Rules for the Classification of Yachts Designed for Commercial Use

Effective from 1 January 2023

Part B

Hull and Stability

+971 2 6922333 +971 2 4454333 info@tasneef.ae 111155, Abu Dhabi, UAE

GENERAL CONDITIONS

Definitions:

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

"IACS" means the International Association of Classification Societies.

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

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

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

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

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

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

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

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

Article 1

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

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various 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, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and 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.tasneef.ae.

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

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

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of 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, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or 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 such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

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

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

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any statutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

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

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

Article 6

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

6.2. However,

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

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

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

Article 7

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

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

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

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

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

Article 8

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

EXPLANATORY NOTE TO PART B

1. Reference edition

The reference edition of these Rules is the edition effective from 1 January 2015.

2. Effective date of the requirements

2.1 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.

2.2 Item 5 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.

3. 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 Tasneef web site (www.tasneef.ae). Except in particular cases, paper copies of Rule Variations or corrigenda are not issued.

4. Rule subdivision and cross-references

4.1 Rule subdivision

The Rules are subdivided into five parts, from A to E.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Electrical Installations, Automation and Fire Protection

Part D: Materials and Welding

Part E: 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.

4.2 Cross-references

Examples: Pt A, Ch 3, Sec 1, [3.2.1] or Pt A, Ch 3, 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 3 means Chapter 3

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.

5. Summary of amendments introduced in the edition effective from 1 January 2020

Foreword

This edition of the Rules for the classification of Yachts Designed for Commercial Use contains amendments whose effective date is **1 January 2020**.

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

Tasneef
هيئة الإمارات للتصنيف
Emirates Classification Society

RULES FOR THE CLASSIFICATION OF YACHTS DESIGNED FOR COMMERCIAL USE

Part B
Hull and Stability

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CHAPTER 6
STABILITY

Part B

Hull and Stability

Chapter 1

GENERAL REQUIREMENTS

SECTION 1 GENERAL REQUIREMENTS

1 Rule application

1.1

1.1.1 Part B consists of six Chapters and applies to hulls of length L_{OA}, defined in [4.2], of 24 m and over of yachts of normal type, monohull craft or catamarans, which are to be classed by Tasneef

Chapter 1 applies in general to all yachts, irrespective of the material used for the construction of the hull.

Chapter 2 contains requirements relevant to the scantlings of hull structures of steel yachts.

Chapter 3 contains requirements relevant to the scantlings of hull structures of aluminium alloy yachts.

Chapter 4 contains requirements relevant to the scantlings of hull structures of yachts constructed of composite materials.

Chapter 5 contains requirements relevant to the scantlings of hull structures of wooden yachts.

Chapter 6 contains requirements relevant to the intact stability of commercial vessels.

Yachts of unusual form, speed or proportions or of types other than those considered in Part B will be given special consideration by Tasneef also on the basis of equivalence criterion.

Yachts built using a combination of the foregoing materials are subject to the applicable requirements of the relevant chapters. Connections between different materials will be the subject of special consideration by Tasneef

2 Equivalents

2.1

2.1.1 In examining constructional plans, Tasneef may take into account material distribution and scantlings which are different from those obtained by applying these requirements, provided that longitudinal, transversal and local strength are equivalent to those of the relevant Rule structure and that such scantlings are found satisfactory by Tasneef also on the basis of direct calculations of the structural strength.

In particular, the structures of yachts similar in performance to high speed craft (HSC) may have scantlings in accordance with Tasneef "Rules for the Classification of High Speed Craft".

In such case, the Master is to be provided with a yacht operating manual indicating the appropriate speed for each sea state.

The use of Tasneef "Rules for the Classification of High Speed Craft" for the scantlings of the structures of the afore mentioned yachts is to be agreed between the yard and Tasneef before the submittance of the drawings for approval and the commencement of the hull.

Special structures not provided for in these Rules, such as decks intended for the carriage of vehicles, side and stern doors and helicopter decks, may have scantlings in accordance with the "Rules for the Classification of Ships".

3 Direct calculations for monohull and twin hull yacht

3.1 Direct calculations for monohull yachts

3.1.1 General

Direct calculations are generally required to be carried out, at the discretion of Tasneef to check the primary structures of yachts which have unusual shapes and/or characteristics.

In addition, direct calculations are to be performed to check the scantlings of primary structures of yachts whenever, in the opinion of Tasneef hull shapes and structural dimensions are such that the scantling formulae used in these Rules are no longer deemed to be effective.

By way of example, this may be the case in the following situations:

- elements of the primary transverse ring (beam, web and floor) have very different cross-sectional inertia, so that the boundary conditions for each are not well defined;
- marked V-shapes, so that floor and web tend to degenerate into a single element;
- complex, non-conventional geometry;
- presence of significant racking effects (yachts with many tiers of superstructure);
- structures contributing to longitudinal strength with large openings.

3.1.2 Loads

In general, the following load conditions specified in a) to d) are to be considered.

The condition in d) is to be checked in yacht for which, in the opinion of Tasneef significant racking effects are anticipated (yachts with many tiers of superstructure).

In relation to special structure or loading configurations, should some load conditions turn out to be less significant than others, the former may be ignored at the discretion of Tasneef By the same token, it may be necessary to consider further load conditions specified by Tasneef in individual cases.

The vertical and transverse accelerations and the impact pressure p_2 are to be calculated as stipulated in Sec 5.

For each primary supporting member, the coefficient F_a, which appears in the formula for impact pressure, is to be calculated as a function of the area supported by the member.

In three dimensional analyses, special attention is to be paid to the distribution of weights and buoyancy and to the dynamic equilibrium of the yacht.

In the case of three dimensional analyses, the longitudinal distribution of impact pressure is considered individually in each case by Tasneef In general, impact pressure is to be considered as acting separately on each transverse section of the model, the remaining sections being subject to hydrostatic pressure.

a) Load condition in still water

   The following loads are to be considered:

   - forces caused by weights present, distributed according to the weight booklet of the yacht;
   - outer hydrostatic load in still water.

b) Combined load condition 1

   The following loads are to be considered:

   - forces caused by weights present, distributed according to the weight booklet of the yacht;
   - forces of inertia due to the vertical acceleration av of the yacht, considered in a downward direction.

c) Combined load condition 2

   The impact pressure acting on the bottom of the yacht is to be considered.

d) Combined load condition 3

   The following loads are to be considered:

   - forces caused by weights present, distributed according to the weight booklet of the yacht;
   - forces of inertia due to the transverse acceleration a_v of the yacht.

3.1.3 Structural model

The primary structures of yachts of this type may usually be modelled with beam elements, according to criteria stipulated by Tasneef When, however, grounds for the admissibility of such model are lacking, or when the geometry of the structures gives reason to suspect the presence of high stress concentrations, finite element analyses are necessary.

In general, the extent of the model is to be such as to allow analysis of the behaviour of the main structural elements and their mutual effects.

On yachts dealt with by these Rules, the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space, generally negligible compared with the stiffness of transverse structures (beams, floors and webs), or their presence may be taken into account by suitable boundary conditions. It is therefore acceptable, in general, to examine primary members in this area of the hull by means of plane analyses of transverse rings.

In cases where such approximation is not acceptable, the model adopted is to be three-dimensional and is to include the longitudinal primary members.

In cases where loads act in the transverse direction (load condition 3), special attention is to be devoted to the modelling of continuous decks and platforms. If they are of sufficient stiffness in the horizontal plane and are sufficiently restrained by fore- and after-bodies, such continuous elements may withstand transverse deformations of primary rings.

In such cases, notwithstanding the provisions above, it is still permissible to examine bidimensional rings, by simulating the presence of decks and platforms with horizontal springs according to criteria specified by Tasneef

3.1.4 Boundary conditions

Depending on the load conditions considered, the following boundary conditions are to be assigned:

a) Load condition in still water and combined load conditions 1 and 2

   - horizontal and transverse restraints in way of the crossing point of bottom and side shells, if the angle between the two shells is generally no greater than 135°,
   - horizontal and transverse restraints, in way of the keel, if the bottom/side angle is greater than approximately 135°.

b) Combined load condition 3

   The vertical and horizontal resultants of the loads, in general other than zero, are to be balanced by introducing two vertical forces and two horizontal forces at the fore and aft ends of the model, distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical and horizontal resultants of the loads.

   Where a plane model is adopted, the resultants are to be balanced by vertical and horizontal forces, distributed as specified above and acting on the plane of the model itself.

3.1.5 Checking criteria

a) For metal structures, the stresses given by the above calculations are to be not greater than the following allowable values, in N/mm²:

   - bending stress:

$$\sigma_{am} = \frac{170}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

   - shear stress:

$$\tau_{am} = \frac{90}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

   - Von Mises equivalent bending stress:

$$\sigma_{eq,am} = \frac{200}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

   where:

   K : material factor defined in Chap. 2 for steel and Chap. 3 for aluminium alloy.

   f'_m : coefficient depending on the material, equal to:

   - 1,0, for steel structures
   - 2,15, for aluminium alloy structures

   f_s : safety coefficient, equal to:

   - 1,00, for combined load conditions
   - 1,25, for load condition in still water.

The compressive values of normal stresses and shear stresses are not to exceed the values of the critical stresses for plates and stiffeners calculated in Ch 2 and Ch 3.

In structural elements also subject to high longitudinal hull girder stresses, the allowable and critical stresses are to be reduced, in accordance with criteria specified by Tasneef

b) For structures made of composite materials, the allowable stresses are defined in Ch 4.

3.2 Direct calculations for twin hull yachts

3.2.1 General

Direct calculations are generally required to be carried out, at the discretion of Tasneef to check the primary structures and connecting structures of the two hulls which have unusual characteristics.

In addition, direct calculations are to be carried out to check the structures connecting the two hulls for yachts in which the structural arrangements do not allow a realistic assessment of their stress level, based on simple models and on the formulae set out in these Rules.

3.2.2 Loads

In general, the following load conditions specified in a) to d) are to be considered.

The condition in a) applies to a still water static condition check.

The conditions in b) and c) apply to the check of the structures connecting the two hulls. The condition in c) only requires checking for yachts of L > 65 m and speed V > 45 knots.

The condition in d) is to be checked in yacht for which, in the opinion of Tasneef significant racking effects are expected (yachts with many tiers of superstructure).

In relation to special structure or loading configurations, should some load conditions turn out to be less significant than others, the former may be ignored at the discretion of Tasneef By the same token, it may be necessary to consider further load conditions specified by Tasneef in individual cases.

The vertical and transverse accelerations and the impact pressure p_2 are to be calculated as stipulated in Sec 5.

For each primary supporting member, the coefficient F_a, which appears in the formula for impact pressure, is to be calculated as a function of the area supported by the member.

In three-dimensional analyses, special attention is to be paid to the distribution of weights and buoyancy and to the dynamic equilibrium of the yacht.

In the case of three-dimensional analyses, the longitudinal distribution of impact pressure is considered individually in each case by Tasneef In general, impact pressure is to be considered as acting separately on each transverse section of the model, the remaining sections being subject to hydrostatic pressure.

a) Load condition in still water

The following loads are to be considered:

- forces caused by weights present, distributed according to the weight booklet of the yacht;
- outer hydrostatic load in still water.

b) Combined load condition 1

The following loads are to be considered:

- forces caused by weights present, distributed according to the weight booklet of the yacht;
- forces of inertia due to the vertical acceleration av of the yacht, considered in a downward direction.

c) Combined load condition 2

The following loads are to be considered:

- forces caused by weights present, distributed according to the weight booklet of the yacht;
- forces of inertia due to the vertical acceleration av of the yacht, considered in a downward direction;
- the impact pressure acting hemisymmetrically on one of the halves of the hull bottom.

d) Combined load condition 3

The following loads are to be considered:

- forces caused by weights present, distributed according to the weight booklet of the yacht;
- forces of inertia due to the transverse acceleration of the yacht.

3.2.3 Structural model

In general, the primary structures of yachts of this type are to be modelled with finite element schematisations adopting a medium size mesh.

At the discretion of Tasneef detailed analyses with fine mesh are required for areas where stresses, calculated with medium-mesh schematisations, exceed the allowable limits and the type of structure gives reason to suspect the presence of high stress concentrations.

In general, the extent of the model is to be such as to allow analysis of the behaviour of the main structural elements and their mutual effects.

On yachts dealt with by these Rules, the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space, generally negligible compared with the stiffness of transverse structures (beams, floors and webs), or their presence may be taken into account by suitable boundary conditions. It is therefore acceptable, in general, to examine primary members in this area of the hull by means of plane analyses of transverse rings.

In cases where such approximation is not acceptable, the model adopted is to be three-dimensional and is to include the longitudinal primary members.

In cases where loads act in the transverse direction (load conditions 2 and 3), special attention is to be devoted to the modelling of continuous decks and platforms. If they are of sufficient stiffness in the horizontal plane and are sufficiently restrained by fore- and after-bodies, such continuous elements may withstand transverse deformations of primary rings.

In such cases, notwithstanding the provisions above, it is still permissible to examine bidimensional rings, by simulating the presence of decks and platforms with horizontal springs according to criteria specified by Tasneef

3.2.4 Boundary conditions

Depending on the load conditions considered, the following boundary conditions are to be assigned:

a) Load condition in still water

The vertical resultant of the loads, in general other than zero, is to be balanced by introducing two vertical forces at the fore and aft ends of the model, both distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical resultant of the loads.

Where a plane model is adopted, the vertical resultant is to be balanced by a single force, distributed as specified above and acting on the plane of the model itself.

b) Combined load condition 1

A vertical restraint is to be imposed in way of the keel of each hull.

c) Combined load condition 2 and 3

The vertical and horizontal resultants of the loads, in general other than zero, are to be balanced by introducing two vertical forces and two horizontal forces at the fore and aft ends of the model, distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical and horizontal resultants of the loads.

Where a plane model is adopted, the resultants are to be balanced by vertical and horizontal forces, distributed as specified above and acting on the plane of the model itself.

3.2.5 Checking criteria

a) a) For metal structures, the stresses given by the above calculations are to be not greater than the following allowable values, in N/mm²:

- bending stress:

$$\sigma_{am} = \frac{170}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

- shear stress:

$$\tau_{am} = \frac{90}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

- Von Mises equivalent bending stress:

$$\sigma_{eq,\,am} = \frac{200}{\mathbf{K} \cdot \mathbf{f'}_m \cdot \mathbf{f}_s}$$

where:

K : material factor defined in Ch 2 for steel and Ch 3 for aluminium alloy

f'_m : coefficient depending on the material, equal to:
- 1,0, for steel structures
- 2,15, for aluminium alloy structures

f_s : safety coefficient, equal to:
- 1,00, for combined load conditions
- 1,25, for load condition in still water.

The compressive values of normal stresses and shear stresses are not to exceed the values of the critical stresses for plates and stiffeners calculated in Ch 2 and Ch 3.

In structural elements also subject to high longitudinal hull girder stresses, the allowable and critical stresses are to be reduced, in accordance with criteria specified by Tasneef

b) For structures made of composite materials, the allowable stresses are defined in Ch 4.

4 Definition and symbols

4.1 General

4.1.1 The definitions and symbols given in [4.2] and [4.3] apply to all Chapters of Part B.

The definitions of symbols having general validity are not normally repeated in the various Chapters, whereas the meanings of those symbols which have specific validity are specified in the relevant Chapters.

4.2 Symbols

4.2.1

L_{OA} : Overall length, is the distance, in m, measured parallel to the static load waterline, from the foreside of the stem to the after side of the stern or transom, excluding rubbing strakes and other projections excluding removable parts that can be detached in a non destructive manner and without affecting the structural integrity of the craft, e.g. pulpits at either ends of the craft, platforms, rubbing strakes and fenders.

L : Scantling length, in m, on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest;

L_{PP} : Length between perpendiculars, is the distance, in m, measured on the full load waterline from **FP** to **AP**.

L_{LL} : Load Line length means 96% of the total length on the waterline of a yacht at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that is greater. In yachts designed with a rake of keel, the waterline on which this is measured is to be parallel to the designed waterline.

FP : Foreword perpendicular, is the perpendicular at the intersection of the full load waterline with the fore side of the stem.

AP : After perpendicular, is the perpendicular at the intersection of the full load waterline with the after side of the rudder post or to the centre of the rudder stock for yachts without a rudder post.

In yachts with unusual stern arrangements or without a rudder, the position of **AP** and the relevant L_{PP} will be specially considered.

B : Maximum outside breadth, in metres.

D : Depth, in metres, measured vertically on the transverse section at the middle of length L, from moulded base line to the top of the deck beam at side on the weather deck.

D_1 : Depth, in metres, measured vertically on the transverse section at the middle of length L, from the lower side of the bar keel, if any, or of the fixed ballast keel, if any, or of the drop keel, to the top of the deck beam at side on the weather deck.

T : Draught, in metres, measured at the middle of length L, in metres, between the full load waterline and the lower side of the keel. In the case of hulls with a drop or ballast keel, the lower side of the keel is intended to mean the intersection of the longitudinal plane of symmetry with the continuation of the external surface of the hull.

T_1 : Draught T, in metres, measured to the lower side - theoretically extended, if necessary, to the middle of length L - of the fixed ballast keel, where fitted, or the drop keel.

Δ : Displacement, in t, of the yacht at draught T.

V : Maximum design speed, in knots, of the yacht at displacement Δ.

s : Spacing of ordinary stiffeners, in metres.

S : Web frame spacing, in metres.

4.3 Definitions

4.3.1 Rule frame spacing

The Rule frame spacing, s_R, in m, of ordinary stiffeners is obtained as follows:

$$s_R = 0,350 + 0,005L$$

In general, spacing of transversal or longitudinal stiffeners is not to exceed 1,2 times the Rule frame spacing.

4.3.2 Superstructure

The superstructure is a decked structure located above the weather deck, extending from side to side of the hull or with the side plating not inboard of the shell plating more than 4% of the local breadth.

Superstructures may be complete, where deck and sides extend for the whole length of the yacht, or partial, where sides extend for a length smaller than that of the yacht, even where the deck extends for the whole length of the yacht.

Superstructures may be of different tiers in relation to their position in respect of the weather deck.

A 1^{st} tier superstructure is one fitted on the weather deck, a 2^{nd} tier superstructure is one fitted on the 1st tier superstructure, and so on.

4.3.3 Bulkhead deck

The bulkhead deck is normally the uppermost complete deck exposed to the weather and sea, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the ship are fitted with permanent means of watertight closing. In a ship having a discontinuous bulkhead deck, the lowest line of the exposed deck and the continuation of that line parallel to the upper part of the deck is taken as the bulkhead deck.

4.3.4 Watertight bulkhead

Watertight bulkheads are bulkheads extended watertight till the freeboard deck, whose scantlings comply with [5.1.4].

4.3.5 Weather deck

The weather deck is the uppermost complete weathertight deck fitted as an integral part of the vessel's structure and which is exposed to the sea and the weather.

4.3.6 Virtual freeboard deck

Where the actual freeboard from the full load waterline to the weather deck exceeds that required by ILLC '66 by at least 1,8 m for yachts having $L_{LL} < 75$ m, or at least 1,80 + 0,01 (L_{LL} - 75) for $75 < L_{LL} < 125$, or at least 2,30 m for $L_{LL} >$ 125 m, a virtual freeboard deck may be defined (hypotetically drawn below and parallel to the weather deck) and, for the determination of the superstructure tier, the superstructure above the weather deck may be considered as a second tier and the second tier in respect to the weather deck may be considered as a third tier and so on. All the fitting above the weather deck, abaft the forward quarter, may be considered in the same way".

The vertical distance as above defined between the assumed freeboard deck corresponding to the relevant watertight weather deck and the minimum freeboard as calculated in accordance with the Load Line Requirements may be used to reduce the requirements for closing appliances for openings in the hull, superstructure, deckhouses, relevant sills above deck and the height of air pipes and ventilators above deck, if not otherwise stated by the flag Administration.

4.3.7 Deckhouse

The deckhouse is a decked structure fitted on the weather deck, a superstructure deck or another deckhouse, having limited length and a spacing between the external longitudinal bulkheads less than 92% of the local breadth of the yacht.

4.3.8 Weathertight

A closing appliance is considered weathertight if it is designed to prevent the passage of water into the yacht in any sea condition.

4.3.9 Watertight

A closing appliance is considered watertight if it is designed to prevent the passage of water in either direction under a head of water for which the surrounding structure is designed.

4.3.10 Cofferdam *(1/1/2020)*

A cofferdam means an empty space arranged so that compartments on each side have no common boundary; a cofferdam may be located vertically or horizontally. As a rule, a cofferdam is to be properly ventilated and of sufficient size to allow for inspection.

5 Subdivision, integrity of hull and superstructure

5.1 Number of watertight bulkheads

5.1.1 All Yachts are to have at least the following transverse watertight bulkheads:

- One collision bulkhead
- Two bulkheads forming the boundaries of the machinery spaces;as an alternative, the transom may be accepted as aft transverse bulkhead.

Additional bulkheads may be required for yachts required to comply with subdivision or damage stability criteria.

5.1.2 Openings in watertight bulkheads and decks *(1/7/2022)*

The number of openings in watertight subdivisions is to be limited to a minimum compatible with the proper working of the yacht. Pipes and electrical cable may be carried through watertight subdivisions provided that both the watertightness and structural integrity of the bulkhead are ensured by devices suitable in the opinion of Tasneef For yachts of more than 500 GT details relevant to these devices and their installation on board are to be sent to Tasneef for approval.

In any case, lead or other sensitive materials are not accepted in systems which penetrate watertight subdivision bulkheads where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkheads.

Doors in watertight bulkheads are to be approved watertight doors; additional characteristics regarding these doors are set out in Part E.

5.1.3 As far as the collision bulkhead is concerned, in general a maximum of two pipes may pass through the collision bulkhead below the freeboard deck. Such pipes are to be fitted with suitable valves operable from above the freeboard deck and the valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are readily accessible under all service conditions. All valves are to be of steel, bronze or other approved ductile material. As a general rule, no access is to be fitted in the collision bulkhead. Special consideration will be given in the case of yachts of particular design, provided the access is positioned as far above the design waterline as possible and its closing appliances are watertight.

For yachts of less than 500GT the collision bulkhead my be penetrated by more than two pipes provided that the passages are located inside a suitable metallic plate.

Such plate is to be installed above the maximum water line in the central position of the bulkhead and the relevant dimensions are to be the minimum compatible with the bore of pipes.

In any case such dimension are to be not more than an equivalent area of 22500 mm^2.

The relevant pipes are to be fitted with valves as above stated.

5.1.4

The strength of watertight bulkheads is to be in conformity with Ch 2, Ch 3 and Ch 4, according to the hull material. For yachts under 500 GT, Tasneef may accept approved hinged doors provided that for such doors an audible and visual alarm is fitted on the bridge indicating when the door is open. The doors are to be kept closed at sea and marked accordingly. For yachts equal to or greater than 500 GT, approved hinged doors may be accepted for infrequently used openings in watertight compartments where a crew member will be in immediate attendance when the door is open at sea. Audible and visual alarms are to be provided on the bridge. Procedures for the operation of watertight doors are to be agreed and posted in suitable locations. Watertight doors are to be normally closed with the exception of sliding watertight doors providing normal access to frequently used living and working spaces. For matters not explicitly dealt with in this paragraph, compliance is required with the requirements given in Appendix 3.

5.1.5

Compartment below the freeboard deck to be used for recreational activities or other services having access openings in the hull are to be enclosed in watertight boundaries.

Such compartments may have access openings to other internal compartments provided that approved sliding doors are fitted for such openings.

For yachts less than 500 GT the above doors may be hinged doors. Openings in the hull are to comply with the requirements in [5.4] and, for matters not dealt with therein, with SOLAS Regulation II - 1 / 15 - 1 "External openings in cargo ships".

Provision is to be made to ensure that doors may be manually closed and locked in the event of power or hydraulic failure.

5.1.6 *(1/7/2022)*

For yachts of more than 500GT the cable transits seal systems in watertight bulkheads and decks are to be type approved regarding watertightness. The pressure for which these cable transits seal systems are to be certified is to be greater than or equal to the one taken for the determination of the scantlings of the structural plate where they are located.

5.2 Collision bulkheads

5.2.1

A collision bulkhead is to be fitted which is to be watertight up to the bulkhead deck.

This bulhead is to be located at a distance from the forward perpendicular of not less than 5% of the length (L) of the yacht and not more than 3 m plus 5% of the length (L) of the yacht.

Where any part of the vessel below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances stipulated above are to be measured from a point either:

- at the midlength of such extension, or
- at a distance 1,5 per cent of the length L of the yacht forward of the forward perpendicular, or
- at a distance 3 metres forward of the forward perpendicular; whichever gives the smallest measurement.

5.2.2 Where a long forward superstructure is fitted, the fore peak or collision bulkhead on all vessels is to be extended weathertight to the next full deck above the bulkhead deck. The extension is to be arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, a bow door.

5.2.3

The bulkhead may have steps or recesses provided they are within the limits in [5.2.1].

