

$$w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{8 R_y} s \ell^2 10^3$$

$$A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y} s \ell$$

Moreover, the depth b_A, in mm, and the net thickness t_A, in mm, of the side girder web are generally to be not less than the values obtained from the following formulae:

b_A = 2,5 (180 + L)

t_A = (6 + 0,018L)$k^{1/2}$

2.7.3 Panting structures

In order to withstand the panting loads, horizontal structures are to be provided. These structures are to be fitted at a spacing generally not exceeding 2 m and consist of side girders supported by panting beams or side transverses whose ends are connected to deck transverses, located under the tank top, so as to form a strengthened ring structure.

Panting beams, which generally consist of sections having the greater side vertically arranged, are to be fitted every two frames.

2.7.4 Connection between panting beams, side frames and side girders

Each panting beam is to be connected to the side transverses by means of brackets whose arms are generally to be not less than twice the panting beam depth.

2.7.5 Connection between side frames and side girders

Side transverses not supporting panting beams are to be connected to side girders by means of brackets having the same thickness as that of the side girder and arms which are to be not less than one half of the depth of the side girder.

Table 9 : Scantling of side plating and ordinary stiffeners *(1/7/2002)*

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 14{,}9 c_a c_r s \sqrt{\gamma_R \gamma_m \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y}}$	Net minimum thickness, in mm: $t = c_F (0{,}038L + 7{,}0)(sk)^{1/2} - c_E$
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{8 R_y} \left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$ Net shear sectional area, in cm²: $A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y} \left(1 - \frac{s}{2\ell}\right) s \ell$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5 L_2^{1/3} k^{1/6}$ • the thickness of the attached plating

Table 10 : Scantling of deck plating and ordinary stiffeners

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 14{,}9 c_a c_r s \sqrt{\gamma_R \gamma_m \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y}}$	Net minimum thickness, in mm: $t = 2{,}1 + 0{,}013 L k^{1/2} + 4{,}5 s$
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{m R_y} \left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5 L_2^{1/3} k^{1/6}$ • the thickness of the attached plating.
	Net shear sectional area, in cm²: $A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y} \left(1 - \frac{s}{2\ell}\right) s \ell$	
Note 1: m : Boundary coefficient, to be taken equal to: • m = 12 for longitudinally framed decks • m = 8 for transversely framed decks.		

2.7.6 Panting beam scantlings

The net area A_B, in cm², and the net inertia J_B, in cm⁴, of the panting beam section are to be not less than the values obtained from the following formulae:

$A_B = 0{,}5\ L - 18$

$J_B = 0{,}34\ (0{,}5\ L - 18)\ b_B^2$

where:

b_B : Beam length, in m, measured between the internal edges of side girders or the internal edge of the side girder and any effective central or lateral support.

Where side girder spacing is other than 2 m, the values A_B and J_B are to be modified according to the relation between the actual spacing and 2 m.

2.7.7 Panting beams of considerable length

Panting beams of considerable length are generally to be supported at the centreline by a wash bulkhead or pillars arranged both horizontally and vertically.

2.7.8 Non-tight platforms

Non-tight platforms may be fitted in lieu of side girders and panting beams. Their openings and scantlings are to be in accordance with [2.9.1].

Their spacing is to be not greater than 2,5 m.

If the peak exceeds 10 m in depth, a non-tight platform is to be arranged at approximately mid-depth.

2.7.9 Additional transverse bulkheads

Where the peak exceeds 10 m in length and the frames are supported by panting beams or non-tight platforms, additional transverse wash bulkheads or side transverses are to be fitted.

2.8 Decks

2.8.1 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than the values obtained from the formulae in Tab 10 and the minimum values in the same table.

2.8.2 Primary supporting members *(1/7/2002)*

Scantlings of primary supporting members are to be in accordance with Ch 7, Sec 3, considering the loads in [2.3].

The partial safety factors to be used are those defined in Ch 7, Sec 3, [1.3].

2.9 Platforms

2.9.1 Non-tight platforms

Non-tight platforms located inside the peak are to be provided with openings having a total area not less than 10% of that of the platforms. Moreover, the thickness of the plating and the section modulus of ordinary stiffeners are to be not less than those required in [2.10] for the non-tight central longitudinal bulkhead.

The number and depth of non-tight platforms within the peak is considered by the Society on a case by case basis.

The platforms may be replaced by equivalent horizontal structures whose scantlings are to be supported by direct calculations.

2.9.2 Platform transverses

The net sectional area of platform transverses, calculated considering a width of attached plating whose net sectional area is equal to that of the transverse flange, is to be not less than the value obtained, in cm², from the following formula:

$$A = 10 \gamma_R \gamma_m \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{C_P R_y} d_S h_S$$

where:

p_S, p_W : Still water pressure and wave pressure, defined in Tab 2, acting at the ends of the platform transverse in the direction of its axis

d_S : Half of the longitudinal distance, in m, between the two transverses longitudinally adjacent to that under consideration

h_S : Half of the vertical distance, in m, between the two transverses vertically adjacent to that under consideration

C_P : Coefficient, to be taken equal to:

$$C_P = 1 \quad \text{for} \quad \frac{d_P}{r_P} \le 70$$

$$C_P = 1{,}7 - 0{,}01\frac{d_P}{r_P} \quad \text{for} \quad 70 < \frac{d_P}{r_P} \le 140$$

When d_P / r_P > 140, the scantlings of the struts are considered by the Society on a case by case basis

d_P : Distance, in cm, from the face plate of the side transverse and that of the bulkhead vertical web, connected by the strut, measured at the level of the platform transverse

r_P : Radius of gyration of the strut, to be obtained, in cm, from the following formula:

$$r_P = \sqrt{\frac{J}{A_E}}$$

J : Minimum net moment of inertia, in cm^4, of the strut considered

A_E : Actual net sectional area, in cm^2, of the transverse section of the strut considered.

2.9.3 Breasthooks

Breasthooks are to have the same thickness of that required for platforms. They are to be arranged on the stem, in way of every side longitudinal, or at equivalent spacing in the case of transverse framing, extending aft for a length equal to approximately twice the breasthook spacing.

2.10 Central longitudinal bulkhead

2.10.1 General

Unless otherwise agreed by the Society on the basis of the ship's dimensions and fore peak arrangement, a centreline non-tight longitudinal bulkhead is to be fitted.

2.10.2 Extension

In the case of a bulbous bow, such bulkhead is generally to extend for the whole length and depth of the fore peak.

Where hull structures are flared, such as those situated above the bulb and in the fore part of the peak, the bulkhead may be locally omitted.

Similarly, the extension of the bulkhead may be limited for bows without a bulb, depending on the shape of the hull. However, the bulkhead is to be fitted in the higher part of the peak.

2.10.3 Plating thickness

The net plating thickness of the lower part of the longitudinal bulkhead over a height at least equal to h_M defined in [2.4.2] is to be not less than that required for the centre girder in [2.4.3].

Elsewhere, the net thickness of the longitudinal bulkhead plating is to be not less than the value obtained, in mm, from the following formula:

$t = 6{,}5 + 0{,}013\ L_1$

2.10.4 Ordinary stiffeners

The net section modulus of ordinary stiffeners is to be not less than the value obtained, in cm^3, from the following formula:

$$w = 3{,}5 s \ell^2 k (z_{TOP} - z_M)$$

where:

z_{TOP} : Z co-ordinate, in m, of the highest point of the tank

z_M : Z co-ordinate, in m, of the stiffener mid-span.

2.10.5 Primary supporting members

Vertical and longitudinal primary supporting members, to be made preferably with symmetrical type sections, are to have a section modulus not less than 50% of that required for the corresponding side or longitudinal webs.

The vertical and longitudinal webs are to be provided with adequate fairing end brackets and to be securely connected to the struts, if any.

2.10.6 Openings

Bulkhead openings are to be limited in the zone corresponding to the centre girder to approximately 2% of the area, and, in the zone above, to not less than 10% of the area. Openings are to be located such as to affect as little as possible the plating sections adjacent to primary supporting members.

2.11 Bulbous bow

2.11.1 General

Where a bulbous bow is fitted, fore peak structures are to effectively support the bulb and are to be adequately connected to its structures.

2.11.2 Shell plating

The thickness of the shell plating of the fore end of the bulb and the first strake above the keel is generally to be not less than that required in [5.2.1] for plate stems. This thickness is to be extended to the bulbous zone, which, depending on its shape, may be damaged by anchors and chains during handling.

2.11.3 Connection with the fore peak

Fore peak structures are to be extended inside the bulb as far as permitted by the size and shape of the latter.

2.11.4 Horizontal diaphragms

At the fore end of the bulb, the structure is generally to be supported by means of horizontal diaphragms, spaced not more than 1 m apart, and a centreline vertical diaphragm.

2.11.5 Longitudinal stiffeners

Bottom and side longitudinals are to extend inside the bulb, forward of the fore end by at least 30% of the bulb length measured from the perpendicular to the fore end of the bulb.

The fore end of longitudinals is to be located in way of a reinforced transverse ring; forward of such ring, longitudinals are to be replaced by ordinary transverse rings.

2.11.6 Floors

Solid floors are to be part of reinforced transverse rings generally arranged not more than 3 frame spaces apart.

2.11.7 Breasthooks

Breasthooks, to be placed in line with longitudinals, are to be extended on sides aft of the stem, so as to form longitudinal side girders.

2.11.8 Longitudinal centreline wash bulkhead

For a bulb of considerable width, a longitudinal centreline wash bulkhead may be required by the Society in certain cases.

2.11.9 Transverse wash bulkhead

In way of a long bulb, transverse wash bulkheads or side transverses of adequate strength arranged not more than 5 frame spaces apart may be required by the Society in certain cases.

3 Reinforcements of the flat bottom forward area

3.1 Area to be reinforced

3.1.1 In addition to the requirements in [2], the structures of the flat bottom forward area are to be able to sustain the dynamic pressures due to the bottom impact. The flat bottom forward area is:

- longitudinally, over the bottom located between ξL and 0,05L aft of the fore end, where the coefficient ξ is obtained from the following formula:

  $$\xi = 0{,}25(1{,}6 - C_B)$$

  without being taken less than 0,2 or greater than 0,25
- transversely, over the whole flat bottom and the adjacent zones up to a height, from the base line, not less than 2L, in mm. In any case, it is not necessary that such height is greater than 300 mm.

3.1.2 The bottom dynamic impact pressure is to be considered if:

T_F < min (0,04L; 8,6 m)

where T_F is the minimum forward draught, in m, among those foreseen in operation in ballast conditions or conditions of partial loading.

3.1.3 The value of the minimum forward draught T_F adopted for the calculations is to be specified in the loading manual.

3.1.4 An alternative arrangement and extension of strengthening with respect to the above may also be required where the minimum forward draught exceeds 0,04 L, depending on the shape of the forward hull body and the ship's length and service speed.

3.2 Bottom impact pressure

3.2.1 The bottom impact pressure p_{BI} is to be obtained, in kN/m², from the following formula:

$$p_{BI} = 25n\left[0{,}004 - \left(\frac{T_F}{L}\right)^2\right]\frac{L_1 L}{T_F}$$

where T_F is the draught defined in [3.1.2].

3.3 Partial safety factors

3.3.1 The partial safety factors to be considered for checking the reinforcements of the flat bottom forward area are specified in Tab 11.

Table 11 : Reinforcements of the flat bottom forward area - Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors		
	Symbol	Plating	Ordinary stiffeners
Still water pressure	γ_{S2}	1,00	1,00
Wave pressure	γ_{W2}	1,10	1,10
Material	γ_m	1,02	1,02
Resistance	γ_R	1,30	1,15

Table 12 : Reinforcements of plating and ordinary stiffeners of the flat bottom forward area *(1/7/2002)*

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 13{,}9 c_a c_r s \sqrt{\gamma_R \gamma_m \frac{\gamma_{W2} p_{BI}}{R_y}}$	Net minimum thickness, in mm: $t = c_F(0{,}038L + 7{,}0)(sk)^{1/2} - c_E$
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{W2} p_{BI}}{16 c_P R_y}\left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5 L_2^{1/3} k^{1/6}$ • the thickness of the attached plating
	Net shear sectional area, in cm²: $A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{W2} p_{BI}}{R_y}\left(1 - \frac{s}{2\ell}\right) s \ell$	
Note 1: c_P : Ratio of the plastic section modulus to the elastic section modulus of the ordinary stiffeners with attached shell plating, to be taken equal to 1,16 in the absence of more precise evaluation.		

3.4 Scantlings

3.4.1 Plating and ordinary stiffeners *(1/7/2010)*

In addition to the requirements in [2.4.1] and [2.5.1], the net scantlings of plating and ordinary stiffeners of the flat bottom forward area, defined in [3.1], are to be not less than the values obtained from the formulae in Tab 12 and the minimum values in the same Table.

The span of ordinary stiffeners to be considered for the calculation of net section modulus and net shear sectional area is to be taken as the distance between the adjacent primary supporting members; the effect of local supports (e.g. additional vertical brackets located between primary supporting members) is considered by the Society on a case-by-case basis.

3.4.2 Tapering

Outside the flat bottom forward area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

3.5 Arrangement of primary supporting members and ordinary stiffeners: longitudinally framed bottom

3.5.1 The requirements in [3.5.2] to [3.5.4] apply to the structures of the flat bottom forward area, defined in [3.1], in addition to the requirements of [2.4].

3.5.2 Bottom longitudinals and side girders, if any, are to extend as far forward as practicable, and their spacing may not exceed that adopted aft of the collision bulkhead.

3.5.3 The spacing of solid floors in a single or double bottom is to be not greater than either that required for the midship section in Ch 4, Sec 4 or (1,35 + 0,007 L) m, whichever is the lesser.

However, where the minimum forward draught T_F is less than 0,02 L, the spacing of floors forward of 0,2 L from the stem is to be not greater than (0,9 + 0,0045 L) m.

3.5.4 The Society may require adequately spaced side girders having a depth equal to that of the floors. As an alternative to the above, girders with increased scantlings may be fitted.

3.6 Arrangement of primary supporting members and ordinary stiffeners: transversely framed double bottom

3.6.1 The requirements in [3.6.2] to [3.6.4] apply to the structures of the flat bottom forward area, defined in [3.1], in addition to the requirements of [2.5].

3.6.2 Solid floors are to be fitted:

- at every second frame between 0,75L and 0,8L from the aft end
- at every frame space forward of 0,8L from the aft end.

3.6.3 Side girders with a depth equal to that of the floors are to be fitted at a spacing generally not exceeding 2,4 m. In addition, the Society may require intermediate half height girders, half the depth of the side girders, or other equivalent stiffeners.

3.6.4 Intercostal longitudinal ordinary stiffeners are to be fitted at a spacing generally not exceeding 1,2 m. Their section modulus is to be not less than 250 cm³.

4 Reinforcements of the bow flare area

4.1 Area to be reinforced

4.1.1 In addition to the requirements in [2], the structures of the bow flare area are to be able to sustain the dynamic pressures due to the bow impact pressure.

4.1.2 *(1/7/2020)*

The bow area is that extending forward of 0,9 L from the aft end of L and above the waterline at the scantling draught.

4.2 Bow impact pressure

4.2.1 *(1/7/2020)*

The bow impact pressure p_{FI} is to be obtained, in kN/m², from the following formula:

$$p_{FI} = nC_S C_L C_Z (0{,}22 + 0{,}15\tan\alpha)(0{,}4V\sin\beta + 0{,}6\sqrt{L})^2$$

where:

C_S : Coefficient depending on the type of structures on which the bow impact pressure is considered to be acting:

- C_S = 1,8 for plating and ordinary stiffeners
- C_S = 0,5 for primary supporting members

C_L : Coefficient depending on the ship's length:

- C_L = 0,0125 L for L < 80 m
- C_L = 1,0 for $L \geq 80$ m

C_Z : Coefficient depending on the distance between the waterline at draught T and the calculation point:

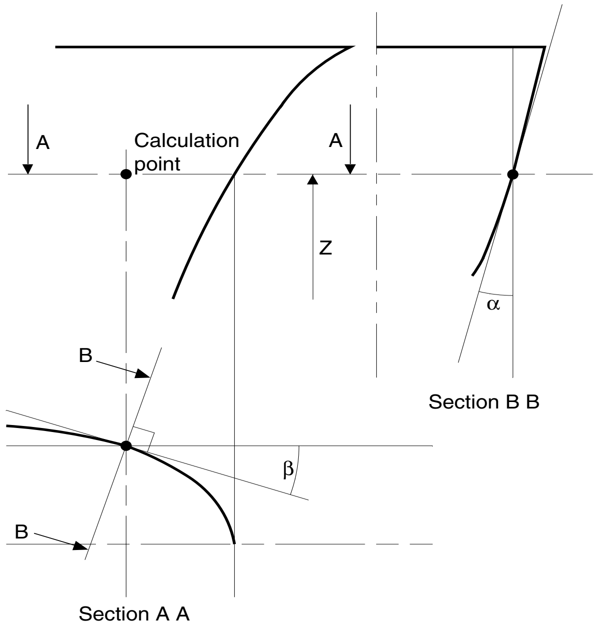
- C_Z = C - 0,5 (z-T) for $z \geq 2C + T - 11$
- C_Z = 5,5 for $z < 2C + T - 11$

C : Wave parameter, defined in Ch 5, Sec 2

α : Flare angle at the calculation point, defined as the angle between a vertical line and the tangent to the side plating, measured in a vertical plane normal to the horizontal tangent to the shell plating (see Fig 1)

β : Entry angle at the calculation point, defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane (see Fig 1).

Figure 1 : Definition of angles α and β



4.3 Partial safety factors

4.3.1 The partial safety factors to be considered for checking the reinforcements of the bow flare area are specified in Tab 13.

Table 13 : Reinforcements of the bow flare area Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors		
	Symbol	Plating	Ordinary stiffeners
Still water pressure	γ_{S2}	1,00	1,00
Wave pressure	γ_{W2}	1,10	1,10
Material	γ_m	1,02	1,02
Resistance	γ_R	1,30	1,02

4.4 Scantlings

4.4.1 Plating and ordinary stiffeners *(1/7/2015)*

In addition to the requirements in [2.6.1] and [2.7.1], the net scantlings of plating and ordinary stiffeners of the bow flare area, defined in [4.1], are to be not less than the values obtained from the formulae in Tab 14 and the minimum values in the same table.

The span of ordinary stiffeners to be considered for the calculation of net section modulus and net shear sectional area is to be taken as the distance between the adjacent primary supporting members measured along the chord of the curve defined by the intersection between the ordinary stiffener and the side shell; the effect of local supports (e.g. additional vertical brackets located between primary supporting members) is considered by the Society on a case-by-case basis.

4.4.2 Tapering

Outside the bow flare area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

4.4.3 Intercostal stiffeners

Intercostal stiffeners are to be fitted at mid-span where the angle between the stiffener web and the attached plating is less than 70°.

4.4.4 Primary supporting members *(1/7/2002)*

In addition to the requirements in [2.6] and [2.7], primary supporting members are generally to be verified through direct calculations carried out according to Ch 7, Sec 3, considering the bow impact pressures defined in [4.2] and the partial safety factors in Tab 1.

5 Stems

5.1 General

5.1.1 Arrangement

Adequate continuity of strength is to be ensured at the connection of stems to the surrounding structure.

Abrupt changes in sections are to be avoided.

Table 14 : Reinforcements of plating and ordinary stiffeners of the bow flare area *(1/7/2002)*

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 11c_a c_r s\sqrt{\gamma_R\gamma_m\dfrac{\gamma_{W2}p_{FI}}{R_y}}$	Net minimum thickness, in mm: $t = c_F(0,038L + 7,0)(sk)^{1/2} - c_E$

Note 1:
c_P : Ratio of the plastic section modulus to the elastic section modulus of the ordinary stiffeners with attached shell plating, to be taken equal to 1,16 in the absence of more precise evaluation.

Element	Formula	Minimum value
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{W2} p_{FI}}{18 c_P R_y}\left(1-\frac{s}{2\ell}\right) s \ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5 L_2^{1/3} k^{1/6}$ • the thickness of the attached plating.
	Net shear sectional area, in cm²: $A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{W2} p_{FI}}{R_y}\left(1-\frac{s}{2\ell}\right) s \ell$	
Note 1: c_P : Ratio of the plastic section modulus to the elastic section modulus of the ordinary stiffeners with attached shell plating, to be taken equal to 1,16 in the absence of more precise evaluation.		

5.1.2 Gross scantlings

With reference to Ch 4, Sec 2, [1], all scantlings and dimensions referred to in [5.2] and [5.3] are gross, i.e. they include the margins for corrosion.

5.2 Plate stems

5.2.1 *(1/7/2020)*

Where the stem is constructed of shaped plates, the gross thickness of the plates below the load waterline is to be not less than the value obtained, in mm, from the following formula:

$$t_S = 1{,}37(0{,}95 + \sqrt{L_3})\sqrt{k}$$

where:

L_3 : Rule length L, in m, but to be taken not greater than 300.

Above the load waterline this thickness may be gradually tapered towards the stem head, where it is to be not less than that required for side plating at ends.

5.2.2 The plating forming the stems is to be supported by horizontal diaphragms spaced not more than 1200 mm apart and connected, as far as practicable, to the adjacent frames and side stringers.

5.2.3 If considered necessary, and particularly where the stem radius is large, a centreline stiffener or web of suitable scantlings is to be fitted.

5.3 Bar stems

5.3.1 The gross area of bar stems constructed of forged or rolled steel is to be not less than the value obtained, in cm², from the following formulae:

$$A_P = \left(0{,}40 + \frac{10T}{L}\right)(0{,}009L^2 + 20)\sqrt{k} \quad \text{for } L \le 90$$

$$A_P = \left(0{,}40 + \frac{10T}{L}\right)(1{,}8L - 69)\sqrt{k} \quad \text{for } 90 < L \le 200$$

where the ratio T/L in the above formulae is to be taken not less than 0,05 or greater than 0,075.

5.3.2 The gross thickness t_B of the bar stem is to be not less than the value obtained, in mm, from the following formula:

$$t_B = (0{,}4L + 13)\sqrt{k}$$

5.3.3 The cross-sectional area of the stem may be gradually tapered from the load waterline to the upper end, where it may be equal to the two thirds of the value as calculated above.

5.3.4 The lower part of the stem may be constructed of cast steel subject to the examination by the Society; where necessary, a vertical web is to be fitted for welding of the centre keelson.

5.3.5 Welding of the bar stem with the bar keel and the shell plating is to be in accordance with Ch 12, Sec 1, [3.4].

6 Transverse thrusters

6.1 Scantlings of the thruster tunnel and connection with the hull

6.1.1 The thickness of the tunnel is to be not less than that of the adjacent hull plating.

6.1.2 When the tunnel is not welded to the hull, the connection devices are examined by the Society on a case by case basis.

SECTION 2 AFT PART

Symbols

L_1, L_2 : Lengths, in m, defined in Ch 1, Sec 2, [2.1.1]

h_1 : Reference value of the ship relative motion, defined in Ch 5, Sec 3, [3.3] or Ch 8, Sec 1, [3.3]

a_{Z1} : Reference value of the vertical acceleration, defined in Ch 5, Sec 3, [3.4] or Ch 8, Sec 1, [3.3]

ρ : Sea water density, in t/m^3

g : Gravity acceleration, in m/s^2:

$g = 9{,}81$ m/s^2

x, y, z : X, Y and Z co-ordinates, in m, of the calculation point with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [4]

p_S, p_W : Still water pressure and wave pressure defined in [2.3]

k : Material factor, defined in Ch 4, Sec 1, [2.3]

R_y : Minimum yield stress, in N/mm^2, of the material, to be taken equal to 235/k, unless otherwise specified

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

c_a : Aspect ratio of the plate panel, equal to:

$$c_a = 1{,}21\sqrt{1+0{,}33\left(\frac{s}{\ell}\right)^2} - 0{,}69\frac{s}{\ell}$$

to be taken not greater than 1,0

c_r : Coefficient of curvature of the panel, equal to:

$c_r = 1 - 0{,}5\ s/r$

to be taken not less than 0,75

r : Radius of curvature, in m

β_b, β_s : Coefficients defined in Ch 7, Sec 2, [3.7.3]

λ_{bS}, λ_{bW}, λ_{sS}, λ_{sW}:Coefficients defined in Ch 7, Sec 2, [3.4.5]

c_E : Coefficient to be taken equal to:

$c_E = 1$ for $L \leq 65$ m

$c_E = 3 - L/30$ for $65\text{ m} < L < 90$ m

$c_E = 0$ for $L \geq 90$ m

c_F : Coefficient:

$c_F = 0{,}8$ for poop sides

$c_F = 1{,}0$ in other cases.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the scantlings of structures located aft of the after peak bulkhead and for the reinforcements of the flat bottom aft area.

1.1.2 Aft peak structures which form the boundary of spaces not intended to carry liquids, and which do not belong to the outer shell, are to be subjected to lateral pressure in flooding conditions. Their scantlings are to be determined according to the relevant criteria in Chapter 7 or Chapter 8, as applicable.

1.1.3 *(1/7/2003)*

For ships less than 65 m in length, the criteria in Ch 8, App 1 may be used for the strength check of plating and ordinary stiffeners as an alternative to those in [3.2.1].

1.2 Connections of the aft part with structures located fore of the after peak bulkhead

1.2.1 Tapering

Adequate tapering is to be ensured between the scantlings in the aft part and those fore of the after peak bulkhead. The tapering is to be such that the scantling requirements for both areas are fulfilled.

1.3 Net scantlings

1.3.1 As specified in Ch 4, Sec 2, [1], all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.

Gross scantlings are obtained as specified in Ch 4, Sec 2.

2 Aft peak

2.1 Partial safety factors

2.1.1 The partial safety factors to be considered for checking aft peak structures are specified in Tab 1.

Table 1 : Aft peak structures - Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors			
	Symbol	Plating	Ordinary stiffeners	Primary supporting members
Still water pressure	γ_{S2}	1,00	1,00	1,00
Wave pressure	γ_{W2}	1,20	1,20	1,20
Material	γ_m	1,02	1,02	1,02
Resistance	γ_R	1,20	1,40	1,60

2.2 Load point

2.2.1 Unless otherwise specified, lateral pressure is to be calculated at:

- the lower edge of the elementary load panel considered, for plating
- mid-span, for stiffeners.

2.3 Load model

2.3.1 General

The still water and wave lateral pressures in intact conditions are to be considered. They are to be calculated as specified in [2.3.2] for the elements of the outer shell and in [2.3.3] for the other elements.

Still water pressure (p_S) includes:

- the still water sea pressure, defined in Tab 2
- the still water internal pressure due to liquid or ballast, defined in Tab 4
- for decks, the still water internal pressure due to dry uniform weights, defined in Tab 5

Wave pressure (p_W) includes:

- the wave pressure, defined in Tab 2
- the inertial pressure due to liquids or ballast, defined in Tab 4
- for decks, the inertial pressure due to uniform loads, defined in Tab 5.

2.3.2 Lateral pressures for the elements of the outer shell

The still water and wave lateral pressures are to be calculated considering separately:

- the still water and wave external sea pressures
- the still water and wave internal pressure, considering the compartment adjacent to the outer shell as being loaded

If the compartment adjacent to the outer shell is not intended to carry liquids, only the external sea pressures are to be considered.

2.3.3 Lateral pressures for elements other than those of the outer shell

The still water and wave lateral pressures to be considered as acting on an element which separates two adjacent compartments are those obtained considering the two compartments individually loaded.

3 After peak

3.1 Arrangement

3.1.1 General

The after peak is, in general, to be transversely framed.

3.1.2 Floors

Solid floors are to be fitted at every frame spacing.

The floor height is to be adequate in relation to the shape of the hull. Where a sterntube is fitted, the floor height is to extend at least above the sterntube. Where the hull lines do not allow such extension, plates of suitable height with upper and lower edges stiffened and securely fastened to the frames are to be fitted above the sterntube.

Table 2 : Still water and wave pressures

Location	Still water sea pressure p, in kN/m²	Wave pressure p_W, in kN/m²
Bottom and side below the waterline: $z \le T$	$\rho g(T - z)$	$\rho g h_1 e^{\frac{-2\pi(T-z)}{L}}$
Side above the waterline: $z > T$	0	$\rho g(T + h_1 - z)$ without being taken less than 0,15L
Exposed deck	Pressure due to the load carried **(1)**	$17{,}5n\varphi$

(1) The pressure due to the load carried is to be defined by the Designer and, in any case, it may not be taken less than 10φ kN/m², where φ is defined in Tab 3.
The Society may accept pressure values lower than 10φ kN/m² when considered appropriate on the basis of the intended use of the deck.

Note 1:

φ : Coefficient defined in Tab 3.

Table 3 : Coefficient for pressure on exposed deck

Exposed deck location	φ
Freeboard deck	1
Superstructure deck	0,75
1st tier of deckhouse	0,56
2nd tier of deckhouse	0,42
3rd tier of deckhouse	0,32
4th tier of deckhouse and above	0,25

Table 4 : Still water and wave internal pressures due to liquids

Still water pressure p_S, in kN/m²	Inertial pressure p_W, in kN/m²
$\rho g(z_L - z)$	$\rho a_{Z1}(z_{TOP} - z)$

Note 1:
z_{TOP} : Z co-ordinate, in m, of the highest point of the tank
z_L : Z co-ordinate, in m, of the highest point of the liquid:
$$z_L = z_{TOP} + 0,5(z_{AP} - z_{TOP})$$
z_{AP} : Z co-ordinate, in m, of the moulded deck line of the deck to which the air pipes extend, to be taken not less than z_{TOP}.

Table 5 : Still water and inertial internal pressures due to uniform loads

Still water pressure p_S, in kN/m²	Inertial pressure p_W, in kN/m²
The value of p_S is, in general, defined by the Designer: in any case it may not be taken less than 10 kN/m². When the value of p_S is not defined by the Designer, it may be taken, in kN/m², equal to 6,9 h_{TD}, where h_{TD} is the compartment 'tweendeck height at side, in m	$p_S \dfrac{a_{Z1}}{g}$

In way of and near the rudder post, propeller post and rudder horn, floors are to be extended up to the peak tank top and are to be increased in thickness; the increase will be considered by the Society on a case by case basis, depending on the arrangement proposed.

Floors are to be fitted with stiffeners having spacing not greater than 800 mm.

3.1.3 Side frames

Side frames are to be extended up to a deck located above the full load waterline.

Side frames are to be supported by one of the following types of structure:

- non-tight platforms, to be fitted with openings having a total area not less than 10% of the area of the platforms
- side girders supported by side primary supporting members connected to deck transverses.

The distance between the above side frame supports is to be not greater than 2,5 m.

3.1.4 Platforms and side girders

Platforms and side girders within the peak are to be arranged in line with those located in the area immediately forward.

Where this arrangement is not possible due to the shape of the hull and access needs, structural continuity between the peak and the structures of the area immediately forward is to be ensured by adopting wide tapering brackets.

Where the after peak is adjacent to a machinery space whose side is longitudinally framed, the side girders in the after peak are to be fitted with tapering brackets.

3.1.5 Longitudinal bulkheads

A longitudinal non-tight bulkhead is to be fitted on the centreline of the ship, in general in the upper part of the peak, and stiffened at each frame spacing.

Where either the stern overhang is very large or the maximum breadth of the peak is greater than 20 m, additional longitudinal wash bulkheads may be required.

3.2 Scantlings

3.2.1 Plating and ordinary stiffeners (side frames)

The net scantlings of plating and ordinary stiffeners are to be not less than those obtained from the formulae in:

- Tab 6 for plating
- Tab 7 for ordinary stiffeners

and not less than the minimum values in the same tables.

3.2.2 Floors

The net thickness of floors is to be not less than that obtained, in mm, from the following formula:

$t_M = 6,5 + 0,023\ L_1\ k^{1/2}$

3.2.3 Side transverses

The net section modulus w, in cm³, and the net shear sectional area A_{SH}, in cm², of side transverses are to be not less than the values obtained from the following formulae:

$$w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2}\lambda_{bS} p_S + \gamma_{W2}\lambda_{bW} p_W}{8R_y} s\ell^2 10^3$$

$$A_{Sh} = 10\gamma_R \gamma_m \beta_s \frac{\gamma_{S2}\lambda_{sS} p_S + \gamma_{W2}\lambda_{sW} p_W}{R_y} s\ell$$

3.2.4 Side girders

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

$$w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{8R_y} s\ell^2 10^3$$

$$A_{Sh} = 10\gamma_R \gamma_m \beta_s \frac{\gamma_{S2} p_S + \gamma_{W2} p_W}{R_y} s\ell$$

3.2.5 Deck primary supporting members *(1/7/2002)*

Scantlings of deck primary supporting members are to be in accordance with Ch 7, Sec 3, considering the loads in [2.3].

The partial safety factors to be used are those defined in Ch 7, Sec 3, [1.3].

Table 6 : Net thickness of plating *(1/7/2002)*

Plating location	Net thickness, in mm	Net minimum thickness, in mm
Bottom, side and transom	$14,9c_a c_r s\sqrt{\gamma_R\gamma_m\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}}$	$t = c_F(0,038L+7,0)(sk)^{1/2}-c_E$
Inner bottom		$2 + 0,017\ L\ k^{1/2} + 4,5\ s$
Deck		For strength deck: $2,1 + 0,013\ L\ k^{1/2} + 4,5\ s$
Platform and wash bulkhead		$1,3 + 0,004\ L\ k^{1/2} + 4,5\ s$ for $L < 120$ m $2,1 + 2,2\ k^{1/2} + s$ for $L \geq 120$ m

Table 7 : Net scantlings of ordinary stiffeners

Ordinary stiffener location	Formulae	Minimum value
Bottom and side	Net section modulus, in cm³: $w = \gamma_R\gamma_m\beta_b\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{8R_y}\left(1-\frac{s}{2\ell}\right)s\ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1,5L_2^{1/3}k^{1/6}$ • the thickness of the attached plating.
	Net shear sectional area, in cm²: $A_{Sh} = 10\gamma_R\gamma_m\beta_s\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}\left(1-\frac{s}{2\ell}\right)s\ell$	
Deck	Net section modulus, in cm³: $w = \gamma_R\gamma_m\beta_b\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{mR_y}\left(1-\frac{s}{2\ell}\right)s\ell^2 10^3$	
	Net shear sectional area, in cm²: $A_{Sh} = 10\gamma_R\gamma_m\beta_s\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}\left(1-\frac{s}{2\ell}\right)s\ell$	
Platform and wash bulkhead	Net section modulus, in cm³: $w = 3,5s\ell^2k(z_{TOP}-z_M)$	

Note 1:

m : Boundary coefficient, to be taken equal to:
- m = 12 for longitudinally framed decks
- m = 8 for transversely framed decks

Z_{TOP} : Z co-ordinate, in m, of the highest point of the peak tank

Z_M : Z co-ordinate, in m, of the stiffener mid-span.

4 Reinforcements of the flat area of the bottom aft

4.1 General

4.1.1 In the flat area of the bottom aft, if any, increased bottom plating thickness as well as additional bottom stiffeners may be considered by the Society on a case by case basis.

5 Connection of hull structures with the rudder horn

5.1 Connection of after peak structures with the rudder horn

5.1.1 General

The requirement of this sub-article apply to the connection between peak structure and rudder horn where the sternframe is of an open type and is fitted with the rudder horn.

5.1.2 Rudder horn

Horn design is to be such as to enable sufficient access for welding and inspection.

The scantlings of the rudder horn, which are to comply with Ch 10, Sec 1, [9.2], may be gradually tapered inside the hull.

Connections by slot welds are not acceptable.

5.1.3 Hull structures

Between the horn intersection with the shell and the peak tank top, the vertical extension of the hull structures is to be not less than the horn height, defined as the distance from the horn intersection with the shell to the mid-point of the lower horn gudgeon.

The thickness of the structures adjacent to the rudder horn, such as shell plating, floors, platforms and side girders, the centreline bulkhead and any other structures, is to be adequately increased in relation to the horn scantlings.

5.2 Structural arrangement above the after peak

5.2.1 Side transverses

Where a rudder horn is fitted, side transverses, connected to deck beams, are to be arranged between the platform forming the peak tank top and the weather deck.

The side transverse spacing is to be not greater than:

- 2 frame spacings in way of the horn
- 4 frame spacings for and aft of the rudder horn
- 6 frame spacings in the area close to the after peak bulkhead.

The side transverses are to be fitted with end brackets and located within the poop. Where there is no poop, the scantlings of side transverses below the weather deck are to be adequately increased with respect to those obtained from the formulae in [3.2.3].

5.2.2 Side girders

Where the depth from the peak tank top to the weather deck is greater than 2,6 m and the side is transversely framed, one or more side girders are to be fitted, preferably in line with similar structures existing forward.

6 Sternframes

6.1 General

6.1.1 Sternframes may be made of cast or forged steel, with a hollow section, or fabricated from plate.

6.1.2 Cast steel and fabricated sternframes are to be strengthened by adequately spaced horizontal plates.

Abrupt changes of section are to be avoided in castings; all sections are to have adequate tapering radius.

6.2 Connections

6.2.1 Connection with hull structure

Sternframes are to be effectively attached to the aft structure and the lower part of the sternframe is to be extended forward of the propeller post to a length not less than 1500 + 6L mm, in order to provide an effective connection with the keel. However, the sternframe need not extend beyond the after peak bulkhead.

The net thickness of shell plating connected with the sternframe is to be not less than that obtained, in mm, from the following formula:

$$t = 0{,}045\ L\ k^{1/2} + 8{,}5$$

6.2.2 Connection with the keel

The thickness of the lower part of the sternframes is to be gradually tapered to that of the solid bar keel or keel plate.

Where a keel plate is fitted, the lower part of the sternframe is to be so designed as to ensure an effective connection with the keel.

6.2.3 Connection with transom floors

Rudder posts and, in the case of ships greater than 90 m in length, propeller posts are to be connected with transom floors having height not less than that of the double bottom and net thickness not less than that obtained, in mm, from the following formula:

$$t = 9 + 0{,}023\ L_1\ k^{1/2}$$

6.2.4 Connection with centre keelson

Where the sternframe is made of cast steel, the lower part of the sternframe is to be fitted, as far as practicable, with a longitudinal web for connection with the centre keelson.

6.3 Propeller posts

6.3.1 Gross scantlings

With reference to Ch 4, Sec 2, [1], all scantlings and dimensions referred to in [6.3.2] to [6.3.4] are gross, i.e. they include the margins for corrosion.

6.3.2 Gross scantlings of propeller posts

The gross scantlings of propeller posts are to be not less than those obtained from the formulae in Tab 8 for single screw ships and Tab 9 for twin screw ships.

Scantlings and proportions of the propeller post which differ from those above may be considered acceptable provided that the section modulus of the propeller post section about its longitudinal axis is not less than that calculated with the propeller post scantlings in Tab 8 or Tab 9, as applicable.

6.3.3 Section modulus below the propeller shaft bossing

In the case of a propeller post without a sole piece, the section modulus of the propeller post may be gradually reduced below the propeller shaft bossing down to 85% of the value calculated with the scantlings in Tab 8 or Tab 9, as applicable.

In any case, the thicknesses of the propeller posts are to be not less than those obtained from the formulae in the tables.

6.3.4 Welding of fabricated propeller post with the propeller shaft bossing

Welding of a fabricated propeller post with the propeller shaft bossing is to be in accordance with Ch 12, Sec 1, [3.3].

6.4 Integral rudder posts

6.4.1 Net section modulus of integral rudder post

The net section modulus around the horizontal axis X (see Fig 1) of an integral rudder post is to be not less than that obtained, in cm^3, from the following formula:

$$w_{RP} = 14{,}4\ C_R\ L_D\ 10^{-6}$$

where:

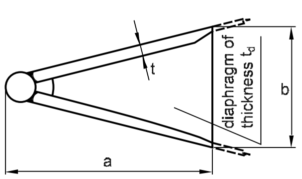
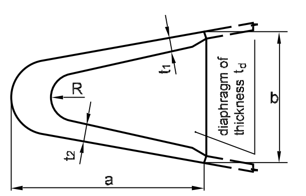
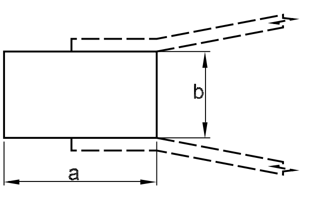
C_R : Rudder force, in N, acting on the rudder blade, defined in Ch 10, Sec 1, [2.1.2] and Ch 10, Sec 1, [2.2.2], as the case may be

L_D : Length of rudder post, in m.

6.5 Propeller shaft bossing

6.5.1 In single screw ships, the thickness of the propeller shaft bossing, included in the propeller post, is to be not less than 60% of the dimension "b" required in [6.3.2] for bar propeller posts with a rectangular section.

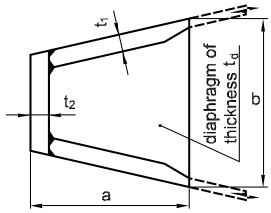
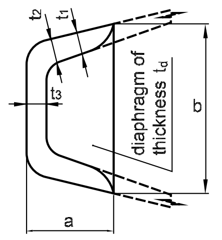
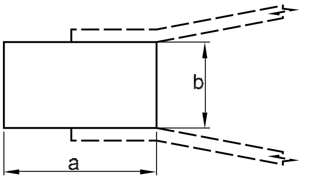
Table 8 : Single screw ships - Gross scantlings of propeller posts *(1/7/2008)*

Gross scantlings of propeller posts, in mm	**Fabricated propeller post** 	**Cast propeller post** 	**Bar propeller post, cast or forged, having rectangular section** 
a	$50\ L^{1/2}$	$33\ L^{1/2}$	$10 \cdot \sqrt{2{,}5(L+10)}$ for $L \le 60$ $10 \cdot \sqrt{7{,}2L-256}$ for $L > 60$
b	$35\ L^{1/2}$	$23\ L^{1/2}$	$10 \cdot \sqrt{1{,}6(L+10)}$ for $L \le 60$ $10 \cdot \sqrt{4{,}6L-164}$ for $L > 60$
t_1 **(1)**	$2{,}5\ L^{1/2}$	$3{,}2\ L^{1/2}$ to be taken not less than 19 mm	ϕ
t_2 **(1)**	ϕ	$4{,}4\ L^{1/2}$ to be taken not less than 19 mm	ϕ
t_D	$1{,}3\ L^{1/2}$	$2{,}0\ L^{1/2}$	ϕ
R	ϕ	50	ϕ

(1) Propeller post thicknesses t_1 and t_2 are, in any case, to be not less than (0,05 L + 9,5) mm.

Note 1: ϕ = not applicable.

Table 9 : Twin screw ships - Gross scantlings of propeller posts

Gross scantlings of propellerposts, in mm	**Fabricated propeller post** 	**Cast propeller post** 	**Bar propeller post, cast or forged, having rectangular section** 
a	25 $L^{1/2}$	12,5 $L^{1/2}$	0,72 L + 90 for $L \leq 50$ 2,40 L + 6 for $L > 50$
b	25 $L^{1/2}$	25 $L^{1/2}$	0,24 L + 30 for $L \leq 50$ 0,80 L + 2 for $L > 50$
t_1 **(1)**	2,5 $L^{1/2}$	2,5 $L^{1/2}$	ϕ
t_2 **(1)**	3,2 $L^{1/2}$	3,2 $L^{1/2}$	ϕ
t_3 **(1)**	ϕ	4,4 $L^{1/2}$	ϕ
t_D	1,3 $L^{1/2}$	2 $L^{1/2}$	ϕ

(1) Propeller post thicknesses t_1, t_2 and t_3 are, in any case, to be not less than (0,05 L + 9,5) mm.
Note 1: ϕ = not applicable.

6.6 Rudder gudgeon

6.6.1 Rudder gudgeons

In general, gudgeons are to be solidly forged or cast with the sternframe.

The height of the gudgeon is to be not greater than 1,2 times the pintle diameter. In any case, the height and diameter of the gudgeons are to be suitable to house the rudder pintle.

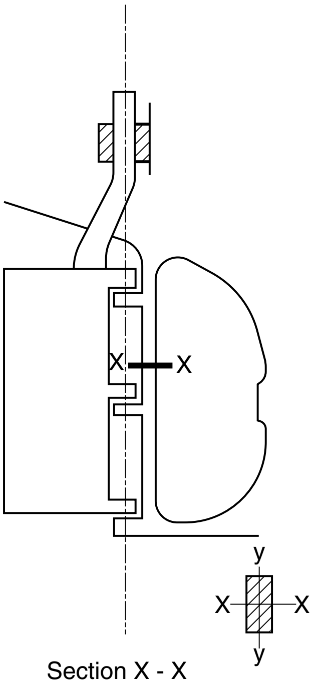
The thickness of the metal around the finished bore of the gudgeons is to be not less than half the diameter of the pintle.

6.7 Sterntubes

6.7.1 The sterntube thickness is considered by the Society on a case by case basis. In no case, however, may it be less than the thickness of the side plating adjacent to the sternframe.

Where the materials adopted for the sterntube and the plating adjacent to the sternframe are different, the sterntube thickness is to be at least equivalent to that of the plating.

Figure 1 : Integral rudder post



SECTION 3 MACHINERY SPACE

Symbols

L_2 : Length, in m, defined in Ch 1, Sec 2, [2.1.1]

k : Material factor, defined in Ch 4, Sec 1, [2.3]

s : Spacing, in m, of ordinary stiffeners

P : Maximum power, in kW, of the engine

n_r : Number of revolutions per minute of the engine shaft at power equal to P

L_E : Effective length, in m, of the engine foundation plate required for bolting the engine to the seating, as specified by the engine manufacturer.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the arrangement and scantling of machinery space structures as regards general strength. It is no substitute to machinery manufacturer's requirements which have to be dealt with at Shipyard diligence.

1.2 Scantlings

1.2.1 Net scantlings

As specified in 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 Ch 4, Sec 2.

1.2.2 General

Unless otherwise specified in this Section, the scantlings of plating, ordinary stiffeners and primary supporting members in the machinery space are to be determined according to the relevant criteria in Chapter 7 or Chapter 8, as applicable. In addition, the minimum thickness requirements specified in this Section apply.

1.2.3 Primary supporting members

The Designer may propose arrangements and scantlings alternative to the requirements of this Section, on the basis of direct calculations which are to be submitted to the Society for examination on a case by case basis.

The Society may also require such direct calculations to be carried out whenever deemed necessary.

1.3 Connections of the machinery space with structures located aft and forward

1.3.1 Tapering

Adequate tapering is to be ensured between the scantlings in the machinery space and those aft and forward. The tapering is to be such that the scantling requirements for all areas are fulfilled.

1.3.2 Deck discontinuities

Decks which are interrupted in the machinery space are to be tapered on the side by means of horizontal brackets.

2 Double bottom

2.1 Arrangement

2.1.1 General

Where the machinery space is immediately forward of the after peak, the double bottom is to be transversely framed. In all other cases it may be transversely or longitudinally framed.

2.1.2 Double bottom height

The double bottom height at the centreline, irrespective of the location of the machinery space, is to be not less than the value defined in Ch 4, Sec 4, [4.2.1]. This depth may need to be considerably increased in relation to the type and depth of main machinery seatings.

The above height is to be increased by the Shipyard where the machinery space is very large and where there is a considerable variation in draught between light ballast and full load conditions.

Where the double bottom height in the machinery space differs from that in adjacent spaces, structural continuity of longitudinal members is to be ensured by sloping the inner bottom over an adequate longitudinal extent. The knuckles in the sloped inner bottom are to be located in way of floors.

2.1.3 Centre bottom girder

In general, the centre bottom girder may not be provided with holes. In any case, in way of any openings for manholes on the centre girder, permitted only where absolutely necessary for double bottom access and maintenance, local strengthening is to be arranged.

2.1.4 Side bottom girders

In the machinery space the number of side bottom girders is to be adequately increased, with respect to the adjacent areas, to ensure adequate rigidity of the structure.

The side bottom girders are to be a continuation of any bottom longitudinals in the areas adjacent to the machinery space and are generally to have a spacing not greater than 3 times that of longitudinals and in no case greater than 3 m.

2.1.5 Side bottom girders in way of machinery seatings

Additional side bottom girders are to be fitted in way of machinery seatings.

Side bottom girders arranged in way of main machinery seatings are to extend for the full length of the machinery space.

Where the machinery space is situated amidships, the bottom girders are to extend aft of the after bulkhead of such space for at least three frame spaces, and beyond to be connected to the hull structure by tapering.

Where the machinery space is situated aft, the bottom girders are to extend as far aft as practicable in relation to the shape of the bottom and to be supported by floors and side primary supporting members at the ends.

Forward of the machinery space forward bulkhead, the bottom girders are to be tapered for at least three frame spaces and are to be effectively connected to the hull structure.

2.1.6 Floors in longitudinally framed double bottom

Where the double bottom is longitudinally framed, the floor spacing is to be not greater than:

- 1 frame spacing in way of the main engine and thrust bearing
- 2 frame spacings in other areas of the machinery space.

Additional floors are to be fitted in way of other important machinery.

2.1.7 Floors in transversely framed double bottom

Where the double bottom in the machinery space is transversely framed, floors are to be arranged at every frame.

Furthermore, additional floors are to be fitted in way of boiler foundations or other important machinery.

2.1.8 Floors stiffeners

In addition to the requirements in Ch 4, Sec 3, [4.7], floors are to have web stiffeners sniped at the ends and spaced not more than approximately 1 m apart.

The section modulus of web stiffeners is to be not less than 1,2 times that required in Ch 4, Sec 3, [4.7].

2.1.9 Manholes and wells

The number and size of manholes in floors located in way of seatings and adjacent areas are to be kept to the minimum necessary for double bottom access and maintenance.

The depth of manholes is generally to be not greater than 40% of the floor local depth, and in no case greater than 750 mm, and their width is to be equal to approximately 400 mm.

In general, manhole edges are to be stiffened with flanges; failing this, the floor plate is to be adequately stiffened with flat bars at manhole sides.

Manholes with perforated portable plates are to be fitted in the inner bottom in the vicinity of wells arranged close to the aft bulkhead of the engine room.

Drainage of the tunnel is to be arranged through a well located at the aft end of the tunnel.

2.2 Minimum thicknesses

2.2.1 The net thicknesses of inner bottom, floor and girder webs are to be not less than the values given in Tab 1.

3 Single bottom

3.1 Arrangement

3.1.1 Bottom girder

For single bottom girder arrangement, the requirements of Ch 4, Sec 4, [4.1] and Ch 4, Sec 4, [4.4] for double bottom apply.

3.1.2 Floors in longitudinally framed single bottom

Where the single bottom is longitudinally framed, the floor spacing is to be not greater than:

- 1 frame spacing in way of the main engine and thrust bearing
- 2 frame spacings in other areas of the machinery spaces.

Additional floors are to be fitted in way of other important machinery.

Table 1 : Double bottom - Minimum net thicknesses of inner bottom, floor and girder webs

Element	Minimum net thickness, in mm	
	Machinery space within 0,4L amidships	Machinery space outside 0,4L amidships
Inner bottom	$[0,75L^{1/2} + 1,35 + 4,5(s - 0,23L^{1/4})]k^{1/2}$ The Society may require the thickness of the inner bottom in way of the main machinery seatings and on the main thrust blocks to be increased, on a case by case basis.	
Margin plate	$L^{1/2} k^{1/4} + 1$	$0,9 L^{1/2} k^{1/4} + 1$
Centre girder	$1,8 L^{1/3} k^{1/6} + 4$	$1,55 L^{1/3} k^{1/6} + 3,5$
Floors and side girders	$1,7 L^{1/3} k^{1/6} + 1$	
Girder bounding a duct keel	$0,8 L^{1/2} k^{1/4} + 2,5$ to be taken not less than that required for the centre girder	

3.1.3 Floors in transversely framed single bottom

Where the single bottom is transversely framed, the floors are to be arranged at every frame.

Furthermore, additional floors are to be fitted in way of boiler foundations or other important machinery.

3.1.4 Floor height

The height of floors in way of machinery spaces located amidships is to be not less than B/14,5. Where the top of the floors is recessed in way of main machinery, the height of the floors in way of this recess is generally to be not less than B/16. Lower values will be considered by the Society on a case by case basis.

Where the machinery space is situated aft or where there is considerable rise of floor, the depth of the floors will be considered by the Society on a case by case basis.

3.1.5 Floor flanging

Floors are to be fitted with welded face plates in way of:

- engine bed plates
- thrust blocks
- auxiliary seatings.

3.2 Minimum thicknesses

3.2.1 The net thicknesses of inner bottom, floor and girder webs are to be not less than the values given in Tab 2.

Table 2 : Single bottom - Minimum net thicknesses of inner bottom, floor and girder webs

Element	Minimum net thickness, in mm	
	Machinery space within 0,4L amidships	Machinery space outside 0,4L amidships
Centre girder	$7 + 0,05\ L_2\ k^{1/2}$	$6 + 0,05\ L_2\ k^{1/2}$
Floors and side girder	$6,5 + 0,05\ L_2\ k^{1/2}$	$5 + 0,05\ L_2\ k^{1/2}$

4 Side

4.1 Arrangement

4.1.1 General

The type of side framing in machinery spaces is generally to be the same as that adopted in the adjacent areas.

4.1.2 Extension of the hull longitudinal structure within the machinery space

In ships where the machinery space is located aft and where the side is longitudinally framed, the longitudinal structure is preferably to extend for the full length of the machinery space.

In any event, the longitudinal structure is to be maintained for at least 0,3 times the length of the machinery space, calculated from the forward bulkhead of the latter, and abrupt structural discontinuities between longitudinally and transversely framed structures are to be avoided.

4.1.3 Side transverses

Side transverses are to be aligned with floors. One is preferably to be located in way of the forward end and another in way of the after end of the machinery casing.

For a longitudinally framed side, the side transverse spacing is to be not greater than 4 frame spacings.

For a transversely framed side, the side transverse spacing is to be not greater than 5 frame spaces. The web height is to be not less than twice that of adjacent frames and the section modulus is to be not less than four times that of adjacent frames.

Side transverse spacing greater than that above may be accepted provided that the scantlings of ordinary frames are increased, according to the Society's requirements to be defined on a case by case basis.

5 Platforms

5.1 Arrangement

5.1.1 General

The location and extension of platforms in machinery spaces are to be arranged so as to be a continuation of the structure of side longitudinals, as well as of platforms and side girders located in the adjacent hull areas.

5.1.2 Platform transverses

In general, platform transverses are to be arranged in way of side or longitudinal bulkhead transverses.

For longitudinally framed platforms, the spacing of platform transverses is to be not greater than 4 frame spacings.

5.2 Minimum thicknesses

5.2.1 The net thickness of platforms is to be not less than that obtained, in mm, from the following formula:

$$t = 0,018L_2k^{1/2} + 4,5$$

6 Pillaring

6.1 Arrangement

6.1.1 General

The pillaring arrangement in machinery spaces is to account both for the concentrated loads transmitted by machinery and superstructures and for the position of main machinery and auxiliary engines.

6.1.2 Pillars

Pillars are generally to be arranged in the following positions:

- in way of machinery casing corners and corners of large openings on platforms; alternatively, two pillars may be fitted on the centreline (one at each end of the opening)
- in way of the intersection of platform transverses and girders
- in way of transverse and longitudinal bulkheads of the superstructure.

In general, pillars are to be fitted with brackets at their ends.

6.1.3 Pillar bulkheads

In general, pillar bulkheads, fitted ‘tweendecks below the upper deck, are to be located in way of load-bearing bulkheads in the superstructures.

Longitudinal pillar bulkheads are to be a continuation of main longitudinal hull structures in the adjacent spaces forward and aft of the machinery space.

Pillar bulkhead scantlings are to be not less than those required in [7.3] for machinery casing bulkheads.

7 Machinery casing

7.1 Arrangement

7.1.1 Ordinary stiffener spacing

Ordinary stiffeners are to be located:

- at each frame, in longitudinal bulkheads
- at a distance of about 750 mm, in transverse bulkheads.

The ordinary stiffener spacing in portions of casings which are particularly exposed to wave action is considered by the Society on a case by case basis.

7.2 Openings

7.2.1 General

All machinery space openings, which are to comply with the requirements in Sec 9, [6], are to be enclosed in a steel casing leading to the highest open deck. Casings are to be reinforced at the ends by deck beams and girders associated to pillars.

In the case of large openings, the arrangement of cross-ties as a continuation of deck beams may be required.

Skylights, where fitted with openings for light and air, are to have coamings of a height not less than:

- 900 mm, if in position 1
- 760 mm, if in position 2.

7.2.2 Access doors

Access doors to casings are to comply with Sec 9, [6.2].

7.3 Scantlings

7.3.1 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than those obtained according to the applicable requirements in Sec 4.

7.3.2 Minimum thicknesses

The net thickness of bulkheads is to be not less than:

- 5,5 mm for bulkheads in way of cargo holds
- 4 mm for bulkheads in way of accommodation spaces.

8 Main machinery seatings

8.1 Arrangement

8.1.1 General

The scantlings of main machinery seatings and thrust bearings are to be adequate in relation to the weight and power of engines and the static and dynamic forces transmitted by the propulsive installation.

8.1.2 Seating supporting structure

Transverse and longitudinal members supporting the seatings are to be located in line with floors and double or single bottom girders, respectively.

They are to be so arranged as to avoid discontinuity and ensure sufficient accessibility for welding of joints and for surveys and maintenance.

8.1.3 Seatings included in the double bottom structure

Where high-power internal combustion engines or turbines are fitted, seatings are to be integral with the double bottom structure. Girders supporting the bedplates in way of seatings are to be aligned with double bottom girders and are to be extended aft in order to form girders for thrust blocks.

The girders in way of seatings are to be continuous from the bedplates to the bottom shell.

8.1.4 Seatings above the double bottom plating

Where the seatings are situated above the double bottom plating, the girders in way of seatings are to be fitted with flanged brackets, generally located at each frame and extending towards both the centre of the ship and the sides.

The extension of the seatings above the double bottom plating is to be limited as far as practicable while ensuring adequate spaces for the fitting of bedplate bolts. Bolt holes are to be located such that they do not interfere with seating structures.

8.1.5 Seatings in a single bottom structure

For ships having a single bottom structure within the machinery space, seatings are to be located above the floors and to be adequately connected to the latter and to the girders located below.

8.1.6 Number of girders in way of machinery seatings

In general, at least two girders are to be fitted in way of main machinery seatings.

One girder may be fitted only where the following three formulae are complied with:

$$L < 150\,m$$

$$P < 7100\,kW$$

$$P < 2{,}3 n_R L_E$$

8.2 Minimum scantlings

8.2.1 *(1/7/2002)*

As a guidance, the net scantlings of the structural elements in way of the internal combustion engine seatings may be obtained from the formulae in Tab 3.

Table 3 : Minimum scantlings of the structural elements in way of machinery seatings

Scantling	Minimum value
Net cross-sectional area, in cm², of each bedplate of the seatings	$40 + 70\dfrac{P}{n_r L_E}$
Bedplate net thickness, in mm	• Bedplates supported by two or more girders: $\sqrt{240 + 175\dfrac{P}{n_r L_E}}$ • Bedplates supported by one girder: $5 + \sqrt{240 + 175\dfrac{P}{n_r L_E}}$
Total web net thickness, in mm, of girders fitted in way of machinery seatings	• Bedplates supported by two or more girders: $\sqrt{320 + 215\dfrac{P}{n_r L_E}}$ • Bedplates supported by one girder: $\sqrt{95 + 65\dfrac{P}{n_r L_E}}$
Web net thickness, in mm, of floors fitted in way of machinery seatings	$\sqrt{55 + 40\dfrac{P}{n_r L_E}}$

SECTION 4 SUPERSTRUCTURES AND DECKHOUSES

Symbols

x, y, z : X, Y and Z co-ordinates, in m, of the calculation point with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [4]

s : Spacing, in m, of ordinary stiffeners

k : Material factor, defined in:
- Ch 4, Sec 1, [2.3], for steel
- Ch 4, Sec 1, [4.4], for aluminium alloys

t_c : Corrosion addition, in mm, defined in Ch 4, Sec 2, Tab 2.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the scantling of plating and associated structures of front, side and aft bulkheads and decks of superstructures and deckhouses, which may or may not contribute to the longitudinal strength.

1.1.2 The requirements of this Section comply with the applicable regulations of the 1966 International Convention on Load Lines, with regard to the strength of enclosed superstructures.

1.2 Net scantlings

1.2.1 As specified in 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 Ch 4, Sec 2.

1.3 Definitions

1.3.1 Superstructures and deckhouses contributing to the longitudinal strength

Superstructures and deckhouses contributing to the longitudinal strength are defined in Ch 6, Sec 1, [2.2].

1.3.2 Tiers of superstructures and deckhouses

The lowest tier is normally that which is directly situated above the freeboard deck.

Where the freeboard exceeds one standard superstructure height, defined in Ch 1, Sec 2, Tab 2 for “all other superstructures”, the lowest tier may be considered as an upper tier when calculating the scantlings of superstructures and deckhouses.

The second tier is that located immediately above the lowest tier, and so on.

1.4 Connections of superstructures and deckhouses with the hull structure

1.4.1 Superstructure and deckhouse frames are to be fitted as far as practicable as extensions of those underlying and are to be effectively connected to both the latter and the deck beams above.

Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, diaphragms, webs or pillars.

Where hatchways are fitted close to the ends of superstructures, additional strengthening may be required.

1.4.2 Connection to the deck of corners of superstructures and deckhouses is considered by the Society on a case by case basis. Where necessary, doublers or reinforced welding may be required.

1.4.3 As a rule, the frames of sides of superstructures and deckhouses are to have the same spacing as the beams of the supporting deck.

Web frames are to be arranged to support the sides and ends of superstructures and deckhouses.

1.4.4 The side plating at ends of superstructures is to be tapered into the bulwark or sheerstrake of the strength deck.

Where a raised deck is fitted, this arrangement is to extend over at least 3 frame spacings.

1.5 Structural arrangement of superstructures and deckhouses

1.5.1 Strengthening in way of superstructures and deckhouses

Web frames, transverse partial bulkheads or other equivalent strengthening are to be fitted inside deckhouses of at least 0,5B in breadth extending more than 0,15L in length within 0,4L amidships. These transverse strengthening reinforcements are to be spaced approximately 9 m apart and are to be arranged, where practicable, in line with the transverse bulkheads below.

Web frames are also to be arranged in way of large openings, boats davits and other areas subjected to point loads.

Web frames, pillars, partial bulkheads and similar strengthening are to be arranged, in conjunction with deck transverses, at ends of superstructures and deckhouses.

1.5.2 Strenghtening of the raised quarter deck stringer plate

When a superstructure is located above a raised quarter deck, the thickness of the raised quarter deck stringer plate is to be increased by 30% and is to be extended within the superstructure.

The increase above may be reduced when the raised quarter deck terminates outside 0,5 L amidships.

1.5.3 Openings

Openings are to be in accordance with Sec 9.

Continuous coamings are to be fitted above and below doors or similar openings.

1.5.4 Access and doors *(1/1/2005)*

Access openings cut in sides of enclosed superstructures are to be fitted with doors made of steel or other equivalent material, and permanently attached.

Special consideration is to be given to the connection of doors to the surrounding structure.

Securing devices which ensure watertightness are to include tight gaskets, clamping dogs or other similar appliances, and are to be permanently attached to the bulkheads and doors. These doors are to be operable from both sides.

Doors are to open outwards, to provide additional security against the impact of the sea, unless otherwise permitted by the Society.

1.5.5 Strengthening of deckhouses in way of lifeboats and rescue boats

Sides of deckhouses are to be strengthened in way of lifeboats and rescue boats and the top plating is to be reinforced in way of their lifting appliances.

1.5.6 Constructional details

Lower tier stiffeners are to be welded to the decks at their ends.

Brackets are to be fitted at the upper and preferably also the lower ends of vertical stiffeners of exposed front bulkheads of engine casings and superstructures or deckhouses protecting pump room openings.

1.5.7 Use of aluminium alloys

Unprotected front bulkheads of first tier superstructures or deckhouses are generally to be built of steel and not of aluminium alloy.

Aluminium alloys may be adopted for front bulkheads of superstructures or deckhouses above the first tier.

2 Design loads

2.1 Sides contributing to the longitudinal strength

2.1.1 Load point

Lateral pressure is to be calculated at:

- the lower edge of the elementary plate panel, for plating
- mid-span, for stiffeners.

2.1.2 Lateral pressure

The lateral pressure is constituted by the still water sea pressure (p_S) and the wave pressure (p_W), defined in Ch 5, Sec 5.

Moreover, when the side is a tank boundary, the lateral pressure constituted by the still water internal pressure (p_S) and the inertial pressure (p_W), defined in Ch 5, Sec 6, [1] is also to be considered.

2.2 Front, side and aft bulkheads not contributing to the longitudinal strength

2.2.1 Load point

Lateral pressure is to be calculated at:

- mid-height of the bulkhead, for plating
- mid-span, for stiffeners.

2.2.2 Lateral pressure *(1/7/2020)*

The lateral pressure to be used for the determination of scantlings of the structure of front, side and aft bulkheads of superstructures and deckhouses is to be obtained, in kN/m², from the following formula:

$$p = 10nac[bf-(z-T)]$$

without being less than p_{min}

where:

n : Navigation coefficient, defined in Ch 5, Sec 1, [2.6]

a : Coefficient defined in Tab 1

c : Coefficient taken equal to:

$$c = 0{,}3 + 0{,}7\frac{b_1}{B_1}$$

For exposed parts of machinery casings, c is to be taken equal to 1

b_1 : Breadth of deckhouse, in m, at the position considered, to be taken not less than $0{,}25B_1$

B_1 : Actual maximum breadth of ship on the exposed weather deck, in m, at the position considered

b : Coefficient defined in Tab 2

f : Coefficient defined in Tab 3

p_{min} : Minimum lateral pressure defined in Tab 4.

2.3 Decks

2.3.1 The lateral pressure for decks which may or may not contribute to the longitudinal strength is constituted by the still water internal pressure (p_S) and the inertial pressure (p_W), defined in Ch 5, Sec 6, [7].

Moreover, when the deck is a tank boundary, the lateral pressure constituted by the still water internal pressure (p_S) and the inertial pressure (p_W), defined in Ch 5, Sec 6, [1] is also to be considered.

Table 1 : Lateral pressure for superstructures and deckhouses - Coefficient a

Type of bulkhead	Location	a	a maximum
Unprotected front	Lowest tier	$2+\frac{L}{120}$	4,5
	Second tier	$1+\frac{L}{120}$	3,5
	Third tier	$0,5+\frac{L}{150}$	2,5
	Fourth tier	$0,9\left(0,5+\frac{L}{150}\right)$	2,25
	Fifth tier and above	$0,8\left(0,5+\frac{L}{150}\right)$	2,0
Protected front	Lowest, second and third tiers	$0,5+\frac{L}{150}$	2,5
	Fourth tier	$0,9\left(0,5+\frac{L}{150}\right)$	2,25
	Fifth tier and above	$0,8\left(0,5+\frac{L}{150}\right)$	2,0
Side	Lowest, second and third tiers	$0,5+\frac{L}{150}$	2,5
	Fourth tier	$0,9\left(0,5+\frac{L}{150}\right)$	2,25
	Fifth tier and above	$0,8\left(0,5+\frac{L}{150}\right)$	2,0
Aft end	All tiers, when: x/L $\le$ 0,5	$0,7+\frac{L}{1000}-0,8\frac{x}{L}$	$1-0,8\frac{x}{L}$
	All tiers, when: x/L > 0,5	$0,5+\frac{L}{1000}-0,4\frac{x}{L}$	$0,8-0,4\frac{x}{L}$

Table 2 : Lateral pressure for superstructures and deckhouses - Coefficient b

Location of bulkhead **(1)**	b
$\frac{x}{L}\le 0,45$	$1+\left(\frac{\frac{x}{L}-0,45}{C_B+0,2}\right)^2$
$\frac{x}{L}> 0,45$	$1+1,5\left(\frac{\frac{x}{L}-0,45}{C_B+0,2}\right)^2$
(1) For deckhouse sides, the deckhouse is to be subdivided into parts of approximately equal length, not exceeding 0,15L each, and x is to be taken as the co-ordinate of the centre of each part considered. **Note 1:** C_B : Block coefficient, with $0,6 \le C_B \le 0,8$	

Table 3 : Lateral pressure for superstructures and deckhouses - Coefficient f *(1/7/2020)*

Rule Length L of ship, in m	f
L < 150	$\frac{L}{10}e^{-L/300}-\left[1-\left(\frac{L}{150}\right)^2\right]$
150 $\le$ L < 300	$\frac{L}{10}e^{-L/300}$
L $\ge$ 300	11,03

Table 4 : Lateral minimum pressure for superstructures and deckhouses *(1/7/2020)*

Type of bulkhead	Location	p_{min}, in kN/m²
Unprotected front	Lowest tier	$30 \le 25,0 + 0,10L \le 50$
	Second and third tiers	$15 \le 12,5 + 0,05L \le 25$
	Fourth and fifth tiers	Linear interpolation
	Sixth tier and above	12,5
Protected front, side and aft end	Lowest, second and third tiers	$15 \le 12,5 + 0,05L \le 25$
	Fourth and fifth tiers	Linear interpolation
	Sixth tier and above	2,5

3 Plating

3.1 Front, side and aft bulkheads

3.1.1 Plating contributing to the longitudinal strength

The net thickness of side plate panels contributing to the longitudinal strength is to be determined in accordance with the applicable requirements of Ch 7, Sec 1 or Ch 8, Sec 3, as applicable, considering the lateral pressure defined in [2.1.2].

3.1.2 Plating not contributing to the longitudinal strength

The net thickness of plating of front, side and aft bulkheads not contributing to the longitudinal strength is to be not less than the value obtained, in mm, from the following formula:

$$t = 0,95s\sqrt{kp} - t_c$$

without being less than the values indicated in Tab 5, where p is the lateral pressure, in kN/m², defined in [2.2].

For plating which forms tank boundaries, the net thickness is to be determined in accordance with [3.1.1], considering the hull girder stress equal to 0.

3.2 Decks

3.2.1 The net thickness of plate panels of decks which may or may not contribute to the longitudinal strength is to be determined in accordance with the applicable requirements of Ch 7, Sec 1 or Ch 8, Sec 3, as applicable.

Table 5 : Superstructures and deckhouses Minimum thicknesses *(1/1/2022)*

Location	Minimum thickness, in mm
Lowest tier	$(5 + 0,01\ L)\ k^{1/2} - t_C$
Second tier and above	$(4 + 0,01\ L)\ k^{1/2} - t_C$
Note 1: L is to be taken not less than 100m and not greater than 300m. **Note 2:** For aluminum superstructures, it is possible to evaluate the minimum thickness on a case-by-case basis taking into account the type and tier level of the superstructure, the position of the superstructure (front, lateral, aft), the spacing of the ordinary stiffeners, the navigation and service notations of the ship.	

3.2.2 For decks sheathed with wood, the net thickness obtained from [3.2.1] may be reduced by 10 percent.

4 Ordinary stiffeners

4.1 Front, side and aft bulkheads

4.1.1 Ordinary stiffeners of plating contributing to the longitudinal strength

The net scantlings of ordinary stiffeners of plating contributing to the longitudinal strength are to be determined in accordance with the applicable requirements of Ch 7, Sec 2 or Ch 8, Sec 4, as applicable.

4.1.2 Ordinary stiffeners of plating not contributing to the longitudinal strength

The net section modulus w of ordinary stiffeners of plating not contributing to the longitudinal strength is to be not less than the value obtained, in cm^3, from the following formula:

$$w = 0{,}35\varphi k s \ell^2 p(1 - \alpha t_c) - \beta t_c$$

where:

- ℓ : Span of the ordinary stiffener, in m, equal to the 'tweendeck height and to be taken not less than 2 m
- p : Lateral pressure, in kN/m^2, defined in [2.2]
- φ : Coefficient depending on the stiffener end connections, and taken equal to:
  - 1 for lower tier stiffeners
  - value defined in Tab 6 for stiffeners of upper tiers
- α, β : Parameters defined in Ch 4, Sec 2, Tab 1.

The section modulus of side ordinary stiffeners need not be greater than that of the side ordinary stiffeners of the tier situated directly below taking account of spacing and span.

For ordinary stiffeners of plating forming tank boundaries, the net scantlings are to be determined in accordance with [4.1.1], considering the hull girder stress equal to 0.

Table 6 : Stiffeners of superstructures and deckhouses - Coefficient φ for end connections

Coefficient φ	Upper end welded to deck	Bracketed upper end	Sniped upper end
Lower end welded to deck	1,00	0,85	1,15
Bracketed lower end	0,85	0,85	1,00
Sniped lower end	1,15	1,00	1,15

4.1.3 Minimum section modulus of stiffeners *(1/7/2020)*

The minimum net section modulus, in cm^3, of stiffeners used for deckhouse and superstructure is to in any case not be less than:

$$w_{min} = 2{,}4\varphi k s \ell^2$$

4.2 Decks

4.2.1 The net scantlings of ordinary stiffeners of decks which may or may not contribute to the longitudinal strength are to be determined in accordance with the applicable requirements of Ch 7, Sec 2.

5 Primary supporting members

5.1 Front, side and aft bulkheads

5.1.1 Primary supporting members of plating contributing to the longitudinal strength

The net scantlings of side primary supporting members of plating contributing to the longitudinal strength are to be determined in accordance with the applicable requirements of Ch 7, Sec 3 or Ch 8, Sec 5, as applicable.

5.1.2 Primary supporting members of plating not contributing to the longitudinal strength

The net scantlings of side primary supporting members of plating not contributing to the longitudinal strength are to be determined in accordance with the applicable requirements of Ch 7, Sec 3 or Ch 8, Sec 5, as applicable, using the lateral pressure defined in [2.2].

5.2 Decks

5.2.1 The net scantlings of primary supporting members of decks which may or may not contribute to the longitudinal strength are to be determined in accordance with the applicable requirements of Ch 7, Sec 3.

6 Additional requirements applicable to movable wheelhouses

6.1 General

6.1.1 The requirements of this Article apply in addition of those in [1] to [5].

6.1.2 The structures of movable wheelhouses are to be checked in low and in high position.

6.1.3 Mechanical locking devices are to be fitted in addition to hydraulic systems.

6.2 Supports and guides, connections with the deck, under deck reinforcements, locking devices

6.2.1 Still water and inertial forces

The supports or guides of movable wheelhouses, connections with the deck, under deck reinforcements and locking devices are to be checked considering the sum of the following forces:

- still water and inertial forces, determined according to Ch 5, Sec 6, [5]
- wind forces, corresponding to a lateral pressure of 1,2kN/m^2.

6.2.2 Checking criteria

It is to be checked that the equivalent stress σ_{VM}, calculated according to Ch 7, App 1, [5.1.2] or Ch 7, App 1, [5.2.2], as applicable, is in compliance with the following formula:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma_{VM}$$

where:

R_y : Minimum yield stress, in N/mm^2, of the material, to be taken equal to 235/k, unless otherwise specified

γ_R : Partial safety factor covering uncertainties regarding resistance, to be taken equal to:

- 1,10 in general
- 1,40 for checking locking devices

γ_m : Partial safety factor covering uncertainties regarding material, to be taken equal to 1,02.

SECTION 5 BOW DOORS AND INNER DOORS

Symbols

L_1 : Length, in m, defined in Ch 1, Sec 2, [2.1.1].

1 General

1.1 Application

1.1.1 *(1/1/2005)*

The requirements of this Section apply to the arrangement, strength and securing of bow doors and inner doors leading to a complete or long forward enclosed superstructure or to a long non-enclosed superstructure, when this is fitted to attain minimum bow height equivalence.

1.1.2 Two types of bow door are provided for:

- visor doors opened by rotating upwards and outwards about a horizontal axis through two or more hinges located near the top of the door and connected to the primary supporting members of the door by longitudinally arranged lifting arms
- side-opening doors opened either by rotating outwards about a vertical axis through two or more hinges located near the outboard edges or by horizontal translation by means of linking arms arranged with pivoted attachments to the door and the ship. It is anticipated that side-opening bow doors are arranged in pairs.

Other types of bow door are considered by the Society on a case by case basis in association with the applicable requirements of this Section.

1.2 Gross scantlings

1.2.1 With reference to Ch 4, Sec 2, [1], all scantlings and dimensions referred to in this Section are gross, i.e. they include the margins for corrosion.

1.3 Arrangement

1.3.1 Bow doors are to be situated above the freeboard deck. A watertight recess in the freeboard deck located forward of the collision bulkhead and above the deepest waterline fitted for arrangement of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.

1.3.2 An inner door is to be fitted as part of the collision bulkhead. The inner door need not be fitted directly above the bulkhead below, provided it is located within the limits specified for the position of the collision bulkhead, as per Ch 2, Sec 1, [2.1].

A vehicle ramp may be arranged for this purpose, provided its position complies with Ch 2, Sec 1, [2.1].

If this is not possible, a separate inner weathertight door is to be installed, as far as practicable within the limits specified for the position of the collision bulkhead.

1.3.3 Bow doors are to be so fitted as to ensure tightness consistent with operational conditions and to give effective protection to inner doors.

Inner doors forming part of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with fixed sealing supports on the aft side of the doors.

1.3.4 Bow doors and inner doors are to be arranged so as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in the case of damage to or detachment of the bow door. If this is not possible, a separate inner weathertight door is to be installed, as indicated in [1.3.2].

1.3.5 The requirements for inner doors are based on the assumption that vehicles are effectively lashed and secured against movement in stowed position.

1.4 Definitions

1.4.1 Securing device

A securing device is a device used to keep the door closed by preventing it from rotating about its hinges.

1.4.2 Supporting device

A supporting device is a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, which transmits loads from the door to the ship's structure.

1.4.3 Locking device

A locking device is a device that locks a securing device in the closed position.

2 Design loads

2.1 Bow doors

2.1.1 Design external pressure

The design external pressure to be considered for the scantlings of primary supporting members and securing and supporting devices of bow doors is to be not less than that obtained, in kN/m^2, from the following formula:

$$p_E = 0,5 n_D C_L C_Z (0,22 + 0,15 \tan\alpha)(0,4 V \sin\beta + 0,6 \sqrt{L_1})^2$$

where:

n_D : Navigation coefficient, defined in Tab 1

V : Maximum ahead service speed, in knots

C_L : Coefficient depending on the ship's length:

$C_L = 0,0125\ L$ for $L < 80$ m

$C_L = 1,0$ for $L \geq 80$ m

C_Z : Coefficient defined in Sec 1, [4.2.1], to be taken equal to 5,5

α : Flare angle at the calculation point, defined as the angle between a vertical line and the tangent to the side plating, measured in a vertical plane normal to the horizontal tangent to the shell plating (see Fig 1)

β : Entry angle at the calculation point, defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane (see Fig 1).

Table 1 : Navigation coefficient

Navigation notation	Navigation coefficient n_D
Unrestricted navigation	1,00
Summer zone	1,00
Tropical zone	0,80
Coastal area	0,80
Sheltered area	0,50

2.1.2 Design external forces *(1/1/2005)*

The design external forces F_X, F_Y, F_Z to be considered for the scantlings of securing and supporting devices of bow doors are to be not less than those obtained, in kN, from the following formulae:

$F_X = p_E\ A_X$

$F_Y = p_E\ A_Y$

$F_Z = p_E\ A_Z$

where:

p_E : External pressure, in kN/m², to be calculated according to [2.1.1], assuming the angles α and β measured at the point on the bow door located ℓ/2 aft of the stem line on the plane h/2 above the bottom of the door, as shown in Fig 1

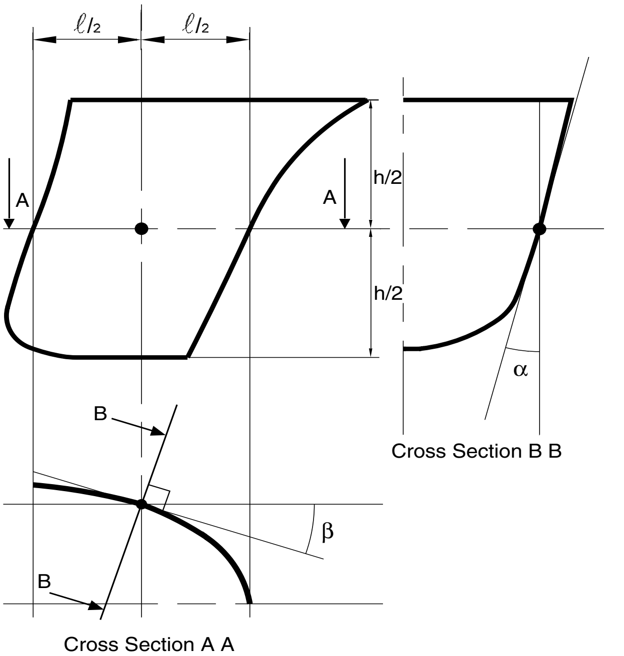
h : Height, in m, to be taken as the lesser of h_1 and h_2

h_1 : Height, in m, of the door between the levels of its bottom and the upper deck

h_2 : Height, in m, of the door between its bottom and top

ℓ : Length, in m, of the door at a height h/2 above the bottom of the door

Figure 1 : Definition of angles α and β



A_X : Area, in m², of the transverse vertical projection of the door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark is to be excluded

A_Y : Area, in m², of the longitudinal vertical projection of the door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser

A_Z : Area, in m², of the horizontal projection of the door between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is the lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser

For bow doors, including bulwark, of unusual form or proportions, e.g. ships with a rounded nose and large stem angles, the areas and angles used for determination of the design values of external forces will be considered on a case by case basis.

2.1.3 Closing moment

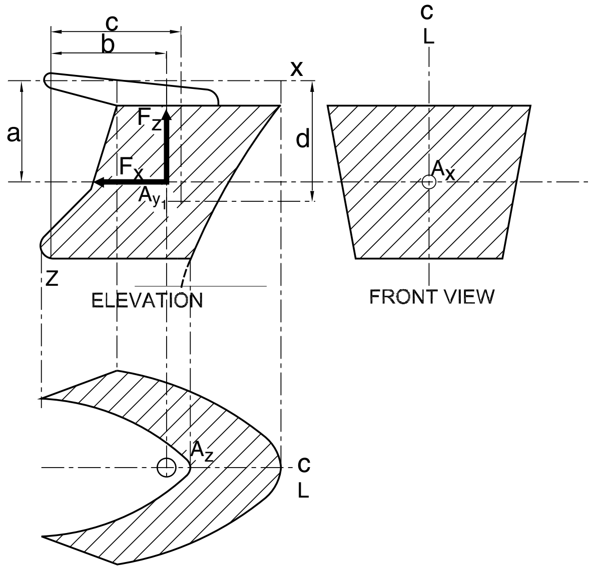
For visor doors, the closing moment under external loads is to be obtained, in kN.m, from the following formula:

$M_Y = F_X a + 10 W c - F_Z b$

where:

- W : Mass of the visor door, in t
- a : Vertical distance, in m, from visor pivot to the centroid of the transverse vertical projected area of the visor door, as shown in Fig 2
- b : Horizontal distance, in m, from visor pivot to the centroid of the horizontal projected area of the visor door, as shown in Fig 2
- c : Horizontal distance, in m, from visor pivot to the centre of gravity of visor mass, as shown in Fig 2.

Figure 2 : Bow doors of visor type



2.1.4 Forces acting on the lifting arms

The lifting arms of a visor door and its supports are to be dimensioned for the static and dynamic forces applied during the lifting and lowering operations, and a minimum wind pressure of 1,5 kN/m² is to be taken into account.

2.2 Inner doors

2.2.1 Design external pressure

The design external pressure to be considered for the scantlings of primary supporting members, securing and supporting devices and surrounding structure of inner doors is to be taken as the greater of the values obtained, in kN/m², from the following formulae:

$p_E = 0{,}45\ L_1$

$p_E = 10\ h$

where:

- h : Distance, in m, from the calculation point to the top of the cargo space.

2.2.2 Design internal pressure

The design internal pressure p_I to be considered for the scantlings of securing devices of inner doors is to be not less than 25 kN/m².

3 Scantlings of bow doors

3.1 General

3.1.1 The strength of bow doors is to be commensurate with that of the surrounding structure.

3.1.2 Bow doors are to be adequately stiffened and means are to be provided to prevent lateral or vertical movement of the doors when closed.

For visor doors, adequate strength for opening and closing operations is to be provided in the connections of the lifting arms to the door structure and to the ship's structure.

3.2 Plating and ordinary stiffeners

3.2.1 Plating

The thickness of the bow door plating is to be not less than that obtained according to the requirements in Sec 1 for the fore part, using the bow door stiffener spacing. In no case may it be less than the minimum required thickness of fore part shell plating.

3.2.2 Ordinary stiffeners

The section modulus of bow door ordinary stiffeners is to be not less than that obtained according to the requirements in Sec 1 for the fore part, using the bow door stiffener spacing.

Consideration is to be given, where necessary, to differences in conditions of fixity between the ends of ordinary stiffeners of bow doors and those of the fore part shell.

3.3 Primary supporting members

3.3.1 Bow door ordinary stiffeners are to be supported by primary supporting members constituting the main stiffening of the door.

3.3.2 The primary supporting members of the bow door and the hull structure in way are to have sufficient stiffness to ensure integrity of the boundary support of the door.

3.3.3 *(1/1/2005)*

Scantlings of primary supporting members are generally to be verified through direct calculations on the basis of the external pressure p_E in [2.1.1] and the strength criteria in [6.1.1] and [6.1.2].

In general, isolated beam models may be used to calculate the loads and stresses in primary supporting members, which are to be considered as having simply supported end connections.

4 Scantlings of inner doors

4.1 General

4.1.1 The gross scantlings of the primary supporting members are generally to be verified through direct calculations on the basis of the external pressure p_E in [2.1.1] and the strength criteria in [6.1.1] and [6.1.2].

In general, isolated beam models may be used to calculate the loads and stresses in primary supporting members.

4.1.2 Where inner doors also serve as vehicle ramps, their scantlings are to be not less than those obtained according to Sec 8.

4.1.3 The distribution of the forces acting on the securing and supporting devices is generally to be supported by direct calculations taking into account the flexibility of the structure and the actual position and stiffness of the supports.

5 Securing and supporting of bow doors

5.1 General

5.1.1 Bow doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.

The hull supporting structure in way of the bow doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered by the Society on a case by case basis.

The maximum design clearance between securing and supporting devices is generally not to exceed 3 mm.

A means is to be provided for mechanically fixing the door in the open position.

5.1.2 Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide local compression of the packing material may generally not be included in the calculation in [5.2.5].

The number of securing and supporting devices is generally to be the minimum practical while taking into account the requirements for redundant provision given in [5.2.6] and [5.2.7] and the available space for adequate support in the hull structure.

5.1.3 For visor doors which open outwards, the pivot arrangement is generally to be such that the visor is self-closing under external loads, i.e. it is to be checked that the closing moment M_Y, defined in [2.1.3], is in compliance with the following formula:

$M_Y > 0$

Moreover, the closing moment M_Y is to be not less than the value M_{Y0}, in kN.m, obtained from the following formula:

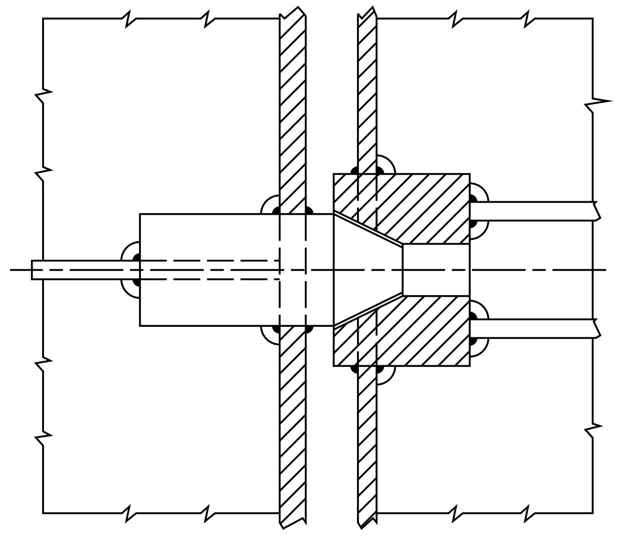
$$M_{Y0} = 10Wc + 0{,}1\sqrt{a^2 + b^2}\sqrt{F_X^2 + F_Z^2}$$

5.1.4 For side-opening doors, a thrust bearing is to be provided in way of girder ends at the closing of the two leaves to prevent one leaf from shifting towards the other under the effect of unsymmetrical pressure (see example in Fig 3).

The parts of the thrust bearing are to be kept secured to each other by means of securing devices.

The Society may consider any other arrangement serving the same purpose.

Figure 3 : Thrust bearing



5.2 Scantlings

5.2.1 Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the allowable stresses defined in [6.1.1].

5.2.2 For visor doors, the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self weight of the door:

- Case 1: F_X and F_Z
- Case 2: $0{,}7F_Y$ acting on each side separately together with $0{,}7F_X$ and $0{,}7F_Z$

where F_X, F_Y and F_Z are to be calculated as indicated in [2.1.2] and applied at the centroid of projected areas.

5.2.3 For side-opening doors, the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self weight of the door:

- Case 1: F_X , F_Y and F_Z acting on both doors
- Case 2: 0,7F_X and 0,7F_Z acting on both doors and 0,7F_Y acting on each door separately

where F_X, F_Y and F_Z are to be calculated as indicated in [2.1.2] and applied at the centroid of projected areas.

5.2.4 The support forces as calculated according to Case 1 in [5.2.2] and Case 1 in [5.2.3] are to generally give rise to a zero moment about the transverse axis through the centroid of the area A_X.

For visor doors, longitudinal reaction forces of pin and/or wedge supports at the door base contributing to this moment are not to be in the forward direction.

5.2.5 The distribution of the reaction forces acting on the securing and supporting devices may need to be supported by direct calculations taking into account the flexibility of the hull structure and the actual position and stiffness of the supports.

5.2.6 The arrangement of securing and supporting devices in way of these securing devices is to be designed with redundancy so that, in the event of failure of any single securing or supporting device, the remaining devices are capable of withstanding the reaction forces without exceeding by more than 20% the allowable stresses defined in [6.1.1].

5.2.7 For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the allowable stresses defined in [6.1.1].

The opening moment M_0 to be balanced by this reaction force is to be taken not less than that obtained, in kN.m, from the following formula:

$M_0 = 10\ W\ d + 5\ A_X\ a$

where:

d	:	Vertical distance, in m, from the hinge axis to the centre of gravity of the door, as shown in Fig 2
a	:	Vertical distance, in m, defined in [2.1.3].

5.2.8 For visor doors, the securing and supporting devices excluding the hinges are to be capable of resisting the vertical design force (F_Z-10W), in kN, within the allowable stresses defined in [6.1.1].

5.2.9 *(1/1/2005)*

All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's structure, including welded connections, are to be of the same strength standard as required for the securing and supporting devices. These elements include pins, supporting brackets and back-up brackets.

6 Strength Criteria

6.1 Primary supporting members and securing and supporting devices

6.1.1 Yielding check

It is to be checked that the normal stresses σ, the shear stress τ and the equivalent stress σ_{VM}, induced in the primary supporting members and in the securing and supporting devices of bow doors by the design load defined in [2], are in compliance with the following formulae:

$\sigma \le \sigma_{ALL}$

$\tau \le \tau_{ALL}$

$\sigma_{VM} = (\sigma^2 + \tau^2)^{0,5} \le \sigma_{VM,ALL}$

where:

σ_{ALL}	:	Allowable normal stress, in N/mm², equal to: $\sigma_{ALL} = 120 / k$
τ_{ALL}	:	Allowable shear stress, in N/mm², equal to: $\tau_{ALL} = 80 / k$
$\sigma_{VM,ALL}$	:	Allowable equivalent stress, in N/mm², equal to: $\sigma_{VM,ALL} = 150 / k$
k	:	Material factor, defined in Ch 4, Sec 1, [2.3], but to be taken not less than 0,72 unless a fatigue analysis is carried out.

6.1.2 Buckling check

The buckling check of primary supporting members is to be carried out according to Ch 7, Sec 3, [6].

6.1.3 Bearings

For steel to steel bearings in securing and supporting devices, it is to be checked that the nominal bearing pressure σ_B, in N/mm², is in compliance with the following formula:

$\sigma_B \le 0,8\ R_{e,HB}$

where:

$$\sigma_B = 10\frac{F}{A_B}$$

F	:	Design force, in kN, defined in [2.1.2]
A_B	:	Projected bearing area, in cm²
$R_{e,HB}$	:	Yield stress, in N/mm², of the bearing material.

For other bearing materials, the allowable bearing pressure is to be determined according to the manufacturer's specification.

6.1.4 Bolts

The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces.

It is to be checked that the tension σ_T in way of threads of bolts not carrying support forces is in compliance with the following formula:

$\sigma_T \le \sigma_{T,ALL}$

where:

$\sigma_{T,ALL}$	:	Allowable tension in way of threads of bolts, in N/mm², equal to: $\sigma_{T,ALL} = 125 / k$

k : Material coefficient defined in [6.1.1].

7 Securing and locking arrangement

7.1 Systems for operation

7.1.1 Securing devices are to be simple to operate and easily accessible.

Securing devices are to be equipped with mechanical locking arrangement (self-locking or separate arrangement), or to be of the gravity type.

The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

7.1.2 Bow doors and inner doors giving access to vehicle decks are to be provided with an arrangement for remote control, from a position above the freeboard deck, of:

- the closing and opening of the doors, and
- associated securing and locking devices for every door.

Indication of the open/closed position of every door and every securing and locking device is to be provided at the remote control stations.

The operating panels for operation of doors are to be inaccessible to unauthorised persons.

A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

7.1.3 Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of hydraulic fluid, the securing devices remain locked.

The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

7.2 Systems for indication/monitoring

7.2.1 Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the bow door and inner door are closed and that their securing and locking devices are properly positioned.

The indication panel is to be provided with a lamp test function. It is not to be possible to turn off the indicator light.

7.2.2 *(1/1/2005)*

The indicator system is to be designed on the fail-safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured.

The power supply for the indicator system for operating and closing doors is to be independent of the power supply for operating and closing the doors and is to be provided with a back-up power supply from the emergency source of power or other secure power supply e.g. UPS.

The sensors of the indicator system are to be protected from water, ice formation and mechanical damage.

Note 1: The indicator system is considered designed on the fail-safe principle when the following conditions occur.

- The indication panel is provided with:
  - a power failure alarm
  - an earth failure alarm
  - a lamp test
  - separate indication for door closed, door locked, door not closed and door unlocked.
- Limit switches are electrically closed when the door is closed (when several limit switches are provided they may be connected in series).
- Limit switches are electrically closed when securing arrangements are in place (when several limit switches are provided they may be connected in series).
- Two electrical circuits (also in one multicore cable) are fitted, one for the indication of door closed / not closed and the other for door locked / unlocked.
- In the case of dislocation of limit switches, indication to show: not closed / unlocked / securing arrangement not in place - as appropriate.

7.2.3 *(1/1/2005)*

The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that an audible alarm is given on the navigation bridge if the ship leaves harbour with the bow door or inner door not closed or with any of the securing devices not in the correct position.

7.2.4 A water leakage detection system with an audible alarm and television surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

7.2.5 Between the bow door and the inner door a television surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room.

The system is to monitor the position of doors and a sufficient number of their securing devices.

Special consideration is to be given to the lighting and contrasting colour of the objects under surveillance.

7.2.6 The indicator system for the closure of the doors and the television surveillance systems for the doors and water leakage detection, and for special category and ro-ro spaces are to be suitable to operate correctly in the ambient conditions on board and to be type approved on the basis of the applicable tests required in Part E, Chapter 1 and/or Part E, Chapter 12.

7.2.7 *(1/1/2005)*

A drainage system is to be arranged in the area between bow door and ramp, or, where no ramp is fitted, between bow door and inner door. The system is to be equipped with an audible alarm providing an indication on the navigation bridge, which is to be activated when the water levels in these areas exceed 0,5 m or the high water level alarm, whichever is the lesser.

8 Operating and maintenance manual

8.1 General

8.1.1 *(1/1/2005)*

An Operating and Maintenance Manual (OMM) for the bow door and inner door is to be provided on board and contain necessary information on:

a) main particulars and design drawings
   - special safety precautions
   - details of vessel, class, statutory certificates
   - equipment and design loading (for ramps)
   - key plan of equipment (doors and ramps)
   - Manufacturer's recommended testing for equipment
   - description of equipment (bow doors, inner bow doors, bow ramp/doors, side doors, stern doors, central power pack, bridge panel, engine control room panel)

b) service conditions
   - limiting heel and trim of ship for loading/unloading
   - limiting heel and trim for door operations
   - door/ramp operating instructions
   - door/ramp emergency operating instructions

c) maintenance
   - schedule and extent of maintenance
   - trouble-shooting and acceptable clearances
   - Manufacturer's maintenance procedures

d) register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

This manual is to be submitted in duplicate to the Society for approval that the above-mentioned items are contained in the OMM and that the maintenance part includes the necessary information with regard to inspections, trouble-shooting and acceptance / rejection criteria.

Note 1: It is recommended that inspections of the doors and supporting and securing devices be carried out by ship's personnel at monthly intervals or following any incidents which could result in damage, including heavy weather or contact in the region of the shell doors. A record is to be kept and any damage found during such inspections is to be reported to the Society.

8.1.2 Documented operating procedures for closing and securing the bow door and inner door are to be kept on board and posted at an appropriate place.

SECTION 6 SIDE DOORS AND STERN DOORS

Symbols

L_1 : Length, in m, defined in Ch 1, Sec 2, [2.1.1].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the arrangement, strength and securing of side doors, abaft the collision bulkhead, and of stern doors leading to enclosed spaces.

1.2 Gross scantlings

1.2.1 With reference to Ch 4, Sec 2, [1], all scantlings and dimensions referred to in this Section are gross, i.e. they include the margins for corrosion.

1.3 Arrangement

1.3.1 Side doors and stern doors are to be so fitted as to ensure tightness and structural integrity commensurate with their location and the surrounding structure.

1.3.2 Where the sill of any side door is below the uppermost load line, the arrangement is considered by the Society on a case by case basis.

1.3.3 *(1/1/2019)*

Pilot doors are to open inwards, while all the other side doors are preferably to open outwards.

1.3.4 *(1/1/2019)*

Side doors opening inwards located in the two tweendecks above the summer loadline are to be fitted with a second independent securing device, such as a strongback or equivalent arrangement, capable of providing weathertight integrity. The application of these requirements to small doors is subject to special consideration.

1.4 Definitions

1.4.1 Securing device

A securing device is a device used to keep the door closed by preventing it from rotating about its hinges or about pivoted attachments to the ship.

1.4.2 Supporting device

A supporting device is a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, which transmits loads from the door to the ship's structure.

1.4.3 Locking device

A locking device is a device that locks a securing device in the closed position.

2 Design loads

2.1 Side and stern doors

2.1.1 Design forces

The design external forces F_E and the design internal forces F_I to be considered for the scantlings of primary supporting members and securing and supporting devices of side doors and stern doors are to be obtained, in kN, from the formulae in Tab 1.

3 Scantlings of side doors and stern doors

3.1 General

3.1.1 The strength of side doors and stern doors is to be commensurate with that of the surrounding structure.

3.1.2 Side doors and stern doors are to be adequately stiffened and means are to be provided to prevent any lateral or vertical movement of the doors when closed.

Adequate strength is to be provided in the connections of the lifting/manoeuvring arms and hinges to the door structure and to the ship's structure.

3.1.3 Where doors also serve as vehicle ramps, the design of the hinges is to take into account the ship angle of trim and heel which may result in uneven loading on the hinges.

3.1.4 Shell door openings are to have well rounded corners and adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

3.2 Plating and ordinary stiffeners

3.2.1 Plating

The thickness of the door plating is to be not less than that obtained according to the requirements in Ch 7, Sec 1 for side plating, using the door stiffener spacing. In no case may it be less than the minimum required thickness of side plating.

Where doors also serve as vehicle ramps, the thickness of the door plating is to be not less than that obtained according to Sec 8.

3.2.2 Ordinary stiffeners

The scantling of door ordinary stiffeners is to be not less than that obtained according to the requirements in Ch 7, Sec 2 for the side, using the door stiffener spacing.

Table 1 : Design forces

Structural elements	External force F_E , in kN	Internal force F_I , in kN
Securing and supporting devices of doors opening inwards	$A\ p_E + F_P$	$F_0 + 10\ W$
Securing and supporting devices of doors opening outwards	$A\ p_E$	$F_0 + 10\ W + F_P$
Primary supporting members **(1)**	$A\ p_E$	$F_0 + 10\ W$

(1) The design force to be considered for the scantlings of the primary supporting members is the greater of F_E and F_I.

Note 1:

A : Area, in m², of the door opening

W : Mass of the door, in t

F_P : Total packing force, in kN; the packing line pressure is normally to be taken not less than 5 N/mm

F_0 : the greater of F_C and 5A, in kN

F_C : Accidental force, in kN, due to loose cargoes etc., to be uniformly distributed over the area A and to be taken not less than 300 kN. For small doors such as bunker doors and pilot doors, the value of F_C may be appropriately reduced. However, the value of F_C may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.

p_E : External design pressure determined at the centre of gravity of the door opening and to be taken not less than that obtained, in kN/m², from the following formulae:

$p_E = 10\ (T - Z_G) + 25$ for $Z_G < T$

$p_E = 25$ for $Z_G \geq T$

Moreover, for stern doors of ships fitted with bow doors, p_E is to be taken not less than that obtained, in kN/m², from the following formula:

$$p_E = 0{,}6 n_D C_L (0{,}8 + 0{,}6\sqrt{L_1})^2$$

T : Draught, in m, at the highest subdivision load line

Z_G : Height of the centre of the area of the door, in m, above the baseline

n_D : Navigation coefficient, defined in Tab 2

C_L : Coefficient depending on the ship's length:

$C_L = 0{,}0125\ L$ for $L < 80$ m

$C_L = 1{,}0$ for $L \geq 80$ m.

Consideration is to be given, where necessary, to differences in conditions of fixity between the ends of ordinary stiffeners of doors and those of the side.

Where doors also serve as vehicle ramps, the scantling of ordinary stiffeners is to be not less than that obtained according to Sec 8.

3.3 Primary supporting members

3.3.1 The door ordinary stiffeners are to be supported by primary supporting members constituting the main stiffening of the door.

3.3.2 The primary supporting members and the hull structure in way are to have sufficient stiffness to ensure structural integrity of the boundary of the door.

3.3.3 *(1/1/2005)*

Scantlings of primary supporting members are generally to be verified through direct calculations on the basis of the design forces in [2.1.1] and the strength criteria in Sec 5, [6.1.1] and Sec 5, [6.1.2].

In general, isolated beam models may be used to calculate the loads and stresses in primary supporting members, which are to be considered as having simply supported end connections.

Table 2 : Navigation coefficient

Navigation notation	Navigation coefficient n_D
Unrestricted navigation	1,00
Summer zone	1,00
Tropical zone	0,80
Coastal area	0,80
Sheltered area	0,50

4 Securing and supporting of doors

4.1 General

4.1.1 Side doors and stern doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.

The hull supporting structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered by the Society on a case by case basis.

The maximum design clearance between securing and supporting devices is generally not to exceed 3 mm.

A means is to be provided for mechanically fixing the door in the open position.

4.1.2 Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide local compression of the packing material may generally not be included in the calculation in [4.2.2].

The number of securing and supporting devices is generally to be the minimum practical while taking into account the requirements for redundant provision given in [4.2.3] and the available space for adequate support in the hull structure.

4.2 Scantlings

4.2.1 Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the allowable stresses defined in Sec 5, [6.1.1].

4.2.2 The distribution of the reaction forces acting on the securing and supporting devices may need to be supported by direct calculations taking into account the flexibility of the hull structure and the actual position of the supports.

4.2.3 The arrangement of securing and supporting devices in way of these securing devices is to be designed with redundancy so that, in the event of failure of any single securing or supporting device, the remaining devices are capable of withstanding the reaction forces without exceeding by more than 20% the allowable stresses defined in Sec 5, [6.1.1].

4.2.4 *(1/1/2005)*

All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's structure, including welded connections, are to be of the same strength standard as required for the securing and supporting devices. These elements include pins, supporting brackets and back-up brackets.

5 Strength criteria

5.1 Primary supporting members and securing and supporting devices

5.1.1 Yielding check

It is to be checked that the normal stress σ, the shear stress τ and the equivalent stress σ_{VM}, induced in the primary supporting members and in the securing and supporting devices of doors by the design load defined in [2], are in compliance with the following formulae:

$\sigma \leq \sigma_{ALL}$

$\tau \leq \tau_{ALL}$

$\sigma_{VM} = (\sigma^2 + \tau^2)^{0,5} \leq \sigma_{VM,ALL}$

where:

σ_{ALL} : Allowable normal stress, in N/mm^2:

$\sigma_{ALL} = 120 / k$

τ_{ALL} : Allowable shear stress, in N/mm^2:

$\tau_{ALL} = 80 / k$

$\sigma_{VM,ALL}$: Allowable equivalent stress, in N/mm^2:

$\sigma_{VM,ALL} = 150 / k$

k : Material factor, defined in Ch 4, Sec 1, [2.3], but to be taken not less than 0,72 unless a fatigue analysis is carried out.

5.1.2 Buckling check

The buckling check of primary supporting members is to be carried out according to Ch 7, Sec 3, [6].

5.1.3 Bearings

For steel to steel bearings in securing and supporting devices, it is to be checked that the nominal bearing pressure σ_B, in N/mm^2, is in compliance with the following formula:

$\sigma_B \leq 0,8\ R_{eH,B}$

where:

$$\sigma_B = 10\frac{F}{A_B}$$

with:

F : Design force, in KN, defined in [2.1.1]

A_B : Projected bearing area, in cm^2

$R_{eH,B}$: Yield stress, in N/mm^2, of the bearing material.

For other bearing materials, the allowable bearing pressure is to be determined according to the manufacturer's specification.

5.1.4 Bolts

The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces.

It is to be checked that the tension σ_T in way of threads of bolts not carrying support forces is in compliance with the following formula:

$\sigma_T \leq \sigma_{T,ALL}$

where:

$\sigma_{T,ALL}$: Allowable tension in way of threads of bolts, in N/mm^2:

$\sigma_{T,ALL} = 125 / k$

k : Material factor, defined in Sec 5, [6.1.1].

6 Securing and locking arrangement

6.1 Systems for operation

6.1.1 Securing devices are to be simple to operate and easily accessible.

Securing devices are to be equipped with mechanical locking arrangement (self-locking or separate arrangement), or to be of the gravity type.

The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

6.1.2 Doors which are located partly or totally below the freeboard deck with a clear opening area greater than 6 m^2 are to be provided with an arrangement for remote control, from a position above the freeboard deck, of:

- the closing and opening of the doors
- associated securing and locking devices.

For doors which are required to be equipped with a remote control arrangement, indication of the open/closed position of the door and the securing and locking device is to be provided at the remote control stations.

The operating panels for operation of doors are to be inaccessible to unauthorised persons.

A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

6.1.3 Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of hydraulic fluid, the securing devices remain locked.

The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

7 Operating and Maintenance Manual

7.1 General

7.1.1 *(1/1/2012)*

An Operating and Maintenance Manual (OMM) for the side doors and stern doors is to be provided on board and contain necessary information on:

a) main particulars and design drawings
   - special safety precautions
   - details of vessel
   - equipment and design loading (for ramps)
   - key plan of equipment (doors and ramps)
   - Manufacturer's recommended testing for equipment
   - description of equipment for bow doors, inner bow doors, bow ramp/doors, side doors, stern doors, central power pack, bridge panel, engine control room panel

b) service conditions
   - limiting heel and trim of ship for loading/unloading
   - limiting heel and trim for door operations
   - door/ramp operating instructions
   - door/ramp emergency operating instructions

c) maintenance
   - schedule and extent of maintenance
   - trouble-shooting and acceptable clearances
   - Manufacturer's maintenance procedures

d) register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

This manual is to be submitted in duplicate to the Society for approval that the above-mentioned items are contained in the OMM and that the maintenance part includes the necessary information with regard to inspections, trouble-shooting and acceptance / rejection criteria.

Note 1: It is recommended that inspections of the door and supporting and securing devices be carried out by ship’s personnel at monthly intervals or following any incidents which could result in damage, including heavy weather or contact in the region of the shell doors. A record is to be kept and any damage recorded during such inspections is to be reported to the Society.

7.1.2 Documented operating procedures for closing and securing the side and stern doors are to be kept on board and posted at an appropriate place.

SECTION 7 HATCH COVERS, HATCH COAMINGS AND CLOSING DEVICES

Symbols

T_{fb} : the least moulded depth, in m, as defined according to Regulation 3 of the International Load Line Convention 1966, as amended.

h_n : standard superstructure height, in m:

- $h_n = 1,05 + 0,01\ L_{LL}$
- $h_n = 1,8 \leq h_n \leq 2,3$

A_{Sh} : Net shear sectional area, in cm², of the ordinary stiffener or primary supporting member, to be calculated as specified in Ch 4, Sec 3, [3.4], for ordinary stiffeners, and Ch 4, Sec 3, [4.3], for primary supporting members

t_C : Corrosion additions, in mm, defined in [1.4]

k : Material factor, defined in Ch 4, Sec 1, [2.3]

a_V : Vertical acceleration according to [3.3.1]

g : Gravity acceleration, in m/s²:

$g = 9,81$ m/s².

1 General

1.1 Application

1.1.1 *(1/7/2019)*

The requirements in [1] to [8] apply to steel hatch covers in positions 1 and 2 on weather decks, defined in Ch 1, Sec 2, [3.16] for all ship types, except ships for which one of the following service notation is assigned:

- **bulk carrier**
- **self-unloading bulk carrier**
- **ore carrier**
- **combination carrier**

for which the specific requirements of Part E apply.

The requirements in [9] apply to steel covers of small hatches fitted on the exposed fore deck over the forward 0,25L.

1.2 Materials

1.2.1 Steel *(1/7/2016)*

Material class I is to be applied for top plate, bottom plate and primary supporting members.

The formulae for scantlings given in the requirements in [4] are applicable to steel.

Materials used for the construction of steel hatch covers are to comply with the applicable requirements of Part D, Chapter 2.

1.2.2 Other materials *(1/7/2012)*

The use of materials other than steel is considered by the Society on a case by case basis, by checking that criteria adopted for scantlings are such as to ensure strength and stiffness equivalent to those of steel hatch covers.

1.3 Net scantlings

1.3.1 *(1/7/2016)*

As specified in Ch 4, Sec 2, [1], unless otherwise specified all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.

Strength calculations using grillage analysis or FEM are to be performed with net scantlings.

The gross scantlings are obtained as specified in Ch 4, Sec 2.

1.4 Corrosion additions

1.4.1 Corrosion additions for hatch covers *(1/7/2012)*

The corrosion addition to be considered for the plating and internal members of hatch covers is the value specified in Tab 1 for the total thickness of the member under consideration.

1.4.2 Corrosion additions for hatch coamings *(1/7/2012)*

The corrosion addition to be considered for the hatch coaming structures and coaming stays is equal to 1,5 mm.

Table 1 : Corrosion additions t_c for hatch covers and hatch coamings *(1/7/2012)*

Application	Structure	t_s [mm]
Weather deck hatches of container ships and passenger ships	hatch cover	1,0
	hatch coamings	1,0
Weather deck hatches of all other ship types	Hatch covers in general	2
	Weather exposed plating and bottom plating of double skin hatch covers	1,5
	Internal structure of double skin hatch covers and closed box girders	1,0
	Hatch coamings not part of the longitudinal hull structure	1,5
	Hatch coamings part of the longitudinal hull structure	1,5
	Coaming stays and stiffeners	1,5

2 Arrangements

2.1 Height of hatch coamings

2.1.1 *(1/7/2012)*

The height above the deck of hatch coamings closed by portable covers is to be not less than:

- 600 mm in position 1
- 450 mm in position 2.

2.1.2 *(1/7/2012)*

The height of hatch coamings in positions 1 and 2 closed by steel covers provided with gaskets and securing devices may be reduced with respect to the above values or the coamings may be omitted entirely.

In such cases the scantlings of the covers, their gasketing, their securing arrangements and the drainage of recesses in the deck are considered by the Society on a case by case basis.

2.1.3 *(1/7/2012)*

Regardless of the type of closing arrangement adopted, the coamings may have reduced height or be omitted in way of openings in closed superstructures or decks below the freeboard deck.

2.2 Hatch covers

2.2.1 *(1/7/2012)*

Hatch covers on exposed decks are to be weathertight.

Hatch covers in closed superstructures need not be weathertight.

However, hatch covers fitted in way of ballast tanks, fuel oil tanks or other tanks are to be watertight.

2.2.2 *(1/7/2012)*

The ordinary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to ensure sufficient load carrying capacity.

2.2.3 *(1/7/2012)*

The spacing of primary supporting members parallel to the direction of ordinary stiffeners is to be not greater than 1/3 of the span of primary supporting members. When strength calculation is carried out by FE analysis using plane strain or shell elements, this requirement can be waived.

2.2.4 *(1/7/2012)*

The breadth of the primary supporting member flange is to be not less than 40% of its depth for laterally unsupported spans greater than 3,0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

2.2.5 *(1/7/2012)*

The covers used in 'tweendecks are to be fitted with an appropriate system ensuring an efficient stowing when the ship is sailing with open 'tweendecks.

2.2.6 *(1/7/2012)*

The ends of hatch covers are normally to be protected by efficiently secured galvanised steel strips.

2.2.7 *(1/7/2012)*

Efficient retaining arrangements are to be provided to prevent translation of the hatch cover under the action of the longitudinal and transverse forces exerted by the stacks of containers on the cover. These retaining arrangements are to be located in way of the hatch coaming side brackets.

Solid fittings are to be welded on the hatch cover where the corners of the containers are resting. These parts are intended to transmit the loads of the container stacks onto the hatch cover on which they are resting and also to prevent horizontal translation of the stacks by means of special intermediate parts arranged between the supports of the corners and the container corners.

Longitudinal stiffeners are to stiffen the hatch cover plate in way of these supports and connect at least the nearest three transverse stiffeners.

2.2.8 *(1/7/2012)*

The width of each bearing surface for hatch covers is to be at least 65 mm.

2.3 Hatch coamings

2.3.1 *(1/7/2012)*

Coamings, stiffeners and brackets are to be capable of withstanding the local forces in way of the clamping devices and handling facilities necessary for securing and moving the hatch covers as well as those due to cargo stowed on the latter.

2.3.2 *(1/7/2012)*

Special attention is to be paid to the strength of the fore transverse coaming of the forward hatch and to the scantlings of the closing devices of the hatch cover on this coaming.

2.3.3 *(1/7/2012)*

Longitudinal coamings are to be extended at least to the lower edge of deck beams.

Where they are not part of continuous deck girders, longitudinal coamings are to extend for at least two frame spaces beyond the end of the openings.

Where longitudinal coamings are part of deck girders, their scantlings are to be as required in Ch 7, Sec 3.

2.3.4 *(1/7/2012)*

Transverse coamings are to extend below the deck at least to the lower edge of longitudinals.

Transverse coamings not in line with ordinary deck beams below are to extend below the deck at least three longitudinal frame spaces beyond the side coamings.

2.3.5 *(1/7/2012)*

Secondary stiffeners of hatch coamings are to be continuous over the breadth and length of hatch coamings.

2.4 Small hatchways

2.4.1 *(1/7/2012)*

The height of small hatchway coamings is to be not less than 600 mm if located in position 1, and 450 mm if located in position 2.

Where the closing appliances are in the form of hinged steel covers secured weathertight by gaskets and swing bolts, the height of the coamings may be reduced or the coamings may be omitted altogether.

2.4.2 *(1/7/2012)*

Small hatch covers are to have strength equivalent to that required for main hatchways and are to be of steel, weathertight and generally hinged.

Securing arrangements and stiffening of hatch cover edges are to be such that weathertightness can be maintained in any sea condition.

At least one securing device is to be fitted at each side. Circular hole hinges are considered equivalent to securing devices.

2.4.3 *(1/7/2012)*

Hold accesses located on the weather deck are to be provided with watertight metallic hatch covers, unless they are protected by a closed superstructure. The same applies to accesses located on the forecastle deck and leading directly to a dry cargo hold through a trunk.

2.4.4 *(1/7/2012)*

Accesses to cofferdams and ballast tanks are to be manholes fitted with watertight covers fixed with bolts which are sufficiently closely spaced.

2.4.5 *(1/7/2012)*

Hatchways of special design are considered by the Society on a case by case basis.

3 Hatch cover and coaming load model

3.1 Vertical weather design load

3.1.1 Pressure *(1/7/2012)*

The pressure p_H, in kN/m^2, on the hatch cover panels is given in Tab 2. The vertical weather design load needs not to be combined with cargo loads according to [3.3] and [3.4].

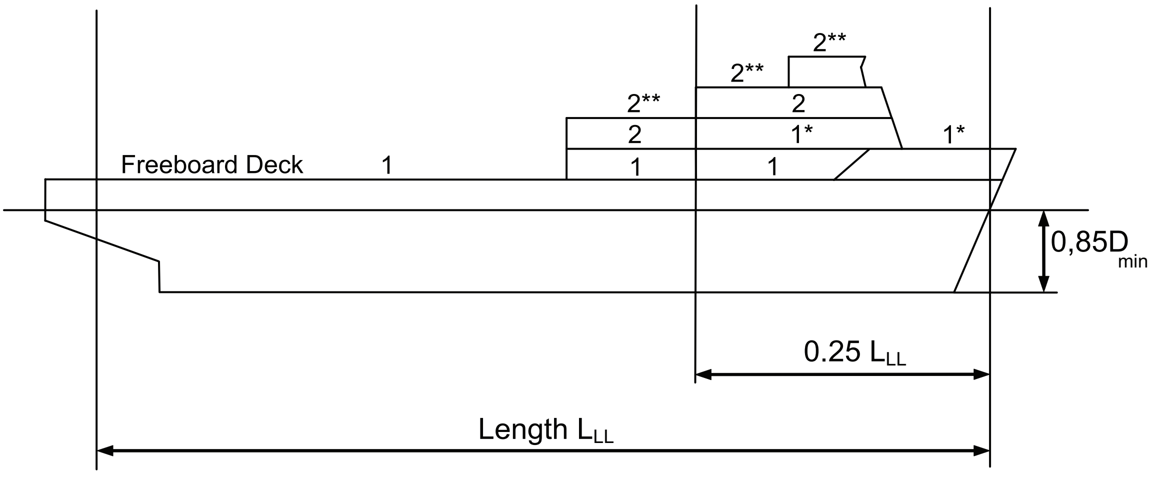
In Fig 1 the positions 1 and 2 are illustrated for an example ship.

Where an increased freeboard is assigned, the design load for hatch covers according to Tab 2 on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to the standard superstructure height h_N below the actual freeboard deck, see Fig 2.

Table 2 : Design load p_H of weather deck hatches *(1/7/2022)*

<table>
<tr><td rowspan="2">Position</td><td colspan="2">Pressure p_h , in kN/m^2</td></tr>
<tr><td>$x / L_{LL} \le 0,75$</td><td>$0,75 < x / L_{LL} \le 1,0$</td></tr>
<tr><td rowspan="8">1</td><td colspan="2">for $24 \text{ m} \le L_{LL} \le 100 \text{ m}$</td></tr>
<tr><td rowspan="2">$\frac{9,81}{76} \cdot (1,5 \cdot L_{LL} + 116)$</td><td>on freeboard deck
$\frac{9,81}{76} \cdot \left[(4,28 \cdot L_{LL} + 28) \cdot \frac{x}{L_{LL}} - 1,71 \cdot L_{LL} + 95\right]$</td></tr>
<tr><td>upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck
$\frac{9,81}{76} \cdot (1,5 \cdot L_{LL} + 116)$</td></tr>
<tr><td colspan="2">for $L_{LL} > 100 \text{ m}$</td></tr>
<tr><td rowspan="4">$9,81 \cdot 3,5$</td><td>on freeboard deck for type B ships according to the IMO International Convention on Load Lines (ICLL)
$9,81 \cdot \left[(0,0296 \cdot L_1 + 3,04) \cdot \frac{x}{L_{LL}} - 0,0222 \cdot L_1 + 1,22\right]$</td></tr>
<tr><td>on freeboard deck for ships with less freeboard than type B according to ICLL
$9,81 \cdot \left[(0,1452 \cdot L_1 - 8,52) \cdot \frac{x}{L_{LL}} - 0,1089 \cdot L_1 + 9,89\right]$</td></tr>
<tr><td>$L_1 = L_{LL}$ but not more than 340 m</td></tr>
<tr><td>upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck
$9,81 \cdot 3,5$</td></tr>
<tr><td rowspan="5">2</td><td colspan="2">for $24 \text{ m} \le L_{LL} \le 100 \text{ m}$</td></tr>
<tr><td colspan="2">$\frac{9,81}{76} \cdot (1,1 \cdot L_{LL} + 87,6)$</td></tr>
<tr><td colspan="2">for $L_{LL} > 100 \text{ m}$</td></tr>
<tr><td colspan="2">$9,81 \cdot 2,6$</td></tr>
<tr><td colspan="2">upon exposed superstructure decks located at least one superstructure standard height above the lowest position 2 deck
$9,81 \cdot 2,1$</td></tr>
</table>

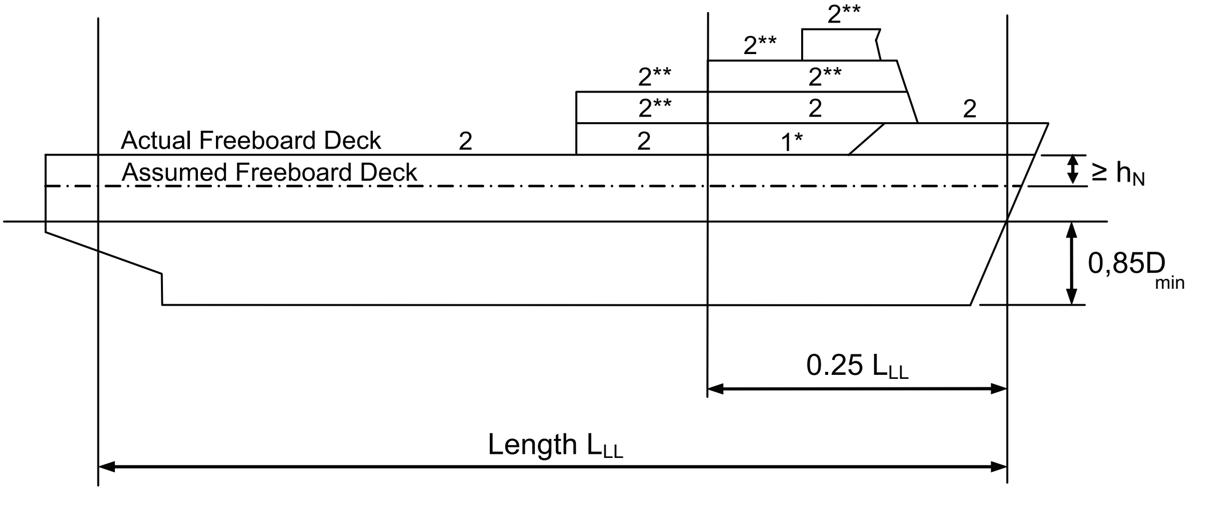
Figure 1 : Positions 1 and 2 *(1/7/2016)*



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck

** reduced load upon exposed superstructure decks of vessels with L_{LL} > 100 m located at least one superstructure standard height above the lowest Position 2 deck

Figure 2 : Positions 1 and 2 for an increased freeboard *(1/7/2016)*



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck

** reduced load upon exposed superstructure decks of vessels with L_{LL} > 100 m located at least one superstructure standard height above the lowest Position 2 deck

3.2 Horizontal weather design load

3.2.1 Design load *(1/7/2016)*

The horizontal weather design load, in kN/m², for determining the scantlings of outer edge girders (skirt plates) of weather deck hatch covers and of hatch coamings is:

$P_A = a \cdot c \cdot (b \cdot cL \cdot f - z)$

$f = L / 25 + 4,1$ for $L < 90$ m

$= 10,75 - [(300 - L) / 100]^{1,5}$ for $90 \le L < 300$ m

$= 10,75$ for $300 \le L < 350$ m

$= 10,75 - [(L - 350) / 150]^{1,5}$ for $350 \le L \le 500$ m

$$c_L = \sqrt{\frac{L}{90}}$$

for $L < 90$ m

$c_L = 1$ for $L \geq 90$ m

$a = 20 + L_1/12$, for unprotected front coamings and hatch cover skirt plates

$a = 10 + L_1/12$, for unprotected front coamings and hatch cover skirt plates, where the distance from the actual freeboard deck to the summer load line exceeds the minimum non-corrected tabular freeboard according to the IMO International Load Lines (ICLL) by at least one standard superstructure height h_N.

$a = 5 + L_1/15$, for side and protected front coamings and hatch cover skirt plates

$a = 7 + L_1/100 - 8 \cdot x' / L$, for aft ends of coamings and aft hatch cover skirt plates abaft amidships

$a = 5 + L_1/100 - 4 \cdot x' / L$, for aft ends of coamings and aft hatch cover skirt plates forward of amidships

L_1 : L, need not be taken greater than 300 m

$$b = 1,0 + \left(\frac{\frac{x'}{L} - 0,45}{C_B + 0,2}\right)^2 \text{ for } \frac{x'}{L} < 0,45$$

$$b = 1,0 + 1,5 \cdot \left(\frac{\frac{x'}{L} - 0,45}{C_B + 0,2}\right)^2 \text{ for } \frac{x'}{L} \geq 0,45$$

$0,6 \leq C_B \leq 0,8$, when determining scantlings of aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_B need not be taken less than 0,8.

x' : distance in m between the transverse coaming or hatch cover skirt plate considered and aft end of the length L. When determining side coamings or side hatch cover skirt plates, the side is to be subdivided into parts of approximately equal length, not exceeding 0,15 L each, and x' is to be taken as the distance between aft end of the length L and the centre of each part considered

z : vertical distance in m from the summer load line to the midpoint of stiffener span, or to the middle of the plate field

c : $0,3 + 0,7 \cdot (b'/B')$

b' : breadth of coaming in m at the position considered

B' : actual maximum breadth of ship in m on the exposed weather deck at the position considered

b'/B' is not to be taken less than 0,25.

The design load p_A is not to be taken less than the minimum values given in Tab 3.

Table 3 : Minimum design load p_{Amin} *(1/7/2012)*

L	p_{Amin} in kN/m² for	
	unprotected fronts	elsewhere
≤ 50	30	15
> 50 < 250	25 + L / 10	12,5 + L / 20
≥ 250	50	25

Note 1: The horizontal weather design load need not be included in the direct strength calculation of the hatch cover, unless it is utilized for the design of substructures of horizontal support according to [7.2.3].

3.3 Cargo loads

3.3.1 Distributed loads *(1/7/2016)*

The load on hatch covers due to distributed cargo loads p_L, in kN/m², resulting from heave and pitch (i.e. ship is upright condition) is to be determined according to the following formula:

$p_L = p_C \ (1 + a_v)$

p_C : uniform cargo load, in kN/m²

a_v : vertical acceleration addition as follows

$a_v = F \cdot m$

$$F = 0,11 \cdot \frac{v_0}{\sqrt{L}}$$

$$m = m_0 - 5(m_0 - 1) \cdot \frac{x}{L} \text{ for } 0 \leq \frac{x}{L} \leq 0,2$$

$$m = 1,0 \text{ for } 0,2 < \frac{x}{L} \leq 0,7$$

$$m = 1 + \frac{m_0 + 1}{0,3} \cdot \left[\frac{x}{L} - 0,7\right] \text{ for } 0,7 < \frac{x}{L} \leq 1,0$$

$m_0 = 1,5 + F$

v_0 = maximum speed at number load line draught, v_0 is not to be taken less than $\sqrt{L}$ in knots

3.3.2 Point loads *(1/7/2016)*

The load P, in kN, due to a concentrated forces P_S, in kN, except for container load, resulting from heave and pitch (i.e. in upright condition) is to be determined as follows:

$P = P_S \ (1 + a_v)$

P_S = single force in kN

3.4 Container loads

3.4.1 General *(1/7/2016)*

The loads defined in [3.4.2] and [3.4.3] are to be applied where containers are stowed on the hatch cover.

3.4.2 *(1/7/2016)*

The load in kN, applied at each corner of a container stack, and resulting from heave and pitch (i.e. ship in upright condition) is to be determined as follows:

$$P = 9,81\frac{M}{4}(1 + a_v)$$

where:

a_v = acceleration addition according to [2.3.1]

M = maximum designed mass of container stack in t

3.4.3 *(1/7/2016)*

The following loads in kN due to heave, pitch, and the ship's rolling motion are to be considered, see also Fig 3.

$$A_Z = 9,81\frac{M}{2} \cdot (1 + a_v) \cdot \left(0,45 - 0,42\frac{h_m}{b}\right)$$

$$B_Z = 9,81\frac{M}{2} \cdot (1 + a_v) \cdot \left(0,45 + 0,42\frac{h_m}{b}\right)$$

B_y = 2,4 · M

- a_v : acceleration addition according to [3.3.1]
- M : maximum designed mass of container stack, in t
- h_m : designed height of centre of gravity of stack above hatch cover top in m, may be calculated as weighted mean value of the stack, where the centre of gravity of each tier is assumed to be located at the centre of each container:

$$= \sum(z_i \cdot W_i) / M$$

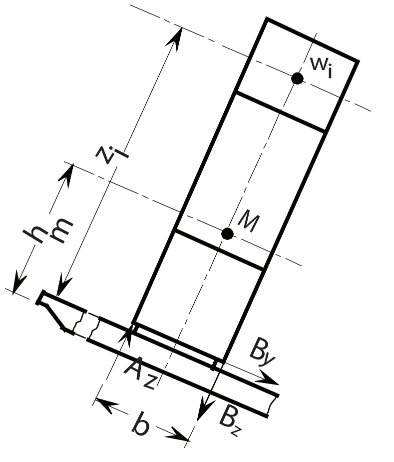
- z_i : distance from hatch cover top to the centre of ith container in m.
- W_i : weight of /th container in t
- b : distance between midpoints of foot points, in m
- A_Z, B_Z : support forces in z-direction at the forward and aft stack corners
- B_Y : support force in y-direction at the forward and aft stack corners.

When strength of the hatch cover structure is assessed by grillage analysis according to 3,5, h_m and z_i need to be taken above the hatch cover supports. Forces By does not need to be considered in this case.

Values of A_Z and B_Z applied for the assessment of hatch cover strength are to be shown in the drawings of the hatch covers.

Note 1: It is recommended that container loads as calculated above are considered as limit for foot point loads of container stacks in the calculations of cargo securing (container lashing).

Figure 3 : Forces due to container loads *(1/7/2016)*



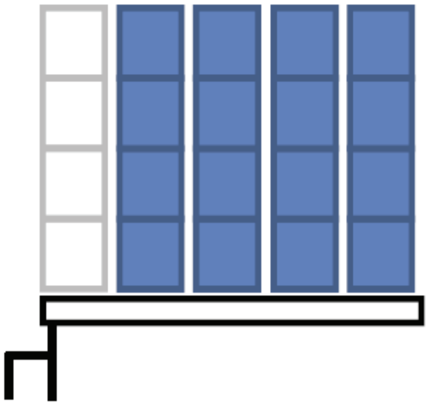
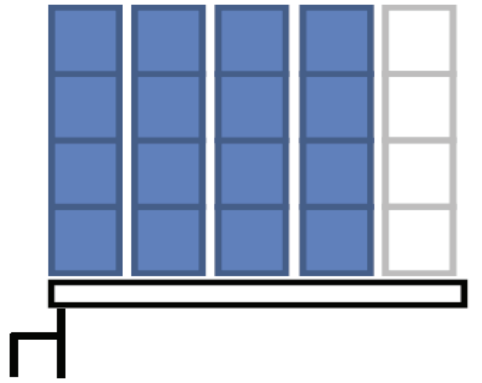
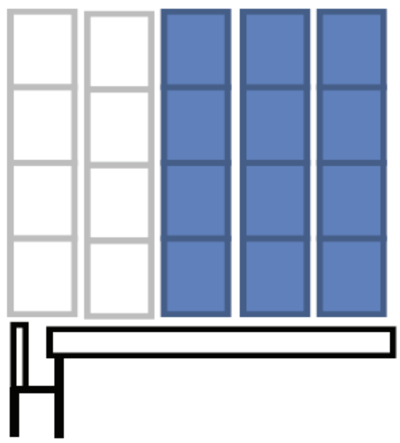
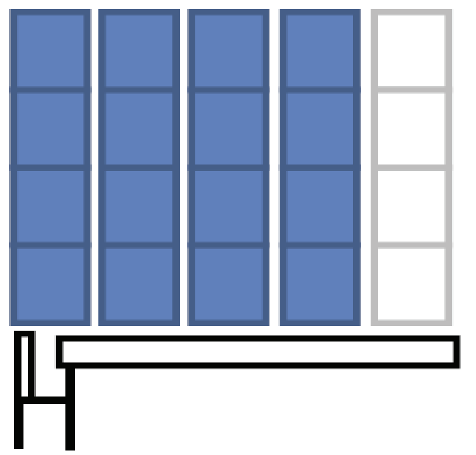
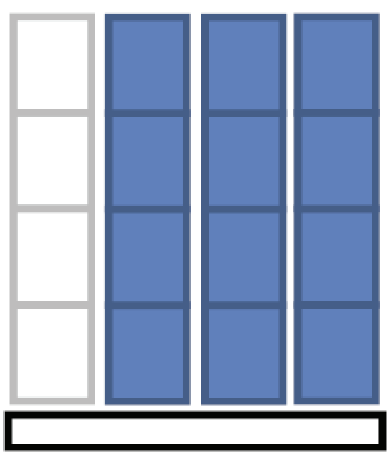
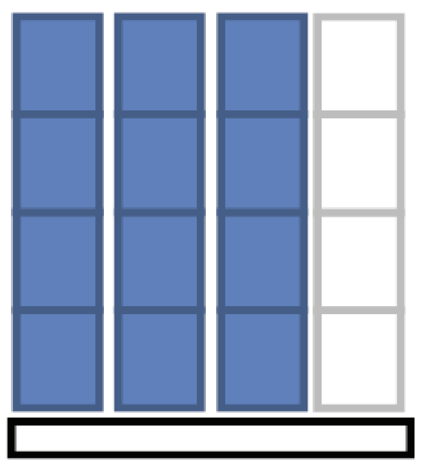
3.4.4 Load cases with partial loading *(1/7/2016)*

The load defined in cases [3.3] and [3.4] are also to be considered for partial non homogeneous loading which may occur in practice, e.g. where specified container stack places are empty. For each hatch cover, the heel directions, as shown in Tab 3, are to be considered

The load case partial loading of container hatch covers can be evaluated using a simplified approach, where the hatch cover is loaded without the outermost stacks, see that are located completely on the hatch cover. If there are additional stacks that are supported partially by the hatch cover and partially by container stanchions then the loads from these stacks are also to be neglected, refer to Tab 3. In addition, the case where only the stack places supported partially by the hatch cover and partially by container stanchions are left empty is to be assessed in order to consider the maximum loads in the vertical hatch cover supports.

It may be necessary to also consider partial load cases where more or different container stack places are left empty. Partial load case should in general be considered.

Table 4 : Partial loading of container hatch covers *(1/7/2016)*

Heel direction	◁-----------------------------------	-----------------------------------▷
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (center hatch covers)		

3.4.5 Mixed stowage of 20' and 40' containers on hatch cover *(1/7/2016)*

In the case of mixed stowage (20'+40' container combined stack), the foot point forces at the fore and aft end of the hatch cover are not to be higher than resulting from the design stack weight for 40' containers, and the foot point forces at the middle of the cover are not to be higher than resulting from the design stack weight for 20' containers.

3.5 Loads due to elastic deformations of the ship's hull

3.5.1 *(1/7/2012)*

Hatch covers, which in addition to the loads according to [3.1] to [3.4] are loaded in the ship's transverse direction by forces due to elastic deformations of the ship's hull, are to be designed such that the sum of stresses does not exceed the permissible values given in [4.1.1].

4 Hatch cover strength criteria

4.1 Permissible stresses and deflections

4.1.1 Stresses *(1/7/2016)*

The equivalent stress σ_v, in N/mm², in steel hatch cover structures related to the net thickness shall not exceed 0,8 σ_F, where σ_F is the minimum yield stress, in N/mm², of the material. For design loads according to [3.2] to [3.5], the equivalent stress σ_v related to the net thickness shall not exceed 0,9 σ_F when the stresses are assessed by means of FEM.

For steels with a minimum yield stress of more than 355 N/mm², the value of σ_F to be applied throughout this requirement is to be considered on a case by case basis but is not to be more than the minimum yield stress of the material and grillage analysis, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2}$$

σ : normal stress, in N/mm²

τ : shear stress, in N/mm².

For FEM calculations, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma^2 - \sigma_x \cdot \sigma_y + \sigma_y^2 + 3\tau^2}$$

σ_x : normal stress, in N/mm², in x-direction

σ_y : normal stress, in N/mm², in y-direction

τ : shear stress, in N/mm², in the x-y plane.

Indices x and y are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell or plane strain elements, the stresses are to be read from the centre of the individual element. It is to be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element centre may lead to non-conservative results. Thus, a sufficiently fine mesh is to be applied in these cases or, the stress at the element edges shall not exceed the allowable stress. Where shell elements are used, the stresses are to be evaluated at the mid plane of the element.

Stress concentrations are to be assessed on a case by case basis.

4.1.2 Deflection *(1/7/2012)*

The vertical deflection of primary supporting members due to the vertical weather design load according to [3.1] is to be not more than 0,0056 l_g , where l_g is the greatest span of primary supporting members.

4.2 Local net plate thickness

4.2.1 General *(1/7/2016)*

The local net plate thickness t, in mm, of the hatch cover top plating is not to be less than:

$$t = F_p \cdot 15,8 \cdot s\sqrt{\frac{p}{0,95 \cdot \sigma_F}}$$

and to be not less than 1% of the spacing of the stiffener or 6 mm if that be greater.

F_p : factor for combined membrane and bending response

= 1,5 in general

= 1,9 · σ / σ_a , for $(\sigma / \sigma_a) \geq 0,8$ for the attached plate flange of primary supporting members

s : stiffener spacing, in m

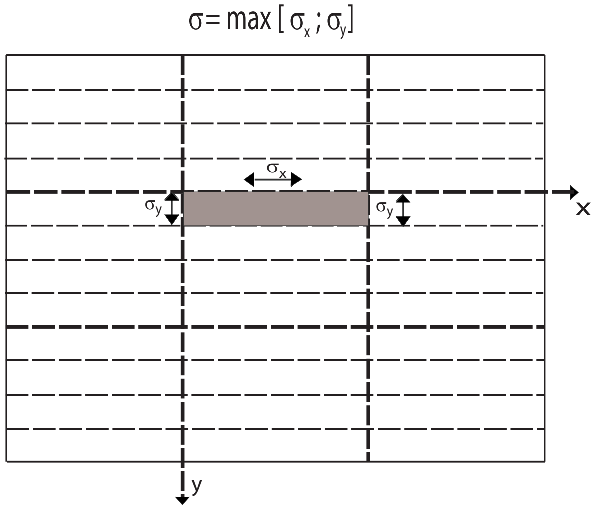
p : pressure p_H and p_L, in kN/m², as defined in [3]

σ : normal stress, in N/mm², of hatch cover top plating

σ_a : 0,8 · σ_F , in N/mm²

For flange plates under compression sufficient buckling strength according to [4.6] is to be demonstrated.

Figure 4 : Determination of normal stress of the hatch cover plating *(1/7/2016)*



4.2.2 Local net plate thickness of hatch covers for wheel loading *(1/7/2012)*

In general, the local net plate thickness of hatch covers for wheel loading is obtained by applying the load and strength criteria of Ch 7, Sec 1, [4].

4.2.3 Lower plating of double skin hatch covers and box girders *(1/7/2016)*

The thickness to fulfill the strength requirements is to be obtained from the calculation according to [4.5] under consideration of permissible stresses according to [4.1.1].

When the lower plating is taken into account as a strength member of the hatch cover, the net thickness, in mm, of lower plating is to be taken not less than 5 mm. When project cargo is intended to be carried on a hatch cover, the net thickness must not be less than:

t : $6{,}5 \cdot s$, in mm

s : stiffener spacing, in m.

Note 1: Project cargo means especially large or bulky cargo lashed to the hatch cover. Examples are parts of cranes or wind power stations, turbines, etc. Cargoes that can be considered as uniformly distributed over the hatch cover, e.g., timber, pipes or steel coils need not to be considered as project cargo.

When the lower plating is not considered as a strength member of the hatch cover, the thickness of the lower plating is to be determined on a case by case basis.

4.3 Net scantling of secondary stiffeners

4.3.1 General *(1/7/2016)*

The net section modulus Z, in cm³, and net shear area A_s, in cm³, of uniformly loaded hatch cover stiffeners constraint at both ends is to be not less than:

$$Z = \frac{104psl^2}{\sigma^F}$$ in cm2, for design load according to [3.1]

$$Z = \frac{93psl^2}{\sigma^F}$$ in cm2, for design loads according to [3.3.1]

$$A_S = \frac{10,8psl}{\sigma^F}$$ in cm2, for design load according to [3.1]

$$A_S = \frac{9,6psl}{\sigma^F}$$ in cm2, for design loads according to [3.3.1]

L : secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member and the edge support, as applicable

s : secondary stiffener spacing, in m

p : pressure p_H and p_L, in kN/m², as defined in [3].

For secondary stiffeners of lower plating of double skin hatch covers, requirements mentioned above are not applied due to the absence of lateral loads.

The net thickness, in mm, of the stiffener (except u-beams/trapeze stiffeners) web is to be taken not less than 4 mm.

The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_w is to be not greater than $15 \cdot k^{0.5}$, where:

h : height of the stiffener

t_w : net thickness of the stiffener

k : $235 / \sigma_F$.

Stiffeners parallel to primary supporting members and arranged within the effective breadth according to [4.5.2] is to be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members. It is to be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses according to [4.1.1]. The requirements of this paragraph are not applied to stiffeners of lower plating of double skin hatch covers if the lower plating is not considered as strength member.

For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling according to [4.6.6] and [4.6.7], respectively, is to be verified.

For hatch covers subject to wheel loading or point loads stiffener scantlings are to be determined under consideration of the permissible stresses according to [4.1.1].

4.4 Net scantling of primary supporting members

4.4.1 Primary supporting members *(1/7/2012)*

Scantlings of primary supporting members are obtained from calculations according to [4.5] under consideration of permissible stresses according to [4.1.1].

For all components of primary supporting members sufficient safety against buckling must be verified according to [4.6]. For biaxial compressed flange plates this is to be verified within the effective widths according to [4.6.5].

The net thickness, in mm, of webs of primary supporting members shall not be less than:

$t = 6{,}5 \cdot s$, in mm

$t_{min} = 5$ mm

s : stiffener spacing, in m.

4.4.2 Edge girders (Skirt plates) *(1/7/2012)*

Scantlings of edge girders are obtained from the calculations according to [4.5] under consideration of permissible stresses according to [4.1.1].

The net thickness, in mm, of the outer edge girders exposed to wash of sea shall not be less than the largest of the following values:

$$t = 15,8 \cdot s \cdot \sqrt{\frac{p_A}{0,95 \cdot \sigma_F}}$$

$t = 8{,}5 \cdot s$, in mm

$t_{min} = 5$ mm

p_A : horizontal pressure as defined in [3.2]

s : stiffener spacing, in m.

The stiffness of edge girders is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, in cm⁴, of edge girders is not to be less than:

I : $6 \cdot q \cdot S^4_{SD}$

q : packing line pressure, in N/mm, minimum 5 N/mm

S_{SD} : spacing, in m, of securing devices.

4.5 Strength calculations

4.5.1 General *(1/7/2016)*

Strength calculation for hatch covers may be carried out by either grillage analysis or FEM. Double skin hatch covers or hatch covers with box girders are to be assessed using FEM, refer to [4.5.3].

4.5.2 Effective cross-sectional properties for calculation by grillage analysis *(1/7/2016)*

Cross-sectional properties are to be determined considering the effective breadth. Cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth can be included, see Fig 6.

The effective breadth of plating e_m of primary supporting members is to be determined according to Tab 5, considering the type of loading. Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

The effective cross sectional area of plates is not to be less than the cross sectional area of the face plate.

For flange plates under compression with secondary stiffeners perpendicular to the web of the primary supporting member, the effective width is to be determined according to [4.6.5].

4.5.3 General requirements for FEM calculations *(1/7/2016)*

For strength calculations of hatch covers by means of finite elements, the cover geometry is to be modeled as realistically as possible. Element size is tobe appropriate to account for effective breadth. In no case the element width is to be greater than the stiffener spacing. In way of force transfer points and cutouts the mesh is to be refined where applicable. The ratio of element length to width is not to exceed 4.

The element height of webs of primary supporting member is not to exceed one-third of the web height. Stiffeners, supporting plates against pressure loads, have to be included in the idealization. Stiffeners may be modelled by using shell elements, plane stress elements or beam elements. Buckling stiffeners may be disregarded for the stress calculation.

Table 5 : Effective breadth e_m of plating of primary supporting members *(1/7/2012)*

l/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0,36	0,64	0,82	0.91	0,96	0,98	1,00	1,00
e_{m2}/e	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,90

e_{m1} : is to be applied where primary supporting members are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads

e_{m2} : is to be applied where primary supporting members are loaded by 3 or less single loads

Intermediate values may be obtained by direct interpolation.

l : length of zero-points of bending moment curve:
$l = l_0$ for simply supported primary supporting members
$l = 0,6 \cdot l_0$ for primary supporting members with both ends constraint,
where l_0 is the unsupported length of the primary supporting member

e : width of plating supported, measured from centre to centre of the adjacent unsupported fields

4.6 Buckling strength of hatch cover structures

4.6.1 *(1/7/2012)*

For hatch cover structures sufficient buckling strength is to be demonstrated according to the requirements of this paragraph.

The buckling strength assessment of coaming parts is to be considered on a case by case basis.

a : length of the longer side of a single plate field in mm (x-direction)

b : breadth of the shorter side of a single plate field in mm (y-direction)

α : aspect ratio of single plate field
= a / b

n : number of single plate field breadths within the partial or total plate field

t : net plate thickness, in mm

σ_x : membrane stress, in N/mm², in x-direction

σ_y : membrane stress, in N/mm², in y-direction

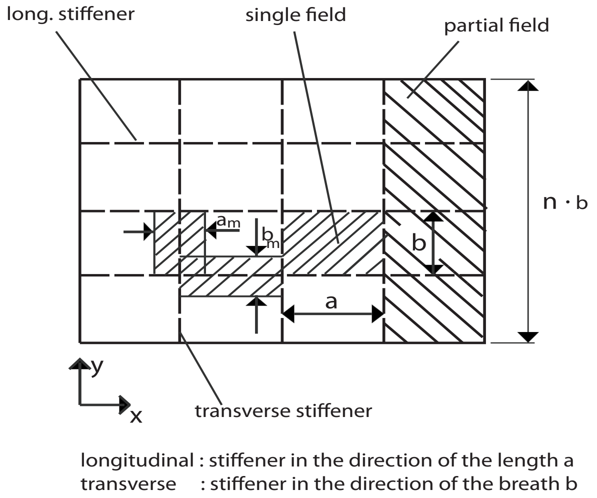
τ : shear stress, in N/mm², in the x-y plane

E : modulus of elasticity, in N/mm², of the material
$= 2,06 \cdot 10^5$ N/mm², for steel

σ_F : minimum yield stress, in N/mm², of the material

Compressive and shear stresses are to be taken positive, tension stresses are to be taken negative.

Figure 5 : General arrangement of panel *(1/7/2012)*



If stresses in the x- and y-direction already contain the Poisson-effect (calculated using FEM), the following modified stress values may be used. Both stresses σ_x^* and σ_y^* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:

$\sigma_x = (\sigma_x^* - 0,3 \cdot \sigma_y^*) / 0,91$

$\sigma_y = (\sigma_y^* - 0,3 \cdot \sigma_x^*) / 0,91$

σ_x^* , σ_y^* : stresses containing the Poisson-effect.

Where compressive stress fulfils the condition $\sigma_y^* < 0,3\sigma_x^*$, then $\sigma_y = 0$ and $\sigma_x = \sigma_x^*$.

Where compressive stress fulfils the condition $\sigma_x^* < 0,3\sigma_y^*$, then $\sigma_x = 0$ and $\sigma_y = \sigma_y^*$.

F_1 : correction factor for boundary condition at the longitudinal stiffeners according to Tab 6.

Table 6 : Correction factor F_1 *(1/7/2012)*

Stiffeners sniped at both ends	1,00
Guidance values **(1)** where both ends are effectively connected to adjacent structures	1,05 for flat bars
	1,10 for bulb sections
	1,20 for angle and tee-sections
	1,30 for u-type sections **(2)** and girders of high rigidity
An average value of F_1 is to be used for plate panels having different edge stiffeners	
(1) Exact values may be determined by direct calculations **(2)** Higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA, to be accepted by the Society on a case-by-case basis, but not greater than 2,0	

σ_e : reference stress, in N/mm², taken equal to

$= 0,9 \cdot E\,(t / b)^2$

ψ : edge stress ratio taken equal to

$= \sigma_2 / \sigma_1$ where:

- σ_1 : maximum compressive stress
- σ_2 : minimum compressive stress or tension stress

S : safety factor (based on net scantling approach), taken equal to:

= 1,25 for hatch covers when subjected to the vertical weather design load according to [3.1]

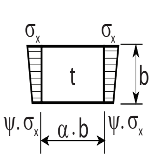
= 1,10 for hatch covers when subjected to loads according to [3.2] to [3.5]

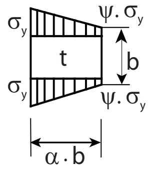
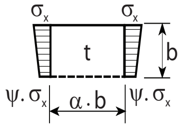
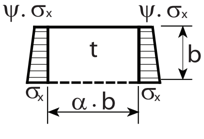
λ : reference degree of slenderness, taken equal to:

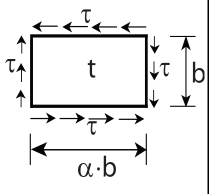
$$= \sqrt{\frac{\sigma_F}{K \cdot \sigma_e}}$$

K : buckling factor according toTab 7.

Table 7 : Buckling and reduction factors for plane elementary plate panels *(1/7/2012)*

Buckling-Load Case	Edge stress ratio ψ	Asp. ratio $\alpha = a/b$	Buckling factor K	Reduction factor k
1 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$k = 8,4 / (\psi + 1,1)$	$k_x = 1$ for $\lambda \leq \lambda_c$ $k_x = c\,[(1/\lambda) - (0,22/\lambda^2)]$ for $\lambda > \lambda_c$ $c = (1,25 - 0,12\,\psi) \leq 1,25$ $\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0,88}{c}}\right)$
	$0 > \psi > -1$		$k = 7,63 - \psi(6,26 - 10\psi)$	
	$\psi \leq -1$		$k = (1 - \psi)^2 \cdot 5,975$	
Explanations for boundary conditions - - - - - plate edge free plate edge simply supported				

<table>
<tr><th>Buckling-
Load Case</th><th>Edge stress
ratio ψ</th><th>Asp. ratio
$\alpha = a/b$</th><th>Buckling factor K</th><th>Reduction factor k</th></tr>
<tr><td rowspan="5">2

</td><td>$1 \geq \psi \geq 0$</td><td>$\alpha \geq 1$</td><td>$K = F_1\left(1+\frac{1}{\alpha^2}\right)^2 \cdot \frac{2,1}{(\psi+1,1)}$</td><td rowspan="5">$K_y = c\left(\frac{1}{\lambda} - \frac{R+F^2(H-R)}{\lambda^2}\right)$
$c = (1,25 - 0,12\,\lambda) \leq 1,25$
$R = \lambda\left(1-\frac{\lambda}{c}\right)$ for $\lambda < \lambda_C$
$R = 0,22$ for $\lambda \geq \lambda_C$
$\lambda_C = \frac{c}{2}\left(1+\sqrt{1-\frac{0,88}{c}}\right)$
$F = \left[1-\left(\frac{k}{0,91}-1\right)/\lambda^2_p\right] \cdot c_1 \geq 0$
$\lambda^2_p = \lambda^2 - 0,5$ for $1 \leq \lambda^2_p \leq 3$
$c_1 = \left(1-\frac{F_1}{\alpha}\right) \geq 0$
$H = \lambda - \frac{2\lambda}{c \cdot (T+\sqrt{T^2-4})} \geq R$
$T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$</td></tr>
<tr><td rowspan="2">$0 > \psi > -1$</td><td>$1 \leq \alpha \leq 1,5$</td><td>$K = F_1\left[\left(1+\frac{1}{\alpha^2}\right)^2 \cdot \frac{2,1(1+\psi)}{1,1} - \frac{\psi}{\alpha^2}(13,9-10\psi)\right]$</td></tr>
<tr><td>$\alpha > 1,5$</td><td>$K = F_1\left[\left(1+\frac{1}{\alpha^2}\right)^2 \cdot \frac{2,1(1+\psi)}{1,1} - \frac{\psi}{\alpha^2} \cdot (5,87 + 1,87\alpha^2 + \frac{8,6}{\alpha^2} - 10\psi)\right]$</td></tr>
<tr><td rowspan="2">$\psi \leq -1$</td><td>$1 \leq \alpha \leq 3(1-\psi)/4$</td><td>$K = F_1\left(\frac{1-\psi}{\alpha}\right)^2 \cdot 5,975$</td></tr>
<tr><td>$\alpha > 3(1-\psi)/4$</td><td>$K = F_1\left[\left(\frac{1-\psi}{\alpha}\right)^2 \cdot 3,9675 + 0,5375 \cdot \left(\frac{1-\psi}{\alpha}\right)^4 + 1,87\right]$</td></tr>
<tr><td rowspan="2">3

</td><td>$1 \geq \psi \geq 0$</td><td rowspan="2">$a > 0$</td><td>$K = \frac{4\left(0,425+\frac{1}{\alpha^2}\right)}{3\psi+1}$</td><td rowspan="3">$K_\tau = 1$ for $\lambda \leq 0,7$
$K_\tau = \frac{1}{\lambda^2+0,51}$ for $\lambda > 0,7$</td></tr>
<tr><td>$0 > \psi \geq -1$</td><td>$K = 4\left(0,425+\frac{1}{\alpha^2}\right)(1+\psi) - 5\psi(1-3,42\psi)$</td></tr>
<tr><td>4

</td><td>$1 \geq \psi \geq -1$</td><td>$\alpha > 0$</td><td>$K = \left(0,425+\frac{1}{\alpha^2}\right)\frac{3-\psi}{2}$</td></tr>
<tr><td colspan="5">Explanations for boundary conditions - - - - - plate edge free
——— plate edge simply supported</td></tr>
</table>

Buckling-Load Case	Edge stress ratio ψ	Asp. ratio α = a/b	Buckling factor K	Reduction factor k
5 	-		$K = K_\tau \cdot \sqrt{3}$	$K_\tau = 1$ for $\lambda \le 0,84$ $K_\tau = \frac{0,84}{\lambda}$ for $\lambda > 0,84$
		$\alpha \ge 1$	$K_\tau = \left[5,34 + \frac{4}{\alpha^2}\right]$	
		$0 < \alpha < 1$	$K_\tau = \left[4 + \frac{5,34}{\alpha^2}\right]$	
Explanations for boundary conditions - - - - - plate edge free ——— plate edge simply supported				

4.6.2 Proof of top and lower hatch cover plating *(1/7/2012)*

Proof is to be provided that the following condition is complied with for the single plate field a · b:

$$\left(\frac{|\sigma_x| \cdot S}{k_x \cdot \sigma_F}\right)^{e1} + \left(\frac{|\sigma_x| \cdot S}{k_y \cdot \sigma_F}\right)^{e2} - B\left(\frac{\sigma_x \cdot \sigma_y \cdot S^2}{\sigma^2_F}\right) + \left(\frac{|\tau| \cdot S \cdot \sqrt{3}}{k_\tau \cdot \sigma_F}\right)^{e3} \le 1,0$$

The first two terms and the last term of the above condition shall not exceed 1,0.

The reduction factors K_x, K_y and K_t are given in Tab 7.

Where $\sigma_x \le 0$ (tension stress), $K_x = 1,0$.

Where $\sigma_y \le 0$ (tension stress), $K_y = 1,0$.

The exponents e_1, e_2 and e_3 as well as the factor B are to be taken as given by Tab 8.

4.6.3 Webs and flanges of primary supporting members *(1/7/2012)*

For non-stiffened webs and flanges of primary supporting members sufficient buckling strength as for the hatch cover top and lower plating is to be demonstrated according to [4.6.2].

Table 8 : Coefficients e_1, e_2 and e_3 and factor B *(1/7/2012)*

Exponents e_1 - e_3 and factor B	Plate panel
e_1	$1 + k_x^4$
e_2	$1 + k_y^4$
e_3	$1 + k_x \cdot k_y \cdot k^2_\tau$
B σ_x and σ_y positive (compression stress)	$(k_x \cdot k_y)^5$
B σ_x and σ_y negative (tension stress)	1

4.6.4 Longitudinal and transverse secondary stiffeners *(1/7/2016)*

It is to be demonstrated that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in [4.6.6] and [4.6.7]. For u-type stiffeners, the proof of torsional buckling strength according to [4.6.7] can be omitted.

Single-side welding is not permitted to use for secondary stiffeners except for u-stiffeners.

4.6.5 Effective width of top and lower hatch cover plating *(1/7/2012)*

For demonstration of buckling strength according to [4.6.6] and [4.6.7] the effective width of plating may be determined by the following formulae:

$b_m = k_x \cdot b$ for longitudinal stiffeners

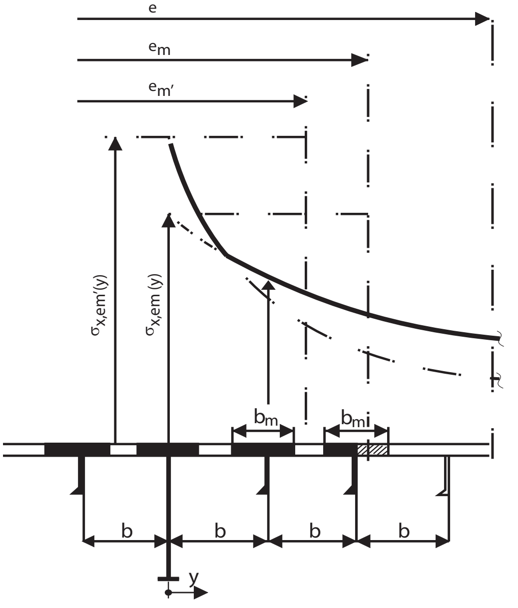
$a_m = k_y \cdot a$ for transverse stiffeners

see also Fig 5.

The effective width of plating is not to be taken greater than the value obtained from [4.5.2].

The effective width e'_m of stiffened flange plates of primary supporting members may be determined as follows (see Fig 6):

Figure 6 : Stiffening parallel to web of primary supporting member *(1/7/2012)*



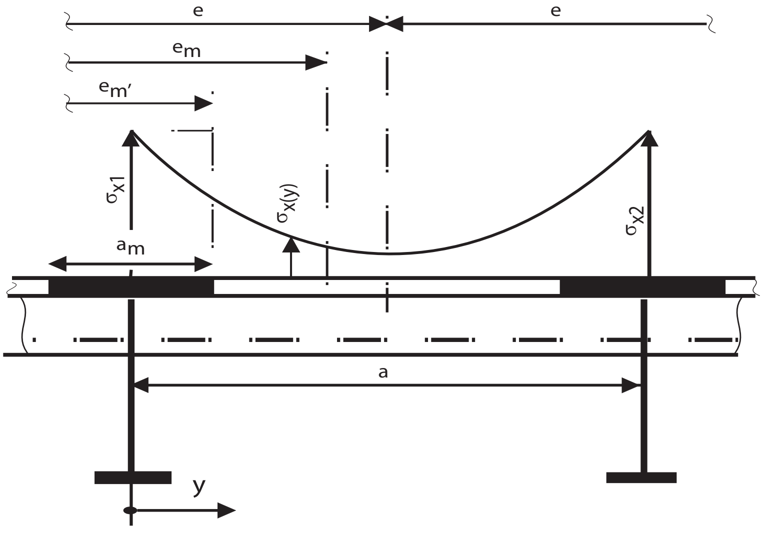
$b < e_m$

$e'_m = n \cdot b_m$

n = integer number of stiffener spacings b inside the effective breadth em according to [4.5.2]

$n = int (e_m / b)$

Figure 7 : Stiffening perpendicular to web of primary supporting member *(1/7/2012)*



$a \geq e_m$

$e'_m = n \cdot a_m < e_m$

$n = 2,7 \cdot e_m/a \leq 1$

e = width of plating supported according to [4.5.2]

For $b \geq e_m$ or $a < e_m$, respectively, b and a have to be exchanged.

a_m and b_m for flange plates are in general to be determined for $\Psi = 1$.

Scantlings of plates and stiffeners are in general to be determined according to the maximum stresses $\sigma_x(y)$ at webs of primary supporting member and stiffeners, respectively. For stiffeners with spacing b under compression arranged parallel to primary supporting members no value less than 0,25 σ_F shall be inserted for $\sigma_x(y=b)$.

The stress distribution between two primary supporting members can be obtained by the following formula:

$$\sigma_x(y) = \sigma_{x1} \cdot \left\{1 - \frac{y}{e}\left[3 + d_1 - 4 \cdot c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2)\right]\right\}$$

c_1 : $\sigma_{x2} / \sigma_{x1}$ for $0 \le c_1 \le 1$

c_2 : $(1{,}5 / e) \cdot (e''_{m1} + e''_{m2}) - 0{,}5$

e''_{m1} : proportionate effective breadth e_{m1} or proportionate effective width e'_{m1} of primary supporting member 1 within the distance e, as appropriate

e''_{m2} : proportionate effective breadth e_{m2} or proportionate effective width e'_{m2} of primary supporting member 2 within the distance e, as appropriate

σ_{x1}, σ_{x2} : normal stresses in flange plates of adjacent primary supporting member 1 and 2 with spacing e, based on cross-sectional properties considering the effective breadth or effective width, as appropriate

y : distance of considered location from primary supporting member 1

Shear stress distribution in the flange plates may be assumed linearly.

4.6.6 Lateral buckling of secondary stiffeners *(1/7/2012)*

$$\frac{\sigma_a + \sigma_b}{\sigma_F} S \le 1$$

σ_a : uniformly distributed compressive stress, in N/mm², in the direction of the stiffener axis

σ_a : σ_x for longitudinal stiffeners

σ_a : σ_y for transverse stiffeners

σ_b : bending stress, in N/mm², in the stiffener

$$= \frac{M_0 + M_1}{Z_{st} \cdot 10^3}$$

M_0 : bending moment, in Nmm, due to the deformation w of stiffener, taken equal to:

$$M_0 = F_{Ki}\frac{p_z \cdot w}{c_f - p_z} \text{ with } (c_f - p_z) > 0$$

M_1 : bending moment, in Nmm, due to the lateral load p equal to:

$$M_1 = \frac{p \cdot b \cdot a^2}{24 \cdot 10^3} \text{ for longitudinal stiffeners}$$

$$M_1 = \frac{p \cdot a \cdot (n \cdot b)^2}{c_s \cdot 8 \cdot 10^3} \text{ for transverse stiffeners}$$

n is to be taken equal to 1 for ordinary transverse stiffeners.

p : lateral load, in kN/m²

F_{Ki} : ideal buckling force, in N, of the stiffener

$$F_{Kix} = \frac{\pi^2}{a^2} \cdot E \cdot I_x \cdot 10^4 \text{ for longitudinal stiffeners}$$

$$F_{Kiy} = \frac{\pi^2}{(n \cdot b)^2} \cdot E \cdot I_y \cdot 10^4 \text{ for transverse stiffeners}$$

I_x, I_y : net moments of inertia, in cm⁴, of the longitudinal or transverse stiffener including effective width of attached plating according to [4.6.5]. I_x and I_y are to comply with the following criteria:

$$I_x \ge \frac{b \cdot t^3}{12 \cdot 10^4}$$

$$I_y \ge \frac{a \cdot t^3}{12 \cdot 10^4}$$

p_z : nominal lateral load, in N/mm², of the stiffener due to σ_x, σ_y and τ

$$p_{zx} = \frac{t}{b}\left[\sigma_{xl} \cdot \left(\frac{\pi \cdot b}{a}\right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2}\tau_1\right] \text{ for longitudinal stiffeners}$$

$$p_{zy} = \frac{t}{a}\left[2 \cdot c_x \cdot \sigma_{xl} + \sigma_y\left(\frac{\pi \cdot a}{n \cdot b}\right)^2\left(1 + \frac{A_y}{a \cdot t}\right) + \sqrt{2}\tau_1\right]$$

for transverse stiffeners

$$\sigma_{xl} = \sigma_x\left(1 + \frac{A_x}{b \cdot t}\right)$$

c_x, c_y : factor taking into account the stresses perpendicular to the stiffener's axis and distributed variable along the stiffener's length

= $0{,}5 \cdot (1 + \Psi)$ for $0 \le \Psi \le 1$

= $0{,}5 / (1 - \Psi)$ for $\Psi < 0$

A_x, A_y : net sectional area, in mm², of the longitudinal or transverse stiffener, respectively, without attached plating

$$\tau_1 = \left[\tau - t\sqrt{\sigma_F \cdot E\left(\frac{m_1}{a^2} + \frac{m_2}{b^2}\right)}\right] \ge 0$$

for longitudinal stiffeners:

a / b ≥ 2,0 : m_1 = 1,47 m_2 = 0,49

a / b < 2,0 : m_1 = 1,96 m_2 = 0,37

for transverse stiffeners:

a / (n · b) ≥ 0,5 : m_1 = 0,37 m_2 = 1,96 / n²

a / (n · b) < 0,5 : m_1 = 0,49 m_2 = 1,47 / n²

$w = w_0 + w_1$

w_0 = assumed imperfection, in mm

$w_{0x} \le$ min (a/250, b/250, 10) for longitudinal stiffeners

$w_{0y} \le$ min (a/250, nb/250, 10) for transverse stiffeners.

For stiffeners sniped at both ends w_0 is to be taken not less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 = Deformation of stiffener, in mm, at midpoint of stiffener span due to lateral load p.

In case of uniformly distributed load the following values for w_1 may be used:

$$w_1 = \frac{p \cdot b \cdot a^4}{384 \cdot 10^7 \cdot E \cdot I_x} \text{ for longitudinal stiffeners}$$

$$w_1 = \frac{5 \cdot a \cdot p \cdot (n \cdot b)^4}{384 \cdot 10^7 \cdot E \cdot I_y \cdot c_s^2} \text{ for transverse stiffeners}$$

c_f : elastic support provided by the stiffener, in N/mm²

- For longitudinal stiffeners:

$$c_{fx} = F_{Kix} \cdot \frac{\pi^2}{a^2} \cdot (1 + c_{px})$$

$$c_{px} = \frac{1}{1 + \dfrac{0,91 \cdot \left(\dfrac{12 \cdot 10^4 \cdot I_x}{t^3 \cdot b} - 1\right)}{c_{xa}}}$$

$$c_{xa} = \left[\frac{a}{2b} + \frac{2b}{a}\right]^2 \text{ for } a \ge 2b$$

$$c_{xa} = \left[1 + \left(\frac{a}{2b}\right)^2\right]^2 \text{ for } (a < 2b)$$

- For transverse stiffeners:

$$c_{fy} = c_s \cdot F_{Kiy} \cdot \frac{\pi^2}{(n \cdot b)^2} \cdot (1 + c_{py})$$

$$c_{py} = \frac{1}{1 + \dfrac{0,91 \cdot \left(\dfrac{12 \cdot 10^4 \cdot I_y}{t^3 \cdot a} - 1\right)}{c_{ya}}}$$

$$c_{ya} = \left[\frac{n \cdot b}{2a} + \frac{2a}{n \cdot b}\right]^2 \text{ for } n \cdot b \ge 2a$$

$$c_{ya} = \left[1 + \left(\frac{n \cdot b}{2a}\right)^2\right]^2 \text{ for } n \cdot b < 2a$$

c_s : factor accounting for the boundary conditions of the transverse stiffener

= 1,0 for simply supported stiffeners

= 2,0 for partially constraint stiffeners

Z_{st} : net section modulus of stiffener (longitudinal or transverse), in cm³, including effective width of plating according to [4.6.5].

If no lateral load p is acting the bending stress σ_b is to be calculated at the midpoint of the stiffener span for that fibre which results in the largest stress value. If a lateral load p is acting, the stress calculation is to be carried out for both fibres of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

4.6.7 Torsional buckling of secondary stiffeners *(1/7/2012)*

a) Longitudinal secondary stiffeners

The longitudinal ordinary stiffeners are to comply with the following criteria:

$$k_T = \frac{\sigma_x \cdot S}{k_T \cdot \sigma_F} \le 1,0$$

k_T : coefficient taken as follows:

$k_T = 1,0$ for $\lambda_T \le 0,2$

$$k_T = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda_T^2}} \text{ for } \lambda_T > 0,2$$

$$\Phi = 0,5(1 + 0,21(\lambda_T - 0,2) + \lambda_T^2)$$

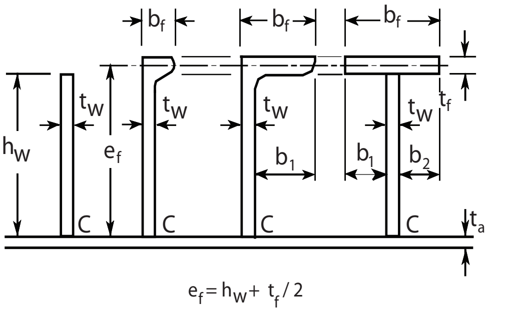
λ_T : reference degree of slenderness taken equal to:

$$\lambda_T = \sqrt{\frac{\sigma_F}{\sigma_{KiT}}}$$

$$\sigma_{KiT} = \frac{E}{I_P}\left(\frac{\pi^2 \cdot I_\omega \cdot 10^2}{a^2}\varepsilon + 0,385 \cdot I_T\right) \text{, in N/mm}^2$$

For I_P , I_T , I_ω see Fig 8 and Tab 9.

Figure 8 : Dimensions of stiffener *(1/7/2012)*



I_P : net polar moment of inertia of the stiffener, in cm⁴, related to the point C

I_T : net St. Venant's moment of inertia of the stiffener, in cm⁴

I_ω : net sectorial moment of inertia of the stiffener, in cm⁶, related to the point C

ε : degree of fixation taken equal to:

$$\varepsilon = 1 + 10^{-3}\sqrt{\frac{a^4}{\frac{3}{4}\pi^4 \cdot I_\omega\left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

h_w : web height, in mm

t_w : net web thickness, in mm

b_f : flange breadth, in mm

t_f : net flange thickness, in mm

A_w : net web area equal to: $A_w = h_w \cdot t_w$

A_f : net flange equal to: $A_f = b_f \cdot t_f$

e_f : $h_w + (t_f / 2)$, in mm

b) Transverse secondary stiffeners

For transverse secondary stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, sufficient torsional buckling strength is to be demonstrated analogously in accordance with a) above.

5 Details of hatch covers

5.1 Container foundations on hatch covers

5.1.1 *(1/7/2012)*

The substructures of container foundations are to be designed for cargo and container loads according to [2], applying the permissible stresses according to [4.1.1].

5.2 Weather tightness

5.2.1 General *(1/7/2012)*

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

5.2.2 Weathertight hatch covers *(1/7/2012)*

a) The arrangement of weathertight hatch covers is to be such that weathertightness can be maintained in al sea conditions.

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

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

5.2.3 Packing material (General) *(1/7/2012)*

The packing material is to be suitable for all expected service conditions of the ship and is to be compatible with the cargoes to be transported. The packing material is to be selected with regard to dimensions and elasticity in such a way that expected deformations can be carried. Forces are to be carried by the steel structure only.

The packings are to be compressed so as to give the necessary tightness effect for all expected operating conditions. Special consideration shall be given to the packing arrangement in ships with large relative movements between hatch covers and coamings or between hatch cover sections.

Table 9 : Moments of inertia *(1/7/2012)*

Section	I_P	I_T	I_ε
Flat bar	$\dfrac{h^3{}_w \cdot t_w}{3 \cdot 10^4}$	$\dfrac{h_w \cdot t^3{}_w}{3 \cdot 10^4}\left(1 - 0,63\dfrac{t_w}{h_w}\right)$	$\dfrac{h^3{}_w \cdot t^3{}_w}{36 \cdot 10^6}$
Sections with bulb or flange	$\left(\dfrac{A_w \cdot h_w{}^2}{3} + A_f \cdot e_f{}^2\right)10^{-4}$	$\dfrac{h_w \cdot t^3{}_w}{3 \cdot 10^4}\left(1 - 0,63\dfrac{t_w}{h_w}\right)$ $\pm$ $\dfrac{b_f \cdot t^3{}_f}{3 \cdot 10^4}\left(1 - 0,63\dfrac{t_f}{b_f}\right)$	for bulb and angle sections: $\dfrac{A_f \cdot e_f{}^2 \cdot b^2{}_f}{12 \cdot 10^6}\left(\dfrac{A_f + 2,6A_w}{A_f + A_w}\right)$ for tee-sections: $\dfrac{b^3{}_f \cdot t_f \cdot e^2{}_f}{12 \cdot 10^6}$

5.2.4 Dispensation of weather tight gaskets *(1/7/2012)*

For hatch covers of cargo holds solely for the transport of containers, upon request by the owners and subject to compliance with the following conditions the fitting of weather tight gaskets according to [5.2.3] may be dispensed with:

- the hatchway coamings shall be not less than 600 mm in height;
- the exposed deck on which the hatch covers are located is situated above a depth H(x). H(x) is to be shown to comply with the following criteria:

  $H(x) \geq T_{fb} + f_b + h$, in m

  T_{fb} : draught, in m, corresponding to the assigned summer load line

  f_b : minimum required freeboard, in m, determined in accordance with the IMO International Convention on Load Lines (ICLL), Reg. 28 as modified by further regulations as applicable

  $h = 4{,}6$ m for $(x / L_{LL}) \leq 0{,}75$

  $h = 6{,}9$ m for $(x / L_{LL}) > 0{,}75$
- Labyrinths, gutter bars or equivalents are to be fitted proximate to the edges of each panel in way of the coamings. The clear profile of these openings is to be kept as small as possible.
- Where a hatch is covered by several hatch cover panels the clear opening of the gap in between the panels shall be not wider than 50 mm.
- The labyrinths and gaps between hatch cover panels are to be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.
- Due regard is to be given to drainage of cargo holds and the necessary fire-fighting system.
- Bilge alarms should be provided in each hold fitted with non-weathertight covers.
- Furthermore, Chapter 3 of IMO MSC/Circ. 1087 is to be referred to concerning the stowage and segregation of containers containing dangerous goods.

5.2.5 Drainage arrangements *(1/7/2012)*

Cross-joints of multi-panel covers are to be provided with efficient drainage arrangements.

6 Hatch coaming strength criteria

6.1 Local net plate thickness of coamings

6.1.1 *(1/7/2012)*

The net thickness of weather deck hatch coamings shall not be less than the larger of the following values:

$$t = 14{,}2 \cdot s \sqrt{\frac{p_A}{0{,}95 \cdot \sigma_F}} \quad \text{, in mm}$$

$$t_{min} = 6 + \frac{L_1}{100} \quad \text{, in mm}$$

s : stiffener spacing, in m

L_1 : L, need not be taken greater than 300 m.

Longitudinal strength aspects are to be observed.

6.2 Net scantling of secondary stiffeners of coamings

6.2.1 *(1/7/2016)*

The stiffeners must be continuous at the coaming stays. For stiffeners with both ends constraint the elastic net section modulus Z, in cm³, and net shear area A_S, in cm², calculated on the basis of net thickness, are to be not less than:

$$Z = \frac{83}{\sigma_F} \cdot s \cdot l^2 \cdot p_A$$

$$A_s = \frac{10 \cdot s \cdot l \cdot p_A}{\sigma_F}$$

l : secondary stiffener span, in m, to be taken as the spacing of coaming stays

s : stiffener spacing, in m.

For sniped stiffeners of coaming at hatch corners section modulus and shear area at the fixed support have to be increased by 35%. The gross thickness of the coaming plate at the sniped stiffener end shall not be less than

$$t = 19{,}6 \sqrt{\frac{p_A \cdot s \cdot (l - 0{,}5s)}{\sigma_F}} \quad \text{, in mm}$$

Horizontal stiffeners on hatch coamings, which are part of the longitudinal hull structure, are to be designed taking into account the hull girder induced stresses.

6.3 Coaming stays

6.3.1 General *(1/7/2012)*

Coaming stays are to be designed for the loads transmitted through them and permissible stresses according to [4.1.1].

6.3.2 Coaming stay section modulus and web thickness *(1/7/2016)*

At the connection with deck, the net section modulus Z, in cm³, and the gross thickness tw, in mm, of the coaming stays designed as beams with flange (examples 1 and 2 are shown in Fig 9) are to be taken not less than:

$$Z = \frac{526}{\sigma_F} \cdot e \cdot h_s^2 \cdot p_A \quad \text{, in cm3}$$

$$t_w = \frac{2}{\sigma_F} \cdot \frac{e \cdot h_S \cdot p_A}{h_w} + t_S \quad \text{, in mm}$$

e : spacing of coaming stays, in m

h_S : height of coaming stays, in m

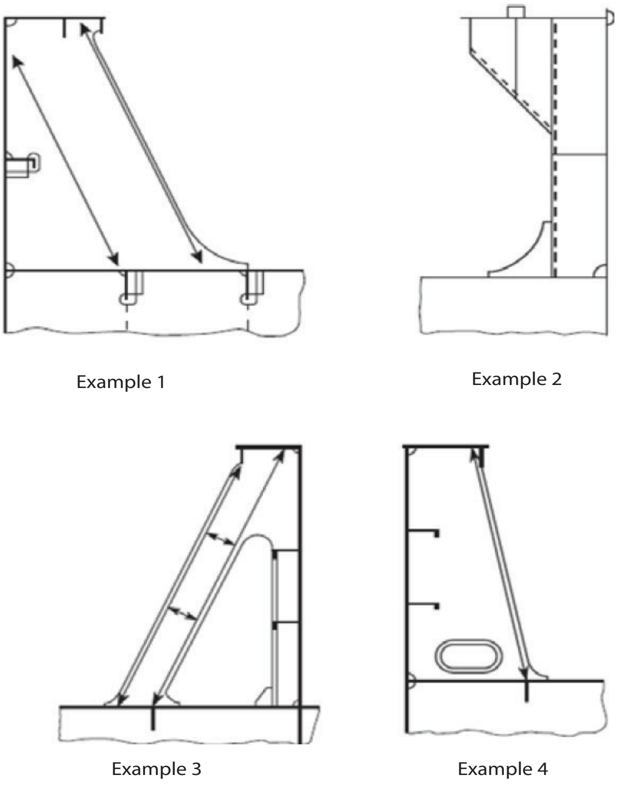
h_w : web height of coaming stay at its lower end in m

t_S : corrosion addition, in m, according to [9].

For other designs of coaming stays, such as those shown in Fig 9, examples 3 and 4, the stresses are to be determined through a grillage analysis or FEM. The calculated stresses are to comply with the permissible stresses according to [4.1.1].

Coaming stays are to be supported by appropriate substructures. Face plates may only be included in the calculation if an appropriate substructure is provided and welding provides an adequate joint. Webs are to be connected to the deck by fillet welds on both sides with a throat thickness of $a=0,44t_w$. The size of welding for toes of webs at the lower end of coaming stays should be according to Ch 12, Sec 1 and Ch 12, Sec 2, [2.7].

Figure 9 : Examples of coaming stays *(1/7/2016)*



6.3.3 Coaming stays under friction load *(1/7/2016)*

For coaming stays, which transfer friction forces at hatch cover supports, fatigue strength is to be considered on a case-by-case basis, refer also to [7.2.2].

6.4 Further requirements for hatch coamings

6.4.1 Longitudinal strength *(1/7/2012)*

Hatch coamings which are part of the longitudinal hull structure are to be designed taking into account the hull girder induced stresses.

For structural members welded to coamings and for cutouts in the top of coamings sufficient fatigue strength is to be verified.

Longitudinal hatch coamings with a length exceeding 0,1·L m are to be provided with tapered brackets or equivalent transitions and a corresponding substructure at both ends. At the end of the brackets they are to be connected to the deck by full penetration welds of minimum 300 mm in length.

6.4.2 Local details *(1/7/2012)*

For design of local details not contemplated by the present Article [6], analyses are to be carried out on a case-by-case basis for the purpose of transferring the loads on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Structures under deck are to be checked against the load transmitted by the stays.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with Ch 12, Sec 1.

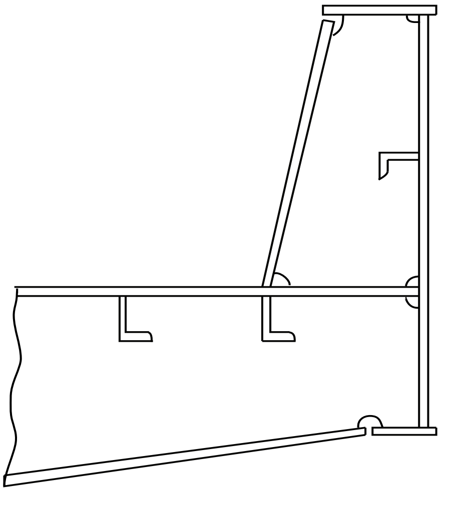
6.4.3 Stays *(1/7/2012)*

On ships carrying cargo on deck, such as timber, coal or coke, the stays are to be spaced not more than 1,5 m apart.

6.4.4 Extend of coaming plates *(1/7/2012)*

Coaming plates are to extend to the lower edge of the deck beams or hatch side girders are to be fitted that extend to the lower edge of the deck beams. Extended coaming plates and hatch side girders are to be flanged or fitted with face bars or half-round bars. Fig 10 gives an example.

Figure 10 : Example for the extend of coaming plates



6.4.5 Drainage arrangement at the coaming *(1/7/2012)*

If drain channels are provided inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming, drain openings are to be provided at appropriate positions of the drain channels.

Drain openings in hatch coamings are to be arranged with sufficient distance to areas of stress concentration (e.g. hatch corners, transitions to crane posts).

Drain openings are to be arranged at the ends of drain channels and are to be provided with non-return valves to prevent ingress of water from outside. It is unacceptable to connect fire hoses to the drain openings for this purpose.

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

7 Closing arrangements

7.1 Securing devices

7.1.1 General *(1/7/2012)*

Securing devices between cover and coaming and at cross-joints are to be installed to provide weathertightness. Sufficient packing line pressure is to be maintained.

Securing devices are to be appropriate to bridge displacements between cover and coaming due to hull deformations.

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

Sufficient number of securing devices is to be provided at each side of the hatch cover considering the requirements of [4.4.2]. This applies also to hatch covers consisting of several parts.

Specifications of the materials are to be shown in the drawings of the hatch covers.

The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices.

The gross moment of inertia of edge elements is not to be less than:

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

where

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

a : maximum of the distances, a_i, between two consecutive securing devices, measured along the hatch cover periphery (see Fig 11), not to be taken as less than 2.5 a_c, [m] a_c : max ($a_{1.1}$, $a_{1.2}$) [m]

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

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

7.1.2 Rod cleats *(1/7/2012)*

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

7.1.3 Hydraulic cleats *(1/7/2012)*

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

7.1.4 Cross-sectional area of the securing devices *(1/7/2012)*

The gross cross-sectional area in cm^2 of the securing devices is not to be less than:

$A = 0{,}28 \cdot q \cdot s_{SD} \cdot k_l$

where

q : packing line pressure, in N/mm, minimum 5 N/mm

s_{SD} : spacing between securing devices, in m, not to be taken less than 2 m

$k_l = (235 / \sigma_F)^e$

where

σ_F is the minimum yield strength of the material, in N/mm^2, but is not to be taken greater than $0{,}7 \cdot \sigma_m$, where σ_m is the tensile strength of the material, in N/mm^2.

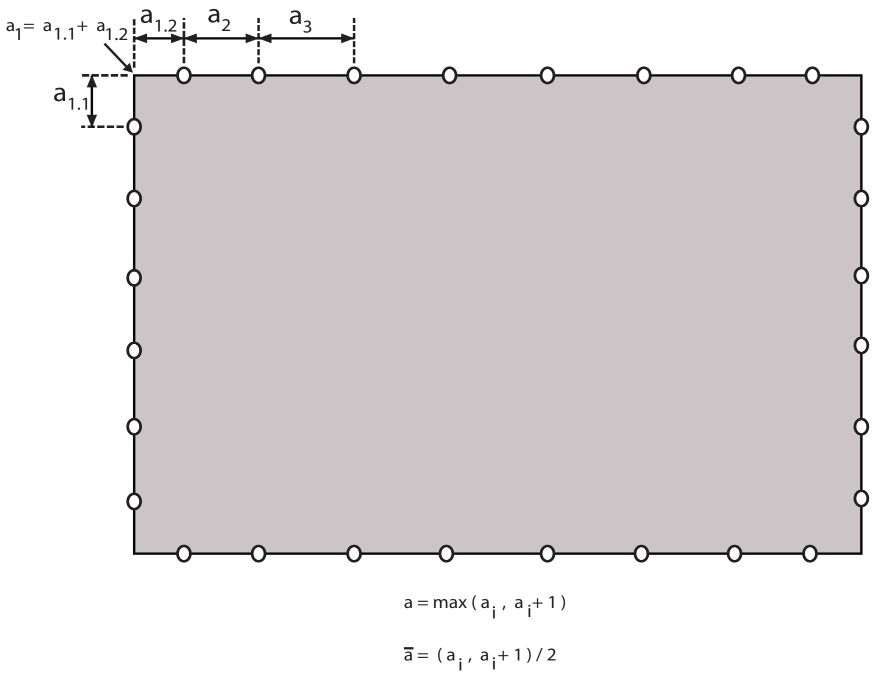
e = 0,75 for σ_F > 235 N/mm^2

= 1,00 for $\sigma_F \leq$ 235 N/mm^2

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

Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to [7.1.5]. As load the packing line pressure q multiplied by the spacing between securing devices s_{SD} is to be applied.

Figure 11 : Distance between securing devices, measured along hatch cover periphery *(1/7/2012)*



7.1.5 Anti lifting devices *(1/7/2012)*

The securing devices of hatch covers, on which cargo is to be lashed, are to be designed for the lifting forces resulting from loads according to [3.4], refer Fig 13. Unsymmetrical loadings, which may occur in practice, are to be considered. Under these loadings the equivalent stress in the securing devices is not to exceed:

$\sigma_v = 150 / k_1$, in N/mm².

Anti-lifting devices may be omitted provided that it is proven by means of grilage and/or finite element analyses that an equilibrium condition is achieved using compression-only boundary elements for the vertical hatch cover supports. If securing devices are omitted, transverse cover guides are to be effective up to a height h_E above the hatch cover supports, where h_E is to be not less than:

$h_E = 1{,}75(2se + d^2)^{0.5} - 0{,}75d$ [mm]

$h_{E,min}$ = height of the cover edge plate +150 [mm]

where (see Fig 12):

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

Figure 12 : Height of transverse cover guides *(1/7/2012)*

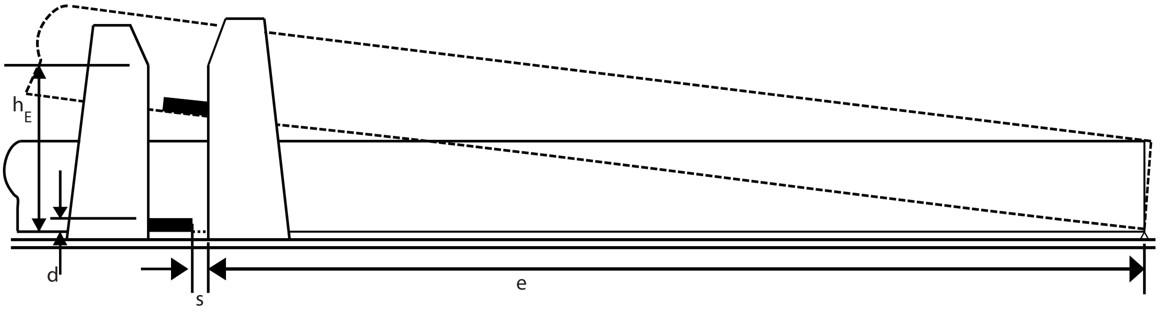
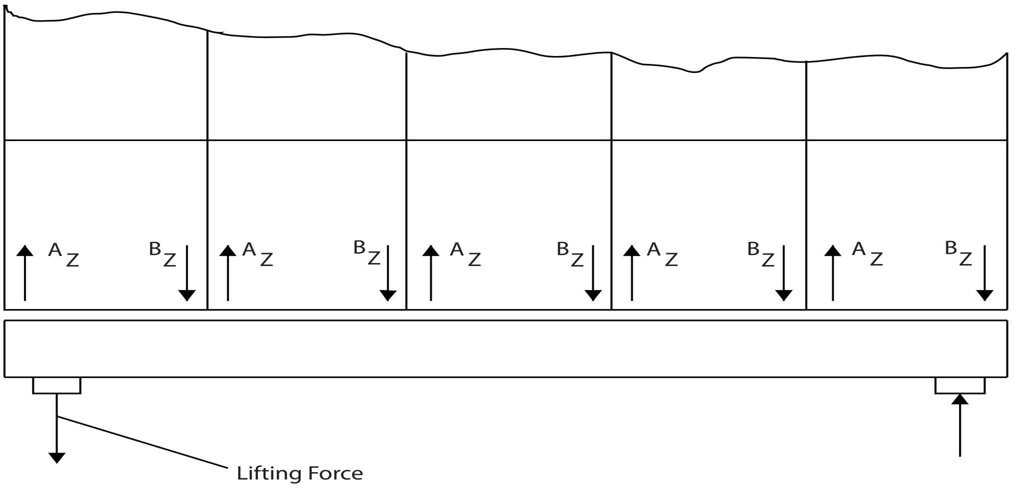


Figure 13 : Lifting forces at a hatch cover *(1/7/2012)*



7.2 Hatch cover supports, stoppers and supporting structures

7.2.1 Horizontal mass forces *(1/7/2016)*

For the design of hatch cover supports the securing devices against shifting the horizontal mass forces $F_h = m \cdot a$ are to be calculated with the following accelerations:

$a_x = 0,2 \cdot g$ in longitudinal direction

$a_y = 0,5 \cdot g$ in transverse direction

m : Sum of mass of cargo lashed on the hatch cover and mass of hatch cover

The accelerations in longitudinal direction and in transverse direction do not need to be considered as acting simultaneously.

7.2.2 Hatch cover supports *(1/7/2016)*

For the transmission of the support forces resulting from the load cases specified in [3] and of the horizontal mass forces specified in [7.2.1], supports are to be provided which are to be designed such that the nominal surface pressures in general do not exceed the following values:

$p_{n\,max} = d \cdot p_n$, in N/mm^2

$d = 3,75 - 0,015L$

$d_{max} = 3,0$

$d_{min} = 1,0$ in general

p_n = see Tab 10

For metallic supporting surfaces not subjected to relative displacements the nominal surface pressure applies:

$p_{n\,max} = 3 \cdot p_n$, in N/mm^2.

Note 1: When the maker of vertical hatch cover support material can provide proof that the material is sufficient for the increased surface pressure, not only statically but under dynamic conditions including relative motion for adequate number of cycles, permissible nominal surface pressure may be relaxed at the discretion of the society. However, realistic long term distribution of spectra for vertical loads and relative horizontal motion should be assumed and agreed with the society.

Drawings of the supports must be submitted. In the drawings of supports the permitted maximum pressure given by the material manufacturer must be specified.

Table 10 : Permissible nominal surface pressure p_n (1/7/2012)

Support material	p_n [N/mm^2] when loaded by	
	Vertical force	Horizontal force (on stoppers)
Hull structural steel	25	40
Hardened steel	35	50
Lower friction materials	50	-

Where large relative displacements of the supporting surfaces are to be expected, the use of material having low wear and frictional properties is recommended.

The substructures of the supports must be of such a design, that a uniform pressure distribution is achieved.

Irrespective of the arrangement of stoppers, the supports must be able to transmit the following force P_h in the longitudinal and transverse direction:

$$P_h = \mu \cdot \frac{P_V}{\sqrt{d}}$$

P_v : vertical supporting force

μ : vertical supporting force = 0,5 in general

For non-metallic, low-friction support materials on steel, the friction coefficient may be reduced but not to be less than 0,35 and to the satisfaction of the Society.

Supports as well as the adjacent structures and substructures are to be designed such that the permissible stresses according to [4.1.1] are not exceeded.

For substructures and adjacent structures of supports subjected to horizontal forces P_h, fatigue strength is to be considered according to the satisfaction of the Society.

7.2.3 Hatch cover stoppers *(1/7/2012)*

Hatch covers shall be sufficiently secured against horizontal shifting. Stoppers are to be provided for hatch covers on which cargo is carried.

The greater of the loads resulting from [3.2] and [7.2.1] is to be applied for the dimensioning of the stoppers and their substructures.

The permissible stress in stoppers and their substructures, in the cover, and of the coamings is to be determined in accordance with [4.1.1]. In addition, the requirements in [7.2.2] are to be complied with.

8 Drainage

8.1 Arrangement

8.1.1 *(1/7/2012)*

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

8.1.2 *(1/7/2012)*

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

8.1.3 *(1/7/2012)*

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

8.1.4 *(1/7/2012)*

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

9 Small hatches fitted on the exposed fore deck

9.1 Application

9.1.1 General *(1/7/2012)*

The requirements in [9] apply to steel covers of small hatches fitted on the exposed fore deck over the forward 0,25L, for ships of equal to or greater than 80 m in length, where the height of the exposed deck in way of the hatch is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser.

Small hatches are hatches designed for access to spaces below the deck and are capable of being closed weathertight or watertight, as applicable. Their opening is generally equal to or less than 2,5 m^2.

9.1.2 Small hatches designed for emergency escape *(1/7/2012)*

Small hatches designed for emergency escape are not required to comply with the requirements in [9.4.1] a) and b), in [9.4.3] and in [9.5].

Securing devices of hatches designed for emergency escape are to be of a quick-acting type (e.g. one action wheel handles are provided as central locking devices for latching/unlatching of hatch cover) operable from both sides of the hatch cover.

9.2 Strength

9.2.1 *(1/7/2012)*

For small rectangular steel hatch covers, the plate thickness, stiffener arrangement and scantlings are to be not less than those obtained, in mm, from Tab 11 and Fig 14.

Ordinary stiffeners, where fitted, are to be aligned with the metal-to-metal contact points, required in [9.3.1] (see also Fig 14). Primary supporting members are to be continuous. All stiffeners are to be welded to the inner edge stiffener (see also Fig 15).

9.2.2 *(1/7/2012)*

The upper edge of the hatchway coamings is to be suitably reinforced by a horizontal section, normally not more than 170 to 190 mm from the upper edge of the coamings.

9.2.3 *(1/7/2012)*

For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement are to comply with the requirements in [4].

9.2.4 *(1/1/2004)*

For small hatch covers constructed of materials other than steel, the required scantlings are to provide equivalent strength.

Table 11 : Structural scantlings of small rectangular steel hatch covers *(1/7/2012)*

Hatch nominal size (mm x mm)	Cover plate thickness (mm)	Primary supporting members	Ordinary stiffeners
		Flat Bar (mm x mm); number	
630 x 630	8	-	-
630 x 830	8	100 x 8 ; 1	-
830 x 630	8	100 x 8 ; 1	-
830 x 830	8	100 x 10 ; 1	-
1030 x 1030	8	120 x 12 ; 1	80 x 8 ; 2
1330 x 1330	8	150 x 12 ; 2	100 x 10 ; 2

9.3 Weathertightness

9.3.1 *(1/7/2012)*

The hatch cover is to be fitted with a gasket of elastic material. This is to be designed to allow a metal-to-metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts are to be arranged close to each securing device in accordance with Fig 14, and to be of sufficient capacity to withstand the bearing force.

9.4 Primary securing devices

9.4.1 *(1/7/2012)*

Small hatches located on the exposed fore deck are to be fitted with primary securing devices such that their hatch covers can be secured in place and weathertight by means of a mechanism employing any one of the following methods:

a) Butterfly nuts tightening onto forks (clamps),

b) Quick acting cleats, or

c) Central locking device.

Dogs (twist tightening handles) with wedges are deemed unacceptable by the Society.

9.4.2 *(1/7/2012)*

The primary securing method is to be designed and manufactured such that the designed compression pressure is achieved by one person without the need for any tools.

9.4.3 *(1/7/2012)*

For a primary securing method using butterfly nuts, the forks (clamps) are to be of robust design. They are to be designed to minimise the risk of butterfly nuts being dislodged while in use, by means of curving the forks upward, a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks is to be not less than 16 mm. An example of arrangement is shown in Fig 15.