5.2.4 *(1/7/2017)*

For yachts having gross tonnage not more than 300, the part of the collision bulkhead above the water level may be fitted at a distance less than 5%L from the forward perpendicular (but in any case not less than 300 mm from the forward perpendicular) under the following conditions (see Fig.1):

a) The lower part of the vertical collision bulkhead is formed by a step having a height from the maximum waterline not less than 500 mm

b) The vertical part of the collision bulkhead indicated under the above point a) is fitted at a distance from the collision bulkhead not less than 5%L

c) The lowest limit of the collision bulkhead is positioned at least 500 mm from the stem post; such distance is to be measured perpendicularly to the stem post

d) If not accessible, the space of the recess below the horizontal part of the bulkhead until the horizontal part of the step fitted at 500 mm above the maximum waterline is filled with closed cell high density foam for grp vessel and empty and arranged for easy visible inspection for vessels made of other materials.

e) The Maritime Administration Rules don't contain requirements adverse to the above arrangement.

5.2.5

Under the conditions stated in [5.2.4] the collision bulkhead is to be fitted aft of the forward perpendicular. Tasneef may accept different arrangements for mass production yachts.

5.2.6 Tasneef may, on a case-by-case basis, accept a distance from the collision bulkhead to the forward perpendicular greater than the maximum specified in [5.2.1], provided that, in the event of flooding of the space forward of the collision bulkhead, subdvision and stability calculations in both the full load departure condition and the arrival condition show compliance with the damage stability requirements set out in Pt E, Ch 2.

5.2.7 *(1/1/2020)*

No essential equipment, except anchor windlass, is to be located forward from the collision bulkhead. Exceptionally, and only if the collision bulkhead is located within the limit set out in [5.2.1] the emergency bilge and/or fire pump may be located forward from the collision bulkhead provided that it has an easy access from the open deck and no other suitable location may be found on board.

5.3 Sea connections and overboard discharge

5.3.1 All openings to the sea located below the weather deck are to be equipped with a closing valve. This valve, made of tough metallic material highly resistant to corrosion, is to be fitted on the shell directly or by means of a nozzle and provided with means of control located in a position which is easily accessible at all times and permanently marked.

When Maltese Cross hull notation is assigned, such valves are to be tested in conformity with Tasneef Rules.

Overboard discharges are to be kept to a minimum and located, as far as practicable, above the full load waterline.

The sea connection for the engine cooling system shall be provided both with a grill fitted directly on the shell using a local stiffener and with a filter after the closing valve.

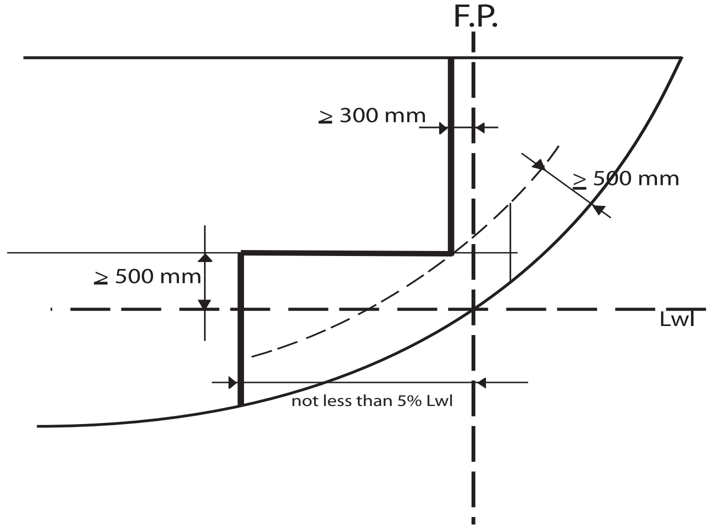
The filter is to be made of metal highly resistant to corrosion, and is to be of substantial dimensions and easy to open.

5.3.2 All pipes leading to the sea and located under the full load waterline are to be of adequate thickness, and of metallic material highly resistant to corrosion and electrochemically compatible with any different materials they may be connected to.

Joints for elbows, valves etc. are to be made of material of the same composition as the pipes, or, where this is not practicable, of material which is electrochemically compatible.

The use of non-metallic pipes and valves will be specially considered.

Figure 1



5.3.3 Pipes for the discharge of exhaust from the engines leading to the shell are to be structural and are to have strength equivalent to that of the bottom structure.

The material is to be suitable to withstand the temperatures reached by the exhaust and, if composite material is used.

Reference is to be made to Ch 4, Sec 1, [6.4].

Engine exhaust outlets which penetrate the hull below the freeboard deck are to be provided with means to prevent back flooding into the hull through a damaged exhaust system. For yachts operating on unrestricted service a positive means of closure is to be provided. The system is to be of equivalent construction to the hull on the outboard side to the closure. For short range yachts it may be accepted that the exhaust piping is looped up above the waterline on the outboard side of the system to a minimum height of 1000 mm and is of equivalent construction to the hull.

5.4 Stern and side doors below the weather deck

5.4.1 Side/shell doors *(1/1/2016)*

Side/shell doors are to comply with the requirements given in App 1.

The lower part of each of these openings shall be above the deepest sea going condition.

Doors are preferably to open outwards.

No essential equipment is to be installed in such compartment.

For yachts of less than 500 GT the emergency bilge and/or the emergency fire pumps may be fitted there if the compartment does not contain petrol and have an access independent from the engine room and the side door,

Such compartment is to be separated from internal compartments by means of watertight bulkheads/doors.

5.4.2 Drawings

Drawings representing the structure of the side/shell doors, their locking devices and their height above the waterline are to be sent in triplicate to Tasneef for approval, with a general arrangement enclosed showing the intended use of the compartment which the doors give access to and the machinery and/or sports craft fitted therein.

5.4.3 Other fittings

Recesses for wells, gangways, winches, platforms, etc are to be watertight and of strength equivalent to that of the adjacent structures. Any penetrations for electrical wiring and piping are to ensure watertight integrity. Discharges are to be provided to prevent the accumulation of water in the normal foreseeable situations of transverse list and trim.

5.5 Hatch on the weather deck

5.5.1 Hatches on the weather deck and deck above are to have a strength equivalent to that of the adjacent structures to which they are fitted and are to be weathertight. In general, hatches are to be hinged on the foreword side.

5.5.2 Where the hatches may be required to be used as a means of escape the securing arrangements are to be operable from both sides and in the direction of escape they are to be openable without a key. All handles on the inside are to be non removable. An escape hatch is to be readily identified and easy and safe to use, having due regard to its position.

5.5.3 *(1/1/2021)*

Flush hatches on the weather deck are generally not to be fitted. Where they are foreseen they are to:

- be closed at sea;
- be fitted in a protected location close to the center line;
- have at least two drains in the aft part leading overboard;
- be fitted with gaskets;
- have at least 4 clips for size 600 x 600 mm;
- have non-oval hinges which can be considered as clips.
- be provided with open/close indication at the navigating bridge.

Flush hatches not satisfying all the above requirements have to be tested watertight

For dimensions bigger than 600 x 600 mm, the acceptance is at the discretion of Tasneef Drawings representing the hatches, their position on deck, their coamings and their system of closure are to be sent for approval.

5.5.4 *(1/1/2020)*

Hatches that are not of flush type are to have weathertight means of closure and coaming height of 300 mm.

5.5.5 *(1/1/2021)*

In general, hatches are to be kept closed at sea.

However, hatchways which may be kept open for access at sea are to be as small as practicable (a maximum of 1 square metre in clear area). Hatchways are to be as near to the centreline as practicable, especially on sailing vessels. Covers of hatchways are to be permanently attached to the hatch coamings.

5.5.6 *(1/1/2020)*

Hatches, which are required to be watertight are to be tested according to the requirements given in Pt B, Ch 1, App 2.

5.6 Scantling of glazing

5.6.1 General *(1/1/2017)*

L is the scantling length in m.

L_{LL} Load line length.

T is the scantling draught in m (see [4.2.1]).

In this paragraph the word "window" is used alternatively with "portlight" and "glazing". These may have frame or not, deadlight or not depending on the context where they are used.

Only in [5.6.15] the word window is used for the larger fixed glazing that include one or more portlights (smaller not easy openable glazing).

Not easy openable means that the windows need a key or a mechanical mean or tool to be opened and that may keep it closed. For windows and door fitted in superstructure not contributing to buoyancy also redundant electrical means may be considered.

Other definitions are given below. In every subparagraph are defined the symbols used, the same symbol may have different meaning in different subparagraph.

For references see also ISO 11336-1 and 11336-2.

5.6.2 Limitations *(1/1/2023)*

This paragraph is intended to be used on yachts (any Length any GT) with restricted and unrestricted navigation, where no Statutory activities relevant to Load Line are required.

This standard does not give a limit in the widows dimensions provided that all its parts are fully satisfied and the scantling of the hull is in accordance with the applicable rules without consider the structural contribution of the glazing.

The following limitations on the location of glazed openings are given.

Glazed openings have to be located at least:

- 200 mm above maximum load water line
- 100 mm aft from the stem post

Glazing located in other positions and in particular submerged glazings will be evaluated on a case-by-case basis

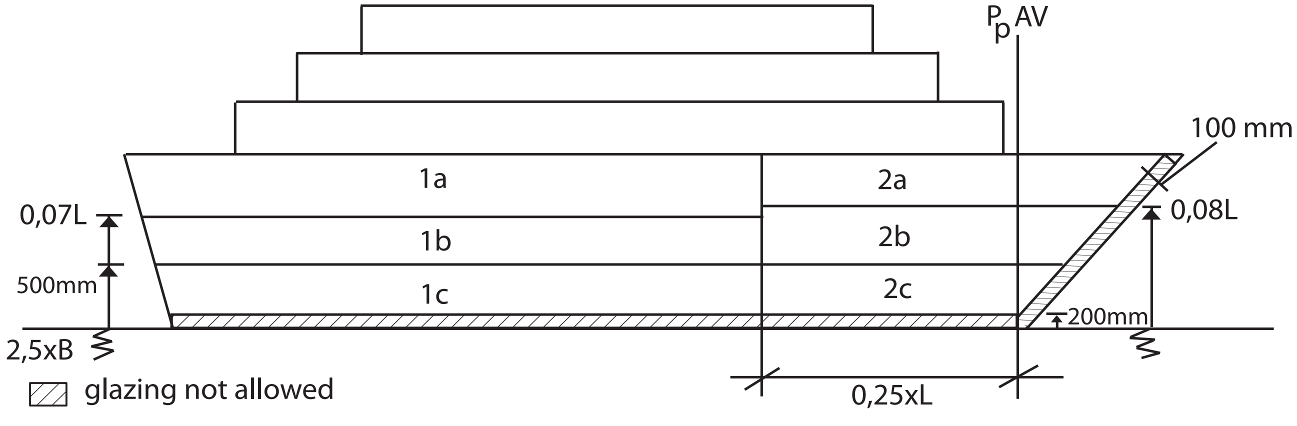
The following limitations on the use of glazing material and in the type of glazing in some locations are applicable:

- Hull and superstructure contributing to the buoyancy

  The following Zones are defined:

  - Zone 1a: the glass is located more than 0.07L mm from the design waterline and is totally aft of 0,25L
  - Zone 1b: the glass is located more than 500 mm or 2,5%B whichever is greater and less than 0.07L from the design waterline and is totally aft of 0,25L
  - Zone 1c: the glass is located less than 500 mm or 2,5%B whichever is greater from the design waterline and is totally aft of 0,25L
  - Zone 2a: the glass is located more than 0.08L from the design waterline and is totally or partially fore of 0,25L
  - Zone 2b: the glass is located more than 500 mm or 2,5%B whichever is greater but less than 0,08L from the design waterline and is totally or partially fore of 0,25L
  - Zone 2c: the glass is located less than 500 mm or 2,5%B whichever is greater from the design waterline and is totally or partially fore of 0,25L.

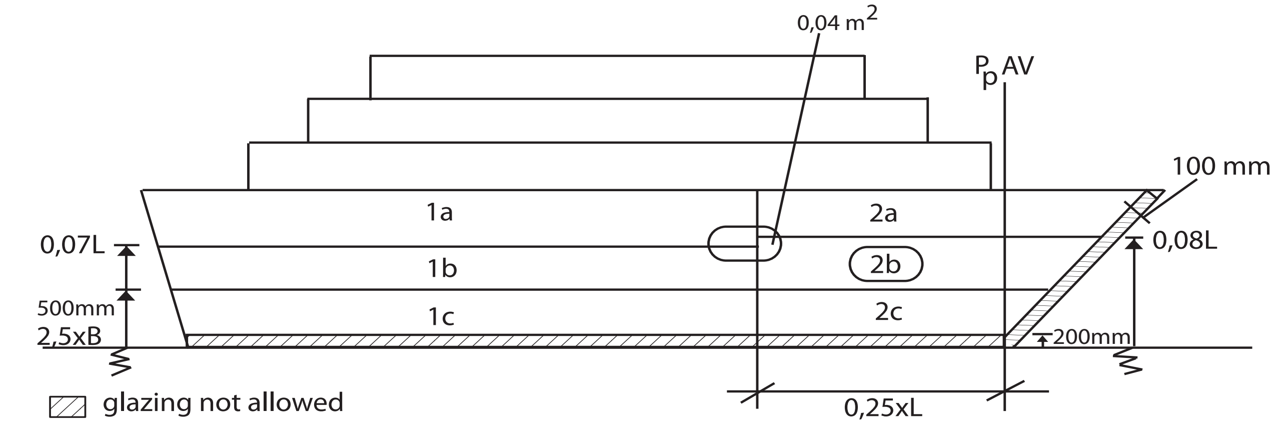
Figure 2 : Definition of hull and superstructure contributing to buoyancy zones *(1/1/2017)*



If a windows is located partially for more than 0,04 m² in more than one Zone the heavier scantling is to be considered.

As an example in Fig 3 the glazing is to be considered as it is located in zone 2b.

Figure 3 : Definition of the zone when the glazing is located in more than one *(1/1/2017)*



- Superstructure not contributing to the buoyancy

  This paragraph is intended also for the scantling of glazing located in superstructure not contributing to the buoyancy, for such glazing no zones are defined, their position is taken into consideration only for the calculation of the design pressure (see [5.6.7]).

  For yachts subject to load line assignment when a superstructure is considered giving a reduction to the tabular required freeboard it has to be considered as a superstructure contributing to buoyancy.

  If the windows fitted in superstructure have a frame it has to be done in general according to [5.6.14]

  If an openable window is not fitted with mechanical means (or an approved redundant electrical mean) to keep it closed in emergency after a single failure it is to be treated as an easy openable window.

  Openable windows of dimensions larger than 2.5 m² are to be made with laminated glass.

- Skylights

  This paragraph may be used also for the scantling of glazing skylights fitted on the weather deck provided that skylights fitted abaft 0,25L are considered as windows fitted in Zone 1a or 1b depending on their height above the WL and those fore of 0,25L as windows fitted in Zone 2a or 2b.

  Skylights fitted in superstructure not contributing to the buoyancy may be treated as a windows located in aft facing in the deck immediately below the one where the skylight is fitted.

  Such skylights are not intended to walk on. Skylights where it's possible to walk on will be considered on a case by case base.

  When used as means of escape they have to satisfy the same requirements as the hatches used as means of escape. If they are flush they have to satisfy the same requirement of flush hatches so be watertight.

- Bulwark

  Portions of bulwark intended as means to prevent the fall overboard may be realized with glazing material provided that provisions of para 5.12 are complied with.

- Doors

  As far as the scantling of the glazing material, glazing doors may be treated as windows located in the same position.

  The doors in general have to be made of laminated glass.

In general aft doors may have monolithic glass.

For lateral glazed doors fitted in the first tier of superstructure one of the following solutions may be adopted:

- laminated glass with thickness increase of at least 30% with an interlayer of 3 mm of polycarbonate or equivalent material
- laminated glass and one of the solutions indicated as alternative to the storm cover
- laminated glass protected by a solid bulwark of at least the required height.

The use of monolithic glass for lateral doors in first tier of superstructure will be evaluated on a case by case base taking into account the dimension of each door panel (if more or less than 2m2) its transversal position (if located at least 0.1B inboard) and if protected by a solid bulwark higher than the minimum required and the increase of thickness (at least 50%).

If the doors fitted in superstructure not contributing to buoyancy have a frame it has to be done in general according to [5.6.14] a) and if glued [5.6.14] b).

See also para [5.8].

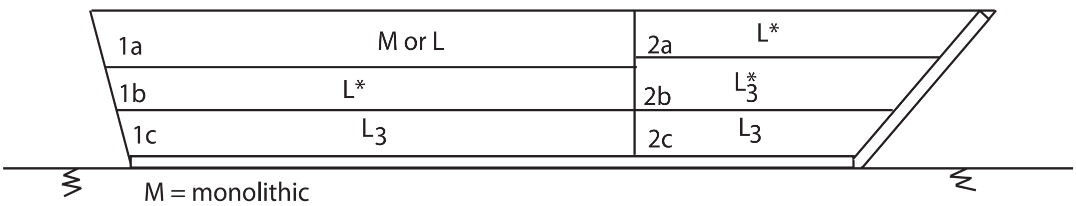
Type of glazing depending on the Zone:

- In Zone 1.a monolithic or laminated glass is acceptable. The use of monolithic polycarbonate or polymetilmetacrylate is also acceptable.
- In Zone 1.b and 2a in general only laminated glass is acceptable, the use of monolithic glass (or monolithic polycarbonate or polymetilmetacrylate) will be evaluated on a case by case base considering the dimension of the glazing and the use of deadlights.
- In Zone 2b laminated glass with at least 3mm polycarbonate or equivalent material as interlayer in general is to be used, the use of laminated with thinner interlayer or monolithic glass (or monolithic polycarbonate or polymetilmetacrylate) will be evaluated on a case by case base considering the dimension of the glazing and the use of deadlights. Normally monolithic glazing is acceptable only if the glazing is smaller than 0,125m² and for glazing of more than 0,025Lx0.07L the use of laminated glass with 3mm of polycarbonate is mandatory.
- In Zone 1c, and 2c only laminated glass with at least 3mm polycarbonate, or equivalent material as interlayer, is acceptable.

As far as the test for the equivalence between polycarbonate and other interlayer materials see [5.6 17].

The windows fitted in superstructure not contributing to buoyancy may be treated as the windows fitted in zone 1a.

Figure 4 : Type of glazing *(1/1/2017)*

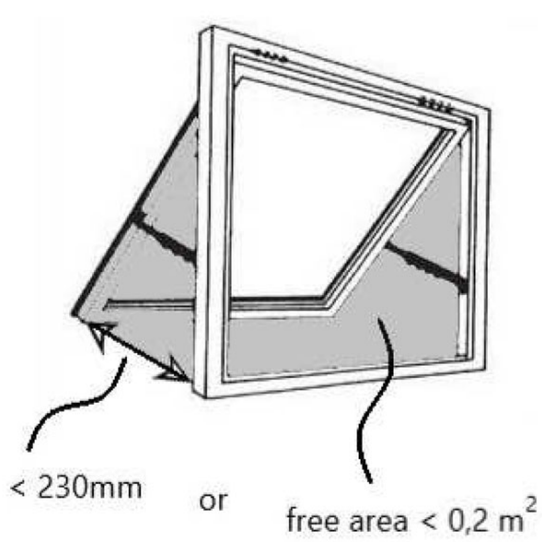


M = monolithic
L = laminated
L_3 = laminated + 3 mm polycarbonate or equivalent
* = other type will be evaluated considering the dimension and the position

Type of opening depending on the Zone:

- In Zone 1a, and 1b and 2a the windows may be fixed or not easily openable type. When a not easy openable glazing unit of more than 0,2m^2 with the lower edge at a distance of less than 1,5m from the internal finisched floor is located on the hull, or in the widebody or in a superstructure where, if accidentally passing through it, it is possible to fall into the sea or on a deck located at more than 1m from the lower edge of the glazed opening , means are to be provided to reduce the effective free area of the glazed opening when open to a maximum of 0,2m^2. The effective free area may be increased its maximum dimension is not more than 230mm. See Fig 5

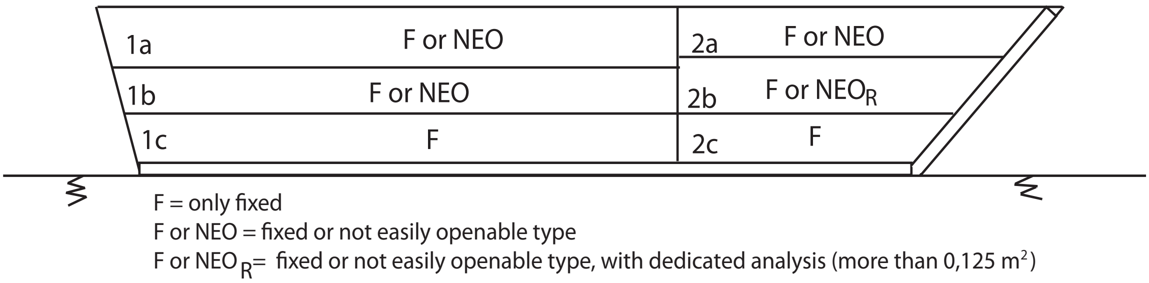
Figure 5 : *(1/1/2021)*



- In Zone, 2b the windows in general to be fixed. The use of not easily openable type windows in such zone, will be evaluated on a case by case base taking into account the dimension of the glazing. If not easily openable type windows of more than 0,125 m^2 are used in this zone a dedicated analysis is to be carried out showing that the consequences in terms of stability, accessibility of means of escape, etc of a flooding of the spaces to which the fixed windows gives access are considered reasonable by Tasneef

- In Zone 1c and 2c windows are to be of fixed type.

Figure 6 : Type of opening *(1/1/2019)*



Where according to what above not easily openable windows are acceptable they have to be securely closed during navigation. An indication of open windows is to be shown in a continuously manned position.

As far as the material to be used as glazing material, and as far as the type of glazing in some locations, the superstructure not contributing to the buoyancy are to be treated as windows located in Zone 1a taking into consideration also what below.

Not easy openable with frame fitted in superstructure not contributing to buoyancy have to satisfy what follows:

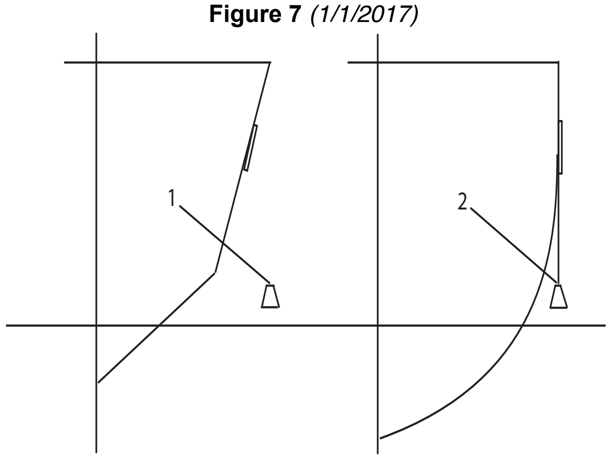
- The glass is to have scantling in acc. with the Rules (if the thickness does not satisfy the formula reported in [5.6.8] the glass pane to be subject to an hydrostatic test on 3 samples at a pressure of $4*p_D$).
- There is to be an indication in the wheelhouse of open windows.
- This window is to be open only in good weather condition.
- If it's electrical it is to be also manual operable.
- The installation on board is to be verified by hose test.

Easy openable windows with or without frame are acceptable only in superstructure not contributing to buoyancy and they have to satisfy what follows:

- If they open sliding, and the sliding movement is vertical is to be from up to down to open.
- The glass is to have scantling in accordance with the rules (if the thickness does not satisfy the formula reported in [5.6.8] the glass pane to be subject to an hydrostatic test on 3 samples at a pressure of $4*p_D$)
- If the window is larger than about 1 m^2 it is to be open only under the supervision of someone of the crew.
- There is to be an indication in the wheelhouse of open windows
- The opening of this windows is under the Responsibility of the Master
- This windows is to be open only in good weather condition
- The windows is to be subject to an hydrostatic test at a pressure of at least p_D on the glazed part; when the windows is not fitted in the wide body the hydrostatic test may be replaced by a hose test carried out at a pressure of at least 350 kPa, at a distance of maximum 1 m from the glazing for at least 5 minutes without passage of water
- If it's electrical it is to be also manual operable.
- The installation on board is to be verified by hose test.

No part of the glued glazing or its framing shall extend outside the local vertical tangent to the hull, deck, rubbing strake, fixed fender, or of a built-in fairing which is an integral part of the hull.

Figure 7 *(1/1/2017)*



Key:

1 The local vertical tangent is outside the porthole: no problem

2 The local vertical tangent is inside the porthole: the porthole shall either be placed in a recess or protected by a built-in fairing.

As far as the possibility to install not easy openable portlights glued to fixed larger windows see [5.6.15] of this paragraph.

Other limitations and restrictions are:

- Only flat glasses or convex towards the load action direction are taken into consideration.
- Fire resisting requirement have not been considered.
- Only semi fixed glass without lateral movement may be used.

5.6.3 Materials *(1/1/2020)*

The following materials may be used:

- thermally strengthened monolithic or laminated glass,
- chemically strengthened laminated glass,
- polymetilmetacrylate and
- polycarbonate.