9.4.4 *(1/7/2012)*

For small hatch covers located on the exposed deck forward of the foremost cargo hatch, the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

9.4.5 *(1/7/2012)*

On small hatches located between the main hatches, for example between hatches No. 1 and No. 2, the hinges are to be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

9.5 Secondary Securing Device

9.5.1 *(1/7/2012)*

Small hatches on the fore deck are to be fitted with an independent secondary securing device e.g. by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

Figure 14 : Structural arrangement of small rectangular steel hatch covers *(1/7/2012)*

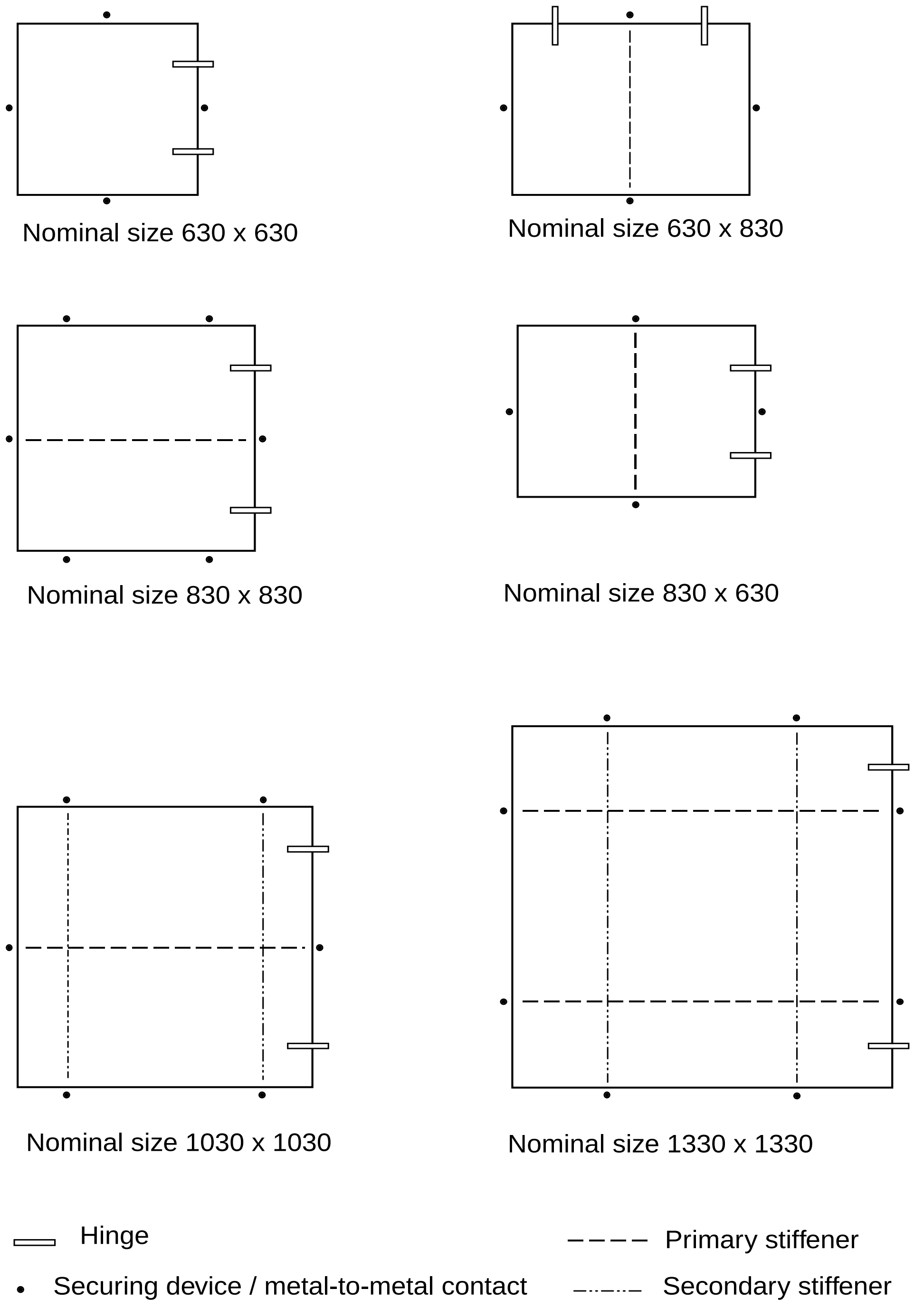
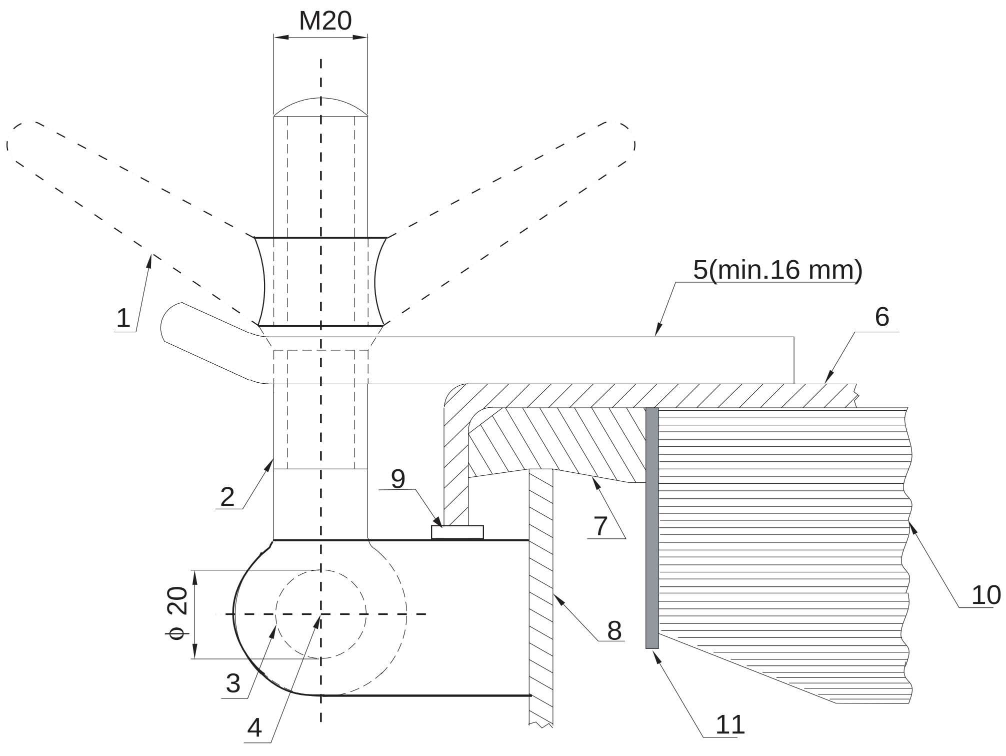


Figure 15 : Example of a primary securing method *(1/7/2012)*



Legend:

1: butterfly nut

2: bolt

3: pin

4: centre of pin

5: fork (clamp) plate

6: hatch cover

7: gasket

8: hatch coaming

9: bearing pad welded on the bracket of a toggle bolt for metal-to-metal contact

10: stiffener

11: inner edge stiffener

***Note**: Dimensions in mm*

SECTION 8 MOVABLE DECKS AND INNER RAMPS - EXTERNAL RAMPS

1 Movable decks and inner ramps

1.1 Application

1.1.1 The requirements of this Article apply to movable decks and inner ramps.

1.2 Materials

1.2.1 The decks and inner ramps are to be made of steel or aluminium alloys complying with the requirements of Part D. Other materials of equivalent strength may be used, subject to a case by case examination by the Society.

1.3 Net scantlings

1.3.1 As specified in 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 Ch 4, Sec 2.

1.4 Plating

1.4.1 *(1/7/2021)*

The net thickness of plate panels subjected to wheeled loads is to be not less than the value obtained from Ch 7, Sec 1, [4.3], where nP_0 is not to be taken less than 5 kN.

1.5 Supporting structure

1.5.1 General

The supporting structure of movable decks and inner ramps is to be verified through direct calculation, considering the following cases:

- movable deck stowed in upper position, empty and locked, at sea
- movable deck in service, loaded, in lower position, resting on supports or supporting legs and locked, at sea
- movable inner ramp in sloped position, supported by hinges at one end and by a deck at the other, with possible intermediate supports, loaded, at harbour
- movable inner ramp in horizontal position, loaded and locked, at sea.

1.5.2 Loading cases

The scantlings of the structure are to be verified in both sea and harbour conditions for the following cases:

- loaded movable deck or inner ramp under loads according to the vehicle distribution indicated by the Designer
- loaded movable deck or inner ramp under uniformly distributed loads corresponding to a pressure, in kN/m², taken equal to:

$$p = \frac{n_V P_V + P_P}{A_P}$$

- empty movable deck under uniformly distributed masses corresponding to a pressure, in kN/m², taken equal to:

$$p = \frac{P_P}{A_P}$$

where:

n_V : Maximum number of vehicles loaded on the movable deck

P_V : Mass of a vehicle, in kN

P_P : Mass of the movable deck, in kN

A_P : Effective area of the movable deck, in m².

Table 1 : Movable decks and inner ramps Still water and inertial pressures

Ship condition	Load case	Still water pressure p_S and inertial pressure p_W, in kN/m²
Still water condition		$p_S = p$
Upright sea condition	"a"	No inertial pressure
	"b"	$p_{W,X} = p\frac{a_{X1}}{g}$ in x direction $p_{W,Z} = p\frac{a_{Z1}}{g}$ in z direction
Inclined sea condition (negative roll angle)	"c" "d"	$p_{W,Y} = p\frac{C_{FA}a_{Y2}}{g}$ in y direction $p_{W,Z} = p\frac{C_{FA}a_{Z2}}{g}$ in z direction
Harbour condition **(1)**	during lifting	$p_{W,X} = 0{,}035p$ in x direction $p_{W,Y} = 0{,}087p$ in y direction $p_{W,Z} = 0{,}2p$ in z direction
	at rest	$p_{W,X} = 0{,}035p$ in x direction $p_{W,Y} = 0{,}087p$ in y direction $p_{W,Z} = 0$ in z direction

(1) For harbour conditions, a heel angle of 5° and a trim angle of 2° are taken into account.

Note 1:

p : Pressure, in kN/m², to be calculated according to [1.5.2] for the condition considered.

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"

1.5.3 Still water and inertial pressures

The still water and inertial pressures transmitted to the movable deck or inner ramp structures are obtained, in kN/m^2, as specified in Tab 1.

1.5.4 Checking criteria

It is to be checked that the combined stress σ_{VM} is in accordance with the criteria defined in Ch 7, Sec 3, [4.3.1].

1.5.5 Allowable deflection

The scantlings of main stiffeners and the distribution of supports are to be such that the deflection of the movable deck or inner ramp does not exceed 5 mm/m.

1.6 Supports, suspensions and locking devices

1.6.1 Scantlings of supports and wire suspensions are to be determined by direct calculation on the basis of the loads in [1.5.2] and [1.5.3], taking account of a safety factor at least equal to 5.

1.6.2 It is to be checked that the combined stress σ_{VM} in rigid supports and locking devices is in accordance with the criteria defined in Ch 7, Sec 3, [4.3.1].

2 External ramps

2.1 General

2.1.1 The external ramps are to be able to operate with a heel angle of 5° and a trim angle of 2°.

2.1.2 The external ramps are to be examined for their watertightness, if applicable, and as a support of vehicles at harbour.

2.1.3 The locking of external ramps in stowage position at sea is examined by the Society on a case by case basis.

2.1.4 The ship's structure under the reactions due to the ramp is examined by the Society on a case by case basis.

SECTION 9 ARRANGEMENT OF HULL AND SUPERSTRUCTURE OPENINGS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the arrangement of hull and superstructure openings excluding hatchways, for which the requirements in Sec 7 apply.

1.2 Definitions

1.2.1 Standard height of superstructure

The standard height of superstructure is that defined in Ch 1, Sec 2, Tab 2.

1.2.2 Standard sheer

The standard sheer is that defined according to regulation 38 of the International Load Line Convention 1966, as amended.

1.2.3 Exposed zones

Exposed zones are the boundaries of superstructures or deckhouses set in from the ship's side at a distance less than or equal to 0,04 B.

1.2.4 Unexposed zones

Unexposed zones are the boundaries of deckhouses set in from the ship's side at a distance greater than 0,04 B.

2 External openings

2.1 General

2.1.1 *All external openings leading to compartments assumed intact in the damage analysis, which are below the final damage waterline, are required to be watertight.*

2.1.2 *External openings required to be watertight in accordance with [2.1.1] are to be of sufficient strength and, except for cargo hatch covers, are to be fitted with indicators on the bridge.*

2.1.3 *Openings in the shell plating below the deck limiting the vertical extent of damage are to be kept permanently closed while at sea. Should any of these openings be accessible during the voyage, they are to be fitted with a device which prevents unauthorised opening.*

2.1.4 *Notwithstanding the requirements of [2.1.3], the Society may authorise that particular doors may be opened at the discretion of the Master, if necessary for the operation of the ship and provided that the safety of the ship is not impaired.*

2.1.5 *Other closing appliances which are kept permanently closed at sea to ensure the watertight integrity of external openings are to be provided with a notice affixed to each appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.*

3 Sidescuttles, windows and skylights

3.1 General

3.1.1 Application

The requirements in [3.1] to [3.4] apply to sidescuttles and rectangular windows providing light and air, located in positions which are exposed to the action of sea and/or bad weather.

3.1.2 Sidescuttle definition

Sidescuttles are round or oval openings with an area not exceeding 0,16 m². Round or oval openings having areas exceeding 0,16 m² are to be treated as windows.

3.1.3 Window definition

Windows are rectangular openings generally, having a radius at each corner relative to the window size in accordance with recognised national or international standards, and round or oval openings with an area exceeding 0,16 m².

3.1.4 Number of openings in the shell plating

The number of openings in the shell plating are to be reduced to the minimum compatible with the design and proper working of the ship.

3.1.5 Material and scantlings

Sidescuttles and windows together with their glasses, deadlights and storm covers, if fitted, are to be of approved design and substantial construction in accordance with, or equivalent to, recognised national or international standards.

Non-metallic frames are not acceptable. The use of ordinary cast iron is prohibited for sidescuttles below the freeboard deck.

3.1.6 Means of closing and opening

The arrangement and efficiency of the means for closing any opening in the shell plating are to be consistent with its intended purpose and the position in which it is fitted is to be generally to the satisfaction of the Society.

3.1.7 Opening of sidescuttles

All sidescuttles, the sills of which are below the bulkhead deck for passenger ships or the freeboard deck for cargo *ships, are to be of such construction as to prevent effectively any person opening them without the consent of the Master of the ship.*

Sidescuttles and their deadlights which are not accessible during navigation are to be closed and secured before the ship leaves port.

The Society, at its discretion, may prescribe that the time of opening such sidescuttles in port and of closing and locking them before the ship leaves port is to be recorded in a log book.

3.2 Opening arrangement

3.2.1 General

Sidescuttles may not be fitted in such a position that their sills are below a line drawn parallel to the freeboard deck at side and having its lowest point 0,025B or 0,5 m, whichever is the greater distance, above the summer load waterline (or timber summer load waterline if assigned).

3.2.2 Sidescuttles below 1,4+0,025B m above the water

Where in 'tweendecks the sills of any of the sidescuttles are below a line drawn parallel to the bulkhead deck at side and having its lowest point 1,4+0,025B m above the water when the ship departs from any port, all the sidescuttles in that 'tweendecks are to be closed watertight and locked before the ship leaves port, and they may not be opened before the ship arrives at the next port. In the application of this requirement, the appropriate allowance for fresh water may be made when applicable.

For any ship that has one or more sidescuttles so placed that the above requirements apply when it is floating at its deepest subdivision load line, the Society may indicate the limiting mean draught at which these sidescuttles are to have their sills above the line drawn parallel to the bulkhead deck at side, and having its lowest point 1,4+0,025B above the waterline corresponding to the limiting mean draught, and at which it is therefore permissible to depart from port without previously closing and locking them and to open them at sea under the responsibility of the Master during the voyage to the next port. In tropical zones as defined in the International Convention on Load Lines in force, this limiting draught may be increased by 0,3 m.

3.2.3 Cargo spaces

No sidescuttles may be fitted in any spaces which are appropriated exclusively for the carriage of cargo or coal.

Sidescuttles may, however, be fitted in spaces appropriated alternatively for the carriage of cargo or passengers, but they are to be of such construction as to prevent effectively any person opening them or their deadlights without the consent of the Master.

If cargo is carried in such spaces, the sidescuttles and their deadlights are to be closed watertight and locked before the cargo is shipped. The Society, at its discretion, may prescribe that the time of closing and locking is to be recorded in a log book.

3.2.4 Non-opening type sidescuttles

Sidescuttles are to be of the non-opening type in the following cases:

- where they become immersed by any intermediate stage of flooding or the final equilibrium waterplane in any required damage case for ships subject to damage stability regulations
- where they are fitted outside the space considered flooded and are below the final waterline for those ships where the freeboard is reduced on account of subdivision characteristics.

3.2.5 Manholes and flush scuttles

Manholes and flush scuttles in positions 1 or 2, or within superstructures other than enclosed superstructures, are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

3.2.6 Ships with several decks

In ships having several decks above the bulkhead deck, such as passenger ships, the arrangement of sidescuttles and rectangular windows is considered by the Society on a case by case basis.

Particular consideration is to be given to the ship side up to the upper deck and the front bulkhead of the superstructure.

3.2.7 Automatic ventilating scuttles

Automatic ventilating sidescuttles, fitted in the shell plating below the bulkhead deck for passenger ships or the freeboard deck for cargo ships, are considered by the Society on a case by case basis.

3.2.8 Window arrangement

Windows may not be fitted below the freeboard deck, in first tier end bulkheads or sides of enclosed superstructures and in first tier deckhouses considered as being buoyant in the stability calculations or protecting openings leading below.

In the front bulkhead of a superstructure situated on the upper deck, in the case of substantially increased freeboard, rectangular windows with permanently fitted storm covers are acceptable.

3.2.9 Skylights

Fixed or opening skylights are to have glass thickness appropriate to their size and position as required for sidescuttles and windows. Skylight glasses in any position are to be protected from mechanical damage and, where fitted in positions 1 or 2, to be provided with permanently attached robust deadlights or storm covers.

3.2.10 Gangway, cargo and coaling ports *(1/1/2005)*

Cargo ports and other similar openings in the sides of ships below the bulkhead deck of passenger ships and the freeboard deck of cargo ships are to be fitted with doors so designed as to ensure the same watertightness and structural integrity as the surrounding shell plating. They are to be effectively closed and secured watertight before the ship leaves port and to be kept closed during navigation. Unless otherwise granted by the Society, these opening are to open outwards.

The number of such openings is to be the minimum compatible with the design and proper working of the ship.

Unless otherwise permitted by the Society, the lower edge of the openings may not be fitted below a line drawn parallel to the freeboard deck at side, which is at its lowest point at least 230 mm above the upper edge of the uppermost load line.

Where it is permitted to arrange cargo ports and other similar openings with their lower edge below the line specified above, additional features are to be fitted to maintain the watertight integrity.

The fitting of a second door of equivalent strength and watertightness is one acceptable arrangement. A leakage detection device is to be provided in the compartment between the two doors. Drainage of this compartment to the bilges, controlled by a readily accessible screw-down valve, is to be arranged. The outer door is to open outwards.

Arrangements for bow doors and their inner doors, side doors and stern doors and their securing are to be in compliance with the requirements specified in Sec 5 and in Sec 6, respectively.

3.3 Glasses

3.3.1 General

In general, toughened glasses with frames of special type are to be used in compliance with, or equivalent to, recognised national or international standards.

The use of clear plate glasses is considered by the Society on a case by case basis.

3.3.2 Thickness of toughened glasses in sidescuttles

The thickness of toughened glasses in sidescuttles is to be not less than that obtained, in mm, from Tab 1.

Type A, B or C sidescuttles are to be adopted according to the requirements of Tab 2, where:

- Zone 1 is the zone comprised between a line, parallel to the sheer profile, with its lowest points at a distance above the summer load waterline equal to 0,025B m, or 0,5 m, whichever is the greater, and a line parallel to the previous one and located 1,4 m above it
- Zone 2 is the zone located above Zone A and bounded at the top by the freeboard deck
- Zone 3 is the first tier of superstructures or deckhouses
- Zone 4 is the second tier of deckhouses
- Zone 5 is the third and higher tiers of deckhouses.

3.3.3 Thickness of toughened glasses in rectangular windows

The thickness of toughened glasses in rectangular windows is to be not less than that obtained, in mm, from Tab 3.

Dimensions of rectangular windows other than those in Tab 3 are considered by the Society on a case by case basis.

Table 1 : Thickness of toughened glasses in sidescuttles

Clear light diameter of sidescuttle, in mm	Thickness, in mm		
	Type A Heavy series	Type B Medium series	Type C Light series
200	10	8	6
250	12	8	6
300	15	10	8
350	15	12	8
400	19	12	10
450	Not applicable	15	10

Table 2 : Types of sidescuttles

<table>
<tr><th>Zone</th><th colspan="2">Aft of 0,875 L from the aft end</th><th>Fwd of 0,875 L from the aft end</th></tr>
<tr><td>5</td><td colspan="2">Type C</td><td>Type B</td></tr>
<tr><td rowspan="2">4</td><td colspan="2">Protecting openings giving direct access to spaces below the freeboard deck: Type B</td><td rowspan="2">Type B</td></tr>
<tr><td colspan="2">Not protecting openings giving direct access to spaces below the freeboard deck: Type C</td></tr>
<tr><td rowspan="3">3</td><td colspan="2">Exposed zones: Type B</td><td rowspan="3">Type B</td></tr>
<tr><td rowspan="2">Unexposed zones</td><td>Protecting openings giving direct access to spaces below the freeboard deck: Type B</td></tr>
<tr><td>Not protecting openings giving direct access to spaces below the freeboard deck: Type C</td></tr>
<tr><td>2</td><td colspan="2">Type B</td><td>Type A</td></tr>
<tr><td>1</td><td colspan="2">Type A</td><td>Type A</td></tr>
</table>

Table 3 : Thickness of toughened glasses in rectangular windows

Nominal size (clear light) of rectangular window, in mm²	Thickness, in mm		Total minimum of closing appliances of openingtype rectangular windows **(1)**
	Unexposed zone of first tier, exposed zone of second tier	Unexposed zone of second tier, exposed zone of third tier and above	
300 x 425	10	8	4
355 x 500	10	8	4
400 x 560	12	8	4
450 x 630	12	8	4
500 x 710	15	10	6
560 x 800	15	10	6
900 x 630	19	12	6
1000 x 710	19	12	8
1100 x 800	Not applicable	15	8

(1) Swing bolts and circular hole hinges of glass holders of opening type rectangular windows are considered as closing appliances.

3.3.4 Thickness of glasses forming screen bulkheads or internal boundaries of deckhouses

The thickness of glasses forming screen bulkheads on the side of enclosed promenade spaces and that for rectangular windows in the internal boundaries of deckhouses which are protected by such screen bulkheads are considered by the Society on a case by case basis.

The Society may require both limitations on the size of rectangular windows and the use of glasses of increased thickness in way of front bulkheads which are particularly exposed to heavy sea.

3.3.5 Windows and sidescuttles of different dimensions *(1/7/2011)*

For windows and sidescuttles with dimensions different from those indicated inTab 1 and Tab 3, the thickness calculation of the glasses is to be obtained according to Standard ISO 21005, considering the pressure indicated in Sec 4, [2.2.2].

3.4 Deadlight arrangement

3.4.1 General *(1/1/2005)*

Sidescuttles to the following spaces are to be fitted with efficient, hinged inside deadlights:

- *spaces below the freeboard deck*
- *spaces within the first tier of enclosed superstructures*
- *first tier deckhouses on the freeboard deck protecting openings leading below or considered buoyant in stability calculations.*

Deadlights are to be capable of being closed and secured watertight if fitted below the freeboard deck and weathertight if fitted above.

3.4.2 Watertight deadlights

Efficient, hinged inside deadlights so arranged that they can be easily and effectively closed and secured watertight, are to be fitted to all sidescuttles except that abaft one eighth of the ship's length from the forward perpendicular and above a line drawn parallel to the bulkhead deck at side and having its lowest point at a height of 3,7+0,025B m above the deepest subdivision load line. The deadlights may be portable in passenger accommodation other than that for steerage passengers, unless the deadlights are required by the International Convention on Load Lines in force to be permanently attached in their proper positions. Such portable deadlights are to be stowed adjacent to the sidescuttles they serve.

3.4.3 Openings at the side shell in the second tier *(1/1/2005)*

Sidescuttles and windows at the side shell in the second tier superstructure, protecting direct access to an opening loading below or considered buoyant in the stability calculations, are to be provided with efficient, hinged inside deadlights capable of being effectively closed and secured weathertight.

3.4.4 Openings set inboard in the second tier *(1/1/2005)*

Sidescuttles and windows set inboard from the side shell in the second tier, protecting direct access below to spaces listed in [3.4.1], are to be provided with either efficient, hinged inside deadlights or, where they are accessible, permanently attached external storm covers of approved design and substantial construction *capable of being effectively closed and secured weathertight.*

Cabin bulkheads and doors in the second tier and above separating sidescuttles and windows from a direct access leading below or in the second tier considered buoyant in the stability calculations may be accepted in place of fitted deadlights or storm covers fitted to the sidescuttles and windows.

Note 1: Deadlights in accordance with recognised standards are fitted to the inside of windows and sidescuttles, while storm covers of comparable specifications to deadlights are fitted to the outside of windows, where accessible, and may be hinged or portable.

3.4.5 Deckhouses on superstructures of less than standard height *(1/1/2005)*

Deckhouses situated on a raised quarterdeck or on the deck of a superstructure of less than standard height may be treated as being in the second tier as far as the provision of deadlights is concerned, provided the height of the raised quarterdeck or superstructure is not less than the standard quarterdeck height.

3.4.6 Openings protected by a deckhouse

Where an opening in a superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or to a space within an enclosed superstructure is protected by a deckhouse, then it is considered that only those sidescuttles fitted in spaces which give direct access to an open stairway need to be fitted with deadlights.

4 Discharges

4.1 Arrangement of discharges

4.1.1 Inlets and discharges

All inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the ship.

4.1.2 Inboard opening of ash-shoot, rubbish-shoot, etc.

The inboard opening of each ash-shoot, rubbish-shoot, etc. is to be fitted with an efficient cover.

If the inboard opening is situated below the bulkhead deck for passenger ships or the freeboard deck for cargo ships, the cover is to be watertight, and in addition an automatic non-return valve is to be fitted in the shoot in an easily accessible position above the deepest subdivision load line. When the shoot is not in use, both the cover and the valve are to be kept closed and secured.

4.2 Arrangement of garbage chutes

4.2.1 Inboard end above the waterline

The inboard end is to be located above the waterline formed by an 8,5° heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, but not less than 1000 mm above the summer load waterline.

Where the inboard end of the garbage chute exceeds 0,01L above the summer load waterline, valve control from the freeboard deck is not required, provided the inboard gate valve is always accessible under service conditions.

4.2.2 Inboard end below the waterline *(1/1/2005)*

Where the inboard end of a garbage chute is below the freeboard deck in a passenger ship, or the equilibrium waterlines of a cargo ship to which damage stability requirements apply then:

- *the inboard end hinged cover/valve is to be watertight;*
- *the valve is to be a screw-down non-return valve fitted in an easily accessible position above the deepest load line; and*
- *the screw-down non-return valve is to be controlled from a position above the bulkhead deck and provided with open/closed indicators. The valve control is to be clearly marked: "Keep closed when not in use".*

4.2.3 Gate valves

For garbage chutes, two gate valves controlled from the working deck of the chute may be accepted instead of a non-return valve with a positive means of closing it from a position above the freeboard deck. In addition, the lower gate valve is to be controlled from a position above the freeboard deck. An interlock system between the two valves is to be arranged.

The distance between the two gate valves is to be adequate to allow the smooth operation of the interlock system.

4.2.4 Hinged cover and discharge flap

The upper gate valve, as required in [4.2.3], may be replaced by a hinged weathertight cover at the inboard end of the chute together with a discharge flap which replaces the lower gate valve.

The cover and discharge flap are to be arranged with an interlock so that the flap cannot be operated until the hopper cover is closed.

4.2.5 Marking of valve and hinged cover

The gate valve controls and/or hinged cover are to be clearly marked: "Keep closed when not in use".

4.3 Scantlings of garbage chutes

4.3.1 Material

The chute is to be constructed of steel. Other equivalent materials are considered by the Society on a case by case basis.

4.3.2 Wall thickness

The wall thickness of the chute up to and including the cover is to be not less than that obtained, in mm, from Tab 4.

Table 4 : Wall thickness of garbage chutes

External diameter d, in mm	Thickness, in mm
$d \leq 80$	7,0
$80 < d < 180$	7,0 + 0,03 (d - 80)
$180 \leq d \leq 220$	10,0 + 0,063 (d - 180)

5 Freeing ports

5.1 General provisions

5.1.1 General

Where bulwarks on the weather portions of freeboard or superstructure decks form wells, ample provision is to be made for rapidly freeing the decks of water and for draining them.

A well is any area on the deck exposed to the weather, where water may be entrapped. Wells are considered to be deck areas bounded on four sides by deck structures; however, depending on their configuration, deck areas bounded on three or even two sides by deck structures may be deemed wells.

5.1.2 Freeing port areas

The minimum required freeing port areas in bulwarks on the freeboard deck are specified in Tab 5.

5.1.3 Freeing port arrangement *(1/1/2005)*

Where a sheer is provided, two thirds of the freeing port area required is to be provided in the half of the well nearer the lowest point of the sheer curve.

One third of the freeing port area required is to be evenly spread along the remaining length of the well.

Where the exposed freeboard deck or an exposed superstructure deck has little or no sheer, the freeing port area is to be evenly spread along the length of the well.

However, bulwarks may not have substantial openings or accesses near the breaks of superstructures, unless they are effectively detached from the superstructure sides.

Table 5 : Freeing port area in bulwark located on freeboard deck

Ship types or ship particulars	Area A of freeing ports, in m²	Applicable requirement
Type A	$0,33\ \ell_B\ h_B$	[5.5.2]
Type B-100	$0,33\ \ell_B\ h_B$	[5.5.2]
Type B-60	$0,25\ \ell_B\ h_B$	[5.5.1]
Ships fitted with a trunk included in freeboard calculation and/or breadth $\geq$ 0,6B	$0,33\ \ell_B\ h_B$	[5.3.1]
Ships fitted with continuous or substantially continuous trunk and/or hatch coamings	A_2	[5.3.1]
Ships fitted with non-continuous trunk and/or hatch coamings	A_3	[5.3.2]
Ships fitted with open superstructure	A_S for superstructures A_W for wells	[5.4.2] [5.4.3]
Other ships	A_1	[5.2.1]

Note 1:

ℓ_B : Length, in m, of bulwark in a well at one side of the ship

h_B : Mean height, in m, of bulwark in a well of length ℓ_B.

5.1.4 Freeing port positioning

The lower edge of freeing ports is to be as near the deck as practicable, at not more than 100 mm above the deck.

All the openings in the bulwark are to be protected by rails or bars spaced approximately 230 mm apart.

5.1.5 Freeing port closures *(1/1/2005)*

If shutters or closures are fitted to freeing ports, ample clearance is to be provided to prevent jamming. Hinges are to have pins or bearings of non-corrodible material. Shutters may not be fitted with securing appliances.

5.1.6 Gutter bars *(1/1/2005)*

Gutter bars greater than 300 mm in height fitted around the weather decks of tankers, in way of cargo manifolds and cargo piping, are to be treated as bulwarks. The freeing port area is to be calculated in accordance with the applicable requirements of this Section. Closures attached to the freeing ports for use during loading and discharge operations are to be arranged in such a way that jamming cannot occur while at sea.

5.2 Freeing port area in a well not adjacent to a trunk or hatchways

5.2.1 Freeing port area *(1/1/2005)*

Where the sheer in way of the well is standard or greater than the standard, the freeing port area on each side of the ship for each well is to be not less than that obtained, in m², in Tab 6.

In ships with no sheer, the above area is to be increased by 50%. Where the sheer is less than the standard, the percentage of increase is to be obtained by linear interpolation.

Wells on raised quarterdecks are to be treated as being on freeboard decks.

Table 6 : Freeing port area in a well not adjacent to a trunk or hatchways

Location	Area A_1 of freeing ports, in m²	
	$\ell_B \leq 20$	$\ell_B > 20$
Freeboard deck and raised quarterdecks	$0,7 + 0,035\ell_B + A_C$	$0,07\ell_B + A_C$
Superstructure decks	$0,35 + 0,0175\ell_B + 0,5A_C$	$0,035\ell_B + 0,5A_C$

Note 1:

ℓ_B : Length, in m, of bulwark in the well, to be taken not greater than 0,7 L

A_C : Area, in m², to be taken, with its sign, equal to:

$$A_C = \frac{\ell_W}{25}(h_B - 1,2) \qquad \text{for } h_B > 1,2$$

$$A_C = 0 \qquad \text{for } 0,9 \leq h_B \leq 1,2$$

$$A_C = \frac{\ell_W}{25}(h_B - 0,9) \qquad \text{for } h_B < 0,9$$

h_B : Mean height, in m, of the bulwark in a well of length ℓ_B.

5.2.2 Minimum freeing port area for a deckhouse having breadth not less than 0,8 B *(1/1/2005)*

Where a flush deck ship is fitted amidships with a deckhouse having breadth not less than 0,8 B and the width of the passageways along the side of the ship not greater than 1,5 m, the freeing port area is to be calculated for two separate wells, before and abaft the deckhouse. For each of these wells, the freeing port area is to be obtained from Tab 6, where ℓ_B is to be taken equal to the actual length of the well considered (in this case the limitation $\ell_B \leq 0,7$ L may not be applied).

5.2.3 Minimum freeing port area for screen bulkhead

Where a screen bulkhead is fitted across the full breadth of the ship at the fore end of a midship deckhouse, the weather deck is to be considered as divided into two wells, irrespective of the width of the deckhouse, and the freeing port area is to be obtained in accordance with [4.1.2].

5.3 Freeing port area in a well contiguous to a trunk or hatchways

5.3.1 Freeing area for continuous trunk or continuous hatchway coaming

Where the ship is fitted with a continuous trunk not included in the calculation of freeboard or where continu-

ous or substantially continuous hatchway side coamings are fitted between detached superstructures, the freeing port area is to be not less than that obtained, in m², from Tab 7.

Where the ship is fitted with a continuous trunk having breadth not less than 0,6 B, included in the calculation of freeboard, and where open rails on the weather parts of the freeboard deck in way of the trunk for at least half the length of these exposed parts are not fitted, the freeing port area in the well contiguous to the trunk is to be not less than 33% of the total area of the bulwarks.

Table 7 : Freeing port area in a well contiguous to a continuous trunk or hatchways

Breadth B_H , in m, of hatchway or trunk	Area A_2 of freeing ports, in m²
$B_H \le 0,4B$	$0,2\ \ell_B\ h_B$
$0,4B < B_H < 0,75B$	$\left[0,2-0,286\left(\frac{B_H}{B}-0,4\right)\right]\ell_B h_B$
$B_H \ge 0,75B$	$0,1\ \ell_B\ h_B$
Note 1: ℓ_B : Length, in m, of bulwark in a well at one side of the ship h_B : Mean height, in m, of bulwark in a well of length ℓ_B.	

5.3.2 Freeing area for non-continuous trunk or hatchway coaming

Where the free flow of water across the deck of the ship is impeded due to the presence of a non-continuous trunk, hatchway coaming or deckhouse in the whole length of the well considered, the freeing port area in the bulwark of this well is to be not less than that obtained, in m², from Tab 8.

Table 8 : Freeing port area in a well contiguous to non-continuous trunk or hatchways

Free flow area f_P , in m²	Freeing port area A_3, in m²
$f_p \le A_1$	A_2
$A_1 < f_P < A_2$	$A_1 + A_2 - f_P$
$f_P \ge A_2$	A_1
Note 1: f_P : Free flow area on deck, equal to the net area of gaps between hatchways, and between hatchways and superstructures and deckhouses up to the actual height of the bulwark A_1 : Area of freeing ports, in m², to be obtained from Tab 6 A_2 : Area of freeing ports, in m², to be obtained from Tab 7.	

5.4 Freeing port area in an open space within superstructures

5.4.1 General

In ships having superstructures on the freeboard or superstructure decks, which are open at either or both ends to wells formed by bulwarks on the open decks, adequate provision for freeing the open spaces within the superstructures is to be provided.

5.4.2 Freeing port area for open superstructures

The freeing port area on each side of the ship for the open superstructure is to be not less than that obtained, in m², from the following formula:

$$A_S = A_1 c_{SH}\left[1-\left(\frac{\ell_W}{\ell_T}\right)^2\right]\left(\frac{b_0 h_S}{2\ell_T h_W}\right)$$

where:

ℓ_T : *Total well length, in m, to be taken equal to:*

$\ell_T = \ell_W + \ell_S$

ℓ_W : *Length, in m, of the open deck enclosed by bulwarks*

ℓ_S : *Length, in m, of the common space within the open superstructures*

A_1 : *Freeing port area, in m², required for an open well of length ℓ_T , in accordance with Tab 6, where A_C is to be taken equal to zero*

c_{SH} : *Coefficient which accounts for the absence of sheer, if applicable, to be taken equal to:*

c_{SH} = *1,0 in the case of standard sheer or sheer greater than standard sheer*

c_{SH} = *1,5 in the case of no sheer*

b_0 : *Breadth, in m, of the openings in the end bulkhead of enclosed superstructures*

h_S : *Standard superstructure height, in m, defined in [1.2.1]*

h_W : *Distance, in m, of the well deck above the freeboard deck.*

5.4.3 Freeing port area for open well

The freeing port area on each side of the ship for the open well is to be not less than that obtained, in m², from the following formula:

$$A_W = A_1 c_{SH}\left(\frac{h_S}{2h_W}\right)$$

A_1 : *Freeing port area, in m², required for an open well of length ℓ_W, in accordance with Tab 6*

c_{SH}, h_S, h_W, ℓ_W: *Defined in [5.4.2].*

The resulting freeing port areas for the open superstructure A_S and for the open well A_W are to be provided along each side of the open space covered by the open superstructure and each side of the open well, respectively.

5.5 Freeing port area in bulwarks of the freeboard deck for ships of types A, B-100 and B-60

5.5.1 Freeing arrangement for type B ships *(1/1/2005)*

For type B-60 ships, the freeing port area in the lower part of the bulwarks of the freeboard deck is to be not less than 25% of the total area of the bulwarks in the well considered.

Type B-100 ships with bulwarks are to have open rails fitted for at least half the length of the weather deck or other equivalent freeing arrangements. A freeing port area, in the lower part of the bulwarks, of 33% of the total area of the bulwarks, is an acceptable equivalent freeing arrangement.

Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

The upper edge of the sheer strake is to be kept as low as possible.

5.5.2 Freeing arrangement for type A ships *(1/1/2005)*

Type A ships with bulwarks are to have open rails fitted for at least half the length of the weather deck or other equivalent freeing arrangements. A freeing port area, in the lower part of the bulwarks, of 33% of the total area of the bulwarks, is an acceptable equivalent freeing arrangement.

Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

The upper edge of the sheer strake is to be kept as low as possible.

6 Machinery space openings

6.1 Engine room skylights

6.1.1 *Engine room skylights in positions 1 or 2 are to be properly framed, securely attached to the deck and efficiently enclosed by steel casings of suitable strength. Where the casings are not protected by other structures, their strength will be considered by the Society on a case by case basis.*

6.2 Closing devices

6.2.1 Machinery casings *(1/1/2005)*

Openings in machinery space casings in positions 1 or 2 are to be fitted with doors of steel or other equivalent materials, permanently and strongly attached to the bulkhead, and framed, stiffened and fitted so that the whole structure is of equivalent strength to the unpierced bulkhead and weathertight when closed. The doors are to be capable of being operated from both sides and, unless otherwise permitted by the Society, to open outwards to give additional protection against wave impact.

Other openings in such casings are to be fitted with equivalent covers, permanently attached in their proper position.

6.2.2 Machinery casings on Type A ships

Machinery casings on Type A ships are to be protected by an enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength, provided that machinery casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery spaces.

However, a weathertight door is permitted in the machinery casing, provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine room by a second weathertight door of steel or other equivalent material.

6.2.3 Height of the sill of the door

The height of the sill of the door is to be not less than:

- *600 mm above the deck if in position 1*
- *380 mm above the deck if in position 2*
- 230 mm in all other cases.

6.2.4 Double doors *(1/1/2005)*

Where casings are not protected by other structures, double doors (i.e. inner and outer doors) are required for ships assigned freeboard less than that based on Table 28.2 of Regulation 28 of the International Convention on Load Lines in force. An inner sill of 230 mm in conjunction with the outer sill of 600 mm is to be provided.

6.2.5 Fiddley openings

Fiddley openings are to be fitted with strong covers of steel or other equivalent material permanently attached in their proper positions and capable of being secured weathertight.

6.3 Coamings

6.3.1 *(1/1/2005)*

Coamings of any fiddley, funnel or machinery space ventilator in an exposed position on the freeboard deck or superstructure deck are to be as high above the deck as is reasonable and practicable.

In general, ventilators necessary to continuously supply the machinery space are to have coamings whose height is in compliance with [8.1.2], but need not be fitted with weathertight closing appliances.

Ventilators necessary to continuously supply the emergency generator room, if this is considered buoyant in the stability calculations or protecting an opening leading below, are to have coamings of sufficient height to comply with [8.1.2], without having to fit weathertight closing appliances.

Where, due to the ship's size and arrangement, this is not practicable, lesser heights for machinery space and emergency generator room ventilator coamings, fitted with weathertight closing appliances in accordance with [8.1.3] or [8.1.4], may be permitted by the Society in combination with other suitable arrangements to ensure an uninterrupted, adequate supply of ventilation to these spaces.

7 Companionway

7.1 General

7.1.1 Openings in freeboard deck

Openings in freeboard deck other than hatchways, machinery space openings, manholes and flush scuttles are to be protected by an enclosed superstructure or by a deckhouse or companionway of equivalent strength and weathertightness.

7.1.2 Openings in superstructures *(1/1/2005)*

Openings in an exposed superstructure deck, in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or a space within an enclosed superstructure, are to be protected by an efficient deckhouse or companionway.

7.1.3 Openings in superstructures having height less than standard height

Openings in the top of a deckhouse on a raised quarterdeck or superstructure of less than standard height, having a height equal to or greater than the standard quarterdeck height are to be provided with an acceptable means of closing but need not be protected by an efficient deckhouse or companionway provided the height of the deckhouse is at least the height of the superstructure.

7.2 Scantlings

7.2.1 Companionways on exposed decks protecting openings leading into enclosed spaces are to be of steel and strongly attached to the deck and are to have adequate scantlings.

7.3 Closing devices

7.3.1 Doors *(1/1/2005)*

Doorways in deckhouses or companionways leading to or giving access to spaces below the freeboard deck or to enclosed superstructures are to be fitted with weathertight doors. The doors are to be made of steel, to be capable of being operated from both sides and, unless otherwise permitted by the Society, to open outwards to give additional protection against wave impact.

Alternatively, if stairways within a deckhouse are enclosed within properly constructed companionways fitted with weathertight doors, the external door need not be watertight.

Where the closing appliances of access openings in superstructures and deckhouses are not weathertight, interior deck openings are to be considered exposed, i.e. situated in the open deck.

7.3.2 Height of sills *(1/1/2005)*

The height above the deck of sills to the doorways in companionways is to be not less than:

- *600 mm in position 1*
- *380 mm in position 2.*

Where access is not provided from above, the height of the sills to doorways in deckhouses on the freeboard deck is to be 600 mm.

Where access is provided to spaces inside a bridge or poop from the deck above as an alternative to access from the freeboard deck, the height of the sills into the bridge or poop is to be 380 mm. This also applies to deckhouses on the freeboard deck.

8 Ventilators

8.1 Closing appliances

8.1.1 General

Ventilator openings are to be provided with efficient weathertight closing appliances of steel or other equivalent material.

8.1.2 Closing appliance exemption

Ventilators need not be fitted with closing appliances, unless specifically required by the Society, if the coamings extend for more than:

- *4,5 m above the deck in position 1*
- *2,3 m above the deck in position 2.*

8.1.3 Closing appliances for ships of not more than 100 m in length

In ships of not more than 100 m in length, the closing appliances are to be permanently attached to the ventilator coamings.

8.1.4 Closing appliances for ships of more than 100 m in length

Where, in ships of more than 100 m in length, the closing appliances are not permanently attached, they are to be conveniently stowed near the ventilators to which they are to be fitted.

8.1.5 Ventilation of machinery spaces and emergency generator room

In order to satisfactorily ensure, in all weather conditions:

- *the continuous ventilation of machinery spaces,*
- *and, when necessary, the immediate ventilation of the emergency generator room,*

the ventilators serving such spaces are to comply with [8.1.2], i.e. their openings are to be so located that they do not require closing appliances.

8.1.6 Reduced height of ventilator coamings for machinery spaces and emergency generator room

Where, due to the ship's size and arrangement, the requirements in [8.1.5] are not practicable, lesser heights may be accepted for machinery space and emergency generator room ventilator coamings fitted with weathertight closing appliances in accordance with [8.1.1], [8.1.3] and [8.1.4] in combination with other suitable arrangements, such as separators fitted with drains, to ensure an uninterrupted, adequate supply of ventilation to these spaces.

8.1.7 Closing arrangements of ventilators led overboard or through enclosed superstructures

Closing arrangements of ventilators led overboard to the ship side or through enclosed superstructures are considered by the Society on a case by case basis. If such ventilators are led overboard more than 4,5 m above the freeboard deck, closing appliances may be omitted provided that satisfactory baffles and drainage arrangements are fitted.

8.2 Coamings

8.2.1 General

Ventilators in positions 1 or 2 to spaces below freeboard decks or decks of enclosed superstructures are to have coamings of steel or other equivalent material, substantially constructed and efficiently connected to the deck.

Ventilators passing through superstructures other than enclosed superstructures are to have substantially constructed coamings of steel or other equivalent material at the freeboard deck.

8.2.2 Scantlings

The scantlings of ventilator coamings exposed to the weather are to be not less than those obtained fromTab 9 .

In exposed locations or for the purpose of compliance with buoyancy calculations, the height of coamings may be required to be increased to the satisfaction of the Society.

Table 9 : Scantlings of ventilator coamings

Feature	Scantlings
Height of the coaming, in mm, above the deck	h = 900 in position 1 h = 760 in position 2
Thickness of the coaming, in mm **(1)**	$t = 5{,}5 + 0{,}01\ d_V$ with $7{,}5 \le t \le 10{,}0$
Support	If h > 900 mm, the coaming is to be suitably stiffened or supported by stays.
(1) Where the height of the ventilator exceeds the height h, the thickness of the coaming may be gradually reduced, above that height, to a minimum of 6,5 mm. **Note 1:** d_V : Internal diameter of the ventilator, in mm.	

8.3 Strength check of ventilators subject to green sea loads

8.3.1 Application *(1/1/2004)*

The requirements in [8.3] apply to strength checks of the ventilator pipes and their closing devices located within the forward quarter length of the ship, for ships of length 80 m or more, where the height of the exposed deck in way of the item is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser.

8.3.2 Green sea loads *(1/7/2014)*

The green sea pressure ρ acting on ventilator pipes and their closing devices is to be obtained, in kN/m², from the following formula:

$p = 0{,}5\ \rho\ V^2\ C_d\ C_s\ C_p$

where:

- ρ : density, t/m³, of sea water, to be taken equal to 1,025 t/m³
- V : velocity, in m/s, of water over the fore deck, to be taken:
  - = 13,5m/sec for $d \le 0{,}5\ d_1$
  - $= 13{,}5\sqrt{2\left(1-\dfrac{d}{d_1}\right)}$ m/sec for $0{,}5\ d_1 < d < d_1$
- d : distance from summer load waterline to exposed deck
- d_1 : 0,1L or 22 m whichever is the lesser
- C_d : shape coefficient:
  - $C_d = 0{,}5$ for pipes
  - $C_d = 1{,}3$ for ventilator heads in general
  - $C_d = 0{,}8$ for a ventilator head of cylindrical form with its axis in the vertical direction
- C_s : slamming coefficient, to be taken equal to 3,2
- C_p : protection coefficient:
  - $C_p = 0{,}7$ for pipes and ventilator heads located immediately behind a breakwater or forecastle,
  - $C_p = 1{,}0$ elsewhere and immediately behind a bulwark.

8.3.3 Green sea forces *(1/1/2004)*

Forces acting in the horizontal direction on the ventilator and its closing device are to be calculated from [8.3.2] using the largest projected area of each component.

8.3.4 Strength Requirements *(1/1/2004)*

Bending moments and stresses in ventilator pipes are to be calculated at the following critical positions:

- at penetration pieces
- at weld or flange connections
- at toes of supporting brackets.

Bending stresses in the net section are to be equal to or less than $0{,}8\ R_{eH}$, where R_{eH} is the minimum yield stress or 0,2% proof stress, in N/mm², of the steel at room temperature, defined in Ch 4, Sec 1, [2]. Irrespective of corrosion protection, a corrosion addition equal to 2,0 mm is then to be applied to the net scantlings.

Pipe thicknesses and bracket heights are to be obtained from Tab 10, for standard ventilators of 900 mm height closed by heads having projected area not greater than the one specified in Tab 10.

Where brackets are required, three or more radial brackets are to be fitted. Bracket thickness is to be not less than 8 mm, bracket length is to be not less than 100 mm and bracket height is to be obtained from Tab 10, but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.

For ventilators of height greater than 900 mm, brackets or alternative means of support are to be fitted. Pipe thickness is not to be taken less than that specified in Pt C, Ch 1, Sec 10, [9.1.8] a).

All component parts and connections of ventilators are to be capable of withstanding the loads defined in [8.3.2].

Rotating type mushroom ventilator heads are deemed not suitable for application in the areas defined in [8.3.1].

9 Tank cleaning openings

9.1 General

9.1.1 Ullage plugs, sighting ports and tank cleaning openings may not be arranged in enclosed spaces.

10 Closure of chain lockers

10.1 General

10.1.1 *(1/7/2022)*

Spurling pipes and chain lockers are to be watertight up to the weather deck.

Bulkheads between separate chain lockers (see Fig 1), or which form a common boundary of chain lockers (see Fig 2), need not however be watertight.

Where means of access is provided, it is to be closed by a substantial cover and secured by closely spaced bolts.

Where a means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements are to be in accordance with recognised standards (e.g. ISO 5894:2018 or equivalent) for watertight manhole covers. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

Spurling pipes through which anchor chains are led are to be provided with permanently attached closing appliances (see Note 1) *to minimise water ingress.*

Note 1: Examples of acceptable closing appliance arrangements are:

- steel plates with cut outs to accommodate chain links;
- canvas hoods with a lashing arrangement that maintains the cover in the secured position.

Figure 1 : Separate chain lockers *(1/7/2006)*

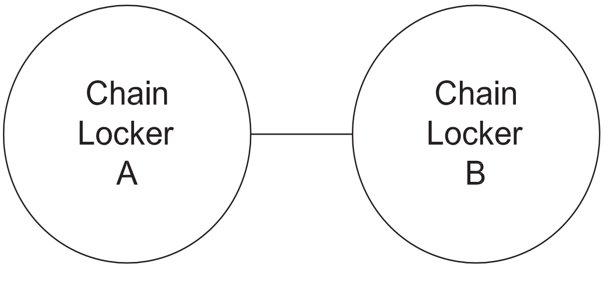


Figure 2 : Chain locker with a common boundary *(1/7/2006)*

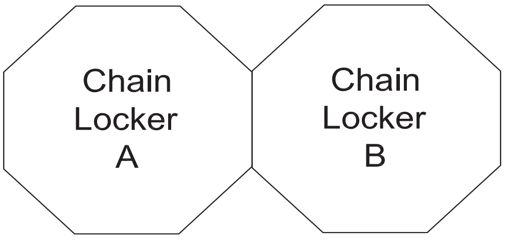


Table 10 : 900 mm Ventilator Pipe Thickness and Bracket Standards *(1/1/2004)*

Nominal pipe diameter (mm)	Minimum fitted gross thickness LL 36(c) (mm)	Maximum projected area of head (cm^2)	Height of brackets (mm)
80A	6,3	-	460
100A	7,0	-	380
150A	8,5	-	300
200A	8,5	550	-
250A	8,5	880	-
300A	8,5	1200	-
350A	8,5	2000	-
400A	8,5	2700	-
450A	8,5	3300	-
500A	8,5	4000	-
Note 1: For other ventilator heights, the relevant requirements in [8.3.4] are to be applied.			

11 Requirements for Type B-60 and B-100 ships

11.1 Requirements for Type B-60 ships

11.1.1 *(1/1/2005)*

Any Type B ships of over 100 metres, may be assigned freeboards less than those required for Type B, provided that, in relation to the amount of reduction granted, the requirements in [11.1.2] to [11.1.4] are considered satisfactory by the Society.

In addition, the requirements stated in Regulation 27 of Part 3, Annex I, Chapter III of the International Convention on Load Lines, 1966 and Protocol of 1988, as amended, are to be complied with.

11.1.2 The measures provided for the protection of the crew are to be adequate.

11.1.3 The freeing arrangements are to comply with the provisions of this Sec 9.

11.1.4 *(1/1/2005)*
The hatchway covers in positions 1 and 2 comply with the provisions of Sec 7.

11.2 Requirements for Type B-100 ships

11.2.1 The requirements in [11.2.2] to [11.2.4] are to be complied with.

In addition, the provisions of Regulation 27 of Part 3, Annex I, Chapter III of the International Convention on Load Lines, 1966 and Protocol of 1988, as amended, are to be complied with.

11.2.2 Machinery casings *(1/1/2005)*
Machinery casings are to be protected by an enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength, provided that machinery casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with the requirements of this Sec 9 may, however, be permitted in the machinery casing, provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine room by a second weathertight door of steel or other equivalent material.

11.2.3 Gangway and access *(1/1/2005)*

An efficiently constructed fore and aft permanent gangway of sufficient strength is to be fitted at the level of the superstructure deck between the poop and the midship bridge or deckhouse where fitted, or equivalent means of access is to be provided such as a well lighted and ventilated underdeck passageway (with a clear opening of at least 0,8 m in width and 2 m in height), as close as practicable to the freeboard deck.

Safe access from the gangway level is to be available between separate crew accommodation spaces and also between crew accommodation spaces and the machinery space.

11.2.4 Freeing arrangements *(1/1/2005)*

Ships with bulwarks are to be provided with open rails fitted for at least half the length of the weather deck or other effective freeing arrangements.

A freeing port area, in the lower part of the bulkwarks, of 33% of the total area of the bulkwarks, is an acceptable equivalent freeing arrangement.

The upper edge of the sheer strake is to be kept as low as practicable.

Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

SECTION 10 HELICOPTER DECKS

1 General

1.1 Application

1.1.1 *(1/7/2010)*

In the case of ships for which the additional class notation **Helideck** or **Helideck-H** is not assigned, but having areas equipped for the landing and take-off of helicopters, and located on a weather deck or on a platform permanently connected to the hull structure, the requirements of Pt F, Ch 13, Sec 16, [3] are to be complied with.

Part B
Hull and Stability

Chapter 10
HULL OUTFITTING

SECTION 1 RUDDERS

Symbols

V_{AV} : maximum ahead service speed, in knots, with the ship on summer load waterline; if V_{AV} is less than 10 knots, the maximum service speed is to be taken not less than the value obtained from the following formula:

$$V_{MIN} = \frac{V_{AV} + 20}{3}$$

V_{AD} : maximum astern speed, in knots, to be taken not less than 0,5 V_{AV}

A : total area of the rudder blade, in m^2, bounded by the blade external contour, including the mainpiece and the part forward of the centreline of the rudder pintles, if any

k_1 : material factor, defined in [1.4.4]

k : material factor, defined in Ch 4, Sec 1, [2.3] (see also [1.4.6]

C_R : rudder force, in N, acting on the rudder blade, defined in [2.1.1] and [2.2.1]

M_{TR} : rudder torque, in N.m, acting on the rudder blade, defined in [2.1.2] and [2.2.2]

M_B : bending moment, in N.m, in the rudder stock, defined in [4.1].

1 General

1.1 Application

1.1.1 Ordinary profile rudders *(1/7/2016)*

The requirements of this Section apply to ordinary profile rudders made of steel, without any special arrangement for increasing the rudder force, whose maximum orientation at maximum ship speed is limited to 35° on each side.

In general, an orientation greater than 35° is accepted for manoeuvres or navigation at very low speed.

1.1.2 High lift profiles *(1/7/2016)*

The requirements of this Section also apply to rudders made of steel fitted with flaps to increase rudder efficiency. For these rudder types, an orientation at maximum speed less than 35° may be accepted. In these cases, the rudder forces are to be calculated by the Designer for the most severe combinations between orientation angle and ship speed. These calculations are to be considered by the Society on a case-by-case basis.

The rudder scantlings are to be designed so as to be able to sustain possible failures of the orientation control system, or, alternatively, redundancy of the system itself may be required.

1.1.3 Steering nozzles

The requirements for steering nozzles are given in [10].

1.1.4 Special rudder types

Rudders others than those in [1.1.1], [1.1.2] and [1.1.3] will be considered by the Society on a case-by- case basis.

1.2 Gross scantlings

1.2.1 With reference to Ch 4, Sec 2, [1], all scantlings and dimensions referred to in this Section are gross, i.e. they include the margins for corrosion.

1.3 Arrangements

1.3.1 Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by means of a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

1.3.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

In addition, structural rudder stops of suitable strength are to be provided, except where the steering gear is provided with its own rudder stopping devices, as detailed in Pt C, Ch 1, Sec 11.

1.3.3 In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

1.4 Materials

1.4.1 *(1/7/2016)*

Rudders made of materials others than steel will be considered by the Society on a case-by-case basis.

1.4.2 Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled steel, steel forgings or steel castings according to the applicable requirements in Part D, Chapter 2.

1.4.3 *(1/1/2021)*

The material used for rudder stocks, pintles, keys and bolts is to have a specified minimum yield stress not less than 200 N/mm^2.

1.4.4 *(1/1/2021)*

The requirements relevant to the determination of scantlings contained in this Section apply to steels having a specified minimum yield stress equal to 235 N/mm^2.

Where the material used for rudder stocks, pintles, coupling bolts, keys and cast parts of rudders has a specified minimum yield stress different from 235 N/mm², the scantlings calculated with the formulae contained in the requirements of this Section are to be modified, as indicated, depending on the material factor k_1, to be obtained from the following formula:

$$k_1 = \left(\frac{235}{R_{eH}}\right)^n$$

where:

- R_{eH} : specified minimum yield stress, in N/mm², of the steel used, and not exceeding the lower of 0,7 R_m and 450 N/mm²
- R_m : minimum ultimate tensile strength, in N/mm², of the steel used
- n : coefficient to be taken equal to:
  - n = 0,75 for R_{eH} > 235 N/mm²
  - n = 1,00 for R_{eH} ≤ 235 N/mm².

1.4.5 *(1/1/2021)*

Significant reductions in rudder stock diameter due to the application of steels with specified minimum yield stresses greater than 235 N/mm² may be accepted by the Society subject to the results of a check calculation of the rudder stock deformations.

Large rudder stock deformations are to be avoided in order to avoid excessive edge pressures in way of bearings.

1.4.6 Welded parts of rudders are to be made of approved rolled hull materials. For these members, the material factor k defined in Ch 4, Sec 1, [2.3] is to be used.

1.5 Welding and design details

1.5.1 *(1/7/2016)*

Slot-welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders.

When slot welding is applied, the length of slots is to be minimum 75 mm with breadth of 2 t, where t is the rudder plate thickness, in mm. The distance between ends of slots is not to be more than 125 mm. The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

Continuous slot welds are to be used in lieu of slot welds. When continuous slot welding is applied, the root gap is to be between 6-10 mm. The bevel angle is to be at least 15°.

1.5.2 *(1/1/2021)*

In way of the rudder horn recess of semi-spade rudders the radii in the rudder plating except in way of solid part in cast steel are not to be less than 5 times the plate thickness, but in no case less than 100 mm. Welding in side plate is to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

1.5.3 *(1/7/2016)*

Welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are to be made as full penetration welds. In way of highly stressed areas e.g. cut-out of semi-spade rudder and upper part of spade rudder, cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible welding is to be performed against ceramic backing bars or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

1.5.4 *(1/7/2016)*

Requirements for welding and design details when the rudder stock is connected to the rudder by horizontal flange coupling are described in [5.1.1].

1.5.5 *(1/7/2016)*

Requirements for welded connections of blade plating to vertical and horizontal webs are given in [7.3.8].

1.5.6 *(1/7/2016)*

Requirements for welding and design details of rudder horns are described in [8.2.6].

1.5.7 *(1/7/2016)*

Requirements for welding and design details of rudder trunks are described in [8.4.2].

2 Force and torque acting on the rudder

2.1 Rudder blade without cut-outs

2.1.1 Rudder blade description

A rudder blade without cut-outs may have trapezoidal or rectangular contour.

2.1.2 Rudder force

The rudder force C_R is to be obtained, in N, from the following formula:

$$C_R = 132\, n_R A\, V^2\, r_1\, r_2\, r_3$$

where:

- n_R : navigation coefficient, defined in Tab 1
- V : V_{AV}, or V_{AD}, depending on the condition under consideration (for high lift profiles see [1.1.2])
- r_1 : shape factor, to be taken equal to:

$$r_1 = \frac{\lambda + 2}{3}$$

- λ : coefficient, to be taken equal to:

$$\lambda = \frac{h^2}{A_T}$$

  and not greater than 2
- h : mean height, in m, of the rudder area to be taken equal to (see Fig 1):

$$h = \frac{z_3 + z_4 - z_2}{2}$$

- A_T : area, in m², to be calculated by adding the rudder blade area A to the area of the rudder post or rudder horn, if any, up to the height h
- r_2 : coefficient to be obtained from Tab 2

r_3 : coefficient to be taken equal to:

- r_3 = 0,8 for rudders outside the propeller jet (centre rudders on twin screw ships, or similar cases)
- r_3 = 1,15 for rudders behind a fixed propeller nozzle
- r_3 = 1,0 in other cases.

Table 1 : Navigation coefficient

Navigation notation	Navigation coefficient n_R
Unrestricted navigation	1,00
Summer zone	0,95
Tropical zone	0,85
Coastal area	0,85
Sheltered area	0,75

Table 2 : Values of coefficient r_2 *(1/1/2021)*

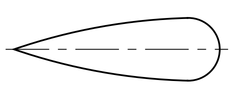
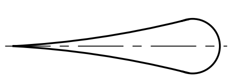
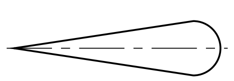
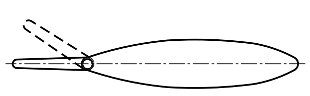
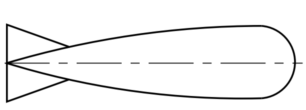
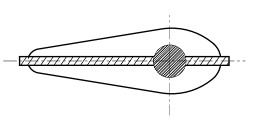
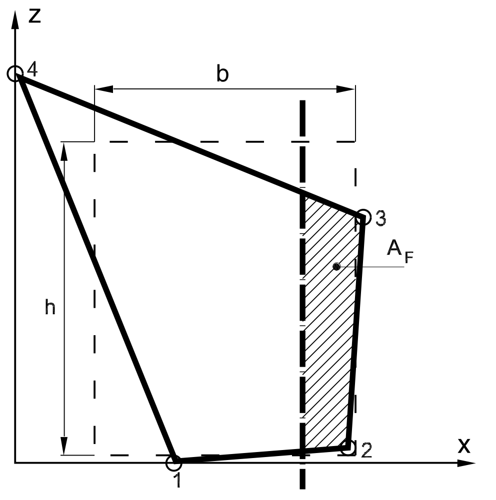
Rudder profile type	r_2 for ahead condition	r_2 for astern condition
NACA 00 - Goettingen 	1,10	0,80
Hollow 	1,35	0,90
Flat side 	1,10	0,90
High lift 	1,70	1,30
Fish tail 	1,40	0,80
Single plate 	1,00	1,00
Mixed profiles (e.g. HSVA)	1,21	0,90

Figure 1 : Geometry of rudder blade without cut-outs



2.1.3 Rudder torque

The rudder torque M_{TR}, for both ahead and astern conditions, is to be obtained, in N.m, from the following formula:

$M_{TR} = C_R\, r$

where:

r : lever of the force C_R, in m, equal to:

$$r = b\left(\alpha - \frac{A_F}{A}\right)$$

and to be taken not less than 0,1 b for the ahead condition

b : mean breadth, in m, of rudder area to be taken equal to (see Fig 1):

$$b = \frac{x_2 + x_3 - x_1}{2}$$

α : coefficient to be taken equal to:

- $\alpha = 0{,}33$ for ahead condition
- $\alpha = 0{,}66$ for astern condition

A_F : area, in m^2, of the rudder blade portion afore the centreline of rudder stock (see Fig 1).

2.2 Rudder blade with cut-outs (semi-spade rudders)

2.2.1 Rudder blade description

A rudder blade with cut-outs may have trapezoidal or rectangular contour, as indicated in Fig 2.

2.2.2 Rudder force

The rudder force C_R, in N, acting on the blade is to be calculated in accordance with [2.1.2].

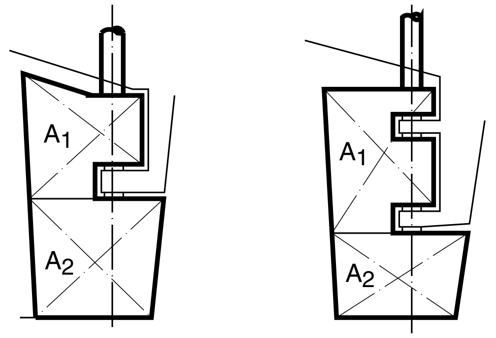
2.2.3 Rudder torque

The rudder torque M_{TR}, in N.m, is to be calculated in accordance with the following procedure.

The rudder blade area A is to be divided into two rectangular or trapezoidal parts having areas A_1 and A_2, defined in Fig 2, so that:

$A = A_1 + A_2$

Figure 2 : Rudder blades with cut-outs



Trapezoidal rudder blade
Semi-spade rudder with
rudder horn - 2 bearings

Trapezoidal rudder blade
Semi-spade rudder with
rudder horn - 3 bearings

The rudder forces C_{R1} and C_{R2} , acting on each part A_1 and A_2 of the rudder blade, respectively, are to be obtained, in N, from the following formulae:

$$C_{R1} = C_R \frac{A_1}{A}$$

$$C_{R2} = C_R \frac{A_2}{A}$$

The levers r_1 and r_2 of the forces C_{R1} and C_{R2}, respectively, are to be obtained, in m, from the following formulae:

$$r_1 = b_1\left(\alpha - \frac{A_{1F}}{A_1}\right)$$

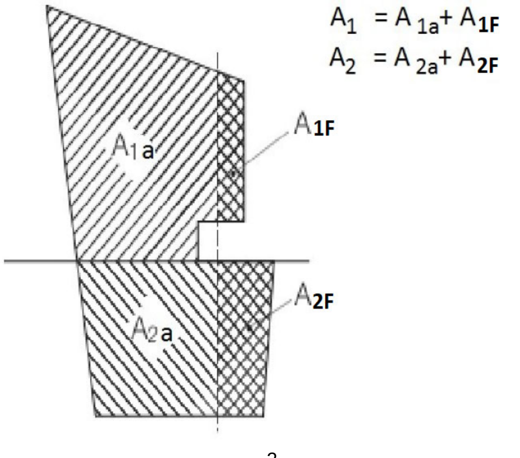
$$r_2 = b_2\left(\alpha - \frac{A_{2F}}{A_2}\right)$$

where:

b_1, b_2 : mean breadths of the rudder blade parts having areas A_1 and A_2, respectively, to be determined according to [2.1.3]

A_{1F}, A_{2F} : areas, in m^2, of the rudder blade parts, defined in Fig 3

Figure 3 : Geometry of rudder blade with cut-outs *(1/1/2021)*



A_{1a} : portion of A_1, in m^2, situated aft of the centre line of the rudder stock

A_{2a} : portion of A_2, in m^2, situated aft of the centre line of the rudder stock

α : coefficient to be taken equal to:

- $\alpha = 0{,}33$ for ahead condition
- $\alpha = 0{,}66$ for astern condition

For rudder parts located behind a fixed structure such as a rudder horn, α is to be taken equal to:

- $\alpha = 0{,}25$ for ahead condition.
- $\alpha = 0{,}55$ for astern condition

The torques M_{TR1} and M_{TR2} , relevant to the rudder blade parts A_1 and A_2 respectively, are to be obtained, in N.m, from the following formulae:

$$M_{TR1} = C_{R1}\, r_1$$

$$M_{TR2} = C_{R2}\, r_2$$

The total torque M_{TR} acting on the rudder stock, for both ahead and astern conditions, is to be obtained, in N.m, from the following formula:

$$M_{TR} = M_{TR1} + M_{TR2}$$

For the ahead condition only, M_{TR} is to be taken not less than the value obtained, in N.m, from the following formula:

$$M_{TR,MIN} = 0{,}1 C_R \frac{A_1 b_1 + A_2 b_2}{A}$$

3 Loads acting on the rudder structure

3.1 General

3.1.1 Loads

The force and torque acting on the rudder, defined in [2], induce in the rudder structure the following loads:

- bending moment and torque in the rudder stock
- support forces
- bending moment, shear force and torque in the rudder body
- bending moment, shear force and torque in rudder horns and solepieces.

3.1.2 Direct load calculations *(1/7/2016)*

The bending moment in the rudder stock, the support forces, and the bending moment and shear force in the rudder body and the loads in the rudder horn are to be determined through direct calculations to be performed in accordance to the static schemes and the load conditions specified in App 1.

For rudders with solepiece or rudder horns these structures are to be included in the calculation model in order to account for the elastic support of the rudder body.

The other loads (i.e. the torque in the rudder stock and in the rudder body and the loads in the solepieces) are to be calculated as indicated in the relevant requirements of this Section.

3.1.3 Simplified methods for load calculation *(1/7/2016)*

For ordinary rudder types, the bending moment in the rudder stock, the support forces, and the bending moment and shear force in the rudder body may be determined through approximate methods specified in the relevant requirements of this Section.

4 Rudder stock scantlings

4.1 Bending moment

4.1.1 General *(1/7/2016)*

The bending moment M_B in the rudder stock is to be obtained as follows:

- for spade rudders, spade rudders with trunk and semi-spade rudders with 2-conjugate elastic support M_B is to be determined according to [4.1.2] through a direct calculation
- for 2 bearing rudders with solepiece and 2 bearing semi-spade rudders with rudder horn, M_B is to be calculated according to:
  - [4.1.2] through a direct calculation, or
  - [4.1.3] through a simplified method
- for 3 bearing semi-spade rudders with rudder horn and for the rudder types shown in Fig 4, M_B may be taken equal to zero.

4.1.2 Bending moment calculated through a direct calculation *(1/7/2016)*

For spade rudders, spade rudders with trunk, 2 bearing rudders with solepiece, 2 bearing semi-spade rudders with rudder horn and semi-spade rudders with 2-conjugate elastic support, where a direct calculation according to the static schemes and the load conditions specified in App 1 is carried out, the bending moment in the rudder stock is to be obtained as specified in App 1.

4.1.3 Bending moment calculated through a simplified method *(1/7/2002)*

For 2 bearing rudders with solepiece and 2 bearing semi-spade rudders with rudder horn, where a direct calculation according to the static schemes and the load conditions specified in App 1 is not carried out, the bending moment M_B in the rudder stock is to be obtained, in N.m, from the following formula:

$$M_B = 0{,}866\frac{HC_R}{A}$$

where H is defined, in m³, in Tab 3.

4.2 Scantlings

4.2.1 Rudder stock subjected to torque only

For rudder stocks subjected to torque only (3 bearing semi-spade rudders with rudder horn in Fig 2 and the rudder types shown in Fig 4), it is to be checked that the torsional shear stress τ, in N/mm², induced by the torque M_{TR} is in compliance with the following formula:

$\tau \le \tau_{ALL}$

where:

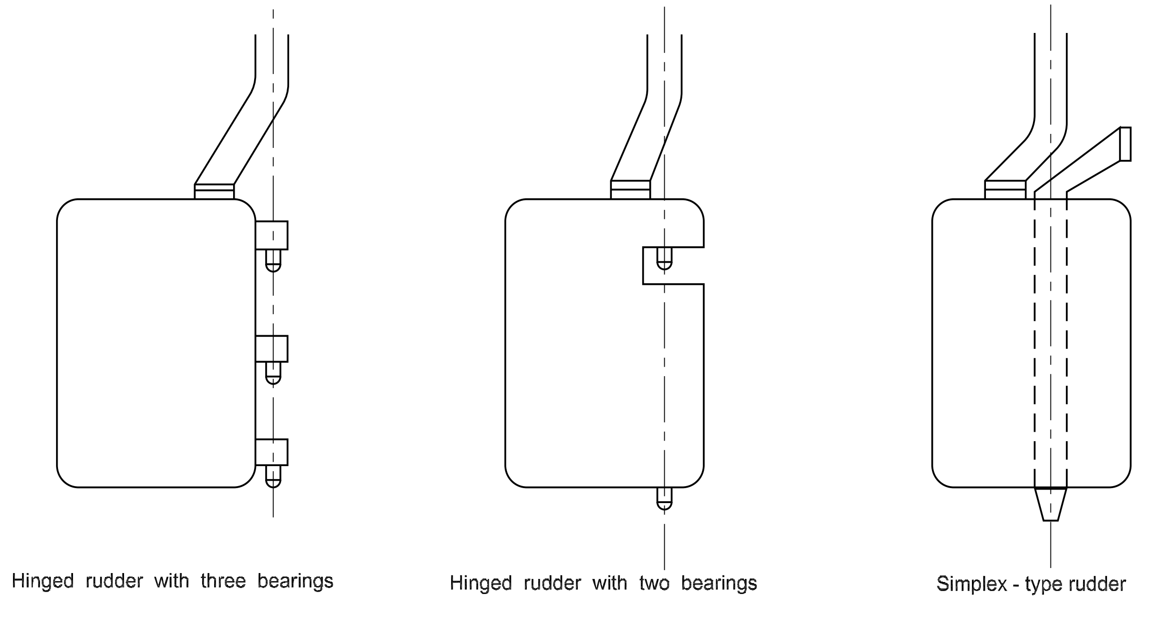
τ_{ALL} : allowable torsional shear stress, in N/mm²:

$\tau_{ALL} = 68/k_1$

For this purpose, the rudder stock diameter is to be not less than the value obtained, in mm, from the following formula:

$d_T = 4{,}2\ (M_{TR}\ k_1)^{1/3}$

Figure 4 : Rudder types



4.2.2 Rudder stock subjected to combined torque and bending *(1/7/2016)*

For rudder stocks subjected to combined torque and bending, it is to be checked that the equivalent stress σ_E induced by the bending moment M_B and the torque M_{TR} is in compliance with the following formula:

$\sigma_E \leq \sigma_{E,ALL}$

where:

σ_E : equivalent stress to be obtained, in N/mm², from the following formula:

$$\sigma_E = \sqrt{\sigma_B^2 + 3\tau_T^2}$$

σ_B : bending stress to be obtained, in N/mm², from the following formula:

$$\sigma_B = 10^3 \frac{10{,}2 M_B}{d_{TF}^3}$$

τ_T : torsional stress to be obtained, in N/mm², from the following formula:

$$\tau_T = 10^3 \frac{5{,}1 M_{TR}}{d_{TF}^3}$$

$\sigma_{E,ALL}$: allowable equivalent stress, in N/mm², equal to:

$\sigma_{E,ALL} = 118/k_1$ N/mm²

Table 3 : Factor H *(1/7/2002)*

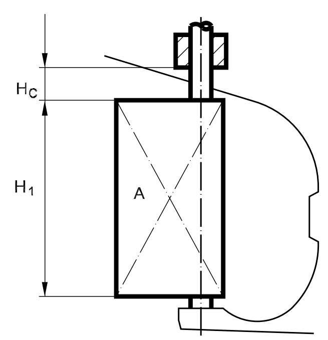
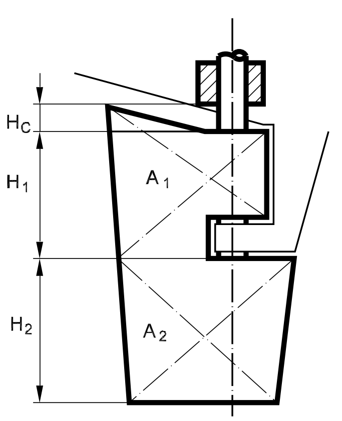
Rudder type	H, in m³
	**2 bearing rudders with solepiece** $A a_1 u H_1$
	**2 bearing semi-spade rudders with rudder horn** 0,83 B **(1)**
(1) B is the greater of the absolute values obtained from the following formulae: • $B = A_1 u H_1 + A_2 (v H_1 + w H_2)$ • $B = A_1 a_2 H_1 - A_2 (a_3 H_1 + 0{,}5 H_2)$ where a_1, a_2, a_3, u, v, w are defined in Tab 4.	

Table 4 : Coefficients for calculating the bending moment in the rudder stock

Coefficient	Value
a_1	$2{,}55 - 1{,}75c$
a_2	$1{,}75c^2 - 3{,}9c + 2{,}35$
a_3	$2{,}65c^2 - 5{,}9c + 3{,}25$
u	$1{,}1c^2 - 2{,}05c + 1{,}175$
v	$1{,}15c^2 - 1{,}85c + 1{,}025$
w	$-3{,}05c^4 + 8{,}14c^3 - 8{,}15c^2 + 3{,}81c - 0{,}735$
Note 1: $c = \frac{H_1}{H_1 + H_C}$ H_1, H_C : as defined in Tab 3, as applicable.	

For this purpose, the rudder stock diameter is to be not less than the value obtained, in mm, from the following formula:

$$d_{TF} = 4{,}2 (M_{TR} k_1)^{1/3} \left(1 + \frac{4}{3}\left(\frac{M_B}{M_{TR}}\right)^2\right)^{1/6}$$

In general, the diameter of a rudder stock subjected to torque and bending may be gradually tapered above the upper stock bearing so as to reach the value of d_T in way of the quadrant or tiller.

5 Rudder stock couplings

5.1 Horizontal flange couplings

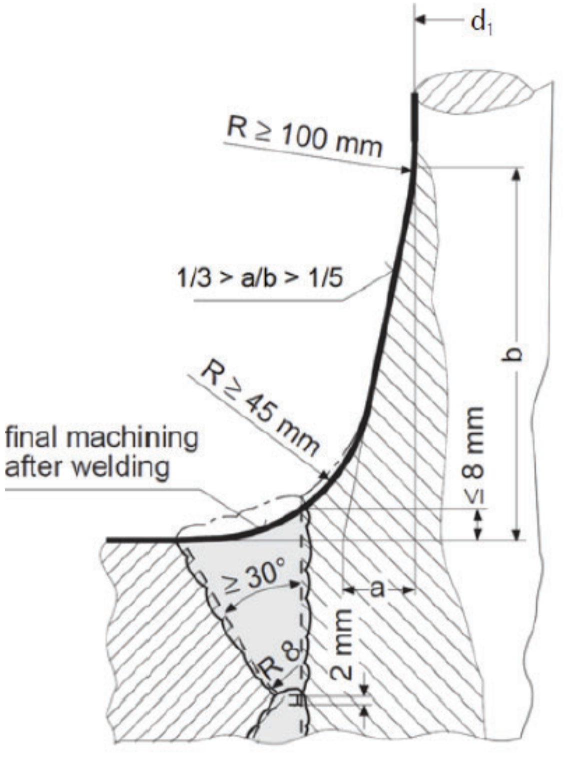
5.1.1 General *(1/7/2016)*

In general, the coupling flange and the rudder stock are to be forged from a solid piece. A shoulder radius as large as practicable is to be provided for between the rudder stock and the coupling flange. This radius is to be not less than 0,13 d_1 or 45 mm, whichever is the greater, where d_1 is the greater of the rudder stock diameters d_T and d_{TF}, in mm, to be calculated in compliance with the requirements in [4.2.1] and [4.2.2], respectively.

Where the rudder stock diameter does not exceed 350 mm, the coupling flange may be welded onto the stock provided that its thickness is increased by 10%, and that the weld extends through the full thickness of the coupling flange and that the assembly obtained is subjected to heat treatment. This heat treatment is not required if the diameter of the rudder stock is less than 75 mm.

Where the coupling flange is welded, the grade of the steel used is to be of weldable quality, particularly with a carbon content not greater than 0,25% and the welding conditions (preparation before welding, choice of electrodes, pre and post heating, inspection after welding) are to be defined to the satisfaction of the Society. The welded joint between the rudder stock and the flange is to be made in accordance with Fig 5. The throat weld at the top of the flange is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius is to be not less than 45 mm (see Fig 5).

Figure 5 : Welded joints between rudder stock and coupling flange *(1/7/2016)*



5.1.2 Bolts

Horizontal flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained, in mm, from the following formula:

$$d_B = 0{,}62\sqrt{\frac{d_1^3 k_{1B}}{n_B e_M k_{1S}}}$$

where:

- d_1 : rudder stock diameter, in mm, defined in [5.1.1]
- k_{1S} : material factor k_1 for the steel used for the rudder stock
- k_{1B} : material factor k_1 for the steel used for the bolts
- e_M : mean distance, in mm, from the bolt axes to the longitudinal axis through the coupling centre (i.e. the centre of the bolt system)
- n_B : total number of bolts, which is to be not less than 6

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of ($0{,}25d_T$ x $0{,}10d_T$) mm² and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B.

5.1.3 Coupling flange

The thickness of the coupling flange is to be not less than the value obtained, in mm, from the following formula:

$$t_P = d_B\sqrt{\frac{k_{1F}}{k_{1B}}}$$

where:

- d_B : bolt diameter, in mm, calculated in accordance with [5.1.2], where the number of bolts n_B is to be taken not greater than 8
- k_{1F} : material factor k_1 for the steel used for the flange
- k_{1B} : material factor k_1 for the steel used for the bolts

In any case, the thickness t_P is to be not less than 0,9 d_B.

5.1.4 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

5.2 Couplings between rudder stocks and tillers

5.2.1 Application *(1/7/2002)*

The requirements in Pt C, Ch 1, Sec 11 apply.

5.2.2 General

The entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

The right fit of the tapered bearing is to be checked before final fit up, to ascertain that the actual bearing is evenly distributed and at least equal to 80% of the theoretical bearing area; push-up length is measured from the relative positioning of the two parts corresponding to this case.

The required push-up length is to be checked after releasing of hydraulic pressures applied in the hydraulic nut and in the assembly

5.2.3 Keyless couplings through special devices

The use of special devices for frictional connections, such as expansible rings, may be accepted by the Society on a case-by-case basis provided that the following conditions are complied with:

- evidence that the device is efficient (theoretical calculations and results of experimental tests, references of behaviour during service, etc.) are to be submitted to the Society
- the torque transmissible by friction is to be not less than 2 M_{TR}
- design conditions and strength criteria are to comply with [5.2.1]
- instructions provided by the manufacturer are to be complied with, notably concerning the pre-stressing of the tightening screws.

5.3 Cone couplings between rudder stocks and rudder blades with key

5.3.1 General *(1/7/2016)*

For cone couplings without hydraulic arrangements for assembling and disassembling the coupling, a key is to be fitted having keyways in both the tapered part and the rudder gudgeon.

The key is to be machined and located on the fore or aft part of the rudder. The key is to be inserted at half-thickness into stock and into the solid part of the rudder.

5.3.2 Tapering and coupling length *(1/7/2016)*

Cone couplings without hydraulic arrangements for mounting and dismounting the coupling should have a taper on diameter in compliance with the following formula:

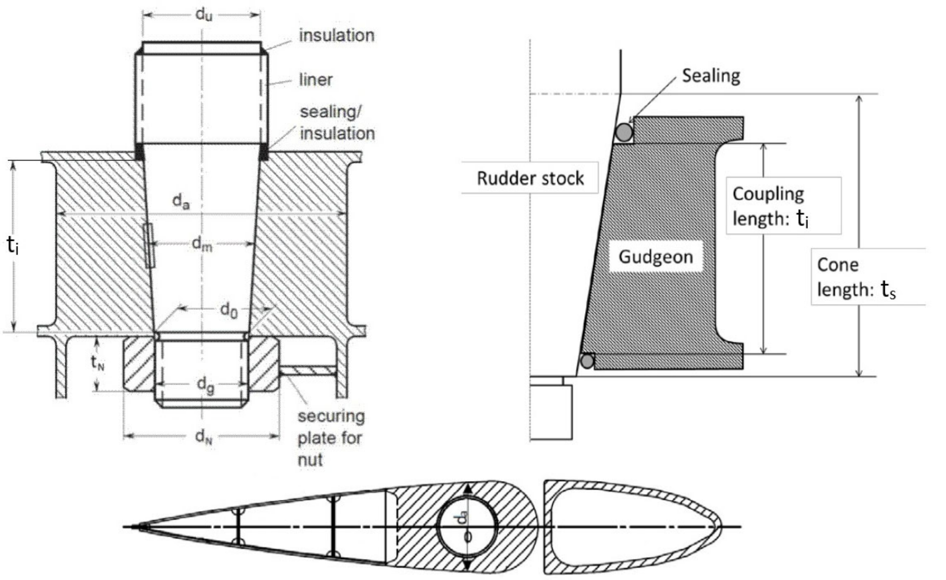
$$\frac{1}{12} \le \frac{d_U - d_0}{t_S} \le \frac{1}{8}$$

where:

d_U, t_S, d_0 : geometrical parameters of the coupling, defined in Fig 6.

The cone shapes are to fit exactly. The coupling length t_S is to be, in general, not less than $1{,}5d_U$.

Figure 6 : Geometry of cone coupling with key *(1/1/2021)*



Gudgeon outer diameter (*d_a*) measurement

5.3.3 Dimensions of key *(1/1/2021)*

The shear area of the key, in cm², is not to be less than:

$$a_S = \frac{17{,}55 Q_F}{d_k R_{eH1}}$$

where:

Q_F : design yield moment of rudder stock, from the following formula:

$$Q_F = 0{,}02664 \frac{d_T^3}{k_1}$$

Where the actual diameter d_{Ta} is greater than the calculated d_T, the diameter d_{Ta} is to be used. However d_{Ta} applied to the above formula need not be taken greater than $1.145 d_T$:

d_T : rudder stock diameter, in mm, defined in [4.2.1]

d_k : mean diameter of the conical part of the rudder stock, in mm, at the key

R_{eH1} : specified minimum yield stress of the key material, in N/mm²

The effective surface area, in cm², of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5 Q_F}{d_k R_{eH2}}$$

where:

R_{eH2} : specified minimum yield stress of the key, stock or coupling material, in N/m², whichever is the less.

5.3.4 Slugging nut *(1/7/2016)*

The cone coupling is to be secured by a slugging nut, whose dimensions are to be in accordance with the following formulae:

$d_G \ge 0{,}65\ du$

$t_N \ge 0{,}60\ d_G$

$d_N \ge 1{,}2\ d_0$ and, in any case, $d_N \ge 1{,}5\ d_G$

where:

d_G, t_N, d_N, d_1, d_0: geometrical parameters of the coupling, defined in Fig 6.

The above minimum dimensions of the locking nut are only given for guidance, the determination of adequate scantlings being left to the Designer.

The nut is to be secured, e.g. by a securing plate as shown in Fig 6.

5.3.5 Push-up *(1/7/2016)*

It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to [5.4.3] and [5.4.4] for a torsional moment $Q'_F = 0{,}5Q_F$.

5.3.6 Rudder torque transmitted entirely by the key *(1/7/2016)*

Notwithstanding the requirements in [5.3.3] and [5.3.5], where a key is fitted to the coupling between stock and rudder and it is considered that the entire rudder torque is transmitted by the key at the couplings, the scantlings of the key as well as the push-up force and push-up length are to be evaluated on a case by case basis. The general criteria for the scantlings of the key are given by the following formulae.

The shear area of the key, in cm², is not to be less than:

$$a_S = \frac{35{,}1 Q_F}{d_k R_{eH1}}$$

The effective surface area, in cm², of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{10 Q_F}{d_k R_{eH2}}$$

5.4 Cone couplings between rudder stocks and rudder blades with special arrangements for mounting and dismounting the couplings

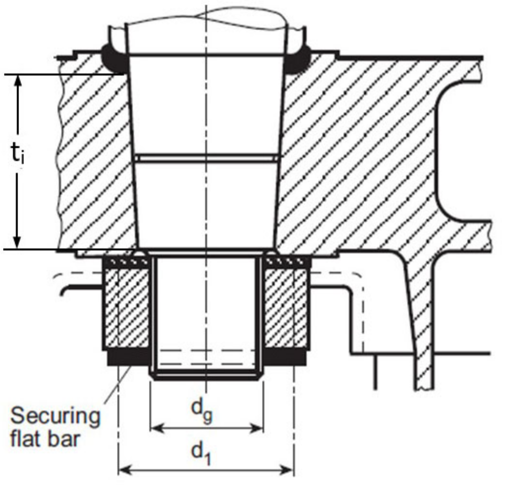
5.4.1 General *(1/7/2016)*

For cone couplings with hydraulic arrangements for assembling and disassembling the coupling, the key may be omitted.

Where the stock diameter exceeds 200 mm, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the nut is to be effectively secured against the rudder stock or the pintle (see Fig 7).

For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to [5.4.3] and [5.4.4] respectively.

Figure 7 : Geometry of cone coupling without key *(1/1/2021)*



5.4.2 Tapering and washer *(1/7/2018)*

Cone couplings with hydraulic arrangements for mounting and dismounting the coupling should have a taper on diameter in compliance with the following formula:

$$\frac{1}{20} \le \frac{d_U - d_0}{t_S} \le \frac{1}{12}$$

where:

d_U, t_S, d_0,: geometrical parameters of the coupling, defined in [5.3.2]

A washer is to be fitted between the nut and the rudder gudgeon, having a thickness not less than 0,09 d_G and an outer diameter not less than 0,13 d_0 or 1,6 d_G, whichever is the greater.

5.4.3 Push-up pressure *(1/1/2021)*

The push-up pressure in N/mm², is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2 Q_F}{d_m^2 \, t_i \pi \mu_0} 10^3$$

$$p_{req2} = \frac{6 M_B}{t_i^2 d_m} 10^3$$

where:

- Q_F : design yield moment of rudder stock, as defined in [5.3.3]
- d_m : mean cone diameter, in mm (see Fig 6)
- t_i : coupling length, in mm, defined in [5.3.2]
- μ_0 : frictional coefficient, equal to 0,15
- M_B : bending moment, in N m, in the cone coupling (e.g. in case of spade rudders)

It has to be provided by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, in N/mm², is to be determined by the following formula:

$$p_{perm} = \frac{0,95 R_{eH}(1-\alpha^2)}{\sqrt{3+\alpha^4}} - p_b \qquad N/mm^2$$

where:

$$p_b = \frac{3,5 M_b}{d_m t_i^2} 10^3$$

R_{eH} : specified minimum yield stress of the gudgeon, in N/mm²

α : coefficient equal to:

$$\alpha = d_m / d_a$$

d_a : outer diameter of the gudgeon, in mm, see Fig 6 (The least diameter is to be considered).

The outer diameter of the gudgeon in mm shall not be less than 1.25 d_0, with d_0 defined in Fig 6.

5.4.4 Push-up length *(1/1/2021)*

The push-up length $\Delta\ell$, in mm, is to comply with the following formula:

$\Delta\ell_1 \leq \Delta\ell \leq \Delta\ell_2$

where:

$$\Delta\ell_1 = \frac{p_{req} d_m}{E\left(\frac{1-\alpha^2}{2}\right)\frac{d_U - d_0}{t_S}} + \frac{0,8 R_{tm}}{\frac{d_U - d_0}{t_S}}$$

$$\Delta\ell_2 = \frac{p_{perm} d_m}{E\frac{d_U - d_0}{t_S}\left(\frac{1-\alpha^2}{2}\right)} + \frac{0,8 R_{tm}}{\frac{d_U - d_0}{t_S}}$$

R_{tm} : mean roughness, in mm, to be taken equal to 0,01

d_U, d_0, t_S : geometrical parameters defined in [5.3.2]

p_{perm} : The permissible surface pressure defined in [5.4.3], in N/mm²

Note 1: in case of hydraulic pressure connections the required push-up force P_e for the cone, in N, may be determined by the following formula:

$$p_e = p_{req} d_m \pi t_i\left(\frac{d_U - d_0}{2 t_S} + 0,02\right)$$

The value of 0,02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subjected to approval by the Society.

5.4.5 Instructions *(1/7/2016)*

All necessary instructions for hydraulic assembly and disassembly of the nut, including indication of the values of all relevant parameters, are to be available on board.

5.5 Vertical flange couplings

5.5.1 Vertical flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained, in mm, from the following formula:

$$d_B = \frac{0,81 d_1}{\sqrt{n_B}} \sqrt{\frac{k_{1B}}{k_{1S}}}$$

where:

d_1 : rudder stock diameter, in mm, defined in [5.1.1]

k_{1S}, k_{1B} : material factors, defined in [5.1.2]

n_B : total number of bolts, which is to be not less than 8.

5.5.2 *(1/7/2016)*

The first moment of area of the sectional area of bolts about the vertical axis through the centre of the coupling is to be not less than the value obtained, in cm³, from the following formula:

$$M_S = 0,43 d_1^3 10^{-3}$$

where:

d_1 : rudder stock diameter, in mm, defined in [5.1.1].

5.5.3 The thickness of the coupling flange, in mm, is to be not less than d_B, defined in [5.5.1].

5.5.4 The distance, in mm, from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B, where d_B is defined in [5.5.1].

5.5.5 A suitable locking device is to be provided to prevent the accidental loosening of nuts.

5.6 Couplings by continuous rudder stock welded to the rudder blade

5.6.1 When the rudder stock extends through the upper plate of the rudder blade and is welded to it, the thickness of this plate in the vicinity of the rudder stock is to be not less than 0,20 d_1, where d_1 is defined in [5.1.1].

5.6.2 The welding of the upper plate of the rudder blade with the rudder stock is to be made with a full penetration weld and is to be subjected to non-destructive inspection through dye penetrant or magnetic particle test and ultrasonic testing.

The throat weld at the top of the rudder upper plate is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius is to be not less than 0,20 d_1, where d_1 is defined in [5.1.1].

5.7 Skeg connected with rudder trunk

5.7.1 In case of a rudder trunk connected with the bottom of a skeg, the throat weld is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius is considered by the Society on a case by case basis.

6 Rudder stock and pintle bearings

6.1 Forces on rudder stock and pintle bearings

6.1.1 Where a direct calculation according to the static schemes and the load conditions specified in App 1 is carried out, the support forces are to be obtained as specified in App 1.

Where such a direct calculation is not carried out, the support forces F_{A1} and F_{A2} acting on the rudder stock bearing and on the pintle bearing, respectively, are to be obtained, in N, from the following formulae:

$$F_{A1} = \left(\frac{A_{G1}}{A} + 0{,}87\frac{h_0}{H_0}\right)C_R$$

$$F_{A2} = \frac{A_{G2}}{A}C_R$$

where:

A_{G1} ,A_{G2} : portions of the rudder blade area A, in m², supported by the rudder stock bearing and by the pintle bearing respectively, to be not less than the value obtained from Tab 5

h_0 : coefficient defined in Tab 5

H_0 : distance, in m, between the points at mid-height of the upper and lower rudder stock bearings.

6.2 Rudder stock bearing

6.2.1 *(1/7/2016)*

The mean bearing pressure acting on the rudder stock bearing is to be in compliance with the following formula:

$p_F \leq p_{F,ALL}$

where:

p_F : mean bearing pressure acting on the rudder stock bearings, in N/mm², equal to:

$$p_F = \frac{F_{A1}}{d_m h_m}$$

F_{A1} : force acting on the rudder stock bearing, in N, calculated as specified in [6.1.1]

d_m : actual inner diameter, in mm, of the rudder stock bearings

h_m : bearing length, in mm. For the purpose of this calculation it is to be taken not greater than:

- $1{,}2d_m$, for spade rudders
- d_m, for rudder of other types

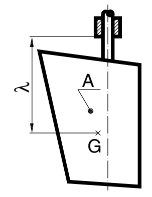
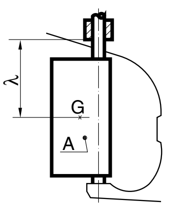
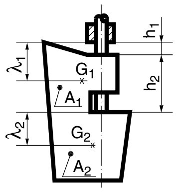
where d_m is defined in [6.2.1]

$p_{F,ALL}$: allowable bearing pressure, in N/mm², defined in Tab 6.

Values greater than those given in Tab 6 may be accepted by the Society in accordance with the Manufacturer's specifications if they are verified by tests, but in no case more than 10 N/mm².

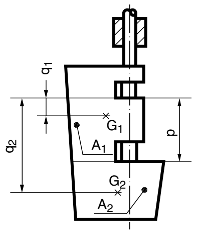
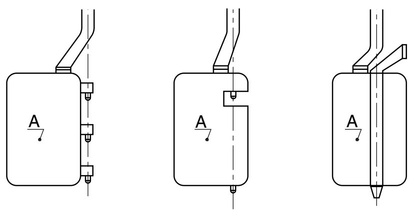
6.2.2 An adequate lubrication of the bearing surface is to be ensured.

Table 5 : Areas A_{G1} , A_{G2} and h_0 *(1/7/2002)*

Rudder type	A_{G1}, in m²	A_{G2}, in m²	h_0 , in m
spade rudders 	A	0	$1{,}15\lambda$
2 bearing rudders with solepiece 	Rudder blade area above a horizontal line equally spaced from the upper and the lower edges	Rudder blade area below a horizontal line equally spaced from the upper and the lower edges	$0{,}3\lambda$
2 bearing semi-spade rudders with rudder horn 	$\dfrac{A_1\lambda_1 h_2^2}{(h_1+h_2)^3}$	The greater of **(1)**: • $\dfrac{\lambda A}{h_1+h_2}$ • A	The greater of: • $0{,}19\dfrac{A_1\lambda_1}{A}$ • $\left\lvert 0{,}3\dfrac{A_1\lambda_1-2A_2\lambda_2}{A}\right\rvert$

(1) $\lambda = \dfrac{(\lambda_2+h_2+h_1)A_2+\lambda_1\cdot A_1}{A}$

Note 1:
G, G_1, G_2 : centres of gravity of area A, A_1 and A_2 respectively,
n : number of pintles.

Rudder type	A_{G1}, in m²	A_{G2}, in m²	h_0 , in m
3 bearing semi-spade rudders with rudder horn 	0	• lower pintle: $\dfrac{A_1q_1 + A_2q_2}{p}$ • upper pintle, the greater of: $A_1 + A_2 - \dfrac{A_1q_1 + A_2q_2}{p}$ $0{,}5\dfrac{A_1q_1 + A_2q_2}{p}$	0
Hinged rudders and Simplex type rudders 	0	$\dfrac{A}{n}$	0

(1) $\lambda = \dfrac{(\lambda_2 + h_2 + h_1)A_2 + \lambda_1 \cdot A_1}{A}$

Note 1:

G, G_1, G_2 : centres of gravity of area A, A_1 and A_2 respectively,

n : number of pintles.

6.2.3 *(1/7/2016)*

The manufacturing tolerance t_0 on the diameter of metallic supports is to be not less than the value obtained, in mm, from the following formula:

$$t_0 = \frac{d_m}{1000} + 1$$

In the case of non-metallic supports, the tolerances are to be carefully evaluated on the basis of the thermal and distortion properties of the materials employed.

The tolerance on support diameter is to be not less than 1,5 mm, unless a smaller tolerance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

6.2.4 *(1/7/2016)*

Liners and bushes are to be fitted in way of bearings. The minimum thickness of liners and bushes is to be equal to:

- t_{min} = 8 mm for metallic materials and synthetic material
- t_{min} = 22 mm for lignum material.

6.3 Pintle bearings

6.3.1 *(1/7/2016)*

The mean bearing pressure acting on the gudgeons is to be in compliance with the following formula:

$$p_F \le p_{F,ALL}$$

where:

p_F : mean bearing pressure acting on the gudgeons, in N/mm², equal to:

$$p_F = \frac{F_{A2}}{d_A h_L}$$

F_{A2} : force acting on the pintle, in N, calculated as specified in [6.1.1]

d_A : actual diameter, in mm, of the rudder pintles

h_L : bearing length, in mm (see [6.3.3])

$p_{F,ALL}$: allowable bearing pressure, in N/mm², defined in Tab 6. Values greater than those given in Tab 6 may be accepted by the Society in accordance with the Manufacturer's specifications if they are verified by tests, but in no case more than 10 N/mm².

6.3.2 An adequate lubrication of the bearing surface is to be ensured.

6.3.3 The bearing length, in mm, is to be not less than d_A, where d_A is defined in [6.4.1]. For the purpose of the calculation in [6.3.1], the bearing length is to be taken not greater than 1,2 d_A.

Table 6 : Allowable bearing pressure *(1/1/2021)*

Bearing material	$p_{F,ALL}$, in N/mm²
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness greater than 60 Shore D **(1)**	5,5
Steel, bronze and hot-pressed bronze-graphite materials **(2)**	7,0

(1) Indentation hardness test at 23°C and with 50% moisture to be performed according to a recognised standard. Type of synthetic bearing materials is to be approved by the Society.
(2) Stainless and wear-resistant steel in combination with stock liner approved by the Society.

6.3.4 *(1/1/2013)*

The manufacturing tolerance t_0 on the diameter of metallic supports is to be not less than the value obtained, in mm, from the following formula:

$$t_0 = \frac{d_A}{1000} + 1$$

In the case of non-metallic supports, the tolerances are to be carefully evaluated on the basis of the thermal and distortion properties of the materials employed.

The tolerance on support diameter is to be not less than 1,5 mm, unless a smaller tolerance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

6.3.5 *(1/7/2016)*

The thickness of any liner or bush, in mm, is to be taken equal to the lesser of the following values:

Metallic materials and synthetic material:

- $t = 0,01\sqrt{F_{A2}}$
- $t = 8mm$

Lignum material:

- $t = 0,01\sqrt{F_{A2}}$
- $t = 22mm$

where:

F_{A2} : force, in N, acting on the pintle, calculated as specified in [6.1.1].

6.4 Pintles

6.4.1 *(1/7/2016)*

Rudder pintles are to have a diameter not less than the value obtained, in mm, from the following formula:

$$d_A = 0,35\sqrt{F_{A2}k_1}$$

where:

F_{A2} : force, in N, acting on the pintle, calculated as specified in [6.1.1].

6.4.2 Provision is to be made for a suitable locking device to prevent the accidental loosening of pintles.

6.4.3 *(1/7/2016)*

The pintles are to have a conical coupling with a taper on diameter in accordance with [5.3.2] for keyed and other manually assembled pintles locking by slugging nut and in accordance with [5.4.2] for pintles mounted with oil injection and hydraulic nut.

The conical coupling is to be secured by a nut, whose dimension are to be in accordance with [5.3.4].

6.4.4 *(1/7/2016)*

The length of the pintle housing in the gudgeon is to be not less than the pintle diameter d_A, where d_A is defined in [6.4.1]. d_A is to be measured on the outside of liners.

The thickness of pintle housing in the gudgeon, in mm, is to be not less than 0,25 d_A.

6.4.5 *(1/7/2019)*

The required push-up pressure for pintle, in N/mm², is to be determined by the following formula:

$$p_{req} = 0,4\frac{F_{A2}d_A}{d^2_{Am}h_L}$$

where:

F_{A2} : force, in N, acting on the pintle, calculated as specified in [6.1.1]

d_A : actual diameter, in mm, of the rudder pintles

d_{Am} : mean cone diameter, in mm

h_L : bearing length, in mm, as defined in [6.3.3].

The push up length is to be calculated similarly as in [5.4.4], using required push-up pressure and properties for the pintle.

7 Rudder blade scantlings

7.1 General

7.1.1 Application

The requirements in [7.1] to [7.6] apply to streamlined rudders and, when applicable, to rudder blades of single plate rudders.

7.1.2 Rudder blade structure

The structure of the rudder blade is to be such that stresses are correctly transmitted to the rudder stock and pintles. To this end, horizontal and vertical web plates are to be provided.

Horizontal and vertical webs acting as main bending girders of the rudder blade are to be suitably reinforced.

7.1.3 Access openings

Streamlined rudders, including those filled with pitch, cork or foam, are to be fitted with plug-holes and the necessary devices to allow their mounting and dismounting.

Access openings to the pintles are to be provided. If necessary, the rudder blade plating is to be strengthened in way of these openings.

The corners of openings intended for the passage of the rudder horn heel and for the dismantling of pintle or stock nuts are to be rounded off with a radius as large as practicable.

Where the access to the rudder stock nut is closed with a welded plate, a full penetration weld is to be provided.

7.1.4 Connection of the rudder blade to the trailing edge for rudder blade area greater than 6 m²

Where the rudder blade area is greater than 6 m^2, the connection of the rudder blade plating to the trailing edge is to be made by means of a forged or cast steel fashion piece, a flat or a round bar.

7.2 Strength checks

7.2.1 Bending stresses

For the generic horizontal section of the rudder blade it is to be checked that the bending stress σ, in N/mm², induced by the loads defined in [3.1], is in compliance with the following formula:

$\sigma \leq \sigma_{ALL}$

where:

σ_{ALL} : allowable bending stress, in N/mm², specified in Tab 7.

Table 7 : Allowable stresses for rudder blade scantlings *(1/7/2019)*

Type of rudder blade	Allowable bending stress σ_{ALL} in N/mm²	Allowable shear stress τ_{ALL} in N/mm²	Allowable equivalent stress $\sigma_{E,ALL}$ in N/mm²
In general except in way of rudder recess sections	110/k	50/k	120/k
In way of the recess for the rudder horn pintle on semi-spade rudders	75	50	100
Note 1: The stresses in way of the recess for the rudder horn pintle on semi-spade rudders apply equally to high tensile and ordinary steel			

7.2.2 Shear stresses

For the generic horizontal section of the rudder blade it is to be checked that the shear stress τ, in N/mm², induced by the loads defined in [3.1], is in compliance with the following formula:

$\tau \leq \tau_{ALL}$

where:

τ_{ALL} : allowable shear stress, in N/mm², specified in Tab 7.

7.2.3 Combined bending and shear stresses *(1/1/2001)*

For the generic horizontal section of the rudder blade it is to be checked that the equivalent stress σ_E is in compliance with the following formula:

$\sigma_E \leq \sigma_{E,ALL}$

where:

σ_E : equivalent stress induced by the loads defined in [3.1], to be obtained, in N/mm², from the following formula:

$$\sigma_E = \sqrt{\sigma^2 + 3\tau^2}$$

Where unusual rudder blade geometries make it practically impossible to adopt ample corner radiuses or generous tapering between the various structural elements, the equivalent stress σ_E is to be obtained by means of direct calculations aiming at assessing the rudder blade areas where the maximum stresses, induced by the loads defined in [3.1], occur

σ : bending stress, in N/mm²

τ : shear stress, in N/mm²

$\sigma_{E,ALL}$: allowable equivalent stress, in N/mm², specified in Tab 7.

7.3 Rudder blade plating

7.3.1 Plate thickness *(1/1/2021)*

The thickness of each rudder blade plate panel is to be not less than the value obtained, in mm, from the following formula:

$$t_f = \left(5{,}5s\beta\sqrt{T + \frac{C_R 10^{-4}}{A}}\right)\sqrt{k} + 2{,}5$$

where:

β : coefficient equal to:

$$\beta = \sqrt{1{,}1 - 0{,}5\left(\frac{s}{b_L}\right)^2}$$

to be taken not greater than 1,0 if $b_L/s > 2{,}5$

s : length, in m, of the shorter side of the plate panel.

b_L : length, in m, of the longer side of the plate panel

T : summer load line draught, in m.

7.3.2 Thickness of the top and bottom plates of the rudder blade

The thickness of the top and bottom plates of the rudder blade is to be not less than the thickness t_F defined in [7.3.1], without being less than 1,2 times the thickness obtained from [7.3.1] for the attached side plating.

Where the rudder is connected to the rudder stock with a coupling flange, the thickness of the top plate which is welded in extension of the rudder flange is to be not less than 1,1 times the thickness calculated above.

7.3.3 Web spacing

The spacing between horizontal web plates is to be not greater than 1,20 m.

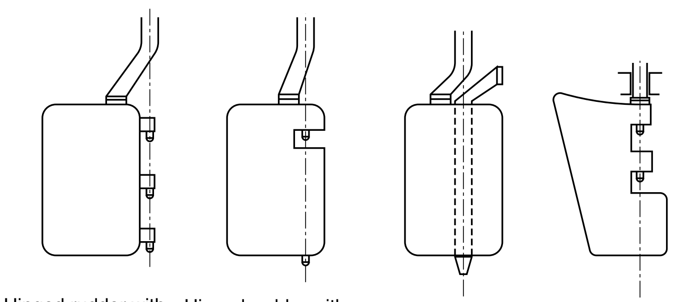
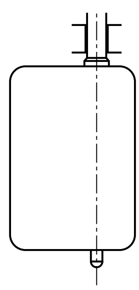
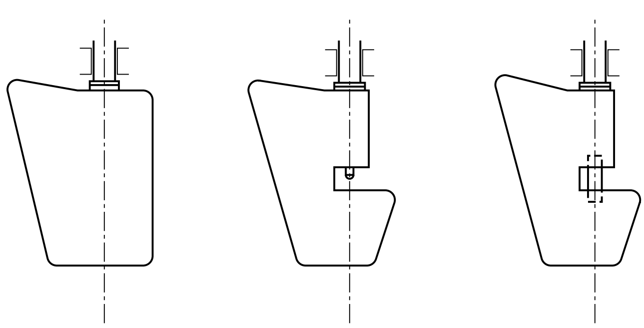
Vertical webs are to have spacing not greater than twice that of horizontal webs.

7.3.4 Web thickness

Web thickness is to be at least 70% of that required for rudder plating and in no case is it to be less than 8 mm, except for the upper and lower horizontal webs, for which the requirements in [7.3.2] apply.

When the design of the rudder does not incorporate a main-piece, this is to be replaced by two vertical webs closely spaced, having thickness not less than that obtained from Tab 8. In rudders having area less than 6 m^2, one vertical web only may be accepted provided its thickness is at least twice that of normal webs.

Table 8 : Thickness of the vertical webs and rudder side plating welded to solid part or to rudder flange

Type of rudder	Thickness of vertical web plates, in mm		Thickness of rudder plating, in mm	
	Rudder blade without opening	At opening boundary	Rudder blade without opening	Area with opening
Hinged rudders, Simplex type rudders and semi-spade with three bearings rudders  Hinged rudder with three bearings; Hinged rudder with two bearings; Simplex - type; 3 bearings semi-spade rudders with rudder horn	t_F	1,3 t_F	t_F	1,2 t_F
Rudder without intermediate pintles 	1,2 t_F	1,6 t_F	1,2 t_F	1,4 t_F
Spade and one bearing rudders  Spade rudder; Simple pintle; Inserted pintle	1,4 t_F	2,0 t_F	1,3 t_F	1,6 t_F

Note 1:
t_F : defined in [7.3.1].

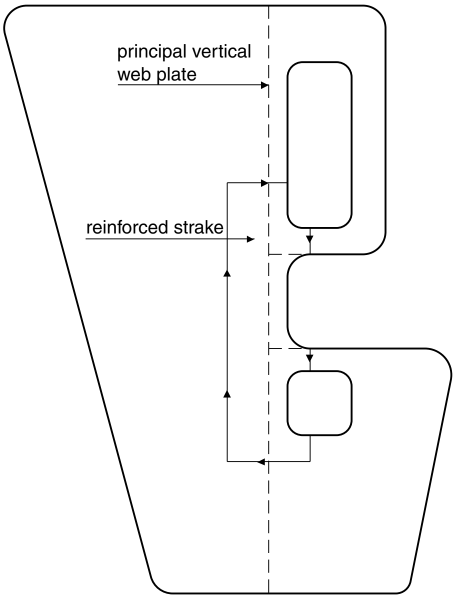
7.3.5 Thickness of side plating and vertical web plates welded to solid part or to rudder flange

The thickness, in mm, of the vertical web plates welded to the solid part where the rudder stock is housed, or welded to the rudder flange, as well as the thickness of the rudder side plating under this solid part, or under the rudder coupling flange, is to be not less than the value obtained, in mm, from Tab 8.

7.3.6 Reinforced strake of semi-spade rudders

A reinforced strake is to be provided in the lower pintle zone of semi-spade rudders. Its thickness is to be not less than 1,6 t_F, where t_F is defined in [7.3.1]. This strake is to be extended forward of the main vertical web plate (see Fig 8).

Figure 8 : Reinforced strake extension for semi-spade rudders



7.3.7 Main vertical webs of semi-spade rudders

The thickness of the main vertical web plate in the area between the rudder blade upper part and the pintle housing of semi-spade rudders is to be not less than 2,6 t_F, where t_F is defined in [7.3.1].

Under the pintle housing the thickness of this web is to be not less than the value obtained from Tab 8.

Where two main vertical webs are fitted, the thicknesses of these webs are to be not less than the values obtained from Tab 8 depending on whether the web is fitted in a rudder blade area without opening or if the web is along the recess cut in the rudder for the passage of the rudder horn heel.

7.3.8 Welding

The welded connections of blade plating to vertical and horizontal webs are to be in compliance with the applicable requirements of Part D of the Rules.

Where the welds of the rudder blade are accessible only from outside of the rudder, slots on a flat bar welded to the webs are to be provided to support the weld root, to be cut on one side of the rudder only.

7.3.9 Rudder nose plate thickness

Rudder nose plates are to have a thickness not less than 1,25 t_F, where t_F is defined in [7.3.1].

In general this thickness need not exceed 22 mm, unless otherwise required in special cases to be considered individually by the Society.

7.4 Connections of rudder blade structure with solid parts in forged or cast steel

7.4.1 General

Solid parts in forged or cast steel which ensure the housing of the rudder stock or of the pintle are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

7.4.2 Minimum section modulus of the connection with the rudder stock housing *(1/7/2016)*

The section modulus of the cross-section of the structure of the rudder blade which is connected with the solid part where the rudder stock is housed, which is made by vertical web plates and rudder plating, is to be not less than that obtained, in cm³, from the following formula:

$$w_S = c_S d_1^3 \left(\frac{H_E - H_X}{H_E}\right)^2 \frac{k}{k_1} 10^{-4}$$

where:

- c_S : coefficient to be taken equal to:
  - c_S:1,0 if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate
  - c_S:1,5 if there is an opening in the considered cross-section of the rudder
- d_1 : rudder stock diameter, in mm, defined in [5.1.1]
- H_E : vertical distance, in m, between the lower edge of the rudder blade and the upper edge of the solid part
- H_X : vertical distance, in m, between the considered cross-section and the upper edge of the solid part
- k, k_1 : material factors, defined in [1.4], for the rudder blade plating and the rudder stock, respectively.

7.4.3 Calculation of the actual section modulus of the connection with the rudder stock housing

The actual section modulus of the cross-section of the structure of the rudder blade which is connected with the solid part where the rudder stock is housed is to be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating to be considered for the calculation of this actual section modulus is to be not greater than that obtained, in m, from the following formula:

$$b = s_V + 2\frac{H_X}{m}$$

where:

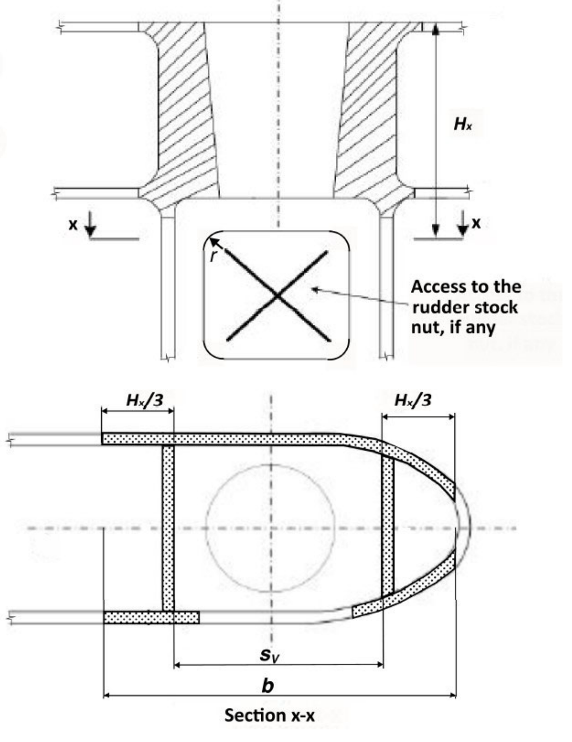
- s_V : spacing, in m, between the two vertical webs (see Fig 9)

H_X : distance defined in [7.4.2]

m : coefficient to be taken, in general, equal to 3

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate according to [7.1.3], they are to be deducted (see Fig 9).

Figure 9 : Cross-section of the connection between rudder blade structure and rudder stock housing, example with opening in only one side shown *(1/1/2021)*



7.4.4 Thickness of horizontal web plates *(1/7/2016)*

The thickness of the horizontal web plates connected to the solid parts, as well as that of the rudder blade plating between these webs, is to be not less than the greater of the values obtained, in mm, from the following formulae:

$t_H = 1,2\ t_F$

$$t_H = 0,045\frac{d_S^2}{s_H}$$

where:

t_F : defined in [7.3.1]

d_S : diameter, in mm, to be taken equal to:

- d_1 for the solid part connected to the rudder stock
- d_A for the solid part connected to the pintle

d_1 : rudder stock diameter, in mm, defined in [5.1.1]

d_A : pintle diameter, in mm, defined in [6.4.1]

s_H : spacing, in mm, between the two horizontal web plates.

The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

Different thickness may be accepted when justified on the basis of direct calculations submitted to the Society for approval.

7.4.5 Thickness of side plating and vertical web plates welded to the solid part *(1/7/2016)*

The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in mm, from Tab 8.

The increased thickness is to extend below the solid piece at least to the next horizontal web.

7.4.6 Solid part protrusions

The solid parts are to be provided with protrusions. Vertical and horizontal web plates of the rudder are to be butt welded to these protrusions.

These protrusions are not required when the web plate thickness is less than:

- 10 mm for web plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders,
- 20 mm for the other web plates.

7.5 Connection of the rudder blade with the rudder stock by means of horizontal flanges

7.5.1 Minimum section modulus of the connection

The section modulus of the cross-section of the structure of the rudder blade which is directly connected with the flange, which is made by vertical web plates and rudder blade plating, is to be not less than the value obtained, in cm^3, from the following formula:

$w_S = 1,3\ d_1^3\ 10^{-4}$

where d_1 is the greater of the rudder stock diameters d_T and d_{TF}, in mm, to be calculated in compliance with the requirements in [4.2.1] and [4.2.2], respectively, taken k_1 equal to 1.

7.5.2 Actual section modulus of the connection

The section modulus of the cross-section of the structure of the rudder blade which is directly connected with the flange is to be calculated with respect to the symmetrical axis of the rudder.

For the calculation of this actual section modulus, the length of the rudder cross-section equal to the length of the rudder flange is to be considered.

Where the rudder plating is provided with an opening under the rudder flange, the actual section modulus of the rudder blade is to be calculated in compliance with [7.4.3].

7.5.3 Welding of the rudder blade structure to the rudder blade flange

The welds between the rudder blade structure and the rudder blade flange are to be full penetrated (or of equivalent strength) and are to be 100% inspected by means of non-destructive tests.

Where the full penetration welds of the rudder blade are accessible only from outside of the rudder, a backing flat bar is to be provided to support the weld root.

The external fillet welds between the rudder blade plating and the rudder flange are to be of concave shape and their throat thickness is to be at least equal to 0,5 times the rudder blade thickness.

Moreover, the rudder flange is to be checked before welding by non-destructive inspection for lamination and inclusion detection in order to reduce the risk of lamellar tearing.

7.5.4 Thickness of side plating and vertical web plates welded to the rudder flange

The thickness of the vertical web plates directly welded to the rudder flange as well as the plating thickness of the rudder blade upper strake in the area of the connection with the rudder flange is to be not less than the values obtained, in mm, from Tab 8.

7.6 Single plate rudders

7.6.1 Mainpiece diameter

The mainpiece diameter is to be obtained from the formulae in [4.2].

In any case, the mainpiece diameter is to be not less than the stock diameter.

For spade rudders the lower third may taper down to 0,75 times the stock diameter.

7.6.2 Blade thickness *(1/7/2016)*

The blade thickness is to be not less than the value obtained, in mm, from the following formula:

$$t_B = 1{,}5 s V_{AV}\sqrt{k} + 2{,}5$$

where:

s : spacing of stiffening arms, in m, to be taken not greater than 1 m (see Fig 10).

7.6.3 Arms

The thickness of the arms is to be not less than the blade thickness.

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

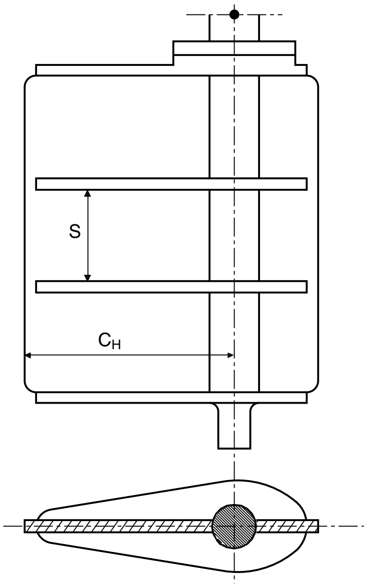
$$Z_A = 0{,}5 s C_H^2 V_{AV}^2 k$$

where:

C_H : horizontal distance, in m, from the aft edge of the rudder to the centreline of the rudder stock (see Fig 10)

s : defined in [7.6.2].

Figure 10 : Single plate rudder



8 Rudder horn and solepiece scantlings

8.1 General

8.1.1 The weight of the rudder is normally supported by a carrier bearing inside the rudder trunk.

In the case of unbalanced rudders having more than one pintle, the weight of the rudder may be supported by a suitable disc fitted in the solepiece gudgeon.

Robust and effective structural rudder stops are to be fitted, except where adequate positive stopping arrangements are provided in the steering gear, in compliance with the applicable requirements of Pt C, Ch 1, Sec 11.

8.2 Rudder horn

8.2.1 General

When the connection between the rudder horn and the hull structure is designed as a curved transition into the hull plating, special consideration is to be paid to the effectiveness of the rudder horn plate in bending and to the stresses in the transverse web plates.

8.2.2 Loads *(1/7/2016)*

The following loads acting on the generic section of the rudder horn are to be considered:

- bending moment
- shear force
- torque

The requirements in App 1, [1.6] ore App 1, [1.8] apply for calculating the above loads in the case of 2 bearing semi-spade rudders and semi-spade rudders with 2-conjugate elastic support respectively.

In the case of 3 bearing semi-spade rudders, these loads are to be calculated on the basis of the support forces at the lower and upper pintles, obtained according to [6.1].

8.2.3 Shear stress check *(1/7/2016)*

For the generic section of the rudder horn it is to be checked that:

$\tau_S + \tau_T \leq \tau_{ALL}$

where:

τ_S : shear stress to be obtained, in N/mm², according to either App 1, [1.6] or App 1, [1.8], depending on the rudder type

τ_T : torsional stress to be obtained for hollow rudder horn, in N/mm², according to either App 1, [1.6] or App 1, [1.8]

τ_{ALL} : allowable shear stress, in N/mm²:

$\tau_{ALL} = 48/k_1$

8.2.4 Combined stress strength check *(1/7/2016)*

For the generic section of the rudder horn, it is to be checked that:

$\sigma_E \leq \sigma_{E,ALL}$

$\sigma_B \leq \sigma_{B,ALL}$

where:

σ_E : equivalent stress to be obtained, in N/mm², from the following formula:

$$\sigma_E = \sqrt{\sigma_B^2 + 3(\tau_S^2 + \tau_T^2)}$$

Where unusual rudder horn geometries make it practically impossible to adopt ample corner radiuses or generous tapering between the various structural elements, the equivalent stress σ_E is to be obtained by means of direct calculations aiming at assessing the rudder horn areas where the maximum stresses, induced by the loads defined in [3.1], occur

σ_B : bending stress to be obtained, in N/mm², according to either App 1, [1.6] or App 1, [1.8], depending on the rudder type

τ_S , τ_T : shear and torsional stresses, in N/mm², to be obtained according to either App 1, [1.6] or App 1, [1.8], depending on the rudder type

$\sigma_{E,ALL}$: allowable equivalent stress, in N/mm², equal to:

$\sigma_{E,ALL} = 120/k_1$ N/mm²

$\sigma_{B,ALL}$: allowable bending stress, in N/mm², equal to:

$\sigma_{B,ALL} = 67/k_1$ N/mm²

8.2.5 Rudder horn plating *(1/1/2021)*

The thickness of the rudder horn side plating, in mm, is not to be less than:

$$t = 2,4\sqrt{Lk}$$

where:

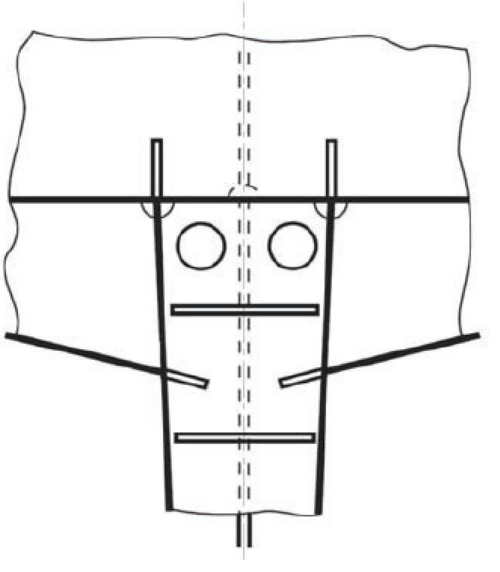
L : rule length, in m.

8.2.6 Welding and connection to hull structure *(1/7/2016)*

The rudder horn plating is to be effectively connected to the aft ship structure, e.g. by connecting the plating to side shell and transverse/ longitudinal girders, in order to achieve a proper transmission of forces, see Fig 11.

Brackets or stringer are to be fitted internally in horn, in line with outside shell plate, as shown in Fig 11.

Figure 11 : Connection of the rudder horn to aft ship structure *(1/7/2016)*



Transverse webs of the rudder horn are to be led into the hull up to the next deck in a sufficient number and must be of adequate thickness.

Strengthened plate floors are to be fitted in line with the transverse webs in order to achieve a sufficient connection with the hull.

The center line bulkhead (wash-bulkhead) in the after peak is to be connected to the rudder horn.

Scallops are to be avoided in way of the connection between transverse webs and shell plating.

The weld at the connection between the rudder horn plating and the side shell is to be full penetration. The welding radius is to be as large as practicable and may be obtained by grinding.

8.3 Solepieces

8.3.1 Bending moment

The bending moment acting on the generic section of the solepiece is to be obtained, in N.m, from the following formula:

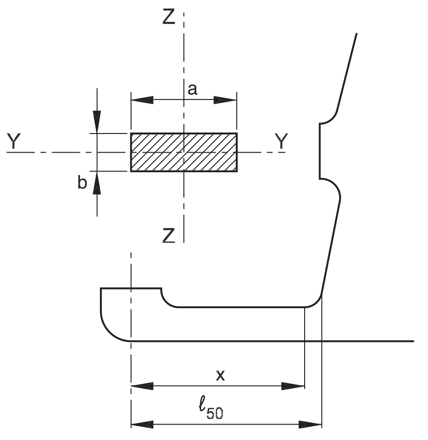
$M_S = F_{A2}\, x$

where:

F_{A2} : supporting force, in N, in the pintle bearing, to be determined through a direct calculation to be performed in accordance with the static schemes and the load conditions specified in App 1; where such a direct calculation is not carried out, this force may be taken equal to:

$$F_{A2} = \frac{C_R}{2}$$

Figure 12 : Solepiece geometry



x : distance, in m, defined in Fig 12.

8.3.2 Strength checks

For the generic section of the solepiece within the length ℓ_{50}, defined in Fig 12, it is to be checked that

$\sigma_E \leq \sigma_{E,ALL}$

$\sigma_B \leq \sigma_{B,ALL}$

$\tau \leq \tau_{ALL}$

where:

σ_E : equivalent stress to be obtained, in N/mm², from the following formula:

$$\sigma_E = \sqrt{\sigma_B^2 + 3\tau^2}$$

σ_B : bending stress to be obtained, in N/mm², from the following formula:

$$\sigma_B = \frac{M_S}{W_Z}$$

τ : shear stress to be obtained, in N/mm², from the following formula:

$$\tau = \frac{F_{A2}}{A_S}$$

M_S : bending moment at the section considered, in N.m, defined in [8.3.1]

F_{A2} : force, in N, defined in [8.3.1]

W_Z : section modulus, in cm³, around the vertical axis Z (see Fig 12)

A_S : shear sectional area in Y direction, in mm²

$\sigma_{E,ALL}$: allowable equivalent stress, in N/mm², equal to:

$\sigma_{E,ALL} = 115/k_1$ N/mm²

$\sigma_{B,ALL}$: allowable bending stress, in N/mm², equal to:

$\sigma_{B,ALL} = 80/k_1$ N/mm²

τ_{ALL} : allowable shear stress, in N/mm², equal to:

$\tau_{ALL} = 48/k_1$ N/mm².

8.3.3 Minimum section modulus around the horizontal axis

The section modulus around the horizontal axis Y (see Fig 12) is to be not less than the value obtained, in cm³, from the following formula:

$W_Y = 0,5\ W_Z$

where:

W_Z : section modulus, in cm³, around the vertical axis Z (see Fig 12).

8.4 Rudder trunk

8.4.1 General *(1/1/2021)*

The requirements of this Article apply to trunk configurations which are extended below stern frame and arranged in such a way that the trunk is stressed by forces due to rudder action.

8.4.2 Materials, welding and connection to the hull *(1/1/2021)*

The steel grade used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0,23% on ladle analysis and a carbon equivalent C_{ER} not exceeding 0,41.

Plating materials for rudder trunks are in general not to be of lower grade than corresponding to class II as defined in Ch 4, Sec 1.

The fillet shoulder radius r, in mm, is to be as large as practicable (see Fig 13) and to comply with the following formulae:

$r = 0,1\ d_1$

without being less than:

r = 60 mm when $\sigma_B \geq 40/k$ N/mm²

r = 30 mm when $\sigma_B < 40/k$ N/mm²

where:

d_1 : rudder stock diameter, in mm, as defined in [5.1.1]

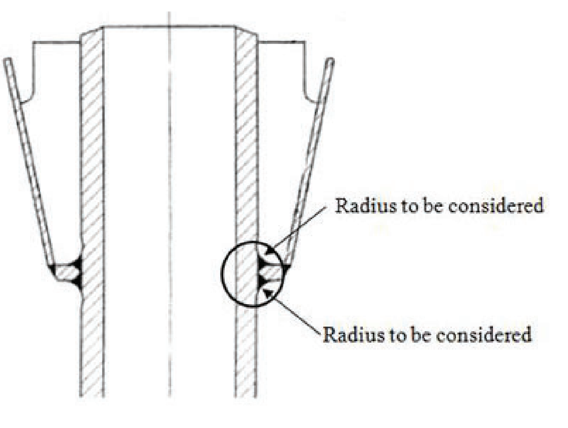
σ_B : bending stress in the rudder trunk, in N/mm².

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld.

The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel are to be specially considered by the Society.

Figure 13 : Fillet shoulder radius *(1/7/2016)*



8.4.3 Strength check *(1/1/2021)*

The scantling of the trunk are to be such that:

- the equivalent stress σ_E, in N/mm², due to bending and shear does not exceed 0,35 R_{EH}
- the bending stress σ_B, in N/mm², on welded rudder trunk is to be in compliance with the following formula:

$\sigma_B \leq 80 / k$ where k is not to be taken less than 0,7

where:

R_{eH} : specified minimum yield stress, in N/mm², of the material used

For calculation of bending stress, the span to be considered is the distance between the mid height of the lower rudder stock bearing and the point where the trunk is clumped into the shell or bottom of the skeg.

9 Simplex rudder shaft

9.1 Scantlings

9.1.1 Diameter of the rudder shaft

The rudder shaft diameter is to be not less than the value obtained, in mm, from the following formula:

$$d = 17,9\left(\frac{\alpha A(V_{AV}+2)^2}{\ell}\right)^{1/3}$$

where:

α : coefficient equal to:

- $\alpha = b(\ell - b + a)$ if $a \leq b$
- $\alpha = a(\ell - a + b)$ if $a > b$

a, b, ℓ : geometrical parameters, in m, defined in Fig 14.

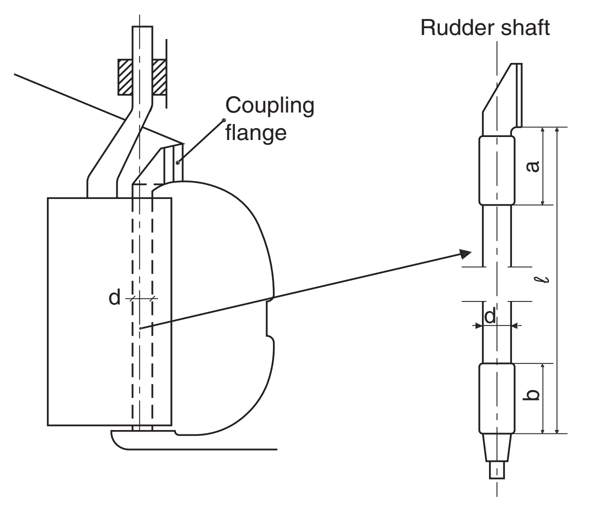
9.1.2 Sectional area of rudder shaft

The overall sectional area of the rudder shaft is to be not less than the greater of the following values:

- 70% of the sectional area for the propeller post defined in Ch 9, Sec 2, [6.3]
- value of the sectional area of the pintle supporting half the rudder blade, whose diameter is to be calculated from the formula in [6.4.1]

If the latter value is the greater, it is to be applied only where the rudder bears on the rudder shaft; in such case, it is recommended that an overthickness or a bush is provided in way of the bearing areas.

Figure 14 : Simplex rudder shaft geometry



9.1.3 Bearings

The bearing length of the rudder shaft is to be not less than 1,2 d, where d is the shaft diameter defined in [9.1.1].

The mean pressure acting on the bearings is not to exceed the relevant allowable values, defined in Tab 5.

9.2 Connections

9.2.1 Connection with the hull

The shaft is to be connected with the hull by means of a vertical coupling flange having thickness at least equal to d/4, where d is the shaft diameter, obtained from the formula in [9.1.1] (see Fig 14).

The coupling flange is to be secured by means of six fitted bolts. The shank diameter of the bolts is to be not less than the coupling flange thickness defined above.

The distance from the bolt centre lines to the coupling flange edge is to be not less than 1,17 times the bolt diameter defined above.

9.2.2 Connection with the solepiece

The rudder shaft is to be connected with the solepiece by means of a cone coupling, having a taper on the radius equal to about 1/10 and housing length not less than 1,1 d, where d is obtained from the formula in [9.1.1] (See Fig 14).

The mean pressure exerted by the rudder shaft on the bearing is to be not greater than the relevant allowable bearing pressure, defined in Tab 5 assuming a rudder with two pintles.

10 Steering nozzles

10.1 General

10.1.1 *(1/7/2008)*

The requirements of this Article apply to scantling steering nozzles for which the power transmitted to the propeller, P, is less than the value P_0 obtained, in kW, from the following formula:

$$P_0 = \frac{16900}{d_M}$$

where:

d_M : inner diameter of the nozzle, in m.

Nozzles for which the power transmitted is greater than the value obtained from the above formula are considered on a case-by-case basis.

The following requirements may apply also to fixed nozzle scantlings.

10.1.2 Nozzles normally consist of a double skin cylindrical structure stiffened by ring webs and other longitudinal webs placed perpendicular to the nozzle.

At least two ring webs are to be fitted, one of which, of greater thickness, is to be placed in way of the axis of rotation of the nozzle.

For nozzles with an inner diameter d_M exceeding 3 m, the number of ring webs is to be suitably increased.

10.1.3 Care is to be taken in the manufacture of the nozzle to ensure the welded connection between plating and webs.

10.1.4 The internal part of the nozzle is to be adequately protected against corrosion.

10.2 Nozzle plating and internal diaphragms

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

$$t_F = (0{,}085\sqrt{Pd_M} + 9{,}65)\sqrt{k} \qquad \text{for} \quad P \le \frac{6100}{d_M}$$

$$t_F = (0{,}085\sqrt{Pd_M} + 11{,}65)\sqrt{k} \qquad \text{for} \quad P > \frac{6100}{d_M}$$

where:

P, d_M : defined in [10.1.1].

The thickness t_F is to be extended to a length, across the transverse section containing the propeller blade tips, equal to one third of the total nozzle length.

Outside this length, the thickness of the inner plating is to be not less than (t_F - 7) mm and, in any case, not less than 7 mm.

10.2.2 The thickness of the outer plating of the nozzle is to be not less than (t_F - 9) mm, where t_F is defined in [10.2.1] and, in any case, not less than 7 mm.

10.2.3 The thicknesses of ring webs and longitudinal webs are to be not less than (t_F - 7) mm, where t_F is defined in [10.2.1], and, in any case, not less than 7 mm.

However, the thickness of the ring web, in way of the headbox and pintle support structure, is to be not less than t_F.

The Society may consider reduced thicknesses where an approved stainless steel is used, in relation to its type.

10.3 Nozzle stock

10.3.1 The diameter of the nozzle stock is to be not less than the value obtained, in mm, from the following formula:

$$d_{NTF} = 64{,}2\,(M_T\,k_1)^{1/3}$$

where:

M_T : torque, to be taken as the greater of those obtained, in kN.m, from the following formulae:
- $M_{TAV} = 0{,}3\,S_{AV}\,a$
- $M_{TAD} = S_{AD}\,b$

S_{AV} : force, in kN, equal to:
$S_{AV} = 0{,}147\,V^2_{AV}\,A_N$

S_{AD} : force, in kN, equal to:
$S_{AD} = 0{,}196\,V^2_{AD}\,A_N$

A_N : area, in m², equal to:
$A_N = 1{,}35\,A_{1N} + A_{2N}$

A_{1N} : area, in m², equal to:
$A_{1N} = L_M\,d_M$

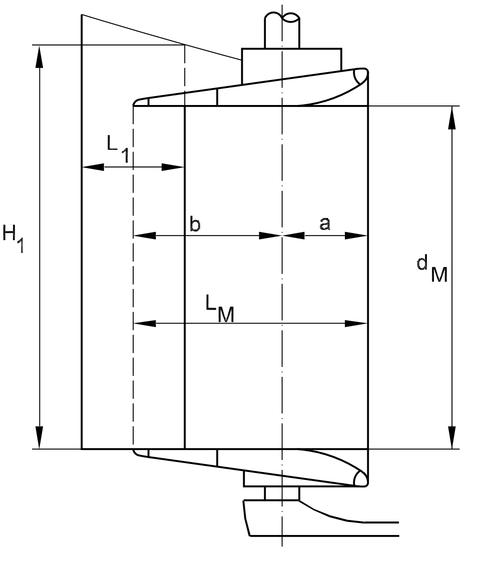
A_{2N} : area, in m², equal to:
$A_{2N} = L_1\,H_1$

a, b, L_M, d_M, L_1, H_1 : geometrical parameters of the nozzle, in m, defined in Fig 15.

The diameter of the nozzle stock may be gradually tapered above the upper stock bearing so as to reach, in way of the tiller or quadrant, the value obtained, in mm, from the following formula:

$$d_{NT} = 0{,}75\,d_{NTF}$$

Figure 15 : Geometrical parameters of the nozzle



10.4 Pintles

10.4.1 The diameter of the pintles is to be not less than the value obtained, in mm, from the following formula:

$$d_A = \left(\frac{11V_{AV}}{V_{AV} + 3}\sqrt{S_{AV}} + 30\right)\sqrt{k_1}$$

where:

S_{AV} : defined in [10.3.1].

10.4.2 The net pintle length h_A, in mm, is to be not less than 1,2 d_A, where d_A is defined in [10.4.1].

Smaller values of h_A may be accepted provided that the pressure on the gudgeon bearing p_F is in compliance with the following formula:

$p_F \le p_{F,ALL}$

where:

p_F : mean bearing pressure acting on the gudgeon, to be obtained in N/mm², from the following formula:

$$p_F = 10^3 \frac{0{,}6S'}{d'_A h'_A}$$

S' : the greater of the values S_{AV} and S_{AD}, in kN, defined in [10.3.1]

d'_A : actual pintle diameter, in mm

h'_A : actual bearing length of pintle, in mm

$p_{F,ALL}$: allowable bearing pressure, in N/mm², defined in Tab 5.

In any case, h_A is to be not less than d_A.

10.5 Nozzle coupling

10.5.1 Diameter of coupling bolts *(1/7/2016)*

The diameter of the coupling bolts is to be not less than the value obtained, in mm, from the following formula:

$$d_B = 0,62\sqrt{\frac{d_{NTF}^3 k_{1B}}{n_B e_M k_{1A}}}$$

where:

d_{NTF} : diameter of the nozzle stock, in mm, defined in [10.3.1]

k_{1A} : material factor k_1 for the steel used for the stock

k_{1B} : material factor k_1 for the steel used for the bolts

e_M : mean distance, in mm, from the bolt axes to the longitudinal axis through the coupling centre (i.e. the centre of the bolt system)

n_B : total number of bolts, which is to be not less than 6.

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of (0,25 d_{NT} x 0,10 d_{NT}) mm², where d_{NT} is defined in [10.3.1], and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B.

10.5.2 Thickness of coupling flange

The thickness of the coupling flange is to be not less than the value obtained, in mm, from the following formula:

$$t_P = 0{,}23 d_{NTF}\sqrt{\frac{k_{1F}}{k_{1B}}}$$

where:

d_{NTF} : diameter of the nozzle stock, in mm, defined in [10.3.1]

k_{1B}, : material factor k_1 for the steel used for the bolts

k_{1F} : material factor k_1 for the steel used for the coupling flange.

10.5.3 Push up length of cone couplings with hydraulic arrangements for assembling and disassembling the coupling *(1/7/2016)*

It is to be checked that the push up length Δ_E of the nozzle stock tapered part into the boss is in compliance with the following formula:

$\Delta_0 \le \Delta_E \le \Delta_1$

where:

Δ_0 : the greater of:

- $$6,2\frac{M_{TR}\eta\gamma}{c d_M t_S \mu_A \beta}$$
- $$16\frac{M_{TR}\eta\gamma}{c t_S^2 \beta}\sqrt{\frac{d_{NTF}^6 - d_{NT}^6}{d_{NT}^6}}$$

$$\Delta_1 = \frac{2\eta + 5}{1,8}\,\frac{\gamma d_0 R_{eH}}{10^6 c(1+\rho_1)}$$

$$\rho_1 = \frac{80\sqrt{d_{NTF}^6 - d_{NT}^6}}{R_{eH} d_M t_S^2\left[1 - \left(\frac{d_0}{d_{NTF}}\right)^2\right]}$$

d_{NTF} : nozzle stock diameter, in mm, to be obtained from the formula in [10.3.1], considering k_1=1

d_{NT} : nozzle stock diameter, in mm, to be obtained from the formula in [10.3.1], considering k_1=1

η : coefficient to be taken equal to:

η = 1 for keyed connections

η = 2 for keyless connections

c : taper of conical coupling measured on diameter, to be obtained from the following formula:

$c = (d_U - d_0) / t_S$

β : coefficient to be taken equal to: $\beta = 1 - (d_M - d_E)^2$

d_M : mean diameter, in mm, of the conical bore, to be obtained from the following formula:

$d_M = d_U - 0{,}5\, c\, t_S$

d_E : external boss diameter, in mm

μ_A : coefficient to be taken equal to: $\mu_A = (\mu^2 - 0{,}25\, c^2)^{1/2}$

μ, γ : coefficients to be taken equal to:

- for nozzle stock and bosses made of steel: μ = 0,15; γ = 1
- for nozzle stock made of steel and bosses made of SG iron: μ = 0,13; γ = 1,24 - 0,1 β

t_S, d_M, d_0: defined in Fig 6

R_{eH} : defined in [1.4.4]

10.5.4 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

11 Azimuth propulsion system

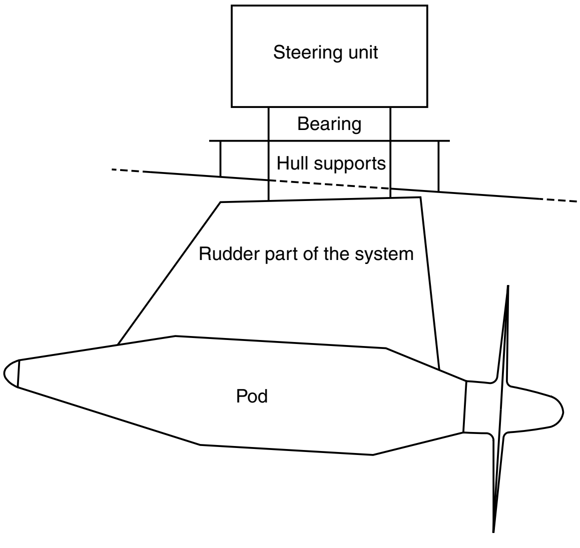
11.1 General

11.1.1 Arrangement

The azimuth propulsion system is constituted by the following sub-systems (see Fig 16):

- the steering unit
- the bearing
- the hull supports
- the rudder part of the system
- the pod, which contains the electric motor in the case of a podded propulsion system.

Figure 16 : Azimuth propulsion system



11.1.2 Application

The requirements of this Article apply to the scantlings of the hull supports, the rudder part and the pod.

The steering unit and the bearing are to comply with the requirements in Pt C, Ch 1, Sec 11 and Pt C, Ch 1, Sec 12, respectively.

11.1.3 Operating conditions

The maximum angle at which the azimuth propulsion system can be oriented on each side when the ship navigates at its maximum speed is to be specified by the Designer. Such maximum angle is generally to be less than 35° on each side.

In general, orientations greater than this maximum angle may be considered by the Society for azimuth propulsion systems during manoeuvres, provided that the orientation values together with the relevant speed values are submitted to the Society for approval.

11.2 Arrangement

11.2.1 Plans to be submitted

In addition to the plans showing the structural arrangement of the pod and the rudder part of the system, the plans showing the arrangement of the azimuth propulsion system supports are to be submitted to the Society for approval. The scantlings of the supports and the maximum loads which acts on the supports are to be specified in these drawings.

11.2.2 Locking device

The azimuth propulsion system is to be mechanically lockable in a fixed position, in order to avoid rotations of the system and propulsion in undesirable directions in the event of damage.

11.3 Design loads

11.3.1 The lateral pressure to be considered for scantling of plating and ordinary stiffeners of the azimuth propulsion system is to be determined for an orientation of the system equal to the maximum angle at which the azimuth propulsion system can be oriented on each side when the ship navigates at its maximum speed.

The total force which acts on the azimuth propulsion system is to be obtained by integrating the lateral pressure on the external surface of the system.

The calculations of lateral pressure and total force are to be submitted to the Society for information.

11.4 Plating

11.4.1 Plating of the rudder part of the azimuth propulsion system

The thickness of plating of the rudder part of the azimuth propulsion system is to be not less than that obtained, in mm, from the formulae in [7.3.1], in which the term C_R/A is to be replaced by the lateral pressure calculated according to [11.3].

11.4.2 Plating of the pod

The thickness of plating of the pod is to be not less than that obtained, in mm, from the formulae in Ch 7, Sec 1, where the lateral pressure is to be calculated according to [11.3].

11.4.3 Webs

The thickness of webs of the rudder part of the azimuth propulsion system is to be determined according to [7.3.4], where the lateral pressure is to be calculated according to [11.3].

11.5 Ordinary stiffeners

11.5.1 Ordinary stiffeners of the pod

The scantlings of ordinary stiffeners of the pod are to be not less than those obtained from the formulae in Ch 7, Sec 2, where the lateral pressure is to be calculated according to [11.3].

11.6 Primary supporting members

11.6.1 Analysis criteria

The scantlings of primary supporting members of the azimuth propulsion system are to be obtained through direct calculations, to be carried out according to the following requirements:

- the structural model is to include the pod, the rudder part of the azimuth propulsion system, the bearing and the hull supports
- the boundary conditions are to represent the connections of the azimuth propulsion system to the hull structures
- the loads to be applied are those defined in [11.6.2].

The direct calculation analyses (structural model, load and stress calculation, strength checks) carried out by the Designer are to be submitted to the Society for information.

11.6.2 Loads

The following loads are to be considered in the direct calculation of the primary supporting members of the azimuth propulsion system:

- gravity loads
- buoyancy
- maximum loads calculated for an orientation of the system equal to the maximum angle at which the azimuth propulsion system can be oriented on each side when the ship navigates at its maximum speed
- maximum loads calculated for the possible orientations of the system greater than the maximum angle at the relevant speed (see [11.1.3])
- maximum loads calculated for the crash stop of the ship obtained through inversion of the propeller rotation
- maximum loads calculated for the crash stop of the ship obtained through a 180° rotation of the pod.

11.6.3 Strength check *(1/1/2021)*

It is to be checked that the Von Mises equivalent stress σ_E in primary supporting members, calculated, in N/mm², for the load cases defined in [11.6.2], is in compliance with the following formula:

$$\sigma_E \leq \sigma_{ALL}$$

where:

σ_{ALL} : allowable stress, in N/mm², to be taken equal to the lesser of the following values:

- 0,275 R_m
- 0,55 R_{eH}

R_m : tensile strength, in N/mm², of the material, defined in Ch 4, Sec 1, [2]

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

11.7 Hull supports of the azimuth propulsion system

11.7.1 Analysis criteria

The scantlings of hull supports of the azimuth propulsion system are to be obtained through direct calculations, to be carried out in accordance with the requirements in [11.6.1].

11.7.2 Loads

The loads to be considered in the direct calculation of the hull supports of the azimuth propulsion system are those specified in [11.6.2].

11.7.3 Strength check

It is to be checked that the Von Mises equivalent stress σ_E in hull supports, in N/mm², calculated for the load cases defined in [11.6.2], is in compliance with the following formula:

$$\sigma_E \leq \sigma_{ALL}$$

where:

σ_{ALL} : allowable stress, in N/mm², equal to:

$$\sigma_{ALL} = 65/k$$

k : material factor, defined in Ch 4, Sec 1, [2.3].

Values of σ_E greater than σ_{ALL} may be accepted by the Society on a case-by-case basis, depending on the localisation of σ_E and on the type of direct calculation analysis.

SECTION 2 BULWARKS AND GUARD RAILS

1 General

1.1 Introduction

1.1.1 The requirements of this Section apply to the arrangement of bulwarks and guard rails provided at boundaries of the freeboard deck, superstructure decks and tops of the first tier of deckhouses located on the freeboard deck.

1.2 General

1.2.1 Efficient bulwarks or guard rails are to be fitted at the boundaries of all exposed parts of the freeboard deck and superstructure decks directly attached to the freeboard deck, as well as the first tier of deckhouses fitted on the freeboard deck and the superstructure ends.

1.2.2 The height of the bulwarks or guard rails is to be at least 1 m from the deck. However, where their height would interfere with the normal operation of the ship, a lesser height may be accepted, if adequate protection is provided.

1.2.3 Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

1.2.4 In type A and B-100 ships, open rails on the weather parts of the freeboard deck for at least half the length of the exposed parts are to be fitted.

Alternatively, freeing ports complying with Ch 9, Sec 9, [5] are to be fitted.

1.2.5 In ships with bulwarks and trunks of breadth not less than 0,6 B, which are included in the calculation of freeboard, open rails on the weather parts of the freeboard deck in way of the trunk for at least half the length of the exposed parts are to be fitted.

Alternatively, freeing ports complying with Ch 9, Sec 9, [4.3.1] are to be fitted.

1.2.6 In ships having superstructures which are open at either or both ends, adequate provision for freeing the space within such superstructures is to be provided.

1.2.7 The freeing port area in the lower part of the bulwarks is to be in compliance with the applicable requirements of Ch 9, Sec 9, [5].

2 Bulwarks

2.1 General

2.1.1 As a rule, plate bulwarks are to be stiffened at the upper edge by a suitable bar and supported either by stays or plate brackets spaced not more than 2,0 m apart.

Bulwarks are to be aligned with the beams located below or are to be connected to them by means of local transverse stiffeners.

As an alternative, the lower end of the stay may be supported by a longitudinal stiffener.

2.1.2 In type A, B-60 and B-100 ships, the spacing forward of 0,07 L from the fore end of brackets and stays is to be not greater than 1,2 m.

2.1.3 Where bulwarks are cut completely, the scantlings of stays or brackets are to be increased with respect to those given in [2.2].

2.1.4 As a rule, bulwarks are not to be connected either to the upper edge of the sheerstrake plate or to the stringer plate.

Failing this, the detail of the connection will be examined by the Society on a case-by-case basis.

2.2 Scantlings

2.2.1

The thickness of bulwarks on the freeboard deck not exceeding 1100 mm in height is to be not less than:

- 5,5 mm for $L \leq 30$ m,
- 6,0 mm for $30 < L \leq 120$ m,
- 6,5 mm for $120 < L \leq 150$ m,
- 7,0 mm for $L > 150$ m.

Where the height of the bulwark is equal to or greater than 1800 mm, its thickness is to be equal to that calculated for the side of a superstructure situated in the same location as the bulwark.

For bulwarks between 1100 mm and 1800 mm in height, their thickness is to be calculated by linear interpolation.

2.2.2 Bulwark plating and stays are to be adequately strengthened in way of eyeplates used for shrouds or other tackles in use for cargo gear operation, as well as in way of hawserholes or fairleads provided for mooring or towing.

2.2.3 At the ends of partial superstructures and for the distance over which their side plating is tapered into the bulwark, the latter is to have the same thickness as the side plating; where openings are cut in the bulwark at these positions, adequate compensation is to be provided either by increasing the thickness of the plating or by other suitable means.

2.2.4 *(1/7/2020)*

The section modulus of stays in way of the lower part of the bulwark is to be not less than the value obtained, in cm^3, from the following formula:

$$Z = 40\, s\, (1 + 0{,}01\, L)\, h_B^2$$

where:

L : Rule length of ship, in m, to be assumed not greater than 100 m,

s : spacing of stays, in m,

h_B : height of bulwark, in m, measured between its upper edge and the deck.

The actual section of the connection between stays and deck structures is to be taken into account when calculating the above section modulus.

To this end, the bulb or face plate of the stay may be taken into account only where welded to the deck; in this case the beam located below is to be connected by double continuous welding.

For stays with strengthening members not connected to the deck, the calculation of the required minimum section modulus is considered by the Society on a case-by-case basis.

At the ends of the ship, where the bulwark is connected to the sheerstrake, an attached plating having width not exceeding 600 mm may also be included in the calculation of the actual section modulus of stays.

2.2.5 Openings in bulwarks are to be arranged so that the protection of the crew is to be at least equivalent to that provided by the horizontal courses in [3.1.2].

For this purpose, vertical rails or bars spaced approximately 230 mm apart may be accepted in lieu of rails or bars arranged horizontally.

2.2.6 In the case of ships intended for the carriage of timber deck cargoes, the specific provisions of the freeboard regulations are to be complied with.

3 Guard rails

3.1

3.1.1 Where guard rails are provided, the upper edge of sheerstrake is to be kept as low as possible.

3.1.2 The opening below the lowest course is to be not more than 230 mm. The other courses are to be not more than 380 mm apart.

3.1.3 In the case of ships with rounded gunwales or sheerstrake, the stanchions are to be placed on the flat part of the deck.

3.1.4 Fixed, removable or hinged stanchions are to be fitted about 1,5 m apart. At least every third stanchion is to be supported by a bracket or stay.

Removable or hinged stanchions are to be capable of being locked in the upright position.

3.1.5 Wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths. Wires are to be made taut by means of turnbuckles.

3.1.6 Chains may only be accepted in short lengths in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

SECTION 3 PROPELLER SHAFT BRACKETS

Symbols

F_C : Force, in kN, taken equal to:

$F_C = (2\pi N / 60)^2 R_P P$

P : Mass of a propeller blade, in t

N : Number of revolutions per minute of the propeller

R_P : Distance, in m, of the centre of gravity of a blade in relation to the rotation axis of the propeller

σ_{ALL} : Allowable stress, in N/mm²:

$\sigma_{ALL} = 70 / k$

where:

k : Material factor, as defined in Ch 4, Sec 1, [2.3]

w_A : Section modulus, in cm³, of the arm at the level of the connection to the hull with respect to a transversal axis

w_B : Section modulus, in cm³, of the arm at the level of the connection to the hull with respect to a longitudinal axis

A : Sectional area, in cm², of the arm

A_S : Shear sectional area, in cm², of the arm

d_P : Propeller shaft diameter, in mm, measured inside the liner, if any.

1 Propeller shaft brackets

1.1 General

1.1.1 Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

1.1.2 *(1/1/2019)*

Shaft bracket arms may be either of solid or welded (built up) construction.

1.1.3 *(1/1/2019)*

Solid bracket arms shall be continuous through the shell plating and shall be given satisfactory support by the internal ship structure.

1.1.4 *(1/1/2021)*

Solid bracket arms shall have adequately rounded fore and aft connections to the propeller shaft boss.

1.1.5 *(1/1/2021)*

If welded (built up) bracket arms are built with a longitudinal centre plate, this plate shall be adequately rounded at fore and aft end in way of the connection with the propeller shaft boss so as to reduce stress concentrations. This requirement can be neglected, if the boss is already provided with adequately rounded protrusions where to weld bracket arm plates.

1.1.6 *(1/1/2019)*

If welded (built up) bracket arms are built with a longitudinal centre plate, this plate shall be continuous through the shell plating and shall be adequately rounded at fore and aft end at the transition to the hull so as to reduce stress concentrations.

1.1.7 *(1/1/2019)*

All bracket arms cross section should in general have an outer form that allows reducing the drag during the navigation: usually elliptical or hydrofoil shapes are used to this purpose.

1.2 Double arm propeller shaft brackets

1.2.1 General *(1/1/2019)*

This type of propeller shaft bracket consists of two arms arranged at right angles and converging in the propeller shaft bossing.

Exceptions to this will be considered by the Society on a case-by-case basis.

1.2.2 Scantlings of elliptical arms *(1/1/2019)*

The bending moment in the arm, in kN m, is to be obtained from the following formula:

$$M = \frac{F_C}{\sin\alpha}\left(\frac{L}{\ell}d_1\cos\beta + L - \ell\right)$$

where:

α : Angle between the two arms.

β : Angle defined in Fig 1

d_1 : Distance, in m, defined in Fig 1

ℓ, L : Lengths, in m, defined in Fig 2.

Figure 1 : Angle β and length d_1 *(1/1/2019)*

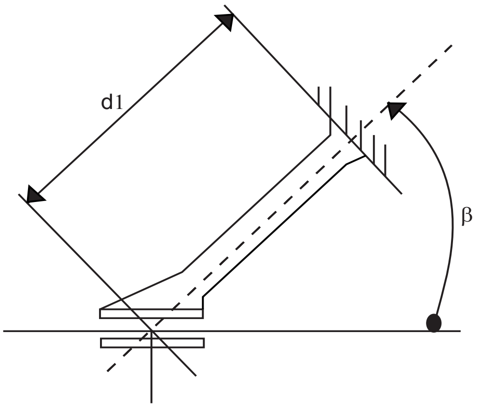
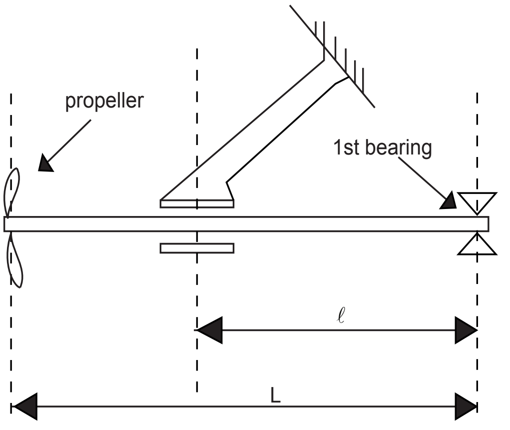


Figure 2 : Lengths L and ℓ *(1/1/2019)*



It is to be checked that the bending stress σ_F, the compressive stress σ_N and the shear stress τ are in compliance with the following formula:

$$(\sigma_F + \sigma_N) \le \sigma_{ALL}$$

$$\tau \le \frac{\sigma_{ALL}}{\sqrt{3}}$$

where:

$$\sigma_F = \frac{M}{w_A} 10^3$$

$$\sigma_N = 10 F_C \frac{L \sin\beta}{A \ell \sin\alpha}$$

$$\tau = 10 F_C \frac{L \cos\beta}{A_S \ell \sin\alpha}$$

1.2.3 Minimum inertia of arm section *(1/1/2021)*

Along the entire length of the arms, the inertia of their cross-sections about their major axis are to be not less than the value obtained, in cm^4, from the following formula:

$J = 0.5 \cdot (d_1 - 0.83 \cdot d_p / 1000) \cdot d_p^3 \cdot 10^{-4}$

where:

d_1 : defined in [1.2.2]

d_p : defined in Symbols.

1.2.4 Scantlings of propeller shaft bossing

The length of the propeller shaft bossing is to be not less than the length of the aft sterntube bearing bushes.

The thickness of the propeller shaft bossing is to be not less than 0,33 d_P.

1.2.5 Bracket arm attachments

In way of bracket arms attachments, the thickness of deep floors or girders is to be suitably increased. Moreover, the shell plating is to be increased in thickness and suitably stiffened.

1.3 Single arm propeller shaft bracket

1.3.1 General *(1/1/2019)*

This type of propeller shaft bracket consists of one arm and may be used only in very small ships.

1.3.2 *(1/1/2019)*

The bending moment in case of a single arm, in kN.m, is to be obtained from the following formula:

$M = d_2 F_C L / \ell$

where:

d_2 : Length of the arm, in m, measured between the propeller shaft axis and the hull

ℓ, L : Lengths, in m, defined in Fig 2.

It is to be checked that the bending stress σ_F and the shear stress τ are in compliance with the following formulae:

$$\sigma_F \le \sigma_{ALL}$$

$$\tau \le \frac{\sigma_{ALL}}{\sqrt{3}}$$

where:

$$\sigma_F = \frac{M}{w_B} 10^3$$

$$\tau = 10 F_C \frac{L}{A_S \ell}$$

1.3.3 Minimum inertia of arm section *(1/1/2021)*

Along the entire length of the arm, the inertia of the cross-section about its major axis is to be not less than the value obtained, in cm^4, from the following formula

$J = 0.5 \cdot (d_2 - 0.83 \cdot d_p / 1000) \cdot d_p^3 \cdot 10^{-4}$ where:

d_2 : defined in [1.3.2]

d_p : defined in Symbols.

1.3.4 Scantlings of propeller shaft bossing *(1/1/2019)*

The length of the propeller shaft bossing is to be not less than the length of the aft sterntube bearing bushes.

The thickness of the propeller shaft bossing is to be not less than 0,33 d_P.

1.3.5 Bracket arm attachment *(1/1/2019)*

In way of bracket arm attachments the thickness of deep floors or girders is to be suitably increased.

Moreover, the shell plating is to be increased in thickness and suitably stiffened.

1.4 Propeller shafts with double arm main brackets and intermediate bracket

1.4.1 Bracket configuration *(1/1/2019)*

In this type of design, propeller shafting outside the hull, is supported by two brackets, the main one connected to the propeller bossing and an intermediate one between the main one and the ship hull.

The main bracket is to be of double arm type, while the intermediate one may be of single arm type.

1.4.2 Scantlings of arms *(1/1/2019)*

The bending moments, normal and shear forces in the arms may be obtained from a direct calculation using beam elements, including the shaft brackets modelled with their actual stiffness.

The beam model shall include the shaft line from the propeller to the 2nd bearing inside the ship hull, including the stern tube bearing. See Fig 3.

The model is to be simply supported (i.e. translations normal to shaft direction are constrained while rotations are free) at the outermost bearing inside the stern tube (named 1st bearing in Fig 3) and clamped at the 2nd bearing inside the ship hull.

The bracket arms are to be clamped (i.e. translations and rotations in all directions are constrained) in way of the connection with the hull.

The number of load cases to be analysed is equal to the total number of arms present (summing up main and intermediate ones): in each load case the same unbalance force F_C as defined in Symbols should be applied in way of the propeller with a direction normal to the plane that contains both the shaft line and the considered bracket arm.

For example, if the intermediate bracket is of single arm type, three load cases are to be analyzed, applying in way of the propeller the same unbalance force F_C as defined in Symbols with a direction:

a) Normal to the plane that contains both the shaft line and the main bracket arm nearest to the centerline.

b) Normal to the plane that contains both the shaft line and the main bracket arm farthest to the centerline.

c) Normal to the plane that contains both the shaft line and the intermediate bracket arm.

For both the main and the intermediate brackets, along their entire length, it is to be checked that the bending stress σ_F, the compressive stress σ_N and the shear stress τ are in compliance with the following formulae:

$$(\sigma_F + \sigma_N) \le \sigma_{ALL}$$

$$\tau \le \frac{\sigma_{ALL}}{\sqrt{3}}$$

where:

σ_F is to be calculated using the beam flexural theory at least at the 4 calculation points A, B, C, D shown in Fig 4, while the compressive stress σ_N and the shear stress τ are calculated by dividing the normal and shear forces in the beam respectively by A and A_S defined in Symbols.

1.4.3 Minimum inertia of arms sections *(1/1/2021)*

Along the entire length of the arms, the inertia of their cross-sections about their major axis are to be not less than the value obtained from [1.2.3] for the double arm main brackets and [1.3.3] for the intermediate bracket.

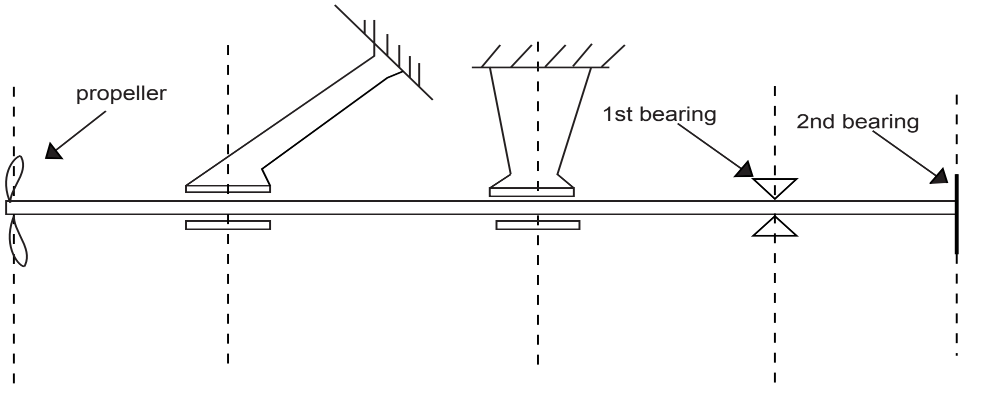
1.4.4 Scantlings of propeller shaft bossing *(1/1/2021)*

The requirements in [1.2.4] apply to the double arm main brackets shaft bossing and the requirements in [1.3.4] apply for the intermediate bracket shaft bossing.

1.4.5 Bracket arms attachments *(1/1/2019)*

In way of all bracket arms attachments, the thickness of deep floors or girders is to be suitably increased. Moreover, the shell plating is to be increased in thickness and suitably stiffened.

Figure 3 *(1/1/2019)*



1.5 Bossed propeller shaft brackets

1.5.1 General

Bossed propeller shaft brackets consist of a U-shaped cast steel arm connected to the hull by means of a substantial palm and ending in a boss for propeller shaft support.

1.5.2 Minimum modulus of arm section *(1/1/2019)*

The section modulus at the root of the arm calculated about the horizontal neutral axis of the root section is to be not less than the value obtained, in cm³, from the following formula:

$$Z = 75 \ell_B d_P^2 10^{-7}$$

where:

ℓ_B : length of the longer arm, in mm, measured from the section at the root of the palm to that at the root of the boss,

d_P : propeller shaft diameter, in mm, measured inside the liner, if any.

1.5.3 Scantling of the boss

The length of the boss, in mm, is to be greater than 2,3 d_P, where d_P is defined in [1.2.2]. In any case, it is to be less than 3 d_P.

The thickness of the boss, in mm, is to be not less than 0,33 d_P.

The aft end of the bossing is to be adequately supported.

1.5.4 Scantling of the end supports

The scantlings of end supports are to be specially considered. Supports are to be adequately designed to transmit the loads to the main structure.

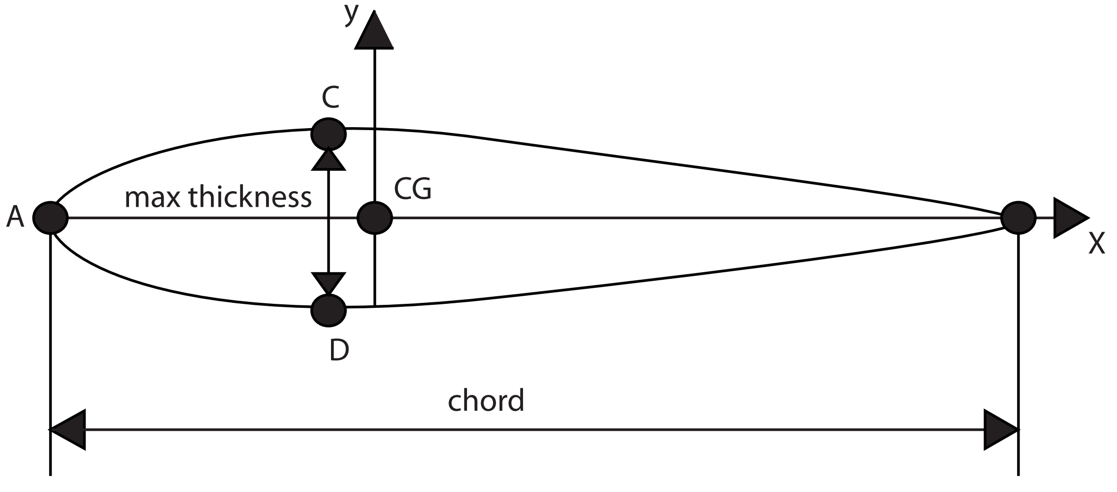
End supports are to be connected to at least two deep floors of increased thickness or connected to each other within the ship.

1.5.5 Stiffening of the boss plating

Stiffening of the boss plating is to be specially considered. At the aft end, transverse diaphragms are to be fitted at every frame and connected to floors of increased scantlings.

At the fore end, web frames spaced not more than four frames apart are to be fitted.

Figure 4 : Cross section of an arm with center of gravity of area (CG) and stress calculation points (A - B - C - D) indicated *(1/1/2019)*



SECTION 4 EQUIPMENT

Symbols

EN : Equipment Number defined in [2.1],

σ_{ALL} : allowable stress, in N/mm^2, used for the yielding check in [4.9.7], [4.10.7], [4.11.2] and [4.11.3], to be taken as the lesser of:

- σ_{ALL} = 0,67 R_{eH}
- σ_{ALL} = 0,40 R_m

R_{eH} : minimum yield stress, in N/mm^2, of the material, defined in Ch 4, Sec 1, [2]

R_m : tensile strength, in N/mm^2, of the material, defined in Ch 4, Sec 1, [2].

1 General

1.1 General

1.1.1 The requirements in [2] to [4] apply to temporary mooring of a ship within or near harbour, or in a sheltered area, when the ship is awaiting a berth, the tide, etc.

Therefore, the equipment complying with the requirements in [2] to [4] is not intended for holding a ship off fully exposed coasts in rough weather or for stopping a ship which is moving or drifting.

1.1.2 The equipment complying with the requirements in [2] to [4] is intended for holding a ship in good holding ground, where the conditions are such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors is to be significantly reduced.

1.1.3 It is assumed that under normal circumstances a ship will use one anchor only.

1.2 Definitions

1.2.1 Nominal capacity condition *(1/1/2022)*

Nominal capacity condition is the theoretical condition where the maximum possible deck cargoes are included in the ship arrangement in their respective positions. For container ships the nominal capacity condition represents the theoretical condition where the maximum possible number of containers is included in the ship arrangement in their respective positions.

1.2.2 Ship Design Minimum Breaking Load (MBL_{SD}) *(1/1/2022)*

Ship Design Minimum Breaking Load is the minimum breaking load of new, dry mooring lines or tow line for which shipboard fittings and supporting hull structures are designed in order to meet mooring restraint requirements or the towing requirements of other towing service.

1.2.3 Line Design Break Force (LDBF) *(1/1/2022)*

Line Design Break Force is the minimum force that a new, dry, spliced, mooring line will break at. This is for all synthetic cordage materials.

2 Equipment number

2.1 Equipment number

2.1.1 General *(1/7/2014)*

All ships are to be provided with equipment in anchors and chain cables (or ropes according to [3.3.5]), to be obtained from Tab 1, based on their Equipment Number EN.

In general, stockless anchors are to be adopted.

For ships with EN greater than 16000, the determination of the equipment will be considered by the Society on a case by case basis.

For ships having the navigation notation **coastal area** or **sheltered area**, the equipment in anchors and chain cables may be reduced. The reduction consists of entering Tab 1 one line higher for ships having the navigation notation **coastal area** and two lines higher for ships having the navigation notation **sheltered area**, based on their Equipment Number EN.

For ships of special design or ships engaged in special services or on special voyages, the Society may consider equipment other than that in Tab 1.

2.1.2 Equipment Number for ships with perpendicular superstructure front bulkhead *(1/1/2022)*

The Equipment Number EN is to be obtained from the following formula:

$$EN = \Delta^{2/3} + 2(h\,B + S_{fun}) + 0{,}1\,A$$

where:

Δ : moulded displacement of the ship, in t, to the summer load waterline,

h : effective height, in m, from the summer load waterline to the top of the uppermost house, to be obtained in accordance with the following formula:

$$h = a + \Sigma h_n$$

When calculating h, sheer and trim are to be ignored (i.e. h is the sum of freeboard amidships plus the height (at centreline) of each tier of houses having a breadth greater than B/4),

a : vertical distance at side hull, in m, from the summer load waterline amidships to the upper deck,

h_n : height, in m, at the centreline of tier “n” of superstructures or deckhouses having a breadth greater than B/4. Where a house having a breadth greater than B/4 is above a house with a breadth of B/4 or less, the upper house is to be included and the lower ignored.

For the lowest tier h_1 is to be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck, (see Fig 1 for an example),

S_{fun} : effective front projected area of the funnel, in m², defined as:

$S_{fun} = A_{FS} - S_{shield}$

A_{FS} : front projected area of the funnel, in m², calculated between the upper deck at centreline, or notional deck line where there is local discontinuity in the upper deck, and the effective height h_F.

A_{FS} is taken equal to zero if the funnel breadth is less than or equal to B/4 at all elevations along the funnel height.

h_F : effective height of the funnel, in m, measured from the upper deck at centreline, or notional deck line where there is local discontinuity in the upper deck, and the top of the funnel.

The top of the funnel may be taken at the level where the funnel breadth reaches B/4.

S_{shield} : is the section of front projected area AFS, in m², which is shielded by all deck houses having breadth greater than B/4. If there are more than one shielded section, the individual shielded sections i.e $S_{shield1}$, $S_{shield\ 2}$ etc as shown in Fig 2 to be added together. To determine S_{shield}, the deckhouse breadth is assumed B for all deck houses having breadth greater than B/4 as shown for $S_{shield1}$, $S_{shield\ 2}$ in.

A : side projected area, in m², of the hull, superstructures, houses and funnels above the summer load waterline which are within the length L_E and also have a breadth greater than B/4 (see Note 1).

The side projected area of the funnel is considered in A when A_{FS} is greater than zero. In this case, the side projected area of the funnel should be calculated between the upper deck, or notional deck line where there is local discontinuity in the upper deck, and the effective height h_F,

L_E : equipment length, in m, equal to L without being taken neither less than 96% nor greater than 97% of the extreme length on the summer load waterline (measured from the forward end of the waterline).

Fixed screens or bulwarks 1,5 m or more in height are to be regarded as parts of houses when determining h and A. In particular, the hatched area shown in Fig 7 is to be included.

The height of hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A.

When several funnels are fitted on the ship, the above parameters are taken as follows:

h_F : effective height of the funnel, in m, measured from the upper deck, or notional deck line where there is local discontinuity in the upper deck, and the top of the highest funnel. The top of the highest funnel may be taken at the level where the sum of each funnel breadth reaches B/4.

A_{FS} : sum of the front projected area of each funnel, in m², calculated between the upper deck, or notional deck line where there is local discontinuity in the upper deck, and the effective height h_F.

A_{FS} is to be taken equal to zero if the sum of each funnel breadth is less than or equal to B/4 at all elevations along the funnels height.

A : side projected area, in m^2, of the hull, superstructures, houses and funnels above the summer load waterline which are within the equipment length of the ship. The total side projected area of the funnels is to be considered in the side projected area of the ship, A, when A_{FS} is greater than zero. The shielding effect of funnels in transverse direction may be considered in the total side projected area, i.e., when the side projected areas of two or more funnels fully or partially overlap, the overlapped area needs only to be counted once.

Note 1: For selection of mooring and towing lines (see [3.5]), deck cargoes as given by the loading manual is to be taken into account for the determination of side-projected area A when calculating the equipment number EN.

Figure 1 : Effective height in case of local discontinuity in the upper deck *(1/1/2022)*

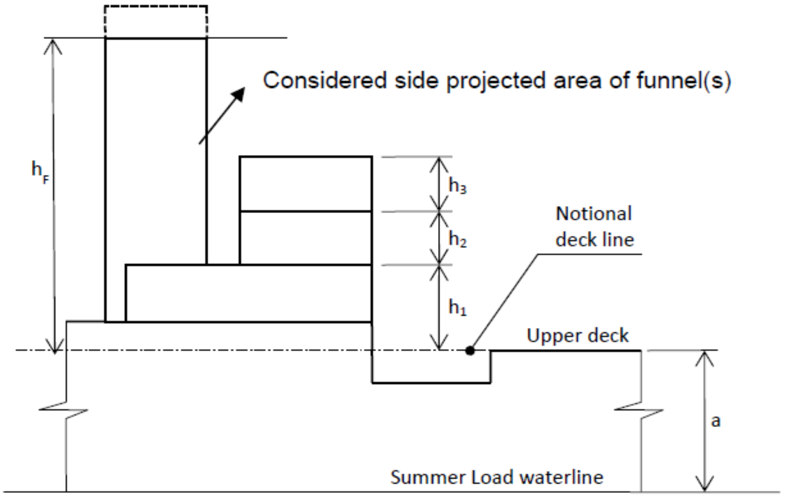


Figure 2 : *(1/1/2022)*

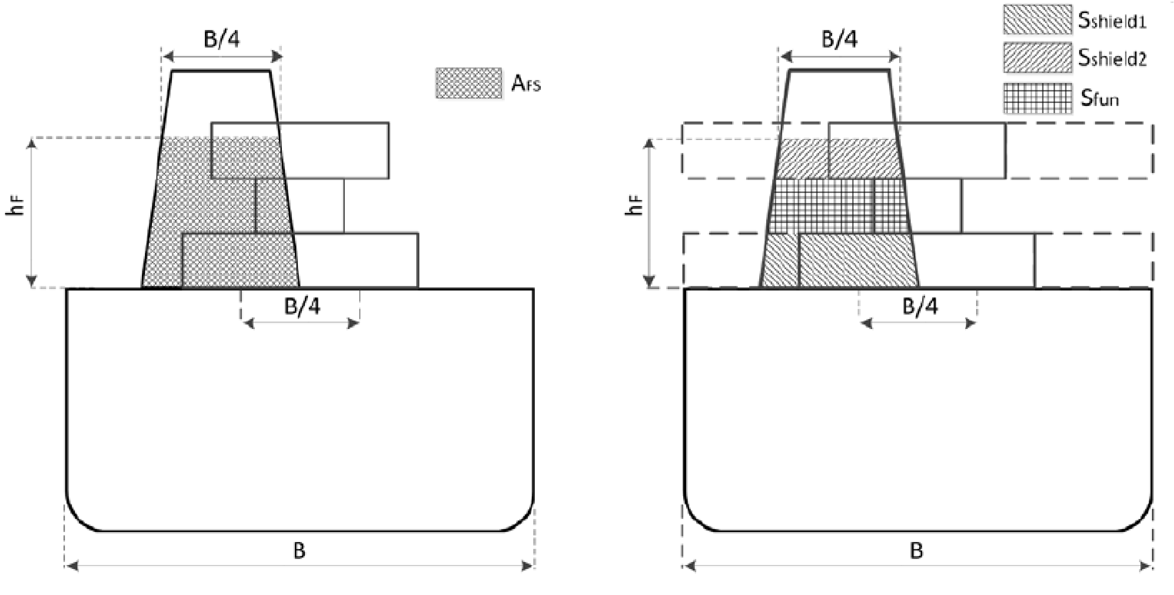


Table 1 : Equipment *(1/7/2018)*

Equipment number EN A < EN ≤ B		Stockless anchors		Stud link chain cables for anchors			
		N	Mass per anchor, in kg	Total length, in m	Diameter, in mm		
A	B				Q1	Q2	Q3
50	70	2	180	220,0	14,0	12,5	
70	90	2	240	220,0	16,0	14,0	
90	110	2	300	247,5	17,5	16,0	
110	130	2	360	247,5	19,0	17,5	
130	150	2	420	275,0	20,5	17,5	
150	175	2	480	275,0	22,0	19,0	
175	205	2	570	302,5	24,0	20,5	
205	240	2	660	302,5	26,0	22,0	20,5
240	280	2	780	330,0	28,0	24,0	22,0
280	320	2	900	357,5	30,0	26,0	24,0
320	360	2	1020	357,5	32,0	28,0	24,0

Equipment number EN A < EN ≤ B		Stockless anchors		Stud link chain cables for anchors			
		N	Mass per anchor, in kg	Total length, in m	Diameter, in mm		
A	B				Q1	Q2	Q3
360	400	2	1140	385,0	34,0	30,0	26,0
400	450	2	1290	385,0	36,0	32,0	28,0
450	500	2	1440	412,5	38,0	34,0	30,0
500	550	2	1590	412,5	40,0	34,0	30,0
550	600	2	1740	440,0	42,0	36,0	32,0
600	660	2	1920	440,0	44,0	38,0	34,0
660	720	2	2100	440,0	46,0	40,0	36,0
720	780	2	2280	467,5	48,0	42,0	36,0
780	840	2	2460	467,5	50,0	44,0	38,0
840	910	2	2640	467,5	52,0	46,0	40,0
910	980	2	2850	495,0	54,0	48,0	42,0
980	1060	2	3060	495,0	56,0	50,0	44,0
1060	1140	2	3300	495,0	58,0	50,0	46,0
1140	1220	2	3540	522,5	60,0	52,0	46,0
1220	1300	2	3780	522,5	62,0	54,0	48,0
1300	1390	2	4050	522,5	64,0	56,0	50,0
1390	1480	2	4320	550,0	66,0	58,0	50,0
1480	1570	2	4590	550,0	68,0	60,0	52,0
1570	1670	2	4890	550,0	70,0	62,0	54,0
1670	1790	2	5250	577,5	73,0	64,0	56,0
1790	1930	2	5610	577,5	76,0	66,0	58,0
1930	2080	2	6000	577,5	78,0	68,0	60,0
2080	2230	2	6450	605,0	81,0	70,0	62,0
2230	2380	2	6900	605,0	84,0	73,0	64,0
2380	2530	2	7350	605,0	87,0	76,0	66,0
2530	2700	2	7800	632,5	90,0	78,0	68,0
2700	2870	2	8300	632,5	92,0	81,0	70,0
2870	3040	2	8700	632,5	95,0	84,0	73,0
3040	3210	2	9300	660,0	97,0	84,0	76,0
3210	3400	2	9900	660,0	100,0	87,0	78,0
3400	3600	2	10500	660,0	102,0	90,0	78,0
3600	3800	2	11100	687,5	105,0	92,0	81,0
3800	4000	2	11700	687,5	107,0	95,0	84,0
4000	4200	2	12300	687,5	111,0	97,0	87,0
4200	4400	2	12900	715,0	114,0	100,0	87,0
4400	4600	2	13500	715,0	117,0	102,0	90,0
4600	4800	2	14100	715,0	120,0	105,0	92,0
4800	5000	2	14700	742,5	122,0	107,0	95,0
5000	5200	2	15400	742,5	124,0	111,0	97,0
5200	5500	2	16100	742,5	127,0	111,0	97,0
5500	5800	2	16900	742,5	130,0	114,0	100,0
5800	6100	2	17800	742,5	132,0	117,0	102,0
6100	6500	2	18800	742,5		120,0	107,0
6500	6900	2	20000	770,0		124,0	111,0
6900	7400	2	21500	770,0		127,0	114,0
7400	7900	2	23000	770,0		132,0	117,0
7900	8400	2	24500	770,0		137,0	122,0
8400	8900	2	26000	770,0		142,0	127,0
8900	9400	2	27500	770,0		147,0	132,0
9400	10000	2	29000	770,0		152,0	132,0

Equipment number EN A < EN ≤ B		Stockless anchors		Stud link chain cables for anchors			
		N	Mass per anchor, in kg	Total length, in m	Diameter, in mm		
A	B				Q1	Q2	Q3
10000	10700	2	31000	770,0			137,0
10700	11500	2	33000	770,0			142,0
11500	12400	2	35500	770,0			147,0
12400	13400	2	38500	770,0			152,0
13400	14600	2	42000	770,0			157,0
14600	16000	2	46000	770,0			162,0

2.1.3 Equipment Number for ships with inclined superstructure front bulkhead *(1/1/2022)*

For ships with navigation notation other than unrestricted navigation and having superstructures with the front bulkhead with an angle of inclination aft, the Equipment Number EN is to be obtained from the following formula:

$EN = \Delta^{2/3} + 2\,(a\,B + \Sigma b_N\, h_N \sin\theta_N + S_{fun}) + 0{,}1\,A$

where:

Δ, a, h_N, A and S_{fun}:as defined in [2.1.2],

θ_N : angle of inclination aft of each front bulkhead, shown in Fig 8,

b_N : greatest breadth, in m, of each tier n of superstructures or deckhouses having a breadth greater than B/4.

Fixed screens or bulwarks 1,5 m or more in height are to be regarded as parts of houses when determining h and A. In particular, the hatched area shown in Fig 8 is to be included.

3 Equipment

3.1 Shipboard fittings and supporting hull structures

3.1.1 Application *(1/7/2018)*

Ships are to be provided with arrangements, equipment and fittings of sufficient safe working load to enable the safe conduct of all towing and mooring operations associated with the normal operations of the ship.

The requirements of [3.1] apply to ships of 500 gross tonnage and upwards; in particular they apply to bollards, bitts, fairleads, stand rollers, chocks used for normal mooring of the ship and similar components used for normal towing of the ship. For emergency towing arrangements, the requirements in [4] are to be applied. Normal towing means towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operations of the ship.

For ships, not subject to Regulation 3-4 of Chapter II-1 of SOLAS Convention, but intended to be fitted with equipment for towing by another ship or a tug, the requirements designated as 'other towing' are to be applied to design and construction of those shipboard fittings and supporting hull structures.

Requirements of [3.1] is not applicable to design and construction of shipboard fittings and supporting hull structures used for special towing services defined as:

- Escort towing: Towing service, in particular for laden oil tankers or LNG carriers, required in specific estuaries. Its main purpose is to control the ship in case of failures of the propulsion or steering system. It should be referred to local escort requirements and guidance given by, e.g., the Oil Companies International Marine Forum (OCIMF); for the requirements of shipboard fittings and supporting hull structures of ships with service notation **escort tug** , see Pt E, Ch 14, [2] and [4].
- Canal transit towing: Towing service for ships transiting canals, e.g. the Panama Canal. It should be referred to local canal transit requirements.
- Emergency towing for tankers: Towing services to assist tankers in case of emergency. For emergency towing arrangements of ships which are to comply with Regulation 3-4 of Chapter II-1 of SOLAS Convention, the requirements in [4] are to be applied.

The supporting hull structures are constituted by that part of the ship's structure on/in which the shipboard fitting is placed and which is directly submitted to the forces exerted on the shipboard fitting. The supporting hull structures of capstans, winches, etc used for normal or other towing and mooring operations are also covered by [3.1].

Other components such as capstans, winches, etc are not covered by this item. Any weld or bolt or equivalent device connecting the shipboard fitting to the supporting structure is part of the shipboard fitting and if selected from an industry standards subject to that standard applicable to this shipboard fitting.

3.1.2 Net scantlings *(1/1/2007)*

The net minimum scantlings of the supporting hull structure are to comply with the requirements in [3.1.9] and [3.1.15]. The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the above required minimum net scantlings. The required gross thicknesses are obtained by adding the total corrosion additions, t_c, given in [3.1.3], to t_{net}.

3.1.3 Corrosion addition *(1/1/2022)*

The total corrosion addition, t_c, in mm, is not to be less than the following values:

a) Ships covered by Common Structural Rules for Bulk Carriers and Oil Tankers:

t_c:, total corrosion addition to be as defined in these rules.

b) Other ships:
   - For the supporting hull structure, according to Ch 4, Sec 2 for the surrounding structure (e.g. deck structures, bulwark structures)
   - For pedestals and foundations on deck which are not part of a fitting according to an accepted industry standard, 2.0 mm
   - For shipboard fittings not selected from an accepted industry standard, 2.0 mm.

3.1.4 Wear allowance *(1/7/2018)*

In addition to the corrosion addition given in [3.1.3] the wear allowance, tw, for shipboard fittings not selected from an accepted industry standard is not to be less than 1.0 mm, added to surfaces which are intended to regularly contact the line.

3.1.5 Towing shipboard fittings selection *(1/1/2022)*

Towing shipboard fittings may be selected from an industry standard accepted by the Society and at least based on the following loads:

a) for normal towing operations, the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan,

b) for other towing service, the Ship Design Minimum Breaking Load of the towline according to Tab 3 for the ship's corresponding EN (see Notes in [3.1.8]),

c) for fittings intended to be used for both, normal and other towing operations, the greater of the loads according to (a) and (b).

Towing bitts (double bollards) may be chosen for the towing line attached with eye splice if the industry standard distinguishes between different methods to attach the line, i.e. figure-of-eight or eye splice attachment.

When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the ship is to be in accordance with [3.1.8] and [3.1.9]. Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice. For strength assessment beam theory or finite element analysis using net scantlings is to be applied, as appropriate. Corrosion additions are to be as defined in [3.1.3]. A wear down allowance is to be included as defined in [3.1.4].

3.1.6 Towing shipboard fittings location *(1/7/2018)*

Shipboard fittings for towing are to be located on stiffeners and/or girders which are part of the deck construction so as to facilitate efficient distribution of the towing loads. Other equivalent arrangements (e.g. chocks in bulwarks) may be accepted provided the strength is confirmed adequate for the intended service.

3.1.7 Arrangement of supporting hull structures for towing fittings *(1/7/2018)*

The arrangement of the reinforced members beneath towing shipboard fittings is to be such as to withstand any variation of direction (laterally and vertically) of the towing forces upon the shipboard fittings (see Fig 3). Proper alignment of fitting and supporting hull structure is to be ensured.

Figure 3 : Sample arrangement of supporting hull structure *(1/7/2018)*

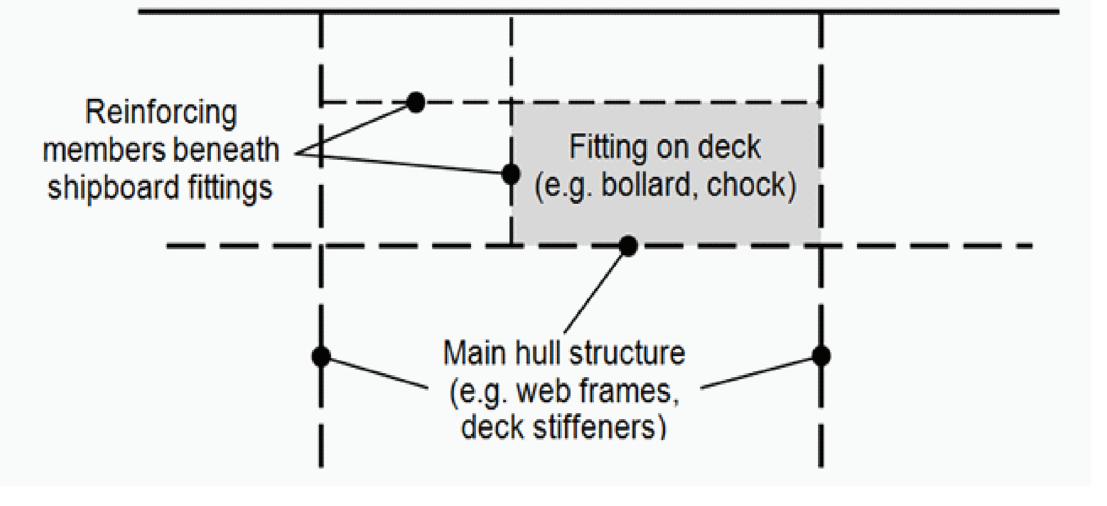
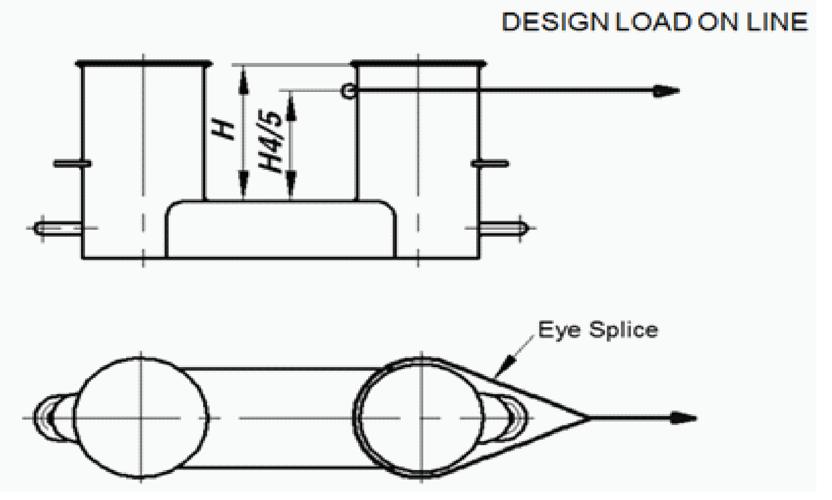


Figure 4 : Attachment point of the towing line *(1/7/2018)*



3.1.8 Towing load model *(1/1/2022)*

The minimum design load applied to supporting hull structures for shipboard fittings is to be:

a) for normal towing operations, 1,25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangement plan.

b) for other towing service, the Ship Design Minimum Breaking Load according to Tab 3 for the ship's corresponding EN (see Note 1 and see Note 2).

c) for fittings intended to be used for both, normal and other towing operations, the greater of the design loads according to a) and b).

This force is to be considered as acting on the shipboard fittings at the attachment point of the towing line or mooring line or at a change in its direction, as applicable. For bollards and bitts the attachment point of the towing line is to be taken not less than 4/5 of the tube height above the base, as shown in Fig 4.

The design load is to be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line (see Fig 5). However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

When a safe towing load TOW greater than that determined according to [3.1.10] is requested by the applicant, then the design load is to be in-creased in accordance with the appropriate TOW/design load relationship given by [3.1.8] and [3.1.10].

Note 1: Side projected area including that of deck cargoes as given by the ship nominal capacity condition is to be taken into account for selection of towing lines and the loads applied to shipboards fittings and supporting hull structures. The nominal capacity condition is defined in [1.2]

Note 2: The increase of the Line Design Break Force for synthetic ropes according to [3.5.7] needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structures.

3.1.9 Allowable stresses for towing fittings *(1/1/2022)*

The allowable stresses for towing fittings are given as follows:

a) For strength assessment of supporting hull structures for towing fittings by means of beam theory or grillage analysis:

- Normal stress: 1,0 R_{eH}
- Shear stress: 0,6 R_{eH}

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors being taken into account.

b) For strength assessment by means of finite element analysis:

- Von Mises stress: 1,0 R_{eH}

For strength assessment by means of finite element analysis the mesh is to be fine enough to represent the geometry as realistically as possible. The aspect ratios of elements are not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges may be modelled by beam or truss elements. The element height of girder webs must not exceed one-third of the web height. In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners may be modelled by using shell, plane stress, or beam elements. The mesh size of stiffeners is to be fine enough to obtain proper bending stress. If flat bars are modeled using shell or plane stress elements, dummy rod elements are to be modelled at the free edge of the flat bars and the stresses of the dummy elements are to be evaluated. Stresses are to be read from the centre of the individual element. For shell elements the stresses are to be evaluated at the mid plane of the element.

R_{eH} is the specified minimum yield stress of the material.

3.1.10 Safe Towing Load (TOW) *(1/1/2022)*

The safe towing load (TOW) is the safe load limit of shipboard fittings used for towing purpose, to be taken as follows:

a) TOW used for normal towing operations is not to exceed 80% of the design load as per [3.1.8] a)

b) TOW used for other towing operations is not to exceed 80% of the design load as per [3.1.8] b)

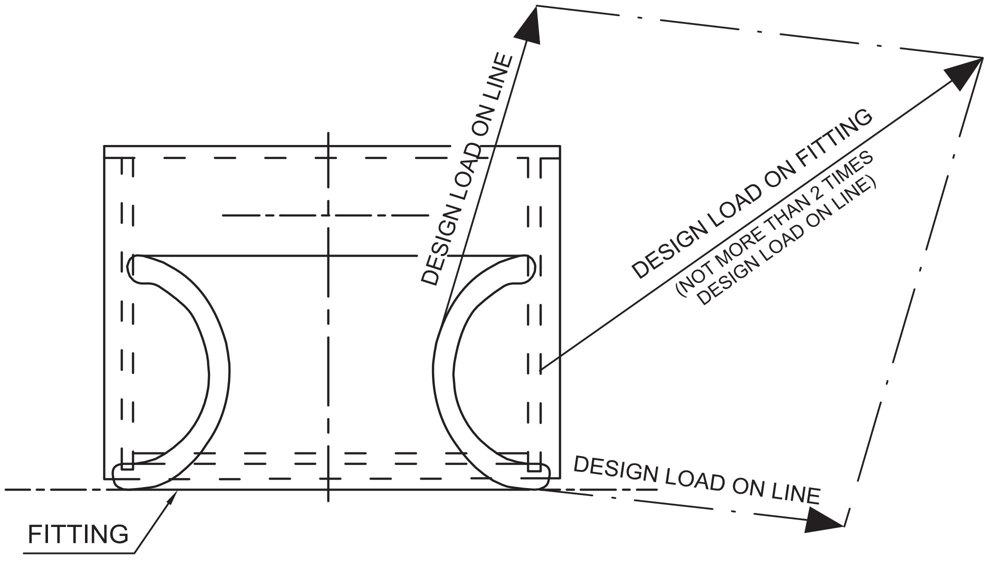
c) For fittings used for both normal and other towing operations, the greater of the safe towing loads according to a) and b) is to be used

d) TOW, in t, of each shipboard fitting is to be marked (by weld bead or equivalent) on the deck fittings used for towing. For fittings intended to be used for both, towing and mooring, SWL, in t, according to [3.1.16] is to be marked in addition to TOW.