Other materials will be considered on a case by case base.

Only thermally or chemically strengthened glass shall be used as pane material or as plies material for laminated constructions.

Thermally strengthened glass used both in monolithic or laminated construction shall meet the requirements of EN 12150-1.

For laminated construction the glazing shall meet the requirements outlined in ISO 12543-1.

Ordinary not strengthened (thermally or chemically) glass is not acceptable.

Chemically strengthened glass shall meet the requirements outlined in EN 12337-1.

When chemically strengthened safety glass is used, windows are to be of laminated type. The minimum depth of chemical strengthening is to be 30 microns on exposed surfaces and the surface is to be subject to regular inspections.

The characteristic of superficial compression (S_c x N/mm^2) and of depth of compression layer l_{CD} (μm) have to be declared by the Manufacturer of the glass.

For monolithic construction only rigid plastic panes with a minimum characteristic failure strength of 90 MPa shall be used.

Plastic panes (monolithic) or plies (laminated) shall be used according to indications of material manufacturers both in terms of chemical compatibility with other materials (adhesives, sealants, gaskets) and application conditions (with special attention to exposure to outdoor environment).

Metallic materials used for frame and other parts of the windows have to be tested by Tasneef

Only laminate with plies of the same material are considered.

Glazing made of multiple panes, either monolithic or laminated, separated by sealed gaps filled with gas (air, argon, etc.) (IGU) have to be verified as follows.

In stepped IGU one of the panes is fixed to the framing while the other pane is not supported by the framing structure. In this case the framed pane of the IGU (either monolithic or laminated) shall be selected according to [5.6.8], [5.6.9] and [5.6.13] if monolithic and [5.6.11], [5.6.12] and [5.6.13] if laminated . The other pane is to have thickness of minimum 4mm.

In unstepped IGU both panes are supported by the framing structure. In this case both the panes of the IGU (either monolithic or laminated) shall be selected according to [5.6.8], [5.6.9] and [5.6.13] if monolithic and [5.6.11], [5.6.12] and [5.6.13] if laminated.

Otherwise the IGU may be tested hydraulically (3 samples) in accordance with [5.6.16].

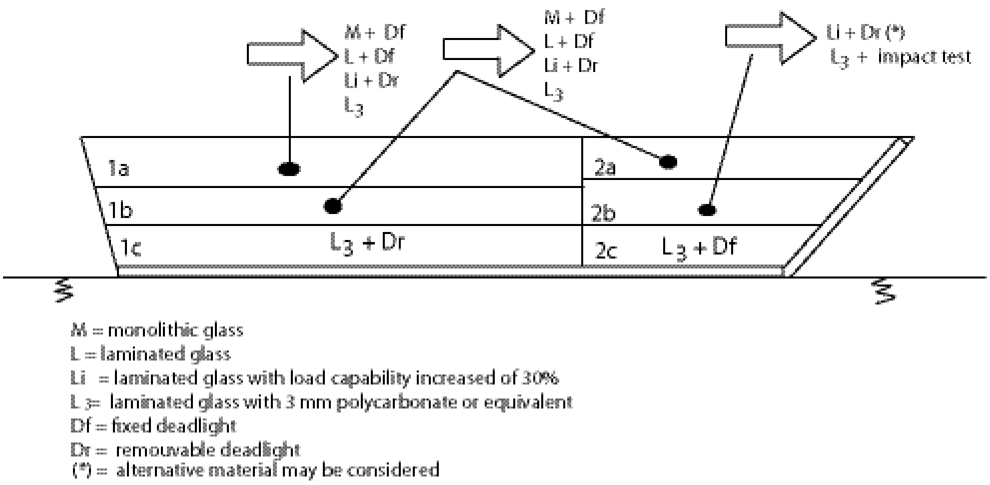
5.6.4 Deadlights and storm covers *(1/1/2020)*

Below the deck and in the superstructures contributing to the buoyancy, a deadlight for each window is to be provided. The position of such deadlights is to satisfy what follows:

- Deadlights in general are to be provided fixed in place.
- Deadlights may be removable when the glass is laminated and its load carrying capability is increased of 30%.
- Deadlights may be avoided for glazing made of laminated with an interlayer of 3mm polycarbonate or equivalent material if located in Zone 1a or 1b or 2a.
- In Zone 2b when laminated glass with an interlayer of 3mm polycarbonate or equivalent material is used a removable deadlight is to be provided.

  The possibility to avoid such deadlight will be evaluated if an impact test on the laminated glass with the external ply fractured is carried out (see [5.6.17]).
- In Zone 1c a fixed or removable deadlight is to be in any case foreseen.
- In Zone 2c a fixed deadlight is to be in any case foreseen.

Figure 8 : Deadlights *(1/7/2021)*



Where portable deadlights are allowed they shall be stored in an easily accessible location and readily and safely mounted in any sea condition.

For fixed glazing glued without frame to the hull/superstructure the connection to the hull of the deadlight is to be found suitable taking into account the material of the hull and of the deadlight taking into account the test required in [5.6.18].

Materials shall be either in accordance with ISO 1751, marine grade aluminium alloy, or composite material as used for hull construction. Cast aluminium alloy shall be of a ductile type with elongation to breakage not less than 6%.

Deadlights shall be dimensioned such that when loaded by the design pressure the yield deformation stress is not exceeded. The deadlight shall be designed considering the same design pressure as required for the glazing. Subject to this pressure the stress in deadlight and all load carrying fittings is not to exceed the yield strength.

When equivalent strength is not shown by calculations, the deadlights in the mounted position shall be tested according to [5.6.18].

Guidance shall be available on board on the sea state at which deadlights shall be fitted and on maintenance and inspection and their means of securing.

In the superstructures not contributing to the buoyancy, normally deadlights need not to be provided except for windows located in the superstructures not contributing to the buoyancy if they are the prosecution of the shell (wide body yachts) when they are located below 0,08L and forward of 0,25L. One blanking plate with the same dimension of the largest window to be foreseen on board.

When due the navigation of the yacht storm covers on windows fitted somewhere in a superstructure not contributing to the buoyancy are required by the Administration the storm cover has to satisfy what follows.

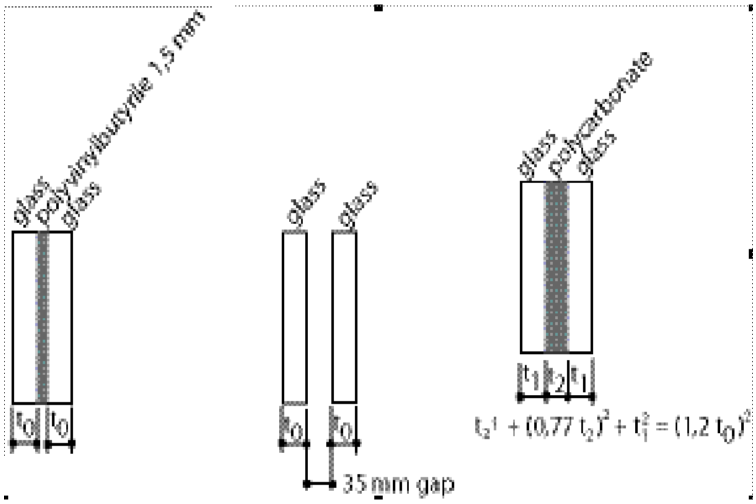
Storm shutters shall be dimensioned such that when loaded by the design pressure the yield deformation stress is not exceeded. The storm shutter shall be designed considering the same design pressure as required for the glazing. Subject to this pressure the stress in storm shutter and all load carrying fittings is not to exceed the yield strength.

When equivalent strength is not shown by calculations, the Storm shutter in the mounted position shall be hydraulically tested at a pressure of at least 4 p_D (the test may be carried out only on the largest storm shutter).

As an alternative a factor of 1,5 over the design pressure together with the use of laminated glass is considered acceptable in lieu of the storm cover.

As another alternative to storm covers also one of the arrangement in Fig 9 may be acceptable.

Figure 9 ***(1/7/2020)***



t_0 is the minimum thickness required.

5.6.5 Preliminary tests for the acceptance of the glass *(1/1/2017)*

Glass panes fitted on the hull and in superstructure contributing or not to the buoyancy are to be in strengthened (thermally and chemically) safety glass.

The tests detailed in this paragraph are to be intended only for the acceptance of the glazing material. They are not to be considered as an alternative to the calculation of the required thickness and the relevant comparison with the proposed ones detailed in the following subparagraphs of this paragraph.

The following test has to be witnessed by the Surveyor.

The glass Manufacturer is to certify the homogeneity of the batches submitted for tests, as regards material, manufacturing procedure, heat treatment and suitability to meet the specified test requirements. Glass panes (thermally or chemically strengthened) are to be tested as specified in the following items a) or b).

a) a hydrostatic test of one glass pane for each batch of 100 (or fraction of 100) glass panes equal in shape and dimensions and manufactured with continuity and using the same procedure and treatments; the pane is to be tested with a load uniformly distributed on the net area, at the test pressures in the following table. The test pressure is to be applied for at least one minute; the glass pane is not to break. In the case of glass panes having shape other than circular, the test is to be performed on a disk obtained from a glass pane for each batch homogeneous as regards dimensions, manufacturing procedure and heat or chemical treatment and with a total surface of 25m^2 or fraction thereof. The disk, for the test and possible re-tests, is to be taken before the tempering process and treated with the glass panes of the batch which it represents.

b) a punch test in accordance with ISO 614 as an alternative to the hydrostatic test mentioned in a).

   This test method is applicable both to non-opening and opening windows; when tested, the glass edges are to be not less than 25mm from the inner edge of the rubber ring. The test consists of applying to the glass pane, which is supported by a steel plate with a circular hole, the required load through a rounded steel shaft acting along the centre of the hole. The test is to be performed on 4 glass panes for each batch homogeneous as specified in a). In the case of batches of 4 glass panes or less, the test is to be performed on each glass pane. In the case of matt glass panes obtained by a special treatment of one of the surfaces of a transparent glass pane, the test is to be performed after the treatment and the load is to be applied to the surface which has not been treated. The required test loads are indicated in the table below, in relation to the thickness of the glass pane and the diameter of the hole in the support plate. The test is to be performed using the equipment and the procedure specified in ISO 614.

Table 1 : Pressure to be used for the hydrostatic test *(1/1/2017)*

Thickness of glass pane (mm)	Pressure (N/mm^2) for a glass pane net diameter (mm) of:					
	200	250	300	350	400	450
4	0,33	0,21	-	-	-	-
5	0,33	0,21	-	-	-	-
6	0,33	0,21	-	-	-	-
8	0,58	0,37	0,26	0,19	-	-
10	0,92	0,58	0,41	0,30	0,23	0,18
12	1,32	0,84	0,59	0,43	0,33	0,26
15	-	1,32	0,92	0,67	0,51	0,41
19	-	-	1,47	1,08	0,83	0,65

Table 2 : Punch test load *(1/7/2021)*

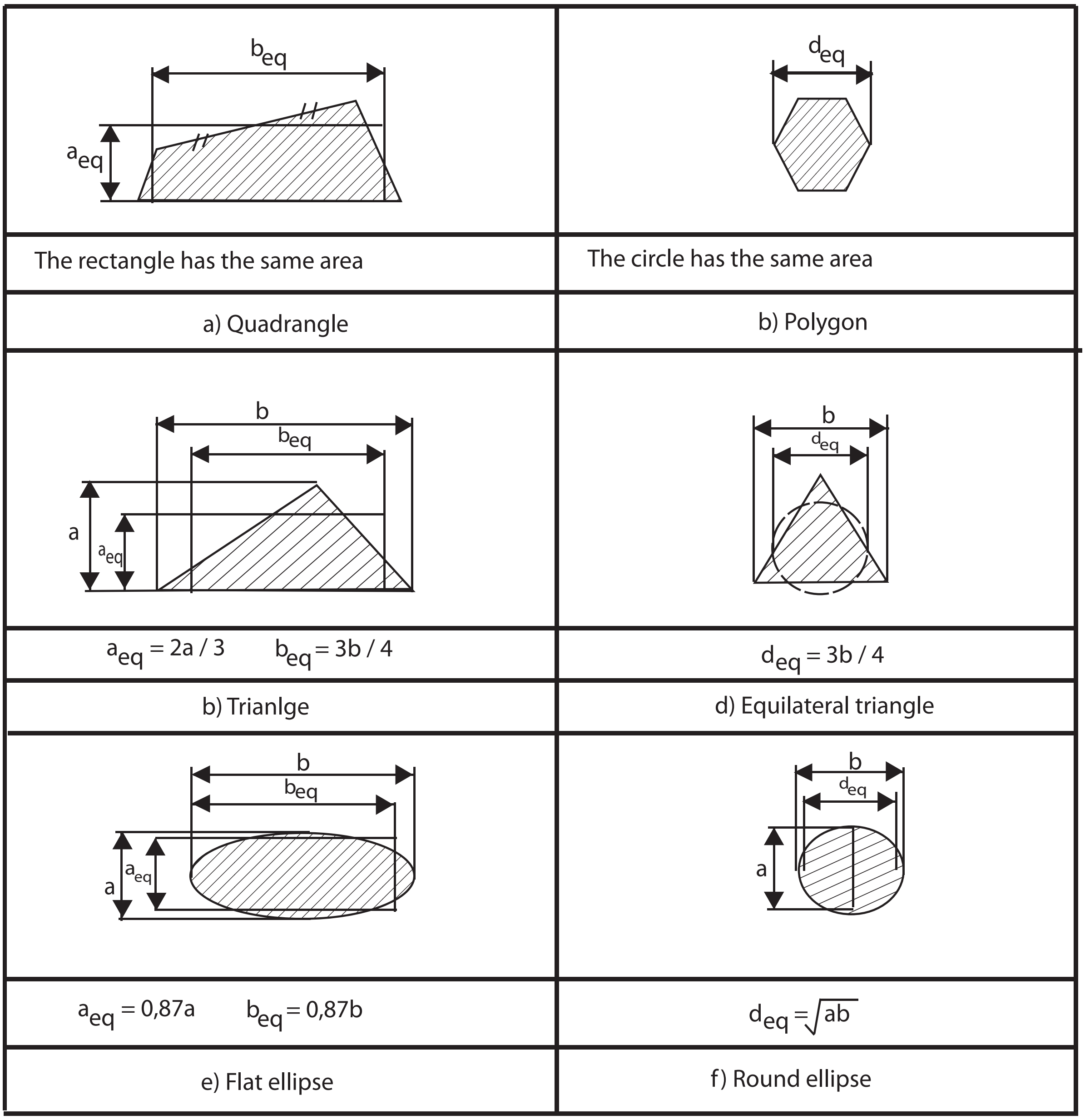
Thickness of glass pane (mm) (tolerance: 0 + 2)	Test loads (N) for a hole diameter in support plate of:	
	200 mm	150 mm
4	1500	1600
5	2400	2600
6	3400	3500
8	6500	6700
10	10200	11000
12	15500	16500
15	24000	25500
19	33400	36800

The witness of the Surveyor to the above mentioned test for glass fitted in superstructure not contributing to buoyancy may be replaced by a Declaration from the Manufacturer together with the production quality system certification issued by an accredited Body.

5.6.6 Glazing with non conventional shapes *(1/1/2020)*

The first step of this scantling procedure foresees that glazing made of non traditional shapes -such trapezoidal or polygonal and all those different from rectangular or circular - are to be transformed in traditional ones using the following criteria to calculate the equivalent dimension a_{eq} and b_{eq} or d_{eq}.

Figure 10 *(1/1/2017)*



5.6.7 Calculation of the pressure to be used for the scantling of the glazing *(1/1/2023)*

For the windows fitted in the hull and in the superstructure contributing to the buoyancy the pressure acting on the glass, P_D in kN/m², that will be used for the calculation of the minimum thickness required, is to be taken as the highest among the following 3 values p1, p2 and p3.

For the windows fitted in the superstructure not contributing to the buoyancy among the following 2 values p1 and p4:

a) In Zone 1a P ref is to be taken from the following Table 3.

Table 3 *(1/1/2017)*

L m	Motor yachts kN/m²	Cruising sailing yachts kN/m²
24	70	70
30	70	70
40	70	70
50	70	83
60	76	96
70	84	109
80	91	121
90	98	133

For motor yachts of more than 90 meters in length the value of f can be taken using the following formula:

$p_{ref} = 0,71\ L + 34$

For cruising sailing yachts of more than 90 meters in length the value of f can be taken using the following formula

$p_{ref} = 1,263\ L + 19,9$

For other zones for glasses of more than 0,85m2 P1 ref is to be taken:

In Zone 1b not less than 1,1 times the value given in the above Table for Zone 1a

In Zone 2a not less than 1,25 times the value given in the above Table for Zone 1a

In Zone 2b not less than 1,35 times the value given in the above Table for Zone 1a

For the following zones $P_{1\ ref}$ is to be taken:

In Zone 1c not less than 1,6 times the value given in the above Table for Zone 1a

In Zone 2c not less than 1,7 times the value given in the above Table for Zone 1a

P_1 is to be calculated using the following formula:

$P_1 = 10,05 * \theta * (b*f-h)$ (kN/m²)

Where:

θ = 5 for windows in the hull or in superstructure contributing to the buoyancy.

For glazing of less than 0,85m² p_1 no need to be taken more than $p_{1\ ref}$

In case p_1 calculated with the above formula is more than 200 kN/m² Tasneef may evaluate the possibility to accept the scantling of the glazing done using 200 kN/m²

For windows located in superstructures not contributing to the buoyancy the coefficient "θ" is to be taken as follows.

Value of "θ" for lateral (in the wide body) and frontal (unprotected) windows:

- Superstructure or deckhouse at more than 0,02 L (m) above design waterline:

  2 + (L/120)

- Superstructure or deckhouse at more than 0,02 L + h_{std} (m) above design waterline:

  1 + (L/120)

- Superstructure or deckhouse at more than 0,02 L + 2 h_{std} (m) above design waterline:

  0,5 + (L/120) (this may be used also for protected frontal windows)

Value of "θ" for lateral (not in the wide body) windows:

0,5 + (L/120)

The value "θ" for lateral windows fitted in superstructure or deckhouses not contributing to buoyancy may be multiplied for value k_s that may be taken as follows:

k_s =0.85 for glazing fitted in the superstructure not contributing to buoyancy for unrestricted navigation

k_s =0.85 for glazing fitted in the superstructure not contributing to buoyancy for short range navigation for sailing yacht

k_s =0.64 for glazing fitted in the superstructure not contributing to buoyancy for short range navigation for motor yacht

Value of "θ" for aft end windows located of an height above the design waterline of more than 0,02 L + h_{std} :

- x/L ≤ 0,5

$$0,7 + \frac{L}{1000} - 0,8\frac{x}{L}$$

- x/L > 0,5

$$0,5 + \frac{L}{1000} - 0,4\frac{x}{L}$$

Value of "θ" for aft end windows located of an height above the design waterline of less than 0,02 L + h_{std} :

The value obtained for windows located at an height above the design waterline more than 0,02 L + h_{std} multiplied by 1,5.

In the table above x is the longitudinal position of the fore end.

h_{std} is the superstructure height in m for vessels up to 75 m load line length: height to be taken as 1,8 m; for vessels over 125 m load line length to be taken as 2,3 m; for vessels of intermediate lengths: height to be obtained by linear interpolation.

b is given below depending on the longitudinal position

- x/L ≤ 0,45

$$1 + \left(\frac{\frac{x}{L} - 0,45}{C_B + 0,2}\right)^2$$

- x/L > 0,45

$$1 + 1,5\left(\frac{\frac{x}{L} - 0,45}{C_B + 0,2}\right)^2$$

C_B is block coefficient, with $0,6 \le C_B \le 0,8$

f is the value given in the following table

Table 4 *(1/1/2017)*

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

h, in m, is the distance from the lower edge of the windows to the design waterline

For the hull p1 is to be taken not less than $p1_{ref}$

In no cases p1 for superstructure not contributing to buoyancy to be taken less than:

L < 50m p_D min front 1st tier forward from 0,25L 21 kN/m², lateral 1st tier if in the widebody forward of 0,25L 15 kN/m².

When the front 1st tier window is located more than 0,25L aft from forward perpendicular the value of p_D may be reduced to 15 kN/m².

p_D lateral 1st tier not in the widebody or in the widebody but aft from 0,25L from forward perpendicular = 12.5 kN/m².

p_D aft 1st tier = 12.5 kN/m².

p_D min elsewhere = 10 kN/m².

L>50m p_D min front 1st tier forward from 0,25L 16+L/10 kN/m², lateral 1st tier if in the widebody forward of 0,25L to 10+ L/10 kN/m².

When the front 1st tier window is located more that 0,25L aft from forward perpendicular the value of p_D may be reduced to 10+ L/10 kN/m².

p_D lateral 1st tier not in the widebody or in the widebody but aft from 0,25L from forward perpendicular = 10+L/20 kN/m².

p_D aft 1st tier = = 10+L/20 kN/m².

p_D min elsewhere = 7.5 + L/20 kN/m².

Small reductions to this value may be taken into consideration taking into account the length of the yacht or the service.

Where the Flag requires different values these have to be used.

b) P2 is to be taken equal to half of the pressure of the bottom calculated in accordance with Sec 5, [5.3]

c) P3 is to be taken equal to the pressure of the side calculated in accordance with Sec 5, [5.4]

d)

$$P_4 = K_{su} \cdot \left(1 + \frac{x_1}{2 \cdot L(C_B + 0,1)}\right)(1 + 0,045 \cdot L - 0,38 \cdot z_1)$$

where:

K_{su} is to be taken equal to 6 for lateral and frontal windows at the first tier of superstructure

K_{su} is to be taken equal to 5 frontal windows at the second tier of superstructure

K_{su} is to be taken equal to 3 for other windows

z_1 is the distance in m of the lower edge of the windows to the waterline

x_1 is the distance in m from frontal windows or from the forward edge of lateral windows to midship perpendicular. For frontal and lateral windows aft of midship and for aft windows is to be taken equal to 0.

C_B and L as before in this paragraph.

5.6.8 Calculation of the thickness required *(1/1/2019)*

Once the pressure P_D id known it is possible to calculate the minimum thickness t_o, in mm, required depending on the area of the glass and its shape:

Rectangular windows:

$$t_o = b \cdot \sqrt{\frac{\beta \cdot p_D}{1000 \cdot \sigma_A}}$$

Circular windows:

$$t_o = 0,5 \cdot d\sqrt{\frac{3 \cdot (3 + \nu) \cdot p_D}{8000 \cdot \sigma_A}}$$

NB: This equation is coming from linear plate theory and it is strictly valid for small deflection of the pane (less than $t_O/2$). A more accurate structural analysis may be based on non-linear FEM calculation. Nevertheless this simplified linear approach has been found to be consistent and conservative for scantling determination of plates when comparing results of hydrostatic tests with the more accurate non-linear FEM calculations.

Where:

d = diameter of the glazing, in mm

b = short side of the glazing, in mm

ν = Poisson's Coefficient

σ_a = flexural strength of the material, in (N/mm²)

$$\sigma_A = \frac{\sigma_C}{\gamma}$$

The value of σ_C is to be taken not less than the values in the Tab 5.

Table 5 *(1/1/2017)*

Material	Acronym	Characteristic failure strength σ_C N/mm²
Polymethylmethacrilate	PMMA	100
Polycarbonate	PC	90
Thermally toughened safety glass	TTG	160
Chemically toughened	CTG	160

For thermally strengthened glasses it's always possible t_o use the value of 160N/mm² for the calculation of t_o.

For chemically strengthened glasses to use the value of 160N/mm² for the calculation of t_o the possibilities are:

- the glasses have to be tested in accordance with ISO 1288-3 on three samples and if the strength reached is on all the three cases more than 160N/mm² in the calculation of to the value of 160 N/mm² may be used if it is satisfied what below

  $\sigma_{Cmin} = \min(\sigma_{C1}, \sigma_{C2}, \sigma_{C3}) \geq 160$ N/mm²

  $s_{Cmax} = \max(s_{C1}, s_{C2}, s_{C3})$

  $C_{Dmax} = \max(C_{D1}, C_{D2}, C_{D3}) > 30$ µm

  If the Manufacturer declares that the value of surface compression and of depth of the compression layer of the glasses fitted on board are more than the tested one σ_C = 160 N/mm² may be used in the calculation of t_o.

  $S_{Cj} >= S_{Cmax}$ and $c_{Dj} >= c_{Dmax}$

- The Manufacturer has to declare that in addition to the depth of the compression layer (that is to be more than 30 µm) the surface compression σ_C is more than 350 N/mm².

  Both for chemically and thermally strengthened glasses if the test in accordance with ISO 1288-3 is carried out on at least 10 sample as detailed in [5.6.10] the characteristic strength obtained may be used in the calculation of t_o.