The above requirements on TOW apply for the use with no more than one line. If not otherwise chosen, for towing bitts (double bollards) TOW is the load limit for a towing line attached with eye-splice.

The towing and mooring arrangements plan mentioned in [3.1.17] is to define the method of use of towing lines.

Figure 5 *(1/1/2007)*



3.1.11 Mooring shipboard fittings selection *(1/1/2022)*

The mooring shipboard fittings may be selected from an industry standard accepted by the Society and at least based on the Ship Design Minimum Breaking Load according to Tab 3 for the ship's corresponding EN (see Notes in [3.1.14]). When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the ship is to be in accordance with [3.1.14] and [3.1.15]. Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion (see Note 1). For strength assessment beam theory or finite element analysis using net scantlings is to be applied, as appropriate. Corrosion additions are to be as defined in [3.1.3]. A wear down allowance is to be included as defined in [3.1.4].

Note 1: With the line attached to a mooring bitt in the usual way (figure-of-eight fashion), either of the two posts of the mooring bitt can be subjected to a force twice as large as that acting on the mooring line. Disregarding this effect, depending on the applied industry standard and fitting size, overload may occur.

3.1.12 Mooring shipboard fittings location *(1/7/2018)*

Shipboard fittings, winches and capstans for mooring are to be located on stiffeners and/or girders which are part of the deck construction so as to facilitate efficient distribution of the mooring load. Other arrangements may be accepted (for chocks in bulwarks, etc) provided the strength is confirmed adequate for the service.

3.1.13 Arrangement of supporting hull structures for mooring fittings *(1/7/2018)*

The arrangement of the reinforced members beneath mooring shipboard fittings, winches and capstans is to be such as to withstand any variation of direction (laterally and vertically) of the mooring forces acting upon the shipboard fittings (see Fig 3). Proper alignment of fitting and sup-porting hull structure is to be ensured.

3.1.14 Mooring load model *(1/1/2022)*

a) The minimum design load applied to supporting hull structures for shipboard fittings is to be 1,15 times the Ship Design Minimum Breaking Load according to Tab 4 and App 2 for the ship's corresponding EN (see Notes 1 and 2).

b) The minimum design load applied to supporting hull structures for winches is to be 1,25 times the intended maximum brake holding load, where the maximum brake holding load is to be assumed not less than 80% of the Ship Design Minimum Breaking Load according to Tab 4 and App 2 (see Note 1 and 2). For supporting hull structures of capstans, 1.25 times the maximum hauling-in force is to be taken as the minimum design load.

c) This force is to be considered as acting on the shipboard fittings at the attachment point of the mooring line or at a change in its direction, as applicable. For bollards and bitts the attachment point of the mooring line is to be taken not less than 4/5 of the tube height above the base. However, if fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins (see Fig 6).

d) The design load is to be applied to mooring fittings in all directions that may to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the mooring line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line (see Fig 5). However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

e) The method of application of the design load to the fittings and supporting hull structures is to be taken into account such that the total load need not be more than twice the design load specified above, i.e. no more than one turn of one line.

f) When a safe working load SWL greater than that determined according to [3.1.16] is requested by the applicant, then the design load is to be increased in accordance with the appropriate SWL/design load relationship given by [3.1.14] and [3.1.16].

Note 1: Side projected area including that of deck cargoes as given by the ship nominal capacity condition is to be taken into account for selection of mooring lines and the loads applied to shipboards fittings and supporting hull structures. The nominal capacity condition is defined in [1.2].

Note 2: The increase of the Line Design Break Force for synthetic ropes according to [3.5.7] needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structure.

3.1.15 Allowable stresses for mooring fittings *(1/1/2022)*

The allowable stresses for towing fittings are given as follows:

a) for strength assessment of supporting hull structures for mooring fittings by means of beam theory or grillage analysis:

- Normal stress: 1,0 R_{eH}
- Shear stress: 0,6 R_{eH}

Normal stress is the sum of bending stress and axial stress. No stress concentration factors being taken into account;

b) for strength assessment by means of finite element analysis:

- Von Mises stress: 1,0 R_{eH}

For strength assessment by means of finite element analysis the mesh is to be fine enough to represent the geometry as realistically as possible. The aspect ratios of elements are not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges may be modelled by beam or truss elements. The element height of girder webs must not exceed one-third of the web height. In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners may be modelled by using shell, plane stress, or beam elements. The mesh size of stiffeners is to be fine enough to obtain proper bending stress. If flat bars are modeled using shell or plane stress elements, dummy rod elements are to be modelled at the free edge of the flat bars and the stresses of the dummy elements are to be evaluated. Stresses are to be read from the centre of the individual element. For shell elements the stresses are to be evaluated at the mid plane of the element.

R_{eH} is the specified minimum yield stress of the material.

3.1.16 Safe Working Load (SWL) *(1/1/2022)*

The Safe Working Load (SWL) is the safe load limit of shipboard fittings used for mooring purpose

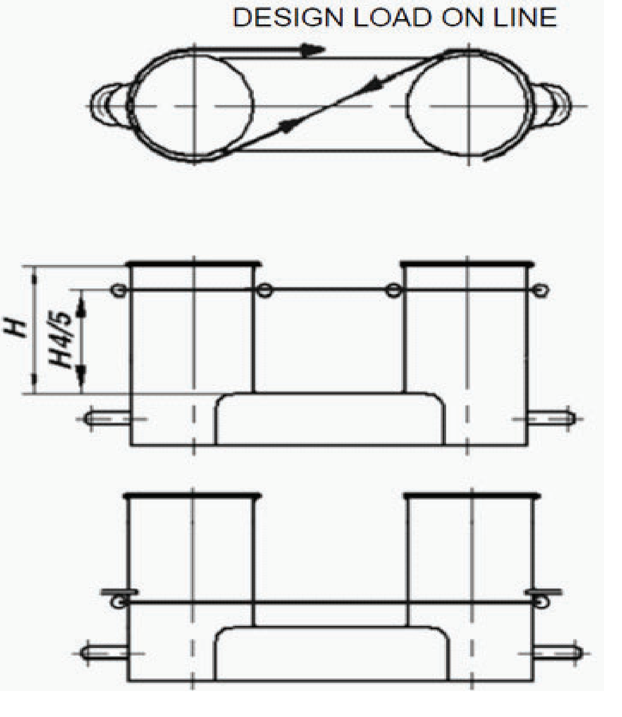
Unless a greater SWL is requested by the applicant according to [3.1.14], the SWL is not to exceed the Ship Design Minimum Breaking Load according to Tab 4 and App 2 (see notes in [3.1.14]).

The SWL, in t, of each shipboard fitting is to be marked (by weld bead or equivalent) on the deck fittings used for towing. For fittings intended to be used for both, towing and mooring, TOW, in t, according to [3.1.10] is to be marked in addition to SWL.

The above requirements on SWL apply for the use with no more than one mooring line.

The towing and mooring arrangement plan mentioned in [3.1.17] is to define the method of use of mooring lines.

Figure 6 : Attachment point of the mooring line *(1/7/2018)*



3.1.17 Towing and mooring arrangement plan *(1/1/2022)*

The SWL and TOW for the intended use for each shipboard fitting is to be noted in the towing and mooring arrangement plan available on board for the guidance of the Master. It is to be noted that TOW is the load limit for the towing purpose and SWL that for mooring purpose. If not otherwise chosen, for towing bitts it is to be noted that TOW is the load limit for a towing line attached with eye-splice.

Information provided on the plan is to include in respect of each shipboard fitting:

- location on the ship;
- fitting type;
- SWL/TOW;
- purpose (mooring/normal (harbour) towing/other towing); and
- manner of applying towing or mooring line load including limiting fleet angle i.e. angle of change in direction of a line at the fitting.

Furthermore, information provided on the plan is to include:

- the arrangement of mooring lines showing the number of lines (N),
- the Ship Design Minimum Breaking Load (MBL_{SD}).

The acceptable environmental conditions (refer for minimum conditions to App 2 for the recommended Ship Design Minimum Breaking Load for ships with Equipment Number EN > 2000:

- 30 second mean wind speed from any direction, see App 2, [1.4.2],
- maximum current speed acting on bow or stern (±10°).

All the information listed is to be incorporated into the pilot card in order to provide the pilot with proper information on normal (harbour) towing and other towing operations.

3.2 Anchors

3.2.1 General *(1/7/2007)*

The anchoring arrangement is to be such as to prevent the cable from being damaged and fouled. Adequate arrangements are to be provided to secure the anchor under all operational conditions.

The scantlings of anchors are to be in compliance with the following requirements.

Anchors are to be manufactured according to approved plans or recognised standards and are to be tested as indicated in Pt D, Ch 4, Sec 1, [1].

3.2.2 Ordinary anchors

The required mass for each anchor is to be obtained from Tab 1.

The individual mass of a main anchor may differ by ±7% from the mass required for each anchor, provided that the total mass of anchors is not less than the total mass required in Tab 1.

The mass of the head of an ordinary stockless anchor, including pins and accessories, is to be not less than 60% of the total mass of the anchor.

Where a stock anchor is provided, the mass of the anchor, excluding the stock, is to be not less than 80% of the mass required in Tab 1 for a stockless anchor. The mass of the stock is to be not less than 25% of the mass of the anchor without the stock but including the connecting shackle.

3.2.3 High and super high holding power anchors

High holding power (HHP) and super high holding power (SHHP) anchors, i.e. anchors for which a holding power higher than that of ordinary anchors has been proved according to Pt D, Ch 4, Sec 1, [1], do not require prior adjustement or special placement on the sea bottom.

Where HHP or SHHP anchors are used as bower anchors, the mass of each anchor is to be not less than 75% or 50%, respectively, of that required for ordinary stockless anchors in Tab 1.

The mass of SHHP anchors is to be, in general, less than or equal to 1500 kg.

3.2.4 Installation of the anchors on board *(1/7/2018)*

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

3.2.5 Test for high holding power anchors approval *(1/7/2018)*

For approval and/or acceptance as a HHP anchor, comparative tests are to be performed on various types of sea bottom. Such tests are to show that the holding power of the HHP anchor is at least twice the holding power of an ordinary stockless anchor of the same mass.

The holding power test load is to be less than or equal to the proof load of the anchor, specified in Pt D, Ch 4, Sec 1, [1.6].

For approval and/or acceptance as a HHP anchor of a whole range of mass, such tests are to be carried out on anchors whose sizes are, as far as possible, representative of the full range of masses proposed. In this case, at least two anchors of different sizes are to be tested. The mass of the maximum size to be approved is to be not greater than 10 times the maximum size tested. The mass of the smallest is to be not less than 0,1 times the minimum size tested.

Figure 7 : Ships with perpendicular front bulkhead
Effective area of bulwarks or fixed screen to be included in the Equipment Number

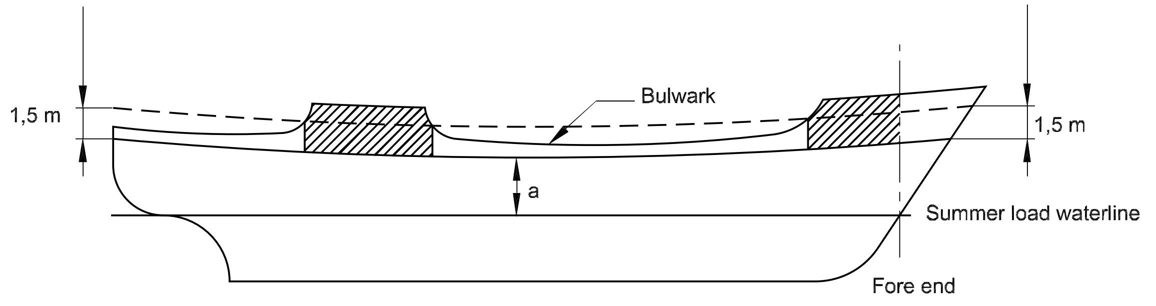
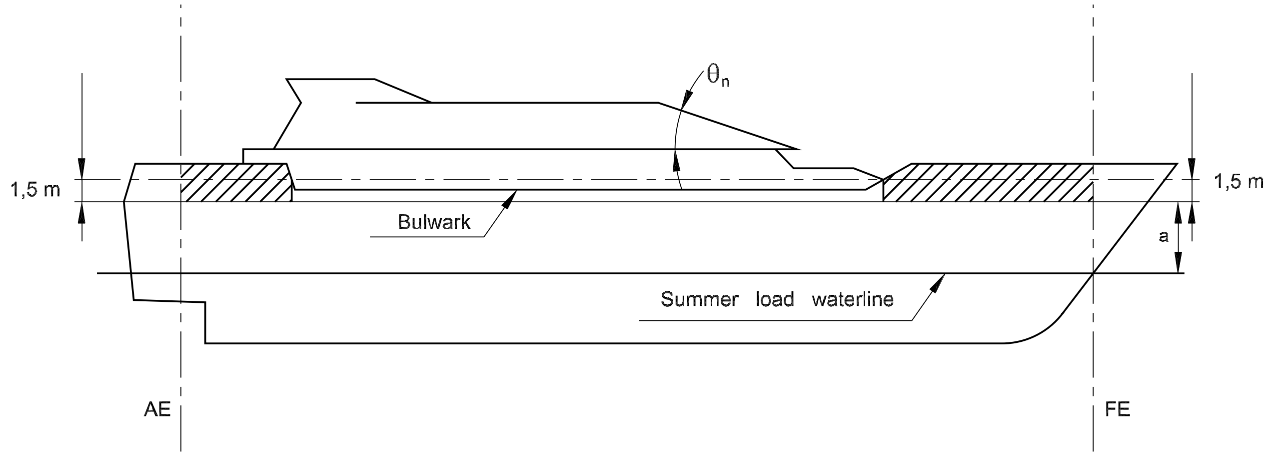


Figure 8 : Ships with inclined front bulkhead
Effective area of bulwarks or fixed screen to be included in the Equipment Number



3.2.6 Test for super high holding power anchors approval

For approval and/or acceptance as a SHHP anchor, comparative tests are to be performed at least on three types of sea bottom: soft mud or silt, sand or gravel and hard clay or similar compounded material. Such tests are to show that the holding power of the SHHP anchor is to be at least four times the holding power of an ordinary stockless anchor of the same mass or at least twice the holding power of a previously approved HHP anchor of the same mass.

The holding power test load is to be less than or equal to the proof load of the anchor, specified in Pt D, Ch 4, Sec 1, [1.6].

For approval and/or acceptance as a SHHP anchor of a whole range of mass, such tests are to be carried out on anchors whose sizes are, as far as possible, representative of the full range of masses proposed. In this case, at least three anchors of different sizes are to be tested. relevant to the bottom, middle and top of the mass range.

3.2.7 Specification for test on high holding power and super high holding power anchors *(1/7/2018)*

Tests are generally to be carried out from a tug. Shore based tests may be accepted by the Society on a case-by-case basis.

Alternatively, sea trials by comparison with a previous approved anchor of the same type (HHP or SHHP) of the one to be tested may be accepted by the Society on a case-by-case basis.

For each series of sizes, the two anchors selected for testing (ordinary stockless and HHP anchors for testing HHP anchors, ordinary stockless and SHHP anchors or, when ordinary stockless anchors are not available, HHP and SHHP anchors for testing SHHP anchors) are to have approximately the same mass.

The length of chain cable connected to each anchor, having a diameter appropriate to its mass, is to be such that the pull on the shank remains practically horizontal. For this purpose a value of the ratio between the length of the chain cable paid out and the water depth equal to 10 is considered normal. A lower value of this ratio not less than 6 may be accepted by the Society on a case-by-case basis.

Three tests are to be carried out for each anchor and type of sea bottom.

The pull is to be measured by dynamometer; measurements based on the RPM/bollard pull curve of tug may, however, be accepted instead of dynamometer readings.

Note is to be taken where possible of the stability of the anchor and its ease of breaking out.

3.3 Chain cables for anchors

3.3.1 Material

The chain cables are classified as grade Q1, Q2 or Q3 depending on the type of steel used and its manufacture.

The characteristics of the steel used and the method of manufacture of chain cables are to be approved by the Society for each manufacturer. The material from which chain cables are manufactured and the completed chain cables themselves are to be tested in accordance with the applicable requirements of Pt D, Ch 4, Sec 1.

Chain cables made of grade Q1 may not be used with high holding power and super high holding power anchors.

3.3.2 Scantlings of stud link chain cables

The mass and geometry of stud link chain cables, including the links, are to be in compliance with the requirements in Pt D, Ch 4, Sec 1.

The diameter of stud link chain cables is to be not less than the value in Tab 1.

3.3.3 Studless link chain cables

For ships with EN less than 90, studless short link chain cables may be accepted by the Society as an alternative to stud link chain cables, provided that the equivalence in strength is based on proof load, defined in Pt D, Ch 4, Sec 1, [3], and that the steel grade of the studless chain is equivalent to the steel grade of the stud chains it replaces, as defined in [3.3.1].

3.3.4 Chain cable arrangement *(1/7/2018)*

Chain cables are to be made by lengths of 27,5 m each, joined together by Dee or lugless shackles.

The total length of chain cable, required in Tab 1, is to be divided in approximately equal parts between the two anchors ready for use.

Where different arrangements are provided, they are considered by the Society on a case-by-case basis.

3.3.5 Wire ropes *(1/7/2018)*

As an alternative to the stud link or short link chain cables mentioned, wire ropes may be used in the following cases:

- wire ropes for both the anchors, for ship length less than 40 m,
- wire ropes for both the anchors, for ships with restricted navigation notations and/or having special anchoring design and operational characteristics, to be considered on a case-by-case basis taking into account the operational and safety aspects; in any case, the weight of the anchors is to be 1,25 times the value required according to Tab 1.

The wire ropes above are to have a total length equal to 1,5 times the corresponding required length of stud link chain cables, obtained from Tab 1, and a minimum breaking load equal to that given for the corresponding stud link chain cable (see [3.3.2]).

Unless incompatible with the anchor operation, to be evaluated on a case-by-case basis, a short length of chain cable is to be fitted between the wire rope and the anchor, having a length equal to 12,5m or the distance from the anchor in the stowed position to the winch, whichever is the lesser.

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

3.4 Attachment pieces

3.4.1 General

Where the lengths of chain cable are joined to each other by means of shackles of the ordinary Dee type, the anchor may be attached directly to the end link of the first length of chain cable by a Dee type end shackle.

A detachable open link in two parts riveted together may be used in lieu of the ordinary Dee type end shackle; in such case the open end link with increased diameter, defined in [3.4.2], is to be omitted.

Where the various lengths of chain cable are joined by means of lugless shackles and therefore no special end and increased diameter links are provided, the anchor may be attached to the first length of chain cable by a special pear-shaped lugless end shackle or by fitting an attachment piece.

3.4.2 Scantlings

The diameters of the attachment pieces, in mm, are to be not less than the values indicated in Tab 2.

Attachment pieces may incorporate the following items between the increased diameter stud link and the open end link:

- swivel, having diameter = 1,2 d
- increased stud link, having diameter = 1,1 d

Where different compositions are provided, they will be considered by the Society on a case-by-case basis.

Table 2 : Diameters of attachment pieces

Attachment piece	Diameter, in mm
End shackle	1,4 d
Open end link	1,2 d
Increased stud link	1,1 d
Common stud link	d
Lugless shackle	d
Note 1: d : diameter, in mm, of the common link.	

3.4.3 Material

Attachment pieces, joining shackles and end shackles are to be of such material and design as to provide strength equivalent to that of the attached chain cable, and are to be tested in accordance with the applicable requirements of Pt D, Ch 4, Sec 1.

3.4.4 Spare attachment pieces

A spare pear-shaped lugless end shackle or a spare attachment piece is to be provided for use when the spare anchor is fitted in place.

3.5 Towlines and mooring lines

3.5.1 General *(1/1/2022)*

The requirements of [3.5] apply for the determination of the characteristics of towlines and mooring lines. The equipment number EN is to be calculated in compliance with [2]. Deck cargoes at the ship nominal capacity condition is to be included for the determination of side-projected area A.

[3.5.3] and [3.5.4] specify the minimum number and minimum strength of mooring lines. As an alternative to [3.5.3] and [3.5.4], the direct mooring analysis in line with the procedure given in App 3 may be carried out.

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

3.5.2 Towlines *(1/1/2022)*

The towlines having the characteristics defined in Tab 3 are intended as those belonging to the ship to be towed by a tug or another ship.

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

3.5.3 Mooring lines for ships with EN ≤ 2000 *(1/7/2018)*

Mooring lines for ships having an Equipment Number EN of less than or equal to 2000 are given in Tab 4.

For ships having the ratio A/EN > 0,9 additional mooring lines are required in addition to the number of mooring lines defined in Tab 4.

The number of these additional mooring lines is defined in Tab 6.

3.5.4 Mooring lines for ships with EN > 2000 *(1/7/2018)*

The minimum strength and number of mooring lines for ships with an Equipment Number EN > 2000 are given in App 2.

3.5.5 Materials *(1/7/2018)*

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

The breaking loads defined in Tab 3, Tab 4 and App 2 refer to steel wires or natural fibre ropes.

Steel wires and fibre ropes are to be tested in accordance with the applicable requirements in Pt D, Ch 4, Sec 1.

3.5.6 Length of mooring lines *(1/7/2018)*

The length of mooring lines for ships with EN of less than or equal to 2000 may be taken from Tab 4. For ships with EN > 2000 the length of mooring lines may be taken as 200 m.

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

3.5.7 Equivalence between the breaking loads of synthetic and natural fibre ropes *(1/1/2022)*

Generally, fibre ropes are to be made of polyamide or other equivalent synthetic fibres (e.g. polyester, polypropylene).

The equivalence between the breaking loads of synthetic fibre ropes B_{LS} and of natural fibre ropes B_{LN} is to be obtained, in kN, from the following formula:

$B_{LS} = 7,4\ \delta\ B_{LN}^{8/9}$ without being less than $1,2\ B_{LN}$

where:

δ : elongation to breaking of the synthetic fibre rope.

For other synthetic ropes different from those mentioned above (e.g. aramid fiber, Ultra High Molecular Weight Poly-Ethylene) the breaking load is to be taken equal to $1,1\ B_{LN}$.

3.5.8 Length of mooring lines for supply vessels

For ships with the service notation **supply vessel**, the length of mooring lines may be reduced. The reduced length ℓ is to be not less than that obtained, in m, from the following formula:

$\ell = L + 20$

Table 3 : Towlines *(1/1/2022)*

Equipment number EN A< EN ≤ B		Towline **(1)**	
A	B	Minimum length, in m	Ship Design Minimum Breaking load, in kN
50	70	180	98
70	90	180	98
90	110	180	98
110	130	180	98
130	150	180	98
150	175	180	98
175	205	180	112
205	240	180	129
240	280	180	150
280	320	180	174
320	360	180	207

(1) The towline is not compulsory. It is recommended for ships having length not greater than 180 m.

Equipment number EN A< EN ≤ B		Towline (1)	
A	B	Minimum length, in m	Ship Design Minimum Breaking load, in kN
360	400	180	224
400	450	180	250
450	500	180	277
500	550	190	306
550	600	190	338
600	660	190	371
660	720	190	406
720	780	190	441
780	840	190	480
840	910	190	518
910	980	190	550
980	1060	200	603
1060	1140	200	647
1140	1220	200	692
1220	1300	200	739
1300	1390	200	786
1390	1480	200	836
1480	1570	220	889
1570	1670	220	942
1670	1790	220	1024
1790	1930	220	1109
1930	2080	220	1168
2080	2230	240	1259
2230	2380	240	1356
2380	2530	240	1453
2530	2700	260	1471
2700	2870	260	1471
2870	3040	260	1471
3040	3210	280	1471
3210	3400	280	1471
3400	3600	280	1471
3600	-	300	1471
(1) The towline is not compulsory. It is recommended for ships having length not greater than 180 m.			

Table 4 : Mooring lines for ships with EN ≤ 2000 *(1/1/2022)*

Equipment number EN A< EN ≤ B		Mooring lines		
A	B	N **(1)**	Lenght of each line, in m	Ship Design Minimum Breaking load, in kN
50	70	3	80	37
70	90	3	100	40
90	110	3	110	42
110	130	3	110	48
130	150	3	120	53
150	175	3	120	59
175	205	3	120	64
(1) See [3.5.3] and [3.5.4]				

Equipment number EN A< EN ≤ B		Mooring lines		
A	B	N **(1)**	Lenght of each line, in m	Ship Design Minimum Breaking load, in kN
205	240	3	120	69
240	280	4	120	75
280	320	4	140	80
320	360	4	140	85
360	400	4	140	96
400	450	4	140	107
450	500	4	140	117
500	550	4	160	134
550	600	4	160	143
600	660	4	160	160
660	720	4	160	171
720	780	4	170	187
780	840	4	170	202
840	910	4	170	218
910	980	4	170	235
980	1060	4	180	250
1060	1140	4	180	272
1140	1220	4	180	293
1220	1300	4	180	309
1300	1390	4	180	336
1390	1480	4	180	352
1480	1570	5	190	352
1570	1670	5	190	362
1670	1790	5	190	384
1790	1930	5	190	411
1930	2000	5	190	437
(1) See [3.5.3] and [3.5.4]				

Table 5 : Steel wire composition

Breaking load B_L ,in kN	Steel wire components		
	Number of threads	Ultimate tensile strength of threads, in N/mm²	Composition of wire
B_L < 216	72	1420 ÷ 1570	6 strands with 7-fibre core
216 ≤ B_L ≤ 490	144	1570 ÷ 1770	6 strands with 7-fibre core
B_L > 490	216 or 222	1770 ÷ 1960	6 strands with 1-fibre core

3.6 Hawse pipes

3.6.1 Hawse pipes are to be built according to sound marine practice.

Their position and slope are to be so arranged as to create an easy lead for the chain cables and efficient housing for the anchors, where the latter are of the retractable type, avoiding damage to the hull during these operations.

For this purpose chafing lips of suitable form with ample lay-up and radius adequate to the size of the chain cable are to be provided at the shell and deck. The shell plating in way of the hawse pipes is to be reinforced as necessary.

Table 6 : Additional mooring lines

A/EN	Number of additional mooring lines
0,9 < A/EN ≤ 1,1	1
1,1 < A/EN ≤ 1,2	2
1,2 < A/EN	3
Note 1: A and EN are defined in [2.1.2].	

3.6.2 In order to obtain an easy lead of the chain cables, the hawse pipes may be provided with rollers. These rollers are to have a nominal diameter not less than 10 times the size of the chain cable where they are provided with full imprints, and not less than 12 times its size where provided with partial imprints only.

3.6.3 All mooring units and accessories, such as thimble, riding and trip stoppers are to be securely fastened to the Surveyor's satisfaction.

3.7 Windlass

3.7.1 General *(1/7/2018)*

The windlass, which is generally single, is to be power driven and suitable for the size of chain cable and the mass of the anchors. Windlass is also to comply with requirements given in Pt C, Ch 1, Sec 15.

In mechanically propelled ships of less than 200 t gross tonnage, a hand-operated windlass may be fitted. In such case it is to be so designed as to be capable of weighing the anchors in a reasonably short time.

The windlass is to be fitted in a suitable position in order to ensure an easy lead of the chain cables to and through the hawse pipes. The deck in way of the windlass is to be suitably reinforced.

3.7.2 Windlass brake *(1/7/2018)*

A windlass brake is to be provided having sufficient capacity to stop the anchor and chain cable when paying out the latter with safety, in the event of failure of the power supply to the prime mover. Windlasses not actuated by steam are also to be provided with a non-return device.

Where a chain cable stopper is fitted, a windlass with brakes applied and the cable lifter declutched is to be able to withstand a pull of 45% of the breaking load of the chain without any permanent deformation of the stressed parts or brake slip.

Where a chain stopper is not fitted a windlass with brakes applied and the cable lifter declutched is to be able to withstand a pull of 80% of the breaking load of the chain without any permanent deformation of the stressed parts or brake slip.

3.7.3 Chain stoppers *(1/7/2018)*

Where a chain stopper is fitted, it is to be able to withstand a pull of 80% of the breaking load of the chain and the windlass is to be able to withstand a pull of 45% of the breaking load of the chain without any permanent deformation of the stressed part or brake slip.

Where a chain cable stopper is fitted, a windlass with brakes applied and the cable lifter declutched is to be able to withstand a pull of 45% of the breaking load of the chain without any permanent deformation of the stressed parts or brake slip.

3.7.4 Strength criteria for windlass subject to anchor and chain loads

The stresses on the parts of the windlass, its frame and stopper are to be less than the yield stress of the material used.

For the calculation of the above stresses, special attention is to be paid to:

- stress concentrations in keyways and other stress raisers,
- dynamic effects due to sudden starting or stopping of the prime mover or anchor chain,
- calculation methods and approximation.

3.7.5 Green sea loads *(1/1/2004)*

For ships of length 80 m or more, where the height of the exposed deck in way of the item is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser, the securing devices of windlasses located within the forward quarter length of the ship are to resist green sea forces.

The green sea pressure and associated areas are to be taken equal to (see Fig 9):

- 200 kN/m^2 normal to the shaft axis and away from the forward perpendicular, over the projected area in this direction,
- 150 kN/m^2 parallel to the shaft axis and acting both inboard and outboard separately, over the multiple of f times the projected area in this direction,

where:

f : 1+ B/H, but not greater than 2,5

B : width of windlass measured parallel to the shaft axis,

H : overall height of windlass.

Where mooring winches are integral with the anchor windlass, they are to be considered as part of the windlass.

3.7.6 Forces in the securing devices of windlasses due to green sea loads *(1/1/2004)*

Forces in the bolts, chocks and stoppers securing the windlass to the deck are to be calculated by considering the green sea loads specified in [3.7.5].

The windlass is supported by N bolt groups, each containing one or more bolts (see also Fig 10).

The axial force R_i in bolt group (or bolt) i, positive in tension, is to be obtained, in kN, from the following formulae:

$R_{xi} = P_x \, hx_i \, A_i / I_x$

$R_{yi} = P_y \, hy_i \, A_i / I_y$

and $R_i = R_{xi} + R_{yi} - R_{si}$

where:

P_x : force, in kN, acting normal to the shaft axis

P_y : force, in kN, acting parallel to the shaft axis, either inboard or outboard, whichever gives the greater force in bolt group i

H : shaft height, in cm, above the windlass mounting

x_i , y_i : x and y coordinates, in cm, of bolt group i from the centroid of all N bolt groups, positive in the direction opposite to that of the applied force

A_i : cross-sectional area, in cm², of all bolts in group i

I_x : $\Sigma A_i \, x_i^2$ for N bolt groups

I_y : $\Sigma A_i \, y_i^2$ for N bolt groups

R_{si} : static reaction, in kN, at bolt group i, due to weight of windlass.

Shear forces F_{xi} , F_{yi} applied to the bolt group i, and the resultant combined force F_i are to be obtained, in kN, from the following formulae:

$F_{xi} = (P_x - \alpha \, g \, M) / N$

$F_{yi} = (P_y - \alpha \, g \, M) / N$

and

$F_i = (F_{xi}^2 + F_{yi}^2)^{0,5}$

where:

α : coefficient of friction, to be taken equal to 0,5

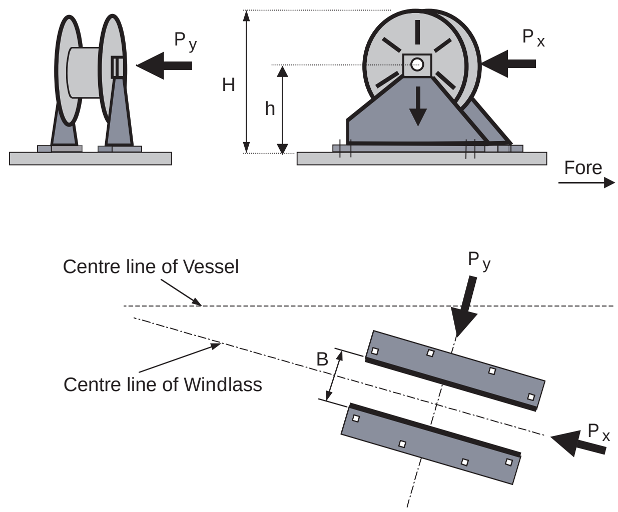
M : mass, in t, of windlass

g : gravity acceleration, in m/s², to be taken equal to 9,81 m/s²

N : number of bolt groups.

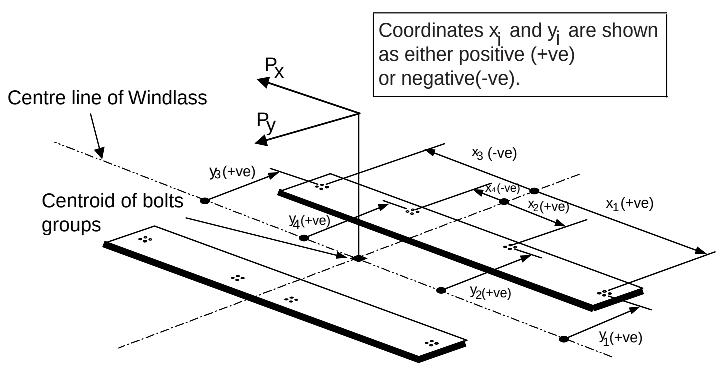
Axial tensile and compressive forces and lateral forces calculated according to these requirements are also to be considered in the design of the supporting structure.

Figure 9 : Direction of Forces and Weight *(1/1/2004)*



Note: Py to be examined from both inboard and outboard directions separately - see [3.7.9]. The sign convention for yi is reversed when Py is from the opposite direction as shown.

Figure 10 : Sign Convention *(1/1/2004)*



3.7.7 Strength criteria for securing devices of windlass *(1/1/2004)*

Tensile axial stresses in the individual bolts in each bolt group i are to be calculated according to the requirements specified in [3.7.6]. The horizontal forces F_{xi} and F_{yi}, to be calculated according to the requirements specified in [3.7.6], are normally to be reacted by shear chocks.

Where "fitted" bolts are designed to support these shear forces in one or both directions, the equivalent Von Mises stress σ, in N/mm², in the individual bolt is to comply with following formula:

$\sigma \leq 0,5 \, \sigma_{BPL}$

where σ_{BPL} is the stress in the bolt considered as being loaded by the proof load.

Where pourable resins are incorporated in the holding down arrangements, due account is to be taken in the calculations.

3.7.8 Connection with deck

The windlass, its frame and the stoppers are to be efficiently bedded to the deck.

3.8 Chain stoppers

3.8.1 A chain stopper is generally to be fitted between the windlass and the hawse pipe in order to relieve the windlass of the pull of the chain cable when the ship is at anchor. A chain stopper is to be capable of withstanding a pull of 80% of the breaking load of the chain cable. The deck at the chain stopper is to be suitably reinforced.

For the same purpose, a piece of chain cable may be used with a rigging screw capable of supporting the weight of the anchor when housed in the hawse pipe or a chain tensioner. Such arrangements are not to be considered as chain stoppers.

3.8.2 Where the windlass is at a distance from the hawse pipes and no chain stoppers are fitted, suitable arrangements are to be provided to lead the chain cables to the windlass.

3.9 Supporting hull structures of anchor windlass and chain stopper

3.9.1 General *(1/1/2022)*

The supporting hull structure of anchor windlass and chain stopper is to be sufficient to accommodate the design sea loads.

3.9.2 Design loads *(1/1/2022)*

The design loads are to be taken not less than:

- for chain stoppers, 80% of the chain cable breaking load,
- for windlasses where no chain stopper is fitted or the chain stopper is attached to the windlass, 80% of the chain cable breaking load,
- for windlasses, where chain stoppers are fitted but not attached to the windlass, 45% of the chain cable breaking load.

The design loads are to be applied in the direction of the chain cable.

3.9.3 Sea loads *(1/7/2018)*

The sea loads are to be taken as defined in [3.7.5].

3.9.4 Allowable stresses *(1/1/2022)*

The stresses acting on the supporting hull structures of windlass and chain stopper, based on the net thickness obtained by deducting the corrosion addition, t_c, given in [3.9.5], are not to be greater than the following permissible values:

a) For strength assessment by means of beam theory or grillage analysis:

- Normal stress: 1,0 R_{eH}
- Shear stress: 0,6 R_{eH}

The normal stress is the sum of bending stress and axial stress. The shear stress to be considered corresponds to the shear stress acting perpendicular to the normal stress. No stress concentration factors are to be taken into account.

b) For strength assessment by means of finite element analysis:

- Von Mises stress: 1.0 R_{eH}

For strength assessment by means of finite element analysis the mesh is to be fine enough to represent the geometry as realistically as possible. The aspect ratios of elements are not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges may be modelled by beam or truss elements. The element height of girder webs must not exceed one-third of the web height. In way of small openings in girder webs, the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners may be modelled using shell, plane stress, or beam elements. The mesh size of stiffeners is to be fine enough to obtain proper bending stress. If flat bars are modeled using shell or plane stress elements, dummy rod elements are to be modelled at the free edge of the flat bars and the stresses of the dummy elements are to be evaluated. Stresses are to be read from the centre of the individual element. For shell elements the stresses are to be evaluated at the mid plane of the element.

Where R_{eH} is the specified minimum yield stress of the material.

3.9.5 Corrosion addition *(1/1/2022)*

The total corrosion addition, t_c, is not to be less than the following values:

a) Ships covered by Common Structural Rules for Bulk Carriers and Oil Tankers:

t_c: total corrosion addition as defined in these rules.

b) Other ships:

For the supporting hull structure, the total corrosion addition, t_c, is defined according to Ch 4, Sec 2 for all considered structural members used in the model (e.g. deck structures).

3.10 Chain locker

3.10.1 The capacity of the chain locker is to be adequate to stow all chain cable equipment and provide an easy direct lead to the windlass.

3.10.2 Where two chains are used, the chain lockers are to be divided into two compartments, each capable of housing the full length of one line.

3.10.3 The inboard ends of chain cables are to be secured to suitably reinforced attachments in the structure by means of end shackles, whether or not associated with attachment pieces.

Generally, such attachments are to be able to withstand a force not less than 15% of the breaking load of the chain cable.

In an emergency, the attachments are to be easily released from outside the chain locker.

3.10.4 Where the chain locker is arranged aft of the collision bulkhead, its boundary bulkheads are to be watertight and a drainage system is to be provided.

3.11 Fairleads and bollards

3.11.1 Fairleads and bollards of suitable size and design are to be fitted for towing, mooring and warping operations.

4 Emergency towing arrangements

4.1 Definitions

4.1.1 Deadweight

Deadweight is the difference, in t, between the displacement of a ship in water of a specific gravity of 1,025 t/m^3 at the load waterline corresponding to the assigned summer freeboard and the lightweight of the ship.

4.2 General and application

4.2.1 *(1/1/2010)*

This Article applies to ships which are to comply with Regulation 3-4 of Chapter II-1 of SOLAS Convention. It concerns the equipment arrangements for towing ships out of danger in emergencies such as complete mechanical breakdowns, loss of power or loss of steering capability.

4.2.2 An emergency towing arrangement is to be fitted at both ends on board of ships of 20000 t deadweight and above with one of the following service notations:

- **combination carrier ESP**,
- **oil tanker ESP**,
- **FLS tanker**,
- **chemical tanker ESP**,
- **liquefied gas carrier**.

4.3 Documentation

4.3.1 Documentation for approval

In addition to the documents in Ch 1, Sec 3, the following documentation is to be submitted to the Society for approval:

- general layout of the bow and stern towing arrangements and associated equipment,
- operation manual for the bow and stern towing arrangements,
- construction drawings of the bow and stern strongpoints (towing brackets or chain cable stoppers) and fairleads (towing chocks), together with material specifications and relevant calculations,
- drawings of the local ship structures supporting the loads applied by strongpoints, fairleads and roller pedestals.

4.3.2 Documentation for information

The following documentation is to be submitted to the Society for information (see Ch 1, Sec 3):

- specifications of chafing gears, towing pennants, pick-up gears and roller fairleads,
- height, in m, of the lightest seagoing ballast freeboard measured at stern towing fairlead,
- deadweight, in t, of the ship at summer load line.

4.4 General

4.4.1 Scope

The emergency towing arrangements are to be so designed as to facilitate salvage and emergency towing operations on the concerned ship, primarily to reduce the risk of pollution.

4.4.2 Main characteristics *(1/7/2002)*

The emergency towing arrangements are, at all times, to be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing ship. At least one of the emergency towing arrangements is to be pre-rigged for rapid deployment.

To demonstrate such rapid and easy deployment, the emergency towing arrangements are to comply with the requirements in [4.12].

Emergency towing arrangements at both ends are to be of adequate strength taking into account the size and deadweight of the ship and the expected forces during bad weather conditions.

To this end, the emergency towing arrangements are to comply with the requirements in [4.6] to [4.11].

4.4.3 Typical layout

Fig 11 shows an emergency towing arrangement which may be used as reference.

4.4.4 List of major components

The major components of the towing arrangements, their position on board and the requirements of this Article which they are to comply with are defined in Tab 7.

4.4.5 Inspection and maintenance

All the emergency towing arrangement components are to be inspected by ship personnel at regular intervals and maintained in good working order.

Figure 11 : Typical emergency towing arrangement

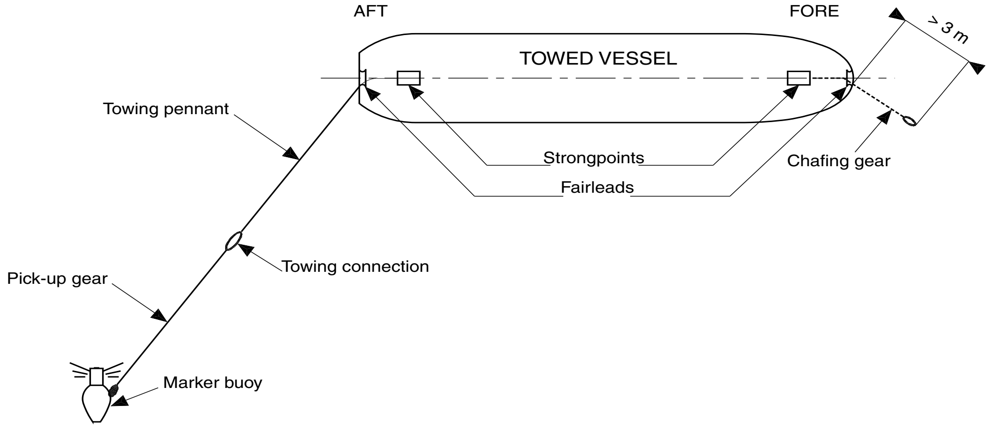


Table 7 : Major components of the emergency towing arrangement *(1/7/2011)*

Towing component	Non-pre-rigged	Pre-rigged	Reference of applicable requirements
Towing pennant	Optional	Required	[4.7]
Fairlead	Required	Required	[4.9]
Strongpoint (inboard end fastening of the towing gear)	Required	Required	[4.10]
Pick-up gear	Optional	Required	No requirements
Pedestal roller fairlead	Required	Depending on design	No requirements
Chafing gear	Required	Depending on design	[4.8]

4.5 Emergency towing arrangement approval

4.5.1 General

Emergency towing arrangements of ships are to comply with the following requirements:

- they are to comply with the requirements of this item,
- they are to be type approved according to the requirements in [4.13],
- Certificates of inspection of materials and equipment are to be provided according to [4.13.2],
- fitting on board of the emergency towing arrangements is to be witnessed by a Surveyor of the Society and a relevant Certificate is to be issued,
- demonstration of the rapid deployment according to the criteria in [4.12] is to be effected for each ship and this is to be reported in the above Certificate.

4.5.2 Alternative to testing the rapid deployment for each ship

At the request of the Owner, the testing of the rapid deployment for each ship according to [4.5.1] may be waived provided that:

- the design of emergency towing arrangements of the considered ship is identical to the type approved arrangements and this is confirmed by the on board inspection required in [4.5.1],
- the strongpoints (chain stoppers, towing brackets or equivalent fittings) are type approved (prototype tested).

In this case, an exemption certificate is to be issued.

In general, such dispensation may be granted to subsequent ships of a series of identical new buildings fitted with identical arrangements.

4.6 Safe working load (SWL) of towing pennants, chafing gears, fairleads and strongpoints

4.6.1 Safe working load

The safe working load (defined as one half of the ultimate strength) of towing pennants, chafing gear, fairleads and strongpoints is to be not less than that obtained, in kN, from Tab 8.

The strength of towing pennants, chafing gear, fairleads and strongpoints is to be sufficient for all pulling angles of the towline, i.e. up to 90° from the ship's centreline to port and starboard and 30° vertical downwards.

The safe working load of other components is to be sufficient to withstand the load to which such components may be subjected during the towing operation.

Table 8 : Safe working load

Ship deadweight DWT, in t	Safe working load,in kN
20000 ≤ DWT < 50000	1000
DWT ≥ 50000	2000

4.7 Towing pennant

4.7.1 Material

The towing pennant may be made of steel wire rope or synthetic fibre rope, which is to comply with the applicable requirements in Pt D, Ch 4, Sec 1.

4.7.2 Length of towing pennant

The length ℓ_P of the towing pennant is to be not less than that obtained, in m, from the following formula:

$\ell_P = 2H + 50$

where:

H : lightest seagoing ballast freeboard measured, in m, at the fairlead.

4.7.3 Minimum breaking strength of towing pennants when separate chafing gear is used

Where a separate chafing gear is used, the minimum breaking strength MBS_p of towing pennants, including their terminations, is to be not less than that obtained from the following formula:

$MBS_P = 2\ \mu\ SWL$

where:

μ : coefficient that accounts for the possible loss in strength at eye terminations, to be taken not less than 1,1

SWL : safe working load of the towing pennants, defined in [4.6.1].

4.7.4 Minimum breaking strength of towing pennants when no separate chafing gear is used

Where no separate chafing gear is used (i.e. where the towing pennant may chafe against the fairlead during towing operation), the minimum breaking strength of the towing pennants MBS_{PC} is to be not less than that obtained, in kN, from the following formula:

$MBS_{PC} = \varphi\ MBS_P$

where:

MBS_P : minimum breaking strength, in kN, defined in [4.7.3],

φ : coefficient to be taken equal to:

$$\varphi = \frac{2\sqrt{\rho}}{2\sqrt{\rho}-1}$$

φ may be taken equal to 1,0 if tests carried out under a test load equal to twice the safe working load defined in [4.6.1] demonstrate that the strength of the towing pennants is satisfactory,

ρ : bending ratio (ratio between the minimum bearing surface diameter of the fairlead and the towing pennant diameter), to be taken not less than 7.

4.7.5 Towing pennant termination

For towing connection, the towing pennant is to have a hard eye-formed termination allowing connection to a standard shackle.

Socketed or ferrule-secured eye terminations of the towing pennant are to be type tested in order to demonstrate that their minimum breaking strength is not less than twice the safe working load defined in [4.6.1].

4.8 Chafing gear

4.8.1 General

Different solutions for the design of chafing gear may be used.

If a chafing chain is to be used, it is to have the characteristics defined in the following requirements.

4.8.2 Type *(1/7/2004)*

Chafing chains are to be stud link chains.

Chafing chains are to be designed, manufactured, tested and certified in accordance with the requirements in Pt D, Ch 4, Sec 1.

Chafing chains are to be manufactured by works approved by the Society in accordance with the requirements in Pt D, Ch 4, Sec 1.

4.8.3 Material *(1/7/2004)*

The materials used for the manufacture of the chafing chain and associated accessories are to comply with the requirements in Pt D, Ch 4, Sec 1.

The common link is to be of grade Q2 or Q3.

4.8.4 Chafing chain length

The chafing chain is to be long enough to ensure that the towing pennant, or the towline, remains outside the fairlead during the towing operation. A chain extending from the strongpoint to a point at least 3m beyond the fairlead complies with this requirement.

4.8.5 Minimum breaking strength

The minimum breaking strength of the stud link chafing chain and the associated links is to be not less than twice the safe working load defined in [4.6.1].

4.8.6 Diameter of the common links *(1/7/2004)*

The nominal diameter of the common links for chafing chains is to be not less than the values indicated in Tab 9.

Table 9 : Nominal diameter of common links for chafing chains *(1/7/2004)*

Safe working load, in kN; refer to [4.6.1]	Nominal diameter, in mm	
	Grade Q2	Grade Q3
1000	62	52
2000	90	76

4.8.7 Chafing chain ends

One end of the chafing chain is to be suitable for connection to the strongpoint. Where a chain stopper is used, the inboard end of the chafing chain is to be efficiently secured in order to prevent any inadvertent loss of the chafing chain when operating the stopping device. Where the chafing chain is connected to a towing bracket, the corresponding chain end may be constructed as shown in Fig 12, but the inner dimension of the pear link may be taken as 5,30d (instead of 5,75d).

The other end of the chafing chain is to be fitted with a standard pear-shaped open link allowing connection to a standard bow shackle. A typical arrangement of this chain end is shown in Fig 12. Arrangements different than that shown in Fig 12 are considered by the Society on a case-by-case basis.

4.8.8 Storing

The chafing chain is to be stored and stowed in such a way that it can be rapidly connected to the strongpoint.

4.9 Fairleads

4.9.1 General

Fairleads are normally to be of a closed type (such as Panama chocks).

Fairleads are to have an opening large enough to pass the largest portion of the chafing gear, towing pennant or towline. The corners of the opening are to be suitably rounded.

Where the fairleads are designed to pass chafing chains, the openings are to be not less than 600mm in width and 450mm in height.

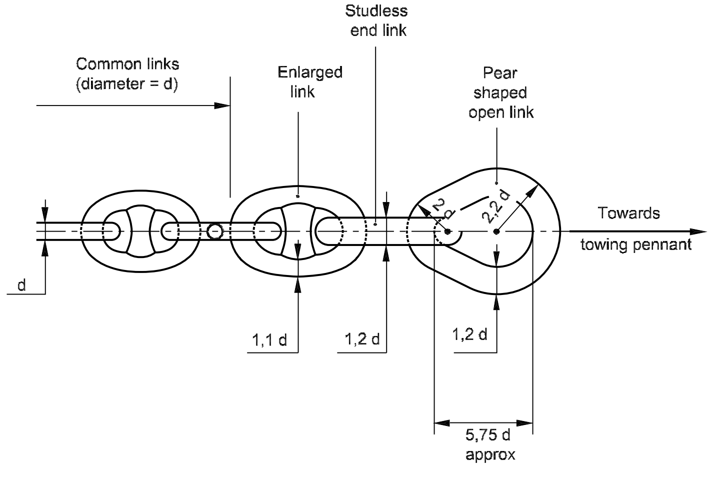
4.9.2 Material

Fairleads are to be made of fabricated steel plates or other ductile materials such as weldable forged or cast steel complying with the applicable requirements of Part D, Chapter 2.

4.9.3 Operating condition

The bow and stern fairleads are to give adequate support for the towing pennant during towing operation, which means bending 90° to port and starboard side and 30° vertical downwards.

Figure 12 : Typical outboard chafing chain end



4.9.4 Positioning

The bow and stern fairleads are to be located so as to facilitate towing from either side of the bow or stern and minimise the stress on the towing system.

The bow and stern 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 strongpoint and the fairlead.

Furthermore, the bow and stern fairleads are normally to be located on the ship's centreline. Where it is practically impossible to fit the towing fairleads exactly on the ship’s centreline, it may be acceptable to have them slightly shifted from the centreline.

4.9.5 Bending ratio

The bending ratio (ratio between the towing pennant bearing surface diameter and the towing pennant diameter) is to be not less than 7.

4.9.6 Fairlead lips

The lips of the fairlead are to be suitably faired in order to prevent the chafing chain from fouling on the lower lip when deployed or during towing.

4.9.7 Yielding check

The equivalent Von Mises stress σ_E, in N/mm^2, induced in the fairlead by a load equal to the safe working load defined in [4.6.1], is to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

Areas subjected to stress concentrations are considered by the Society on a case-by-case basis.

Where the fairleads are analysed through fine mesh finite element models, the allowable stress may be taken as 1,1 σ_{ALL}.

4.9.8 Alternative to the yielding check

The above yielding check may be waived provided that fairleads are tested with a test load equal to twice the safe working load defined in [4.6.1] and this test is witnessed by a Surveyor of the Society. In this case, the Designer is responsible for ensuring that the fairlead scantlings are sufficient to withstand such a test load.

Unless otherwise agreed by the Society, components subjected to this test load are considered as prototype items and are to be discarded.

4.10 Strongpoint

4.10.1 General

The strongpoint (inboard end fastening of the towing gear) is to be a chain cable stopper or a towing bracket or other fitting of equivalent strength and ease of connection*. The strongpoint can be designed integral with the fairlead.*

The strongpoint is to be type approved according to [4.13] and is to be clearly marked with its SWL.

4.10.2 Materials

The strongpoint is to be made of fabricated steel or other ductile materials such as forged or cast steel complying with the applicable requirements of Part D, Chapter 2.

Use of spheroidal graphite cast iron (SG iron) may be accepted for the main framing of the strongpoint provided that:

- the part concerned is not intended to be a component part of a welded assembly,
- the SG iron is of ferritic structure with an elongation not less than 12%,
- the yield stress at 0,2% is measured and certified,
- the internal structure of the component is inspected by suitable non-destructive means.

The material used for the stopping device (pawl or hinged bar) of chain stoppers and for the connecting pin of towing brackets is to have mechanical properties not less than those of grade Q3 chain cables, defined in Pt D, Ch 4, Sec 1.

4.10.3 Typical strongpoint arrangement

Typical arrangements of chain stoppers and towing brackets are shown in Fig 13, which may be used as reference.

Chain stoppers may be of the hinged bar type or pawl (tongue) type or of other equivalent design.

4.10.4 Position and operating condition

The operating conditions and the positions of the strongpoints are to comply with those defined in [4.9.3] and [4.9.4], respectively, for the fairleads.

4.10.5 Stopping device

The stopping device (chain engaging pawl or bar) is to be arranged, when in closed position, to prevent the chain stopper from working in the open position, in order to avoid chain cable release 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.

4.10.6 Connecting pin of the towing bracket

The scantlings of the connecting pin of the towing bracket are to be not less than those of a pin of a grade Q3 end shackle, as shown in Fig 13, provided that clearance between the two side lugs of the bracket does not exceed 2,0d, where d is the chain diameter specified in [4.8.6] (see also Fig 12).

4.10.7 Yielding check

The equivalent Von Mises stress σ_E , in N/mm², induced in the strongpoint by a load equal to the safe working load defined in [4.6.1], is to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

Areas subjected to stress concentrations are considered by the Society on a case-by-case basis.

Where the strongpoints are analysed through fine mesh finite element models, the allowable stress may be taken as 1,1 σ_{ALL}.

4.10.8 Alternative to the yielding check

The above yielding check may be waived provided that strongpoints are tested with a test load equal to twice the safe working load defined in [4.6.1] and this test is witnessed by a Surveyor. In this case, the Designer is responsible for ensuring that the fairlead scantlings are sufficient to withstand such a test load.

Unless otherwise agreed by the Society, components subjected to this test load are considered as prototype items and are to be discarded.

4.10.9 Bolted connection

Where a chain stopper or a towing bracket is bolted to a seating welded to the deck, the bolts are to be relieved from shear force by means of efficient thrust chocks capable of withstanding a horizontal force equal to 1,3 times the safe working load defined in [4.6.1] within the allowable stress defined in [4.10.7].

The steel quality of bolts is to be not less than grade 8.8 as defined by ISO standard No. 898/1.

Bolts are to be pre-stressed in compliance with appropriate standards and their tightening is to be suitably checked.

4.11 Hull structures in way of fairleads or strongpoints

4.11.1 Materials and welding

The materials used for the reinforcement of the hull structure in way of the fairleads or the strongpoints are to comply with the applicable requirements of Part D.

Main welds of the strongpoints with the hull structure are to be 100% inspected by adequate non-destructive tests.

4.11.2 Yielding check of bulwark and stays

The equivalent Von Mises stress σ_E , in N/mm², induced in the bulwark plating and stays in way of the fairleads by a load equal to the safe working load defined in [4.6.1], for the operating condition of the fairleads defined in [4.9.3], is to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

4.11.3 Yielding check of deck structures

The equivalent Von Mises stress σ_E , in N/mm², induced in the deck structures in way of chain stoppers or towing brackets, including deck seatings and deck connections, by a horizontal load equal to 1,3 times the safe working load defined in [4.6.1], is to comply with the following formula:

$\sigma_E \leq \sigma_{ALL}$

4.11.4 Minimum gross thickness of deck plating

The gross thickness of the deck is to be not less than:

- 12 mm for a safe working load, defined in [4.6.1], equal to 1000 kN,
- 15 mm for a safe working load, defined in [4.6.1], equal to 2000 kN.

4.12 Rapid deployment of towing arrangement

4.12.1 General

To facilitate approval of towing arrangements and to ensure rapid deployment, emergency towing arrangements are to comply with the requirements of this item.

4.12.2 Marking

All components, including control devices, of the emergency towing arrangements are to be clearly marked to facilitate safe and effective use even in darkness and poor visibility.

4.12.3 Pre-rigged *(1/7/2011)*

The pre-rigged emergency towing arrangement is to be capable of being deployed in a controlled manner in harbour conditions in not more than 15 minutes.

The pick-up gear for the pre-rigged towing pennant is to be designed at least for manual operation by one person taking into account the absence of power and the potential for adverse environmental conditions that may prevail during such emergency towing operations.

The pick-up gear is to be protected against the weather and other adverse conditions that may prevail.

4.12.4 Non-pre-rigged *(1/7/2011)*

The non-pre-rigged emergency towing arrangement is to be capable of being deployed in harbour conditions in not more than 1 hour.

The forward emergency towing arrangement is to be designed at least with a means of securing a towline to the chafing gear using a suitably positioned pedestal roller to facilitate connection of the towing pennant.

Pre-rigged emergency towing arrangements at both ends of the ship may be accepted.

4.13 Type approval

4.13.1 Type approval procedure

Emergency towing arrangements are to be type approved according to the following procedure:

- the arrangement design is to comply with the requirements of this Section,
- each component of the towing arrangement is to be tested and its manufacturing is to be witnessed and certified by a Surveyor according to [4.13.2],
- prototype tests are to be carried out in compliance with [4.13.3].

4.13.2 Inspection and certification

The materials and equipment are to be inspected and certified as specified in Tab 10.

4.13.3 Prototype tests

Prototype tests are to be witnessed by a Surveyor and are to include the following:

- demonstration of the rapid deployment according to the criteria in [4.12],
- load test of the strongpoints (chain stoppers, towing brackets or equivalent fittings) under a proof load equal to 1,3 times the safe working load defined in [4.6.1].

A comprehensive test report duly endorsed by the Surveyor is to be submitted to the Society for review.

Table 10 : Material and equipment certification status

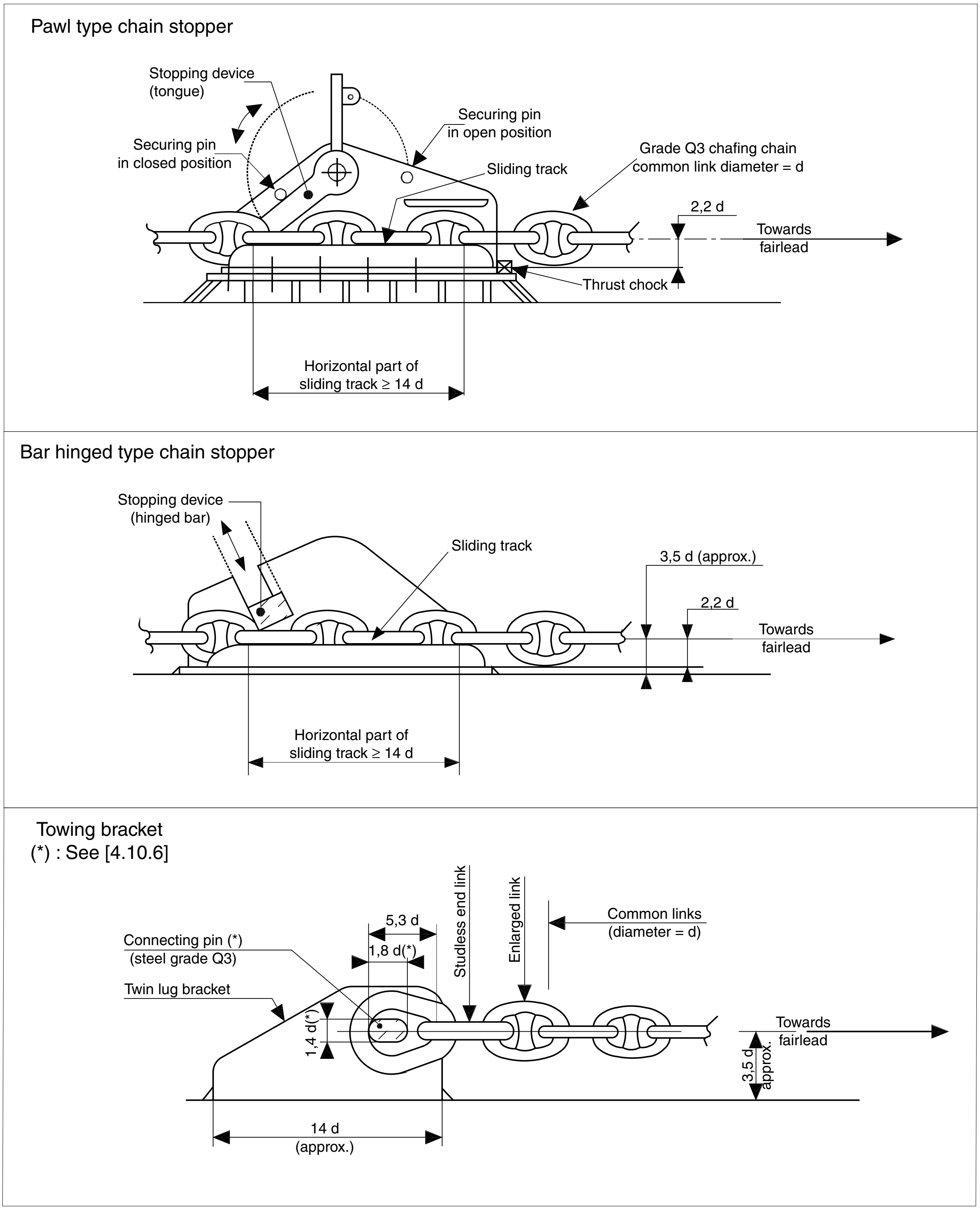
Component	Material		Equipment	
	Certificate	Reference of applicable requirements	Certificate	Reference of applicable requirements
Towing pennant	Not applicable	[4.7.1]	COI **(1)**	[4.7]
Chafing chain and associated accessories	COI **(2)**	[4.8.3]	COI **(1)**	[4.8]
Fairleads	CW	[4.9.2]	COI	[4.9]

(1) according to Pt D, Ch 4, Sec 1.
(2) according to Part D, Chapter 1.
(3) to be type approved.
(4) may be type approved.
Note 1:
COI : certificate of inspection,
CW : works' certificate 3.1.B according to EN 10204.

Component	Material		Equipment	
	Certificate	Reference of applicable requirements	Certificate	Reference of applicable requirements
Strongpoint:			COI **(3)**	[4.10]
• main framing	COI **(2)**	[4.10.2]		
• stopping device	COI **(2)**	[4.10.2]		
Pick-up gear:				[4.11]
• rope	Not applicable	-	CW	[4.11.1] and [4.11.2]
• buoy	Not applicable	-	Not required **(4)**	[4.11.3]
• line-throwing appliance	Not applicable	-	Not required **(4)**	[4.11.4]
Pedestal roller fairlead	CW	-	Not required **(4)**	[4.12]

(1) according to Pt D, Ch 4, Sec 1.
(2) according to Part D, Chapter 1.
(3) to be type approved.
(4) may be type approved.
Note 1:
COI : certificate of inspection,
CW : works' certificate 3.1.B according to EN 10204.

Figure 13 : Typical strongpoint arrangement



APPENDIX 1 CRITERIA FOR DIRECT CALCULATION OF RUDDER LOADS

Symbols

ℓ_{10}, ℓ_{20}, ℓ_{30}, ℓ_{40} : lengths, in m, of the individual girders of the rudder system

ℓ_{50} : length, in m, of the solepiece (see Fig 3)

J_{10}, J_{20}, J_{30}, J_{40} : moments of inertia about the x axis, in cm^4, of the individual girders of the rudder system having lengths ℓ_{10}, ℓ_{20}, ℓ_{30}, ℓ_{40}. For rudders supported by a solepiece only, J_{20} indicates the moment of inertia of the pintle in the sole piece

J_{50} : moment of inertia about the z axis, in cm^4, of the solepiece (see Fig 3)

C_R : rudder force, in N, acting on the rudder blade, defined in Sec 1, [2.1.1]

C_{R1}, C_{R2} : rudder forces, in N, defined in Sec 1, [2.2.3]

E : Young’s modulus, in N/m^2

$E = 2{,}06\ 10^{11}\ N/m^2$

G : Shear elasticity modulus, in N/m^2

$G = 7{,}85\ 10^{10}\ N/m^2$

1 Criteria for direct calculation of the loads acting on the rudder structure

1.1 General

1.1.1 Application *(1/7/2016)*

The requirements of this Appendix apply to the following types of rudders:

- spade rudders (see Fig 1)
- spade rudders with trunk (see Fig 2)
- 2 bearing rudders with solepiece (see Fig 3)
- 2 bearing semi-spade rudders with rudder horn (see Fig 4)
- semi-spade rudders with 2-conjugate elastic support (see Fig 7)

The requirements of this Appendix provide the criteria for calculating the following loads:

- bending moment M_B in the rudder stock
- support forces F_A
- bending moment M_R and shear force Q_R in the rudder body

1.1.2 Load calculation *(1/7/2016)*

The loads in [1.1.1] are to be calculated through direct calculations depending on the type of rudder.

They are to be used for the stress analysis required in:

- Sec 1, [4], for the rudder stock
- Sec 1, [6], for the rudder pintles and the pintle bearings
- Sec 1, [7] for the rudder blade
- Sec 1, [8] for the solepiece and the rudder trunk.

1.2 Data for the direct calculation

1.2.1 Forces per unit length *(1/7/2016)*

The force per unit length p_R (see Fig 1) acting on the rudder body is to be obtained in N/m, from the following formula:

$$p_R = \frac{C_R}{l_{10}}$$

1.2.2 Moments and forces *(1/7/2016)*

For spade rudders, the results of direct calculations carried out in accordance with [1.1.2] may be expressed in an analytical form. The loads in [1.1.1] may therefore be obtained from the following formulae (See Fig 1):

- maximum bending moment M_B in the rudder stock, in N.m:

$$M_B = C_R\left(\ell_{20} + \frac{\ell_{10}(2C_1 + C_2)}{3(C_1 + C_2)}\right)$$

where C_1 and C_2 are the lengths, in m, defined in Fig 1

- support forces, in N:

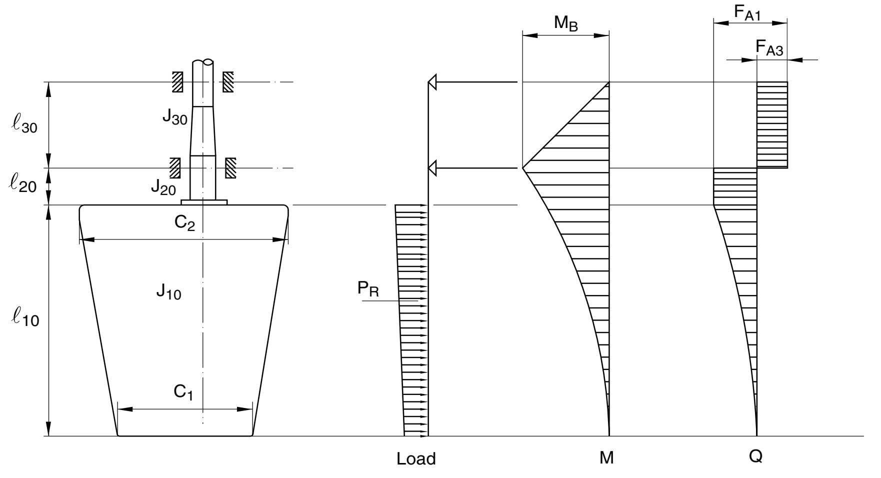
$$F_{A3} = \frac{M_B}{\ell_{30}}$$

$$F_{A1} = C_R + F_{A3}$$

- maximum shear force in the rudder body, in N:

$Q_R = C_R$

Figure 1 : Spade rudders *(1/7/2016)*



1.3 Spade rudders with trunk

1.3.1 Force per unit length *(1/7/2016)*

The force per unit length p_R (see Fig 2) acting on the rudder body is to be obtained, in N/m, from the following formula:

$$p_R = \frac{C_R}{\ell_{10} + \ell_{20}}$$

1.3.2 Moments and forces *(1/7/2019)*

For spade rudders with trunk, the results of direct calculations carried out in accordance with [1.1.2] may be expressed in an analytical form. The loads in [1.1.1] may therefore be obtained from the following formulae (see Fig 2):

- Bending moment M_R for the scantling of the rudder blade, in N·m, shall be taken as the greatest of the following values:

$M_{CR2} = C_{R2} (\ell_{10} - \ell_{CG2})$

$M_{CR1} = C_{R1} (\ell_{CG1} - \ell_{10})$

where:

C_{R1} : Rudder force over the rudder blade area A_1

C_{R2} : Rudder force over the rudder blade area A_2

ℓ_{CG1} : Vertical position of the centre of gravity of the rudder blade area A_1 from base

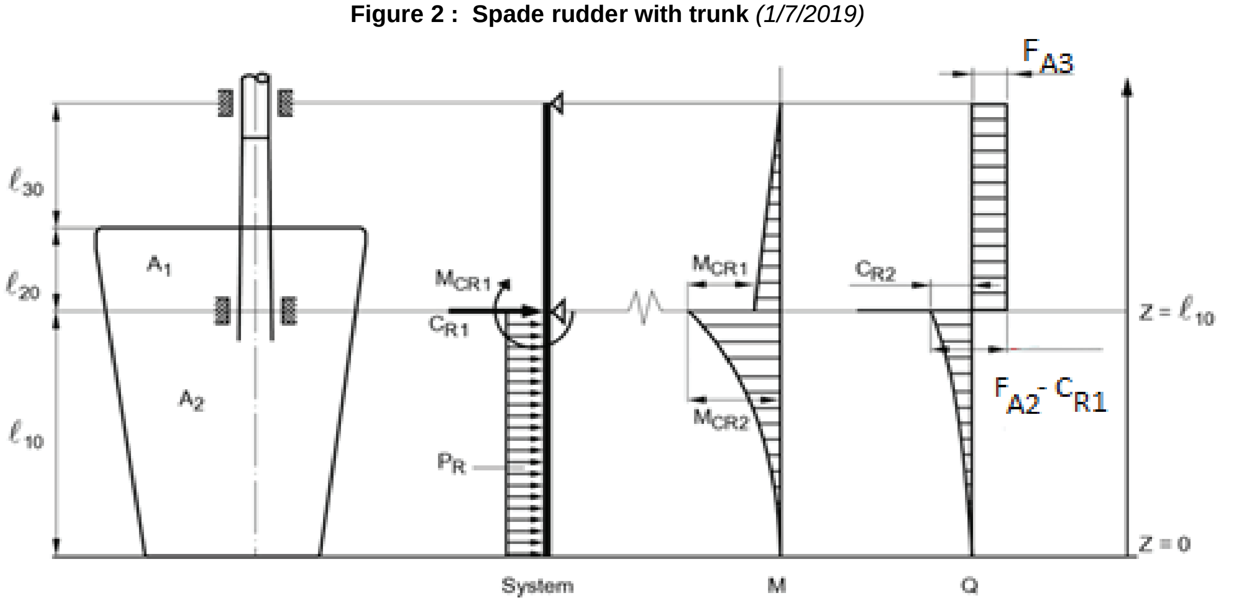
ℓ_{CG2} : Vertical position of the centre of gravity of the rudder blade area A_2 from base

- $C_R = C_{R1} + C_{R2}$
- Support forces F_{A2} and F_{A3}, in N:

$F_{A3} = (MC_{R2} - M_{CR1})/(\ell_{20} - \ell_{30})$

$F_{A2} = C_R + F_{A3}$

Figure 2 : Spade rudder with trunk *(1/7/2019)*



1.4 Two bearing rudders with solepiece

1.4.1 Force per unit length *(1/7/2016)*

The force per unit length p_R (see Fig 3) acting on the rudder body is to be obtained, in N/m, from the following formula:

$$p_R = \frac{C_R}{\ell_{10}}$$

1.4.2 Support spring *(1/7/2016)*

The spring constant Z_C for the support in the solepiece (see Fig 3) is to be obtained, in N/m, from the following formula:

$$Z_C = \frac{6180 \cdot CJ_{50}}{\ell_{50}^3}$$

1.5 Two bearing semi-spade rudders with rudder horn

1.5.1 Force per unit length *(1/7/2016)*

The forces per unit length p_{R10} and p_{R20} (see Fig 4) acting on the rudder body are to be obtained, in N/m, from the following formulae:

$$p_{R10} = \frac{C_{R2}}{\ell_{10}}$$

$$p_{R20} = \frac{C_{R1}}{\ell_{20}}$$

1.5.2 Support spring *(1/1/2021)*

The spring constant Z_P for the support in the rudder horn (see Fig 4) is to be obtained, in N/m, from the following formula:

$$Z_P = \frac{1}{f_B + f_T}$$

where:

- f_B : unit displacement of rudder horn due to a unit force of 1 N acting in the centroid of the rudder horn, to be obtained, in m/N, from the following formula:

$$f_B = 1{,}3\frac{d^3}{6180 J_N}$$

- d : height, in m, of the rudder horn, defined in Fig 4. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle.
- J_N : moment of inertia of rudder horn about the x axis, in cm⁴ (see Fig 5)
- f_T : unit displacement of rudder horn due to torsion to be obtained, in m/N, from the following formula:

$$f_T = 10^{-8}\frac{de^2}{3140 F_T^2}\sum_i \frac{u_i}{t_i}$$

- b, e : lengths, in m, defined in Fig 4
- F_T : mean sectional area of rudder horn, in m²
- u_i : length, in mm, of the individual plates forming the mean horn sectional area
- t_i : thickness of the individual plates mentioned above, in mm.

Figure 3 : Two bearing rudders with solepiece *(1/7/2016)*

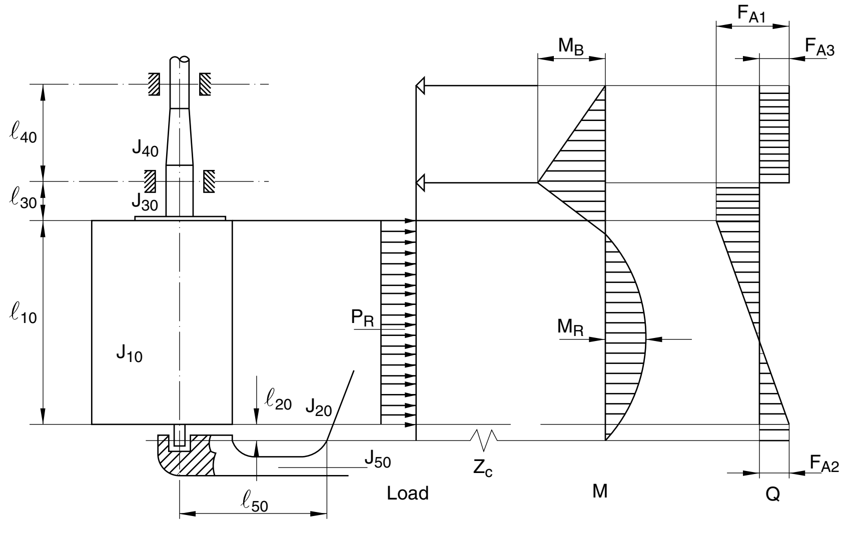
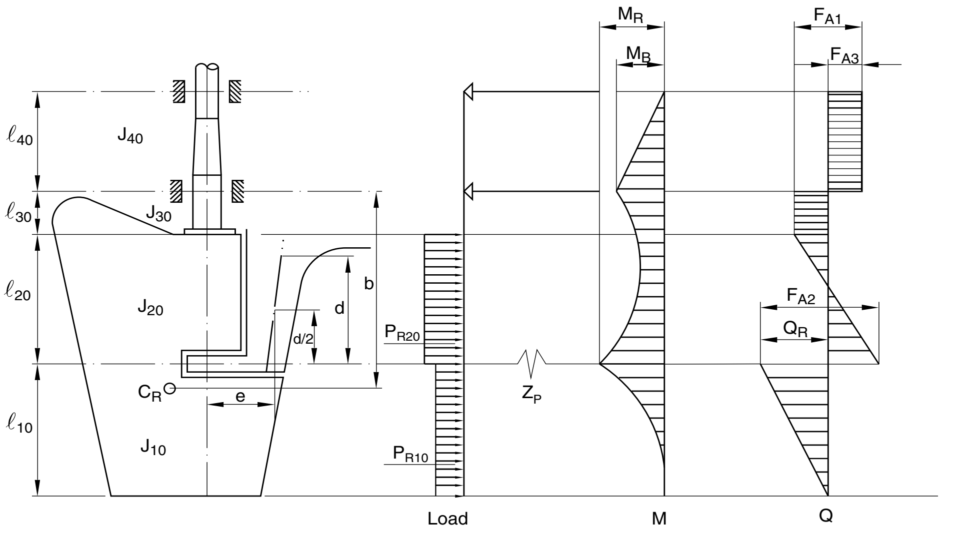


Figure 4 : Two bearing semi-spade rudders with rudder horn *(1/7/2016)*



1.6 Rudders horn calculation (case of Two bearing semi-spade rudders)

1.6.1 Bending moment *(1/7/2016)*

For two bearing semi-spade rudders, the bending moment acting on the generic section of the rudder horn is to be obtained, in N·m, from the following formula:

$$M_H = F_{A2} z$$

where:

F_{A2} : support force, in N, to be determined through a direct calculation to be performed in accordance with the static scheme and the load condition specified in [1.5]. As an alternative, it may be obtained from the following formula:

$$F_{A2} = C_R \frac{b}{\ell_{20} + \ell_{30}}$$

b, ℓ_{20}, ℓ_{30}: height, in m, of the rudder horn, defined in Fig 5

z : distance, in m, defined in Fig 6, in any case to be taken less than the distance d, in m, defined in the same figure.

Figure 5 : Rudder and rudder horn geometries (Two bearing semi-spade rudder) *(1/7/2016)*

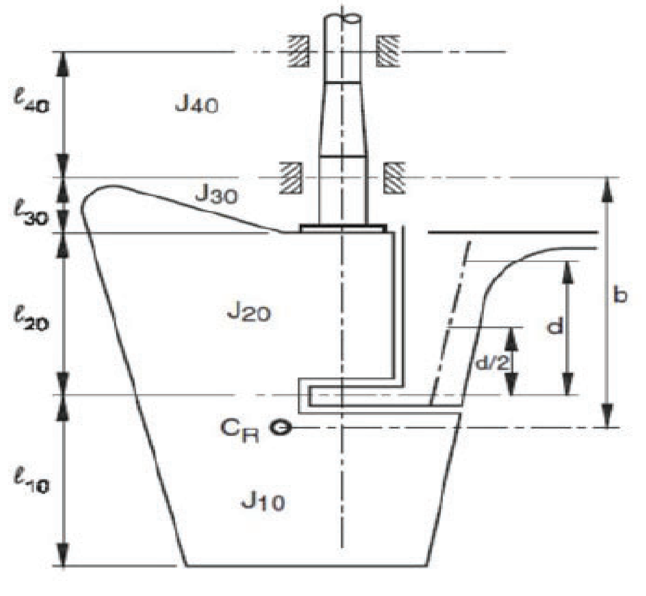
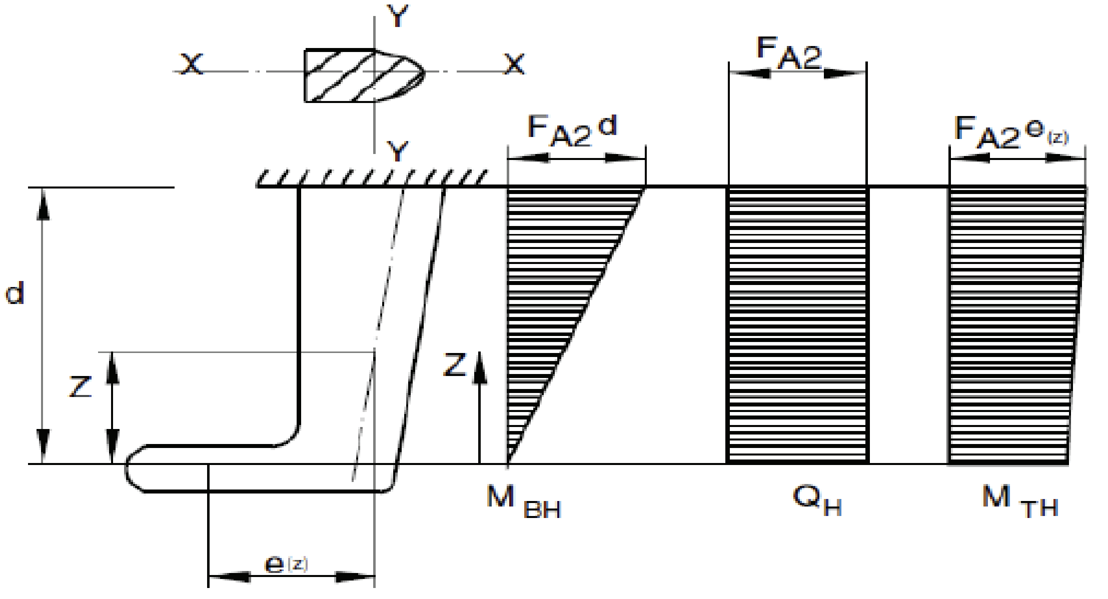


Figure 6 : Rudder horn geometry (Two bearing semi-spade rudder) *(1/7/2016)*



1.6.2 Shear force *(1/7/2016)*

The shear force Q_H acting on the generic section of the rudder horn is to be obtained, in N, from the following formula:

$$Q_H = F_{A2}$$

F_{A2} : force, in N, defined in [1.6.1].

1.6.3 Torque *(1/7/2016)*

The torque acting on the generic section of the rudder horn is to be obtained, in N, from the following formula:

$$M_T = F_{A2} e_{(z)}$$

where:

F_{A2} : force, in N, defined in [1.6.1]

$e_{(z)}$: torsion lever, in m, defined in Fig 6.

1.6.4 Stress calculations *(1/7/2019)*

For the generic section of the rudder horn, the following stresses are to be calculated:

σ_B : bending stress to be obtained, in N/mm², from the following formula:

$$\sigma_B = \frac{M_H}{M_X}$$

M_H : bending moment at the section considered, in N m, defined in [1.6.1]

W_X : section modulus, in cm³, around the horizontal axis X (see Fig 6)

τ_S : shear stress to be obtained, in N/mm², from the following formula:

$$\tau_S = \frac{F_{A2}}{A_H}$$

F_{A2} : force, in N, defined in [1.6.1]

A_H : effective shear sectional area of the rudder horn in Y direction, in mm²

τ_T : torsional stress to be obtained for the hollow rudder horn, in N/mm², from the following formula:

$$\tau_T = \frac{M_T \cdot 10^{-3}}{2 A_T t_H}$$

For solid rudder horn, τ_T is to be considered by the Society on a case by case basis

M_T : torque, in N m, defined in [1.6.3]

A_T : area of the horizontal section enclosed by the rudder horn, in m²

t_H : plate thickness of the rudder horn, in mm.

1.7 Semi-spade rudders with 2-conjugate elastic support

1.7.1 Force per unit length *(1/7/2016)*

The force per unit length p_{R10} and p_{R20} (see Fig 7) acting on the rudder body is to be obtained, in N/m, from the following formulae:

$$p_{R10} = \frac{C_R}{\ell_{10}}$$

$$p_{R20} = \frac{C_R}{\ell_{20}}$$

1.7.2 Support stiffness properties *(1/7/2016)*

The 2-conjugate elastic supports (see Fig 7) are defined in terms of horizontal displacements y_i by the following equations:

- At the lower rudder horn bearing:

$$y_1 = K_{12} F_{A2} - K_{22} F_{A1}$$

- At the upper rudder horn bearing:

$$y_2 = K_{11} F_{A2} - K_{12} F_{A1}$$

where:

y_1, y_2 : Horizontal displacements, in m, at the lower and upper rudder horn bearings, respectively.

F_{A1}, F_{A2} : Horizontal support forces, in N, at the lower and upper rudder horn bearings, respectively

K_{11}, K_{22}, K_{12} : Rudder horn compliance constants obtained, in m/N, from the following formulae:

$$K_{11} = 1,3 \cdot \frac{\lambda^3}{3EJ_{1h}} + \frac{e^2 \cdot \lambda}{GJ_{th}}$$

$$K_{12} = 1,3 \cdot \left[\frac{\lambda^2}{3EJ_{1h}} + \frac{\lambda^2 \cdot (d-\lambda)}{2EJ_{1h}}\right] + \frac{e^2 \cdot \lambda}{GJ_{th}}$$

$$K_{22} = 1,3 \cdot \left[\frac{\lambda^2}{3EJ_{1h}} + \frac{\lambda^2 \cdot (d-\lambda)}{EJ_{1h}} + \frac{\lambda \cdot (d-\lambda)^2}{EJ_{2h}} + \frac{(d-\lambda)^3}{3EJ_{2h}}\right] + \frac{e^2 d}{GJ_{th}}$$

where:

d : Height of the rudder horn, in m, defined in Fig 8 and Fig 9. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, till the mid-line of the lower rudder horn pintle

λ : Length, in m, as defined in Fig 8 and Fig 9. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, till the mid-line of the upper rudder horn bearing. For $\lambda = 0$, the above formulae converge to those of spring constant Z for a rudder horn with 1-elastic support (see [1.5.2]), and assuming a hollow cross-section for this part.

e : Rudder horn torsion lever, in m, as defined in Fig 8 and Fig 9 (value taken as z = d/2)

J_{1h} : Moment of inertia of rudder horn about the x axis, in m^4, for the region above the upper rudder horn bearing. Note that J_{1h} is an average value over the length see Fig 9)

J_{2h} : Moment of inertia of rudder horn about the x axis, in m^4, for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length d - λ (see Fig 9)

J_{th} : Torsional stiffness factor of the rudder horn, in m^4.

For any thin wall closed section:

$$J_{th} = \frac{4F_T^2}{\Sigma_i \frac{u_i}{t_i}}$$

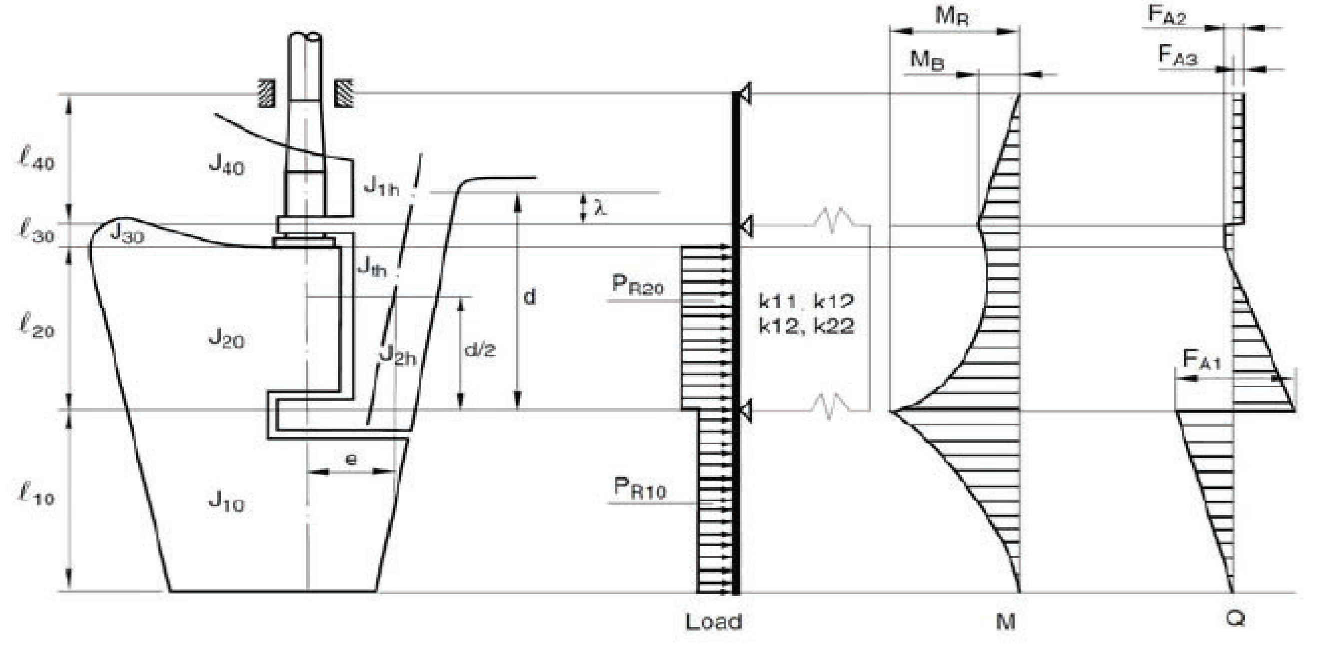
F_T : Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, in m^2

t_i : Length, in mm, of the individual plates forming the mean horn sectional area

u_i : Thickness, in mm, of the individual plates mentioned above

Note that the J_{th} value is taken as an average value, valid over the rudder horn height.

Figure 7 : Semi-spade rudders with 2-conjugate elastic support



1.8 Rudder horn calculation (case of Semi-spade rudder with 2-conjugate elastic support)

1.8.1 Bending moment *(1/7/2016)*

For semi-spade rudders with 2-conjugate elastic support, the bending moment acting on the generic section of the rudder horn is to be obtained, in N m, from the following formulae:

- between the lower and upper supports provided by the rudder horn:

$$M_H = F_{A1} z$$

- above the rudder horn upper-support:

$$M_H = F_{A1} z + F_{A2}(z - d_{lu})$$

where:

F_{A1} : support force at the rudder horn lower-support, in N, to be obtained through a direct calculation to be performed in accordance with the static scheme and the load condition specified in [1.7]

F_{A2} : support force at the rudder horn upper-support, in N, to be obtained through a direct calculation to be performed in accordance with the static scheme and the load condition specified in [1.7]

z : distance, in m, defined in Fig 9, in any case to be taken less than the distance d, in m, defined in the same figure

d_{lu} : distance, in m, defined in Fig 8, between the rudder horn lower and upper support (according to Fig 8, $d_{lu} = d - \lambda$).

Figure 8 : Rudder horn geometry (Semi-spade rudder with 2-conjugate elastic support) *(1/7/2016)*

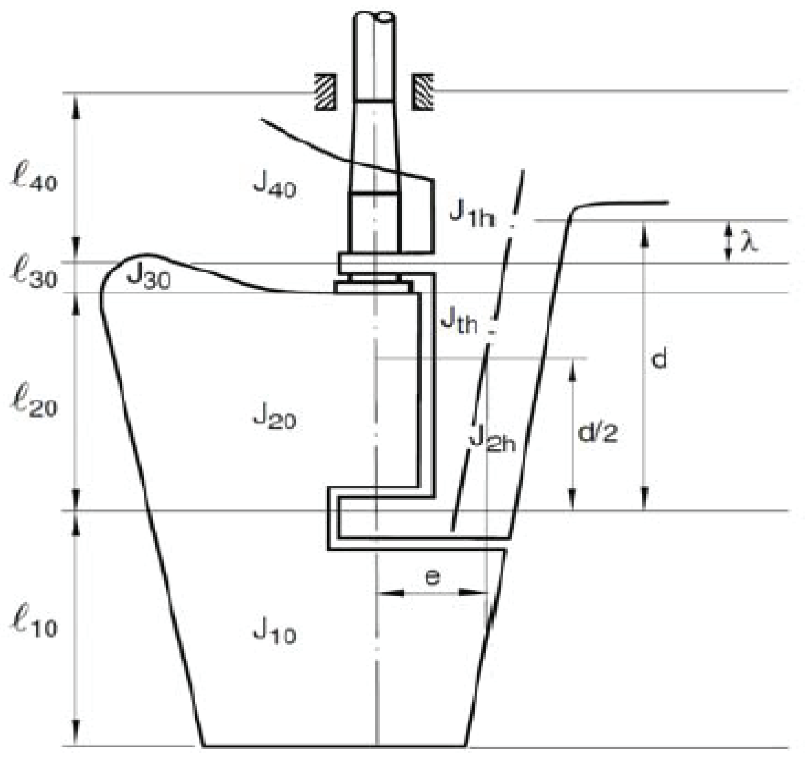
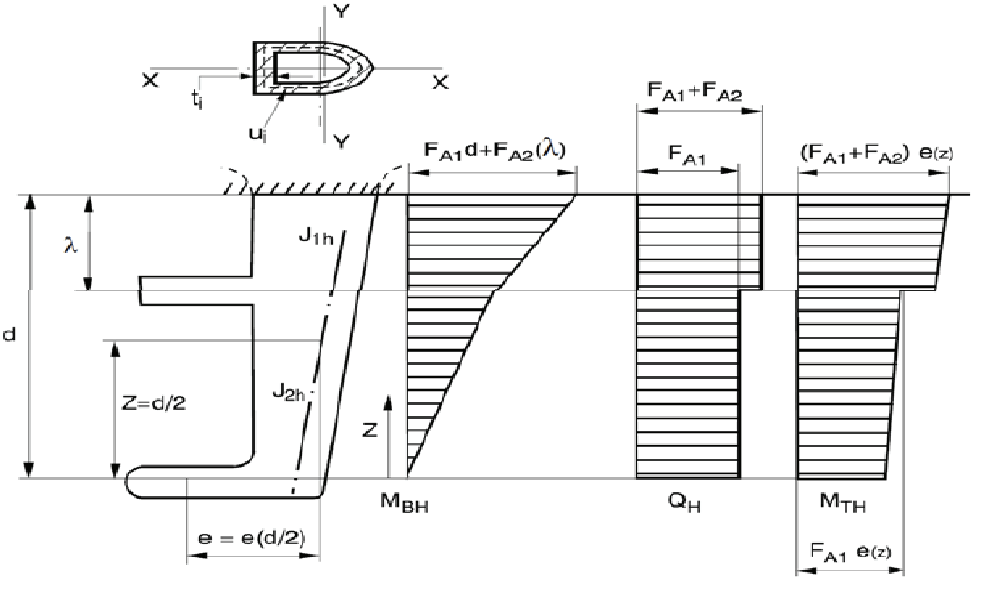


Figure 9 : Rudder and rudder geometries (Semi-spade rudder with 2-conjugate elastic support) *(1/7/2016)*



1.8.2 Shear force *(1/7/2016)*

The shear force Q_H acting on the generic section of the rudder horn is to be obtained, in N, from the following formula:

- between the lower and upper supports provided by the rudder horn:

$$Q_H = F_{A1}$$

- above the rudder horn upper-support:

$$Q_H = F_{A1} + F_{A2}$$

F_{A1}, F_{A2} : support forces, in N, defined in [1.8.1].

1.8.3 Torque *(1/7/2016)*

The torque acting on the generic section of the rudder horn is to be obtained, in N, from the following formulae:

- between the lower and upper supports provided by the rudder horn:

$$M_T = F_{A1}e_{(z)}$$

- above the rudder horn upper-support:

$$M_T = F_{A1}e_{(z)} + F_{A2}e_{(z)}$$

where:

F_{A1}, F_{A2} : support force at the rudder horn lower-support, in N, to be obtained through a direct calculation to be performed in accordance with the static scheme and the load condition specified in [1.7]

$e_{(z)}$: torsion lever, in m, defined in Fig 9.

1.8.4 Shear stress calculation *(1/7/2019)*

a) For a generic section of the rudder horn, located between its lower and upper support, the following stresses are to be calculated:

τ_S : shear stress to be obtained, in N/mm², from the following formula:

$$\tau_S = \frac{F_{A1}}{A_H}$$

τ_T : torsional stress to be obtained for the hollow rudder horn, in N/mm², from the following formula:

$$\tau_T = \frac{M_T \cdot 10^{-3}}{2F_T t_H}$$

For solid rudder horn, τ_T is to be considered by the Society on a case by case basis.

b) For a generic section of the rudder horn, located in the region above its upper support, the following stresses are to be calculated:

τ_S : shear stress to be obtained, in N/mm², from the following formula:

$$\tau_S = \frac{F_{A1} + F_{A2}}{A_H}$$

τ_T : torsional stress to be obtained for the hollow rudder horn, in N/mm², from the following formula:

$$\tau_T = \frac{M_T \cdot 10^{-3}}{2F_T t_H}$$

For solid rudder horn, τ_T is to be considered by the Society on a case by case basis.

where:

F_{A1}, F_{A2} : support forces, in N, defined in [1.8.1]

A_H : effective shear sectional area of the rudder horn in Y direction, in mm²

M_T : torque, in N, defined in [1.8.3]

F_T : mean of areas enclosed by outer and inner boundaries of the thin walled section of the rudder horn, in m^2.

t_h : plate thickness of the rudder horn, in mm. For a given cross of the rudder horn, the maximum value of τ_H, is obtained at the minimum value of t_H.

1.8.5 Bending moment stress calculation *(1/7/2016)*

For the generic section of the rudder horn within the length d, defined in Fig 9, the following stresses are to be calculated:

σ_B : bending stress to be obtained, in N/mm², from the following formula:

$$\sigma_B = \frac{M_H}{M_X}$$

M_H : bending moment at the section considered, in N m, defined in [1.8.1]

W_X : section modulus, in cm³, around the horizontal axis X (see Fig 9).

APPENDIX 2 MOORING LINES FOR SHIPS WITH EN > 2000

1 General

1.1 Application

1.1.1 *(1/7/2018)*

The requirements of this Appendix apply for the determination of the minimum strength and number of mooring lines for ships with an Equipment number EN > 2000. The length of mooring lines is given in Sec 4, [3.5.6].

1.2 Definitions

1.2.1 Breast line *(1/7/2018)*

Breast line is a mooring line that is deployed perpendicular to the ship, restraining the ship in the off-berth direction (see Fig 1).