  γ is the safety factor:

  For glass (Thermally strengthened safety glass or chemically strengthened) fitted in Zone 1a and in superstructure not contributing to buoyancy may be taken equal to 4. For glass fitted in other zones of the hull may be taken equal to 4 for glasses equal or less than 0,85m² and as below indicated for glasses of more than 0,85m²:

  Zone forward of 0,25L (2a,2b,2c)

  L > 50m

  γ = 4 + 0,25* (A - 0,85) + 3* (x/L - 0,75)+ (0,2966*$L^{-0.031}$ - h * (3,6959*$L^{-1.03}$))

  L < 50m

  γ = 4+ 0,25* (A - 0,85) + 3* (x/L - 0,75)+ (0,3226*$L^{-0,058}$ - h * (2,5779*$L^{-1,058}$))

  Zone aft of 0,25L (1b,1c)

  γ = 4 + 0,2* (A - 0,85) + (0,3537*$L^{-0,067}$ - h * (5,0426*$L^{-1.06}$))

  For polymethylmethacrilate or polycarbonate fitted in Zone 1c,2b,2c it is to be taken at least 4 elsewhere is to be taken equal to 3,5.

  b_P shorter side of the rectangular windows, (mm).

  d is the diameter of the circular windows (mm).

  β coefficient given below:

  - β for circular windows is to be taken as 0,284
  - β for rectangular windows

  β = 0,54*(a/b)-0,078(a/b)² - 0,17 if a/b < 3

  β = 0,75 if (a/b) > 3

  Where a, b are the longest and the shortest side of the glazing.

  For curved glazing in the direction of the shortest side of the window it is possible to multiply the value of t_O obtained with the above formula by the curvature factor K_c.

  K_c is to be calculate as below indicated:

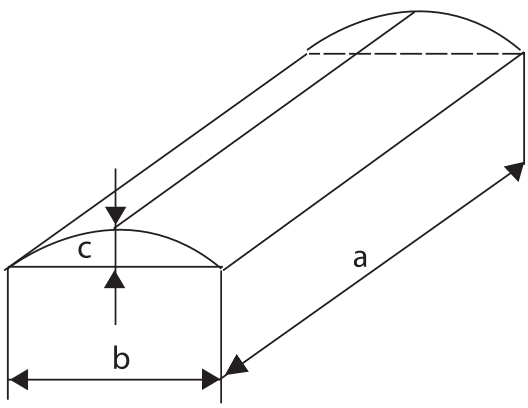
  K_c = 1 - c/b

  where:

  c is the crown height of the curved glazing (mm).

  b shortest side on the windows (mm).

Figure 11 *(1/1/2017)*



In any case K_c can't be taken smaller than 0,77.

5.6.9 Verification of maximum deflection *(1/1/2020)*

The maximum deflection is to be calculated as follows:

$\delta_{max} = \alpha * ((P_D * b_P^4)/(1000*M)$

where:

δ_{max} is the maximum pane deflection, in mm;

α is the pane aspect-ratio deflection coefficient (see Tab 6)

Table 6 *(1/1/2017)*

Aspect ratio AR = a_p/b_p	α
1,0	0,004 06
1,1	0,004 85
1,2	0,005 64
1,3	0,006 38
1,4	0,007 05
1,5	0,007 72
1,6	0,008 30
1,7	0,008 83
1,8	0,009 31
1,9	0,009 74
2,0	0,010 13
3,0	0,012 23
4,0	0,012 82
5,0	0,012 97
oo	0,013 02

When the value of A_R is not in the table the value of a may be taken with linear interpolation.

p_D is the design pressure (see 7) (kN/m²);

b_P is the unsupported short side of a rectangular pane or "equivalent short side" of a pane, in mm;

M is the pane stiffness calculated according as below where t_W is the physical thickness in case of monolithic glazing, in N*mm, and is:

- in case of laminated glass with independent plies

$$t_W = \sqrt[3]{t^3_1 + t^3_2 + \ldots + t^3_n}$$

- in case of laminated glass with collaborating plies

$$t_W = t_{eq;W}$$

M is the pane stiffness calculated according to:

$$M = \frac{E \cdot t_w^3}{12 \cdot (1 - \upsilon^2)}$$

where:

$t_w = t_{eq}$

E, in N/mm² Young's modulus;

ν Poisson's ratio;

if unknown the following table may be used:

Table 7 *(1/1/2017)*

Material	Acronym	Young's modulus E N/mm²	Poisson's ratio ν
Polymethylmethacri-late	PMMA	3300	0,37
Polycarbonate	PC	2300	0,38
Glass	TTG/CTG	70000	0,23

The rectangular (or equivalent to rectangular) glazing is acceptable if:

$\delta_{max} \le a_p / 50$

where a_p, in mm, is the clear opening long side of a rectangular pane or "equivalent long side" of a pane.

As an alternative to what above a hydrostatic test in accordance with [5.6.16] is to be carried out.

5.6.10 Calculation of characteristic failure strength *(1/1/2020)*

Characteristic flexural strength of glass materials may be determined by flexural four point bending test according to ISO 1288-3 (for glass), or by flexural three point bending test according to EN 178 (for rigid plastic material).

The characteristic failure strength,σ_C, shall be determined by mechanical tests as follows:

N = number of test specimens (at least 10).

The breaking position is to occurs inside the loading rolls. The specimens where the breaking occur outside the loading rolls is to be disregarded. There shall be at least 10 specimens where the breaking occurred inside the loading rolls.

For glass:

σ_i breaking stress (MPa) for each test specimen tested in acc. with ISO 1288-3 and for rigid plastic material where not applicable the yield strength.

For rigid plastic:

σ_i breaking stress (MPa) or, where not applicable, yield stress for each test specimen;

σ_{av} average value;

$$\sigma_{av} = \frac{1}{N} \cdot \sum_{i=1}^{N} \sigma_i$$

S_x standard deviation;

$$s_x = \sqrt{\frac{\sum_{i=1}^{N}(\sigma_i - \sigma_{av})^2}{N-1}}$$

C_V coefficient of variation;

$$C_v = \frac{S_x}{\sigma_{av}}$$

Kn statistic coefficient corresponding to 90 % confidence limit. This value depends on the number of test specimens, N, according to the t-Student statistical distribution, see below.

Table 8 *(1/1/2017)*

Number of test specimens N	Kn
10	1,833
11	1,812
12	1,796
13	1,782
14	1,771
15	1,761
20	1,729
25	1,711
30	1,699
40	1,685
60	1,671
100	1,660
oo	1,645

With the above definitions, σ_C, characteristic failure strength is:

$\sigma_C = \sigma_{av} \times (1 - Kn \times C_v)$

A test report will be issued by Tasneef with the identification of:

- glass composition,
- thickness,
- treatment,
- edge description
- color and serigraphy if any

of the glass tested.

In the report will be indicated the strength of the glass obtained from the test and the calculation of the characteristic strength σ_C calculated according to this subparagraph.

Calibration certificates of the instruments are to be provided and the samples are to be identified.

The test may be considered acceptable for a maximum of 5 years. The procedure of renewal is to be agreed with Tasneef At request of the Shipyard or of the Manufacturer a type approval may be issued.

The value of a monolithic glass strength obtained with this procedure may be used for the calculation of t_o.

The required thickness t_0 has to be compared with the thickness of the monolithic glass proposed or with the equivalent thickness of a laminated glass (composed by single pane of glass of the same composition and thickness of the monolithic tested) in accordance with the procedure set out in [5.6.11].

When it's used a laminated glass with two or more plies of different thickness in the calculation of t_o is to be used the smaller characteristic strength among the one tested in accordance with ISO 1288-3 of different thickness.

As far as the possibility to perform this test on a laminated glazing see [5.6.12].

A Declaration of conformity from the Manufacturer to the a.m. test report is to be foreseen for every glazing fitted on board. All the characteristic of the glass has to be declared to be at least equal or higher than those reported in the test report.

The test is valid for:

- the same composition of glass,
- the same treatment,
- and the same edge treatment, the same color and serigraphy (except if the Manufacturer declares that the edge treatment the color or the serigraphy used do not modify the glass strength),
- as far as the thickness the following procedure may be applied (both for chemically and for thermally strengthened glasses).

Normally the test is valid for the thickness tested. In order to have the validation of a range of thicknesses t_j (for example from t_{min} to t_{max}) at least 3 thicknesses have to be tested in accordance with [5.6 10].

The three thicknesses to be tested (t_i) have to be taken in this way:

$t_1 = t_{min} + 2$ mm

$t_2 = t_{max} - 3$ mm

t_3 = chosen by the Manufacturer as the thickness available closest to $(t_1 + t_2)/2$

The values of the characteristic strength for the thicknesses not tested may be derived by interpolation for the thicknesses within the tested ones, and constant equal to the closest tested value for the estreme ones provided that the value of the superficial compression (S_{Cj}) and the depth of the compression layer (c_{Dj}) of the thickness not tested are equal or more of the ones of the thicknesses tested.

Example of a test report in accordance with this subparagraph.

Figure 12

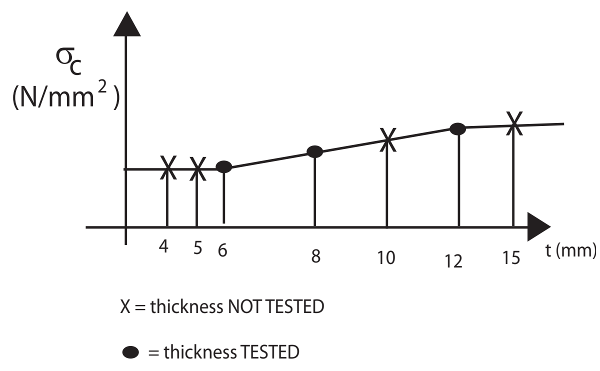


Figure 13

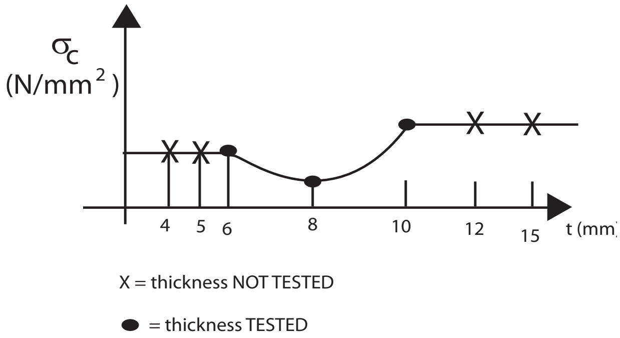


Figure 14

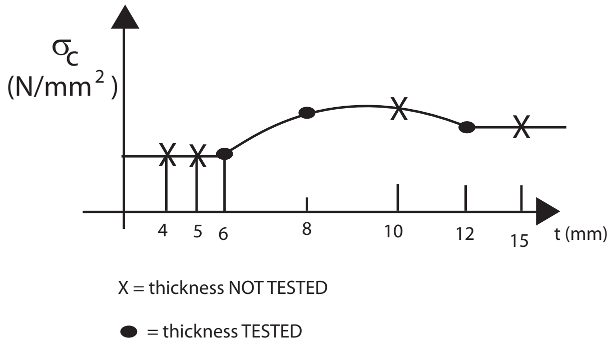


Table 9 : Test Report *(1/1/2017)*

Applicant: (name of the Manufacturer of the glass)	
Project and/or Shipyard: (number of project and/or name of the Shipyard)	
Test type: (e.g. Determination of bending strength)	
Test method: ISO 1288-3	
Sample acceptance date:	
Starting/End test date:	
Sampling and sampling description:	
Test method description:	
Temperature and humidity of the test:	
Instrument calibration: (e.g. an instrument calibrated has been used the relevant certificate of calibration has been handed to Tasneef Surveyor)	
Description of testing apparatus:	
Procedure of uncertainty evaluation:	
Type and name of glass:	
Chemical composition of the glass (if available):	
Pre stressing: (e.g. chemically strengthened, depth of compression layer 30 σm, surface compression 350MPa)	
Surface treatment: (e.g. none)	
Edge finishing: (e.g. polished flat)	
Number of specimens:	
Number of specimen not broken in accordance with clause 8 of ISO 1288-3:	
Signature of Test responsible:	
Signature of Laboratory Responsible:	
Signature Tasneef Surveyor for witness:	

Sample ID	Average thickness h (mm)	Average width B (mm)	Force at breakage F_{max} (N)	Breaking position referred to loading rolls IN/OUT	Breakage origin EDGE/BODY	Time to breakage (s)	Uncertainty U (N/mm²)	Surfaces in contact with loading rolls	Bending strength σ_{bB} (N/mm²)

5.6.11 Calculation of equivalent thickness of a laminated glass *(1/1/2020)*

Once the required monolithic thickness t_0 is calculated, the following procedure to be followed to check if the laminated glass proposed has an equivalent monolithic thickness higher than the required one, so acceptable. This procedure takes into consideration the possibility of having independent plies or collaborating plies:

Independent plies:

When the mechanical properties of the interlayer material (the laminating adhesive material) are not known, the plies of the laminated glazing have to be considered as mechanically independent.

The equivalent thickness of laminates made of n independent plies of thicknesses: t_{p1}, t_{p2}, ..., t_{pn}, shall be calculated and compared with the basic thickness, t_O, calculated as explained above.

The equivalent thickness of n independent plies shall be calculated as follows. The thickness of one ply of the laminate is indicated generically as, t_j, where the index j is ranging from 1 to n.

For each ply of the laminate a partial equivalent thickness, $t_{eq,j}$, is calculated as:

$$t_{eq,j} = \sqrt{\frac{\sum_{i=1}^{N} t^3_1}{t_j}}$$

and the equivalent thickness of the laminate t_{eq} shall be the minimum of the n $t_{eq,j}$ values:

$$t_{eq} = \min[t_{eq,j}]; \qquad j = 1, n$$

The laminate construction is accepted when it results:

$t_{eq} \geq t_o$

Collaborating plies:

When the mechanical properties of the interlayer are known in terms of shear modulus, G (N/mm²), at 25 °C for 60 s duration load the equivalent thickness shall be calculated as follows.

Preliminary calculation:

$$hs = 0,5 \cdot (t_1 + t_2) + t_l$$

$$t_{s;2} = \frac{hs \cdot t_2}{t_1 + t_2}; \qquad t_{s;1} = \frac{hs \cdot t_1}{t_1 + t_2}$$

$$Is = t_1 \cdot t^2_{s;2} + t_2 \cdot t^2_{s;1}$$

Shear transfer coefficient evaluation:

$$\Gamma = \frac{1}{1 + 9,6 \cdot \frac{E}{G} \cdot \frac{Is}{hs^2} \cdot \frac{t_l}{b^2}}$$

Equivalent thickness evaluation:

$$t_{eq;w} = \sqrt[3]{t^3_1 + t^3_2 + 12 \cdot \Gamma \cdot Is}$$

$$t_{1ef;\sigma} = \sqrt{\frac{t^3_{eq;w}}{t_1 + 2 \cdot \Gamma \cdot t_{s;2}}} \qquad t_{2ef;\sigma} = \sqrt{\frac{t^3_{eq;w}}{t_2 + 2 \cdot \Gamma \cdot t_{s;1}}}$$

The equivalent thickness is:

$$t_{eq} = \min[t_{1ef;\sigma}, t_{2ef;\sigma}]$$

where:

t_1 ply thickness (mm);

t_2 ply thickness (mm);

t_l interlayer thickness (mm);

a shortest clear opening dimension of the glazing laminate (mm);

E Young's modulus of the ply (N/mm²);

G shear modulus of the interlayer at 25 °C (N/mm²).

Acceptable value for polyvinylbutyral (PVB) is: G = 1,6 N/mm². For other interlayer materials the shear modulus value at 25 °C for short time duration load (60 s) shall be declared by the interlayer material Manufacturer in form of a Statement where evidence of the test carried out to calculate G is given.

In case this value is not known the plies shall be considered independent.

If for the interlayer a value is available only for Young's modulus, E (MPa), a shear modulus may be assumed as G = E/3.

In case of 3 or more plies the calculation is to be iterated.

The laminate construction is accepted when it results:

$t_{eq} \geq t_o$

Laminate made of plies of different materials will be specially considered.

5.6.12 Selection of laminate thickness by flexural testing *(1/1/2020)*

The flexural strength of a multiply laminate of physical thickness, t_{Lam}, can be determined as characteristic flexural strength by a four point bending strength test according to the method described in ISO 1288-3.

The measured characteristic flexural strength value is strictly to be referred to the actual cross section of the tested laminated pane.

The characteristic flexural strength of the laminate divided by the design factor of glass (γ) is to be considered as the allowable design flexural stress of the laminate.

Scantling equation giving t_o may be used to calculate the basic pane thickness, t_o, resulting from design pressure, geometry of the laminated pane and its allowable flexural strength.

The physical thickness of the laminate, t_{Lam}, shall be compared with the calculated t_0 and it is accepted when:

$t_{Lam} \geq t_o$

Note 1: To be considered acceptable the test is to be carried out on the same composition of glass and interlayer material, the same cross section (same glass and interlayer thickness), same treatment, and same color (the color and the serigraphy - if any - according to the Manufacturer if it may modify the glass strength).

For small porlights equipped with monolithic glass, fitted in doors located in the superstructure different considerations may be done.

5.6.13 Minimum thickness *(1/1/2019)*

The following minimum thickness in mm has to be in any case granted.

Poly(methyl)methacrylate PMMA t_{min} = 8 + 0,1 (L - 4)

Polycarbonate PC t_{min} = 8 + 0,1 (L - 4)

Monolithic tempered glass TG t min = 4 + 0,1 (L - 4)

Laminated glass LG t_{min} = 6 + 0,1 (L - 4)

For laminated glass the thickness of the interlayer may be included. The thickness of the interlayer is to be always less than the thickness of the single ply.

For the calculation of minimum thickness for yachts more than 100m in length L may be taken equal to 100.

5.6.14 Fastening requirements *(1/1/2020)*

This subparagraph is applicable when the strength of the surround is so high to consider that the mechanical behaviour of the glazing is independent from the adjacent structure. The structure of the yacht is to be verified without the structural contribution of the glass. The glass is supposed not carrying loads from the adjacent structures and not having structural function. When the installation of the glazing requires that structural elements are interrupted the local strength of the structure is to be analysed and verified by fem calculations.

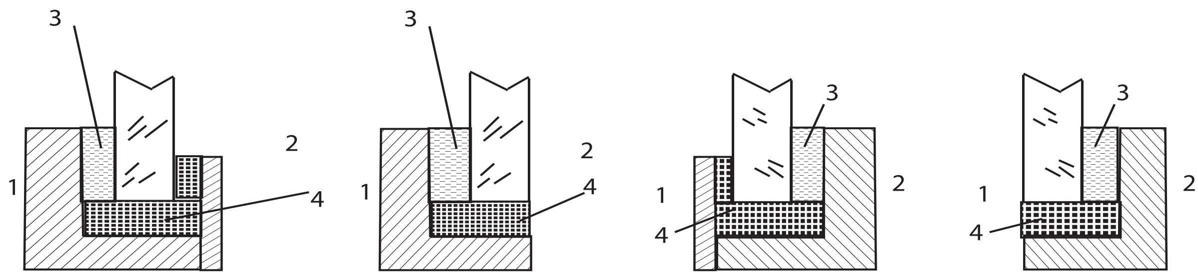
The glazing can have a frame or not and the can be mechanically connected or glued to the hull or superstructure.

a) If they have a frame it is to be considered what follows:

   The framing shall provide a safe and secure fixing of the glazing. The glazing shall either be clamped with elastomer gaskets or bonded and additionally secured with an elastomer gasket between glazing and retaining frame, or bonded at both sides.

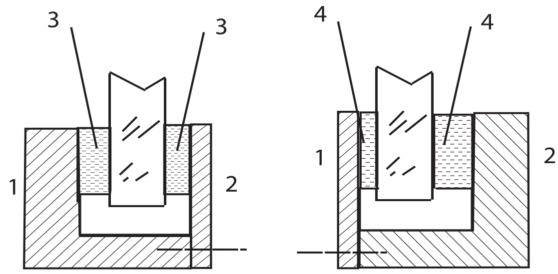
   The following figures 15, 16, 17, 18 and 19 show possible solutions:

Figure 15 *(1/1/2017)*



Key:
1 inside
2 outside
3 bonding
4 seal

Figure 16 *(1/1/2017)*



Key:
1 inside
2 outside
3 rubber gasket
4 rubber gasket

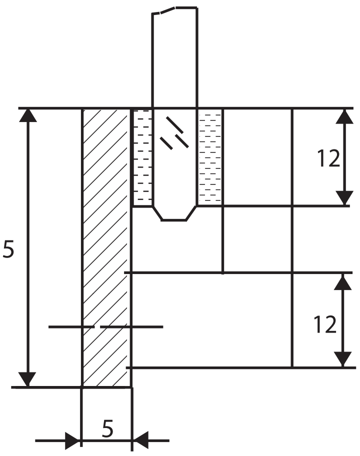
Minimum dimensions:

A < 0,45 m^2: ISO 3903 is applicable.

For larger windows ISO 3903 may be applied as far as the scantling of the frame and the closing devices (if any) and in addition is to be satisfied what below:

0,45 m^2 < A < 1 m^2:

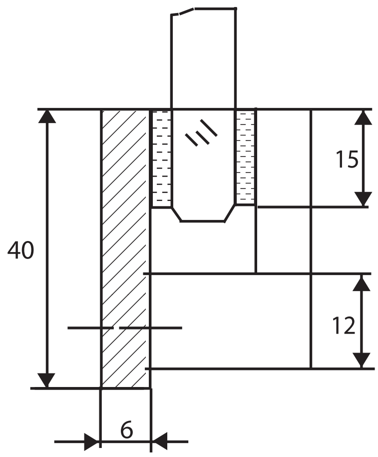
Figure 17 *(1/1/2017)*



Elastomer gaskets shall have the following characteristics: Shore A 50-70, width ≤ 12 mm, thickness outside 2 mm to 6 mm (not in compression) thickness inside 2 mm to 4 mm (not in compression). The gaskets shall be properly secured against dislocation (i.e. gluing, positive fit). The distance between frame and glass shall not be less than 5 mm.

1 m^2 < A < 2,5 m^2 :

Figure 18 *(1/1/2017)*



Elastomer gaskets shall have the following characteristics: Shore A 55-70, width ≤ 15 mm, thickness outside 4 mm to 6 mm (not in compression), thickness inside 2 mm to 4 mm (not in compression). The distance between frame and glass shall not be less than 7 mm.

A > 2,5 m^2: the minimum dimension of the frame will be considered on a case by case base. For yachts of more than 90m where the structure is subject also to longitudinal global loads the frame is to be designed to receive the movements of the structure. A detailed calculation is to be sent.

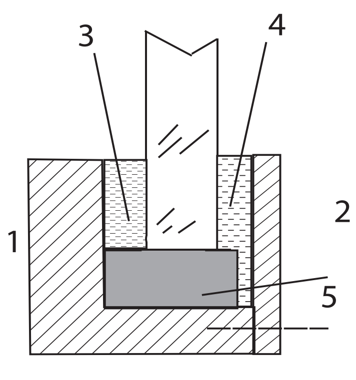
Chamfered edge or other preparations (i.e. bullnose) of the glass edge cannot be included in the width of overlap.

The direct contact between frame and glazing shall be avoided.

Windows which are fitted in such a way that the adhesive is under tension load are not permitted.

Support of the glass mass and secure positioning within the frame shall be achieved by support pads with comparable elastic properties as the elastomeric gasket or the bonding material. The compatibility of materials between support pad and bonding shall be assured.

Figure 19 *(1/1/2017)*



Key:
1 inside
2 outside
3 bonding
4 elastomer gasket
5 support pad

The strength of metal frames shall ensure under the window design pressures that the minimum yield strength of the material is not exceeded. Non-metallic frames are to be considered on a case by case base.

The bolt material shall be compatible with the frame. The supplier shall ensure that the mechanical properties are achieved and valid documentation shall be provided.

For windows and doors fitted in the superstructure not contributing to buoyancy solutions different from what above may be acceptable on a case by case base.

b) If they are glued it is to be considered what follows:

The adhesive used for the gluing is to be flexible and suitable for the gluing of the glazing material or the frame material to material of the hull.

The gluing characteristics have to be determined as indicated below.

Glued joints shall be resistant to (or protected against) sunlight (UV, heat, etc.) and all environmental effects or cleaning chemicals normally encountered in the manufacture and use of the craft.

The bonding has to work in compression. The gluing details have to be sent for examination.

As far as the bonding there are the following two possibilities of perform the verification by calculation or performing tests.

1) Calculation of the bonding:

For windows fitted on the hull or in superstructure contributing to the buoyancy this calculation is applicable.

Possible bonding details (see Fig 20 and 21).