1.2.2 Spring line *(1/7/2018)*

Spring line is a mooring line that is deployed almost parallel to the ship, restraining the ship in the fore or aft direction (see Fig 1).

1.2.3 Head/Stern line *(1/7/2018)*

Head/Stern line is a mooring line that is oriented between longitudinal and transverse direction, restraining the ship in the off-berth and in fore or aft direction. The amount of restraint in fore or aft and off-berth direction depends on the line angle relative to these directions (see Fig 1).

1.3 Calculation of side projected area A_1

1.3.1 *(1/1/2022)*

The strength of mooring lines and the number of head, stern, and breast lines (see Note) for ships with an Equipment Number EN > 2000 are based on the side-projected area A1. Side projected area A1 is to be calculated similar to the side-projected area A according to Sec 4, [2.1] but considering the following conditions:

- The ballast draft is to be considered for the calculation of the side-projected area A1For ship types having small variation in the draft, like e.g. passenger and RO/RO vessels, the side projected area A1 may be calculated using the summer load waterline;
- wind shielding of the pier can be considered for the calculation of the side-projected area A1 unless the ship is intended to be regularly moored to jetty type piers. A height of the pier surface of 3 m over waterline may be assumed, i.e. the lower part of the side projected area with a height of 3 m above the waterline for the considered loading condition may be disregarded for the calculation of the side-projected area A_1;
- deck cargoes at the ship nominal capacity condition is to be included for the determination of side-projected area A_1. For the condition with cargo on deck, the summer load waterline may be considered. Deck cargoes may not need to be considered if ballast draft condition generates a larger side-projected area A_1 than the full load condition with cargoes on deck. The larger of both side-projected areas is to be chosen as side-projected area A_1. The nominal capacity condition is defined in Sec 4, [1.2].

1.4 Environmental conditions

1.4.1 Current *(1/7/2018)*

The mooring lines characteristics, as given in this Appendix, are based on a maximum current speed of 1 m/s.

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

1.4.2 Wind *(1/7/2018)*

The mooring lines characteristics, as given in this Appendix, are based on the maximum wind speed v_W, in m/s, given in the following.

- for ships with one of the service notations ro-ro cargo ships, passenger ship or ro-ro passenger ship:

  $v_W = 25 - 0{,}002\,(A_1 - 2000)$ for $2000\ m^2 \leq A_1 \leq 4000\ m^2$

  $v_W = 21$ for $A_1 \geq 4000\ m^2$

- for other ship types:

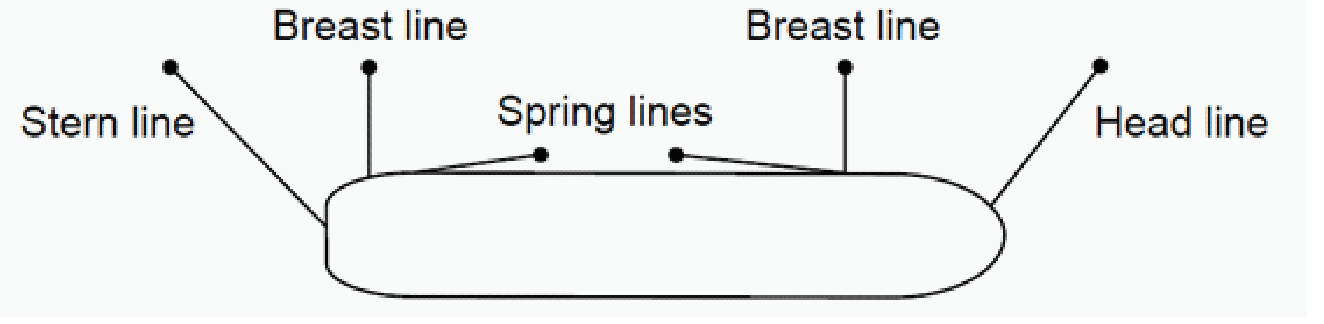
  $v_W = 25$

The wind speed is considered representative of a 30 second mean speed from any direction and at a height of 10 m above the ground.

1.4.3 Additional loads *(1/7/2018)*

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

Figure 1 : Mooring lines *(1/7/2018)*



2 Mooring lines characteristics

2.1 Ship Design Minimum Breaking Load

2.1.1 *(1/1/2022)*

The Ship Design Minimum Breaking Load, in kN, is to be obtained from the following formula:

$MBL_{SD} = 0{,}1A_1 + 350$

2.1.2 *(1/1/2022)*

The Ship Design Minimum Breaking Load may be limited to 1275 kN. However, in this case the moorings are to be considered as not sufficient for environmental conditions given in [1.4]. For these ships, the acceptable wind speed v_W*, in m/s, can be estimated from the following formula:

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

where:

- v_W : wind speed, in m/s, given in [1.4.2]
- MBL_{SD} : Ship Design Minimum Breaking Load, in kN, according to the formulation given in [2.1.1]
- MBL_{SD}* : Ship Design Minimum Breaking Load of the mooring lines intended to be supplied, not to be taken less than corresponding to an acceptable wind speed of 21 m/s:

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

2.1.3 *(1/1/2022)*

If lines are intended to be supplied for an acceptable wind speed v_W* higher than v_W given in [1.4.2], the Ship Design Minimum Breaking Load is to be obtained from the following formula:

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

2.2 Number of mooring lines

2.2.1 *(1/7/2018)*

The total number of head, stern and breast lines, rounded to the nearest whole number, is to be taken as:

- For oil tankers, chemical tankers, bulk carriers and ore carriers:

  $n = 8{,}3\ 10^{-4}\ A_1 + 4$
- For other ship types:

  $n = 8{,}3\ 10^{-4}\ A_1 + 6$

2.2.2 *(1/1/2022)*

The number of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the Ship Design Minimum Breaking Load of the lines. The adjusted Ship Design Minimum Breaking Load, MBL_{SD}**, is to be obtained from the following formulae:

for increased number of lines:

$MBL_{SD}^{**} = 1{,}2\ MBL_{SD}\ n/n^{**} \leq MBL_{SD}$

for reduced number of lines:

$MBL_{SD}^{**} = MBL_{SD}\ n/n^{**}$

where:

- MBL_{SD} : is MBL_{SD} or MBL_{SD}* defined in [2.1], as appropriate
- n : number of lines for the considered ship type as calculated by the above formulas without rounding
- n** : increased or decreased total number of head, stern and breast lines

Vice versa, the Ship Design Minimum Breaking Loadof head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the number of lines.

2.2.3 *(1/1/2022)*

The total number of spring lines is to be taken not less than:

- 2 spring lines for EN < 5000
- 4 spring lines for EN ≥ 5000

The Ship Design Minimum Breaking Load of spring lines is to be the same as that of the head, stern and breast lines. If the number of head, stern and breast lines is increased in conjunction with an adjustment to the Ship Design Minimum Breaking Load of the lines, the number of spring lines is to be taken as follows, but rounded up to the nearest even number.

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

where:

- MBL_{SD} : is MBL_{SD} or MBL_{SD}* defined in [2.1], as appropriate
- n_s : number of spring lines as given above
- n_s* : increased number of spring lines

APPENDIX 3 DIRECT MOORING ANALYSES

1 General

1.1

1.1.1 *(1/1/2022)*

As an alternative to the prescriptive approach in Sec 4, [3.5.3] and Sec 4, [3.5.4], direct mooring analysis may be performed to determine the necessary mooring restraint, i.e. number and strength of mooring lines.

Direct analyses allow to optimize mooring equipment and arrangement for the individual ship and the port mooring facilities typical for the considered ship type and size.

2 Documentation

2.1

2.1.1 *(1/1/2022)*

The calculations are to be documented in a report. The report is to include all assumptions made in calculations for the finally chosen mooring equipment, including lines, and its arrangement, reflected in the mooring arrangement plan as required by Sec 4, [3.1.17].

3 Analysis methodology

3.1

3.1.1 *(1/1/2022)*

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

4 Environmental conditions

4.1

4.1.1 *(1/1/2022)*

Mooring line forces are to be calculated for environmental conditions given in Sec 4, [3.5.4]. Additional loads, e.g. wave loads or cross currents, or increased wind and current loads are to be considered for certain ship types or for specific ports intended to be regularly called.

5 Steps to be taken in a direct mooring analysis

5.1

5.1.1 *(1/1/2022)*

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

a) Determine port mooring facilities representative for the considered ship type and size

b) Determine shipboard mooring equipment and arrangement

c) Determine mooring line type(s) to be used

d) Determine mooring layout(s) to be assessed

e) Determine ship loading condition(s) to be assessed

f) Select or determine wind and current drag coefficients

g) Determine wind and current forces and moments

h) Compute forces acting on all mooring line

i) Determine necessary strength of mooring lines

j) If strength of mooring lines should be altered, modify steps b), c) and/or d) with or without changing the number of mooring lines and repeat steps h) and i).

6 Port mooring facilities

6.1

6.1.1 *(1/1/2022)*

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

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

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

7 Shipboard mooring equipment and arrangement

7.1

7.1.1 *(1/1/2022)*

The mooring equipment and arrangement is to be chosen for the mooring analysis, i.e. location of mooring decks and location of mooring winches and fairleads. As a starting point, mooring equipment for the number of lines as determined by the prescriptive approach is to be chosen, (see App 2, [2.2]).

8 Mooring lines

8.1

8.1.1 *(1/1/2022)*

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

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

9 Mooring layout

9.1

9.1.1 *(1/1/2022)*

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

The maximum number of lines connected to one shore mooring point are to be limited to not load the shore side mooring points unrealistically high. For multipurpose piers the number of lines per shore bollard are to be limited to three. For other types of berths, the number mooring lines per shore mooring point is also limited, e.g., by the available number of hooks. Reasonable assumptions are to be made based on typical berth types encountered by the considered ship type.

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

10 Loading conditions

10.1

10.1.1 *(1/1/2022)*

Mooring line forces are to be calculated for loading conditions given in Sec 4, [3.5.4].

11 Wind and current drag coefficients

11.1

11.1.1 *(1/1/2022)*

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

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

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

12 Calculation of wind and current forces and moments

12.1

12.1.1 *(1/1/2022)*

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

Wind forces and moments are to be calculated for all directions in intervals of preferably 15°, but not more than 30°. Current forces and moments are to be calculated for selected directions as per Sec 4, [3.5.4]. For ships regularly moored to non-solid piers or jetties, cross current is to be considered in addition.

13 Calculation of mooring line forces

13.1

13.1.1 *(1/1/2022)*

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

In case of all lines are intended to be attached to winches, brake rendering is to be considered to better distribute line loads among all lines in a group of lines in the same service. Then, the average mooring line force of a group of lines is to be determined and taken as mooring line force used to determine the necessary strength of the mooring lines according to [14].

14 Strength of mooring lines

14.1

14.1.1 *(1/1/2022)*

The necessary strength of mooring lines, i.e., the Ship Design Minimum Breaking Load (MBL_{SD}), results from the calculated maximum mooring line force ($F_{L,\ max}$) divided by the Work Load Limit (WLL) factor of mooring lines. The WLL factor and the resulting MBL_{SD} for different mooring line materials are shown in Tab 1.

Table 1

Mooring line material	WLL factor	MBL_{SD}
Steel wire	0,55	$1{,}82 \cdot F_{L,\ max}$
Synthetic fibers	0,5	$2{,}0 \cdot F_{L,\ max}$

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

Part B
Hull and Stability

Chapter 11
CORROSION PROTECTION AND LOADING INFORMATION

SECTION 1 PROTECTION OF HULL METALLIC STRUCTURES

1 Protection by coating

1.1 General

1.1.1 It is the responsibility of the shipbuilder and the Owner to choose the coating and have it applied in accordance with the manufacturer's requirements.

1.2 Structures to be protected

1.2.1 All salt water ballast spaces with boundaries formed by the hull envelope are to have a corrosion protective coating, epoxy or equivalent, applied in accordance with the manufacturer's requirements.

1.2.2 Corrosion protective coating is not required for internal surfaces of spaces intended for the carriage of cargo oil or fuel oil.

1.2.3 Narrow spaces are generally to be filled by an efficient protective product, particularly at the ends of the ship where inspections and maintenance are not easily practicable due to their inaccessibility.

2 Cathodic protection

2.1 General

2.1.1 Internal structures in spaces intended to carry liquids may be provided with cathodic protection.

Cathodic protection may be fitted in addition to the required corrosion protective coating, if any.

2.1.2 Details concerning the type of anodes used and their location and attachment to the structure are to be submitted to the Society for approval.

2.2 Anodes

2.2.1 *(1/7/2003)*

Magnesium or magnesium alloy anodes are not permitted in oil cargo tanks and tanks adjacent to cargo tanks.

2.2.2 *(1/7/2003)*

Aluminium anodes are only permitted in cargo tanks and tanks adjacent to cargo tanks in locations where the potential energy does not exceed 28 kg m. The height of the anode is to be measured from the bottom of the tank to the centre of the anode, and its weight is to be taken as the weight of the anode as fitted, including the fitting devices and inserts.

However, where aluminium anodes are located on horizontal surfaces such as bulkhead girders and stringers not less than 1 m wide and fitted with an upstanding flange or face flat projecting not less than 75 mm above the horizontal surface, the height of the anode may be measured from this surface.

Aluminium anodes are not to be located under tank hatches or Butterworth openings, unless protected by the adjacent structure.

2.2.3 There is no restriction on the positioning of zinc anodes.

2.2.4 Anodes are to have steel cores and are to be declared by the Manufacturer as being sufficiently rigid to avoid resonance in the anode support and designed so that they retain the anode even when it is wasted.

2.2.5 The steel inserts are to be attached to the structure by means of a continuous weld. Alternatively, they may be attached to separate supports by bolting, provided a minimum of two bolts with lock nuts are used. However, other mechanical means of clamping may be accepted.

2.2.6 The supports at each end of an anode may not be attached to separate items which are likely to move independently.

2.2.7 Where anode inserts or supports are welded to the structure, they are to be arranged by the Shipyard so that the welds are clear of stress peaks.

2.3 Impressed current systems

2.3.1 Impressed current systems are not permitted in oil cargo tanks.

3 Protection against galvanic corrosion

3.1 General

3.1.1 Non-stainless steel is to be electrically insulated from stainless steel or from aluminium alloys.

3.1.2 Where stainless steel or aluminium alloys are fitted in the same tank as non-stainless steel, a protective coating is to cover both materials.

4 Protection of bottom by ceiling

4.1 General

4.1.1 In double bottom ships, ceiling is to be laid over the inner bottom and lateral bilges, if any.

Ceiling on the inner bottom is not required where the thickness of the inner bottom is increased in accordance with Ch 7, Sec 1, [2.3.1].

4.2 Arrangement

4.2.1 Planks forming ceiling over the bilges and on the inner bottom are to be easily removable to permit access for maintenance.

4.2.2 Where the double bottom is intended to carry fuel oil, ceiling on the inner bottom is to be separated from the plating by means of battens 30 mm high, in order to faclilitate the drainage of oil leakages to the bilges.

4.2.3 Where the double bottom is intended to carry water, ceiling on the inner bottom may lie next to the plating, provided a suitable protective composition is applied beforehand.

4.2.4 The Shipyard is to take care that the attachment of ceiling does not affect the tightness of the inner bottom.

4.2.5 In single bottom ships, ceiling is to be fastened to the reversed frames by galvanised steel bolts or any other equivalent detachable connection.

A similar connection is to be adopted for ceiling over the lateral bilges in double bottom ships.

4.3 Scantlings

4.3.1 The thickness of ceiling boards, when made of pine, is to be not less than 60 mm. Under cargo hatchways, the thickness of ceiling is to be increased by 15 mm.

Where the floor spacing is large, the thicknesses may be considered by the Society on a case by case basis.

5 Protection of decks by wood sheathing

5.1 General

5.1.1 Where decks are intended to carry specific loads, such as caterpillar trucks and unusual vehicles, the Society may require such decks wood sheathed.

5.2 Arrangement

5.2.1 Wood sheathing is to be fixed to the plating by welded studs or bolts of at least 12 mm in diameter, every second frame.

5.2.2 Before fitting the wood sheathing, deck plates are to be provided with protective coating declared to be suitable by the Shipyard.

Caulking is Shipyard’s responsibility.

5.3 Scantlings

5.3.1 The thickness of wood sheathing of decks is to be not less than:

- 65 mm if made of pine
- 50 mm if made of hardwood, such as teak.

The width of planks is not to exceed twice their thickness.

6 Protection of cargo sides by battens

6.1 General

6.1.1 The requirements in [6.2] apply to sides in cargo spaces of ships with the service notation **general cargo ship** or **livestock carrier**.

6.2 Arrangement

6.2.1 In the case of transversally framed sides, longitudinal battens formed by spaced planks are to be fitted to the frames by means of clips.

6.2.2 Where sides are longitudinally framed, battens are to be fitted vertically.

6.2.3 Battens are to extend from the bottom of the cargo space to at least the underside of the beam knees.

6.2.4 Cargo battens are to be not less than 50 mm in thickness and 150 mm in width. The space between battens is not to exceed 300 mm.

SECTION 2 LOADING MANUAL AND LOADING INSTRUMENTS

1 Definitions

1.1 Perpendiculars

1.1.1 Forward perpendicular

The forward perpendicular is the perpendicular to the waterline at the forward side of the stem on the summer load waterline

1.1.2 After perpendicular

The after perpendicular is the perpendicular to the waterline at the after side of the rudder post on the summer load waterline. For ships without rudder post, the after perpendicular is the perpendicular to the waterline at the centre of the rudder stock on the summer load waterline.

1.1.3 Midship perpendicular

The midship perpendicular is the perpendicular to the waterline at half the distance between forward and after perpendiculars.

2 Loading manual and loading instrument requirement criteria

2.1 Ship categories

2.1.1 Category I ships

- Ships with large deck openings where combined stresses due to vertical and horizontal hull girder bending and torsional and lateral loads need to be considered
- Ships liable to carry non-homogeneous loadings, where the cargo and/or ballast may be unevenly distributed; exception is made for ships less than 120 metres in length, when their design takes into account uneven distribution of cargo or ballast: such ships belong to Category II
- Ships having the service notation **chemical tanker ESP** or **liquefied gas carrier**.

2.1.2 Category II ships

- Ships whose arrangement provides small possibilities for variation in the distribution of cargo and ballast
- Ships on a regular and fixed trading pattern where the loading manual gives sufficient guidance
- the exception given under Category I.

2.2 Requirement criteria

2.2.1 All ships *(1/7/2010)*

An approved loading manual is to be supplied for all ships, except those of Category II less than 90 m in length in which the deadweight does not exceed 30% of the displacement at the summer loadline draught.

For ships with length less than 65 m, the Society may waive the above-mentioned request for an approved loading manual at its discretion taking into account the ship's service and arrangement.

In addition, an approved loading instrument is to be supplied for all ships of Category I equal to or greater than 100 m in length.

The loading instrument is ship specific onboard equipment and the results of the calculations are only applicable to the ship for which it has been approved.

An approved loading instrument may not replace an approved loading manual.

2.2.2 Bulk carriers, ore carriers and combination carriers equal to or greater than 150 m in length

Ships with one of the service notations **bulk carrier ESP**, **ore carrier ESP** or **combination carrier ESP**, and equal to or greater than 150 m in length, are to be provided with an approved loading manual and an approved computer-based loading instrument, in accordance with the applicable requirements of this Section.

3 Loading manual

3.1 Definitions

3.1.1 All ships

A loading manual is a document which describes:

- the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moment and shear force
- the results of the calculations of still water bending moments, shear forces and, where applicable, limitations due to torsional and lateral loads
- the allowable local loading for the structure (hatch covers, decks, double bottom, etc.).

3.1.2 Bulk carriers, ore carriers and combination carriers equal to or greater than 150 m in length *(1/7/2001)*

In addition to [3.1.1], for ships with one of the service notations **bulk carrier ESP**, **ore carrier ESP** or **combination carrier ESP**, and equal to or greater than 150 m in length, the loading manual is also to describe:

- for ships with the service notation **bulk carrier ESP**: envelope results and permissible limits of still water bending moments and shear forces in the hold flooded condition, as applicable according to Pt E, Ch 4, Sec 3, [5.1.1].

- the cargo hold(s) or combination of cargo holds which might be empty at full draught. If no cargo hold is allowed to be empty at full draught, this is to be clearly stated in the loading manual.
- maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position
- maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions.
- maximum allowable tank top loading together with specification of the nature of the cargo for cargoes other than bulk cargoes
- maximum allowable load on deck and hatch covers. If the ship is not approved to carry load on deck or hatch covers, this is to be clearly stated in the loading manual.
- the maximum rate of ballast change together with the advice that a load plan is to be agreed with the terminal on the basis of the achievable rates of change of ballast.

3.2 Conditions of approval

3.2.1 All ships

The approved loading manual is to be based on the final data of the ship. The manual is to include the design (cargo and ballast) loading conditions, subdivided into departure and arrival conditions as appropriate, upon which the approval of the hull scantlings is based, defined in Ch 5, Sec 2, [2.1.2].

In the case of modifications resulting in changes to the main data of the ship, a new approved loading manual is to be issued.

3.2.2 Bulk carriers, ore carriers and combination carriers equal to or greater than 150 m in length

In addition to [3.2.1], for ships with one of the service notations **bulk carrier ESP**, **ore carrier ESP** or **combination carrier ESP**, and equal to or greater than 150 m in length, the following loading conditions, subdivided into departure and arrival conditions as appropriate, are also to be included in the loading manual:

- alternate light and heavy cargo loading conditions at maximum draught, where applicable
- homogeneous light and heavy cargo loading conditions at maximum draught
- ballast conditions.

  For ships with ballast holds adjacent to topside wing, hopper and double bottom tanks, it may be acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty. Partial filling of the peak tanks is not acceptable in the design ballast conditions, unless effective means are provided to prevent accidental overfilling.
- short voyage conditions where the ship is to be loaded to maximum draught but with a limited amount of bunkers
- multiple port loading/unloading conditions
- deck cargo conditions, where applicable
- typical loading sequences where the ship is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions are also to be included.

  The typical loading/unloading sequences are also to be developed to not exceed applicable strength limitations. The typical loading sequences are also to be developed paying due attention to the loading rate and deballasting capability.
- typical sequences for change of ballast at sea, where applicable.

3.2.3 Language

The loading manual is to be prepared in a language understood by the users. If this is not English, a translation into English is to be included.

4 Loading instrument

4.1 Definitions

4.1.1 All ships

A loading instrument is an instrument which is either analog or digital and by means of which it can be easily and quickly ascertained that, at specified read-out points, the still water bending moments, shear forces and still water torsional moments and lateral loads, where applicable, in any load or ballast condition, do not exceed the specified permissible values.

An operational manual is always to be provided for the loading instrument.

Single point loading instruments are not acceptable.

4.1.2 Bulk carriers, ore carriers and combination carriers equal to or greater than 150 m in length

For ships with one of the service notations **bulk carrier ESP**, **ore carrier ESP** or **combination carrier ESP**, and equal to or greater than 150 m in length, the loading instrument is an approved digital system as defined in [4.1.1]. In addition to [4.1.1], it is also to ascertain as applicable that:

- the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position
- the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds
- the still water bending moment and shear forces in the hold flooded conditions

do not exceed the specified permissible values.

4.2 Conditions of approval

4.2.1 All ships

The loading instrument is subject to approval, which is to include:

- verification of type approval, if any
- verification that the final data of the ship have been used
- acceptance of number and position of all read-out points
- acceptance of relevant limits for read-out points
- checking of proper installation and operation of the instrument on board, under agreed test conditions, and that a copy of the operation manual is available.

4.2.2 Bulk carriers, ore carriers and combination carriers equal to or greater than 150 m in length

In addition to [4.2.1], for ships with one of the service notations **bulk carrier ESP**, **ore carrier ESP** or **combination carrier ESP**, and equal to or greater than 150 m in length, the approval is also to include, as applicable:

- acceptance of hull girder bending moment limits for all read-out points
- acceptance of hull girder shear force limits for all read-out points
- acceptance of limits for the mass of cargo and double bottom contents of each hold as a function of draught
- acceptance of limits for the mass of cargo and double bottom contents in any two adjacent holds as a function of draught.

4.2.3 In the case of modifications implying changes in the main data of the ship, the loading instrument is to be modified accordingly and approved.

4.2.4 The operation manual and the instrument output are to be prepared in a language understood by the users. If this is not English, a translation into English is to be included.

4.2.5 The operation of the loading instrument is to be verified upon installation under the agreed test conditiony. It is to be checked that the agreed test conditions and the operation manual for the instrument are available on board.

4.2.6 *(1/7/2005)*

When the loading instrument also performs stability calculations, it is to be approved for stability purposes in accordance with the procedures indicated in [4.5], [4.6], [4.7] and [4.8], as applicable.

4.3 Approval procedure

4.3.1 General

The loading instrument approval process includes the following procedures for each ship:

- data verification which results in endorsed test conditions
- approval of computer hardware, where necessary, as specified in Pt C, Ch 3, Sec 6, [2.5.1]
- installation testing which results in an Installation Test Report.

4.3.2 Data verification approval - Endorsed test conditions

The Society is to verify the results and actual ship data used by the calculation program for the particular ship on which the program will be installed.

Upon application for data verification, the Society is to advise the applicant of a minimum of four loading conditions, taken from the ship's approved loading manual, which are to be used as the test conditions. Within the range of these test conditions, each compartment is to be loaded at least once. The test conditions normally cover the range of load draughts from the deepest envisaged loaded condition to the light ballast condition. In addition, the lightship test condition is to be submitted.

When the loading instrument also performs stability calculations, the test conditions are to be taken from the ship's approved trim and stability booklet.

The data indicated in [4.3.3] and contained in the loading program are to be consistent with the data specified in the approved loading manual. Particular attention is drawn to the final lightship weight and centres of gravity derived from the inclining experiment or lightweight check.

The approval of the computer application software is based on the acceptance of the results of the test conditions according to [4.4], [4.6], [4.7], and [4.8], as applicable.

When the requested information has been submitted and the results of the test conditions are considered satisfactory, the Society endorses the test conditions, a copy of which is to be available on board.

4.3.3 Data to be submitted

The following data, submitted by the applicant, are to be consistent with the as-built ship:

- identification of the calculation program including the version number
- main dimensions, hydrostatic particulars and, if applicable, ship profile
- position of the forward and after perpendiculars and, if appropriate, the calculation method to derive the forward and after draughts at the actual position of the ship's draught marks
- ship lightweight and lightweight distribution along the ship's length
- lines plans and/or offset tables
- compartment definitions, including frame spacing and centre of volumes, together with capacity tables (sounding/ullage tables), if appropriate
- deadweight definitions for each loading condition.

4.3.4 Installation testing

During the installation test, one of the ship's senior officers is to operate the loading instrument and calculate the test conditions. This operation is to be witnessed by a Surveyor of the Society. The results obtained from the loading instrument are to be identical to those stated in the endorsed test conditions. If the numerical output from the loading instrument is different from the endorsed test conditions, no approval will be confirmed.

An installation test is also to be carried out on the second nominated computer, when applicable as indicated in Pt C, Ch 3, Sec 6, [2.5.1], which would be used in the event of failure of the first computer. Where the installation test is carried out on a type approved computer, a second nominated computer and test are not required.

Subject to the satisfactory completion of installation tests, the Society's Surveyor endorses the test conditions, adding details of the place and the date of the installation test survey, as well as the Society stamp and the Surveyor's signature.

4.3.5 Operational manual

A uniquely identified ship specific operational manual is to be submitted to the Society for documentation.

The operational manual is to be written in a concise and unambiguous manner. The use of illustrations and flowcharts is recommended.

The operational manual is to contain:

- a general description of the program denoting identification of the program and its stated version number
- details of the hardware specification needed to run the loading program
- a description of error messages and warnings likely to be encountered, and unambiguous instructions for subsequent actions to be taken by the user in each case
- where applicable, the shear force correction factors
- where applicable, the local permissible limits for single and two adjacent hold loadings as a function of the appropriate draught and the maximum weight for each hold
- where applicable, the Society's restrictions (maximum allowable load on double bottom, maximum specific gravity allowed in liquid cargo tanks, maximum filling level or percentage in liquid cargo tanks)
- example of a calculation procedure supported by illustrations and sample computer output
- example computer output of each screen display, complete with explanatory text.

4.3.6 Calculation program specifications

The software is to be written so as to ensure that the user cannot alter the critical ship data files containing the following information:

- lightship weight and lightship weight distribution and associated centres of gravity
- the Society's structural limitations or restrictions
- geometric hull form data
- hydrostatic data and cross curves, where applicable
- compartment definitions, including frame spacing and centre of volumes, together with capacity tables (sounding/ullage tables), if appropriate.

Any changes in the software are to be made by the manufacturer or his appointed representative and the Society is to be informed immediately of such changes. Failure to advise of any modifications to the calculation program may invalidate the approval issued. In cases where the approval is considered invalid by the Society, the modified calculation program is to be re-assessed in accordance with the approval procedure.

4.3.7 Functional specification

The calculation program is to be user-friendly and designed such that it limits possible input errors by the user.

The forward, midship and after draughts, at the respective perpendiculars, are to be calculated and presented to the user on screen and hardcopy output in a clear and unambiguous manner.

It is recommended that the forward, midship and after draughts, at the actual position of the ship's draught marks are calculated and presented to the user on screen and hard copy output in a clear and unambiguous manner.

The displacement is to be calculated for the specified loading condition and corresponding draught readings and presented to the user on screen and hardcopy output.

The loading instrument is to be capable of producing printouts of the results in both numerical and graphical forms. The numerical values are to be given in both forms, as absolute values and as the percentage of the permissible values. This print-out is to include a description of the corresponding loading condition.

All screen and hardcopy output data is to be presented in a clear and unambiguous manner with an identification of the calculation program (the version number is to be stated).

4.4 Hull girder forces and moments

4.4.1 General

The loading program is to be capable of calculating the following hull girder forces and moments in accordance with Ch 5, Sec 2, [2]:

- Still Water Shear Force (SWSF) including the shear force correction, where applicable
- Still Water Bending Moment (SWBM)
- Still Water Torsion Moment (SWTM), where applicable
- For ships with relatively large deck openings, additional considerations such as torsional loads are to be considered.

The data which are to be provided to or accepted by the Society are specified in Tab 1.

Read-out points are usually to be selected at the position of the transverse bulkheads or other obvious boundaries. Additional read-out points may be required between bulkheads of long holds or tanks, or between container stacks.

Where the still water torsion moments are required to be calculated, one test condition is to demonstrate such a calculation.

The calculated forces and moments are to be displayed in both graphical and tabular formats, including the percentage of permissible values. The screen and hardcopy output is to display the calculated forces or moments, and the corresponding permissible limits, at each specified read-out point. Alternative limits may be considered by the Society on a case by case basis.

Table 1 : Data to be provided to/or accepted by the Society

Calculation	Data to be provided to or accepted by the Society
Still Water Shear Force (SWSF)	• The read-out points (frame locations) for the SWSF calculations. These points are normally selected at the position of the transverse bulkhead or other obvious boundaries. Additional read-out points may be specified between the bulkheads of long holds or tanks or between container stacks. • Shear force correction factors and method of application. • The permissible seagoing and harbour SWSF limits at the read-out points. Where appropriate, additional sets of permissible SWSF values may be specified.
Still Water Bending Moment (SWBM)	• The read-out points (frame locations) for the SWBM calculations. These points are normally selected at the position of the transverse bulkhead, mid-hold or other obvious boundaries. • The permissible seagoing and harbour SWBM limits at the read-out points. Where appropriate, additional sets of permissible SWBM values may be specified.
Still Water Torsion Moment (SWTM), where applicable	• The read-out points (frame locations) for the SWTM calculations, where applicable. • The permissible limits at the read-out points.

4.4.2 Acceptable tolerances

The accuracy of the calculation program is to be within the acceptable tolerance band, specified in Tab 2, of the results at each read-out point obtained by the Society, using an independent program or the approved loading manual with identical input.

Table 2 : Tolerance band for the comparison of computational accuracy

Computation	Tolerance (percentage of the permissible values)
Still Water Shear Force	± 5%
Still Water Bending Moment	± 5%
Still Water Torsion Moment, where applicable	± 5%

4.4.3 Permissible limits and restrictions

The user is to be able to view the following Society structural limitations in a clear and unambiguous manner:

- all permissible still water shear forces and still water bending moments
- where applicable, the permissible still water torsion moments
- where applicable, all local loading limits both for one hold and for adjacent hold loadings
- cargo hold weight
- ballast tank/hold capacities
- filling restrictions.

It is to be readily apparent to the user when any of the structural limits has been exceeded.

4.5 Stability

4.5.1 Premise *(1/7/2018)*

These requirements are applicable to software which calculates the stability of actual loading conditions and which is installed on ships and on units subject to compliance with the 1966 Load Line Convention or the 1988 Protocol to the Load Line Convention, as amended, the IMO MODU Code and/or the 2008 IS Code.

The use of shipboard computers for stability calculations is not a requirement of class.

Stability software installed on board is to cover all mandatory class and statutory intact and damage stability requirements applicable to the ship. These provisions, require approval of software installed on onboard computers which is capable of performing stability calculations.

Active and passive systems are defined in [4.5.3]. These requirements cover passive systems and the off-line operation mode of active systems only.

4.5.2 General *(1/7/2018)*

The scope of stability calculation software is to be in accordance with the stability information as approved by the Society and is to at least include all information and perform all calculations or checks as necessary to ensure compliance with the applicable stability requirements.

Approved stability software is not a substitute for the approved stability information, and is used as a supplement to the approved stability information to facilitate stability calculations.

The input/output information shall be easily comparable with approved stability information so as to avoid confusion and possible misinterpretation by the operator relative to the approved stability information.

An operation manual is to be provided for the shipboard computer stability software.

The language in which the stability information is displayed and printed out and in which the operation manual written shall be the same as that used for the ship's approved stability information. The Society may require a translation into a language considered appropriate.

The shipboard computer software for stability calculations is to be ship specific and the results of the calculations are to be only applicable to the ship for which it has been approved.

In the case of modifications implying changes in the main data or internal arrangement of the ship, the specific approval of any original stability calculation software is no longer valid. The software is to be modified accordingly and re-approved.

4.5.3 Calculation systems *(1/7/2005)*

A passive system requires manual data entry, an active system replaces the manual entry with sensors reading and entering the contents of tanks, etc., and a third system, an integrated system, controls or initiates actions based on the sensor supplied inputs and is not within the scope of these requirements.

4.5.4 Types of stability software *(1/7/2018)*

Four types of calculations performed by stability software are acceptable depending upon a vessel's stability requirements:

- Type 1: software calculating intact stability only (for vessels not required to meet a damage stability criterion)
- Type 2: software calculating intact stability and checking damage stability on the basis of a limit curve (e.g. for vessels applicable to SOLAS Part B-1 damage stability calculations, etc.) checking all the stability requirements (intact and damage stability) on the basis of a limit curve
- Type 3: software calculating intact stability and damage stability by direct application of pre-programmed damage cases based on the relevant Conventions or Codes or each loading condition (for some tankers etc.)
- Type 4: Software calculating damage stability associated with an actual loading condition and actual flooding case, using direct application of user defined damage, for the purpose of providing operational information for safe return to port (SRtP).

Damage stability of both Type 3 and Type 4 stability software shall be based on a hull form model, that is, directly calculated from a full three-dimensional geometric model.

4.5.5 Functional requirements *(1/7/2021)*

a) General requirements for any type of stability software

1) The calculation program is to present relevant parameters of each loading condition in order to assist the Master in his judgement on whether the ship is loaded within the approval limits. The following parameters are to be presented for a given loading condition:
   - deadweight data;
   - lightship data;
   - trim;
   - draft at the draft marks and perpendiculars;
   - summary of loading condition displacement, VCG, LCG and, if applicable, TCG;
   - downflooding angle and corresponding downflooding opening (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, downflooding angle and the corresponding downflooding opening shall be indicated);
   - compliance with stability criteria: listing of all calculated stability criteria, the limit values, the values obtained and the conclusions (criteria fulfilled or not fulfilled)) (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, the limit values, the obtained values and the conclusion shall be indicated).

2) A clear warning is to be given on screen and in hard copy printout if any of the loading limitations are not complied with.

   Loading limitations shall include, but may not be limited to:
   - Trim, draught, liquid densities, tank filling levels, initial heel;
   - Use of limit KG/GM curves in conjunction with above for Type 2;
   - Restrictions to the stowage height for timber where timber load lines are assigned.

3) Type 3 software is to include pre-defined relevant damage cases for both sides of the ship according to the applicable rules for automatic check of a given loading condition.

4) The date and time of a saved calculation are to be part of the screen display and hard copy printout.

5) Each hard copy printout is to contain identification of the calculation program, including version number.

6) Units of measurement are to be clearly identified and used consistently within a loading calculation.

7) For Type 3 and Type 4 software, the system shall be pre-loaded with a detailed computer model of the complete hull, including appendages, all compartments, tanks and the relevant parts of the superstructure considered in the damage stability calculation, wind profile, down-flooding and up-flooding openings, cross-flooding arrangements, internal compartment connections and escape routes, as applicable and according to the type of stability software.

8) For Type 1 and Type 2 software, in case a full three dimensional model is used for stability calculations, the requirements of the computer model are to be as per item 7) above to the extent as applicable and according to the type of stability software.

b) Further requirements for Type 4 stability software:

1) The normal (Type 1, 2 and 3) and SRtP (Type 4) software need not be "totally separated". Where the normal and SRtP software are not totally separated:
   - the function of switching between normal software and Type 4 software shall be provided
   - the actual intact loading condition is to be the same for both functions (normal operation and SRtP); and
   - the SRtP module needs only to be activated in case of an incident.

   Approval of Type 4 (SRtP) software is for stability only.

2) In passenger ships which are subject to SRtP and have an onboard stability computer and shore-based support, such software need not be identical.

3) Each internal space shall be assigned its permeability as shown in Tab 1, unless a more accurate permeability has been reflected in the approved stability information.

4) The system shall be capable of accounting for applied moments such as wind, lifeboat launching, cargo shifts and passenger relocation.

5) The system shall account for the effect of wind by using the method in SOLAS regulation II-1/7-2.4.1.2 as the default, but allow for manual input of the wind speed/pressure if the on-scene pressure is significantly different (P = 120 N/m2 equates to Beaufort 6; approximately 13.8 m/s or 27 knots).

6) The system shall be capable of assessing the impact of open main watertight doors on stability (e.g. for each damage case provided for verification, additional damage stability calculation shall be done and presented, taking into account any watertight door located within the damaged compartment(s)).

7) The system shall utilize the latest approved lightship weight and centre of gravity information.

8) The output of the software is to be such that it provides the master with sufficient clear unambiguous information to enable quick and accurate assessment of the stability of the vessel for any actual damage, the impact of flooding on the means of escape and the controls of devices necessary for managing and/or controlling the stability of the ship.

   When the actual loading condition is input in the SRtP software, the following output (intact stability) shall be available:

   - deadweight data;
   - lightship data;
   - trim;
   - heel;
   - draft at the draft marks and perpendiculars;
   - summary of loading condition displacement, VCG, LCG and, if applicable, TCG;
   - downflooding angle and corresponding downflooding opening;
   - free surfaces;
   - GM value;
   - GZ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0 5 10 15 20 25 30 40 50 60 deg;
   - compliance with relevant intact stability criteria (i.e. 2008 IS Code): listing of all calculated intact stability criteria, the limiting values, the obtained values and the evaluation (criteria fulfilled or not fulfilled);
   - GM/KG limiting curve according to SOLAS, Ch II-1, Regulation 5-1.

   When the actual loading condition is associated to the actual damage case(s) due to the casualty, the following output (damage stability) shall be available:

   - trim;
   - heel;
   - draft at the draft marks and perpendiculars;
   - progressive flooding angle and corresponding progressive flooding openings;
   - GM value;
   - GZ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0 5 10 15 20 25 30 40 50 60 deg;
   - compliance with stability criteria: listing of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled);
   - the survivability criteria for Type 4 software (SRtP) are left to the discretion of the Administration;
   - relevant flooding points (unprotected or weathertight) with the distance from the damage waterline to each point;
   - list of all flooded compartments with the permeability considered;
   - amount of water in each flooded compartment;
   - escape route immersion angles;
   - a profile view, deck views and cross-sections of the ship indicating the flooded water- plane and the damaged compartments.

9) For ro-ro passenger ships there shall be algorithms in the software for estimating the effect of water accumulation on deck (WOD) (e.g. 1. In addition to the predefined significant wave height taken from the approved stability document, there shall be possibility for the crew to input manually the significant wave height of the ship navigation area in the system, 2. In addition to the predefined significant wave height taken from the approved stability document, calculations with two additional significant wave heights shall be submitted for checking the correctness of the algorithms in the software for estimating the effect of WOD). See Note 1.

Note 1: This paragraph applies to Ro-Ro Passenger ships subject to the Stockholm Agreement (IMO Circular Letter No. 1891).

Table 3

Spaces	Permeability			
	Default	Full	Partially filled	Empty
Container Spaces	0,95	0,70	0,80	0,95
Dry Cargo spaces	0,95	0,70	0,80	0,95
Ro-Ro spaces	0,95	0,90	0,90	0,95
Cargo liquids	0,95	0,70	0,80	0,95
Intended for consumable liquids	0,95	0,95	0,95	0,95
Stores	0,95	0,60	0,60	0,95
Occupied by machinery	0,85			
Void spaces	0,95			
Occupied by accommodation	0,95			

4.5.6 Acceptable tolerances *(1/7/2005)*

Depending on the type and scope of programs, the acceptable tolerances are to be determined differently, according to a) or b) below, as appropriate. Deviation from these tolerances are not acceptable unless the Society considers that there is a satisfactory explanation for the difference and that there will be no adverse effect on the safety of the ship.

Examples of pre-programmed input data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT versus draught.
- Stability data: KN or MS values at appropriate heel/ trim angles versus displacement, stability limits.
- Compartment data: Volume, LCG, VCG, TCG and FSM/ Grain heeling moments vs level of the compartment's contents.

Examples of output data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT versus draught as well as actual draughts, trim.
- Stability data: FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, allowable grain heeling moments, derived stability criteria, e.g. areas under the GZ curve, weather criteria.
- Compartment data: Calculated Volume, LCG, VCG, TCG and FSM/ Grain heeling moments vs level of the compartment's contents.

The computational accuracy of the calculation program results is to be within the acceptable tolerances specified in a) or b) below as appropriate, in comparison with the results obtained by the Society using an independent program or the approved stability information with identical input.

a) Programs which use only pre-programmed data from the approved stability information as the basis for stability calculations are to have zero tolerances for the printouts of input data.

   Output data tolerances are to be close to zero; however, small differences associated with calculation rounding or abridged input data are acceptable.

   Additionally, differences associated with the use of hydrostatic and stability data for trims that differ from those in the approved stability information are acceptable subject to review by the Society.

b) Programs which use hull form models as their basis for stability calculations are to have tolerances for the printouts of basic calculated data established against either data from the approved stability information or data obtained using the approval Society's model. Acceptable tolerances are to be in accordance with Tab 4.

Table 4 : Applicable tolerances *(1/7/2018)*

Hull Form Dependent	
Displacement	± 2%
Longitudinal centre of bouyancy, from AP	± 1% / 50 cm
Vertical centre of bouyancy	± 1% / 5 cm
Transverse centre of bouyancy	± 0,5% of B / 5 cm
Longitudinal centre of flotation, from AP	± 1% / 50 cm
Moment to trim 1 cm	± 2%
Transverse metacentric height	± 1% / 5 cm
Longitudinal metacentric height	± 1% / 50 cm
Cross curves of stability	± 5 cm
Compartment dependent	
Volume or deadweight	± 2%
Longitudinal centre of gravity, from AP	± 1% / 50 cm
Vertical centre of gravity	± 1% / 5 cm
Transverse centre of gravity	± 0,5% of B / 5 cm
Free surface moment	± 2%
Shifting moment	± 5%
Level of contents	± 2%
Trim and stability	
Draughts (forward, aft, mean)	± 1% / 5 cm
GMt (both solid and corrected for free surfaces)	± 1% / 5 cm
GZ values	± 5% / 5 cm
Downflooding angle	± 2°
Equilibrium angles	± 1°
Distance from WL to unprotected and weathertight openings, or other relevant point, if applicable	± 5 % / 5 cm
Areas under righting arm curve	± 5 % / 0,0012 mrad

Notes:
(1) Deviation in % = {(base value-applicant's value)/base value} *100, where the "base value" may be from the approved stability information or the Society's computer model.
(2) When applying the tolerances in Table 1 having two values, the allowable tolerance is the greater of the two values
(3) Where differences in calculation methodology exist between the programs used in the comparison, this may be a basis for accepting deviations greater than that specified in Table 1 provided a software examination is carried out in sufficient detail to clearly document that such differences are technically justifiable
(4) Deviation from these tolerances shall not be accepted unless the Society considers that there is a satisfactory explanation for the difference and that it is clearly evident from the Society's stability calculations that the deviation does not impact compliance with the required stability criteria for the ship under consideration.

4.5.7 Approval Procedure *(1/7/2018)*

The shipboard software used for stability calculations is subject to approval, which is to include:

- verification of type approval, if any;
- verification that the data used is consistent with the current condition of the ship (see item c));
- verification and approval of the test conditions;
- verification that the software is appropriate for the type of ship and stability calculations required;
- verification of functional requirements under paragraph [4.1.2].

The satisfactory operation of the software with the shipboard computer(s) for stability calculations is to be verified by testing upon installation in compliance with [4.5.9]. A copy of the approved test conditions and the operation manual for the computer/ software are to be available on board.

a) The Society verifies the accuracy of the computational results and actual ship data used by the calculation program for the particular ship on which the program will be installed.

b) Upon application to the Society for data verification, the Society and the applicant are to agree on a minimum of four loading conditions, taken from the ship's approved stability information, which are to be used as the test conditions. For ships carrying liquids in bulk, at least one of the conditions is to include partially filled tanks. For ships carrying grain in bulk, one of the grain loading conditions is to include a partially filled grain compartment. Within the test conditions each compartment is to be loaded at least once. The test conditions normally are to cover the range of load draughts from the deepest envisaged loaded condition to the light ballast condition and are to include at least one departure and one arrival condition. For Type 4 stability software for SRtP, the Society shall examine at least three damage cases, each of them associated with at least three loading conditions taken from the ship's approved stability information. Output of the software is to be compared with results of corresponding load / damage case in the approved damage stability booklet or an alternative independent software source.

c) The Society is to verify that the following data, submitted by the applicant, are consistent with arrangements and the most recently approved lightship characteristics of the ship according to current plans and documentation on file with the Society, subject to possible further verification on board:
   - identification of the calculation program including version number;
   - main dimensions, hydrostatic particulars and, if applicable, the ship profile;
   - the position of the forward and after perpendiculars, and if appropriate, the calculation method to derive the forward and after draughts at the actual position of the ship's draught marks;
   - ship lightweight and centre of gravity derived from the most recently approved inclining experiment or lightweight check;
   - lines plan, offset tables or other suitable presentation of hull form data if necessary for the Society to model the ship;
   - compartment definitions, including frame spacing, and centres of volume, together with capacity tables (sounding/ullage tables), free surface corrections, if appropriate;
   - cargo and consumables distribution for each loading condition.

Verification by the Society does not absolve the applicant and Owner from responsibility for ensuring that the information programmed into the shipboard computer software is consistent with the current condition of the ship.

4.5.8 Operation manual *(1/7/2005)*

A simple and straightforward operation manual is to be provided, containing descriptions and instructions, as appropriate, for at least the following:

- installation
- function keys
- menu displays
- input and output data
- required minimum hardware to operate the software
- use of the test loading conditions
- computer-guided dialogue steps
- list of warnings.

4.5.9 Installation testing *(1/7/2018)*

To ensure correct working of the computer after the final or updated software has been installed, it is the responsibility of the ship's Master to have test calculations carried out according to a) or b) in the presence of a Surveyor of the Society.

a) In compliance with [4.3.4], test conditions are to be selected and the test calculation performed by entering all deadweight data for each selected test condition into the program as if it were a proposed loading.

b) From the approved test conditions at least one load case (other than lightship) is to be calculated.

   The following steps are to be performed:
   - retrieve the test load case and start a calculation run; compare the stability results with those in the documentation;
   - change several items of deadweight (tank weights and the cargo weight) sufficiently to change the draught or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the approved test condition;
   - revise the above modified load condition to restore the initial test condition and compare the results.

Confirm that the relevant input and output data of the approved test condition have been replicated.

In general, the test conditions are permanently stored in the computer.

The results are to be verified as identical to those in the approved copy of the test conditions.

If the numerical output from the loading instrument is different from the endorsed test conditions, no approval will be confirmed.

An installation test is also to be carried out on the second nominated computer, when applicable as indicated in Pt C, Ch 3, Sec 6, [2.5.1], which would be used in the event of failure of the first computer. Where the installation test is carried out on a type approved computer, a second nominated computer and test are not required.

Subject to the satisfactory completion of installation tests, the Society's Surveyor endorses the test conditions, adding details of the place and date of the installation test survey, as well as the Society stamp and the Surveyor's signature.

Actual loading condition results are not suitable for checking the correct working of the computer.

4.5.10 Additional requirements *(1/7/2005)*

Protection against unintentional or unauthorised modification of programs and data is to be provided.

The program is to monitor operation and activate an alarm when the program is incorrectly or abnormally used.

The program and any data stored in the system are to be protected from corruption by loss of power.

Error messages with regard to limitations such as filling a compartment beyond capacity, or exceeding the assigned load line, etc. are to be included.

4.6 Intact stability

4.6.1 Application

The loading instrument approval for stability purposes is required when a loading instrument to be installed on board a ship performs stability calculations, as stated in [4.2.6].

4.6.2 Data verification approval - Endorsed test conditions

The requirements in [4.3.2] apply. In addition, at least one of the four loading conditions required is to show the compartments, intended for liquid loads in which the free surface effect is considerable, filled in order to have the maximum free surface moment.

The additional data necessary for the approval of the loading instrument for stability purposes are specified in [4.6.3].

In order to obtain the approval of the loading instrument, all the intact stability requirements (and relevant criteria) applicable to the ship, reported in Ch 3, Sec 2 as well as in Part E, are to be available in the computer output; the lack of any one of them is sufficient to prevent the endorsement of the test conditions.

4.6.3 Additional data to be submitted

In addition to the data required in [4.3.3], the following are to be submitted:

- cross curves of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered in the computation of these curves,
- capacity tables indicating, for each compartment or space, the values of the co-ordinates X_G, Y_G and Z_G of the centre of gravity, as well as the inertia, corresponding to an adequate number of filling percentages
- list of all the openings (location, tightness, means of closure), pipes or other sources which may lead to progressive flooding
- deadweight definitions for each loading condition in which, for any load taken into account, the following information is to be specified:
  - weight and centre of gravity co-ordinates
  - percentage of filling (if liquid load)
  - free surface moment (if liquid load)
- information on loading restrictions (maximum filling level or percentage in liquid cargo tanks, maximum KG or minimum GM curve or table which can be used to determine compliance with the applicable intact and damage stability criteria), when applicable
- all the intact stability criteria applicable to the ship concerned.

4.7 Grain loading

4.7.1 Application

The loading instrument approval for stability purposes is required when a loading instrument to be installed on board a ship performs grain loading stability calculations, as stated in [4.2.6].

In such case, the loading instrument is also to perform intact stability calculations, and therefore the approval is to be based on the requirements specified in [4.6].

Additional requirements relevant to grain stability are provided in [4.7.2] and [4.7.3].

4.7.2 Data verification approval - Endorsed test conditions

The requirements stated in [4.6.2] apply. In addition, when the ship is allowed to carry grain in slack hold, at least one of the four loading conditions required is to include partially filled holds.

The additional data necessary for the approval of the loading instrument for grain stability purposes are specified in [4.7.3].

In order to obtain the approval of the loading instrument, all the grain stability requirements and relevant criteria specified in Pt E, Ch 4, Sec 3, [2.2] are to be available in the computer output.

In addition, the outputs are to include:

- the reference to the type of calculation (trimmed or untrimmed ends)
- the value of the actual grain heeling moment for each hold
- the value of the maximum permissible grain heeling moment for each hold
- the total value of the actual grain heeling moment
- the total value of the maximum permissible grain heeling moment.

The lack of any of the above is sufficient to prevent the endorsement of the test conditions.

4.7.3 Additional data to be submitted

In addition to the data required in [4.6.3], the following are to be submitted:

- calculation of the total grain heeling moment
- calculation of the maximum permissible total grain heeling moment as a function of the draught (or displacement) and maximum KG
- curves or tables of volume, centre of volume and volumetric heeling moment for partially filled compartments (if applicable)
- for filled holds: volumetric heeling moment for trimmed and/or untrimmed ends, as applicable, including temporary bulkheads, if any.

4.8 Damage stability

4.8.1 Application

The loading instrument approval for stability purposes is required when a loading instrument to be installed on board a ship performs damage stability calculations, as stated in [4.2.6].

In such case, the loading instrument is also to perform intact stability calculations, and therefore the approval is to be based on the requirements specified in [4.6].

Additional requirements relevant to damage stability are given in [4.8.2] and [4.8.3].

4.8.2 Data verification approval - Endorsed test conditions

The requirements specified in [4.6.2] apply.

The additional data necessary for the approval of the loading instrument for stability purposes are specified in [4.8.3].

The approval of damage stability calculations performed by a loading instrument is limited to those relevant to deterministic damage stability rules specified in Part E applicable to ships with one of the service notations **passenger ship**, **oil tanker ESP**, **chemical tanker ESP** or **liquefied gas carrier**. In order to obtain the approval of the loading instrument, all the damage stability requirements (and relevant criteria) applicable to the ship are to be available in the computer output. The lack of any one of them is sufficient to prevent the endorsement of the test conditions.

4.8.3 Additional data to be submitted

In addition to the data required in [4.6.3], the following are to be submitted:

- list of all the damage cases which are to be considered in accordance with the relevant deterministic damage stability rules. Each damage case is to clearly indicate all the compartments or spaces taken into account, as well as the permeability associated with each compartment or space.

  This information is to be taken from the approved damage stability documentation, and the source details are to be clearly indicated; in the case of unavailability of such documentation, the above-mentioned information may be requested from the Society.

- all the damage stability criteria applicable to the ship concerned.

Part B
Hull and Stability

Chapter 12
CONSTRUCTION AND TESTING

SECTION 1 WELDING AND WELD CONNECTIONS

1 General

1.1 Application

1.1.1 *(1/1/2005)*

The requirements of this Section apply for the preparation, execution and inspection of welded connections in hull structures.

The general requirements relevant to fabrication by welding and qualification of welding procedures are given in Part D, Chapter 5. As guidance see also the indications given in the "Guide for Welding".

The requirements relevant to the non-destructive examination of welded connections are given in the Rules for carrying out non-destructive examination of welding.

1.1.2 Weld connections are to be executed according to the approved plans. Any detail not specifically represented in the plans is, in any event, to comply with the applicable requirements.

1.1.3 It is understood that welding of the various types of steel is to be carried out by means of welding procedures approved for the purpose, even though an explicit indication to this effect may not appear on the approved plans.

1.1.4 The quality standard adopted by the shipyard is to be submitted to the Society and applies to all constructions unless otherwise specified on a case-by-case basis.

1.2 Base material

1.2.1 The requirements of this Section apply for the welding of hull structural steels or aluminium alloys of the types considered in Part D or other types accepted as equivalent by the Society.

1.2.2 The service temperature is intended to be the ambient temperature, unless otherwise stated.

1.3 Welding consumables and procedures

1.3.1 Approval of welding consumables and procedures *(1/7/2006)*

Welding consumables and welding procedures adopted are to be approved by the Society.

The requirements for the approval of welding consumables are given in Pt D, Ch 5, Sec 2.

The requirements for the approval of welding procedures for the individual users are given in Pt D, Ch 5, Sec 4 and Pt D, Ch 5, Sec 5.

1.3.2 Consumables

For welding of hull structural steels, the minimum consumable grades to be adopted are specified in Tab 1 depending on the steel grade.

For welding of other materials, the consumables indicated in the welding procedures to be approved are considered by the Society on a case by case basis.

Table 1 : Consumable grades

Steel grade	Consumable minimum grade	
	Butt welding, partial and full T penetration welding	Fillet welding
A	1	1
B - D	2	
E	3	
AH32 - AH36 DH32 - DH36	2Y	2Y
EH32 - EH36	3Y	
FH32 - FH36	4Y	
AH40	2Y40	2Y40
DH40 - EH40	3Y40	
FH40	4Y40	

Note 1:
Welding consumables approved for welding higher strength steels (Y) may be used in lieu of those approved for welding normal strength steels having the same or a lower grade; welding consumables approved in grade Y40 may be used in lieu of those approved in grade Y having the same or a lower grade.
Note 2:
In the case of welded connections between two hull structural steels of different grades, as regards strength or notch toughness, welding consumables appropriate to one or the other steel are to be adopted.

1.3.3 Electrodes for manual welding

Basic covered electrodes are to be used for the welding of structural members made in higher strength steels and, irrespective of the steel type, for the welding of special and primary structural members, as defined in Ch 4, Sec 1, Tab 3 and Ch 4, Sec 1, Tab 8, as applicable.

Non-basic covered electrodes are generally allowed for manual fillet welding of structural members of moderate thickness (gross thickness less than 25 mm) made in normal strength steels.

1.4 Personnel and equipment

1.4.1 Welders *(1/7/2002)*

Manual and semi-automatic welding is to be performed by welders certified by the Society in accordance with recognised standards (see Pt D, Ch 5, Sec 1, [2.2.3] and Pt D, Ch 5, Sec 1, [2.2.5]); the welders are to be employed within the limits of their respective approval.

1.4.2 Automatic welding operators

Personnel manning automatic welding machines and equipment are to be competent and sufficiently trained.

1.4.3 Organisation

The internal organisation of the shipyard is to be such as to ensure compliance in full with the requirements in [1.4.1] and [1.4.2] and to provide for assistance and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

1.4.4 NDT operators *(1/7/2006)*

Non-destructive tests are to be carried out by operators qualified according to the requirements of Pt D, Ch 1, Sec 1, [3.6.4].

The qualifications are to be appropriate to the specific applications.

1.4.5 Technical equipment and facilities

The welding equipment is to be appropriate to the adopted welding procedures, of adequate output power and such as to provide for stability of the arc in the different welding positions.

In particular, the welding equipment for special welding procedures is to be provided with adequate and duly calibrated measuring instruments, enabling easy and accurate reading, and adequate devices for easy regulation and regular feed.

Manual electrodes, wires and fluxes are to be stocked in suitable locations so as to ensuring their preservation in good condition.

1.5 Documentation to be submitted

1.5.1 The structural plans to be submitted for approval, according to Ch 1, Sec 3, are to contain the necessary data relevant to the fabrication by welding of the structures and items represented. Any detail not clearly represented in the plans is, in any event, to comply with the applicable Rule requirements.

For important structures, the main sequences of prefabrication, assembly and welding and non-destructive examination planned are also to be represented in the plans.

1.5.2 A plan showing the location of the various steel types is to be submitted at least for outer shell, deck and bulkhead structures.

1.6 Design

1.6.1 General

For the various structural details typical of welded construction in shipbuilding and not dealt with in this Section, the rules of good practice, recognised standards and past experience are to apply as agreed by the Society.

1.6.2 Plate orientation

The plates of the shell and strength deck are generally to be arranged with their length in the fore-aft direction. Possible exceptions to the above will be considered by the Society on a case by case basis; tests as deemed necessary (for example, transverse impact tests) may be required by the Society.

1.6.3 Overall arrangement

Particular consideration is to be given to the overall arrangement and structural details of highly stressed parts of the hull.

Special attention is to be given to the above details in the plan approval stage; accurate plans relevant to the special details specified in Sec 2 are to be submitted.

1.6.4 Prefabrication sequences

Prefabrication sequences are to be arranged so as to facilitate positioning and assembling as far as possible.

The amount of welding to be performed on board is to be limited to a minimum and restricted to easily accessible connections.

1.6.5 Distance between welds

Welds located too close to one another are to be avoided. The minimum distance between two adjacent welds is considered on a case by case basis, taking into account the level of stresses acting on the connected elements.

In general, the distance between two adjacent butts in the same strake of shell or deck plating is to be greater than two frame spaces.

2 Type of connections and preparation

2.1 General

2.1.1 The type of connection and the edge preparation are to be appropriate to the welding procedure adopted, the structural elements to be connected and the stresses to which they are subjected.

2.2 Butt welding

2.2.1 General

In general, butt connections of plating are to be full penetration, welded on both sides except where special procedures or specific techniques, considered equivalent by the Society, are adopted.

Connections different from the above may be accepted by the Society on a case by case basis; in such cases, the relevant detail and workmanship specifications are to be approved.

2.2.2 Welding of plates with different thicknesses

In the case of welding of plates with a difference in gross thickness equal to or greater than:

- 3 mm, if the thinner plate has a gross thickness equal to or less than 10 mm

- 4 mm, if the thinner plate has a gross thickness greater than 10 mm,

a taper having a length of not less than 4 times the difference in gross thickness is to be adopted for connections of plating perpendicular to the direction of main stresses. For connections of plating parallel to the direction of main stresses, the taper length may be reduced to 3 times the difference in gross thickness.

When the difference in thickness is less than the above values, it may be accommodated in the weld transition between plates.

2.2.3 Edge preparation, root gap

Typical edge preparations and gaps are indicated in the "Guide for welding".

The acceptable root gap is to be in accordance with the adopted welding procedure and relevant bevel preparation.

2.2.4 Butt welding on permanent backing

Butt welding on permanent backing, i.e. butt welding assembly of two plates backed by the flange or the face plate of a stiffener, may be accepted where back welding is not feasible or in specific cases deemed acceptable by the Society.

The type of bevel and the gap between the members to be assembled are to be such as to ensure a proper penetration of the weld on its backing and an adequate connection to the stiffener as required.

2.2.5 Section, bulbs and flat bars *(1/7/2006)*

When lengths of longitudinals of the shell plating and strength deck within 0,6 L amidships, or elements in general subject to high stresses, are to be connected together by butt joints, these are to be full penetration. Other solutions may be adopted if deemed acceptable by the Society on a case by case basis.

The work is to be done in accordance with an approved procedure; in particular, this requirement applies to work done on board or in conditions of difficult access to the welded connection. Special measures may be required by the Society.

2.3 Fillet welding

2.3.1 General

In general, ordinary fillet welding (without bevel) may be adopted for T connections of the various simple and composite structural elements, where they are subjected to low stresses (in general not exceeding 30 N/mm^2) and adequate precautions are taken to prevent the possibility of local laminations of the element against which the T web is welded.

Where this is not the case, partial or full T penetration welding according to [2.4] is to be adopted.

2.3.2 Fillet welding types

Fillet welding may be of the following types:

- continuous fillet welding, where the weld is constituted by a continuous fillet on each side of the abutting plate (see [2.3.3])
- intermittent fillet welding, which may be subdivided (see [2.3.4]) into:
  - chain welding
  - scallop welding
  - staggered welding.

2.3.3 Continuous fillet welding

Continuous fillet welding is to be adopted:

- for watertight connections
- for connections of brackets, lugs and scallops
- at the ends of connections for a length of at least 75mm
- where intermittent welding is not allowed, according to [2.3.4].

Continuous fillet welding may also be adopted in lieu of intermittent welding wherever deemed suitable, and it is recommended where the spacing p, calculated according to [2.3.4], is low.

2.3.4 Intermittent welding

The spacing p and the length d, in mm, of an intermittent weld, shown in:

- Fig 1, for chain welding
- Fig 2, for scallop welding
- Fig 3, for staggered welding

are to be such that:

$$\frac{p}{d} \le \varphi$$

where the coefficient φ is defined in Tab 2 and Tab 3 for the different types of intermittent welding, depending on the type and location of the connection.

In general, staggered welding is not allowed for connections subjected to high alternate stresses.

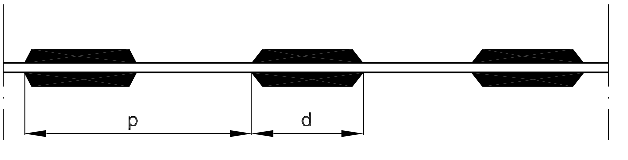
In addition, the following limitations are to be complied with:

- chain welding (see Fig 1):

  $d \ge 75$ mm

  $p\text{-}d \le 200$ mm

Figure 1 : Intermittent chain welding



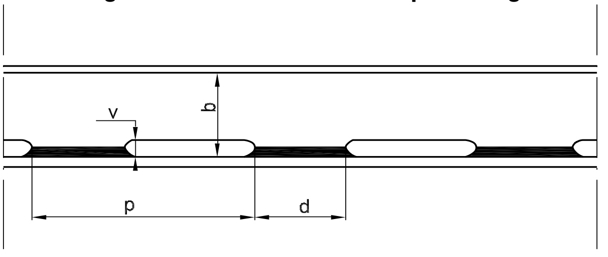
- scallop welding (see Fig 2):

  $d \ge 75$ mm

  $p\text{-}d \le 150$ mm

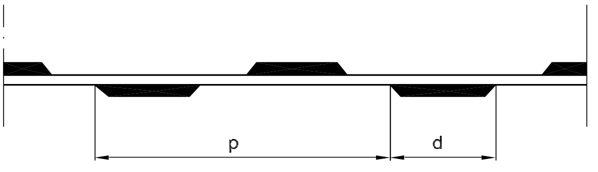
  $v \le 0{,}25b$, without being greater than 75 mm

Figure 2 : Intermittent scallop welding



- staggered welding (see Fig 3):
  $d \geq 75$ mm
  $p-2d \leq 300$ mm
  $p \leq 2d$ for connections subjected to high alternate stresses.

Figure 3 : Intermittent staggered welding



2.3.5 Throat thickness of fillet weld T connections *(1/1/2001)*

The throat thickness of fillet weld T connections is to be obtained, in mm, from the following formula:

$$t_T = w_F t \frac{p}{d}$$

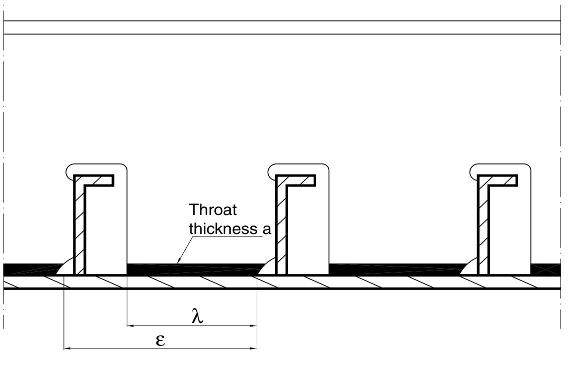
where:

w_F : Welding factor, defined in Tab 2 for the various hull structural connections; for connections of primary supporting members belonging to single skin structures and not mentioned in Tab 2, w_F is defined in Tab 3; for some connections of specific ship types, the values of w_F specified in Part E for these ship types are to be used in lieu of the corresponding values in Tab 2 or Tab 3

t : Actual gross thickness, in mm, of the structural element which constitutes the web of the T connection

p, d : Spacing and length, in mm, of an intermittent weld, defined in [2.3.4].

Figure 4 : Continuous fillet welding between cut-outs



For continuous fillet welds, p/d is to be taken equal to 1.

In no case may the throat thickness be less than:

- 3,0 mm, where the gross thickness of the thinner plate is less than 6 mm
- 3,5 mm, otherwise.

The throat thickness may be required by the Society to be increased, depending on the results of structural analyses.

For some connections of special structural details, as defined in Sec 2, the throat thickness is specified in the relevant sheets of App 1.

The leg length of fillet weld T connections is to be not less than 1,4 times the required throat thickness.

2.3.6 Weld dimensions in a specific case

Where intermittent fillet welding is adopted with:

- length d = 75 mm
- throat thickness t_T specified in Tab 4 depending on the thickness t defined in [2.3.5]

the weld spacing may be taken equal to the value p_1 defined in Tab 2. The values of p_1 in Tab 2 may be used when $8 \leq t \leq 16$ mm.

For thicknesses t less than 8 mm, the values of p_1 may be increased, with respect to those in Tab 2, by:

- 10 mm for chain or scallop welding
- 20 mm for staggered welding

without exceeding the limits in [2.3.4].

For thicknesses t greater than 16 mm, the values of p_1 are to be reduced, with respect to those in Tab 2, by:

- 10 mm for chain or scallop welding
- 20 mm for staggered welding.

Figure 5 : Intermittent scallop fillet welding between cut-outs

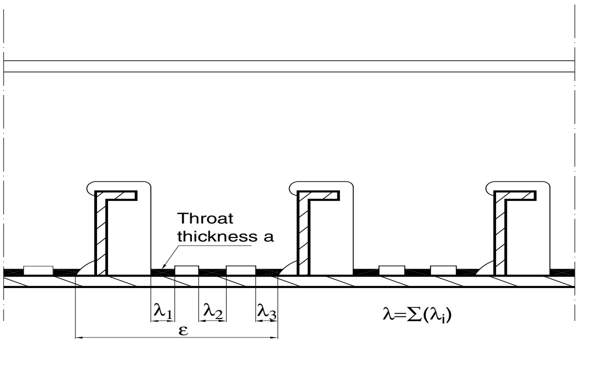


Table 2 : Welding factors w_F and coefficient φ for the various hull structural connections *(1/7/2002)*

Hull area	Connection: of	Connection: to		w_F **(1)**	φ **(2) (3)** CH	SC	ST	p_1, in mm (see [2.3.6]) **(3)**
General, unless otherwise specified in the table	watertight plates	boundaries		0,35				
	webs of ordinary stiffeners	plating		0,13	3,5	3,0	4,6	ST 260
		face plate of fabricated stiffeners	at ends **(4)**	0,13				
			elsewhere	0,13	3,5	3,0	4,6	ST 260
Bottom and double bottom	longitudinal ordinary stiffeners	bottom and inner bottom plating		0,13	3,5	3,0	4,6	ST 260
	centre girder	keel		0,25	1,8	1,8		CH/SC 130
		inner bottom plating		0,20	2,2	2,2		CH/SC 160
	side girders	bottom and inner bottom plating		0,13	3,5	3,0	4,6	ST 260
		floors (interrupted girders)		0,20	2,2			CH 160
	floors	bottom and inner bottom plating	in general	0,13	3,5	3,0	4,6	ST 260
			at ends (20% of span) for longitudinally framed double bottom	0,25	1,8			CH 130
		inner bottom plating in way of brackets of primary supporting members		0,25	1,8			CH 130
		girders (interrupted floors)		0,20	2,2			CH 160
		side girders in way of hopper tanks		0,35				
	partial side girders	floors		0,25	1,8			CH 130
	web stiffeners	floor and girder webs		0,13	3,5	3,0	4,6	ST 260
Side and inner side	ordinary stiffeners	side and inner side plating		0,13	3,5	3,0	4,6	ST 260
	girders in double side skin ships	side and inner side plating		0,35				
Deck	strength deck	side plating		Partial penetration welding				
	non-watertight decks	side plating		0,20	2,2			CH 160
	ordinary stiffeners and intercostal girders	deck plating		0,13	3,5	3,0	4,6	ST 260
	hatch coamings	deck plating	in general	0,35				
			at corners of hatchways for 15% of the hatch length	0,45				
	web stiffeners	coaming webs		0,13	3,5	3,0	4,6	ST 260

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.
(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted and continuous welding is to be adopted.
(3) CH = chain welding, SC = scallop welding, ST = staggered welding.
(4) Ends of ordinary stiffeners means the area extended 75 mm from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes.
(5) In tanks intended for the carriage of ballast or fresh water, continuous welding with $w_F = 0,35$ is to be adopted.
(6) For connections not mentioned, the requirements for the central part apply.
(7) A is the face plate sectional area of the side girders, in cm^2.

Hull area	Connection of	Connection to		w_F **(1)**	φ **(2) (3)** CH	SC	ST	p_1, in mm (see [2.3.6]) **(3)**
Bulkheads	tank bulkhead structures	tank bottom	plating and ordinary stiffeners (plane bulkheads)	0,45				
			vertical corrugations (corrugated bulkheads)	Full penetration welding				
		boundaries other than tank bottom		0,35				
	watertight bulkhead structures	boundaries		0,35				
	non-watertight bulkhead structures	boundaries	wash bulkheads	0,20	2,2	2,2		CH/SC 160
			others	0,13	3,5	3,0	4,6	ST 260
	ordinary stiffeners	bulkhead plating	in general **(5)**	0,13	3,5	3,0	4,6	ST 260
			at ends (25% of span), where no end brackets are fitted	0,35				
Structures located forward of 0,75 L from the AE **(6)**	bottom longitudinal ordinary stiffeners	bottom plating		0,20	2,2			CH 160
	floors and girders	bottom and inner bottom plating		0,25	1,8			CH 130
	side frames in panting area	side plating		0,20	2,2			CH 160
	webs of side girders in single side skin structures	side plating and face plate	A< 65 cm² **(7)**	0,25	1,8	1,8		CH/SC 130
			A ≥ 65 cm² **(7)**	See Tab 3				
After peak **(6)**	internal structures	each other		0,20				
	side ordinary stiffeners	side plating		0,20				
	floors	bottom and inner bottom plating		0,20				
Machinery space **(6)**	centre girder	keel and inner bottom plating	in way of main engine foundations	0,45				
			in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,25	1,8	1,8		CH/SC 130
	side girders	bottom and inner bottom plating	in way of main engine foundations	0,45				
			in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,20	2,2	2,2		CH/SC 160
	floors (except in way of main engine foundations)	bottom and inner bottom plating	in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,20	2,2	2,2		CH/SC 160

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.

(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted and continuous welding is to be adopted.

(3) CH = chain welding, SC = scallop welding, ST = staggered welding.

(4) Ends of ordinary stiffeners means the area extended 75 mm from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes.

(5) In tanks intended for the carriage of ballast or fresh water, continuous welding with $w_F = 0,35$ is to be adopted.

(6) For connections not mentioned, the requirements for the central part apply.

(7) A is the face plate sectional area of the side girders, in cm².

Hull area	Connection			w_F **(1)**	φ **(2) (3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
	floors in way of main engine foundations	bottom plating		0,35				
		foundation plates		0,45				
	floors	centre girder	single bottom	0,45				
			double bottom	0,25	1,8	1,8		CH/SC 130
Superstructures and deckhouses	external bulkheads	deck	in general	0,35				
			engine and boiler casings at corners of openings (15% of opening length)	0,45				
	internal bulkheads	deck		0,13	3,5	3,0	4,6	ST 260
	ordinary stiffeners	external and internal bulkhead plating		0,13	3,5	3,0	4,6	ST 260
Hatch covers	ordinary stiffener	plating		0,13	3,5	3,0	4,6	ST 260
Pillars	elements composing the pillar section	each other (fabricated pillars)		0,13				
	pillars	deck	pillars in compression	0,35				
			pillars in tension	Full penetration welding				
Ventilators	coamings	deck		0,35				
Rudders	webs in general	each other		0,20		2,2		SC 160
		plating	in general	0,20		2,2		SC 160
			top and bottom plates of rudder plating	0,35				
		solid parts or rudder stock		According to Ch 10, Sec 1, [7.4] or Ch 10, Sec 1, [7.5]				
	horizontal and vertical webs directly connected to solid parts	each other		0,45				
		plating		0,35				

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.
(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted and continuous welding is to be adopted.
(3) CH = chain welding, SC = scallop welding, ST = staggered welding.
(4) Ends of ordinary stiffeners means the area extended 75 mm from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes.
(5) In tanks intended for the carriage of ballast or fresh water, continuous welding with $w_F = 0,35$ is to be adopted.
(6) For connections not mentioned, the requirements for the central part apply.
(7) A is the face plate sectional area of the side girders, in cm².

2.3.7 Throat thickness of welds between cut-outs

The throat thickness of the welds between the cut-outs in primary supporting member webs for the passage of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formula:

$$t_{TC} = t_T \frac{\varepsilon}{\lambda}$$

where:

t_T : Throat thickness defined in [2.3.5]

ε, λ : Dimensions, in mm, to be taken as shown in:
- Fig 4, for continuous welding
- Fig 5, for intermittent scallop welding.

2.3.8 Throat thickness of welds connecting ordinary stiffeners with primary supporting members *(1/7/2019)*

The throat thickness of fillet welds connecting ordinary stiffeners and collar plates, if any, to the web of primary supporting members is to be not less than $0,35t_W$, where t_W is the web gross thickness of the ordinary stiffeners, in mm. Further requirements are specified in Sec 2.

In certain cases the Society may require the above throat thickness to be obtained, in mm, from the following formula:

$$t_T = \frac{4k(\gamma_{S2}p_S + \gamma_{W2}p_W)s\ell\left(1 - \frac{s}{2\ell}\right)}{u + v\left(\frac{c + 0,2d}{b + 0,2d}\right)}$$

where:

k : Greatest material factor of the steels used in the considered assembly, defined in Ch 4, Sec 1, [2.3]

γ_{S2}, γ_{W2} : Partial safety factors defined in Ch 7, Sec 2, [1.2.1]

p_S, p_W : Still water and wave pressure, respectively, in kN/m^2, acting on the ordinary stiffener, defined in Ch 7, Sec 2, [3.3.2]

b,c,d,u,v: Main dimensions, in mm, of the cut-out shown in Fig 6.

Table 3 : Welding factors w_F and coefficient φ for connections of primary supporting members

Primary supporting member	Connection			w_F **(1)**	φ **(2) (3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
General **(4)**	web, where A < 65 cm^2	plating and face plate	at ends	0,20				
			elsewhere	0,15	3,0	3,0		CH/SC 210
	web, where A ≥ 65 cm^2	plating		0,35				
		face plate	at ends	0,35				
			elsewhere	0,25	1,8	1,8		CH/SC 130
	end brackets	face plate		0,35				
In tanks, where A < 65 cm^2 **(5)**	web	plating	at ends	0,25				
			elsewhere	0,20	2,2	2,2		CH/SC 160
		face plate	at ends	0,20				
			elsewhere	0,15	3,0	3,0		CH/SC 210
	end brackets	face plate		0,35				
In tanks, where A ≥ 65 cm^2	web	plating	at ends	0,45				
			elsewhere	0,35				
		face plate		0,35				
	end brackets	face plate		0,45				

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.
(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted.
(3) CH = chain welding, SC = scallop welding, ST = staggered welding.
(4) For cantilever deck beams, continuous welding is to be adopted.
(5) For primary supporting members in tanks intended for the carriage of ballast or fresh water, continuous welding is to be adopted.

Note 1:
A is the face plate sectional area of the primary supporting member, in cm^2.

Note 2:
Ends of primary supporting members means the area extended 20% of the span from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 100 mm beyond the bracket toes.

Figure 6 : End connection of ordinary stiffener Dimensions of the cut-out

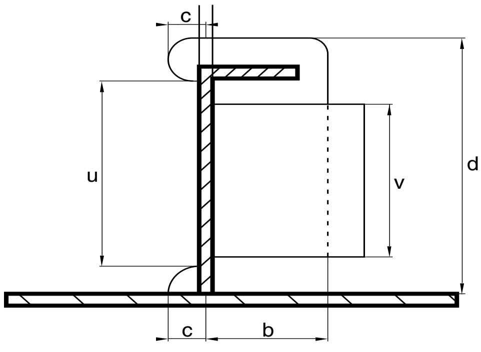


Table 4 : Required throat thickness

t, in mm	t_T, in mm	t, in mm	t_T, in mm
6	3,0	17	7,0
8	3,5	18	7,0
9	4,0	19	7,5
10	4,5	20	7,5
11	5,0	21	8,5
12	5,5	22	8,5
13	6,0	23	9,0
14	6,0	24	9,0
15	6,5	25	10,0
16	6,5	26	10,0

2.3.9 Throat thickness of deep penetration fillet welding

When fillet welding is carried out with automatic welding procedures, the throat thickness required in [2.3.5] may be reduced up to 15%, depending on the properties of the electrodes and consumables. However, this reduction may not be greater than 1,5 mm.

The same reduction applies also for semi-automatic procedures where the welding is carried out in the downhand position.

2.4 Partial and full T penetration welding

2.4.1 General

Partial or full T penetration welding is to be adopted for connections subjected to high stresses for which fillet welding is considered unacceptable by the Society.

Partial or full T penetration welding is required, in any event, where indicated for the connections specified in Part E depending on the ship type. Further requirements are specified in Sec 2.

Typical edge preparations are indicated in:

- for partial penetration welds: Fig 7 and Fig 8, in which f, in mm, is to be taken between 3 mm and t/3, and α between 45° and 60°
- for full penetration welds: Fig 9 and Fig 10, in which f, in mm, is to be taken between 0 and 3 mm, and α between 45° and 60°

  Back gouging is generally required for full penetration welds.

2.4.2 Lamellar tearing

Precautions are to be taken in order to avoid lamellar tears, which may be associated with:

- cold cracking when performing T connections between plates of considerable thickness or high restraint
- large fillet welding and full penetration welding on higher strength steels.

2.5 Lap-joint welding

2.5.1 General

Lap-joint welding may be adopted for:

- peripheral connection of doublers
- internal structural elements subjected to very low stresses.

Elsewhere, lap-joint welding may be allowed by the Society on a case by case basis, if deemed necessary under specific conditions.

Continuous welding is generally to be adopted.

2.5.2 Gap

The surfaces of lap-joints are to be in sufficiently close contact.

2.5.3 Dimensions

The dimensions of the lap-joint are to be specified and are considered on a case by case basis. Typical details are given in the “Guide for welding”.

Figure 7 : Partial penetration weld

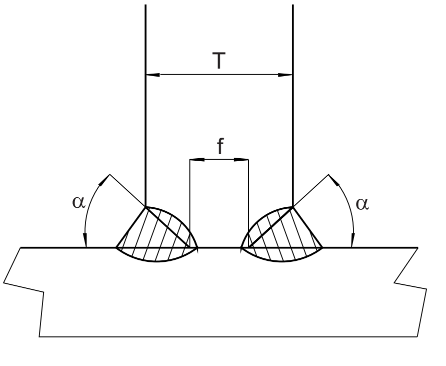


Figure 8 : Partial penetration weld

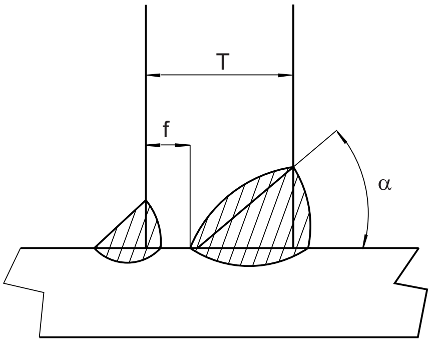


Figure 9 : Full penetration weld

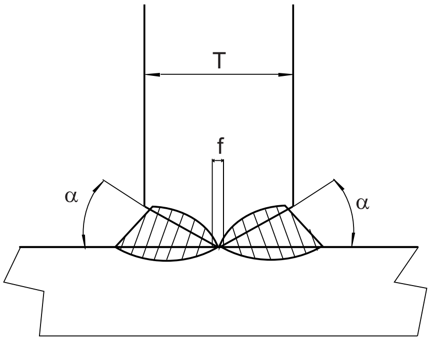
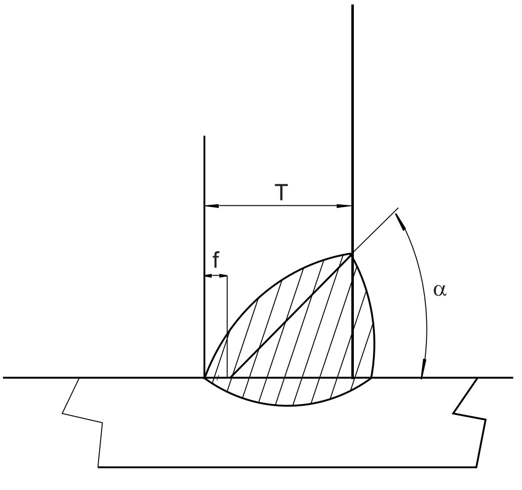


Figure 10 : Full penetration weld



2.6 Slot welding

2.6.1 General

Slot welding may be adopted in very specific cases subject to the special agreement of the Society, e.g. for doublers according to Ch 4, Sec 3, [2.1].

In general, slot welding of doublers on the outer shell and strength deck is not permitted within 0,6L amidships. Beyond this zone, slot welding may be accepted by the Society on a case by case basis.

Slot welding is, in general, permitted only where stresses act in a predominant direction. Slot welds are, as far as possible, to be aligned in this direction.

2.6.2 Dimensions

Slot welds are to be of appropriate shape (in general oval) and dimensions, depending on the plate thickness, and may not be completely filled by the weld.

Typical dimensions of the slot weld and the throat thickness of the fillet weld are given in the "Guide for welding".

The distance between two consecutive slot welds is to be not greater than a value which is defined on a case by case basis taking into account:

- the transverse spacing between adjacent slot weld lines
- the stresses acting in the connected plates
- the structural arrangement below the connected plates.

2.7 Plug welding

2.7.1 Plug welding may be adopted only when accepted by the Society on a case by case basis, according to specifically defined criteria. Typical details are given in the "Guide for welding".

3 Specific weld connections

3.1 Corner joint welding

3.1.1 Corner joint welding, as adopted in some cases at the corners of tanks, performed with ordinary fillet welds, is permitted provided the welds are continuous and of the required size for the whole length on both sides of the joint.

3.1.2 Alternative solutions to corner joint welding may be considered by the Society on a case by case basis.

3.2 Bilge keel connection

3.2.1 The intermediate flat, through which the bilge keel is connected to the shell according to Ch 4, Sec 4, [6], is to be welded as a shell doubler by continuous fillet welds.

The butt welds of the doubler and bilge keel are to be full penetration and shifted from the shell butts.

The butt welds of the bilge plating and those of the doublers are to be flush in way of crossing, respectively, with the doubler and with the bilge keel.

3.3 Connection between propeller post and propeller shaft bossing

3.3.1 Fabricated propeller posts are to be welded with full penetration welding to the propeller shaft bossing.

3.4 Bar stem connections

3.4.1 The bar stem is to be welded to the bar keel generally with butt welding.

The shell plating is also to be welded directly to the bar stem with butt welding.

4 Workmanship

4.1 Forming of plates

4.1.1 Hot or cold forming is to be performed according to the requirements of recognised standards or those accepted by the Society on a case by case basis depending on the material grade and rate of deformation.

Recommendations for cold and hot forming are given in the "Guide for welding".

4.2 Welding procedures and consumables

4.2.1 The various welding procedures and consumables are to be used within the limits of their approval and in accordance with the conditions of use specified in the respective approval documents.

4.3 Welding operations

4.3.1 Weather protection

Adequate protection from the weather is to be provided to parts being welded; in any event, such parts are to be dry.

In welding procedures using bare, cored or coated wires with gas shielding, the welding is to be carried out in weather protected conditions, so as to ensure that the gas outflow from the nozzle is not disturbed by winds and draughts.

4.3.2 Butt connection edge preparation

The edge preparation is to be of the required geometry and correctly performed. In particular, if edge preparation is carried out by flame, it is to be free from cracks or other detrimental notches.

Recommendations for edge preparation are given in the "Guide for welding".

4.3.3 Surface condition

The surfaces to be welded are to be free from rust, moisture and other substances, such as mill scale, slag caused by oxygen cutting, grease or paint, which may produce defects in the welds.

Effective means of cleaning are to be adopted particularly in connections with special welding procedures; flame or mechanical cleaning may be required.

The presence of a shop primer may be accepted, provided it has been approved by the Society.

Shop primers are to be approved by the Society for a specific type and thickness according to Pt D, Ch 5, Sec 3.

4.3.4 Assembling and gap

The setting appliances and system to be used for positioning are to ensure adequate tightening adjustment and an appropriate gap of the parts to be welded, while allowing maximum freedom for shrinkage to prevent cracks or other defects due to excessive restraint.

The gap between the edges is to comply with the required tolerances or, when not specified, it is to be in accordance with normal good practice.

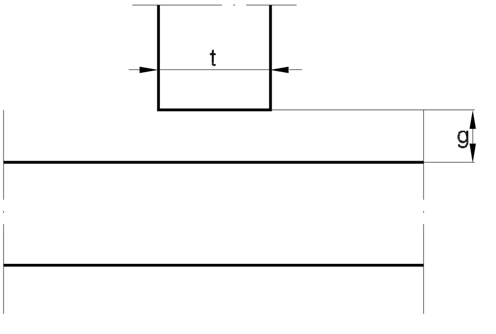
4.3.5 Gap in fillet weld T connections *(1/7/2011)*

In fillet weld T connections, a gap g, as shown in Fig 11, not greater than 2 mm may be accepted without increasing the throat thickness calculated according to [2.3.5] to [2.3.9], as applicable.

In the case of a gap greater than 2 mm, the above throat thickness is to be increased accordingly as specified in Sec 2 for some special connections of various ship types. Recommendations are also given in the "Guide for welding".

In any event, the gap g may not exceed 3 mm.

Figure 11 : Gap in fillet weld T connections



4.3.6 Plate misalignment in butt connections *(1/7/2011)*

The misalignment m, measured as shown in Fig 12, between plates with the same gross thickness t is to be less than 0,15t, without being greater than 4 mm, where t is the gross thickness of the thinner abutting plate.

4.3.7 Misalignment in cruciform connections

The misalignment m in cruciform connections, measured on the median lines as shown in Fig 13, is to be less than:

- t/2, in general, where t is the gross thickness of the thinner abutting plate
- the values specified in Sec 2 for some special connections of various ship types.

The Society may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

Figure 12 : Plate misalignment in butt connections

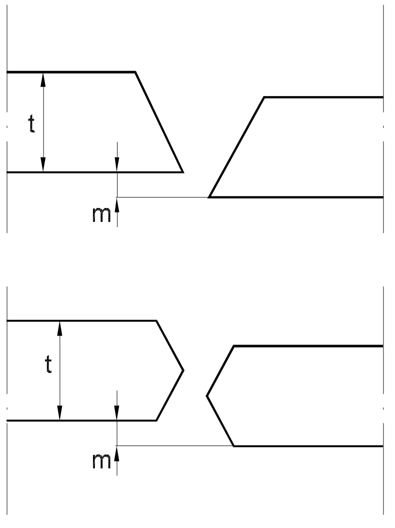
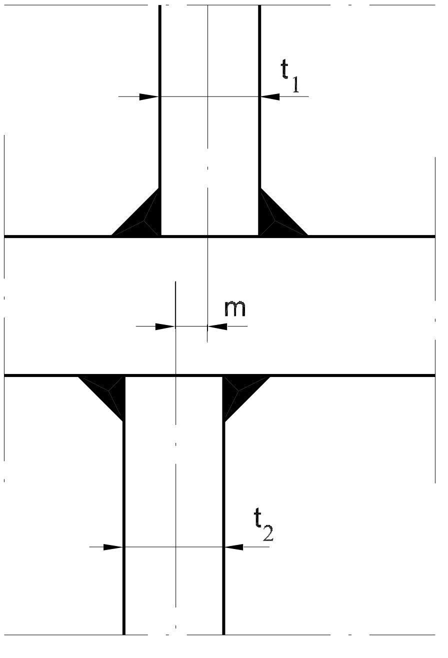


Figure 13 : Misalignment in cruciform connections



4.3.8 Assembling of aluminium alloy parts

When welding aluminium alloy parts, particular care is to be taken so as to:

- reduce as far as possible restraint from welding shrinkage, by adopting assembling and tack welding procedures suitable for this purpose
- keep possible deformations within the allowable limits.

4.3.9 Preheating and interpass temperatures

Suitable preheating, to be maintained during welding, and slow cooling may be required by the Society on a case by case basis.

4.3.10 Welding sequences

Welding sequences and direction of welding are to be determined so as to minimise deformations and prevent defects in the welded connection.

All main connections are generally to be completed before the ship is afloat.

Departures from the above provision may be accepted by the Society on a case by case basis, taking into account any detailed information on the size and position of welds and the stresses of the zones concerned, both during ship launching and with the ship afloat.

4.3.11 Interpass cleaning

After each run, the slag is to be removed by means of a chipping hammer and a metal brush; the same precaution is to be taken when an interrupted weld is resumed or two welds are to be connected.

4.3.12 Stress relieving

It is recommended and in some cases it may be required that special structures subject to high stresses, having complex shapes and involving welding of elements of considerable thickness (such as rudder spades and stern frames), are prefabricated in parts of adequate size and stress-relieved in the furnace, before final assembly, at a temperature within the range 550°C ÷ 620°C, as appropriate for the type of steel.

4.4 Crossing of structural elements

4.4.1 In the case of T crossing of structural elements (one element continuous, the other physically interrupted at the crossing) when it is essential to achieve structural continuity through the continuous element (continuity obtained by means of the welded connections at the crossing), particular care is to be devoted to obtaining the correspondence of the interrupted elements on both sides of the continuous element. Suitable systems for checking such correspondence are to be adopted.

5 Modifications and repairs during construction

5.1 General

5.1.1 Deviations in the joint preparation and other specified requirements, in excess of the permitted tolerances and found during construction, are to be repaired as agreed with the Society on a case by case basis.

5.2 Gap and weld deformations

5.2.1 When the gap exceeds the required values, welding by building up or repairs are to be authorised by the Society’s Surveyor.

Recommendations for repairing gap and weld deformations not complying with the required standards are given in the “Guide for welding”.

5.3 Defects

5.3.1 Defects and imperfections on the materials and welded connections found during construction are to be evaluated for possible acceptance on the basis of the applicable requirements of the Society.

Where the limits of acceptance are exceeded, the defective material and welds are to be discarded or repaired, as deemed appropriate by the Surveyor on a case by case basis.

When any serious or systematic defect is detected either in the welded connections or in the base material, the manufacturer is required to promptly inform the Surveyor and submit the repair proposal.

The Surveyor may require destructive or non-destructive examinations to be carried out for initial identification of the defects found and, in the event that repairs are undertaken, for verification of their satisfactory completion.

5.4 Repairs on structures already welded

5.4.1 In the case of repairs involving the replacement of material already welded on the hull, the procedures to be adopted are to be agreed with the Society on a case by case basis, considering these modifications as repairs of the in-service ship's hull.

6 Inspections and checks

6.1 General

6.1.1 Materials, workmanship, structures and welded connections are to be subjected, at the beginning of the work, during construction and after completion, to inspections suitable to check compliance with the applicable requirements, approved plans and standards.

6.1.2 The manufacturer is to make available to the Surveyor a list of the manual welders and welding operators and their respective qualifications.

The manufacturer's internal organisation is responsible for ensuring that welders and operators are not employed under improper conditions or beyond the limits of their respective qualifications and that welding procedures are adopted within the approved limits and under the appropriate operating conditions.

6.1.3 The manufacturer is responsible for ensuring that the operating conditions, welding procedures and work schedule are in accordance with the applicable requirements, approved plans and recognised good welding practice.

6.2 Visual and non-destructive examinations

6.2.1 After completion of the welding operation and workshop inspection, the structure is to be presented to the Surveyor for visual examination at a suitable stage of fabrication.

As far as possible, the results on non-destructive examinations are to be submitted.

6.2.2 Non-destructive examinations are to be carried out with appropriate methods and techniques suitable for the individual applications, to be agreed with the Surveyor on a case by case basis.

6.2.3 Radiographic examinations are to be carried out on the welded connections of the hull in accordance with the Society's requirements, the approved plans and the Surveyor's instructions.

6.2.4 The Society may allow radiographic examinations to be partially replaced by ultrasonic examinations.

6.2.5 When the visual or non-destructive examinations reveal the presence of unacceptable defects, the relevant connection is to be repaired to sound metal for an extent and according to a procedure agreed with the Surveyor. The repaired zone is then to be submitted to non-destructive examination, using a method at least as effective as that adopted the first time and deemed suitable by the Surveyor to verify that the repair is satisfactory.

Additional examinations may be required by the Surveyor on a case by case basis.

6.2.6 Ultrasonic and magnetic particle examinations may also be required by the Surveyor in specific cases to verify the quality of the base material.

SECTION 2 SPECIAL STRUCTURAL DETAILS

Symbols

T_B : Ship's draft in light ballast condition, see Ch 5, Sec 1, [2.4.3].

1 General

1.1 Application

1.1.1 Special structural details are those characterised by complex geometry, possibly associated with high or alternate stresses.

In addition, the hull areas in which they are located are such that the ship operation and overall safety could be impaired by an unsatisfactory structural performance of the detail.

1.1.2 For special structural details, specific requirements are to be fulfilled during:

- design
- construction
- selection of materials
- welding
- survey.

The purpose of these requirements is specified in [1.2] to [1.6].

1.1.3 Special structural details are those listed in [2] together with the specific requirements which are to be fulfilled.

Other structural details may be considered by the Society as special details, when deemed necessary on the basis of the criteria in [1.1.1]. The criteria to be fulfilled in such cases are defined by the Society on a case by case basis.

1.1.4 As regards matters not explicitly specified in [2], the Rule requirements are to be complied with in any event; in particular:

- Chapter 4 for design principles and structural arrangements
- Chapter 7 or Chapter 8, as applicable, for structural scantling
- Chapter 12 for construction and welding requirements
- the applicable requirements in Part E and Part F.

1.2 Design requirements

1.2.1 General requirements

Design requirements specify:

- the local geometry, dimensions and scantlings of the structural elements which constitute the detail
- any local strengthening
- the cases where a fatigue check is to be carried out according to Ch 7, Sec 4.

1.2.2 Fatigue check requirements

Where a fatigue check is to be carried out, the design requirements specify see Ch 7, Sec 4, [3]:

- the locations (hot spots) where the stresses are to be calculated and the fatigue check performed
- the direction in which the normal stresses are to be calculated
- the stress concentration factors K_h and $K\ell$ to be used for calculating the hot spot stress range.

1.3 Constructional requirements

1.3.1 Constructional requirements specify the allowable misalignment and tolerances, depending on the detail arrangement and any local strengthening.

1.4 Material requirements

1.4.1 Material requirements specify the material quality to be used for specific elements which constitute the detail, depending on their manufacturing procedure, the type of stresses they are subjected to, and the importance of the detail with respect to the ship operation and overall safety.

In addition, these requirements specify where material inspections are to be carried out.

1.5 Welding requirements

1.5.1 *(1/1/2001)*

Welding requirements specify where partial or full T penetration welding (see Sec 1, [2.4]) or any particular welding type or sequence is to be adopted. In addition, these requirements specify when welding procedures are to be approved.

For some fillet welding connections the minimum required throat thickness is also specified.

Since weld shape and undercuts are influencing factors on fatigue behaviour, fillet welds are to be elongated in the direction of the highest stresses and care is to be taken to avoid undercuts, in particular at the hot spots.

1.6 Survey requirements

1.6.1 Survey requirements specify where non-destructive examinations of welds are to be carried out and, where this is the case, which type is to be adopted.

2 List and characteristics of special structural details

2.1 General

2.1.1 This Article lists and describes, depending on the ship type, the special structural details and specifies the specific requirements which are to be fulfilled according to [1.2] to [1.6]. This is obtained through:

- a description of the hull areas where the details are located
- the detail description
- the requirements for the fatigue check
- a reference to a sheet in the Appendixes where a picture of the detail is shown together with the specific requirements which are to be fulfilled.

2.2 All types of ships with longitudinally framed sides

2.2.1 The special structural details relevant to all types of longitudinally framed ships are listed and described in Tab 1.

2.3 Oil tankers and chemical tankers

2.3.1 The special structural details relevant to ships with the service notation **oil tanker ESP** and **chemical tanker ESP** are listed and described in Tab 2 for various hull areas.

When the structural arrangement in a certain area is such that the details considered in Tab 2 are not possible, specific requirements are defined by the Society on a case by case basis, depending on the arrangement adopted.

2.4 Liquefied gas carriers

2.4.1 The special structural details relevant to ships with the service notation **liquefied gas carrier** are listed and described in Tab 3 for various hull areas.

When the structural arrangement in a certain area is such that the details considered in Tab 3 are not possible, specific requirements are defined by the Society on a case by case basis, depending on the arrangement adopted.

2.5 Bulk carriers

2.5.1 The special structural details relevant to ships with the service notation **bulk carrier ESP** are listed and described in Tab 4 for various hull areas.

When the structural arrangement in a certain area is such that the details considered in Tab 4 are not possible, specific requirements are defined by the Society on a case by case basis, depending on the arrangement adopted.

2.6 Ore carriers and combination carriers

2.6.1 The special structural details relevant to ships with the service notation **ore carrier ESP** and **combination carrier ESP** are listed and described in Tab 5 for various hull areas.

When the structural arrangement in a certain area is such that the details considered in Tab 5 are not possible, specific requirements are defined by the Society on a case by case basis, depending on the arrangement adopted.

2.7 Container ships

2.7.1 The special structural details relevant to ships with the service notation **container ship** are listed and described in Tab 6 for various hull areas.

When the structural arrangement in a certain area is such that the details considered in Tab 6 are not possible, specific requirements are defined by the Society on a case by case basis, depending on the arrangement adopted.

Table 1 : Ships with longitudinally framed sides - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
1	Part of side extended: • longitudinally, between the after peak bulkhead and the collision bulkhead • vertically, between 0,7T_B and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 1.1 to 1.6
		Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For L≥150m	Sheets 1.7 to 1.13

Table 2 : Oil tankers and chemical tankers - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
1	Part of side extended: • longitudinally, between the after peak bulkhead and the collision bulkhead • vertically, between 0,7T_B and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 1.1 to 1.6
		Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For L≥150m	Sheets 1.7 to 1.13
2	Part of inner side and longitudinal bulkheads in the cargo area extended vertically above half tank height, where the tank breadth exceeds 0,55B	Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 2.1 to 2.6
		Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For L≥150m	Sheets 2.7 to 2.13
3	Double bottom in way of transverse bulkheads	Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors	For L≥150m	Sheets 3.1 to 3.3
		Connection of inner bottom with transverse bulkheads or lower stools	For L≥150m	Sheet 3.4
4	Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	For L≥150m	Sheets 4.1 to 4.4
5	Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads	For L≥150m	Sheets 5.1 to 5.7
		Connection of lower stools with corrugated bulkheads	For L≥150m (No for 5.11, 5.15)	Sheets 5.8 to 5.15
6	Lower part of inner side	Connection of hopper tank sloping plates with inner side	For L≥150m	Sheets 6.1 to 6.7

Table 3 : Liquefied gas carriers - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
1	Part of side extended: • longitudinally, between the after peak bulkhead and the collision bulkhead • vertically, between 0,7T_B and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 1.1 to 1.6
		Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For L≥150m	Sheets 1.7 to 1.13
3	Double bottom in way of transverse bulkheads	Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors	For L≥150m	Sheets 3.1 to 3.3
		Connection of inner bottom with transverse cofferdam bulkheads	For L≥150m	Sheet 3.5
4	Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	For L≥150m	Sheets 4.5 to 4.7
6	Lower part of inner side	Connection of hopper tank sloping plates with inner side	For L≥150m	Sheets 6.8, 6.9

Table 4 : Bulk carriers - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
3	Double bottom in way of transverse bulkheads	Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors	For L≥150m	Sheets 3.1 to 3.3
		Connection of inner bottom with transverse bulkheads or lower stools	For L≥150m	Sheet 3.4
4	Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	For L≥150m	Sheets 4.1 to 4.4
5	Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads	For L≥150m	Sheets 5.1 to 5.7
		Connection of lower stools with corrugated bulkheads	For L≥150m (No for 5.11,5.15)	Sheets 5.8 to 5.15
6	Lower part of inner side	Connection of hopper tank sloping plates with inner side	For L≥150m	Sheets 6.1 to 6.7
7	Side frames	Connection of side frames with hopper and topside tanks	No	Sheets 7.1, 7.2
8	Topside tanks	Connection of transverse corrugated bulkheads with topside tanks	No	Sheet 8.1
10	Hatch corners	Deck plating in way of hatch corners	No	Sheet 10.1
		Ends of longitudinal hatch coamings	No	Sheets 10.2, 10.3

Table 5 : Ore carriers and combination carriers - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
1	Part of side extended: • longitudinally, between the after peak bulkhead and the collision bulkhead • vertically, between 0,7T_B and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 1.1 to 1.6
		Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For L≥150m	Sheets 1.7 to 1.13
3	Double bottom in way of transverse bulkheads	Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors	For L≥150m	Sheets 3.1 to 3.3
		Connection of inner bottom with transverse bulkheads or lower stools	For L≥150m	Sheet 3.4
4	Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	For L≥150m	Sheets 4.1 to 4.4
5	Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads	For L≥150m	Sheets 5.1 to 5.7
		Connection of lower stools with corrugated bulkheads	For L≥150m (No for 5.11, 5.15)	Sheets 5.8 to 5.15
6	Lower part of inner side	Connection of hopper tank sloping plates with inner side	For L≥150m	Sheets 6.1 to 6.7
8	Topside tanks	Connection of transverse corrugated bulkheads with topside tanks	No	Sheet 8.1
10	Hatch corners	Deck plating in way of hatch corners	No	Sheet 10.1
		Ends of longitudinal hatch coamings	No	Sheets 10.2, 10.3

Table 6 : Container ships - Special structural details

Area reference number	Area description	Detail description	Fatigue check	Reference sheet in App 1
1	Part of side extended: • longitudinally, between the after peak bulkhead and the collision bulkhead • vertically, between $0,7T_B$ and $1,15T$ from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members	No	Sheets 1.1 to 1.6
		Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members	For $L \geq 150m$	Sheets 1.7 to 1.13
9	Cross decks	Connection of cross decks with side transverses	No	Sheet 9.1
		Connection between face plates of cross decks and deck girders	No	Sheet 9.2
10	Hatch corners	Deck plating in way of hatch corners	No	Sheet 10.1
		Ends of longitudinal hatch coamings	No	Sheets 10.2, 10.3

SECTION 3 TESTING

1 General

1.1 Purpose and application

1.1.1 Purpose *(1/1/2018)*

The test procedures in this Section are to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which form the watertight subdivisions of ships (see Note 1). These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs (see Note 2) is to be confirmed by these test procedures prior to the delivery of the ship.

Note 1: Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

Note 2: Major repair means a repair affecting structural integrity.

1.1.2 Application *(1/1/2016)*

All gravity tanks (see Note 1) and other boundaries required to be watertight or weathertight are to be tested in accordance with the requirements of this Section and proven to be tight and structurally adequate as follows:

- Gravity Tanks for their tightness and structural adequacy,
- Watertight Boundaries Other Than Tank Boundaries for their watertightness, and
- Weathertight Boundaries for their weathertightness.

The testing of structures not listed in Tab 1 or Tab 2 is to be specially considered.

Note 1: Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

1.1.3 SOLAS Ships *(1/1/2018)*

The testing procedures of watertight compartments reported in [2.2.2] apply to ships subjected to SOLAS Convention, unless:

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Flag Administration for an exemption from the application of SOLAS Chapter II-1, Regulation 11, or for an equivalency agreeing that the content of [2.2.3] is equivalent to SOLAS Chapter II-1, Regulation 11; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Flag Administration.

1.1.4 Non-SOLAS Ships and SOLAS Exemption/Equivalent Ships *(1/1/2018)*

The testing procedures of watertight compartments reported in [2.2.2] apply to ships not subjected to SOLAS Convention and to ships subjected to SOLAS Convention for which:

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Flag Administration for an exemption from the application of SOLAS Chapter II-1, Regulation 11, or for an equivalency agreeing that the content of [2.2.3] is equivalent to SOLAS Chapter II-1, Regulation 11; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Flag Administration.

1.2 Definitions

1.2.1 Shop primer

Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

1.2.2 Protective coating

Protective coating is a final coating protecting the structure from corrosion.

1.2.3 Structural test *(1/7/2013)*

A structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

1.2.4 Leak test *(1/1/2016)*

A leak test is a test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated in Tab 1, Note 3.

1.2.5 Hydrostatic test (leak and structural) *(1/1/2016)*

A hydrostatic test is a test wherein a space is filled with a liquid to a specified head.

1.2.6 Hydropneumatic test (leak and structural) *(1/1/2016)*

A hydropneumatic test is a test combining a hydrostatic test and an air test, wherein a space is partially filled with liquid and pressurized with air.

1.2.7 Hose test (leak) *(1/1/2016)*

A hose test is a test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.

1.2.8 Air test (leak) *(1/1/2016)*

An air test is a test to verify the tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests.

1.2.9 Compressed air fillet weld test (leak) *(1/1/2016)*

A compressed air fillet weld test is an air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.

1.2.10 Vacuum box test (leak) *(1/1/2016)*

A vacuum box test is a box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.

1.2.11 Ultrasonic test (leak) *(1/1/2016)*

An ultrasonic test is a test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.

1.2.12 Penetration test (leak) *(1/1/2016)*

A penetration test is a test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

1.2.13 Margin line

The margin line is a line drawn at least 76 mm below the upper surface of the bulkhead deck at side.

1.2.14 Sister ship

A sister ship is a ship having the same main dimensions, general arrangement, capacity plan and structural design as those of the first ship in a series.

2 Test procedures

2.1 General

2.1.1 *(1/7/2013)*

Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints.

In particular, tests are to be carried out after air vents and sounding pipes have been fitted.

Specific test requirements are given in [2.4] and Tab 1. For the timing of the application of coating and the provision of safe access to joints, see [2.5], [2.6] and Tab 3.

2.2 Structural test procedures

2.2.1 Type and time of test *(1/1/2016)*

Where a structural test is specified in Tab 1 or Tab 2, a hydrostatic test in accordance with [2.4.1] will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with [2.4.2] may be accepted instead.

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat, provided the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

2.2.2 SOLAS Ships: Testing schedule for new construction or major structural conversion *(1/1/2018)*

The requirements given in the following apply to SOLAS ships, as defined in [1.1.3].

a) Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship (see Note 1), shall be tested for tightness and structural strength as indicated in Tab 1 and Tab 2.

b) The tank boundaries are to be tested from at least one side. The tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

c) The watertight boundaries of spaces other than tanks for structural testing may be exempted, provided that the water-tightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempted and the requirements for structural testing of tanks in a) and b) shall apply, for ballast holds, chain lockers and a representative cargo hold if intended for in-port ballasting.

d) Tanks which do not form part of the watertight subdivision of the ship (see Note 1), may be exempted from structural testing provided that the water-tightness of boundaries of exempted spaces is verified by leak tests and inspections.

Note 1: Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

2.2.3 Non-SOLAS Ships and SOLAS Exemption/Equivalent Ships: Testing schedule for new construction or major structural conversion *(1/1/2018)*

The requirements given in the following apply to Non-SOLAS ships and to SOLAS exemption/equivalent ships, as defined in [1.1.4].

a) The tank boundaries are to be tested from at least one side. The tanks for structural testing are to be selected so that all representative structural members are tested for the expected tension and compression.

b) Structural tests are to be carried out on at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the attending Surveyor) on each vessel provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

c) Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

d) Where the structural adequacy of the tanks of a vessel was verified by the structural testing required in Tab 1, subsequent vessels in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

1) Watertightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out.
2) Structural testing is carried out on at least one tank of each type among all tanks of each sister vessel.
3) Additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending Surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, the provisions of b) are to be applied in lieu of d) 2)

e) Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with d) at the discretion of the Society, provided that:

1) general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Society) and,
2) an enhanced NDT plan is implemented and evaluated by the Society for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with IACS Recommendation 47, "Shipbuilding and Repair Quality Standard", or a recognised fabrication standard which has been accepted by the Society prior to the commencement of fabrication/construction. The work is to be carried out in accordance with the requirements and under survey of the Society.

2.3 Leak test procedures

2.3.1 *(1/1/2018)*

For the leak test specified in Tab 1, tank air tests, compressed air fillet weld test, vacuum box test in accordance with [2.4.4] to [2.4.6], or their combination will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that [2.5], [2.6] and [2.7] are complied with. Hose tests will also be acceptable for such locations as specified in Tab 1, Note 3, in accordance with [2.4.3].

The application of the leak test for each type of welded joint is specified in Tab 3.

Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. See also [2.5.1] for the application of final coatings and [2.6] for the safe access to joints and the summary in Tab 3.

2.4 Test methods

2.4.1 Hydrostatic test *(1/1/2018)*

Unless another liquid is approved, hydrostatic tests are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Tab 1 or Tab 2. See also [2.7].

In cases where a tank is designed for cargo densities greater than sea water and testing is with fresh water or sea water, the testing pressure height is to simulate the actual loading for those greater cargo densities as far as practicable.

All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

2.4.2 Hydropneumatic test *(1/1/2018)*

Hydropneumatic tests, where approved, are to be such that the test condition in conjunction with the approved liquid level and supplemental air pressure will simulate the actual loading as far as practicable. The requirements and recommendations for tank air tests in [2.4.4] will also apply to hydropneumatic tests. See also [2.7].

All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

2.4.3 Hose test *(1/1/2016)*

Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at $2 \cdot 10^5$ Pa during the test. The nozzle is to have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1,5 m.

The water jet is to impinge directly upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

2.4.4 Tank air test *(1/1/2018)*

All boundary welds, erection joints and penetrations, including pipe connections, are to be examined in accordance with approved procedure and under a stabilized pressure differential above atmospheric pressure not less than $0,15 \cdot 10^5$ Pa, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

A U-tube with a sufficient height to hold a head of water corresponding to the required test pressure is to be arranged. The cross sectional of the U-tube is not to be less than that of the pipe supplying air to the tank.

Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in F5.1 and F7.4 of IACS Recommendation 140, "Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems".

A double inspection is to be made of tested welds. The first is to be immediately upon applying the leak indicating solution; the second is to be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

2.4.5 Compressed air fillet weld test *(1/1/2016)*

In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least $0,15 \cdot 10^5$ Pa can be verified at each end of all passages within the portion being tested.

Note 1: Where a leak test *is required for fabrication involving* partial penetration *welds*, a compressed air test is *also* to be applied in the same manner as for a fillet weld *where the root face is large, i.e., 6-8 mm*.

2.4.6 Vacuum box test *(1/1/2016)*

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of $0,20 \cdot 10^5$ - $0,26 \cdot 10^5$ Pa inside the box.

2.4.7 Ultrasonic test *(1/1/2016)*

An ultrasonic echo transmitter is to be arranged inside a compartment and a receiver is to be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

2.4.8 Penetration test *(1/1/2016)*

A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

2.4.9 Other tests *(1/7/2013)*

Other methods of testing may be considered by the Society upon submission of full particulars prior to commencement of testing.

2.5 Application of coating

2.5.1 Final coating *(1/1/2016)*

For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

Surveyors reserve the right to require a leak test prior to the application of final coating over automatic erection butt welds.

For all other joints, the final coating is to be applied after completion of the leak test of the joint. See also Tab 3.

2.5.2 Temporary coating *(1/1/2016)*

Any temporary coating which may conceal defects or leaks is to be applied at the time as specified for the final coating (see [2.5.1]). This requirement does not apply to shop primer.

2.6 Safe access to joints

2.6.1 *(1/7/2013)*

For leak tests, safe access to all joints under examination is to be provided. See also Tab 3.

2.7 Hydrostatic or hydropneumatic tightness test

2.7.1 *(1/1/2016)*

In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries must be dew-free, otherwise small leaks are not visible.

2.8 Other testing methods

2.8.1 Other testing methods may be accepted, at the discretion of the Society, based upon equivalency considerations.

2.9 Acceptance criteria for watertight doors

2.9.1 *(1/7/2007)*

The following acceptable leakage criteria apply:

Doors with gaskets:	No leakage
Doors with metallic sealing:	Maximum leakage 1 l/min

Limited leakage may be accepted for pressure tests on large doors located in cargo spaces employing gasket seals or guillotine doors located in conveyor tunnels, in accordance with the following:

Leakage rate (l/min) = $(P + 4,572)\, h^3 / 6568$

where:

P = perimeter of door opening, in m

h = test head of water, in m

However, in the case of doors where the water head taken for the determination of the scantling does not exceed 6,1 m, the leakage rate may be taken equal to 0,375 l/min if this value is greater than that calculated by the above-mentioned formula.

For doors of passenger ships which are normally open and used at sea and which become submerged by the equilibrium or intermediate waterplane, a prototype test is to be conducted, on each side of the door, to check the satisfactory closing of the door against a force equivalent to a water height of at least 1 m above the sill on the centreline of the door.

2.9.2 *(1/7/2007)*

For large doors intended for use in watertight subdivision boundaries of cargo spaces, structural analysis may be accepted in lieu of pressure testing on a case-by-case basis. Where such doors use gasket seals, a prototype pressure test is to be carried out to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis.

3 Miscellaneous

3.1 Watertight decks, trunks, etc.

3.1.1 *After completion, a hose or flooding test is to be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators.*

3.2 Doors in bulkheads above the bulkhead deck

3.2.1 Doors are to be designed and constructed as weathertight doors and, after installation, subjected to a hose test from each side for weathertightness.

3.3 Semi-watertight doors

3.3.1 Semi-watertight doors are those defined in Pt F, Ch 13, Sec 11, [2.1.4].

These means of closure are to be subjected to a structural test at the manufacturer's works. The head of water is to be up to the highest waterline after damage at the equilibrium of the intermediate stages of flooding. The duration of the test is to be at least 30 min.

A leakage quantity of approximately 100 l/hour is considered as being acceptable for a 1,35 m^2 opening.

The means of closure are to be subjected to a hose test after fitting on board.

3.4 Steering nozzles

3.4.1 Upon completion of manufacture, the nozzle is to be subjected to a leak test.

4 Working tests

4.1 Working test of windlass

4.1.1 The working test of the windlass is to be carried out on board in the presence of a Surveyor.

4.1.2 The test is to demonstrate that the windlass complies with the requirements of Ch 10, Sec 4, [3.7] and, in particular, that it works adequately and has sufficient power to simultaneously weigh the two bower anchors (excluding the housing of the anchors in the hawse pipe) when both are suspended to 55 m of chain cable, in not more than 6 min.

4.1.3 Where two windlasses operating separately on each chain cable are adopted, the weighing test is to be carried out for both, weighing an anchor suspended to 82,5 m of chain cable and verifying that the time required for the weighing (excluding the housing in the hawse pipe) does not exceed 9 min.

Table 1 : Test Requirements for tanks and boundaries *(1/1/2018)*

Item	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	Double bottom tanks **(4)**	Leak and structural **(1)**	The greater of: - top of the overflow, - to 2,4m above top of tank **(2)**, or - to bulkhead deck	
2	Double bottom voids **(5)**	Leak	See [2.4.4] through [2.4.6], as applicable	Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I

(1) Refer to [2.2.2] or [2.2.3] as the case may be.
(2) The top of a tank is the deck forming the top of the tank, excluding any hatchways.
(3) Hose Test may also be considered as a test medium. See [1.2.4].
(4) Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.
(5) Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22 respectively.
(6) Where watertightness of a watertight doors has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.
(7) As an alternative to the hose test, other testing methods listed in [2.4.7] through [2.4.9] may be applicable subject to the adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1. For watertight bulkheads (item 11.a), alternatives to hose testing may only be used where a hose test is not practicable.
(8) A "Leak and structural test", see [2.2.3] is to be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting is to be the maximum loading that will occur in-port as indicated in the loading manual.
(9) Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they are to be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

Item	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
3	Double side tanks	Leak and structural **(1)**	The greater of - top of the overflow, - to 2,4m above top of tank **(2)**, or - to bulkhead deck	
4	Double side voids	Leak	See [2.4.4] through [2.4.6], as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural **(1)**	The greater of - top of the overflow, or - to 2.4m above top of tank **(2)**	
6	Cargo oil tanks	Leak and structural **(1)**	The greater of - top of the overflow, - to 2,4m above top of tank **(2)**, or - to top of tank **(2)** plus setting of any pressure relief valve	
7	Ballast hold of bulk carriers	Leak and structural **(1)**	Top of cargo hatch coaming	
8	Peak tanks	Leak and structural **(1)**	The greater of - top of the overflow, or - to 2,4m above top of tank **(2)**	After peak to be tested after installation of stern tube
9	a) Fore peak spaces with equipment	Leak	See [2.4.3] through [2.4.6], as applicable	
	b) Fore peak voids	Leak	See [2.4.4] through [2.4.6], as applicable	
	c) Aft peak spaces with equipment	Leak	See [2.4.3] through [2.4.6], as applicable	
	d) Aft peak voids	Leak	See [2.4.4] through [2.4.6], as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	See [2.4.4] through [2.4.6], as applicable	
11	a) Watertight bulkheads	Leak **(8)**	See [2.4.3] through [2.4.6], as applicable **(7)**	
	b) Superstructure end bulkheads	Leak	See [2.4.3] through [2.4.6], as applicable	
12	Watertight doors below freeboard or bulkhead deck	Leak **(6) (7)**	See [2.4.3] through [2.4.6], as applicable	

(1) Refer to [2.2.2] or [2.2.3] as the case may be.
(2) The top of a tank is the deck forming the top of the tank, excluding any hatchways.
(3) Hose Test may also be considered as a test medium. See [1.2.4].
(4) Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.
(5) Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22 respectively.
(6) Where watertightness of a watertight doors has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.
(7) As an alternative to the hose test, other testing methods listed in [2.4.7] through [2.4.9] may be applicable subject to the adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1. For watertight bulkheads (item 11.a), alternatives to hose testing may only be used where a hose test is not practicable.
(8) A "Leak and structural test", see [2.2.3] is to be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting is to be the maximum loading that will occur in-port as indicated in the loading manual.
(9) Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they are to be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

Item	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
13	Double plate rudder blades	Leak	See [2.4.4] through [2.4.6], as applicable	
14	Shaft tunnels clear of deep tanks	Leak **(3)**	See [2.4.3] through [2.4.6], as applicable	
15	Shell doors	Leak **(3)**	See [2.4.3] through [2.4.6], as applicable	
16	Weathertight hatch covers and closing appliances	Leak **(3) (7)**	See [2.4.3] through [2.4.6], as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tanks/dry cargo hatch covers	Leak **(3) (7)**	See [2.4.3] through [2.4.6], as applicable	In addition to structural test in item 6 or 7 of this table
18	Chain lockers	Leak and structural **(1)**	Top of chain pipe	
19	L.O. sump. tanks and other similar tanks/spaces under main engines	Leak **(9)**	See [2.4.3] through [2.4.6], as applicable	
20	Ballast ducts	Leak and structural **(1)**	The greater of - ballast pump maximum pressure, or - setting of any pressure relief valve	
21	Fuel Oil Tanks	Leak and structural **(1)**	The greater of- top of the overflow, - to 2.4m above top of tank **(2)**, or - to top of tank **(2)** plus setting of any pressure relief valve, or - to bulkhead deck	

(1) Refer to [2.2.2] or [2.2.3] as the case may be.

(2) The top of a tank is the deck forming the top of the tank, excluding any hatchways.

(3) Hose Test may also be considered as a test medium. See [1.2.4].

(4) Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.

(5) Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22 respectively.

(6) Where watertightness of a watertight doors has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.

(7) As an alternative to the hose test, other testing methods listed in [2.4.7] through [2.4.9] may be applicable subject to the adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1. For watertight bulkheads (item 11.a), alternatives to hose testing may only be used where a hose test is not practicable.

(8) A "Leak and structural test", see [2.2.3] is to be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting is to be the maximum loading that will occur in-port as indicated in the loading manual.

(9) Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they are to be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

Table 2 : Additional test requirements for special service ships/tanks *(1/1/2018)*

	Type of ship/tank	Structures to be tested	Type of test	Test head or pressure	Remarks
1	Liquefied gas carrier	Integral tanks	Leak and structural	The greater of - to 2,4m above top of tank **(2)**, or - to top of tank **(2)** plus setting of any pressure relief valve See also Pt E, Ch 9, Sec 4, [13.1]	Where a cargo tank is designed for the carriage of cargoes with specific gravities greater than 1,0, an appropriate additional head is to be considered
		Hull structure supporting membrane or semi-membrane tanks		The greater of - to 2,4m above top of tank **(2)**, or - to top of tank **(2)** plus setting of any pressure relief valve See also Pt E, Ch 9, Sec 4, [13.3]	Where a cargo tank is designed for the carriage of cargoes with specific gravities greater than 1,0, an appropriate additional head is to be considered
		Independent tanks type A		See Pt E, Ch 9, Sec 4, [13.4]	
		Independent tanks type B		See Pt E, Ch 9, Sec 4, [13.4]	
		Independent tanks type C		See Pt E, Ch 9, Sec 4, [13.4]	
2	Edible liquid tanks	Independent tanks	Leak and structural **(1)**	The greater of - top of the overflow, or - to 0,9m above top of tank **(2)**	
3	Chemical carriers	Integral or independent cargo tanks	Leak and structural **(1)**	The greater of - to 2,4m above top of tank **(2)**, or - to top of tank **(2)** plus setting of any pressure relief valve	Where a cargo tank is designed for the carriage of cargoes with specific gravities greater than 1,0, an appropriate additional head is to be considered

(1) Refer to [2.2.2] or [2.2.3], as the case may be
(2) Top of tank is deck forming the top of the tank excluding any hatchways.

Table 3 : Application of leak test, coating and provision of safe access for type of welded joints *(1/1/2016)*

Type of welded joints		Leak test	Coating **(1)**		Safe access **(2)**	
			Before leak test	After leak test but before structural test	Leak test	Structural test
Butt	Automatic	Not required	Allowed **(3)**	N/A	Not required	Not required
	Manual or Semi-automatic **(4)**	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

(1) Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
(2) Temporary means of access for verification of the leak test.
(3) The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.
(4) Flux Core Arc Welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDE testing show no significant defects.

APPENDIX 1 REFERENCE SHEETS FOR SPECIAL STRUCTURAL DETAILS

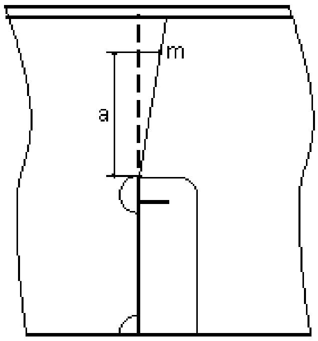
1 Contents

1.1 General

1.1.1 This appendix includes the reference sheets for special structural details, as referred to in Sec 2.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with transverse primary supporting members - No collar plate	Sheet 1.1



t_W = web thickness of transverse primary supporting member

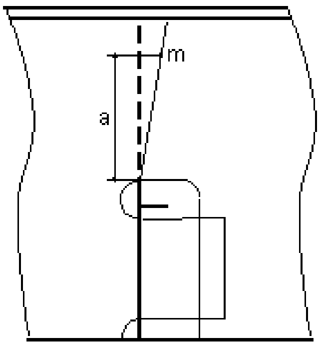
SCANTLINGS:	FATIGUE:
Net sectional area of the web stiffener according to Ch 4, Sec 3, 4.7.	Fatigue check not required.
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50. • Cut-outs in the web free of sharps notches. • Gap between web and side longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

Welding requirements:

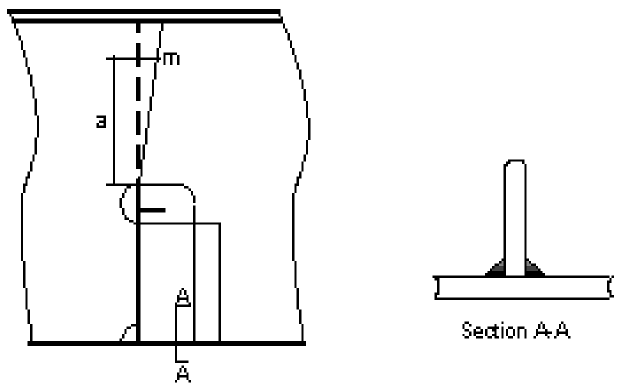
- continuous fillet welding along the connection of web with side longitudinal,
- throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
- weld around the cuts in the web at the connection with the longitudinal and the side shell,
- avoid burned notches on web.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

<table>
<tr><td>AREA 1: Side between 0,7T_B and 1,15T from the baseline</td><td colspan="2">Connection of side longitudinal ordinary stiffeners with transverse primary supporting members - One collar plate</td><td>Sheet 1.2</td></tr>
<tr><td colspan="4">
t_W = web thickness of transverse primary supporting member
t_{CP} = collar plate thickness</td></tr>
<tr><td colspan="2">SCANTLINGS:</td><td colspan="2">FATIGUE:</td></tr>
<tr><td colspan="2">Net sectional area of the web stiffener according to Ch 4, Sec 3, 4.7.</td><td colspan="2">Fatigue check not required.</td></tr>
<tr><td colspan="2">CONSTRUCTION:</td><td colspan="2">NDE:</td></tr>
<tr><td colspan="2">• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50.
• Misalignment between web and collar plate $\leq t_{CP}$.
• Cut-outs in the web free of sharps notches.
• Gap between web and side longitudinal and between collar plate and side longitudinal to be not greater than 4 mm.</td><td colspan="2">Visual examination 100%.</td></tr>
<tr><td colspan="4">WELDING AND MATERIALS:</td></tr>
<tr><td colspan="4">• Welding requirements:
- continuous fillet welding along the connection of web and collar plate with side longitudinal and at the lap joint between web and collar plate,
- throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
- weld around the cuts in the web at the connection with the longitudinal and the side shell,
- avoid burned notches on web.
• Fillet welding of overlapped joint to be done all around.</td></tr>
</table>

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with transverse primary supporting members - One large collar plate**	**Sheet 1.3**



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

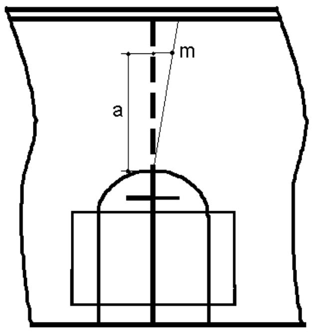
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50. • Misalignment between web and collar plate $\leq t_{CP}$. • Cut-outs in the web free of sharps notches. • Gap between web and side longitudinal and between collar plate and side longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of web and collar plate with side longitudinal and at the lap joint between web and collar plate,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - T joint connection of collar plate with side shell: see section A-A,
  - weld around the cuts in the web at the connection with the longitudinal and the side shell,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with transverse primary supporting members - Two collar plates**	**Sheet 1.4**



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

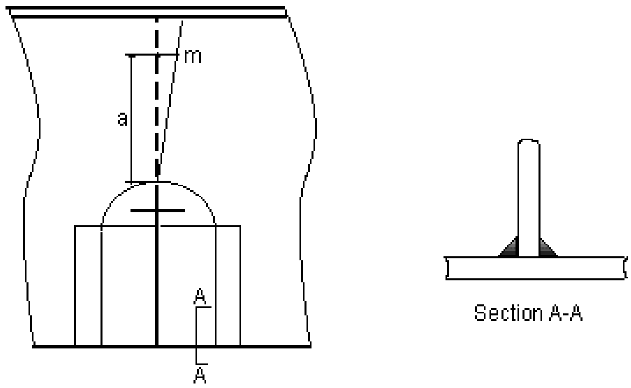
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50. • Misalignment between collar plates across the side longitudinal $\leq t_{CP}$ / 2. • Cut-outs in the web free of sharps notches. • Gap between collar plates and side longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of collar plates with side longitudinal and at the lap joint between web and collar plates,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with transverse primary supporting members - Two large collar plates**	**Sheet 1.5**



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

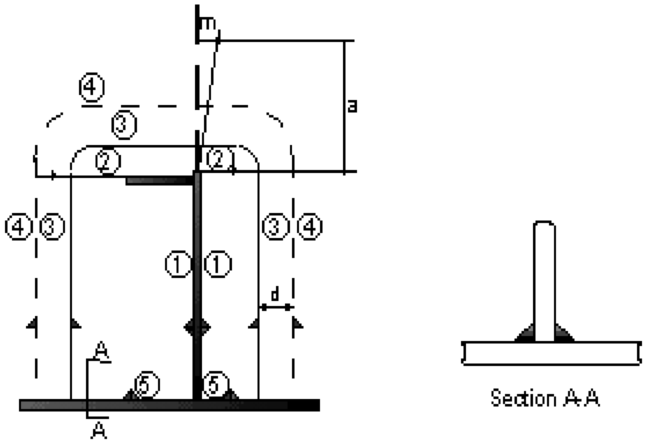
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50. • Misalignment between collar plates across the side longitudinal $\leq t_{CP}$ / 2. • Cut-outs in the web free of sharps notches. • Gap between collar plates and side longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of collar plates with side longitudinal and at the lap joint between web and collar plates,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - T joint connection of collar plates with side shell: see section A-A,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Watertight connection of side longitudinal ordinary stiffeners with watertight side diaphragms or transverse bulkheads – Example of connection with lugs**	**Sheet 1.6**



t_W = transverse bulkhead web thickness

t_L = lug thickness

SCANTLINGS:	**FATIGUE:**
• d = 30 ÷ 60 mm. • $t_L \geq t_W$.	Fatigue check not required.

CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the side longitudinal $\leq$ a / 50. • Misalignment between lugs across the side longitudinal $\leq t_L / 2$. • Misalignment at the butts within lug parts $\leq t_L / 5$. • Gap between bulkhead plating and lugs to be not greater than 4 mm.	• Visual examination 100%. • Magnetic particle or dye penetrant examination: when deemed necessary depending on the quality of the lap joint weld.

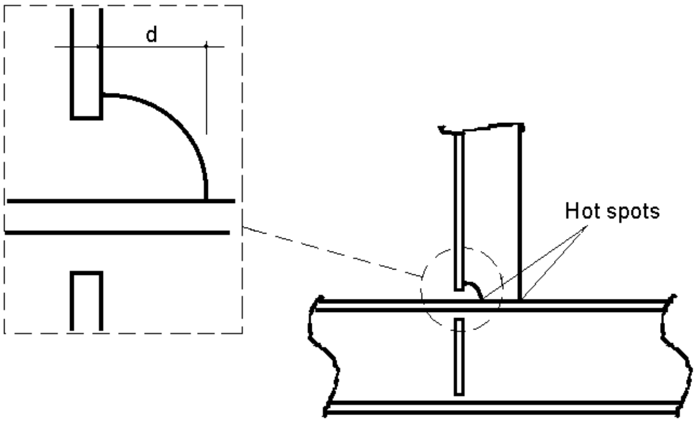
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding along the connection of lugs with the side longitudinal and at the lap joints between web and lugs,
- throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
- T joint connection of collar plates with side shell: see section A-A,
- welding sequence: ① to ⑤ (see sketch).

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0{,}7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - No bracket**	**Sheet 1.7** (1/1/2001)



t = minimum thickness between those of:
- web of side longitudinal,
- stiffener of transverse primary supporting member.

SCANTLINGS:	**FATIGUE:**
d to be as small as possible, maximum 35 mm recommended.	Fatigue check to be carried out for L ≥ 150 m: $K_h = 1{,}3$ $K_\ell = 1{,}65$

CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal and web stiffener to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

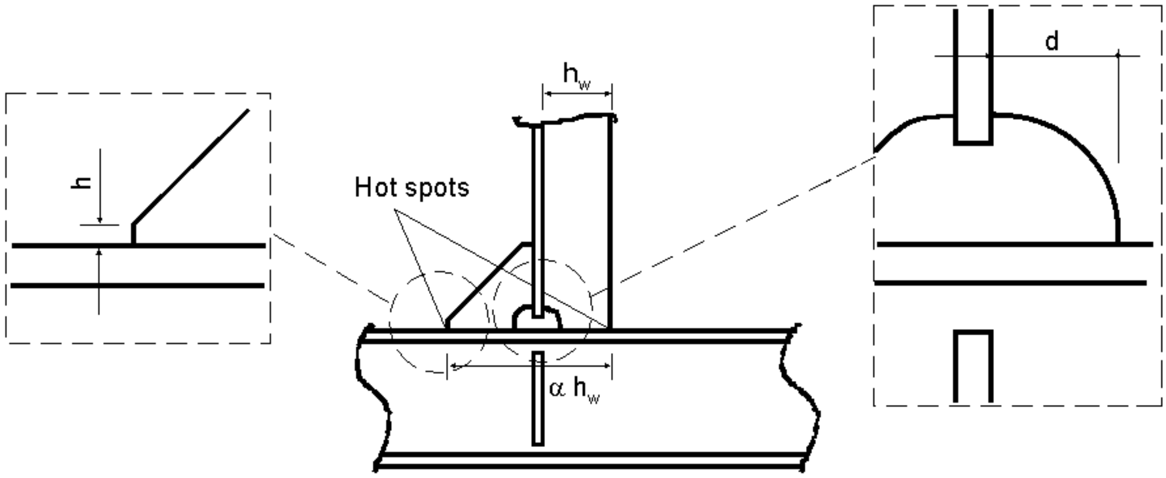
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One bracket	Sheet 1.8 (1/1/2001)



t = minimum thickness among those of the connected elements

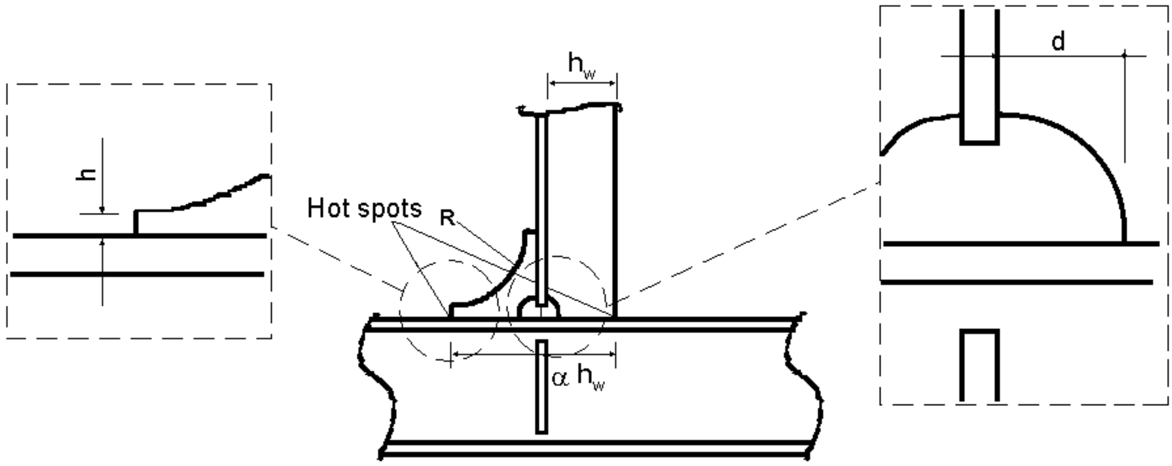
SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • Bracket to be symmetric. • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: – for $2 \leq \alpha < 2,5$ $K_h = 1,2$ $K_\ell = 1,4$ – for $\alpha \geq 2,5$ $K_h = 1,15$ $K_\ell = 1,4$
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

WELDING AND MATERIALS:

Welding requirements:
- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One radiused bracket	Sheet 1.9 (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • Bracket to be symmetric. • $R \geq 1,5\ (\alpha - 1)\ h_W$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$ $K_h = 1,15$ $K_\ell = 1,35$ - for $\alpha \geq 2,5$ $K_h = 1,1$ $K_\ell = 1,35$

CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

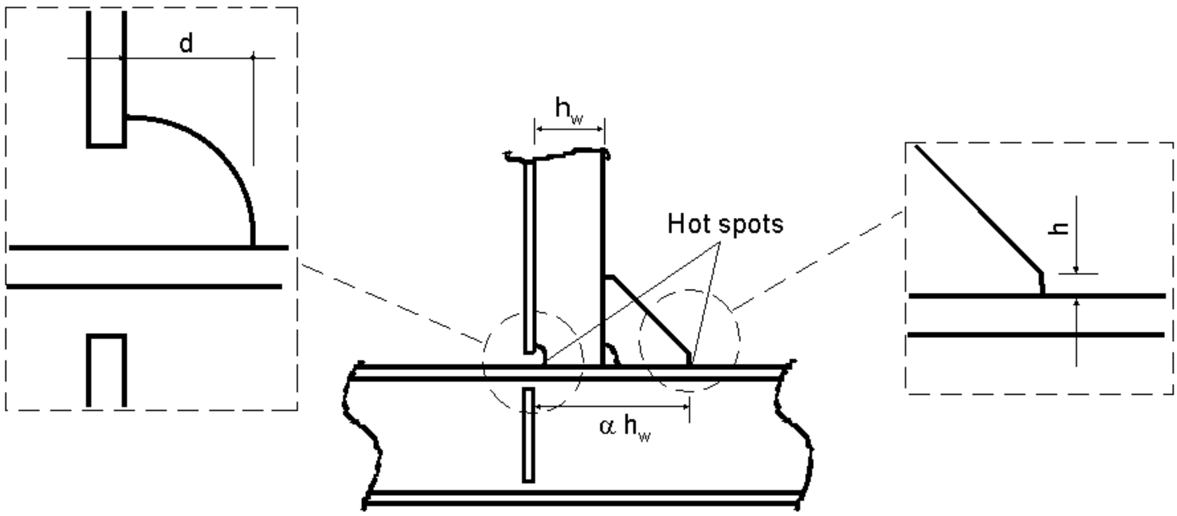
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = $0,45\ t_W$, where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One bracket**	**Sheet 1.10** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • Bracket to be symmetric. • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$ $K_h = 1,3$ $K_\ell = 1,55$ - for $\alpha \geq 2,5$ $K_h = 1,25$ $K_\ell = 1,5$

CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

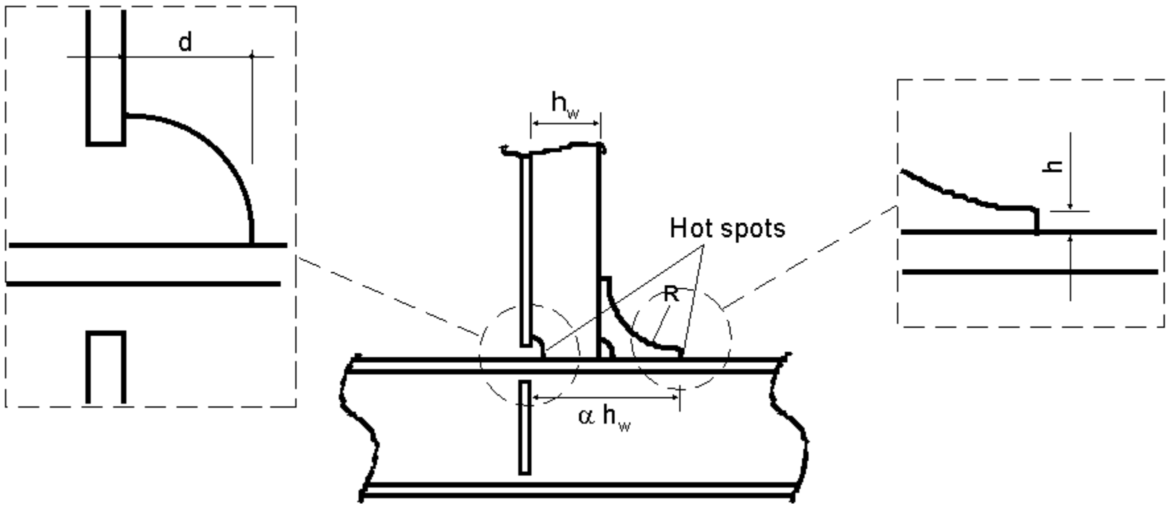
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0{,}7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One radiused bracket**	**Sheet 1.11** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• $\alpha \geq 2$ • Bracket to be symmetric. • $R \geq 1{,}5\ (\alpha - 1)\ h_W$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2{,}5$: $K_h = 1{,}25$, $K_\ell = 1{,}5$ - for $\alpha \geq 2{,}5$ $K_h = 1{,}2$, $K_\ell = 1{,}45$
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

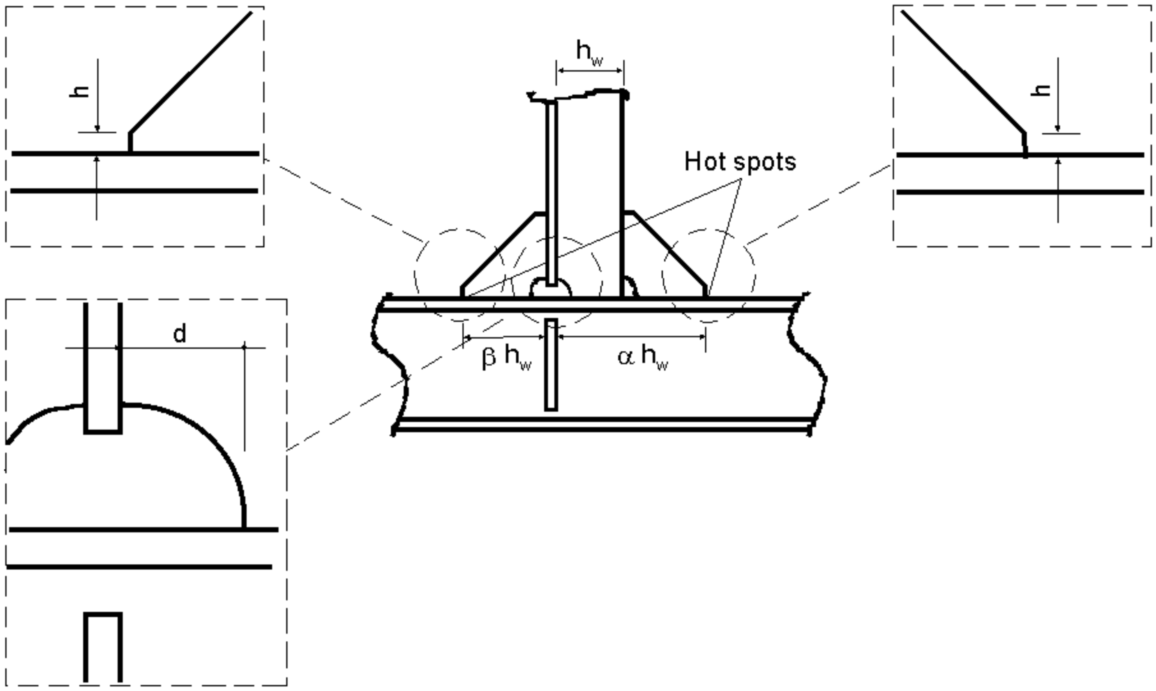
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = $0{,}45\ t_W$, where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - Two brackets	Sheet 1.12 (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • $\beta \geq 1$. • Brackets to be symmetric. • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the brackets to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$ and $1 \leq \beta < 1,5$: $K_h = K_\ell = 1,15$ - for $\alpha \geq 2,5$ and $\beta \geq 1,5$: $K_h = K_\ell = 1,1$

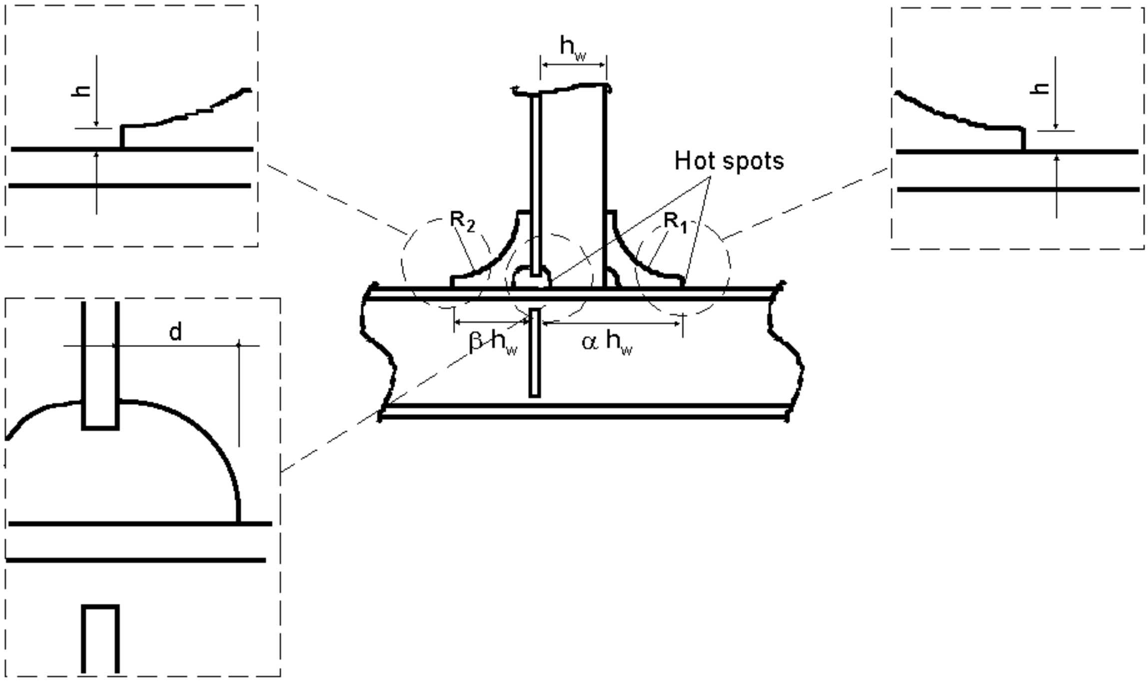
CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding,
  - throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
  - weld around the stiffener’s toes,
  - fair shape of fillet at toes in longitudinal direction.
- Material requirements:
  - material of brackets to be the same of longitudinals.

ALL LONGITUDINALLY FRAMED SIDE SHIPS

AREA 1: Side between $0,7T_B$ and 1,15T from the baseline	**Connection of side longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - Two radiused brackets**	**Sheet 1.13** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• $\alpha \geq 2$. • $\beta \geq 1$. • Brackets to be symmetric. • $R_1 \geq 1,5\ (\alpha - 1)\ h_W$ • $R_2 \geq 1,5\ \beta\ h_W$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the brackets to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$ and $1 \leq \beta < 1,5$: $K_h = K_\ell = 1,1$ - for $\alpha \geq 2,5$ and $\beta \geq 1,5$: $K_h = K_\ell = 1,05$

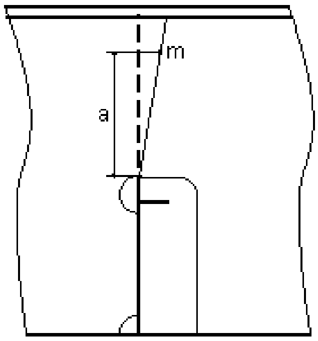
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding,
  - throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
  - weld around the stiffener's toes,
  - fair shape of fillet at toes in longitudinal direction.
- Material requirements:
  - material of brackets to be the same of longitudinals.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members - No collar plate	Sheet 2.1



t_W = web thickness of transverse primary supporting member

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, 4.7.	Fatigue check not required.

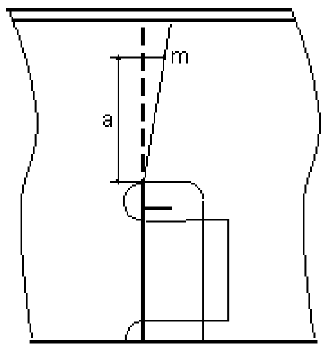
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal $\leq$ a / 50. • Cut-outs in the web free of sharps notches. • Gap between web and longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding along the connection of web with longitudinal,
- throat thickness according to Ch 12, Sec 1, 2.3.7, in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
- weld around the cuts in the web at the connection with the longitudinal and the plating,
- avoid burned notches on web.

OIL TANKERS, CHEMICAL TANKERS

<table>
<tr><td>AREA 2: Inner side and longitudinal bulkheads above 0,5H</td><td>Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members - One collar plate</td><td>Sheet 2.2</td></tr>
<tr><td colspan="3">
t_W = web thickness of transverse primary supporting member
t_{CP} = collar plate thickness</td></tr>
</table>

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, 4.7.	Fatigue check not required.

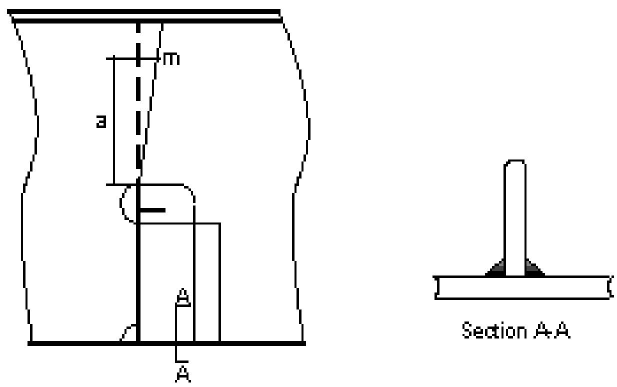
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal ≤ a / 50. • Misalignment between web and collar plate ≤ t_{CP}. • Cut-outs in the web free of sharps notches. • Gap between web and longitudinal and between collar plate and longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of web and collar plate with longitudinal and at the lap joint between web and collar plate,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - weld around the cuts in the web at the connection with the longitudinal and the plating,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	**Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members - One large collar plate**	**Sheet 2.3**



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	**FATIGUE:**
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

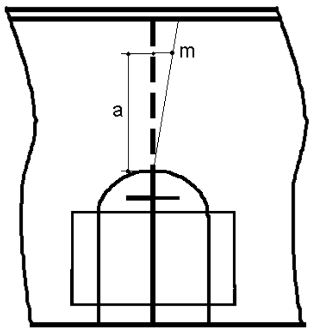
CONSTRUCTION:	**NDE:**
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal ≤ a / 50. • Misalignment between web and collar plate ≤ t_{CP}. • Cut-outs in the web free of sharps notches. • Gap between web and longitudinal and between collar plate and longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of web and collar plate with longitudinal and at the lap joint between web and collar plate,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - T joint connection of collar plate with the plating: see section A-A,
  - weld around the cuts in the web at the connection with the longitudinal and the plating,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members - Two collar plates	Sheet 2.4



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	FATIGUE:
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

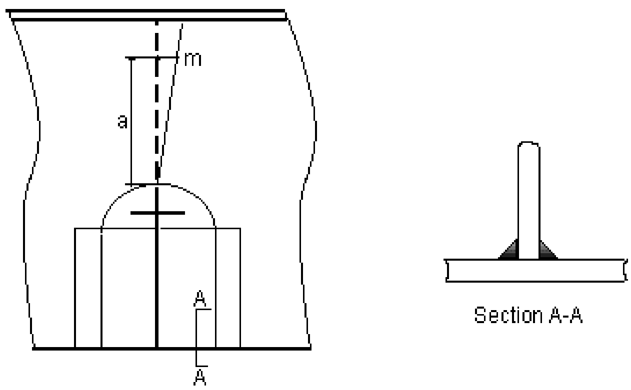
CONSTRUCTION:	NDE:
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal $\leq$ a / 50. • Misalignment between collar plates across the longitudinal $\leq t_{CP}$ / 2. • Cut-outs in the web free of sharps notches. • Gap between collar plates and longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of collar plates with longitudinal and at the lap joint between web and collar plates,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with transverse primary supporting members - Two large collar plates	Sheet 2.5



t_W = web thickness of transverse primary supporting member

t_{CP} = collar plate thickness

SCANTLINGS:	FATIGUE:
Net sectional area of the web stiffener according to Ch 4, Sec 3, [4.7].	Fatigue check not required.

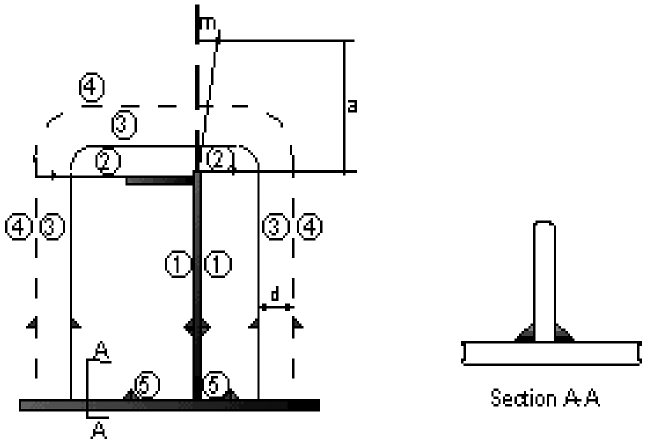
CONSTRUCTION:	NDE:
• Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal $\leq$ a / 50. • Misalignment between collar plates across the longitudinal $\leq t_{CP} / 2$. • Cut-outs in the web free of sharps notches. • Gap between collar plates and longitudinal to be not greater than 4 mm.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding along the connection of collar plates with longitudinal and at the lap joint between web and collar plates,
  - throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
  - T joint connection of collar plates with the plating: see section A-A,
  - avoid burned notches on web.
- Fillet welding of overlapped joint to be done all around.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Watertight connection of inner side or bulkhead longitudinal ordinary stiffeners with watertight side diaphragms or transverse bulkheads – Example of connection with lugs	Sheet 2.6



t_W = transverse bulkhead web thickness

t_L = lug thickness

SCANTLINGS:

- d = 30 ÷ 60 mm.
- $t_L \geq t_W$.

FATIGUE:

Fatigue check not required.

CONSTRUCTION:

- Web stiffener not compulsory. When fitted, its misalignment m with the web of the longitudinal $\leq$ a / 50.
- Misalignment between lugs across the longitudinal $\leq t_L / 2$.
- Misalignment at the butts within lug parts $\leq t_L / 5$.
- Gap between bulkhead plating and lugs to be not greater than 4 mm.

NDE:

- Visual examination 100%.
- Magnetic particle or dye penetrant examination: when deemed necessary depending on the quality of the lap joint weld.

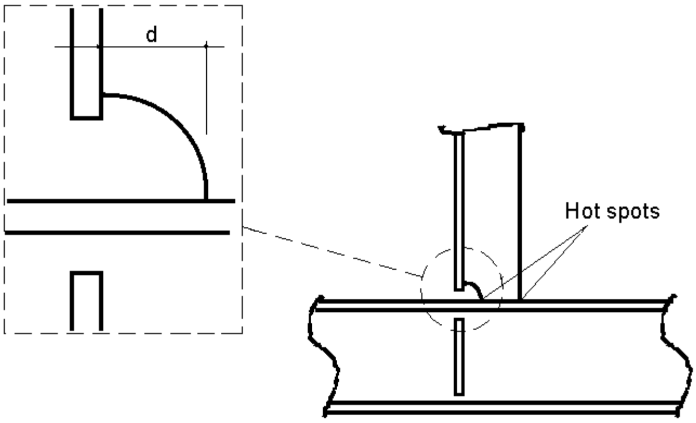
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding along the connection of lugs with the longitudinal and at the lap joints between web and lugs,
- throat thickness according to Ch 12, Sec 1, [2.3.7], in case of gap g greater than 2 mm increase the throat thickness by 0,7(g-2) mm,
- T joint connection of collar plates with the plating: see section A-A,
- welding sequence: ① to ⑤ (see sketch).

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - No bracket	Sheet 2.7 (1/1/2001)



t = minimum thickness between those of:
- web of longitudinal,
- stiffener of transverse primary supporting member.

SCANTLINGS:	FATIGUE:
d to be as small as possible, maximum 35 mm recommended.	Fatigue check to be carried out for $L \geq 150$ m: $K_h = 1,3$ $K_\ell = 1,65$

CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal and web stiffener to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

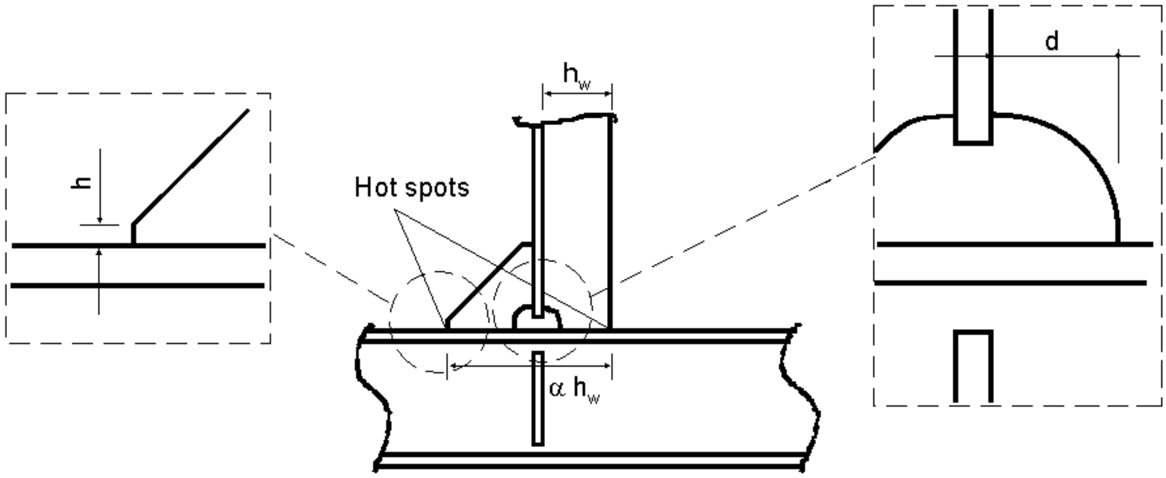
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener’s toes,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	**Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One bracket**	**Sheet 2.8** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• $\alpha \geq 2$. • Bracket to be symmetric. • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for $L \geq 150$ m: – for $2 \leq \alpha < 2,5$ $K_h = 1,2$ $K_\ell = 1,4$ – for $\alpha \geq 2,5$ $K_h = 1,15$ $K_\ell = 1,4$
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

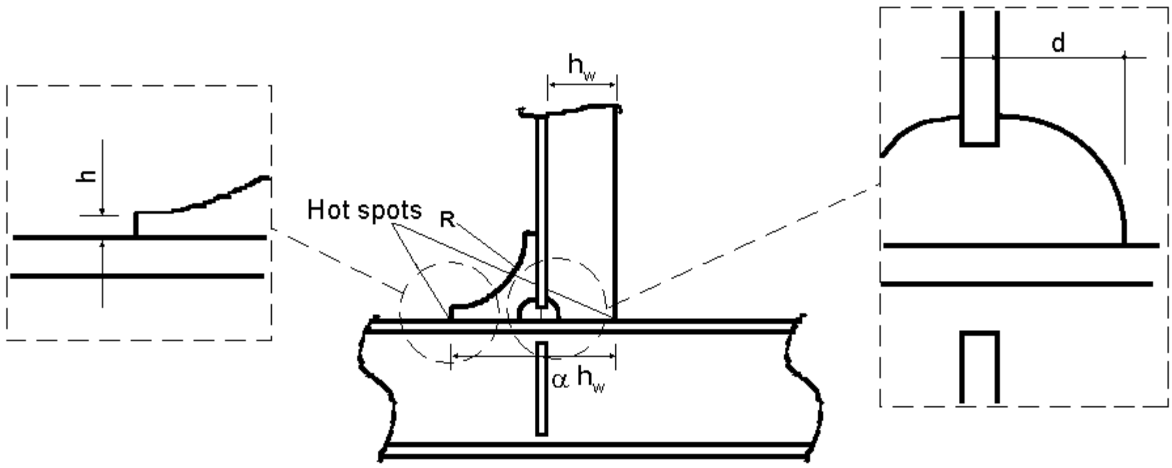
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	**Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One radiused bracket**	**Sheet 2.9** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• $\alpha \geq 2$. • Bracket to be symmetric. • $R \geq 1,5\ (\alpha - 1)\ h_W$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$ $K_h = 1,15$ $K_\ell = 1,35$ - for $\alpha \geq 2,5$ $K_h = 1,1$ $K_\ell = 1,35$
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

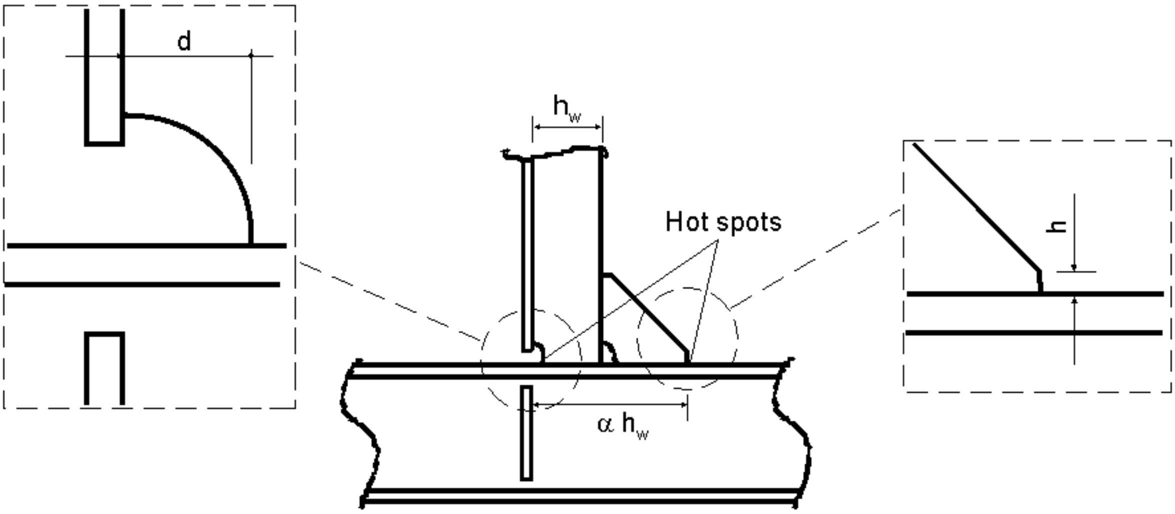
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One bracket	Sheet 2.10 (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • Bracket to be symmetric. • h as necessary to allow the required fillet throat size, but $\leq$ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L $\geq$ 150 m: - for $2 \leq \alpha < 2,5$ $K_h = 1,3$ $K_\ell = 1,55$ - for $\alpha \geq 2,5$ $K_h = 1,25$ $K_\ell = 1,5$

CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

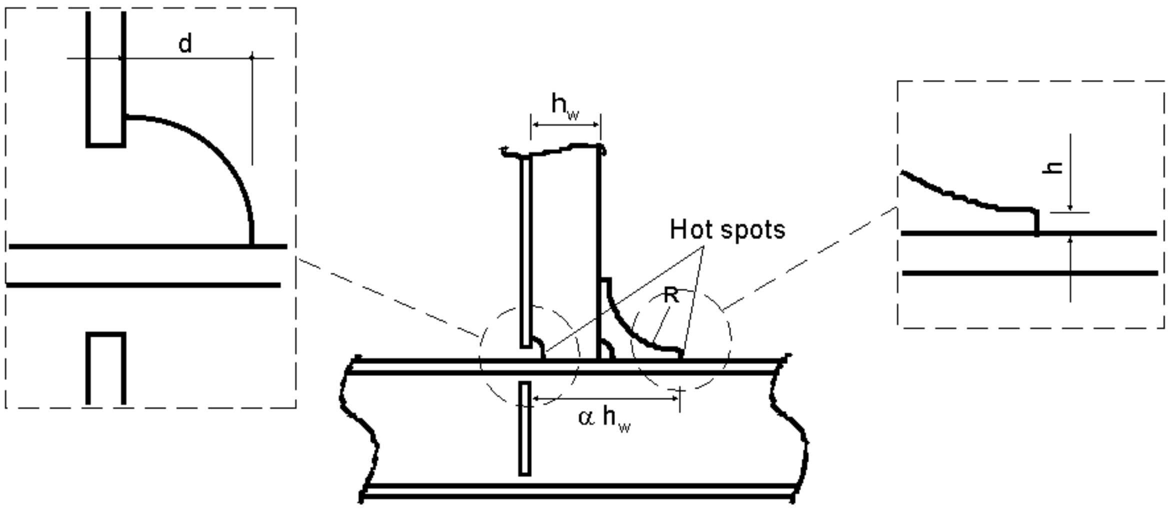
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	**Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - One radiused bracket**	**Sheet 2.11** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• $\alpha \geq 2$ • Bracket to be symmetric. • $R \geq 1,5 (\alpha - 1) h_W$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the bracket to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2,5$: $K_h = 1,25$, $K_\ell = 1,5$ - for $\alpha \geq 2,5$: $K_h = 1,2$, $K_\ell = 1,45$

CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

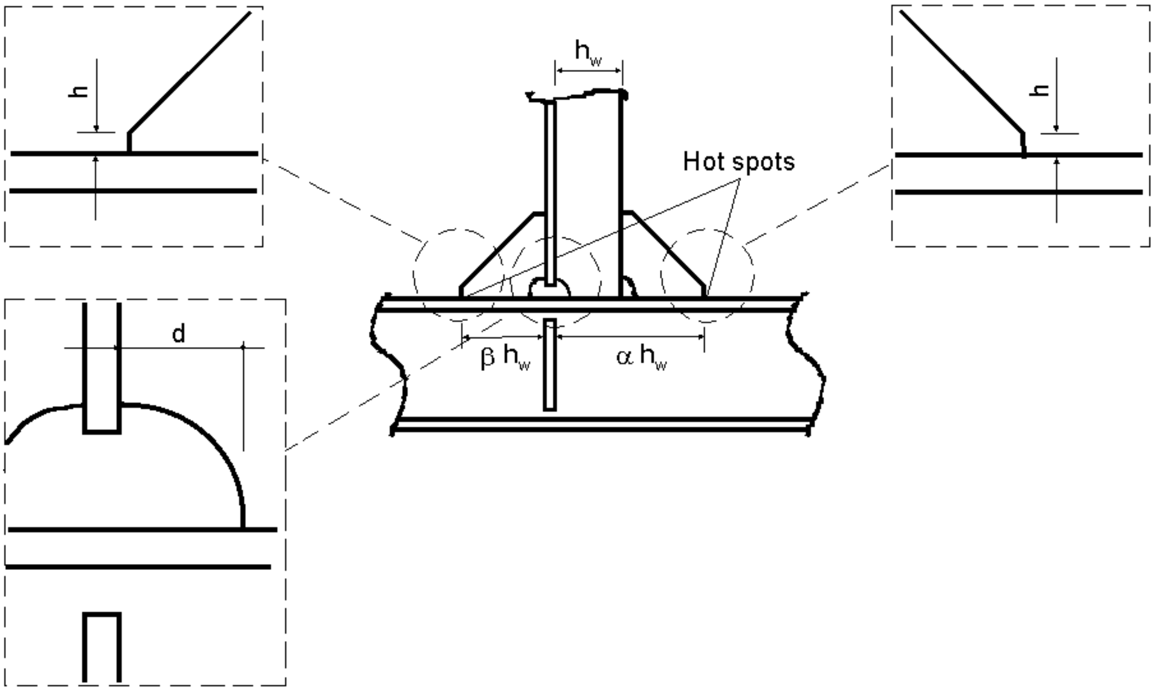
WELDING AND MATERIALS:

Welding requirements:

- continuous fillet welding,
- throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
- weld around the stiffener's toes,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - Two brackets	Sheet 2.12 (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	FATIGUE:
• $\alpha \geq 2$. • $\beta \geq 1$. • Brackets to be symmetric. • h as necessary to allow the required fillet throat size, but ≤ 15 mm. • d to be as small as possible, maximum 35 mm recommended. • Thickness of the brackets to be not less than that of web stiffener.	Fatigue check to be carried out for L ≥ 150 m: - for $2 \leq \alpha < 2{,}5$ and $1 \leq \beta < 1{,}5$: $K_h = K_\ell = 1{,}15$ - for $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$: $K_h = K_\ell = 1{,}1$

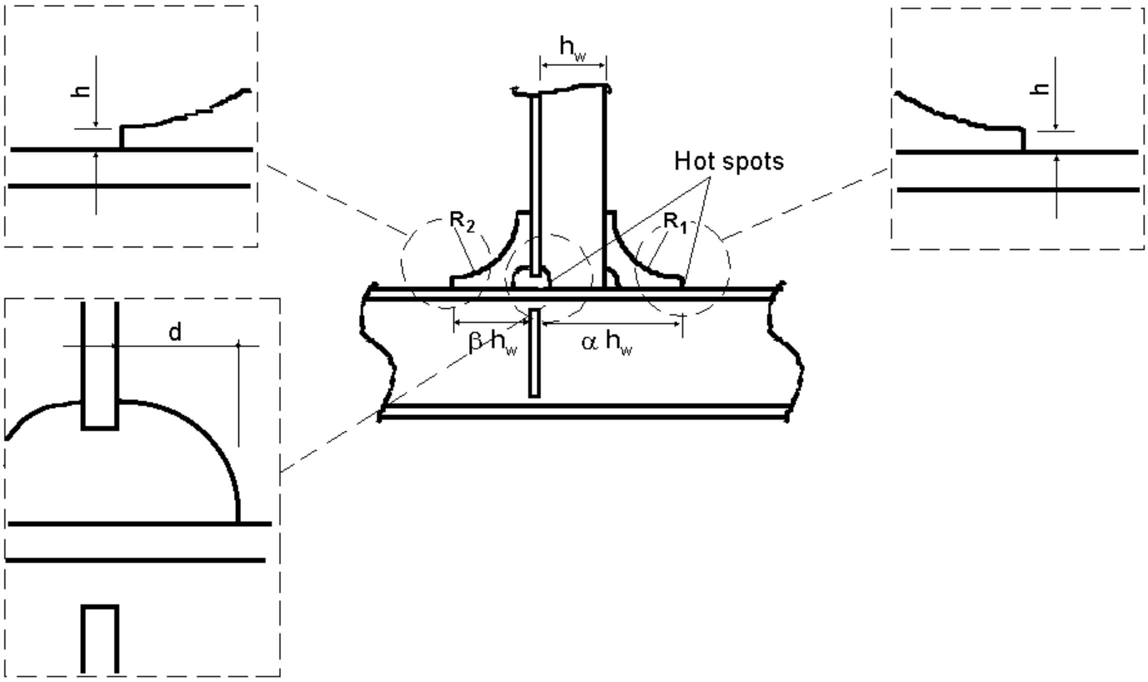
CONSTRUCTION:	NDE:
Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding,
  - throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
  - weld around the stiffener's toes,
  - fair shape of fillet at toes in longitudinal direction.
- Material requirements:
  - material of brackets to be the same of longitudinals.

OIL TANKERS, CHEMICAL TANKERS

AREA 2: Inner side and longitudinal bulkheads above 0,5H	Connection of inner side or bulkhead longitudinal ordinary stiffeners with stiffeners of transverse primary supporting members - Two radiused brackets	Sheet 2.13 (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:

- $\alpha \geq 2$.
- $\beta \geq 1$.
- Brackets to be symmetric.
- $R_1 \geq 1,5\ (\alpha - 1)\ h_W$
- $R_2 \geq 1,5\ \beta\ h_W$
- h as necessary to allow the required fillet throat size, but ≤ 15 mm.
- d to be as small as possible, maximum 35 mm recommended.
- Thickness of the brackets to be not less than that of web stiffener.

FATIGUE:

Fatigue check to be carried out for L ≥ 150 m:

- for $2 \leq \alpha < 2,5$ and $1 \leq \beta < 1,5$:

  $K_h = K_\ell = 1,1$

- for $\alpha \geq 2,5$ and $\beta \geq 1,5$:

  $K_h = K_\ell = 1,05$

CONSTRUCTION:

Misalignment (measured between the outer edges) between longitudinal, web stiffener and bracket to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.

NDE:

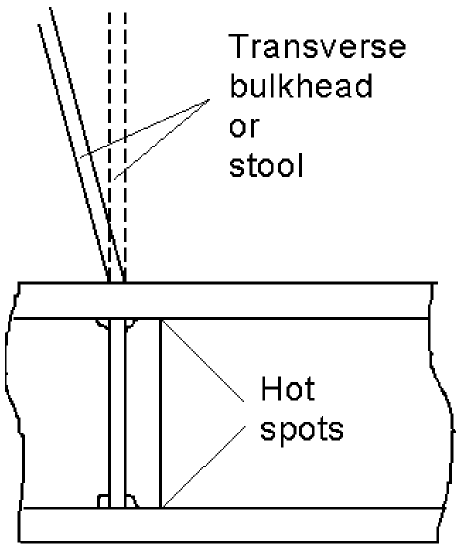
Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - continuous fillet welding,
  - throat thickness = 0,45 t_W , where t_W is the web stiffener thickness,
  - weld around the stiffener’s toes,
  - fair shape of fillet at toes in longitudinal direction.
- Material requirements:
  - material of brackets to be the same of longitudinals.

OIL TANKERS, CHEMICAL TANKERS, LIQUEFIED GAS CARRIERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 3: Double bottom in way of transverse bulkheads	**Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors - No bracket**	**Sheet 3.1** (1/1/2001)



t = minimum thickness between those of:
- web of bottom or inner bottom longitudinal,
- floor stiffener.

SCANTLINGS:	**FATIGUE:**
	Fatigue check to be carried out for L ≥ 150 m: $K_h = 1,3$ $K_\ell = 1,65$

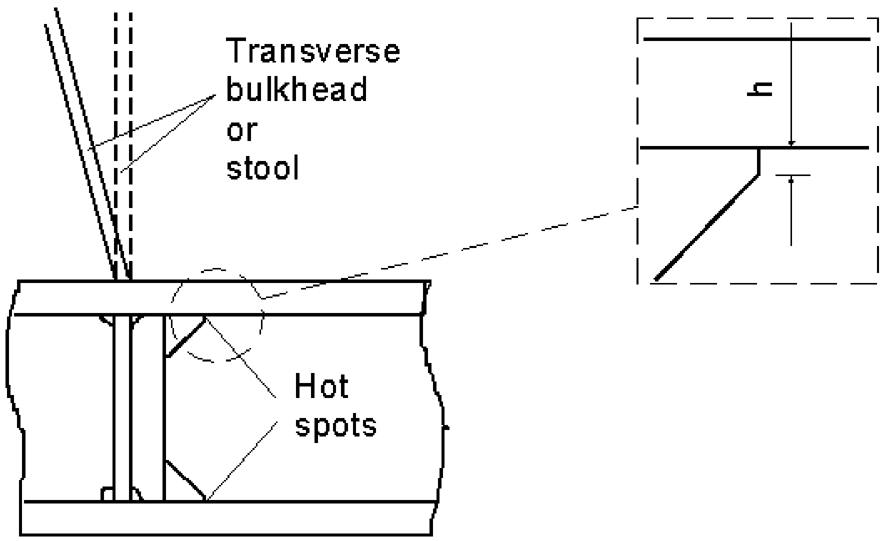
CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between webs of bottom and inner bottom longitudinals with floor stiffener to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

WELDING AND MATERIALS:

Welding requirements:
- floor stiffeners to be connected with continuous fillet welding to bottom and inner bottom longitudinals,
- throat thickness = 0,45 t_W , where t_W is the floor stiffener thickness,
- weld all around the stiffeners,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS, LIQUEFIED GAS CARRIERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 3: Double bottom in way of transverse bulkheads	**Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors - Brackets**	**Sheet 3.2** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
h as necessary to allow the required fillet throat size, but ≤ 15 mm.	Fatigue check to be carried out for $L \geq 150$ m: $K_h = 1,3$ $K_\ell = 1,55$

CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between webs of bottom and inner bottom longitudinals with floor stiffener to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

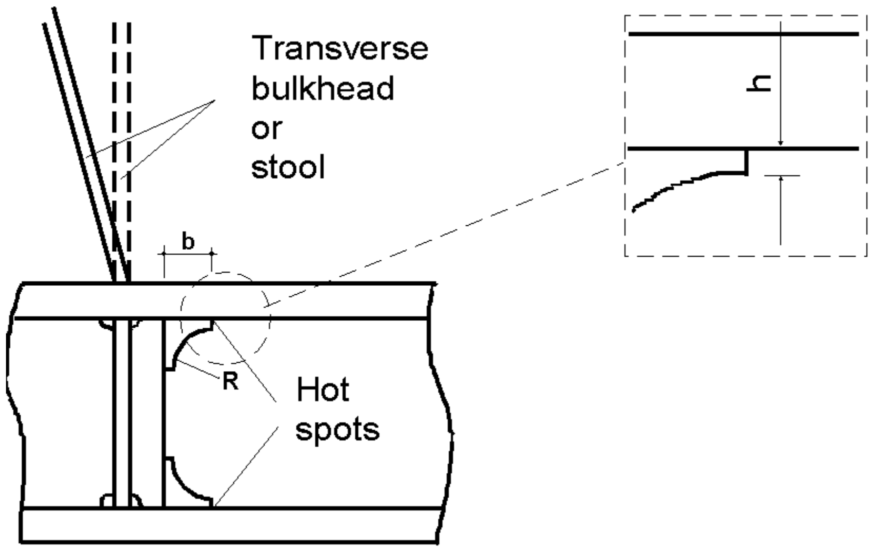
WELDING AND MATERIALS:

Welding requirements:

- floor stiffeners and brackets to be connected with continuous fillet welding to bottom and inner bottom longitudinals,
- throat thickness = 0,45 t_W , where t_W is the floor stiffener or bracket thickness, as applicable,
- partial penetration welding between stiffeners and brackets,
- weld all around the stiffeners and brackets,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS, LIQUEFIED GAS CARRIERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 3: Double bottom in way of transverse bulkheads	**Connection of bottom and inner bottom longitudinal ordinary stiffeners with floors - Radiused brackets**	**Sheet 3.3** (1/1/2001)



t = minimum thickness among those of the connected elements

SCANTLINGS:	**FATIGUE:**
• Brackets to be symmetric. • $R \geq 1,5\ b$ • h as necessary to allow the required fillet throat size, but ≤ 15 mm.	Fatigue check to be carried out for $L \geq 150$ m: $K_h = 1,25$ $K_\ell = 1,5$

CONSTRUCTION:	**NDE:**
Misalignment (measured between the outer edges) between webs of bottom and inner bottom longitudinals with floor stiffener to be in general equal to or less than 0,7 t. For bulbs, a misalignment equal to 0,8 t may generally be accepted.	Visual examination 100%.

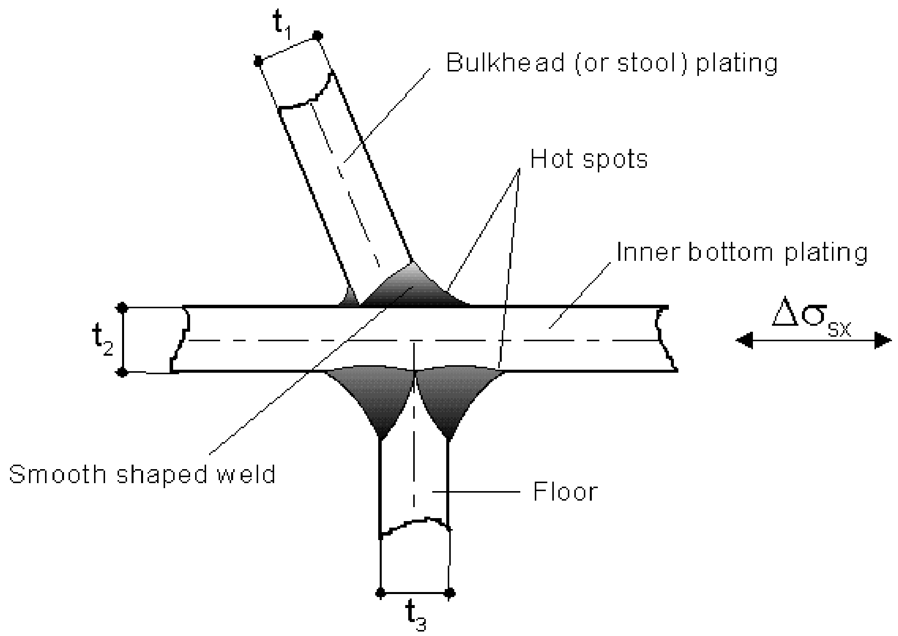
WELDING AND MATERIALS:

Welding requirements:

- floor stiffeners and brackets to be connected with continuous fillet welding to bottom and inner bottom longitudinals,
- throat thickness = 0,45 t_W , where t_W is the floor stiffener or bracket thickness, as applicable,
- partial penetration welding between stiffeners and brackets,
- weld all around the stiffeners and brackets,
- fair shape of fillet at toes in longitudinal direction.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 3: Double bottom in way of transverse bulkheads	Connection of inner bottom with transverse bulkheads or lower stools	Sheet 3.4 (1/7/2002)



Hot spot stresses:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{sx}$

$t = \min (t_1, t_2, t_3)$

SCANTLINGS:	FATIGUE:
	Fatigue check to be carried out for $L \geq 150$ m: $K_{SX} = 3,85$

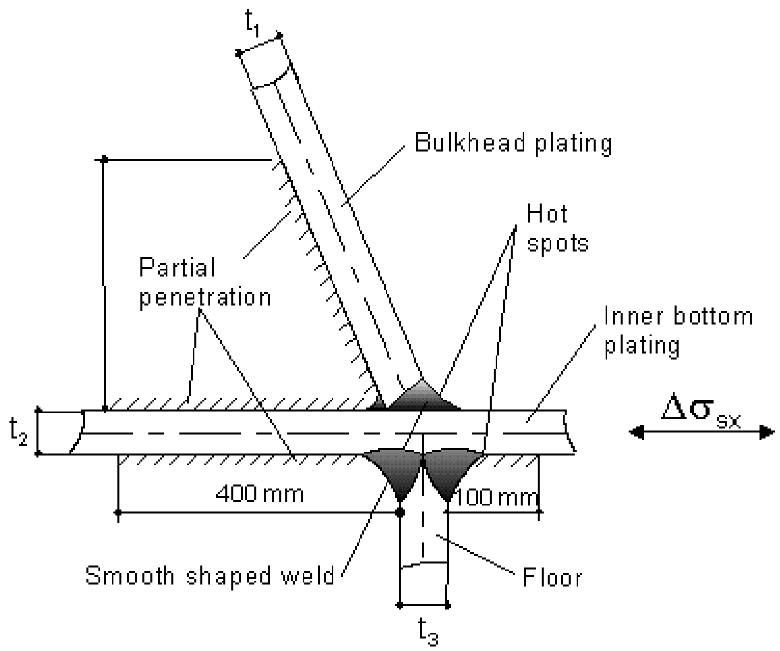
CONSTRUCTION:	NDE:
• Misalignment (median lines) between floor and bulkhead (or stool) plating $\leq t / 3$. • Cut-outs for connections of the inner bottom longitudinals to double bottom floors to be closed by collar plates welded to the inner bottom.	The following NDE are required: – VE 100%, – UE 35% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - bulkhead (or stool) plating and supporting floors generally to be connected with full penetration welding to inner bottom plating (if not full penetration welding, the weld preparation is to be indicated on the approved drawings),
  - corrugated bulkheads (without stool) to be connected with full penetration welding to inner bottom plating,
  - in the case of corrugated bulkheads, stool side plating (if any) and supporting floors to be connected with full penetration or partial penetration welding to inner bottom plating,
  - special approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating.
- Material requirements:
  - the strake of inner bottom plating in way of the connection is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding.

LIQUEFIED GAS CARRIERS

AREA 3: Double bottom in way of transverse bulkheads	Connection of inner bottom with transverse cofferdam bulkheads	Sheet 3.5



Hot spot stresses:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

$t = \min(t_1, t_2, t_3)$

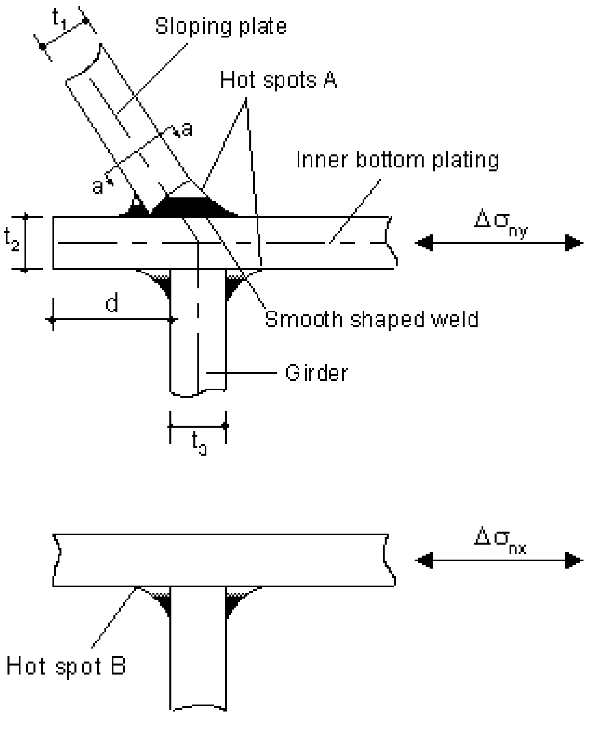
SCANTLINGS:	FATIGUE:
	Fatigue check to be carried out for $L \geq 150$ m: $K_{SX} = 3{,}85$
CONSTRUCTION:	**NDE:**
• Misalignment (median lines) between floor and bulkhead plating $\leq t / 3$, max 6 mm. • Cut-outs for connections of the inner bottom longitudinals to double bottom floors to be closed by collar plates, welded to the inner bottom.	The following NDE are required: – VE 100%, – UE 35% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - bulkhead plating and supporting floors to be connected with full penetration welding to inner bottom plating,
  - bulkhead vertical girders and bottom girders are to be connected with partial penetration to inner bottom plating for the extension shown in the sketch,
  - special approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating.
- Material requirements:
  - the strake of inner bottom plating in way of the connection is to be of Z25/ZH25 or of a steel of the same mechanical performances. In particular cases, grade E/EH steel may be accepted by the Society provided that the results of 100% UE of the plate in way of the weld, carried out prior to and after welding, are submitted for review.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	Sheet 4.1



Section a - a

Hot spot stresses:

- At hot spot A:

  $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$

- At hot spot B:

  $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

$t_A = \min(t_1, t_2, t_3)$,

t_B = minimum among:
- floor thickness,
- hopper transverse web thickness,
- t_3.

SCANTLINGS:	FATIGUE:
$d \geq 50$ mm.	Fatigue check to be carried out for $L \geq 150$ m: – K_{SY} = 3,85 where closed scallops 5,4 where open scallops – K_{SX} = 1,3 – K_{SYX} = 2,0

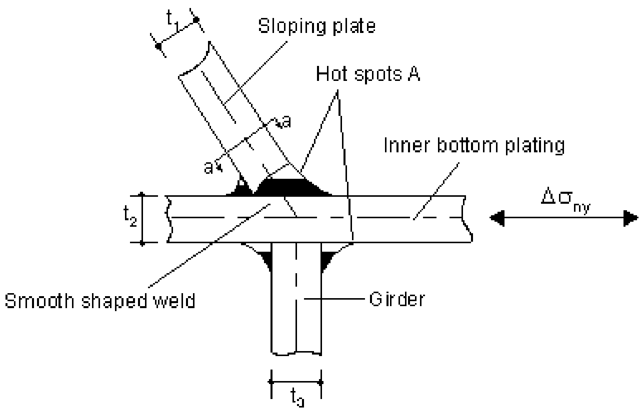
CONSTRUCTION:	NDE:
• Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$. • Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$.	The following NDE are required: – VE 100%, – UE 25% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

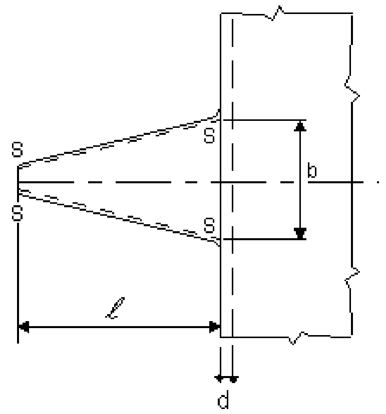
WELDING AND MATERIALS:

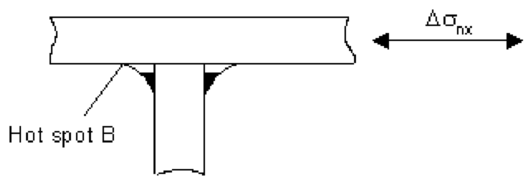
- Welding requirements:
  - sloping plate to be connected with partial penetration welding to inner bottom plating,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating on tank side.
- Material requirements:
  - the strake of inner bottom plating in way of the connection is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates – Prolonging brackets	Sheet 4.2







Section a - a

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$
- At hot spot B: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

$t_A = \min(t_1, t_2, t_3)$,

t_B = minimum among:
- floor thickness,
- hopper transverse web thickness,
- t_3.

SCANTLINGS:

- Inner bottom plating to be prolonged within the hopper tank structure by brackets as shown in the sketch.
- $d \geq 50$ mm.
- Guidance values, to be confirmed by calculations carried out according to Ch 7, Sec 3:
  - thickness of the above brackets $\geq t_2$,
  - $b \geq 0,4$ times the floor spacing,
  - $\ell \geq 1,5b$.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:

- K_{SY} = 2,4 where closed scallops
  3,4 where open scallops
- K_{SX} = 1,3
- K_{SYX} = 1,5

CONSTRUCTION:

- Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$.

NDE:

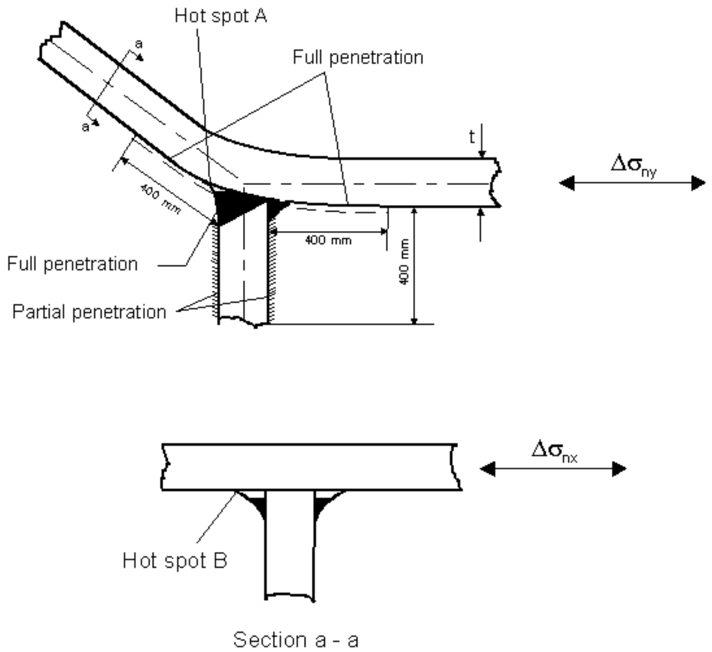
The following NDE are required:
- VE 100%,
- UE 25% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirement:
  - sloping plate to be connected with partial penetration welding to inner bottom plating,
  - brackets to be connected with full penetration welding to inner bottom plating,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating on tank side.
- Material requirement:
  - the strake of inner bottom plating in way of the connection is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of prolonging brackets to be not less than those of the inner bottom plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates – Radiused construction	Sheet 4.3



Hot spot stresses:

- At hot spot A:

  $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$

- At hot spot B:

  $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

t_A = minimum thickness between those of the girder and sloping plate,

t_B = minimum among:
- floor thickness,
- hopper transverse web thickness,
- girder thickness.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- Transverse brackets extended to the closest longitudinals to be fitted on each side of the girder, at mid-span between floors.
- Thickness of these brackets, in mm $\geq 9 + 0{,}03\ L_1 \sqrt{k}$.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SY} = 3{,}15$
- $K_{SX} = 1{,}3$
- $K_{SYX} = 2{,}05$

CONSTRUCTION:

- Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$.
- In floor or transverse webs, in way of the bent area, scallops to be avoided or closed by collar plates.

NDE:

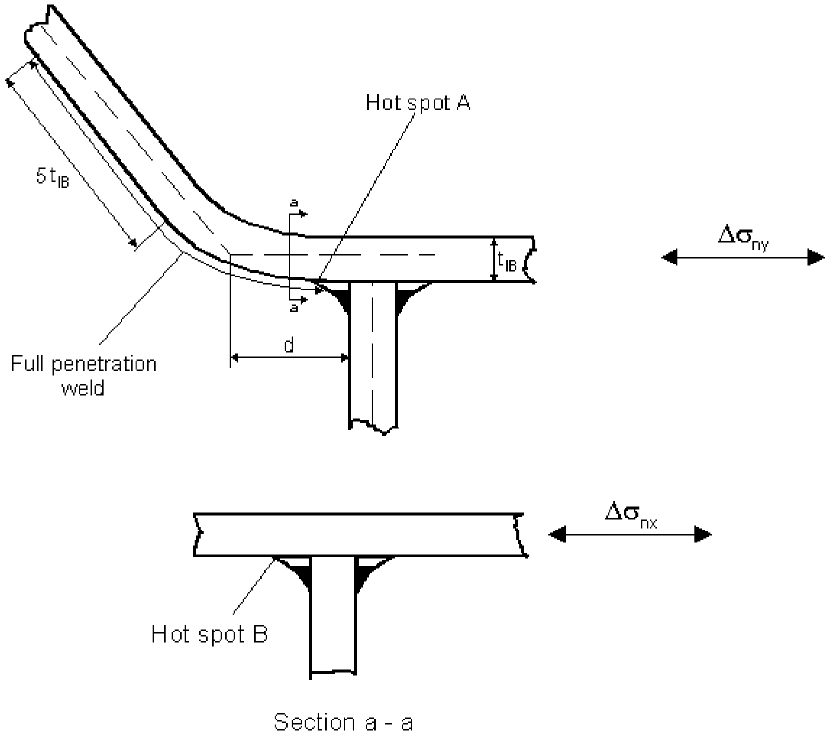
The following NDE are required:
- VE 100%,
- UE 25% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - floors to be connected (see sketches):
    - with full penetration welding to the inner bottom for a length ≥ 400 mm,
    - with partial penetration welding to the girder for a length ≥ 400 mm,
    - with continuous fillet welding in the remaining areas,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - welding procedures of longitudinal girder to the bent plate to be submitted to the Society for review, with evidence given that there is no risk of ageing after welding,
  - weld finishing of butt welds well faired to the inner bottom plating on ballast tank,
  - fair shape of fillet at hot spots.
- Material requirements:
  - the radiused construction may be accepted provided that the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates – Radiused construction	Sheet 4.4



Hot spot stresses:

- At hot spot A:

$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$

- At hot spot B:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

t = minimum among:

- floor thickness,
- hopper transverse web thickness,
- girder thickness,

t_{IB} = inner bottom plating.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- d ≤ 40 mm.
- Transverse brackets extended to the closest longitudinals to be fitted on each side of the girder, at mid-span between floors.
- Thickness of these brackets, in mm ≥ 9 + 0,03 $L_1 \sqrt{k}$.