Figure 20 *(1/1/2017)*

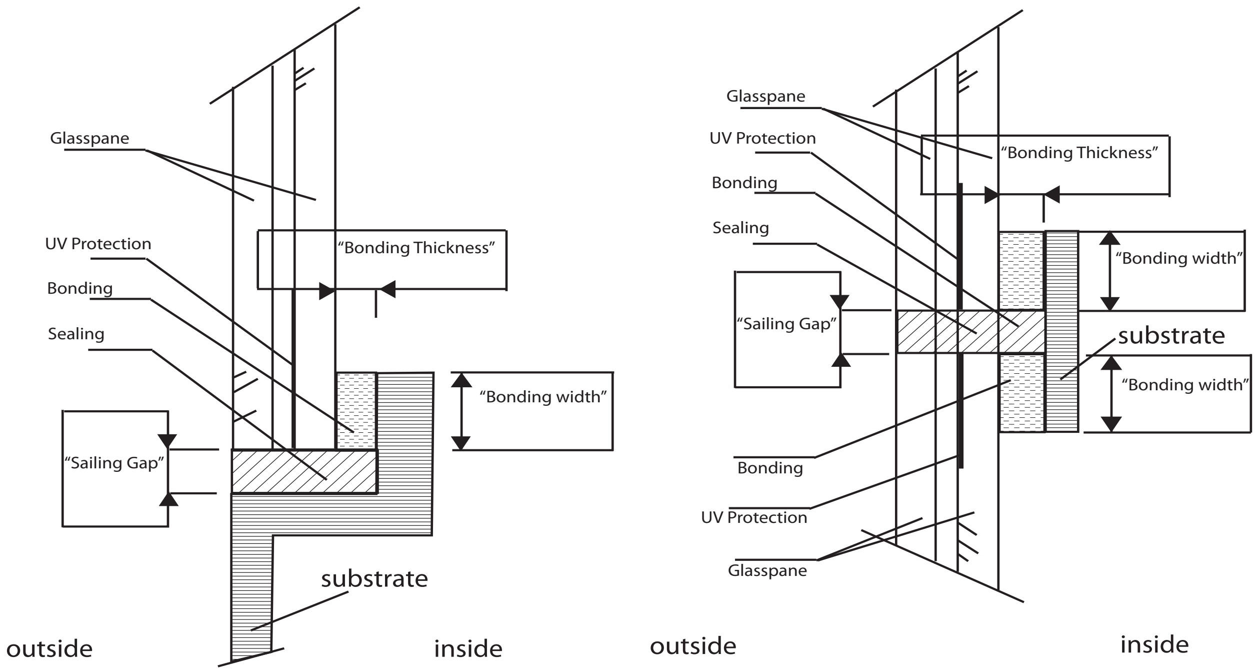
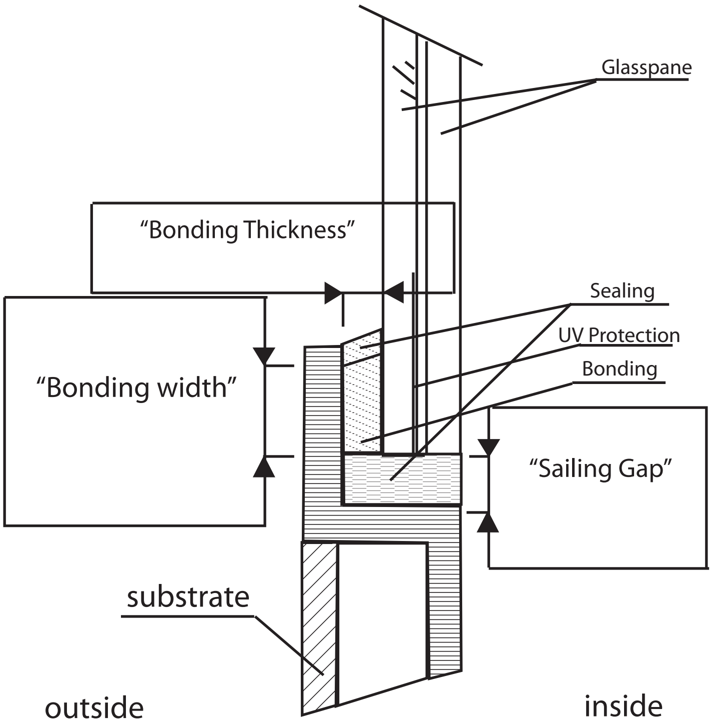


Figure 21 *(1/1/2017)*



Symbols and definitions:

σ_{zul} - allowable strength, N/mm^2

σ_v - equivalent stress, N/mm^2

σ_{lab} - Characteristic Strength value at lab condition (95% confidence), N/mm^2

$f_{red,T}$ - Reduction factor for temperature exposure

$f_{red,S}$ - Reduction factor for permanent static load

$f_{red,D}$ - Reduction factor for dynamic cyclic load

$f_{red,F}$ - Reduction factor for fatigue cyclic load

$f_{red,A}$ - Reduction factor for aging conditions

S - Additional safety factor

R - Ratio compression strength to tensile strength

c - Elastic limit of shear strain,

P_{sea} - sea design pressure, kN/m^2

$P_{wind,h}$ - Maximum wind load (Dynamic load), N

$P_{wind,m}$ - Medium wind load (Fatigue load), N

T_{design} - Maximum/minimum design temperature of the window, deg C

$T_{application}$ - Temperature of joint application, deg C

a_{max} - Maximum acceleration due to sea swell (m/s^2)

a_{min} - Medium acceleration due to sea swell (m/s^2)

α_g - linear thermal expansion coefficient of glazing material

α_s - linear thermal expansion coefficient of substrate material

τ - Shear Stress, N/mm^2

τ_{Supp} - Supported Shear Stress, N/mm^2

τ_{Unsupp} - Supported Shear Stress, N/mm^2

β - Glazing Angle deg

The bonding material shall be chosen according to the substrate and glazing that need to be joined. If necessary the surfaces of the glazing or the substrate have to be prepared in accordance with the application guidance of the bonding manufacturer.

The glazing itself and/or its coating must be suitable for the application of the bonding.

If different types of bonding are used they must be compatible.

A record of the bonding application guidance and bonding installation procedures shall be provided and kept on board.

Where no previous information on the installed bonding is available, and it is required to install new bonding compatibility tests shall be made.

The bonding material shall meet the minimum requirements listed below.

Physical characteristic of bonding:

Flexural Modulus

Tests according to ISO 37, ISO 527 and DIN 53504

Elongation

Tests according to ISO 37, ISO 527 and DIN 53504

Shear Modulus

Tests according to ISO 11003-1 and ISO 11003-2, DIN 6701

Tensile Strength

Tests according to ISO 37 and DIN 53504

Shore Hardness

Tests according to DIN 53505 and ISO 7619:2012 and ISO 7619:2012

Environmental Resistance

The resistance of the bonding material shall be tested and documented by the manufacturer to ensure it is suitable for the intended purpose.

An alternative to this is the installation of a protective layer or sealing. The long term suitability of this layer and/or sealing for protection shall be tested and documented.

Long term properties

Long term properties of the bonding material are to be tested and documented.

These shall include:

- Adhesion (to all required substrate materials)
- Cohesive Strength
- Elasticity
- Creep
- Environmental Resistance

The surface preparation of the substrate and glazing to be bonded shall be in accordance with the application guidance of the bonding manufacturers.

The installer shall ensure the bonding and sealing materials are compatible with the glazing material.

The bonding material shall have the following minimum material properties:

Minimum tensile strength - 0,70 N/mm^2

Tensile Stress at 12,5% elongation - 0,14 N/mm^2

Fracture elongation - 50%

Testing / qualification shall be carried out in accordance with ISO 8339. The short and long term performance of the adhesion between the glue and the substrate shall be documented.

Bonding shall in general be in a recess designed to accommodate the glazing appliance, contained with an appropriate sealing gap and the required bonding thickness and width. The external edge of the glazing shall not protrude beyond the immediate surrounding surface (e.g. the filler, adjacent structure, or other glazing). The main motivation for this is to protect the edges of the glazing, bonding and sealing.

Attention should be paid to the design of the recess and its adjacent structure, in so far as to minimize both deflection and stress concentrations of/ in the structure under thermal, local or global loads.

For local loads the glazing, bonding recess and adjacent structure shall be designed for the pressure load defined below.

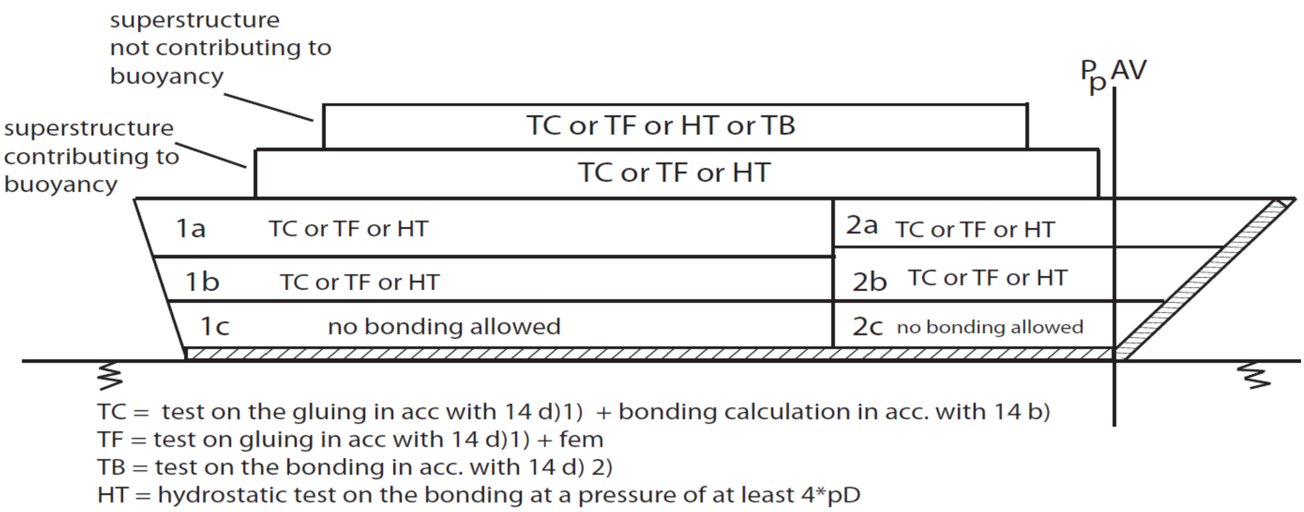
The global deflection of the structure of the vessel and the local deflection of the glazing panel may induce loads which have to be considered when designing the bond. The global deflection to be declared by the Shipyard.

Contact between the glazing panel and the adjacent structure (or adjacent glazing) of the vessel under local pressure or thermal loads shall be avoided.

The dimensions of the bond shall also account it's elastic limit, and general production and installation tolerances of both the glazing and adjacent structure.

Gluing arrangement for yachts of less than 90 m.

Figure 22 *(1/1/2020)*



Note 1: For Type 1 in the hull and in superstructure contributing to buoyancy the retainer is to have scantling suitable to support p_D.

The glass is not to protrude outside the surround. See the below possible details.

Figure 23 *(1/1/2017)*

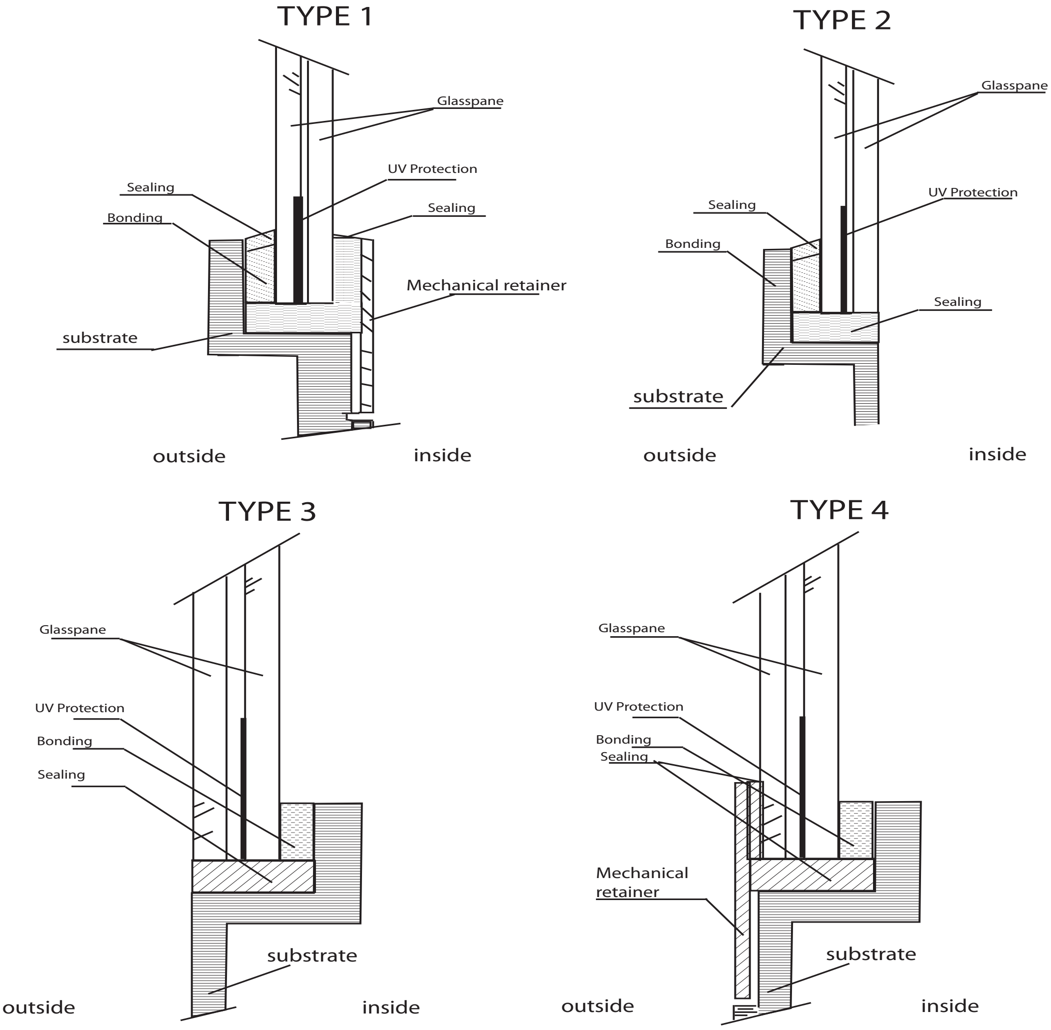
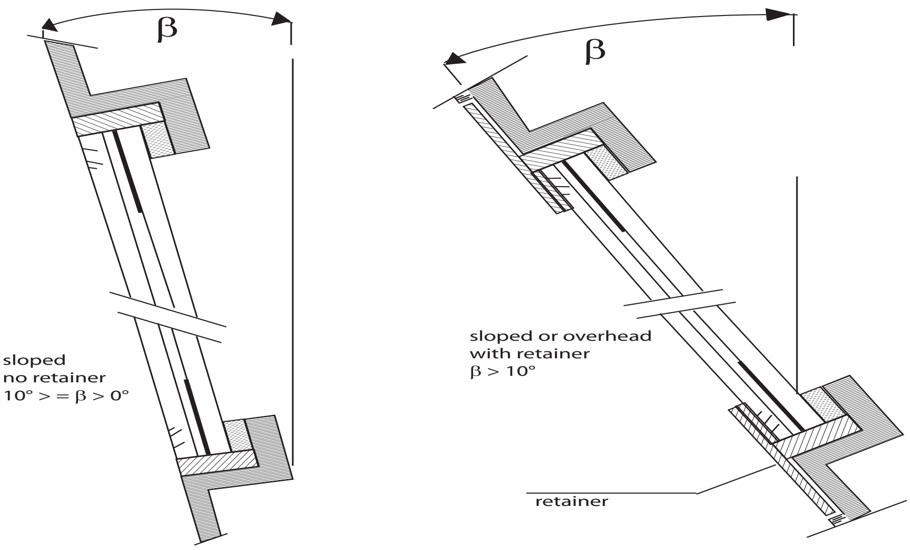


Figure 24 *(1/1/2017)*



For sloped glazed openings (angle to vertical, 10deg >= β >0) the bond is considered in tension and where retainers are not provided the bonding have be considered on a case by case base.

For sloped & overhead glazed openings (angle to vertical, β >10 deg), a retainer shall be provided. The retainer shall be designed to take the loads required to hold the glazing in place.

In order to avoid the retainer when $\beta > 10°$ an hydrostatic test at a pressure of at least 4* the weight of the glass on the larger glazing, or direct calculation of the gluing is to be carried out.

Tasneef may decide, after consideration on the angle the dimension of the glazing and service of the yacht, to require calculation in addition to or as an alternative to the hydrostatic test

Type 1 with the retainer not verified for a pressure of 4 p_D and Type 2 are not to be used for windows fitted in the hull or in superstructure contributing to the buoyancy unless the bonding is verified by calculation with a pressure of p_D and is hydrostatically tested at the same pressure. The test may be carried out on the largest glazing.

Other type of bonding will be considered on case by case base.

An overhead glazed opening that persons can stand on or is located above an area where persons can be underneath shall be fitted with a mechanical retainer.

Overhead glazing require different load cases, such as personnel loads, impact, etc. and will be considered on a case by case base.

Where required the mechanical retainer shall prevent the window from falling out in case of bonding failure. Design of the mechanical retention of the glazing shall take into account the installation and location.

Overhead glazing which has no mechanical retainer shall approved individually under special consideration of the long-time behavior and resistance of the bonding, on a case by case basis.

The design of the bonding for the following installation types is not taken into consideration. They have specific requirements that should be considered on a case by case basis.

- Fire Protected Areas
- Glazed Bulwarks
- Underwater glazing
- Pool Glazing
- Glazing for use in Polar areas
- Bonded Joint Design
- This standard considers the following types of load
- Environmental Loads (Water & Wind Pressure)
- Self Weight and Inertial loads
- Internal (or None Load Side) Impact
- Thermal Expansion of glazing and structure

In general this approach limits the design to applications where the bonded joint is stressed by tensile and compressive and shear components. Applications where peel or cleavage take place are outside the scope.

As mentioned in the scope this standard is limited to bonding that exhibits linear elastic behavior, and excludes rigid bonding and nonlinear elastic bonding.

Bonding that is considered outside the scope of the standard should be considered on a case by case basis.

Design of bonded joints in terms of their structural integrity shall be considered by the comparison of the allowable strength σ_{zul}) of the adhesive material to the equivalent stress (σ_v) generated by the loading conditions of the adhesive joint.

The allowable strength shall be determined from the characteristic strength value determined by testing in laboratory conditions at 95% confidence limit (σ_{lab}) and from the reduction factors $f_{red,i}$ that take into account different strength reduction mechanisms. An additional design factor "S" is considered to take into account additional reduction situations. The allowable strength shall be evaluated according to the following general relationship (i=1..N reduction factors).

$$\sigma_{zul} = \frac{\sigma_{lab} \cdot f_{redT} \cdot f_{redS} \cdot f_{redD} \cdot f_{redF} \cdot f_{redA} \cdot f_{redi}}{S}$$

The acceptable condition shall be:

$$\sigma_v \leq \sigma_{zul}$$

The comparison of the allowable strength to the equivalent stress the resultant safety factor (S_i) for each load case (i=1 to n):

$$S_i = \frac{\sigma_{zul,\,i}}{\sigma_{v,\,i}} \geq 1$$

The adhesive material characteristics to be provided for the determination of the allowable strength shall be:

Adhesive material characteristics:

σ_{lab} - Characteristic Strength value at lab condition (95% confidence)

$f_{red,T}$ - Reduction factor for temperature exposure

$f_{red,S}$ - Reduction factor for permanent static load

$f_{red,D}$ - Reduction factor for dynamic cyclic load

$f_{red,F}$ - Reduction factor for fatigue cyclic load

$f_{red,A}$ - Reduction factor for aging conditions

S - Additional material safety factor as described by the bonding manufacturer, otherwise S is 1

R - Ratio compression strength to tensile strength c - Elastic limit of shear strain

The above material characteristics shall be confirmed by the bonding manufacturer.

The equivalent stress in load conditions (σ_v) shall be determined on the basis of the load condition parameters.

Load Conditions parameters:

P_{sea} - sea design pressure equal to p_D

$P_{wind,h}$ - Maximum wind load (Dynamic load)

$P_{wind,m}$ - Medium wind load (Fatigue load)

T_{design} - Maximum/minimum design temperature of the window

$T_{application}$ - Temperature of joint application

a_{max} - Maximum acceleration due to sea swell

a_{med} - Medium acceleration due to sea swell

Other data to be provided are the linear thermal expansion coefficients of the materials involved in the bond line that is glazing material and substrate material:

α_g - linear thermal expansion coefficient of glazing material

α_s - linear thermal expansion coefficient of substrate material

The thickness of the bonding and the sealing gap shall be calculated by considering the relative movement:

$$\Delta s = |(T_{design} - T_{application}) \cdot (\alpha_g - \alpha_s)| \cdot \sqrt{\left(\frac{H}{2}\right)^2 + \left(\frac{W}{2}\right)^2}$$

$$d = \frac{\Delta s}{c}$$

$$b \geq \frac{\Delta s}{c_{gap}}$$

For the scope of this standard the equivalent stress σ_v shall be evaluated by calculating the tensile stress (σ_1) and shear stress (τ) in the loading conditions below,

$$\sigma_v = \frac{(R-1) \cdot \sigma_1 + \sqrt{(R-1)^2 \cdot \sigma_1^2 + 4 \cdot R \cdot (\sigma_1^2 + 3 \cdot \tau^2)}}{2 \cdot R}$$

When the stress due to loading conditions is not multiaxial only the mono axial component (tensile or shear) shall be used.

The glazing and bondline parameters shall be:

W(mm) - glazing width

H(mm) - glazing height

m (kg) - Glazing weight

d (mm) - Bonding thickness

w (mm) - Bonding width

b (mm) - sealing gap

p (mm) - Bonding perimeter

A = pw (mm^2) - Bonding surface

Δs (mm) - relative elongation of glass to adjacent structure

c - Elastic limit of shear strain that is movement accommodation capability of the adhesive (if not known use 0.125)

c_{gap} - limit of distance from glazing edge to the adjacent structure or adjacent glazing edge in order to avoid material contact (if not known use 0.125).

The comparison between allowable stress and service stress shall be performed in the following load cases:

LC1 - Static permanent Load only applicable to unsupported system.

For unsupported glazing systems the dead load of the glazing will be taken by the adhesive joint, reduction factors shall be temperature, static permanent and aging.

$$\sigma_{zul} = \sigma_{lab} \cdot f_{redT} \cdot f_{redS} \cdot f_{redA}$$

Service stress will be only the shear component due to glazing self weight:

$$\tau = \frac{m \cdot g}{A}$$

In case of shear the equivalent stress will be:

$\sigma_v = \tau$

If f_{redT}, f_{redS}, f_{redA} are not known the product f_{redT} x f_{redS} x f_{redA} can be taken equal to 0,025

LC2 - Dynamic load

In this load case for tensile stress component it will be considered the longitudinal maximum acceleration due to sea swell a_{max} of the glazing and the maximum wind pressure or the design load (sea design pressure) in case of type 2 bonding arrangement. For shear component it will be considered the vertical acceleration a_{max} due to sea swell and (if the glazing is unsupported) the dead load. Reduction factors shall be temperature, dynamic and aging.

$$\sigma_{zul} = \sigma_{lab} \cdot f_{redT} \cdot f_{redD} \cdot f_{redA}$$

with (Type 2 bonding arrangement and also for Type 1 if the retainer is not built and connected to support p_D)

$$\tau_{Unsupp} = \frac{m \cdot g + m \cdot a_{max}}{A}$$

$$\tau_{Supp} = \frac{m \cdot a_{max}}{A}$$

$$\sigma_1 = \frac{m \cdot a_{max} + P_{wind,h}(H \cdot W)}{A}$$

$$\sigma_1 = \frac{m \cdot a_{max} + P_D(H \cdot W)}{A}$$

$$\sigma_v = \frac{(R-1) \cdot \sigma_1 + \sqrt{(R-1)^2 \cdot \sigma_1^{\;2} + 4 \cdot R \cdot (\sigma_1^{\;2} + 3 \cdot \tau^2)}}{2 \cdot R}$$

If f_{redT}, f_{redD}, f_{redA} are not known the product f_{redT}, f_{redD}, f_{redA} can be taken equal to 0,2.

LC3 - Fatigue load

In this load case for tensile stress component it will be considered the longitudinal medium acceleration due to sea swell a_{med} of the glazing and the medium wind pressure or the design load (sea design pressure) in case of type 2 bonding arrangement. For shear component it will be considered the vertical acceleration a_{med} due to sea swell and (if the glazing is unsupported) the dead load; reduction factors shall be temperature, fatigue and aging.

$$\sigma_{zul} = \sigma_{lab} \cdot f_{redT} \cdot f_{redF} \cdot f_{redA}$$

$$\tau_{Unsupp} = \frac{m \cdot g + m \cdot a_{med}}{A}$$

$$\tau_{Supp} = \frac{m \cdot a_{med}}{A}$$

with (Type 2 bonding arrangement and also for Type 1 if the retainer is not built and connected to support p_D)

$$\sigma_1 = \frac{m \cdot a_{med} + P_{wind,h}(H \cdot W)}{A}$$

$$\sigma_1 = \frac{m \cdot a_{med} + P_D(H \cdot W)}{A}$$

$$\sigma_v = \frac{(R-1) \cdot \sigma_1 + \sqrt{(R-1)^2 \cdot \sigma_1^{\;2} + 4 \cdot R \cdot (\sigma_1^{\;2} + 3 \cdot \tau^2)}}{2 \cdot R}$$

If f_{redT}, f_{redF}, f_{redA} are not known the product f_{redT}, f_{redF}, f_{redA} can be taken equal to 0,05.

Bondline parameters limitations

In general, in order to limit edge stress concentration effects in the adhesive joint a limitation shall be considered for the width versus thickness ratio of the bondline as follows:

$1 \le w / d \le 3$

Other limitations are related to minimum values of the bondline parameters:

$w \ge 10$ mm

$d \ge 6$ mm

$b \ge 10$ mm

2) Design Loads

The design loads to be considered for the structural integrity evaluation of the adhesive joint shall be:

$$|(T_{design} \cdot T_{application})| = 70K$$

LC1

Self weight of the glazing (dead weight) to be taken by the joint - m (kg)

Gravity acceleration - g=9,81 m/s²

LC2

Acceleration value in strong sea swell conditions a_{max} = 19,62 m/s^2 (2g) (or a_v defined for the calculation of p2 if higher)

High wind pressure $P_{wind,h}$ = 2,5 kPa

LC3

Acceleration value in medium sea swell conditions a_{med} = 9.81 m/s^2 (1g)

Medium wind pressure $P_{wind,m}$ = 1,0 kPa

For unsupported glazing all above loading condition shall be considered.

For supported glazing above loading conditions shall be considered except LC1.

For Type 1 and Type 2 bonding arrangements (bonding from inside) water pressure loads P_D are dominating over wind loads P_{wind}.

For Type 1 if the retainer is designed according to the design load this means that the integrity evaluation of the adhesive joint for Type 1 will be performed only for inertial and wind loads.

For Type 1 and Type 4 bonding arrangement the mechanical fastener (retainer) shall be calculated (thickness and fixing) considering the relevant design load: 4 x P_D for Type 1 and 4 x P_W for Type 4.

To account for internal accidental load scenarios (e.g. accidental passenger loads, loads from shifting of furniture) as a minimum, the bonded joint shall be assessed to withstand an internal pressure of 3kN/m^2.

3) Design Parameters

The structurally bonded joints parameters are shown below.

Note that for a glass to glass arrangement, the glass to glass gap shall be around one time and half / two times the glass to flange gap.

Figure 25 : Bonded joint parameter "Glass to Flange" *(1/1/2017)*

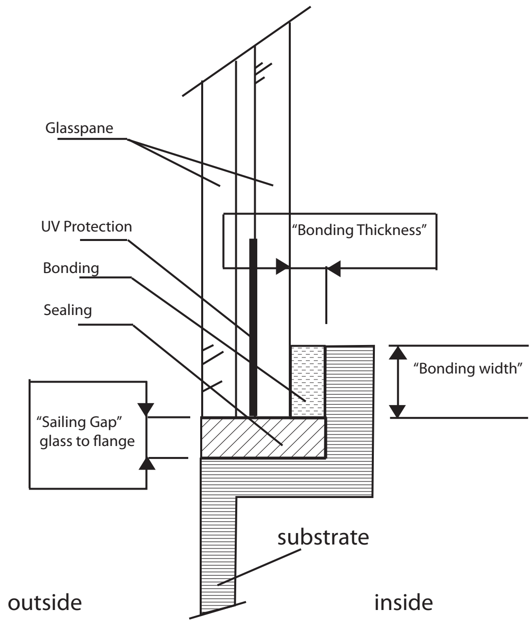
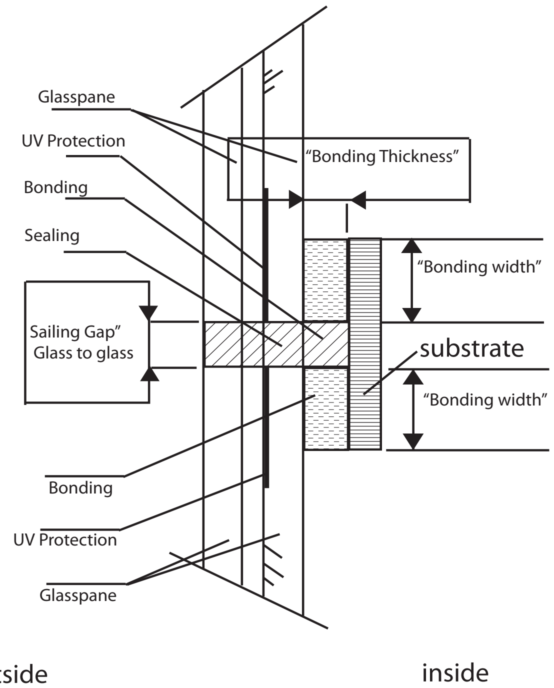


Figure 26 : Bonded joint parameters "Glass to Glass" *(1/1/2017)*



c) Bonding Installation

1) Bonding Application Guidelines

The bonding manufacturers shall provide guidance to the bonding installer to ensure that the product is used as intended. This guidance may include advice on:

- Storage and Shelf Life
- Environmental Conditions
- Chemical Compatibility
- Surface Preparation and Priming
- Use of Spacer, Setting Block and Resting Pad
- Alignment and Tolerances
- Mixing and Application
- Cure
- Sealing and UV Protection
- Maintenance Inspection & Testing

2) Bonding Installation Procedure

The bonding installer shall develop specific bonding procedures for their products. These shall be used by the workers undertaking the installation, and act as a permanent record that the guidance of the Bonding Manufacturer was followed.

Bonding personnel shall be suitably experienced.

Survey requirements for bonding and sealing are detailed in [5.6.3] of this standard.

d) Testing

1) Testing of Materials

Adhesive material properties shall be provided by the adhesive manufacturer on the basis of the design parameters outlined above namely:

lab - Characteristic Strength value at lab condition (95% confidence limit)

fred,T - Reduction factor for temperature exposure (70 °C)

fred,S - Reduction factor for permanent static load

fred,D - Reduction factor for dynamic cyclic load (10.000 cycles)

fred,F - Reduction factor for fatigue cyclic load (> 107 cycles)

fred,A - Reduction factor for aging conditions

R - Ratio compression strength to tensile strength

c - Elastic limit of shear strain

Reference for adhesive material characterization shall be DIN 6701-3 appendix A.

The characteristic strength value at lab conditions shall be determined using "component-like" specimens, reflecting the loading situation as real as possible, e.g. lap-shear specimen (EN 1465) or tensile H-specimen (ISO 8339). The characteristic strength value shall represent the 95% probability of no failure (ISO 16269:2009).

For solutions different to what above the characteristic of the bonding have to be evaluated by test and declared by the Manufacturer. The value of the strength obtained with the above mentioned tests have to be compared with the value of stresses in the gluing obtained by a FEM analysis. The procedure to carry out fem analysis is to be agree with Tasneef The value of safety factor is to be agreed with Tasneef

Windows fitted in such a way that the adhesive is in tension are not to be fitted in the hull and in superstructure contributing to buoyancy.

The a.m. calculation is to be carried out also in case of a windows with a frame that is glued to the hull (e.g. grp hull) provided that the characteristic of the glass are replaced by the characteristic of the material of the frame.

As an alternative to the calculation of the bonding above required, an hydrostatic test carried out at a pressure of at least 4 p_D may be accepted. If the cross section has been already qualified in accordance with [5.6.8] the sample may be only one.

In metallic vessels of more than 90 m in length and on wooden yachts of any length on the hull the bonding is not acceptable.

When the area of the window is higher than 2,5 m^2 for yachts of more than 90m where the structure is subject also to longitudinal global loads the bonding is to be designed to receive the movements of the structure. A detailed calculation is to be sent.

In zone 1c and 2c glued glazing are normally not to be fitted. The windows have to be framed and mechanically connected.

2) Test of the bonding

As an alternative for glass fitted in superstructure not contributing to buoyancy the following test may be carried out:

- Inside pressure test

  The sample shall consist of a flat plate with an unsupported area between 0,02 m^2 and 0,16 m^2, made with the same jointing procedure, plate and support material as used by the manufacturer of the appliance.

  The test sample gluing area, Asg, expressed in square metres, is determined from:

  Asg = lp (af + as)

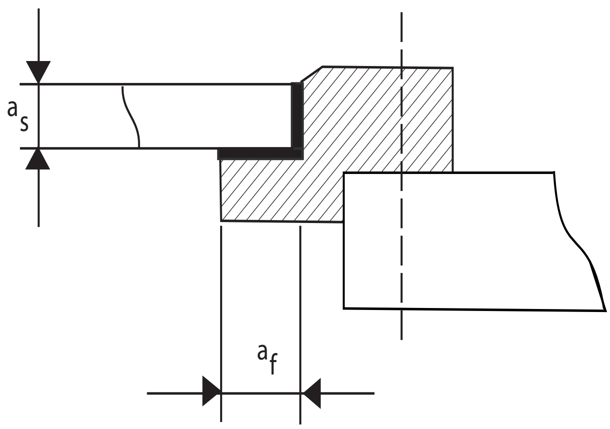
  where:

  lp is the plate perimeter, expressed in metres;

  af is the face gluing dimension, expressed in metres;

  as is the side gluing dimension, expressed in metres.

Figure 27 *(1/1/2017)*



The test procedure consist of Using a suitable jig to apply an inside water pressure of at least 625 Asg, expressed in kilopascals, tending to push the plate out of its support.

The test pressure shall be maintained for at least 3 min.

The test is passed if there is no apparent damage to the glue joint and no sign of leakage.

- Separation test

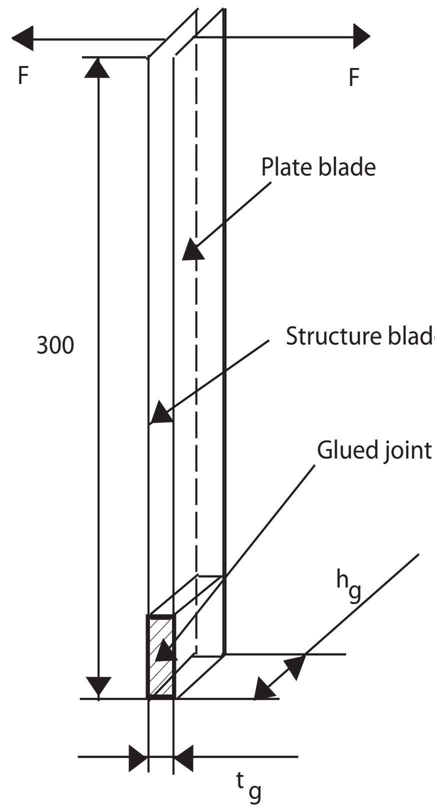
  Two test blades, 300 mm by 25 mm, shall be made from the same materials as the plate and structure to be glued together. The thicknesses of the blades shall be the same as those of the actual plate and structure.

  The test blades shall be glued together with the same glue joint dimensions (thickness, tg, and height, hg) and gluing procedure as used on the craft.

  The procedure consist of applying two equal and opposite forces, F, to the sample.

  F is applied up to the point of breaking or permanent deformation of one element of the blades of the sample. The separation forces may be induced manually.

Figure 28 *(1/1/2017)*



The test is passed if one of the three following conditions is met:

- one of the test blades yields or breaks before any visible yielding or breaking of the glue joint during the test;
- no permanent deformation nor break is shown inside the glue joint after the test;

- the glue joint disconnects from one of the test blades, and some part of the blade (delamination, woodbreaking, etc.) has been torn away.

The bonding is to be suitable for the environment and to be protected from ageing effects.

The above mentioned test have to be carried out on a suitable number of samples representative of the dimension of the opening and the material used (e.g. GRP laminate - thermally strengthened glass or GRP sandwich - chemically strengthened glass, or aluminium- thermally strengthened glass, … etc)

The test may be witnessed by Tasneef or not in this second case a Declaration is to be issued by the Manufacturer or the Shipyard.

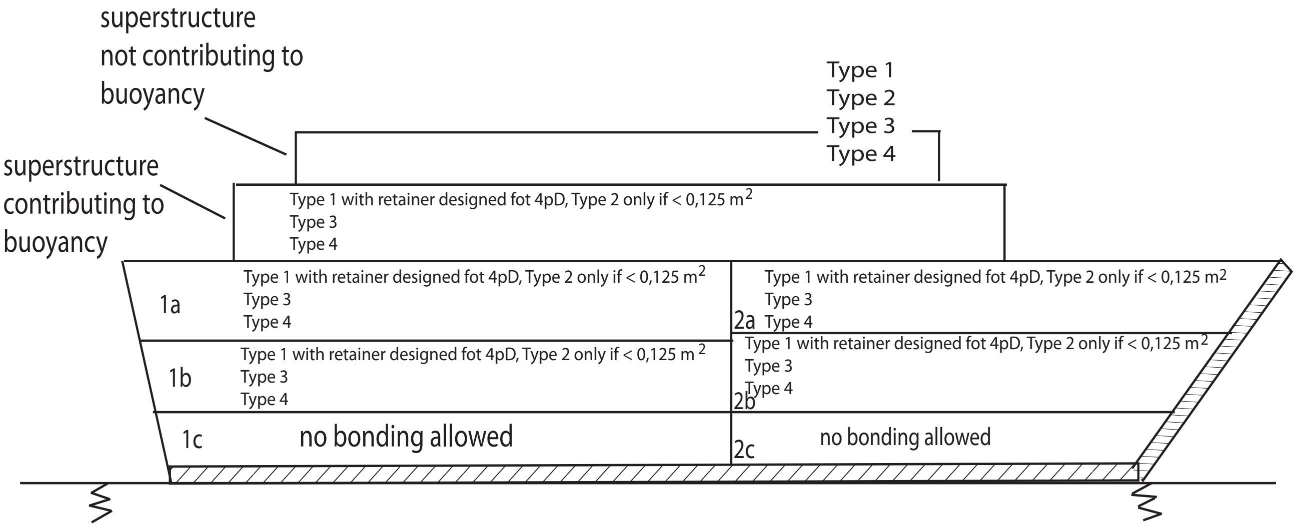
When the bonding does not satisfy 14.1 or 14.2 what above it has to be tested hydrostatically and mechanically at a pressure of at least 4 p_D.

The test is to be carried out on a mockup representative of the situation on board as far as glass thickness substrate and dimensions.

The test apparatus and method shall be consistent with the actual installation on board.

Possibilities of verification for yachts of less than 90m

Figure 29 *(1/1/2017)*



5.6.15 Openable portholes glued to larger fixed windows *(1/1/2021)*

a) In Zone 1a and in the superstructures not contributing to the buoyancy it is normally acceptable to install one or more not easy openable portlights, with the same or with different shapes, glued to larger non openable windows provided that the following conditions are satisfied:

1) The gluing of the fixed windows to the hull or the superstructure is in accordance with [5.6.14] of this paragraph, having considered the glass representative of the windows glued to the material of the hull with the adhesive used.
2) The gluing of the frame of the portlight to the fixed window is in accordance with [5.6.14] of this paragraph, having considered the glass representative of the windows glued to the material of the frame of the portlight with the adhesive used.
3) The scantling of the glazing of the windows is calculated and verified in accordance with this paragraph.
4) The scantling of the glazing of the portlight is calculated and verified in accordance with this paragraph.
5) The total area of the portlights is to be not more than 20% of the area of the fixed windows where it is glued. The total area of the portlights may be increased up to 50% of the fixed windows area if the thickness of the fixed window is increased of at least 30%.
6) The distance of the portlight from the windows sides is not less than the half of the diameter of the portlight if it is circular or half of the shorter side of the portlight if it is rectangular. If more than one porlight are glued to one fixed window also the distance between the portlights is to be not less than the diameter or the shorter side or the diameter of the larger portlight.
7) If fitted in Zone 1a the portlight and the windows are provided with a deadlight or equivalent arrangement covering both, in accordance with [5.6.4]. of this paragraph.
8) The fixed windows has laminated glass.

   Only for superstructure not contributing to buoyancy monolithic thermally strengthened glass for the fixed window may be accepted provided that a removable storm shutter is to be provided for the whole arrangement.
9) An indication is given in a suitable continuously manned position when the portlight/s is/are open.
10) The portlights are to be of a not readily openable type if fitted on the hull.
11) A mockup of the whole arrangement (hull or superstructure + fixed windows + portlight) without

deadlights and with the portlight closed is to be hydraulically tested at a pressure not less than $4P_D$ applying the procedure detailed in [5.6.16]. If the portlight has been already tested separately (in accordance to what required by this paragraph) and the large window is glued to the hull the test pressure may be reduced to p_D. If the large window has a frame and the portlight has been already tested separately (in accordance to what required by this paragraph) for the whole arrangement the test pressure may be reduced to p_D and the large window is to be subject also to a mechanical test in accordance with ISO 614 at a pressure of 3 p_D.

When a hydrostatic test is required to a pressure of p_D the test procedure to be used is always the one reported in [5.6.16] but instead of p_D the first part of the test is to be carried out at $0.25p_D$ and instead of 4 p_D in the last part is to be reached p_D.

b) In Zone 1b, 2a and 2b it is acceptable to install not easy openable portlights glued to larger non openable windows provided that the following conditions are satisfied:

1) The requirements from A) 1. to A) 11. are satisfied.

2) A dedicated analysis is carried out showing that the consequences in terms of stability, accessibility of means of escape, etc of a flooding of the spaces to which the fixed windows give access are considered reasonable by Tasneef taking into account the service and the use of the yacht taking into account what is reported at Fig 6.

c) In Zone 1c and 2c it is normally not acceptable to install not easy openable portlights glued to larger non openable windows.

The hydraulic test detailed in A) 11. above may be considered acceptable also for other arrangement slightly different provided that it is satisfied what below:

- The fixed windows fitted on board has the shape and its diameter, if it's circular, or both the sides, if it's rectangular shorter than the sides of the windows tested.
- The portlight/s fitted on board has/have its/their shape and its/their diameter, if circular, or both the sides, if rectangular, shorter than the diameters or the sides respectively of the portlight tested.
- The arrangement fitted on board satisfies all the other requirements set out above from 1. To 10.
- The thickness or the thicknesses of the lamination of the fixed windows and the thickness or the thicknesses of the lamination of the portlights are the same or are greater than the ones tested.
- In order to evaluate which is the most unfavorable position of the portlight/s special considerations is to be done to the maximum deflection of the large window (When applying [5.6.9] the maximum deflection to be taken equal to of $\alpha p/300$.

The fixed windows may have a frame or be glued according to what requested in the previous subparagraph of this paragraph.

As far as the assessment procedure for the verification of the deadlight and the connection hull-window and portlight-window reference to be made to [5.6.18].

Note 1: Within the scope of this subparagraph the indication of the Zones is to be referred to the position of the fixed windows, not of the portlight/s.

5.6.16 Hydraulic test *(1/1/2017)*

Where an hydraulic test is required it is to be carried out as here indicated.

The test shall be carried out using a testing basin which ensures the watertightness up to the requested test pressure. The basin shall show the real assembly situation on board, using identical or equivalent materials and dimensions.

The filling water piping and the basin pressure measuring piping shall be separated.

During filling the basin with water, ensure that air trapping is eliminated or at least minimized.

The supporting structure of the tested window system shall be stiff enough to prevent edge deflection which will influence the test results.

It is a technical responsibility of test operators to run tests with calibrated measuring instruments meeting metrological criteria in terms of reference to international measuring unit system, accuracy and repeatability.

The tested sample shall be representative of the glazed opening construction and installation on board. A drawing of sample construction and fixing shall be provided and included in the test documentation.

The test shall be carried out by laboratories or institutions meeting, in general, the requirements of ISO/IEC 17025.

Alternatively, window manufacturers fulfilling the equivalent minimum standard may perform such tests.

The test shall be carried out as follows:

Procedure A:

a) Dimensions of all main components (basin and glazed opening) shall be checked and recorded.

b) Measuring instruments gauges shall be calibrated.

c) Design test pressure, P_D (kN/m^2), is to be established.

Chamber pressure shall be raised up to P_D and maintained for at least 5 min. The pressure in the test chamber shall be raised up to design factor times the design load pressure (y x P_D).

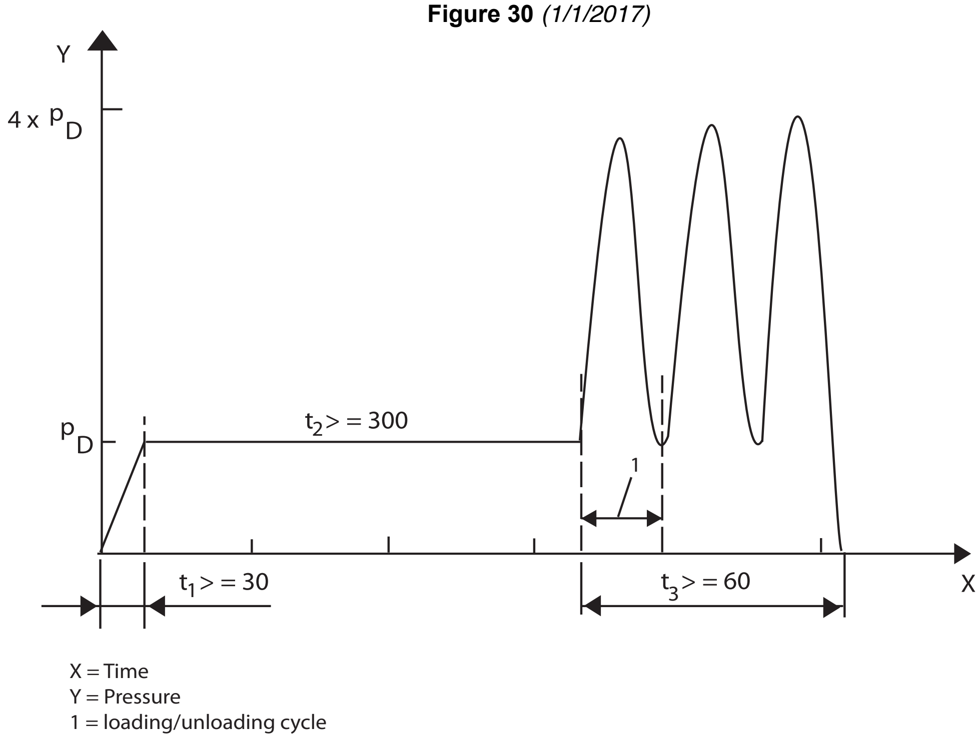
Three unloading/loading cycles shall be performed within the pressure range from 1 x PD to y x PD starting at below 1/2 y x P_D and going to y x P_D.

d) Central deflection shall be measured and recorded up to the design pressure. The basin pressure shall be measured and recorded continuously during the test.

e) Any event such as loss of watertightness (from the glazing or from the fixing system) or glass plies breakage shall be recorded by the test operators with the relevant test pressure

f) Unless otherwise specified and if possible, the sample shall be taken to final collapse.

Figure 30 *(1/1/2017)*



Procedure (B):

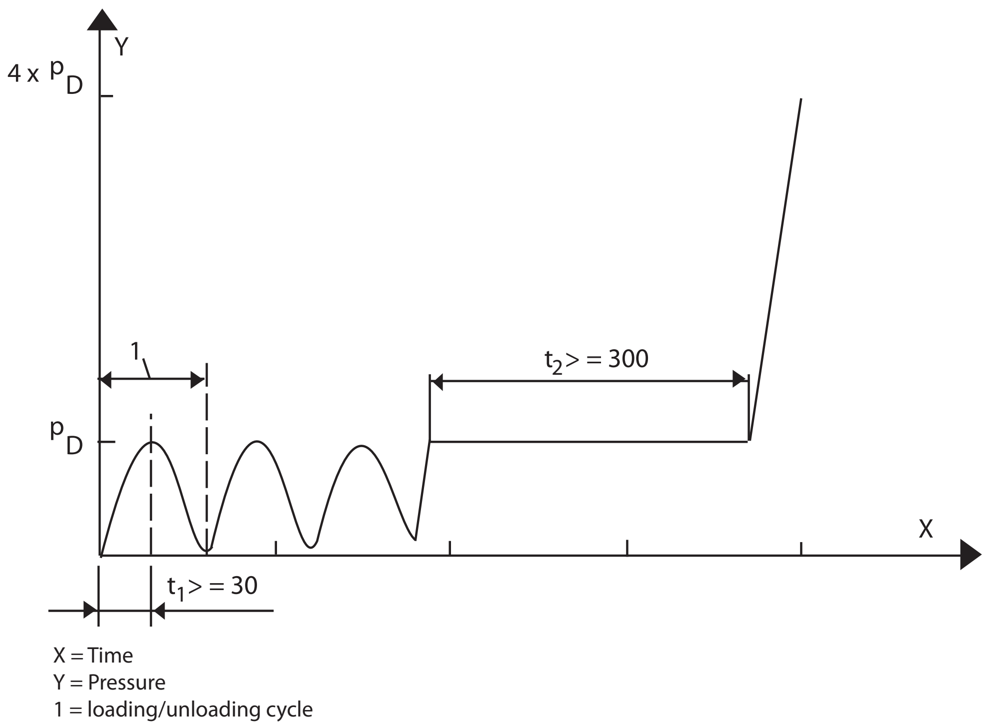
Preliminary operations included in procedure (A) [namely a), b) and c)] shall be completed.

Pressure cycle shall be as in the figure below (cyclic phase, hold phase and final rise to test pressure).