FATIGUE:

Fatigue check to be carried out for L ≥ 150m

- K_{SY} = 3,85
- K_{SX} = 1,3
- K_{SYX} = 4,5

CONSTRUCTION:

- Misalignment (median lines) between floor and hopper transverse web ≤ t / 3.
- In floor or transverse webs, in way of the bent area, scallops to be avoided or closed by collar plates..

NDE:

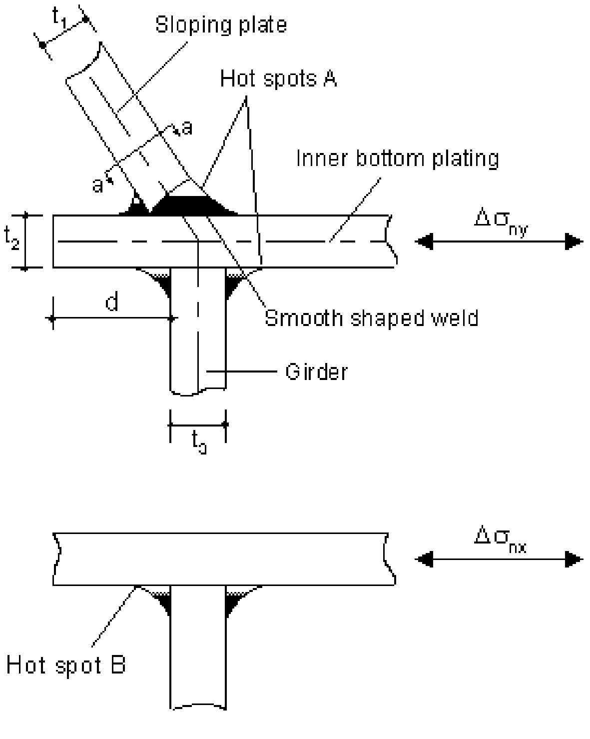
Visual examination 100%.

WELDING AND MATERIALS:

- Welding requirements:
  - floors to be connected with full penetration welding to the inner bottom plating for a length ≥ 5t_{IB},
  - where girder is welded within the bent area, welding procedures to be submitted to the Society for review.
- Material requirements:
  - where girder is welded within the bent area, folding procedure to be submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.

LIQUEFIED GAS CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates	Sheet 4.5



Section a - a

Hot spot stresses:

- At hot spot A:

  $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$

- At hot spot B:

  $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

$t_A = \min(t_1, t_2, t_3)$,

t_B = minimum among:
- floor thickness,
- hopper transverse web thickness,
- t_3.

SCANTLINGS:	FATIGUE:
$d \geq 50$ mm.	Fatigue check to be carried out for $L \geq 150$ m: – K_{SY} = 3,85 where closed scallops 5,4 where open scallops – K_{SX} = 1,3 – K_{SYX} = 2,0

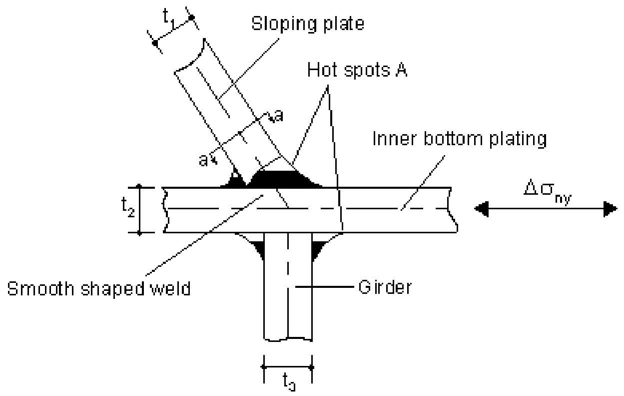
CONSTRUCTION:	NDE:
• Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$, max 6 mm. • Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$, max 6 mm.	The following NDE are required: – VE 100%, – UE 35% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

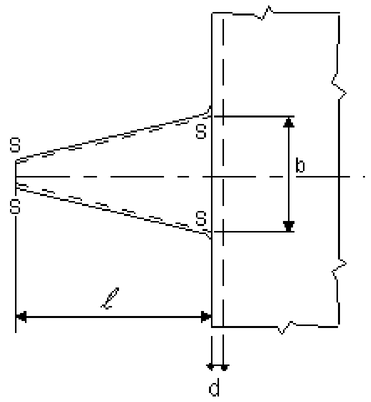
WELDING AND MATERIALS:

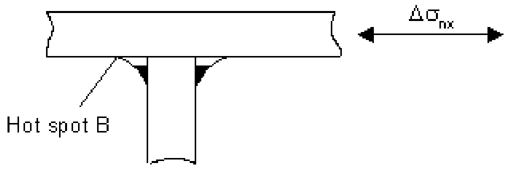
- Welding requirements:
  - sloping plate to be connected with full penetration welding to inner bottom plating, except in way of void spaces where partial penetration may be accepted,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating on tank side.
- Material requirements:
  - the strake of inner bottom plating in way of the connection is to be of Z25/ZH25 or of a steel of the same mechanical performances. In particular cases, grade E/EH low temperature steel may be accepted by the Society provided that the results of 100% UE of the plate in way of the weld, carried out prior to and after welding, are submitted for review.

LIQUEFIED GAS CARRIERS

AREA 4: Double bottom in way of hopper tanks	**Connection of inner bottom with hopper tank sloping plates - Prolonging brackets**	**Sheet 4.6**







Section a - a

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$
- At hot spot B: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

t_A = min (t_1, t_2, t_3),

t_B = minimum among:

- floor thickness,
- hopper transverse web thickness,
- t_3.

SCANTLINGS:

- Inner bottom plating to be prolonged within the hopper tank structure by brackets as shown in the sketch.
- $d \geq 50$ mm.
- Guidance values, to be confirmed by calculations carried out according to Ch 7, Sec 3:
  - thickness of the above brackets $\geq t_2$,
  - $b \geq 0,4$ times the floor spacing,
  - $\ell \geq 1,5b$.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:

- K_{SY} = 2,4 where closed scallops
  3,4 where open scallops
- K_{SX} = 1,3
- K_{SYX} = 1,5

CONSTRUCTION:

- Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$, max 6 mm.
- Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$, max 6 mm.

NDE:

The following NDE are required:

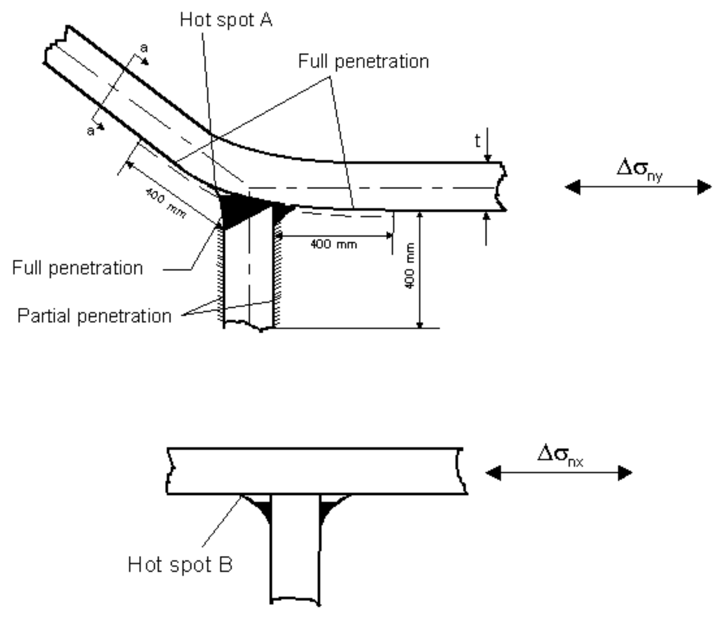
- VE 100%,
- UE 35% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - sloping plate to be connected with full penetration welding to inner bottom plating, except in way of void spaces where partial penetration may be accepted,
  - prolonging brackets to be connected with full penetration welding to inner bottom plating
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - weld finishing well faired to the inner bottom plating on tank side.
- Material requirements:
  - the strake of inner bottom plating in way of the connection is to be of Z25/ZH25 or of a steel of the same mechanical performances. In particular cases, grade E/EH low temperature steel may be accepted by the Society provided that the results of 100% UE of the plate in way of the weld, carried out prior to and after welding, are submitted for review,
  - material properties of prolonging brackets to be not less than those of the inner bottom plating.

LIQUEFIED GAS CARRIERS

AREA 4: Double bottom in way of hopper tanks	Connection of inner bottom with hopper tank sloping plates – Radiused construction	Sheet 4.7



Section a - a

Hot spot stresses:

- At hot spot A:

  $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY}$

- At hot spot B:

  $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX} + K_{SYX} \cdot \Delta\sigma_{nY}$

t_A = minimum thickness between those of the girder and sloping plate,

t_B = minimum among:
- floor thickness,
- hopper transverse web thickness,
- girder thickness.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- Transverse brackets extended to the closest longitudinals to be fitted on each side of the girder, at mid-span between floors.
- Thickness of these brackets, in mm $\geq 9 + 0{,}03\ L_1 \sqrt{k}$.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- K_{SY} = 3,15
- K_{SX} = 1,3
- K_{SYX} = 2,05

CONSTRUCTION:

- Misalignment (median lines) between girder and sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between floor and hopper transverse web $\leq t_B / 3$.
- In floor or transverse webs, in way of the bent area, scallops to be avoided or closed by collar plates.

NDE:

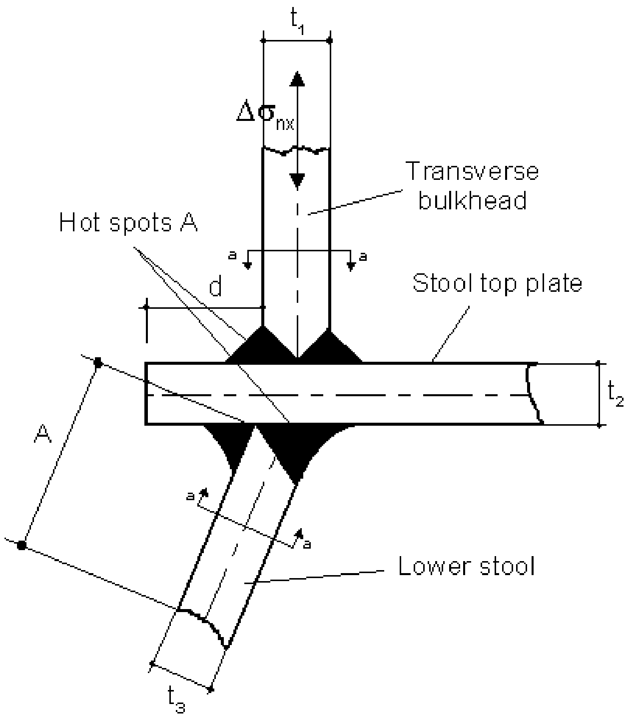
The following NDE are required:
- VE 100%,
- UE 25% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

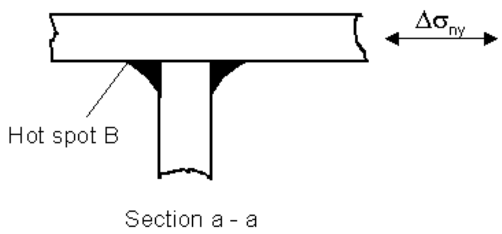
WELDING AND MATERIALS:

- Welding requirements:
  - floors to be connected (see sketches):
    - with full penetration welding to the inner bottom for a length ≥ 400 mm,
    - with partial penetration welding to the girder for a length ≥ 400 mm,
    - with continuous fillet welding in the remaining areas,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing,
  - welding procedures of longitudinal girder to the bent plate to be submitted to the Society for review, with evidence given that there is no risk of ageing after welding,
  - weld finishing of butt welds well faired to the inner bottom plating on ballast tank,
  - fair shape of fillet at hot spots.
- Material requirements:
  - the radiused construction may be accepted provided that the bent plate is of grade E or EH and the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with plane bulkheads**	**Sheet 5.1**





A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above stool top plate,
- thickness of member below stool top plate,
- t_2.

SCANTLINGS:

- $d \geq t_1$.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of members above and below stool top plate to be not less than that of bulkhead vertical webs.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 3{,}85$
- $K_{SY} = 1{,}3$
- $K_{SXY} = 2{,}0$

CONSTRUCTION:

- Misalignment (median lines) between bulkhead plating and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between members above and below stool top plate $\leq t_B / 3$.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

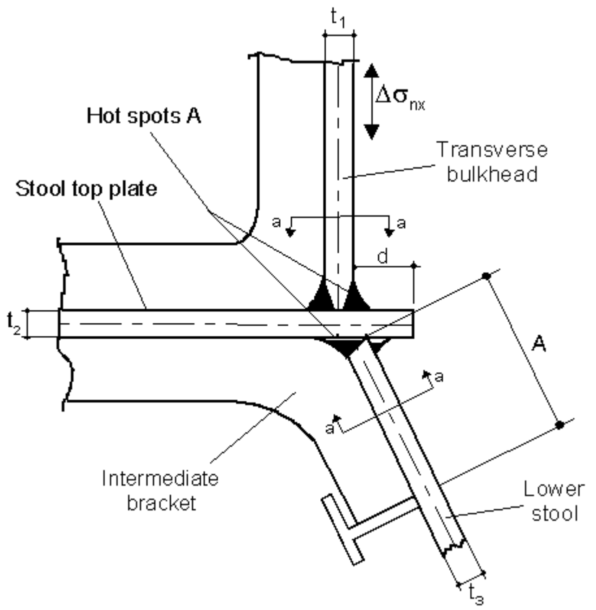
WELDING AND MATERIALS:

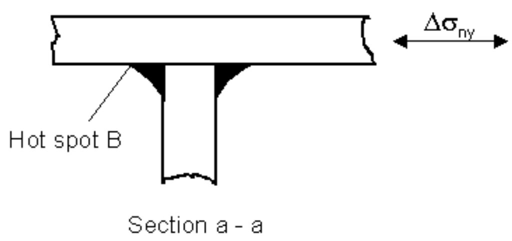
- Welding requirements:
  - bulkhead and stool side plating generally to be connected with full penetration welding to stool top plate (if not full penetration welding, the weld preparation is to be indicated on the approved drawings),
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the stool top plate,
  - weld finishing well faired to the stool top plate.
- Material requirements:
  - the stool top plate is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads in way of intermediate brackets	Sheet 5.2





A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min (t_1, t_2, t_3)$

t_B = minimum among:

- thickness of member above stool top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:	FATIGUE:
• $d \geq t_1$. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of intermediate brackets and members above stool top plate to be not less than that of bulkhead vertical webs.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 3{,}55$ – $K_{SY} = 1{,}3$ – $K_{SXY} = 1{,}75$

CONSTRUCTION:	NDE:
• Misalignment (median lines) between bulkhead plating and stool side plating $\leq t_A / 3$. • Misalignment (median lines) between intermediate bracket and member above stool top plate $\leq t_B/3$. • Intermediate brackets to be fitted in place and welded after the welding of the joint between the stool side plating and the stool top plate.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

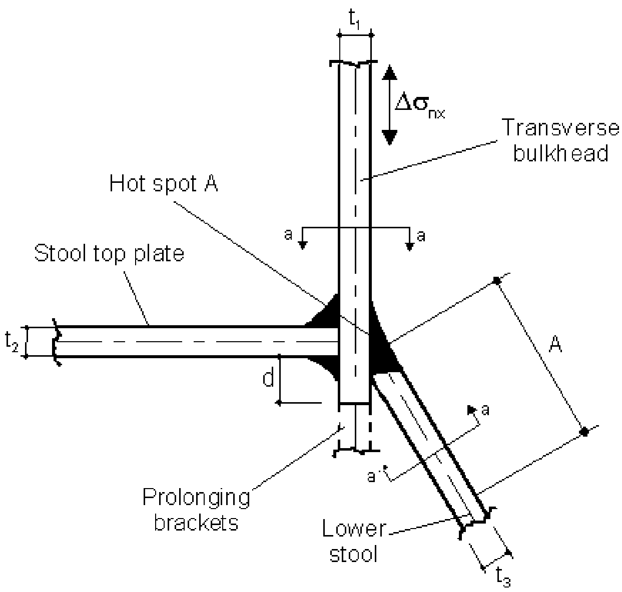
WELDING AND MATERIALS:

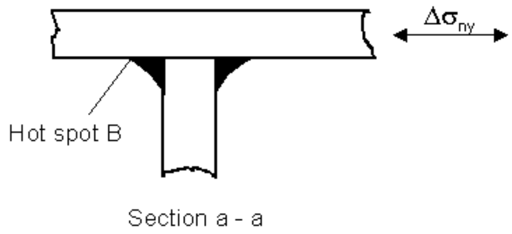
- Welding requirements:
  - bulkhead and stool side plating generally to be connected with full penetration welding to stool top plate (if not full penetration welding, the weld preparation is to be indicated on the approved drawings),
  - brackets to be connected with continuous fillet welding to plating and stiffeners,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the stool top plate,
  - weld finishing well faired to the stool top plate.
- Material requirements:
  - the stool top plate is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads – Prolonging brackets	Sheet 5.3





A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:

- thickness of member above stool top plate,
- thickness of member below stool top plate,
- t_2.

SCANTLINGS:	FATIGUE:
• $d \geq 50$ mm. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of prolonging brackets $\geq t_1$. • Thickness of members above and below stool top plate to be not less than that of bulkhead vertical webs.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 2,4$ – $K_{SY} = 1,3$ – $K_{SXY} = 1,5$

CONSTRUCTION:	NDE:
• Misalignment (median lines) between stool top plate and stool side plating $\leq t_A / 3$. • Misalignment (median lines) between members above and below stool top plate $\leq t_B / 3$.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

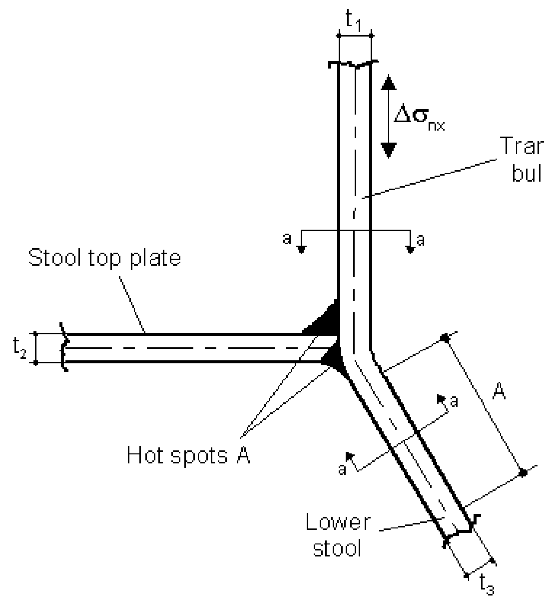
WELDING AND MATERIALS:

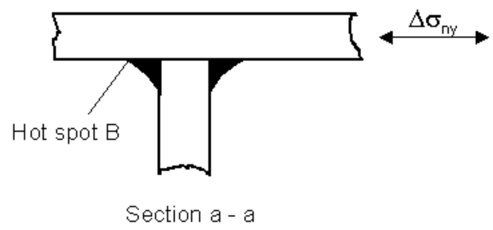
- Welding requirements:
  - stool side plating to be connected with full penetration welding to the bulkhead plating. Root gap to be checked along the production steps as appropriate,
  - brackets to be connected with full penetration welding to transverse bulkhead plating,
  - full penetration weld of stool side plating to bulkhead plating to be welded first,
  - welding sequence against lamellar tearing in the bulkhead plating is recommended.
- Material requirements:
  - the lower strake of transverse bulkhead plating is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the strake in way of the weld is required prior to and after welding,
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the transverse bulkhead plating,
  - material properties of prolonging brackets to be not less than those of the bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads – Radiused construction	Sheet 5.4





A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:
- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

t_A = min (t_1, t_2, t_3)

t_B = minimum among:
- thickness of member above stool top plate,
- thickness of member below stool top plate,
- t_2.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of members above and below stool top plate to be not less than that of bulkhead vertical webs.

FATIGUE:

Fatigue check to be carried out for L ≥ 150 m:
- K_{SX} = 3,3
- K_{SY} = 1,3
- K_{SXY} = 2,25

CONSTRUCTION:

- Misalignment (median lines) between stool top plate and stool side plating ≤ t_A / 3.
- Misalignment (median lines) between members above and below stool top plate ≤ t_B / 3.
- If not full penetration welding of stool top plate to bulkhead, the weld preparation is to be indicated on the approved drawings.
- Butt welds between transverse bulkhead and stool side plating at a distance greater than 500 mm from the stool top plate.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

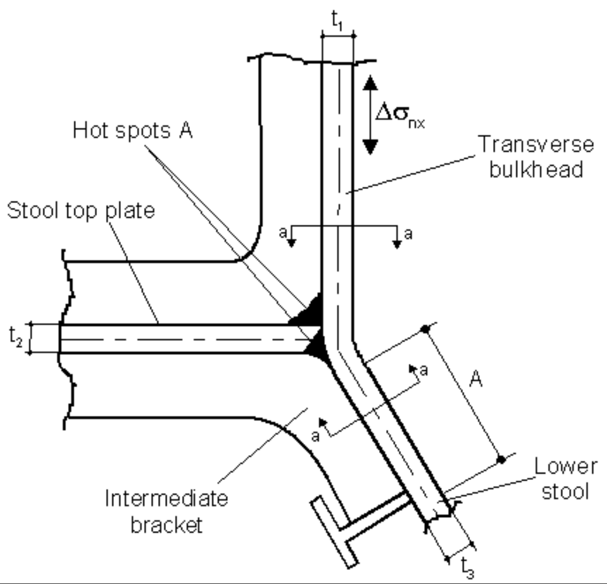
WELDING AND MATERIALS:

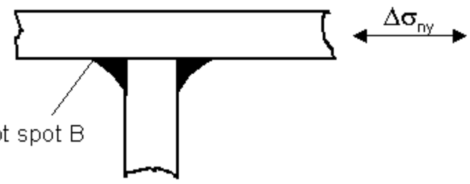
- Welding requirements:
  - welding sequence against the risk of lamellar tearing in the bulkhead plate is recommended,
  - weld finishing well faired to the bulkhead plating and stool side plating.
- Material requirements:
  - the radiused construction may be accepted provided that the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads in way of intermediate brackets – Radiused construction	Sheet 5.5





Section a - a

A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min (t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above stool top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of intermediate brackets and members above stool top plate to be not less than that of bulkhead vertical webs.

FATIGUE:

Fatigue check to be carried out for L ≥ 150 m:
- $K_{SX} = 3,15$
- $K_{SY} = 1,3$
- $K_{SXY} = 2,05$

CONSTRUCTION:

- Misalignment (median lines) between stool top plate and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between intermediate bracket and member below stool top plate $\leq t_B/3$.
- If not full penetration welding of stool top plate to bulkhead, the weld preparation is to be indicated on the approved drawings.
- Intermediate brackets to be fitted in place and welded after the welding of the joint between the stool top plate and the bulkhead plating.
- Butt welds between transverse bulkhead and stool side plating at a distance greater than 500 mm from the stool top plate.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

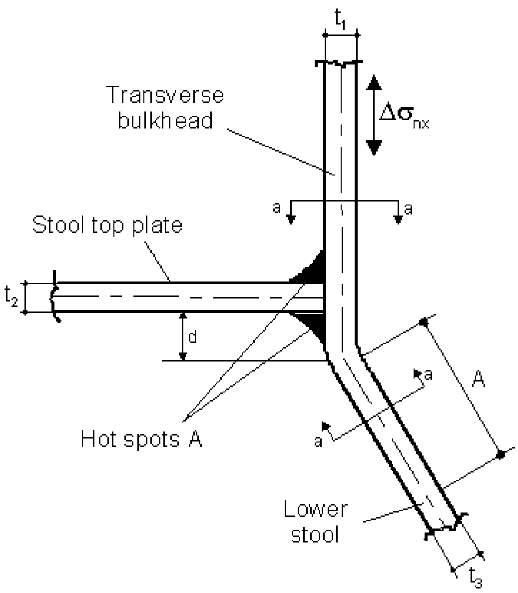
WELDING AND MATERIALS:

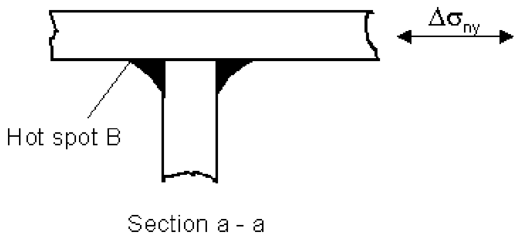
- Welding requirements:
  - brackets to be connected with continuous fillet welding to plating and stiffeners,
  - welding sequence against the risk of lamellar tearing in the bulkhead plate is recommended,
  - weld finishing well faired to the bulkhead plating and stool side plating.
- Material requirements:
  - the radiused construction may be accepted provided that the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with plane bulkheads – Radiused construction**	**Sheet 5.6**





A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

t = minimum among:

- thickness of member above stool top plate,
- thickness of member below stool top plate,
- t_2.

SCANTLINGS:	**FATIGUE:**
• Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan. • $d \leq 40$ mm. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of members above and below stool top plate to be not less than that of bulkhead vertical webs.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 4,5$ – $K_{SY} = 1,3$ – $K_{SXY} = 5,6$

CONSTRUCTION:	**NDE:**
• Misalignment (median lines) between members above and below stool top plate $\leq t / 3$. • If not full penetration welding of stool top plate to bulkhead, the weld preparation is to be indicated on the approved drawings. • Butt welds between transverse bulkhead and stool side plating at a distance greater than 500 mm from the stool top plate.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

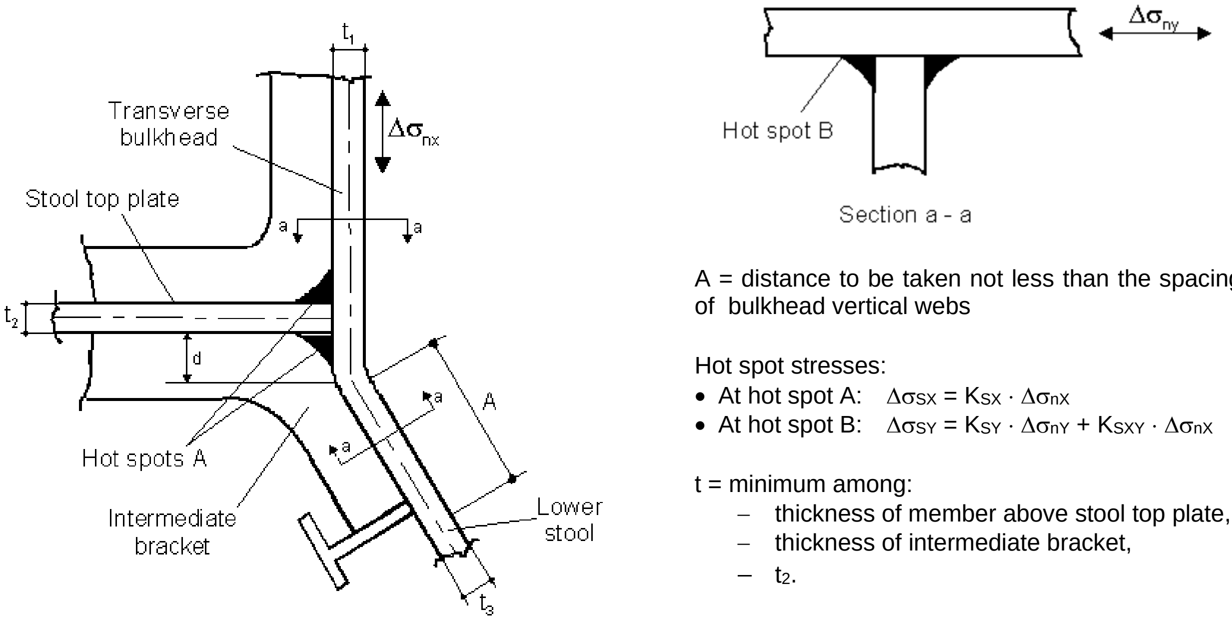
Material requirements:

- where stool top plate is welded within the bent area, folding procedure to be submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation,
- material properties of:
  - the stool top plate,
  - the portion A of the stool side plating,

  to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with plane bulkheads in way of intermediate brackets - Radiused construction	Sheet 5.7



A = distance to be taken not less than the spacing of bulkhead vertical webs

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

t = minimum among:

- thickness of member above stool top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:	FATIGUE:
• Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan. • $d \le 40$ mm. • $t_2 \ge t_1$. • $t_3 \ge t_1$ in portion A. • Thickness of intermediate brackets and members above stool top plate to be not less than that of bulkhead vertical webs.	Fatigue check to be carried out for $L \ge 150$ m: – $K_{SX} = 3,85$ – $K_{SY} = 1,3$ – $K_{SXY} = 4,5$

CONSTRUCTION:	NDE:
• Misalignment (median lines) between intermediate bracket and member above stool top plate $\le t/3$. • If not full penetration welding of stool top plate to bulkhead, the weld preparation is to be indicated on the approved drawings. • Intermediate brackets to be fitted in place and welded after the welding of the joint between the stool top plate and the bulkhead plating. • Butt welds between transverse bulkhead and stool side plating at a distance greater than 500 mm from the stool top plate.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

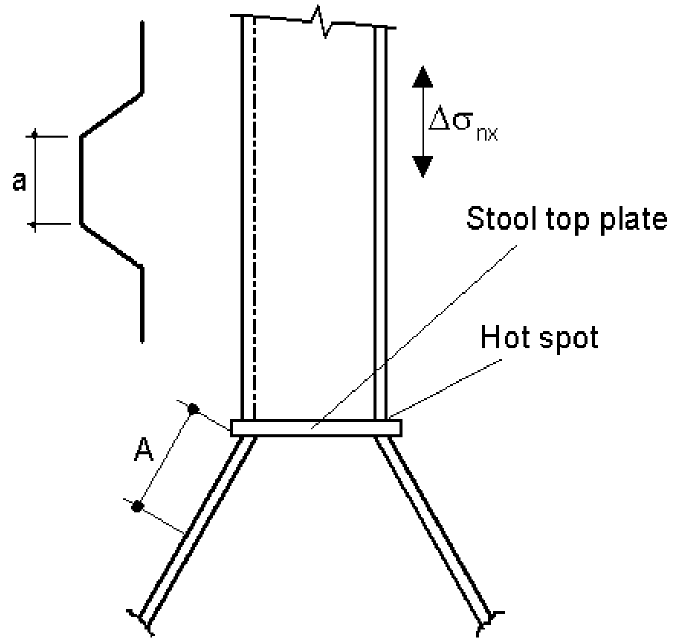
Material requirements:

- where stool top plate is welded within the bent area, folding procedure to be submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation,
- material properties of:
  - the stool top plate,
  - the portion A of the stool side plating,

  to be not less than those of the transverse bulkhead plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with corrugated bulkheads**	**Sheet 5.8** (1/7/2002)



$A \geq a$.

Hot spot stress:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,

$t = \min (t_F, t_T, t_S)$.

SCANTLINGS:

- $t_T \geq t_F$.
- $t_S \geq t_F$ in portion A.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 2,35$

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t / 3$.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3]

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

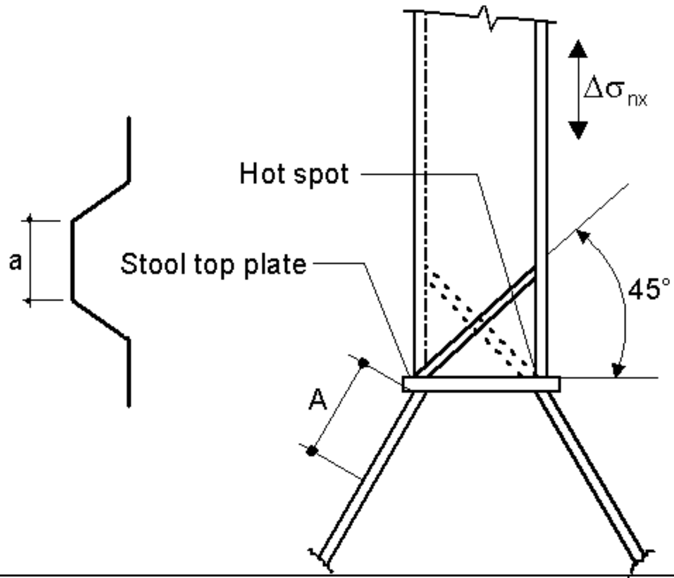
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with corrugated bulkheads – Shedder plates 45°	Sheet 5.9 (1/7/2002)



A ≥ a.

Hot spot stress:
$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_{SH} = shedder plate thickness,

$t_A = \min(t_F, t_T, t_S)$,

$t_B = \min(t_{SH}, t_T, t_S)$.

SCANTLINGS:	FATIGUE:
• $t_T \geq t_F$. • $t_S \geq t_F$ in portion A. • $t_{SH} \geq 0{,}75\ t_F$	Fatigue check to be carried out for L ≥ 150 m: – K_{SX} = 1,35

CONSTRUCTION:	NDE:
• Misalignment (median lines) between corrugation flanges and stool side plating ≤ t_A / 3. • Misalignment (median lines) between lower edge of shedder plates and stool side plating ≤ t_B / 3. • Knuckled shedder plates are to be avoided. • Distance from the edge of the stool top plate to the surface of the corrugation flanges ≥ t_F. • Corrugation radius according to Ch 4, Sec 7, [3.1.3]. • In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.	The following NDE are required: • VE 100%, • UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

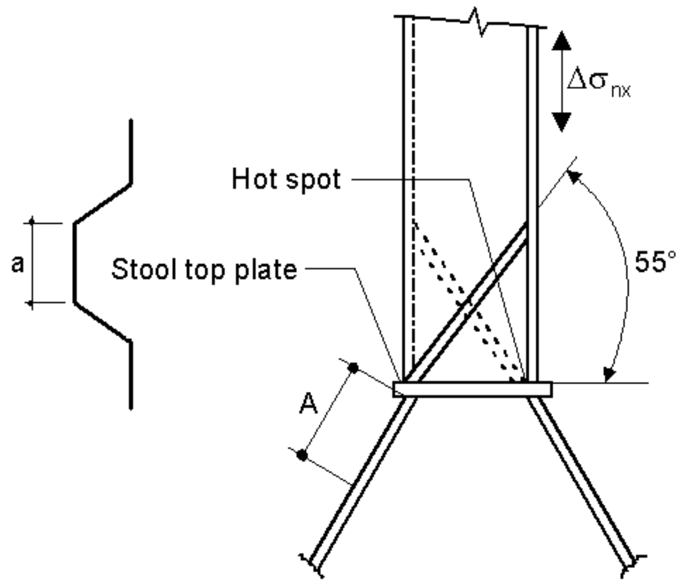
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with corrugated bulkheads – Shedder plates 55°**	**Sheet 5.10** (1/7/2002)



$A \geq a$.

Hot spot stress:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_{SH} = shedder plate thickness,

$t_A = \min(t_F, t_T, t_S)$,

$t_B = \min(t_{SH}, t_T, t_S)$.

SCANTLINGS:

- $t_T \geq t_F$.
- $t_S \geq t_F$ in portion A.
- $t_{SH} \geq 0{,}75\ t_F$

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 1{,}25$

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between lower edge of shedder plates and stool side plating $\leq t_B / 3$.
- Knuckled shedder plates are to be avoided.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].
- In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

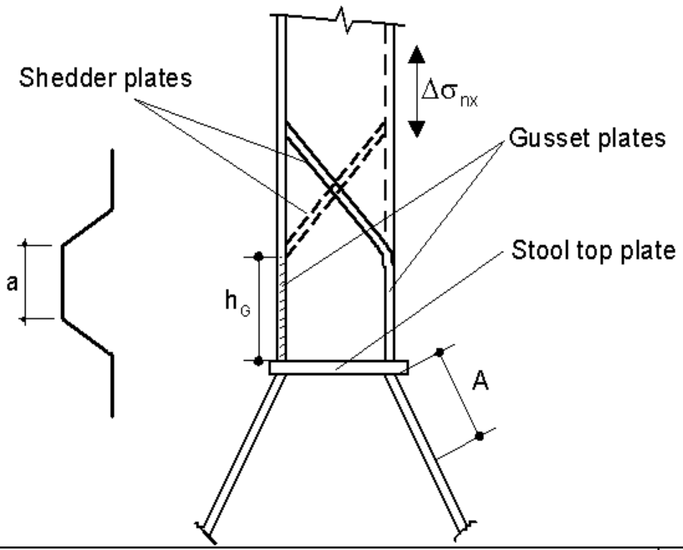
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with corrugated bulkheads - Gusset and shedder plates**	**Sheet 5.11** (1/7/2002)



$A \geq a$.

Hot spot stress:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_G = gusset plate thickness,
t_{SH} = shedder plate thickness,

$t_A = \min(t_F, t_T, t_S)$,

$t_B = \min(t_G, t_T, t_S)$.

SCANTLINGS:

- $t_T \geq t_F$ $t_S \geq t_F$ in portion A
- $t_G \geq t_F$ $t_{SH} \geq 0{,}75\ t_F$ $h_G \geq a / 2$.

FATIGUE:

Fatigue check not required.

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between lower edge of gusset plates and stool side plating $\leq t_B / 3$.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].
- In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.

NDE:

The following NDE are required:

- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

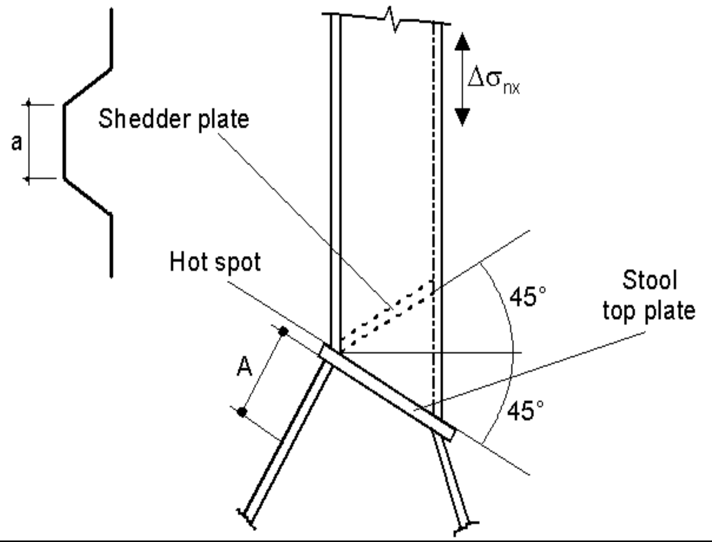
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - gusset plates to be connected with full penetration welding to stool top plate and with one side penetration, or equivalent, to corrugations and shedder plates,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and gusset plates,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the gusset plates,
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	**Connection of lower stools with corrugated bulkheads - Sloping stool top plate**	**Sheet 5.12** (1/7/2002)



$A \geq a$.

Hot spot stress:
$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_{SH} = shedder plate thickness,

$t_A = \min(t_F, t_T, t_S)$,

$t_B = \min(t_{SH}, t_T, t_S)$.

SCANTLINGS:

- $t_T \geq t_F$.
- $t_S \geq t_F$ in portion A.
- $t_{SH} \geq 0,75\ t_F$

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 1,9$

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between lower edge of shedder plates and stool side plating $\leq t_B / 3$.
- Knuckled shedder plates are to be avoided.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].
- In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

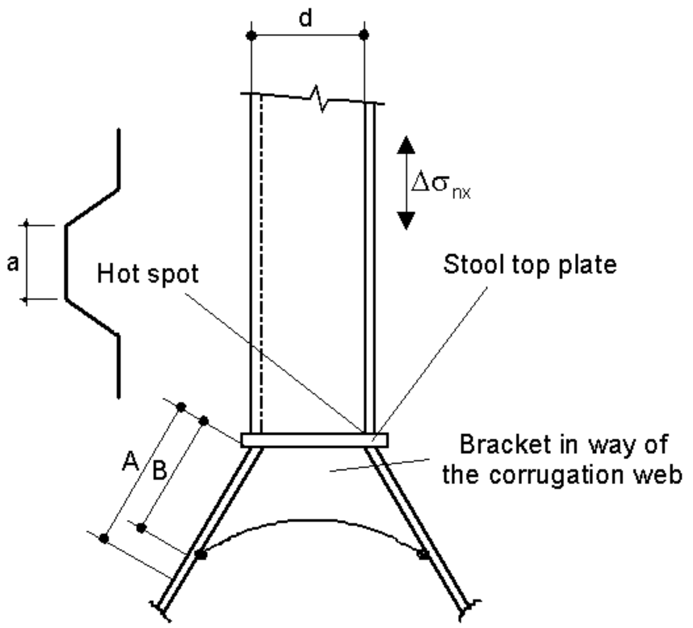
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with corrugated bulkheads - Brackets below stool top plate	Sheet 5.13 (1/7/2002)



$A \geq a$,

B = bracket dimension.

Hot spot stress:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_W = corrugation web thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_B = bracket thickness,

$t_A = \min(t_F, t_T, t_S)$,
$t_B = \min(t_W, t_T, t_B)$.

SCANTLINGS:

- $t_T \geq t_F$
- $t_S \geq t_F$ in portion A
- $t_B \geq t_W$
- $B \geq d$

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
– $K_{SX} = 1{,}95$

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between corrugation webs and brackets below stool top plate $\leq t_B / 3$.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].

NDE:

The following NDE are required:

- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

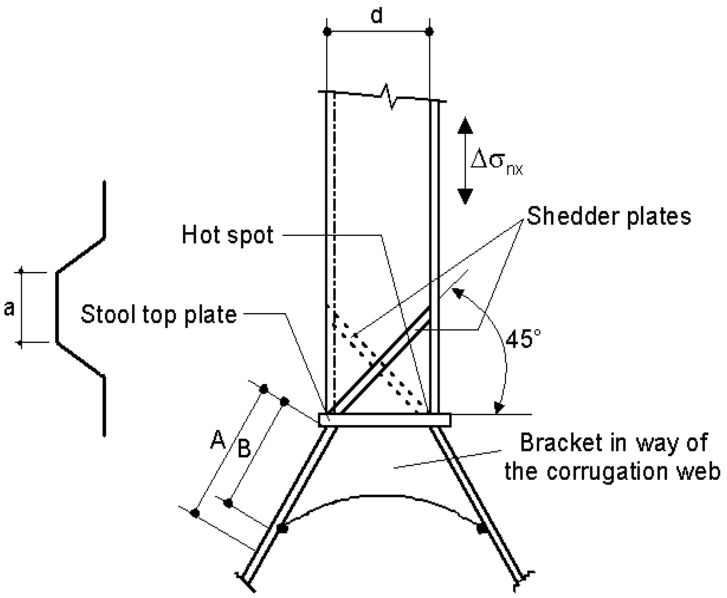
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with corrugated bulkheads - Shedder plates 45° and brackets below stool top plate	Sheet 5.14 (1/7/2002)



$A \geq a$,

B = bracket dimension.

Hot spot stress:
$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_W = corrugation web thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_{SH} = shedder plate thickness,
t_B = bracket thickness,

$t_A = \min(t_F, t_T, t_S)$,
$t_B = \min(t_{SH}, t_T, t_S)$
$t_C = \min(t_W, t_T, t_B)$.

SCANTLINGS:

- $t_T \geq t_F$ $t_S \geq t_F$ in portion A
- $t_{SH} \geq 0{,}75\ t_F$ $t_B \geq t_W$ $B \geq d$

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
– $K_{SX} = 1{,}25$

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between lower edge of shedder plates and stool side plating $\leq t_B / 3$.
- Misalignment (median lines) between corrugation webs and brackets below stool top plate $\leq t_C / 3$.
- Knuckled shedder plates are to be avoided.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].
- In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.

NDE:

The following NDE are required:
- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

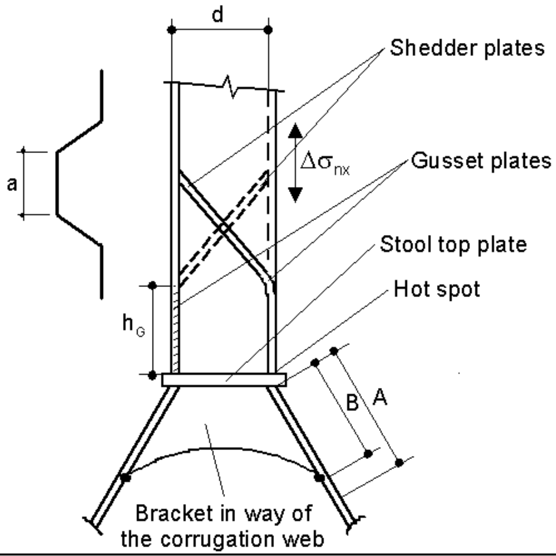
WELDING AND MATERIALS:

- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top plate; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and stool top plate,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 5: Lower part of transverse bulkheads with lower stools	Connection of lower stools with corrugated bulkheads - Gusset and shedder plates and brackets below stool top plate	Sheet 5.15 (1/7/2002)



$A \geq a$,
B = bracket dimension.

Hot spot stress:

$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$

t_F = corrugation flange thickness,
t_W = corrugation web thickness,
t_T = stool top plate thickness,
t_S = stool side plating thickness,
t_G = gusset plate thickness,
t_{SH} = shedder plate thickness,
t_B = bracket thickness,

$t_A = \min(t_F, t_T, t_S)$,
$t_B = \min(t_G, t_T, t_S)$

$t_C = \min(t_W, t_T, t_B)$.

SCANTLINGS:	FATIGUE:
• $t_T \geq t_F$ $t_S \geq t_F$ in portion A $t_G \geq t_F$ $t_{SH} \geq 0,75\ t_F$ • $t_B \geq t_W$ $h_G \geq a / 2$ $B \geq d$	Fatigue check not required.

CONSTRUCTION:

- Misalignment (median lines) between corrugation flanges and stool side plating $\leq t_A / 3$.
- Misalignment (median lines) between lower edge of gusset plates and stool side plating $\leq t_B / 3$.
- Misalignment (median lines) between corrugation webs and brackets below stool top plate $\leq t_C / 3$.
- Distance from the edge of the stool top plate to the surface of the corrugation flanges $\geq t_F$.
- Corrugation radius according to Ch 4, Sec 7, [3.1.3].
- In ships with service notations combination carriers, oil tankers or chemical tankers, closed spaces to be filled with suitable compound compatible with the products carried.

NDE:

The following NDE are required:

- VE 100%,
- UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

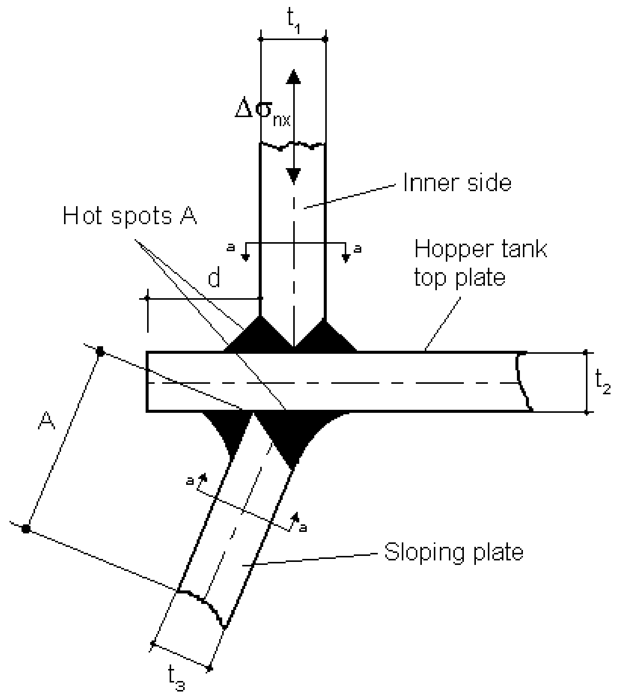
WELDING AND MATERIALS:

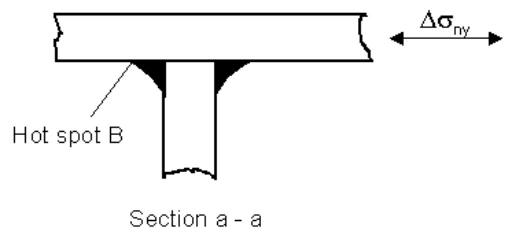
- Welding requirements:
  - corrugations to be connected with full penetration welding to stool top; root gap to be checked along the production,
  - stool side plating to be connected with full penetration or partial penetration welding to stool top plate,
  - gusset plates to be connected with full penetration welding to stool top and with one side penetration, or equivalent, to corrugations and shedder plates,
  - shedder plates to be connected with one side penetration, or equivalent, to corrugations and gusset plates,
  - welding sequence against the risk of lamellar tearing
  - start and stop welding away from the locations of corrugation bents,
  - weld finishing well faired to the stool top plate, corrugation flanges and stool side plating.
- Material requirements:
  - the stool top plate is recommended to be of Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of:
    - the gusset plates,
    - the shedder plates,
    - the stool top plate,
    - the portion A of the stool side plating,

    to be not less than those of the corrugation flanges.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side	Sheet 6.1





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above hopper tank top plate,
- thickness of member below hopper tank top plate,
- t_2.

SCANTLINGS:

- $d \geq t_1$.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of members above and below hopper tank top plate to be not less than that of side transverses.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 3,85$
- $K_{SY} = 1,3$
- $K_{SXY} = 2,0$

CONSTRUCTION:

- Misalignment (median lines) between inner side plating and hopper tank sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between members above and below hopper tank top plate $\leq t_B / 3$.

NDE:

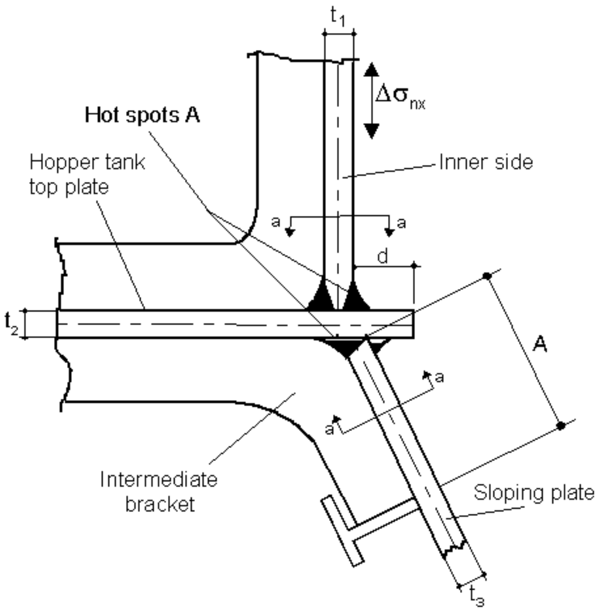
The following NDE are required:
- VE 100%,
- UE 25% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

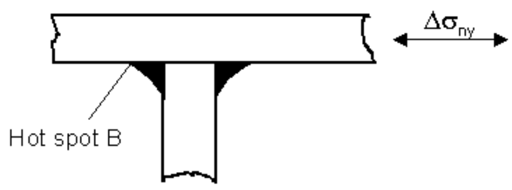
WELDING AND MATERIALS:

- Welding requirements:
  - inner side and hopper tank sloping plate generally to be connected with full penetration welding to hopper tank top plate (if not full penetration welding, the weld preparation is to be indicated on the approved drawings),
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the hopper tank top plate,
  - weld finishing well faired to the hopper tank top plate.
- Material requirements:
  - the hopper tank top plate is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side in way of intermediate brackets	Sheet 6.2





Section a - a

A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:

- thickness of member above hopper tank top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:	FATIGUE:
• $d \geq t_1$. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of intermediate brackets and members above hopper tank top plate to be not less than that of side transverses.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 3,55$ – $K_{SY} = 1,3$ – $K_{SXY} = 1,75$

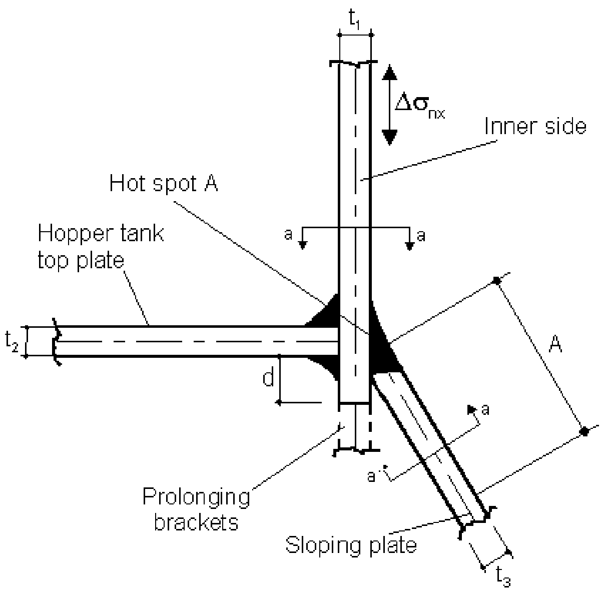
CONSTRUCTION:	NDE:
• Misalignment (median lines) between inner side plating and hopper tank sloping plate $\leq t_A / 3$. • Misalignment (median lines) between intermediate bracket and member above hopper tank top plate $\leq t_B/3$. • Intermediate brackets to be fitted in place and welded after the welding of the joint between the hopper tank sloping plate and the hopper tank top plate.	The following NDE are required: – VE 100%, – UE 25% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

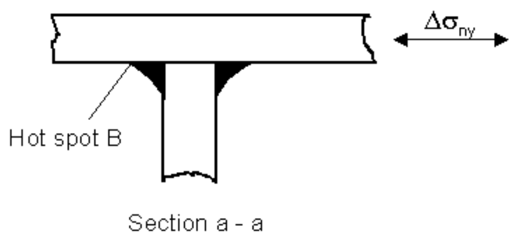
WELDING AND MATERIALS:

- Welding requirements:
  - inner side and hopper tank sloping plate generally to be connected with full penetration welding to hopper tank top plate (if not full penetration welding, the weld preparation is to be indicated on the approved drawings),
  - brackets to be connected with continuous fillet welding to plating and stiffeners,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the hopper tank top plate,
  - weld finishing well faired to the hopper tank top plate.
- Material requirements:
  - the hopper tank top plate is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the plate in way of the weld is required prior to and after welding,
    material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side – Prolonging brackets	Sheet 6.3





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:
- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above hopper tank top plate,
- thickness of member below hopper tank top plate,
- t_2.

SCANTLINGS:
- $d \geq 50$ mm.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of prolonging brackets $\geq t_1$.
- Thickness of members above and below hopper tank top plate to be not less than that of side transverses.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 2,4$
- $K_{SY} = 1,3$
- $K_{SXY} = 1,5$

CONSTRUCTION:
- Misalignment (median lines) between hopper tank top plate and hopper tank sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between members above and below hopper tank top plate $\leq t_B / 3$.

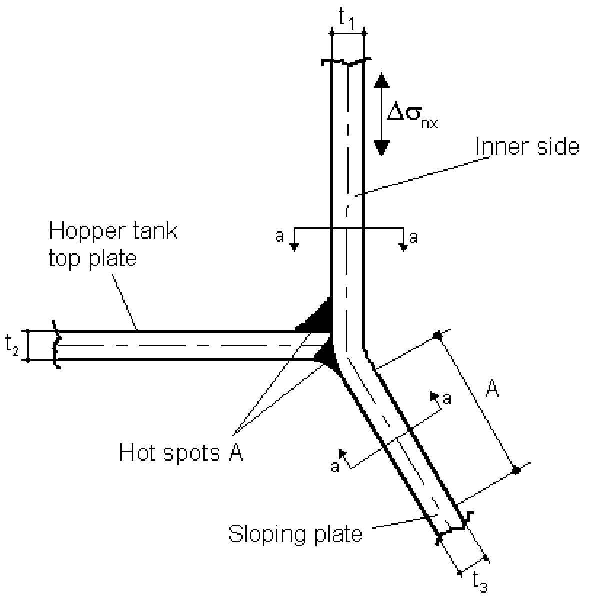
NDE:

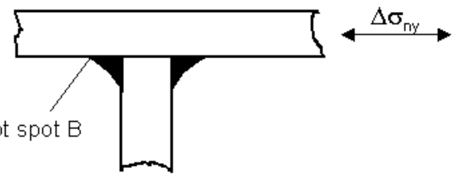
The following NDE are required:
- VE 100%,
- UE 25% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:
- Welding requirements:
  - Hopper tank sloping plate to be connected with full penetration welding to the inner side plating. Root gap to be checked along the production steps as appropriate,
  - Prolonging brackets to be connected with full penetration welding to inner side plating,
  - full penetration weld of hopper tank sloping plate to inner side plating to be welded first,
  - welding sequence against lamellar tearing in the inner side plating is recommended.
- Material requirements:
  - the lower strake of inner side plating is recommended to be Z25/ZH25 quality. If a steel of such a quality is not adopted, 100% UE of the strake in way of the weld is required prior to and after welding,
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating,
  - material properties of prolonging brackets to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side – Radiused construction	Sheet 6.4





Section a - a

A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:
- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above hopper tank top plate,
- thickness of member below hopper tank top plate,
- t_2.

SCANTLINGS:	FATIGUE:
• Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of members above and below hopper tank top plate to be not less than that of side transverses.	Fatigue check to be carried out for L ≥ 150 m: – $K_{SX} = 3,3$ – $K_{SY} = 1,3$ – $K_{SXY} = 2,25$

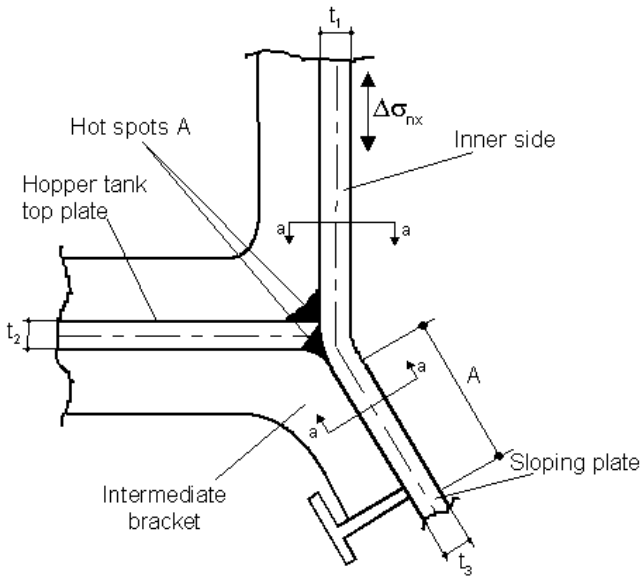
CONSTRUCTION:	NDE:
• Misalignment (median lines) between hopper tank top plate and hopper tank sloping plate ≤ t_A / 3. • Misalignment (median lines) between members above and below hopper tank top plate ≤ t_B / 3. • If not full penetration welding of hopper tank top plate to inner side, the weld preparation is to be indicated on the approved drawings. • Butt welds between inner side and hopper tank sloping plate at a distance greater than 500 mm from the hopper tank top plate.	The following NDE are required: – VE 100%, – UE 25% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

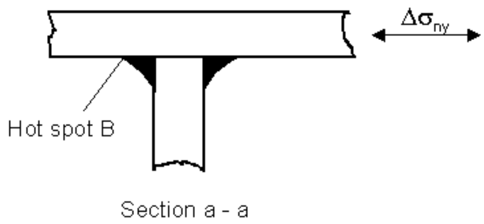
WELDING AND MATERIALS:

- Welding requirements:
  - Welding sequence against the risk of lamellar tearing in the inner side plate is recommended,
  - Weld finishing well faired to the inner side plating and hopper tank sloping plate.
- Material requirements:
  - the radiused construction may be accepted provided that the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side in way of intermediate brackets – Radiused construction	Sheet 6.5





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:
- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above hopper tank top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of intermediate brackets and members above hopper tank top plate to be not less than that of side transverses.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:
- $K_{SX} = 3{,}15$
- $K_{SY} = 1{,}3$
- $K_{SXY} = 2{,}05$

CONSTRUCTION:

- Misalignment (median lines) between hopper tank top plate and hopper tank sloping plate $\leq t_A / 3$.
- Misalignment (median lines) between intermediate bracket and member below hopper tank top plate $\leq t_B/3$.
- If not full penetration welding of hopper tank top plate to inner side, the weld preparation is to be indicated on the approved drawings.
- Intermediate brackets to be fitted in place and welded after the welding of the joint between the hopper tank top plate and the inner side plating.
- Butt welds between inner side and hopper tank sloping plate at a distance greater than 500 mm from the hopper tank top plate.

NDE:

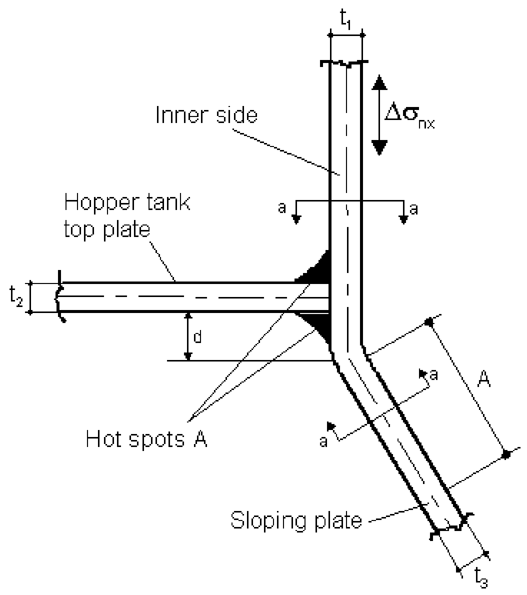
The following NDE are required:
- VE 100%,
- UE 25% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

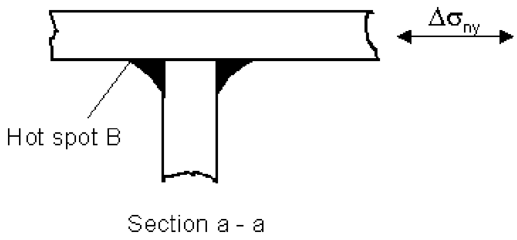
WELDING AND MATERIALS:

- Welding requirements:
  - brackets to be connected with continuous fillet welding to plating and stiffeners,
  - welding sequence against the risk of lamellar tearing in the inner side plate is recommended,
  - weld finishing well faired to the inner side plating and hopper tank sloping plate.
- Material requirements:
  - the radiused construction may be accepted provided that the folding procedure is submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation.
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side – Radiused construction	Sheet 6.6





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

t = minimum among:

- thickness of member above hopper tank top plate,
- thickness of member below hopper tank top plate,
- t_2.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- $d \leq 40$ mm.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of members above and below hopper tank top plate to be not less than that of side transverses.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:

- $K_{SX} = 4,5$
- $K_{SY} = 1,3$
- $K_{SXY} = 5,6$

CONSTRUCTION:

- Misalignment (median lines) between members above and below hopper tank top plate $\leq t / 3$.
- If not full penetration welding of hopper tank top plate to inner side, the weld preparation is to be indicated on the approved drawings.
- Butt welds between inner side and hopper tank sloping plate at a distance greater than 500 mm from the hopper tank top plate.

NDE:

The following NDE are required:

- VE 100%,
- UE 25% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

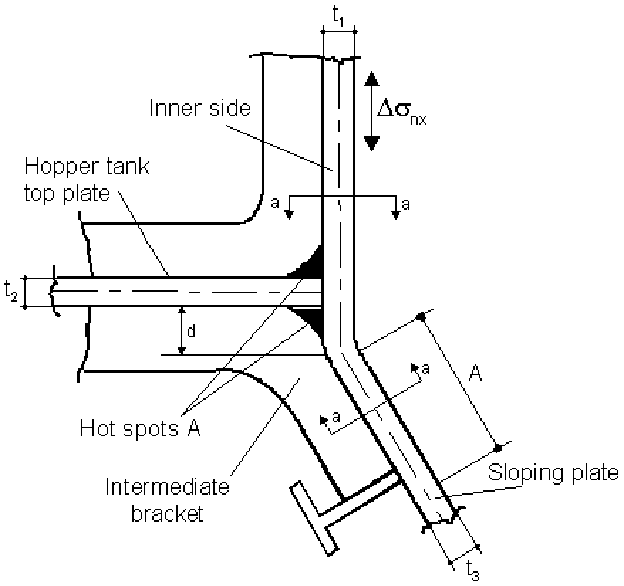
WELDING AND MATERIALS:

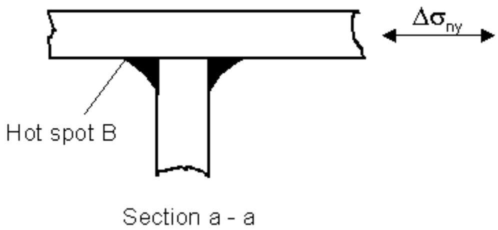
Material requirements:

- where hopper tank top plate is welded within the bent area, folding procedure to be submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation,
- material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

OIL TANKERS, CHEMICAL TANKERS, BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side in way of intermediate brackets - Radiused construction	Sheet 6.7





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

t = minimum among:

- thickness of member above hopper tank top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:

- Inner radius of the bent plate to be between 3,5 and 5 times the thickness of the bent plate and to be indicated in the approved plan.
- $d \leq 40$ mm.
- $t_2 \geq t_1$.
- $t_3 \geq t_1$ in portion A.
- Thickness of intermediate brackets and members above hopper tank top plate to be not less than that of side transverses.

FATIGUE:

Fatigue check to be carried out for $L \geq 150$ m:

- $K_{SX} = 3{,}85$
- $K_{SY} = 1{,}3$
- $K_{SXY} = 4{,}5$

CONSTRUCTION:

- Misalignment (median lines) between intermediate bracket and member above hopper tank top plate $\leq t/3$.
- If not full penetration welding of hopper tank top plate to inner side, the weld preparation is to be indicated on the approved drawings.
- Intermediate brackets to be fitted in place and welded after the welding of the joint between the hopper tank top plate and the inner side plating.
- Butt welds between inner side and hopper tank sloping plate at a distance greater than 500 mm from the hopper tank top plate.

NDE:

The following NDE are required:

- VE 100%,
- UE 25% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

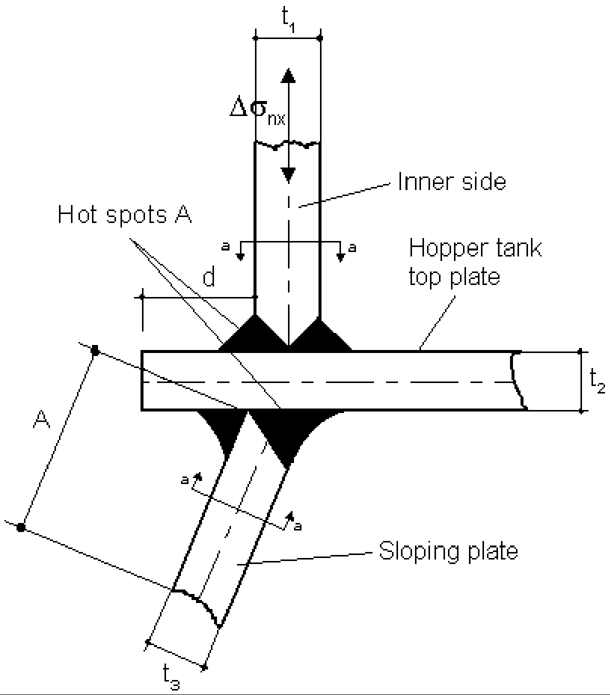
WELDING AND MATERIALS:

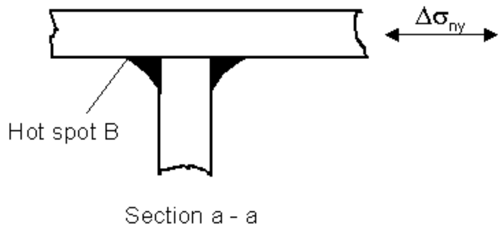
Material requirements:

- where hopper tank top plate is welded within the bent area, folding procedure to be submitted to the Society for review, with evidence given that the mechanical properties and, in particular, the impact properties are not deteriorated by the folding operation,
- material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

LIQUEFIED GAS CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side	Sheet 6.8





A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min (t_1, t_2, t_3)$

t_B = minimum among:
- thickness of member above hopper tank top plate,
- thickness of member below hopper tank top plate,
- t_2.

SCANTLINGS:	FATIGUE:
• $d \geq t_1$. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of members above and below hopper tank top plate to be not less than that of side transverses.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 3{,}85$ – $K_{SY} = 1{,}3$ – $K_{SXY} = 2{,}0$

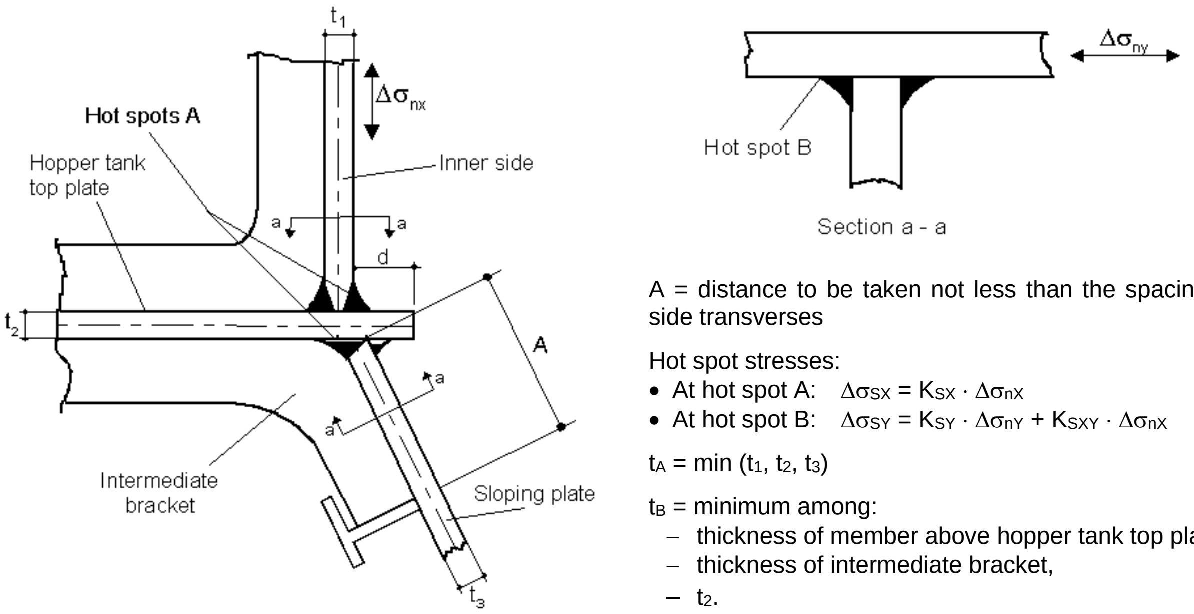
CONSTRUCTION:	NDE:
• Misalignment (median lines) between inner side plating and hopper tank sloping plate $\leq t_A / 3$, max 6 mm. • Misalignment (median lines) between members above and below hopper tank top plate $\leq t_B / 3$, max 6 mm.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - inner side and hopper tank sloping plate to be connected with full penetration welding to hopper tank top plate, except in way of void spaces where partial penetration may be accepted,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the hopper tank top plate,
  - weld finishing well faired to the hopper tank top plate.
- Material requirements:
  - the hopper tank top plate is to be of Z25/ZH25 or of a steel of the same mechanical performances. In particular cases, grade E/EH low temperature steel may be accepted by the Society provided that the results of 100% UE of the plate in way of the weld, carried out prior to and after welding, are submitted for review,
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

LIQUEFIED GAS CARRIERS

AREA 6: Lower part of inner side	Connection of hopper tank sloping plates with inner side in way of intermediate brackets	Sheet 6.9



A = distance to be taken not less than the spacing of side transverses

Hot spot stresses:

- At hot spot A: $\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nX}$
- At hot spot B: $\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{nY} + K_{SXY} \cdot \Delta\sigma_{nX}$

$t_A = \min(t_1, t_2, t_3)$

t_B = minimum among:

- thickness of member above hopper tank top plate,
- thickness of intermediate bracket,
- t_2.

SCANTLINGS:	FATIGUE:
• $d \geq t_1$. • $t_2 \geq t_1$. • $t_3 \geq t_1$ in portion A. • Thickness of intermediate brackets and members above hopper tank top plate to be not less than that of side transverses.	Fatigue check to be carried out for $L \geq 150$ m: – $K_{SX} = 3,55$ – $K_{SY} = 1,3$ – $K_{SXY} = 1,75$

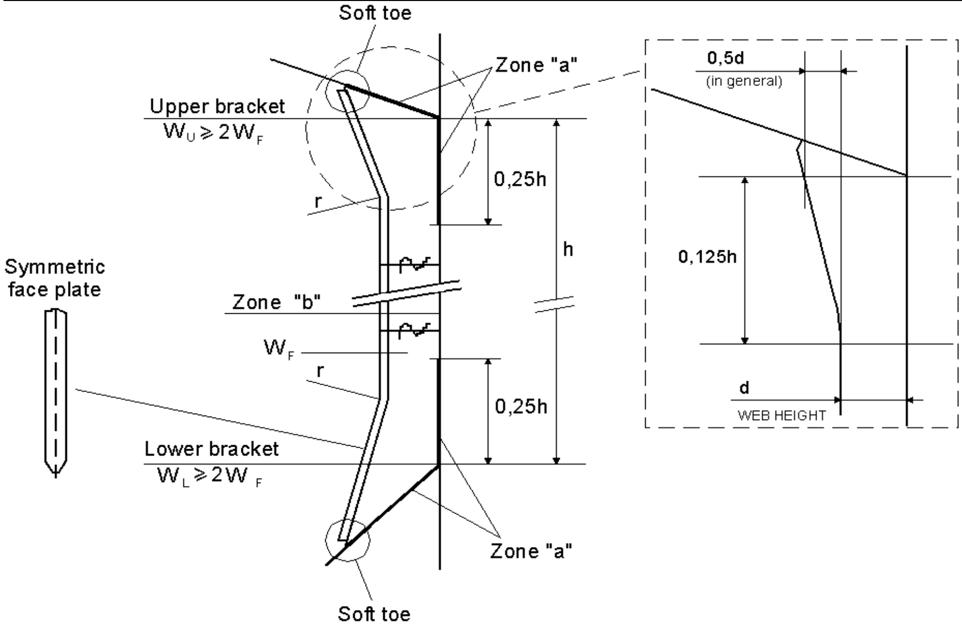
CONSTRUCTION:	NDE:
• Misalignment (median lines) between inner side plating and hopper tank sloping plate $\leq t_A / 3$, max 6 mm. • Misalignment (median lines) between intermediate bracket and member above hopper tank top plate $\leq t_B/3$, max 6 mm. • Intermediate brackets to be fitted in place and welded after the welding of the joint between the hopper tank sloping plate and the hopper tank top plate.	The following NDE are required: – VE 100%, – UE 35% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - inner side and hopper tank sloping plate to be connected with full penetration welding to hopper tank top plate, except in way of void spaces where partial penetration may be accepted,
  - brackets to be connected with continuous fillet welding to plating and stiffeners,
  - approval of the procedure on a sample representative of the actual conditions foreseen in production,
  - welding sequence against the risk of lamellar tearing is recommended in case Z material is not adopted for the hopper tank top plate,
  - weld finishing well faired to the hopper tank top plate.
- Material requirements:
  - the hopper tank top plate is to be of Z25/ZH25 or of a steel of the same mechanical performances. In particular cases, grade E/EH low temperature steel may be accepted by the Society provided that the results of 100% UE of the plate in way of the weld, carried out prior to and after welding, are submitted for review,
  - material properties of the portion A of the hopper tank sloping plate to be not less than those of the inner side plating.

BULK CARRIERS

AREA 7: Side frames	Connection of side frames with hopper and topside tanks - Symmetric face plate frame with integral brackets	Sheet 7.1



t_w	=	fitted thickness, in mm, of side frame web	$t_{w,min}$	=	$7,0 + 0,03L_1$ mm
b_F	=	bracket flange width, in mm,	t_F	=	bracket flange thickness, in mm.

SCANTLINGS:

- Thickness of lower bracket, in mm $\geq$ max (t_w, $t_{w,min}$ + 2).
- Thickness of upper bracket, in mm $\geq$ max (t_w, $t_{w,min}$).
- Section modulus of the frame with the upper or lower bracket, at the locations shown in the sketch, to be not less than twice the section modulus required for the frame mid-span area.
- Dimensions of lower and upper brackets to be not less than those shown in the sketch.
- Structural continuity with the upper and lower end connections of side frames is to be ensured within hopper tanks and upper wing tanks by connecting brackets.
- Frame flange to be curved (not knuckled) at the connection with the end brackets, r $\geq \dfrac{0,4b_F^2}{t_F}$.
- Ends of flange to be sniped.

FATIGUE:

Fatigue check not required.

CONSTRUCTION:

- Misalignment between frame web and the connecting brackets inside hopper tank and upper wing tank $\leq$ t / 3, where t is the minimum thickness among those of the connected elements.
- Soft toe: tapering of frame flange at ends: thickness 1:3, width 1:5.

NDE:

The following NDE are required:

– VE 100%, with particular care for fillet shape and undercuts on the plating at the soft toes,

– ME or dye penetrant depending on the results of VE.

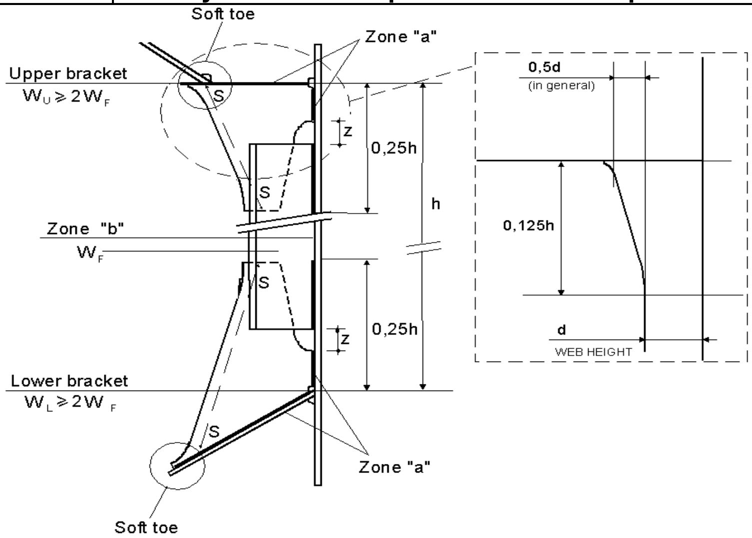
WELDING AND MATERIALS:

- Welding requirements:
  - – frames and brackets to be connected with continuous fillet welding to side plating, hopper tank and upper wing tank plating, with throat thickness to be not less than :
    - 0,45 t in “zone a”,
    - 0,40 t in “zone b”,

    where t is the minimum thickness between those of the two connected elements,
  - –welding sequence to minimise restraints at the frame butt joints, i.e.:
    - leaving about 200 mm unwelded, each side of butt joint, of the connections between frame web and side plating and between frame web and flange,
    - performing the frame butt joints,
    - completing the fillet welding,
  - –turn the fillet weld all around the end of integral brackets and scallops giving an elongated shape, well faired to the plating,
  - – avoid burned notches at the scallops, if existing, in way of frame flange butt joints; if scallops not adopted, care to be taken to avoid end defects at web butt joints.

BULK CARRIERS

AREA 7: Side frames	Connection of side frames with hopper and topside tanks - Non symmetric face plate frame with separate brackets	Sheet 7.2



This solution is permitted only for ships less than 190 m in length with side frames built in normal strength steel.

t_W = fitted thickness, in mm, of side frame web $t_{W,min}$ = $7,0 + 0,03L_1$ mm

b_F = bracket flange width, in mm, t_F = bracket flange thickness, in mm.

SCANTLINGS:

- Thickness of lower bracket, in mm $\geq$ max (t_W, $t_{W,min}$ + 2).
- Thickness of upper bracket, in mm $\geq$ max (t_W, $t_{W,min}$).
- Section modulus of the frame with the upper or lower bracket, at the locations shown in the sketch, to be not less than twice the section modulus required for the frame mid-span area.
- Dimensions of lower and upper brackets to be not less than those shown in the sketch.
- Structural continuity with the upper and lower end connections of side frames is to be ensured within hopper tanks and upper wing tanks by connecting brackets.
- Ends of flange to be sniped.
- $z \leq 50$ mm.

FATIGUE:

Fatigue check not required.

CONSTRUCTION:

- Misalignment between frame brackets and the connecting brackets inside hopper tank and upper wing tank $\leq t / 3$, where t is the minimum thickness among those of the connected elements.
- Bracket overlap: $\geq 1,5d$, in mm.
- Soft toe: tapering of frame flange at ends: thickness 1:3, width 1:5.

NDE:

The following NDE are required:

- VE 100%, with particular care for fillet shape and undercuts on the plating at the soft toes ,
- ME or dye penetrant depending on the results of VE.

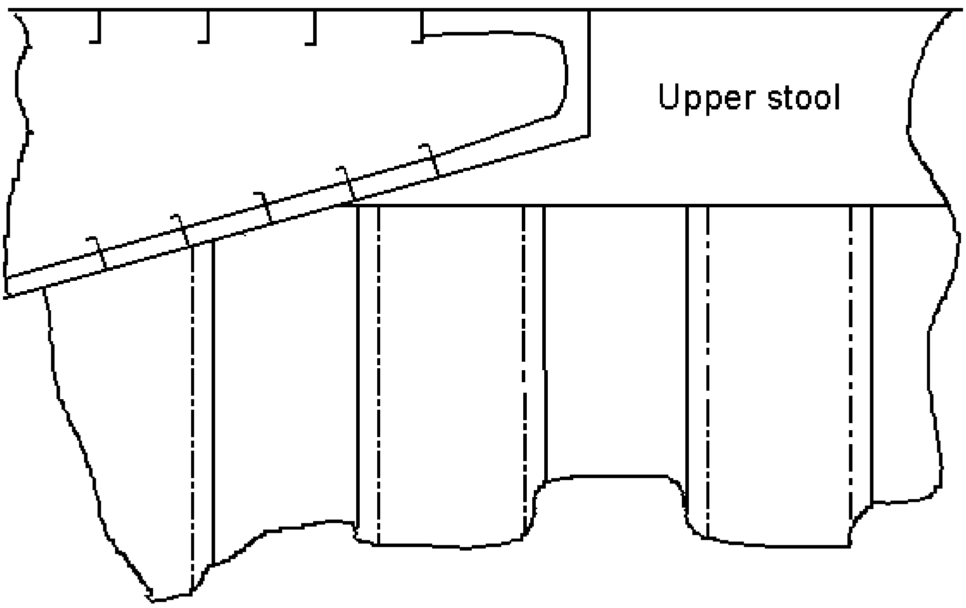
WELDING AND MATERIALS:

- Welding requirements:
  - frames and brackets to be connected with continuous fillet welding to side plating, hopper tank and upper wing tank plating, with throat thickness to be not less than :
    - 0,45 t in “zone a”,
    - 0,40 t in “zone b”,

    where t is the minimum thickness between those of the two connected elements,
  - brackets to be connected with continuous fillet welding to frames, with throat thickness to be not less than half thickness of brackets.
  - welding procedure of frame butt joint, if any, to be approved with particular care for the welding of the bulbs and of the corner in case of L sections,
  - welding sequence to minimise restraints at the frame butt joints, i.e.:
    - leaving about 200 mm unwelded, each side of butt joint, of the connections between frame web and side plating and between frame web and flange,
    - performing the frame butt joints,
    - completing the fillet welding,
  - turn the fillet weld all around the end of integral brackets and scallops giving an elongated shape, well faired to the plating,
  - avoid burned notches at fillet welds of overlapped joints and at scallops.

BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS

AREA 8: Topside tanks	Connection of transverse corrugated bulkheads with topside tanks	Sheet 8.1



t = minimum thickness among those of the connected elements.

SCANTLINGS:	FATIGUE:
A transverse web or an intercostal reinforcement is to be fitted inside the topside tank in line with the flanges of corrugation and the upper stool side plating. Its arrangement is to be indicated in the approved plan.	Fatigue check not required.

CONSTRUCTION:	NDE:
Misalignments between: – transverse web or intercostal reinforcement fitted inside the upper wing tank and corrugation flanges, – transverse web or intercostal reinforcement fitted inside the upper wing tank and upper stool side plating, – upper stool side plating and corrugation flanges are to be ≤ t/3.	The following NDE are required: – VE 100%, with particular care for fillet shape and undercuts on the plating, – UE 100% of full penetration weld for absence of cracks, lack of penetration and lamellar tears.

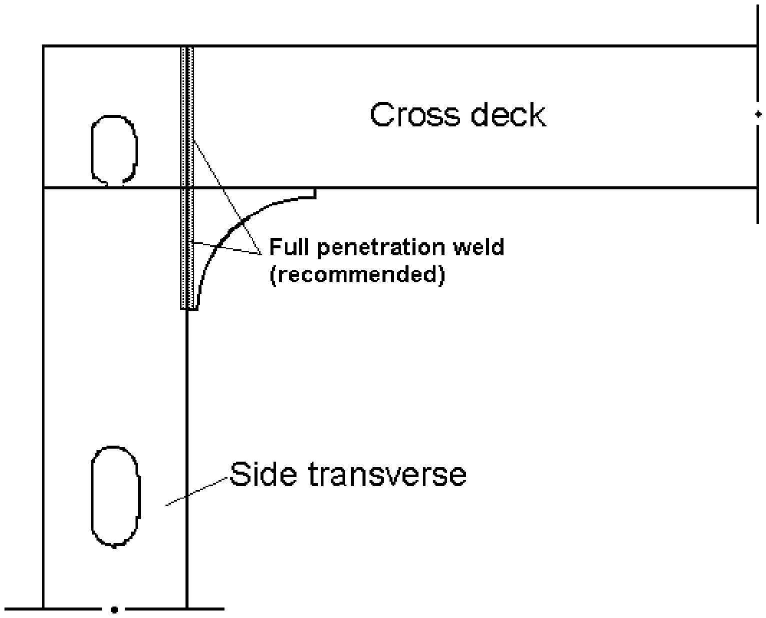
WELDING AND MATERIALS:

Welding requirements:

- bulkhead plating to be connected with continuous fillet welding to topside plating and upper stool plating, full penetration weld is recommended in way of corner of vertical and inclined plating of upper wing tank,
- throat thickness = 0,45 t, where t is the minimum thickness between those of the two connected elements,
- gap at T joint reduced to the minimum,
- welding sequence to minimise restraints.

CONTAINER SHIPS

AREA 9: Cross decks	Connection of cross decks with side transverses	Sheet 9.1



t = minimum thickness among those of the connected elements

SCANTLINGS:

- Cross deck strips between hatches to be suitably overlapped at ends.
- Stresses due to forces transmitted by cross deck strips to web frames calculated taking into account frame openings.

FATIGUE:

Fatigue check not required

CONSTRUCTION:

Misalignment between brackets and webs of cross decks and web frames $\leq t/3$.

NDE:

The following NDE are required:

- Visual examination 100%, with particular care for:
  - fillet shape and undercuts at ends of brackets, if grinding on plating is not adopted,
  - quality of cuts at bracket free edge,
- UE 100% of full penetration welds, if any, for absence of cracks, lack of penetration and lamellar tears.

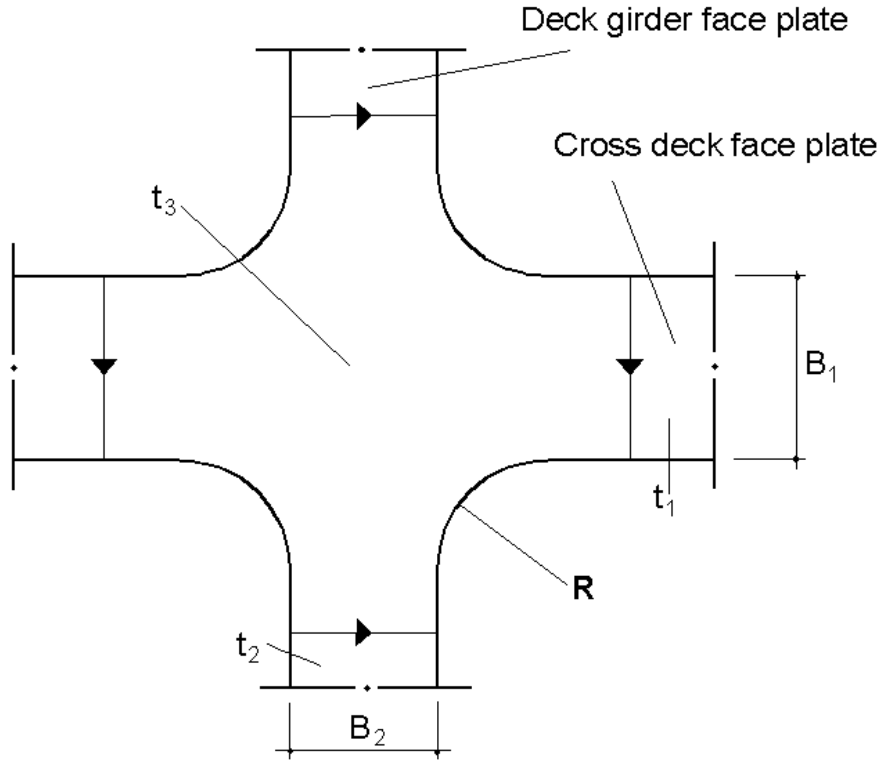
WELDING AND MATERIALS:

Welding requirements:

- cross deck structures to be connected with continuous fillet welding to web frame structures, full penetration weld recommended in areas indicated in the sketch,
- throat thickness = 0,45 t, where t is the minimum thickness between those of the two connected elements,
- turn the fillet weld all around the bracket ends giving an elongated shape, well faired to the frame and cross deck, avoiding notches; grinding recommended.

CONTAINER SHIPS

AREA 9: Cross decks	Connection between face plates of cross decks and deck girders	Sheet 9.2



B = min (B_1, B_2)

SCANTLINGS:	FATIGUE:
• $R \geq B$. • $t_3 \geq \max(t_1, t_2)$.	Fatigue check not required.

CONSTRUCTION:	NDE:
Cut edges to be carefully executed.	• Visual examination 100%. • UE 100% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

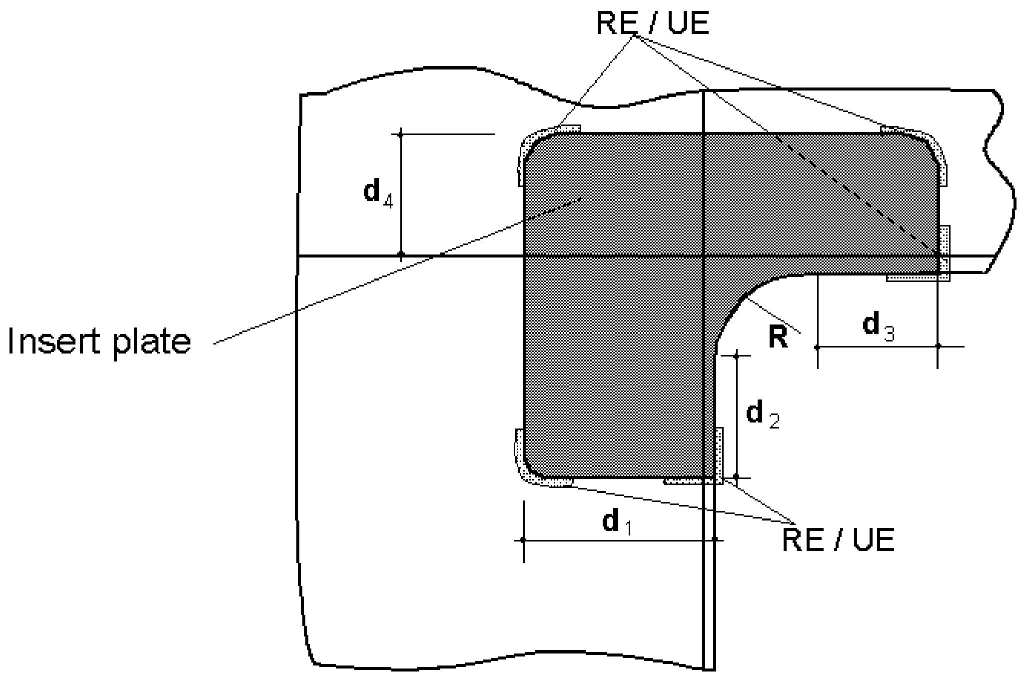
Welding requirements:

– brackets to be connected with full penetration welding to deck girder and cross deck face plates,

– welds recommended to be continued on auxiliary pieces temporarily fitted at both end of each joint, to be cut away; joint ends to be carefully ground.

BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS, CONTAINER SHIPS

AREA 10: Hatch corners	Deck plating in way of hatch corners	Sheet 10.1



SCANTLINGS:	FATIGUE:
• Insert plates with circular profiles in general to be fitted in way of corners of hatchways located within the cargo area. The radius of circular corners to be in accordance with Ch 4, Sec 6, [6.2.1]. • Insert plates not required in way of corners of hatchways located in the above positions, where corners have an elliptical or parabolic profile according to Ch 4, Sec 6, [6.2.2]. • Where insert plates are required, their thickness to be defined according to Ch 4, Sec 6, [6.2.3] and their extension to be such that d_1, d_2, d_3 and $d_4 \geq s$, s being the ordinary frame spacing.	Fatigue check not required.

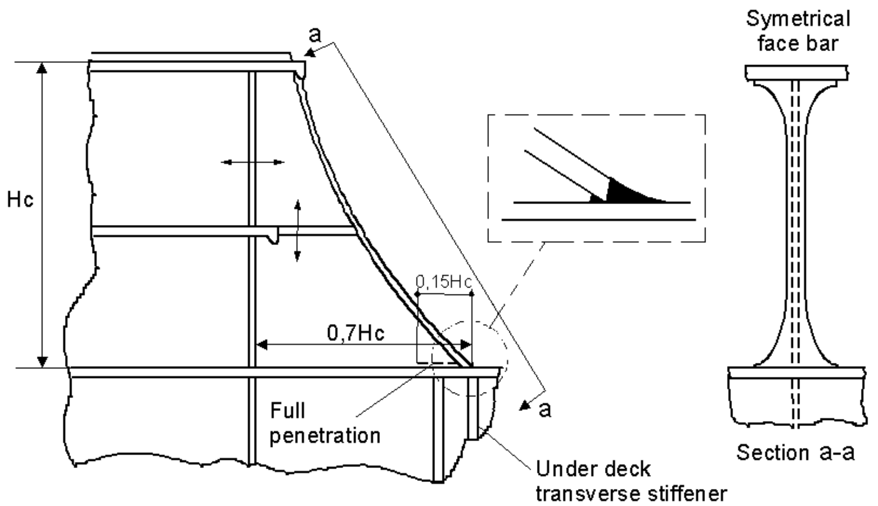
CONSTRUCTION:	NDE:
• Corners of insert plates to be rounded, unless corresponding to joints of deck strakes. • Insert cut edges to be carefully executed.	The following NDE are required: – VE 100%, – RE / UE in areas indicated in the sketch.

WELDING AND MATERIALS:

- Welding requirements:
  - welds recommended to be continued on auxiliary pieces temporarily fitted at the free end of each joint, to be cut away; the joint ends are to be carefully ground.
- Materials requirements:
  - insert plate material of same or higher quality than the adjacent deck plating, depending on the insert thickness according to Ch 4, Sec 1, [2].

BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS, CONTAINER SHIPS

AREA 10: Hatch corners	Ends of longitudinal hatch coamings – Bracket welded to deck plating	Sheet 10.2



t_A = minimum among:
- –thickness of bracket flange at lower end,
- –deck plating thickness,
- –under deck transverse stiffener web thickness,

t_B = minimum among:
- –bracket web thickness,
- –deck plating thickness,
- –thickness of the under deck longitudinal member.

SCANTLINGS:	FATIGUE:
An additional under deck transverse stiffener is to be fitted in way of termination bracket toe, where the toe is clear of normal stiffener.	Fatigue check not required.

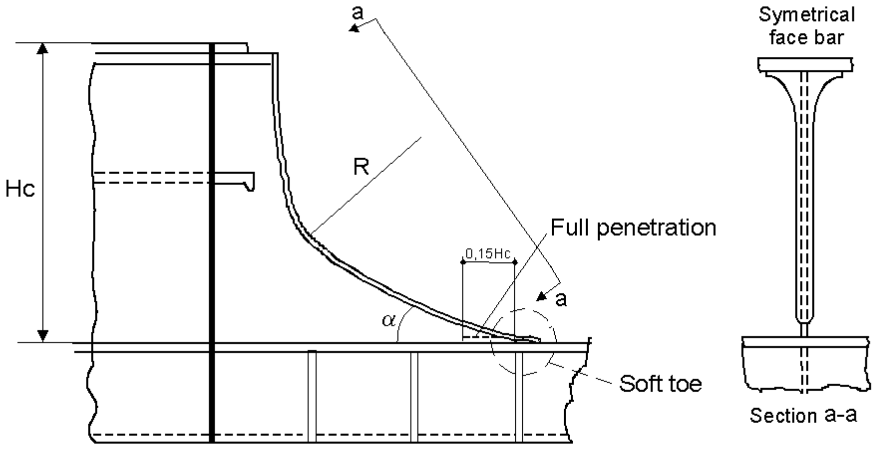
CONSTRUCTION:	NDE:
• Misalignment between bracket flange and under deck transverse stiffener ≤ t_A / 3. • Misalignment between bracket and under deck longitudinal ≤ t_B / 3.	The following NDE are required: – VE 100%, with particular care for the weld shape and undercuts on deck plating at the bracket flange connection, – UE 100% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - bracket flange to be connected with full penetration welding to deck plating, with half V bevel and weld shape elongated on deck plating (see sketch),
  - ends of bracket webs to be connected with full penetration welding to deck plating for the extension shown in the sketch, with half X bevel,
  - under deck transverse stiffener to be connected with full penetration welding to deck plating in way of the bracket flange,
  - care is to be taken to ensure soundness of the crossing welds at the bracket toe, if the case, adopting small scallop to be closed by welding.

BULK CARRIERS, ORE CARRIERS, COMBINATION CARRIERS, CONTAINER SHIPS

AREA 10: Hatch corners	Ends of longitudinal hatch coamings – Bracket sniped at deck plating	Sheet 10.3



t = minimum among:
- –bracket web thickness,
- –deck plating thickness,
- –thickness of the under deck longitudinal member.

SCANTLINGS:	FATIGUE:
• $R \geq 500$ mm. • $\alpha \leq 30°$	Fatigue check not required.

CONSTRUCTION:	NDE:
• Misalignment between bracket and under deck longitudinal $\leq = t_B / 3$. • Soft toe: tapering of bracket flange at ends: thickness 1:3, width 1:5.	The following NDE are required: – VE 100%, with particular care for the weld shape and undercuts on deck plating, – UE 100% of full penetration welds for absence of cracks, lack of penetration and lamellar tears.

WELDING AND MATERIALS:

- Welding requirements:
  - – ends of bracket webs to be connected with full penetration welding to deck plating for the extension shown in the sketch, with half X bevel.