Operations requested for procedure (A) [namely d), e) and f)] shall be completed.

Chamber pressure shall be raised up to P_D and three unloading/loading cycles shall be performed within the pressure range from unloaded to P_D. Then the pressure should be maintained for at least 5 min. Finally the water pressure shall be raised up to 4 times the design load pressure (4 x P_D).

Figure 31 *(1/1/2017)*



Procedure (C):

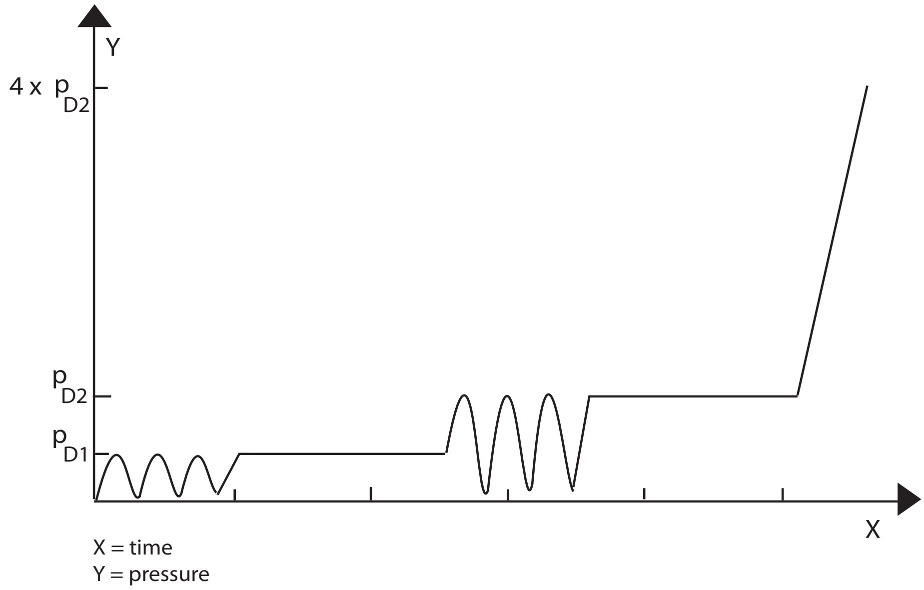
This is a procedure for a stepped test, in which one glass construction is tested for two (or more) different design loads.

Preliminary operations included in procedure (A) [namely a),b) and c)] shall be completed.

Pressure cycle shall be as in the figure below (cyclic phase at pressure P_{D1}, cyclic phase at pressure P_{D2}, hold phase and final rise to test pressure).

Operations requested for procedure (A) [namely d), e) and f)] shall be completed.

Figure 32 *(1/1/2017)*



The test is passed if the system withstands the design factor times P_D load pressure without failure of any part of the system and the watertightness is maintained. Design pressure shall be reached in not less than 30 s for both procedure (A) and (B) and first design pressure for procedure (C) and the three unloading/loading cycles for procedure (A) shall be performed in not less than 60 s. Providing that the fixing system is maintained in terms of construction details, geometrical dimensions and materials, and the pane cross section is identical, test acceptance may be extended to any glazed opening with lower requirements regarding strength (design pressure P_D) and size.

Any changes to the glazing materials or any change to the cross section or larger dimensions of the glazing shall require re-testing.

Tolerances for size extension are limited to a maximum of 5% of each individual clear length of the glazing.

In case of earlier breakage of the sample the maximum achieved pressure value can be divided by safety factor in order to define the maximum load capacity for the tested glass construction.

5.6.17 Test for the equivalence between polycarbonate and other interlayer materials *(1/1/2019)*

a) Hydrostatic test (mandatory for zones 1a, 1b, 2a)

Aim of the test

Demonstration of the suitability of the interlayer material (IM) as alternative to a traditional deadlight.

Samples

A technical specification stating chemical/physical properties of the interlayer material and polycarbonate must be delivered to Tasneef Surveyor.

One panel of size 500 mm x 500 mm is to be prepared, mounted on the same tank, consisting of laminated glass having composition 8 mm thermally strengthened glass /3 mm IM Interlayer/8 mm thermally strengthened glass.

The outer pane of the panel will be fractured, creating cracks that extend throughout the depth of stratified in such a way as to put pressure on the face of the IM and polycarbonate.

Description and evaluation of test result.

The panel will then be brought to the test pressure prescribed in Regulation (4x20kPa = 80 kPa) putting the fractured slab in contact with water under pressure.

Under these circumstances you must ensure that watertight integrity is maintained (waterproof) for a time of at least 15 minutes.

A limited infiltration of water can be tolerated, not exceeding 0.3 litres/hour, which will be recorded in the test report.

b) Impact test (additional to the hydrostatic test above and mandatory for zones 2b)

1st option: test with ISO 614:

- Prepare a panel with laminated glass. The thickness of the 2 layers of glass may be equal or different. The interlayer is to be at least 3mm of the material that it's intended to certify. The area of the panel to be at least 0,85m[2].

- Destroy or damage significantly the external glass layer.
- Apply on the damaged side a load of at least 2 time the pressure required in area 2b. This means the load applied by the punch (N) divided by the area of the glass (mm[2]). This pressure is to be more than $2*P_D$. If the glass reaches the maximum deflection without the interlayer breaking another test is to be carried out on glass with diameter 150mm or 200mm and it's to be recorded the pressure when the interlayer breaks. This pressure is to be more than $2*P_D$.

2 nd option: test with EN ISO 356:

- Prepare a panel with laminated glass. The thickness of the 2 layers of glass may be equal or different. The interlayer is to be at least 3mm of the material that it's intended to certify. The area of the panel to be in accordance with the rule.
- Destroy or damage significantly the external glass layer.
- The interlayer is to withstand the test foresee by the rule without breakage. The category p5A to be reached.
- Axe test is not required, for the rest the rule to be applied fully.

The tests to be witnessed by Tasneef

The tests to be carried out by the Manufacturer of the glass.

For both the a.m. tests a statement will be issued by Tasneef which can be used for all subsequent deliveries with the same thickness, chemical/physical characteristics and type of interlayer (3 mm IM), providing a declaration of conformity.

5.6.18 Assessing procedure *(1/7/2017)*

Glazing and fixing system (frames, bonding …) installed on board of a yacht on the hull or in superstructure contributing to the buoyancy have to be assessed in accordance with the following procedure:

a) Glued glazing without frame, with or without deadlight if:
   - the relevant cross section has been assessed in accordance to the scantling determination procedure above indicated, and
   - the bonding has been assessed in accordance with [5.6.14] a) or [5.6.14] b) using a suitable number of different glazing thicknesses (normally the thinner and the higher of the monolithic glazing used on board and at least 4 types of laminates representative of those used on board). The procedure of gluing and the list of the adhesives that may be used have to be available on board.

     No test are required while, if the glazing cross section has been assessed in accordance to the scantling determination procedure above indicated, an hydrostatic test as described above, understood as a qualification of the bonding system, has to be performed a pressure of at least 4 p_D for a selected number of cross sections and for the larger dimension of the window.

     In location where deadlights are required (see [5.6.4]):

     - if they are already dimensioned in accordance with [5.6.4] an hydrostatic test at the design pressure p_D is to be carried out on a mockup consisting of the deadlight and the hull an it's intended only to verify the fixing arrangement. It may be carried out on the largest and thinner deadlight,
     - if they are not already dimensioned in accordance with [5.6.4] in addition to the hydrostatic test above mentioned a mechanical test in accordance with ISO 614 on a mockup consisting of the hull and the deadlight closed at a pressure at least equal to 2 p_D is to be carried out.

b) Mechanically connected glazing with frame, fixed or not easy openable, with or without deadlight:
   - the connection of the frame and the hull have to be approved.

     If the relevant cross section has been assessed in accordance to the scantling determination procedure above indicated and the frame is in accordance with [5.6.14].

     - opt 1.a

       an hydrostatic test as described above, has to be performed on one sample for each cross section and each dimension (same material and same details) at a pressure of at least 4 p_D on the portlight
     - opt 2.a
       - an hydrostatic test as described above, has to be performed on one sample for each cross section and each dimension (same material and same details) at the design pressure on the portlight
       - a mechanical test in accordance with ISO 614 on the portlight at a pressure of at least 3 p_D

       while, if:

       only the relevant cross section has been assessed in accordance to the scantling determination procedure above indicated,
     - opt 1.b
       - an hydrostatic test as described above, has to be performed on one sample for each cross section and each dimension (same material and same details) at 4 times the design pressure on the portlight.
       - a mechanical test in accordance with ISO 614 on the portlight at 2 times the design pressure (this may be avoided if the frame is in accordance with [5.6.14])
     - opt 2.b
       - an hydrostatic test as described above, has to be performed on one sample for each cross

section and each dimension (same material and same details) at the design pressure on the portlight

- a mechanical test in accordance with ISO 614 on the portlight at 4 times the design pressure

c) Glazing with frame glued to the hull, with or without deadlight

For the windows and its frame see the tests required above in A.2 and for the bonding see what required for A.1.

In location where deadlights are required (see [5.6.4]):

- if they are already dimensioned in accordance with [5.6.4] an hydrostatic test at the design pressure p_D is to be carried out on a mockup consisting of the deadlight and the hull an it's intended only to verify the fixing arrangement. It may be carried out on the largest and thinner deadlight,
- if they are not already dimensioned in accordance with [5.6.4] in addition to the hydrostatic test above mentioned a mechanical test in accordance with ISO 614 on a mockup consisting of the hull and the deadlight closed at a pressure at least equal to 2 p_D is to be carried out.

If a fixed or not easy openable window has been already tested in accordance with ISO 614 at a pressure of at least 3 p_D and also the deadlight has been subject to the mechanical test in accordance with ISO 614 at a pressure of at least 2 p_D, the hydrostatic test may be waived if after visual inspection and taking into consideration the result of the mechanical tests on the deadlight and on the portlight the Surveyor considers it unnecessary.

After the test in accordance with ISO 614 on the deadlight, any permanent deformation shall not be more than 1 % (0,01 times) the smaller dimension of the clear opening.

When a mechanical test on the portlight is required it is to be performed adding a steel plate of suitable thickness leaning on the frame and the punch is to push on the steel plate. After the test the permanent deformations of the frame are not be more than 1% of the smaller dimension of the frame.

The materials has to be tested by Tasneef

For windows or portlights with frame at the request if the Manufacturer a type approval may be issued. The type approval is valid for 5 years.

When the hydrostatic test is required it is to be carried out in accordance with [5.6.16], where the maximum pressure required is different from 4p_D where in [5.6.16] is written 4p_D it is to be substitute by the maximum pressure required.

Arrangement different from the ones indicated above will be considered on a case by case base.

In any case glazing not assessed in accordance to the scantling determination procedure are normally not acceptable in any case it to be required at least an hydrostatic test carried out on at least three samples with the same cross section, dimensions and details at a pressure of at least 4 times the design pressures to be carried out.

All the test required in this paragraph except where written different has to be witnessed by Tasneef

After installation on board every glazed opening have to be subject to waterjet test at the Surveyor's satisfaction.

In the Tab 10 below are reported all the possibilities of assessment and the required documentation.

Table 10 *(1/1/2023)*

	Verification of the connection the hull	Preliminary acceptance of the glass	Verification of the glass thickness according to the position and the dimension	Verification of the windows/portlight as product (the connection between glass and frame and the fixing arrangement)	Verification of the deadlight and its fixing arrangement **(2)**
Fixed glass without frame glued to the hull with or without deadlight	Bonding in accordance with [5.6 14]b1) • calculation • declaration of bonding characteristic • bonding application guidance OR Bonding tested in accordance with [5.6 14]d) 2) where possible • bonding application guidance OR • hydrostatic test on a make-up at a pressure of at least 4 P_D (3 samples)	• Punch test in accordance with ISO 614 OR • hydrostatic test in accordance with [5.6 5]	Scantling of the glass in accordance with Subparagraphs from [5.6.8] to [5.6.13]: • drawing of the glazing • calculation • declaration of Sc and c_D from Manufacturer • test on 3 samples in accordance with ISO 1288-3 or Declaration from the Manufacturer in accordance with [5.6.8] (only for chemically strengthened glasses) • test in accordance with ISO 1288-3 on 10 samples where required • calculation and/or Manufacturer's declaration where required in [5.6.10] for acceptance of thickness range OR • hydrostatic test on a make-up at a pressure of at least 4 P_D (3 samples)	-	• deadlight in accordance with [5.6 4] • calculation • hydrostatic test on the deadlight at a pressure of at least P_D **(1)** OR • mechanical test in accordance with ISO 614 on the deadlight at a pressure of at least 2 P_D • hydrostatic test on the deadlight at a pressure of at least P_D **(1)**

(1) The test may be waived after visual inspection of the result of mechanical test on the window/portlight at a pressure of at least 3 P_D and on the deadlight at a pressure of at least 2 P_D

(2) As far as the equivalence between 3mm of polycarbonate and other type of interlayer's material to avoid the deadlight see [5.6.17]

	Verification of the connection the hull	Preliminary acceptance of the glass	Verification of the glass thickness according to the position and the dimension	Verification of the windows/portlight as product (the connection between glass and frame and the fixing arrangement)	Verification of the deadlight and its fixing arrangement **(2)**
Glass with frame fixed or not easy openable glued to the hull with or without deadlight	Bonding in accordance with [5.6 14]a): • calculation of the bonding or fem • declaration of bonding characteristic • bonding application guidance OR Bonding tested in accordance with [5.6 14]d) 2) where possible • bonding application guidance OR • hydrostatic test on a make-up at a pressure of at least 4 P_D (3 samples)	• Punch test in accordance with ISO 614 OR • hydrostatic test in accordance with [5.6 5]	Scantling of the glass in accordance with Subparagraphs from [5.6.8] to [5.6.13]: • drawing of the glazing • calculation • declaration of Sc and c_D from Manufacturer • test on 3 samples in accordance with 1288-3 or Declaration from the Manufacturer in accordance with [5.6.8] (only for chemically strengthened glasses) • test in accordance with 1288-3 on 10 samples where required • calculation and/or Manufacturer's declaration where required in [5.6.10] for acceptance of thickness range OR • hydrostatic test on a make-up at a pressure of at least 4 P_D (3 samples)	Opt 1a • frame in accordance with [5.6.14] • hydrostatic test on the windows/portlight at a pressure of at least 4 P_D Opt 2a • frame in accordance with [5.6.14] • hydrostatic test on the windows/portlight at a pressure of at least P_D • mechanical test in accordance with ISO 614 on the windows/portlight at a pressure of at least 3 P_D Opt 1b • hydrostatic test on the windows/portlight at a pressure of at least 4 P_D • mechanical test in accordance with ISO 614 on the portlight at a pressure of at least 2 P_D Opt 2b • hydrostatic test on the windows/portlight at a pressure of at least P_D • mechanical test in accordance with ISO 614 on the portlight at a pressure of at least 4 P_D	• deadlight in accordance with [5.6 4] • calculation • hydrostatic test on the deadlight at a pressure of at least P_D **(1)** OR • mechanical test in accordance with ISO 614 on the deadlight at a pressure of at least 2 P_D • hydrostatic test on the deadlight at a pressure of at least P_D **(1)**

(1) The test may be waived after visual inspection of the result of mechanical test on the window/portlight at a pressure of at least 3 P_D and on the deadlight at a pressure of at least 2 P_D

(2) As far as the equivalence between 3mm of polycarbonate and other type of interlayer's material to avoid the deadlight see [5.6.17]

	Verification of the connection the hull	Preliminary acceptance of the glass	Verification of the glass thickness according to the position and the dimension	Verification of the windows/portlight as product (the connection between glass and frame and the fixing arrangement)	Verification of the deadlight and its fixing arrangement **(2)**
Glass with frame fixed or not easy openable mechanically connected to the hull with or without deadlight	The mechanical connection is to be approved: • drawing with the detail of the connection	• Punch test in accordance with ISO 614 OR • hydrostatic test in accordance with [5.6 5]	Scantling of the glass in accordance with subparagraphs from [5.6.8] to [5.6.13]: • drawing of the glazing • calculation • declaration of Sc and c_D from Manufacturer • test on 3 samples in accordance with 1288-3 or Declaration from the Manufacturer in accordance with [5.6.8] (only for chemically strengthened glasses) • test in accordance with 1288-3 on 10 samples where required • calculation and/or Manufacturer's declaration where required in [5.6.10] for acceptance of thickness range OR • hydrostatic test on a make-up at a pressure of at least 4 P_D (3 samples)	Opt 1a • frame in accordance with [5.6.14] • calculation • hydrostatic test on the windows/portlight at a pressure of at least 4 P_D Opt 2a • frame in accordance with [5.6.14] • hydrostatic test on the windows/portlight at a pressure of at least P_D • mechanical test in accordance with ISO 614 on the windows/portlight at a pressure of at least 3 P_D Opt 1b • hydrostatic test on the windows/portlight at a pressure of at least 4 P_D • mechanical test in accordance with ISO 614 on the portlight at a pressure of at least 2 P_D Opt 2b • hydrostatic test on the windows/portlight at a pressure of at least P_D • mechanical test in accordance with ISO 614 on the portlight at a pressure of at least 4 P_D	• deadlight in accordance with [5.6 4] • calculation • hydrostatic test on the deadlight at a pressure of at least P_D (1) OR • mechanical test in accordance with ISO 614 on the deadlight at a pressure of at least 2 P_D • hydrostatic test on the deadlight at a pressure of at least P_D **(1)**

(1) The test may be waived after visual inspection of the result of mechanical test on the window/portlight at a pressure of at least 3 P_D and on the deadlight at a pressure of at least 2 P_D

(2) As far as the equivalence between 3mm of polycarbonate and other type of interlayer's material to avoid the deadlight see [5.6.17]

5.7 Skylights

5.7.1 *(1/1/2017)*

The relevant locking devices are to be the same as required for flush hatches (see [5.5.3]).

For yachts of 500 GT and over the skylight glazing material and its method of securing within the frame are to meet the requirements of Pt B, Ch 9, Sec 9 of the Tasneef Rules or an equivalent national or international standard.

5.7.2 *(1/1/2017)*

A minimum of one portable cover for each size of glazed opening is to be provided which can be assessed rapidly and efficiently secured in the event of breakage of the skylight.

5.7.3 *Skylights which are designated for escape purposes are to be openable from either side and in the direction of escape they are to be openable without a key.*

All handles on the inside are to be non-removable. An escape skylight is to be readily identified and easy and safe to use, having due regard to its position.

5.8 Outer doors

5.8.1 Doors in the superstructure's side *(1/1/2019)*

Doors of exposed bulkheads of superstructures are to be of adequate dimensions and construction such as to guarantee their weathertight integrity and to be hinged in the forward edge.

The use of FRP for doors on the weather deck other than machinery spaces may be accepted, providing the doors are sufficiently strong.

For glazed doors see [5.6.2].

Where the doors may be required to be used as a means of escape, the securing arrangements are to be operable from both sides.

Where the doors may be required to be used as a means of escape, and are electrically operated they have to be also manually operable from both sides of the door in case of failure of the electrical system.

If the door is not fitted with mechanical means (or an approved redundant electrical mean) to keep it closed in emergency after a single failure it is to be treated as an easy openable window.

Doors to be kept closed during navigation and if openable out of the harbor indication in the wheelhouse of the door open is to be foreseen.

The height of the sills of doors above the exposed deck that give access to compartments below the deck is to be not less than the following value:

	Deck position 1	Deck position 2
Outer doors	100 mm	75 mm
Companionways	100 mm	75 mm

Doors on the weather deck which give direct access to machinery spaces are to have a minimum of six clips and to be outward opening.

Doors on the weather deck to 1st tier accommodation or other spaces protecting access below may have four clips.

5.9 Drawings

5.9.1 A plan showing the position portlights, windows, skylights, external doors and glass walls is to be submitted; their dimensions, their sills is to be clearly indicated.

5.10 Ventilation ducts

5.10.1 General

Accommodation spaces are to be protected from gas or vapour fumes from machinery, exhaust and fuel systems. The yacht is to be adequately ventilated throughout all spaces. The accommodation is to be protected from the entry of gas and/or vapour fumes from machinery, exhaust and fuel systems.

Ventilation ducts are to be of efficient construction and, generally, when serving any spaces below the freeboard deck or an enclosed superstructure are to have a coming of a minimum height as indicated in Tab 11.

Table 11

Location	Coming height (mm) Short range navigation	Coming height (mm) Unrestricted navigation
Forward quarter length	450	900
Elsewhere	380	760

Ventilation ducts are to be kept as far inboard as practicable and the height above the deck of the ventilation ducts openings is to be sufficient to prevent the ingress of water when the vessel heels.

Machinery spaces are to be adequately ventilated so as to ensure that, when machinery therein is operating at full power in all weather conditions, an adequate supply of air is maintained to the spaces for safety and for the operation of the machinery, according to the Manufacturer's instructions.

The design and positioning of ventilation duct openings are to be considered with care, above all in zones of high stress or in exposed zones. The deck plating in way of the coamings is to be adequately stiffened.

The scantlings of ventilation ducts exposed to the weather are to be equivalent to those of the adjacent deck or bulkhead.

Ventilation ducts are to be adequately stayed.

Ventilation ducts which, for any reason, can be subjected to liquid pressure are to be made watertight and have scantlings suitable for withstanding the foreseen pressure.

For engine exhaust outlets, reference is to be made to [5.3.3].

5.10.2 Closing appliances *(1/1/2021)*

All ventilation ducts openings are to be provided with efficient weathertight closing appliances unless:

- The height of the coaming is greater than 4,5 m if in Position 1;
- The height of the coaming is greater than 2,3 m if in Position 2.

As a general rule, closing appliances are to be permanently attached to the ventilation ducts coaming.

Ventilation ducts are to be fitted with a suitable means of preventing ingress of water and spray when open and have a suitable drainage arrangements leading overboard.

5.11 Air pipes

5.11.1 General

Air pipes serving fuel and other tanks is to be of efficient construction and provided with permanently attached means of weathertight closure. Means of closure may be omitted if it can be shown that the open and of an air pipe is afforded adequate protection by other structures which will prevent the ingress of water.

In addition, air and sounding pipes are to comply with the requirements of Pt C, Ch 1, Sec 9, [7].

5.11.2 Height of air pipes

Where located on the weather deck, air pipes are to be kept as far inboard as practicable and be fitted with a coming of sufficient height to prevent inadvertent flooding. Generally, air pipes to tanks are to have a minimum coming height as indicated in Tab 13.

Table 12

Location	Coming height (mm) Short range navigation	Coming height (mm) Unrestricted navigation
On weather deck	380	760
Elsewhere	225	450

5.12 Bulwarks and guardrails or guardline

5.12.1 General *(1/7/2021)*

Bulwarks or railings are to be arranged on exposed decks.

Where this is not practicable, handrails or stays are to be provided.

Bulwarks are to be of strong construction and adequately supported.

The height of bulwarks or rails, or a combination of both, is to be not less than 1000 mm.

The maximum clearance below the lowest course of the guardline is to be 230 mm. The other courses of guardline are to be not more than 380 mm.

The stanchions are to be spaced at not more than 2,2 m.

The scantling of a solid bulwark is to be equivalent of that of the adjacent structures of the side shell.

External glass balustrades are to provide water freeing areas in accordance with [5.13]. Openings for water freeing are to be not more than 230 mm.

Stanchions and top rail are to be able to withstand the a load of at least 1 kN in the most critical point. The scantling of the top rail and the stanchions to be carried out in accordance with [5.12.2].

If the scantling of the top rail and the stanchions is not in accordance with [5.12.2], direct calculation with 1 kN as concentrated load are to sent.

Notwithstanding of the application of [5.12.2] or the alternative calculation a practical test in accordance with ISO 15085 using 1 kN instead of the value proposed by the a.m. ISO standard is required. No permanent deformation has to occur. If the top rail yield strength more than 315N/mm^2, has minimum section modulus of at least 17cm^3 and the stanchions has yield strength more than 315 N/mm^2, minimum section modulus of 20 cm^3 if spaced up to 1,5m and 40 cm^3 if spaced up to 2,2 m the a.m. test is not required.

The material used for the construction of the stanchions and the top rail is to have minimum yield strength of at least 235 N/mm^2.

For yachts of less than 500 GT. The minimum section modulus of the top rail is to be in any case more than 3cm^3 for stanchions spaced up to 1,5m and 5 cm^3 for stanchions spaced up to 2,2 m if the top rail is connected to the glazing. If the top rail is not connected to the glazing the minimum section modulus may be reduced to 2 cm^3 if the stanchions are spaced up to 1,5m and 3 cm^3 if the stanchions are spaced up to 2,2m. The minimum section modulus of the stanchions is to be in any case more than 3cm^3 (2 cm^3 are acceptable for stanchions height up to 500 mm).

For yachts of more than 500 GT the minimum section modulus of the top rail is to be at least 17cm^3. The minimum section modulus of the stanchions is to be at least 20cm^3 for stanchions spaced up to 1,5m and 40cm^3 for stanchions spaced up to 2,2m.

The maximum admissible stress have to be assumed as the 80% of the minimum yield strength of the material.

The top rail is to have ergonomic shape.

The stanchions shall be rigidly fixed at their lower ends to resist rotational displacements.

The stanchions are to be structurally connected to the hull and in case of different material bimetallic joints have to be used.

Where the rails are substituted by glazing materials what follow applies. Normally stanchions and handrails have to be provided the glazing may be substitute the other transversal rails.

What follows is not applicable to small glazing panel that does not substitute rails. They have to be considered on a case by case base.

Glazing substituting the rails should not be situated in areas deemed essential for the operation of the ship. Such areas include mooring decks, lifeboat decks, external muster stations and in the vicinity of davits. Where external glass balustrades are not to be used, more traditional bulwarks or guard rails are to be fitted.

Where the glazing substitutes rails the scantling of the stanchions and of the top rails have to take into account in addition to the personnel load also the load due to the weather.

The scantling of the top rail and the stanchions have to be carried out according to [5.12.2] adding the weather load to personnel load. As an alternative to the application of [5.12.2] fem or direct calculation considering personnel and weather loads have to be sent for examination.

When the scantling of top rails and stanchions are not in accordance with [5.12.2] but are validated with fem or direct calculation the test a.m. required in accordance with ISO 15085 is to be performed with personnel and weather load. The impact test required below in accordance with EN 13094 if carried out also on the stanchions and top rail may be considered as alternative.

The weather load is to be taken not less than:

- 1st tier deck (main deck): p_1 calculated as for a windows in the first tier of superstructure or 12,5 kN/m^2 for lateral and aft glazing and 30 kN/m^2 for front glazing whichever is higher
- 2nd tier deck (upper deck): p_1 calculated as for a windows in the second tier of superstructure or 6 kN/m^2 for lateral and aft glazing and 10 kN/m^2 for front glazing whichever is higher
- 3rd tier deck (sun deck): p_1 calculated as for a windows in the third tier of superstructure or 2.5 kN/m^2 for lateral and aft glazing and 7.5 kN/m^2 for front glazing whichever is higher.

For restricted navigations (e.g. short range yacht where the yacht is intended to sail with wind condition of maximum Beaufort scale 4) the weather loads for 2nd and 3rd deck may be reduced of 50%.

Provision are to be available to fit adequately spaced rails in case of failure of the glazing.

Glass or other glazing materials such as polycarbonate may be used.

If glass is used it is to be thermally or chemically strengthened glass of laminated type.

The relevant scantling is to be calculated with the above mentioned weather loads and personnel load (1 kN/m^2 considered additional to weather load) as it is supported on four sides.

In Tab 13 are reported the thickness required for different locations and different interlayer material.

If the arrangement on board foresees less than 4 supporting sides a fem calculation is to be send to demonstrate that the acceptability of the thickness proposed in Tab 13 also in case of less than 4 supporting sides. The scantling calculated with 4 sides supported is to be in any case granted.

In Tab 13 are reported the required composition of the glazing for 4 different area, 2 different characteristic strength, 2 different type of interlayer and different deck levels for unrestricted navigation.

The direct calculation above required may be omitted if the thickness of the glazing supported on less than 4 sides is increased up to the value reported in Tab 14.

The safety factors for the glass and for the polycarbonate are the same as for windows located in the superstructure.

If the glazing is made of glass, laminated glass is to be used, the minimum composition is to be 4+ 1,52+4.

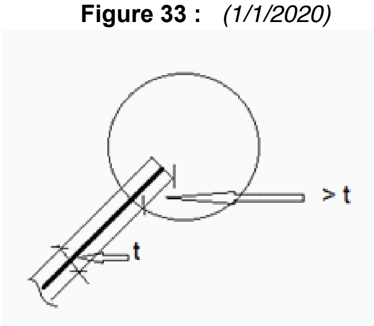
Connection between glazing and stanchions and top rail:

The vertical sides of the glazing are to be connected to the stanchions with continuous line - double side - support filled with structural gluing.

The glazing weight to be mechanically supported.

The thickness of the double side support is to be at least equal to the thickness of the glazing. See Fig 33.

Figure 33 : *(1/1/2020)*



The horizontal side of the glazing may or not be connected with the top rail or to the deck or a solid bulwark and the scantling of the rop rail, of the stanchions and the glazing to be calculated accordingly. If the glazing has one or 2 free edges these have to be suitably protected (edge protection or finishes).

Bulwark with rails made with glazing material are to be subject to a prototype pendulum impact test in accordance with EN 13049:2003 Windows - Soft and heavy body impact - Test method, safety requirements and classification or an equivalent National or International Standard (e.g. EN 12600) without permanent deformation utilizing a drop height of not less than 1,5m as an alternative the height may be reduced to 1,2m but in this case the test is to be repeated 3 times. If after this test the glazing has not enough residual stregth (e.g. when thermally toughened glass is used and after the test all the plies are broken) suitable means are to be provided to prevent falling in case of failure of the glazing (e.g. tensionable rails or wires connected to the stanchions).

Note 1: “Without permanent deformation” is to be intended that after the impact test the glazing is not to exit from the continuous support and the permanent deflection is to be less than about 100mm.

The test specimens including the retaining arrangements should be the same as the finished installation.

If the bulwark has glazing with different dimensions (but of the same thickness) the test may be carried out on the larger glazing (maximum height and maximum length).

The a.m. test is not required if:

a) the interlayer is at least 3mm of a structural material that passed the impact test to avoid deadlight for glazing fitted in the hull

b) the glazing has at least 2 sides with continuous line - double side- support (for bulwark with rails made of glazing material).

c) the top rail is made of a material with yield strength of at least 315 N/mm^2 and has section modulus of at least 20 cm^3 if the stanchions are spaced up to 1,5m and 40cm^3 if the stanchions are spaced up to 2,2,m

d) the stanchions are made of a material with yield strength of at least 315 N/mm^2 and have minimum section modulus of 30 cm^3 if spaced up to 1,5m and 40 cm^3 if spaced up to 2,2 m

e) the weather load calculated according to what above is less than 30 kN/m^2

f) the glass is chemically streghtened

Different considerations may be done if the deck can not be accessed during navigation.

Solutions different from what above will be considered on a case by case base.

Table 13 : *(1/7/2020)*

	A = inter-layer	B = interlayer made of structural material that passed test to avoid deadlight in area 2b				
Area	2200 x 1000					
	Main deck (31kN/m^2) 1st frontal		Main deck lateral (13,5kN/m^2)		Upped deck (11kN/m^2) 2nd frontal	
	A	B	A	B	A	B
σc 160	14+3+14	10+3+10	10+1,52+8	8+1,52+6	5+1,52+4	4+1,52+4
σc 235	12+3+10	8+3+8	8+3+6	5+3+5	4+1,52+4	4+1,52+4
polycarbonate	26		19		16	
Area	1500 x 1000					
	Main deck (31kN/m^2)1st frontal		Main deck lateral (13,5kN/m^2)		Upped deck (11kN/m^2) 2nd frontal	
	A	B	A	B	A	B
σc 160	12+3+10	8+3+8 or 10+1,52+8	8+1,52+6	6+1,52+5	6+1,52+5	4+3+4or5+1.52+4
σc 235	10+1,52+8	6+3+6 or 8+1,52+6	5+1,52+5	5+1,52+4 or 4+3+4	4+1,52+4	4+1,52+4
polycarbonate	22		16		13	
Area	1200 x 850					
	Main deck (31kN/m^2)1st frontal		Main deck lateral (13,5kN/m^2)		Upped deck (11kN/m^2) 2nd frontal	
	A	B	A	B	A	B
σc 160	10+3+8	6+3+6	6+3+5 or 6+1,52+6	4+3+4	5+1,52+4	4+1.52+4

	A = inter-layer	B = interlayer made of structural material that passed test to avoid deadlight in area 2b				
σc 235	8+1,52+6	5+3+5 or 6+1,52+6	4+1,52+4	4+1,52+4	4+1,52+4	4+1,52+4
polycarbonate	18		13		11	
Area	1500 x 600					
	Main deck (31kN/m²)1st frontal		Main deck lateral (13,5kN/m²)		Upped deck (11kN/m²) 2nd frontal	
	A	B	A	B	A	B
σc 160	10+1,52+8	6+1,52+6	5+1,52+5	4+1,52+4	4+1,52+4	4+1.52+4
σc 235	8+1,52+6	5+1,52+4	4+1,52+4	4+1,52+4	4+1,52+4	4+1,52+4
polycarbonate	16		12		10	
other location 4+1,25+4						

Table 14 : *(1/1/2020)*

Area	2200 x 1000	1500 x 1000	1500 x 600	1200 x 850
σc 160	14+3+14	10+3+12	10+3+8	10+3+10
σc 235	12+3+12	10+3+10	8+3+6	8+3+8
polycarbonate	40	33	25	28
Structural interlayer that passed impact test to avoid deadlight in area 2b				

Table 15 : *(1/1/2020)*

<table>
<tr><td colspan="8">Bulwark with top rail and stanchions</td></tr>
<tr><td colspan="3">Without glazing material</td><td colspan="5">With glazing material</td></tr>
<tr><td colspan="3">Calc of top rail and stanchions as [5.12.2]</td><td colspan="5">Calc of top rail and stanchions as [5.12.2]</td></tr>
<tr><td colspan="2">yes</td><td>no</td><td colspan="2">yes</td><td colspan="3">no</td></tr>
<tr><td colspan="2">top rail $z>17cm^3$, $\sigma > 315N/mm^2$ and stanchions $z>20cm^3$ up to 1,5m or $40cm^3$ up to 2,2m $\sigma > 315N/mm^2$?</td><td>fem or direct calculation with 1kN concentrated load</td><td colspan="2">top rail $z>20cm^3$, if stanchions are spaces up to 1,5m and $40cm^3$ if stanchions are spaced up to 2,2m $\sigma > 315N/mm^2$ and stanchions $z>30cm^3$ up to 1,5m or $40cm^3$ up to 2,2m $\sigma > 315N/mm^2$?</td><td colspan="3">fem or direct calculation with 1kN concentrated load + weather load (kN/m^2)</td></tr>
<tr><td>yes</td><td>no</td><td>+</td><td>yes</td><td>no</td><td colspan="3">+</td></tr>
<tr><td>-</td><td>test ISO 15085 but with 1kN transversal load</td><td>test ISO 15085 but with 1kN transversal load</td><td>-</td><td>test ISO 15085 but with 1kN transversal load</td><td colspan="3">test ISO 15085 but with 1kN transversal load + weather load (kN/m^2)</td></tr>
<tr><td></td><td></td><td></td><td colspan="5">Glass supported in 4 sides?</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">yes</td><td colspan="3">no</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Scantling of glazing in acc. with Tab 13 + iterlayer 3mm structural material and top rail $z>20cm^3$, if stanchions are spaces up to 1,5m and $40cm^3$ if stanchions are spaced up to 2,2m $\sigma > 315N/mm^2$ and stanchions $z>30cm^3$ up to 1,5m or $40cm^3$ up to 2,2m $\sigma > 315N/mm^2$, weather load less than $30kN/m^2$?</td><td colspan="3">Increased thickness of glazing in acc. with Tab 14</td></tr>
<tr><td></td><td></td><td></td><td>yes</td><td>no</td><td>yes</td><td colspan="2">no</td></tr>
<tr><td></td><td></td><td></td><td>-</td><td>impact test ISO 13049</td><td>interlayer 3mm structural material and top rail $z>20cm^3$, if stanchions are spaces up to 1,5m and $40cm^3$ if stanchions are spaced up to 2,2m $\sigma > 315N/mm^2$ and stanchions $z>30cm^3$ up to 1,5m or $40cm^3$ up to 2,2m $\sigma > 315N/mm^2$, weather load less than $30kN/m^2$?</td><td colspan="2">fem with 2 or 3 sides supported in addition to scantling in acc. with Tab 13</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>yes</td><td>no</td><td>+</td></tr>
</table>

					-	impact test ISO 13049	interlayer 3mm structural material and top rail z>20cm^3, if stanchions are spaces up to 1,5m and 40cm^3 if stanchions are spaced up to 2,2m σ > 315N/mm^2 and stanchions z>30cm^3 up to 1,5m or 40cm^3 up to 2,2m σ > 315N/mm^2, weather load less than 30kN/m^2?
							yes/no
							-/impact test ISO 13049

5.12.2 Scantling of stanchions and rails for yacht *(1/1/2020)*

- For bulwark without glazing material:

  The personnel load is to be taken at least equal to 1 KN and is to be considered concentrated, in the center of the top rail length for the scantling of the top rail and on top of the stanchions for the scantling of the stanchions.

  The top rail is assumed simply supported, the stanchions are assumed clamped to the deck.

- For bulwark with glazing material (in addition to what above):

  The weather load is to be added to the personnel load above mentioned.

  The weather load is considered distributed in the area included by the top rail the stanchions and the deck. (i.e. even when a gap is foreseen between the glazing and the deck and/or the top rail the area of the glazing is assumed equal to the area included between stanchions top rail and deck).

When the upper part of the glazing is not connected to the top rail with double side continuous line the weather load is assumed supported all by the stanchions and the top rail support only the personnel load.

When the upper part of the glazing is connected to the top rail the weather load aging on the glazing is assumed supported half by the stanchions half by the top rail.

5.13 Freeing ports

5.13.1 Any bulwarks or guardrails are to be provided with freeing port openings having dimensions for each side not less than the value given from formula:

$A = 0,07\, l$

Where:

A (m^2) = freeing port area for each side;

l (m) = length of bulwark on one side, but need not exceed 0,7 L_{LL}

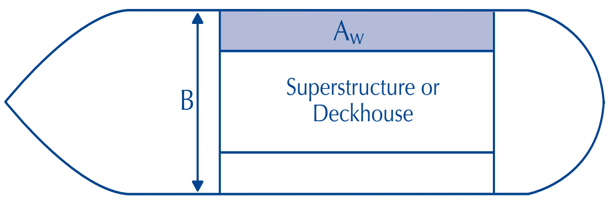
The value given from the above formula is to be corrected for the height of the bulwarks according to the following criteria.

If the bulwark height exceeds 1,2 m, the freeing port area is to be increased by 0,004 m^2 per metre of bulwark length for each 0,1 m difference in height. Where the bulwark height is less than 0,9 m, the freeing port area is to be decreased by the same ratio.

On a flush deck ship with a deckhouse amidships having a breadth at least 80% of the beam of the ship and the passageways along the side of the ship not exceeding 1.5 m in width, two wells are formed. Each shall be given the required freeing port area based upon the length of each well.

Additionally, where a well is created on each side of the vessel between a superstructure or deckhouse, and the bulwark in way of that superstructure or deckhouse, the following formula may be used to determine the required freeing port areas on each side of the vessel for the well concerned:

Figure 34



$FP_{REQ} = 0,28 \times A_w / B$

A_w = Area of well in way of superstructure or deckhouse

B = Full beam at deck

On sailing vessels, where the solid bulwark height does not exceed 150 mm, specific freeing ports, as defined above, are not required.

5.13.2 In individual cases, when Tasneef considers that the above requirements cannot be met, alternative arrangements to achieve adequate safety standards may be considered and approved.

5.13.3 For superstructure deck higher than the first tier, the value given in the formula in [5.13.1] is to be applied.

5.13.4 Recesses

Any recess in the weather deck is to be of weathertight construction and is to be self draining under all normal conditions of heel and trim of the vessel.

A swimming pool or spa bath open to the elements is to be treated as a recess.

The means of drainage provided is to be capable of efficient operation when the vessel is heeled to an angle of 10° in the case of a motor vessel, and 30° in the case of a sailing vessel.

The drainage arrangements is to have the capability of draining the recess (when fully charged with water) within 3 minutes (see Note 1) when the vessel is upright and at the load line draught. Means are to be provided to prevent the backflow of sea water into the recess.

When it is not practical to provide drainage which meets the above requirements, alternative safety measures may be considered by Tasneef

Where the above requirements for quick drainage cannot be met, the effect on intact and damage stability is to be considered taking into account the mass of water and its free surface effect.

Note 1: Regardless the drainage time, the effect of the swimming pool full of water with maximum free surfaces correction is to be taken into consideration at least in intact stability calculations.

5.14 Tanks

5.14.1 *(1/1/2016)*

"Tanks" means the structural tanks that are part of the hull and intended to contain liquids (water, fuel oil or lube oil). In order to contain fuel oil with a flashpoint ≤ 55° C, the use of non structural tanks is required. As far as non structural fuel tanks see Sec 4. Tanks, complete with all pipe connections, are to be subjected to a hydraulic pressure test with a head above the tank top equal to h, as defined in Sec 5, or to the overflow pipe, whichever is the greater. At the discretion of Tasneef leak testing with an air pressure of 0,015 MPa may be accepted as an alternative, provided that it is possible, using liquid solutions of proven effectiveness in the detection of air leaks, to carry out a visual inspection of all parts of the tanks with particular reference to pipe connections.

As far as tanks in reinforced plastic hulls see Ch 4, Sec 1, [6.3].

For yachts of more than 500 GT the tanks have to be tested in accordance with Pt B, Ch 12, Sec 3, Tab 1 of the Rules for the Classification of Ships.

5.15 Cofferdam arrangement

5.15.1 *(1/1/2020)*

For Yachts of 500GT and over, cofferdams are to be provided between compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and those intended for fresh water (drinking water, water for propelling machinery and boilers) as well as tanks intended for the carriage of liquid foam for fire extinguishing.

For yachts of less than 500GT other solutions may be adopted if deemed acceptable by Tasneef on a case by case basis.

5.15.2 *(1/1/2020)*

Cofferdams separating fuel oil tanks from lubricating oil tanks and the latter from those intended for the carriage of liquid foam for fire extinguishing or fresh water or boiler feed water may not be required when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness required by 2 mm in the case of tanks carrying fresh water or boiler feed water, and by 1 mm in all other cases
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to the required pressure head.

5.15.3 *(1/1/2020)*

Cofferdams are only required between fuel oil double bottoms and tanks immediately above where the inner bottom plating is subjected to the head of fuel oil contained therein, as in the case of a double bottom with its top raised at the sides.

Where a corner to corner situation occurs, tanks are not be considered to be adjacent.

SECTION 2 HULL OUTFITTING

1 Rudders and steering gear

1.1 General

1.1.1 *(1/1/2020)*

For yachts having gross tonnage equal to or greater than 500, reference is to be made to Sec 6.

In Sec 6 are reported the requirements for spade rudders. For other type of rudder reference is to be made to Tasneef Rules for Ships Pt.B, Ch. 10, Sec.1 and Pt B, Ch 10, App 1.

For yacht of less than 500 GT Sec 6 are applicable but the value of the rudder stock diameter and the thickness of the rudder blade given in Sec.6 may be reduced to the relevant values calculated according to Sec 6.

For sailing vessels special considerations may be done.

These requirements apply to ordinary profiles rudders without any special arrangement for increasing the rudder force, such as fins or flaps, steering propellers, etc.

Unconventional rudders of unusual type or shape and those with speeds exceeding 45 knots will be the subject of special consideration by Tasneef

In such cases, the scantlings of the rudder and the rudder stock will be determined by means of direct calculations to be agreed with Tasneef as regards the loads and schematisation.

Rudder stock made of composite material will be considered on a case by case base taking into account the shear strength of the composite material.

1.1.2 Rudders with blade made of composite material *(1/1/2019)*

For yachts of less than 500 GT the rudder blade may be built in composite provided that what above is satisfied.

Such rudders are to have, in particular:

- stock and mainpiece, in solid or tubular bar, made of hull steel or light alloy, and mainpiece arms, of the same material, structurally connected to the mainpiece;
- blade made of a single plate or composed of two preformed plates, made of composite material, complying with the requirements of Chap. 4 and filled with light material;
- in case of the glass reinforced the plastic the mass per unit surface, m, in kg/m2, of the glass reinforcement of the material, m = 0,6Vb, where V is the maximum speed in knots and b is the width, in metres, of the rudder, if the latter has a rectangular contour; for rudders with non-rectangular contours, b = A/h is to be taken, where h is the rudder height, in m, in way of the centreline of pintles. The thickness of the plate is, in any case, to be not less than 5 mm. In case of carbon fiber or composite other than glass reinforced plastic direct calculations have to be sent. The admissible values of strength have to be taken from Ch 4, Sec 1, Tab 1 for keel, bottom plating.

1.2 Steering gear and associated apparatus

1.2.1 Premise

These requirements apply to the most commonly used types of steering gear, which are dealt with below; any different types will be specially considered by Tasneef in each case.

1.2.2 Types of steering gear *(1/1/2019)*

Remote controlled steering gear of one of the following types:

- tiller, chain or rope with or without tackles, rudder wheel;
- tiller; hydraulic actuator of the tiller and associated piping; valves and hydraulic pump controlled by rudder wheel;
- the above apparatus, with the addition of an electric pump feeding the actuator through distributor and gyropilot follow-up link.

1.2.3 Steering gear of remote controlled type with rope or chain *(1/1/2019)*

The rudder tiller, or quadrant, is to have:

- hub of height $h \geq D_T$, in mm, and thickness $t \geq 0{,}4\ D_T$, in mm;
- section modulus Z, in cm³, in way of the connection to the hub, given by the following formula:

$$Z \geq 0{,}15 \cdot \frac{D_T^3}{1000} \cdot \frac{a-b}{a}$$

where:

D_T : Rule diameter, in mm, of the rudder stock subject to torque only;

a : length, in mm, of the tiller, measured from the rudder stock to the point of connection of rope or chain to the stock;

b : $0{,}5\ D_T + t$, in mm.

The tiller-stock coupling is to be of the type with square section, or with cylindrical section and key, and the tiller hub is to be bolted, in particular:

- the hub bolts are to have diameter d_b, in mm, not less than the value given by the formula:

$$d_b = \frac{0{,}4D}{2n^{0{,}5}}$$

  where n is the number of bolts on each side of the hub; in any case the diameter d_b is to be not less than 12 mm;
- the coupling key is to have rounded edges, length, in mm, equal to the hub thickness, thickness, in mm, equal to $0{,}17\ D_T$ and section area, in mm², equal to $0{,}25\ D_T^2$.

The chain or rope connected to the rudder tiller, in general, shall have breaking load CR in kN not less than the value given by the formula:

$CR = 0.1\ d_s^3 / L$

Where L (in mm) and ds are defined above.

The chain or rope shall run as straight as possible and driving pulley shall have pitch diameter not less than 16 times the diameter of the chain or rope and in no case less than 45mm. Such pulley and the connections of any tackles shall be securely fastened to the hull.

The rudder wheel and windlass shall be securely fastened to a column or equivalent support provided for the purpose, and it shall be possible, in general, to rotate the rudder up to the maximum side angle with no more than 5 turns of the rudder wheel.

Alternative arrangements will be subject of special consideration by Tasneef

1.2.4 Steering gear with hydraulic or electro-hydraulic type remote control

The parts of such steering gear are to comply with the specific requirements of Part C, Ch 1, Sec 10 of these Rules.

2 Propeller shaft brackets

2.1 Double arm brackets

2.1.1 *(1/1/2021)*

Double arm propeller shaft brackets consist of two arms forming an angle as near as practicable to 90°, and converging into a propeller shaft bossing.

Arms having elliptical or trapezoidal section with round fairing are to have each an area A, in mm², at the root not less than that given by the following relationship:

$$A = 87,5 \cdot 10^{-3} d_P^2 \cdot \left(\frac{1600 + R_{ma}}{R_{ma}}\right)$$

where:

- d_p : Rule diameter of the propeller shaft made of steel with ultimate tensile strength R_m = 400 N/mm² measured inside the liner, if any, in mm,
- R_{ma} : minimum ultimate tensile strength, in N/mm², of the material of the brackets.

The maximum thickness in way of the above section is to be not less than 0,4 d_p.

Considering the diameter (d) of the shaft propellers calculated according to the formula given in Pt C, Ch 1, Sec 6, [2.2.3] or [2.2.4] as applicable taking in account the effective material mechanical characteristics the boss is to have length not more than 4 d, but in no case may a length less than 3 d be accepted.

The boss is to have thickness of not less than 0,25 d when the diameter shaft propeller is calculated according Pt C, Ch 1, Sec 6, [2.2.3] and not less than 0,35 d, when the diameter of the propeller shaft is calculated according to Pt C, Ch 1, Sec 6, [2.2.4].

When the brackets are connected by means of palms, the latter are to have thickness not less than 0,2 d_p and are to be connected to the hull by means of bolts with nuts and lock nuts on the internal hull structures, which are to be suitably stiffened to the satisfaction of Tasneef

The thickness of the plating in the vicinity of the connection is to be increased by 50%.

In the case of metal hulls and brackets of the same material, the connection between bracket and hull is to be carried out by means of welding.

The brackets are to be continuous through the plating and to be connected internally to suitable transverse or longitudinal structures.

The plating in way of the bracket connection is to be suitably increased and connected to the arm bracket with full penetration welding.

2.2 Single arm brackets

2.2.1 *(1/1/2021)*

Single arm shaft brackets are to have a section modulus at ship plating level, in cm³, of not less than:

$W = (30 / R_{ma})\ 10^{-3}\ l\ d^2_{so}\ (n\ d_{so})^{0,5}$

where:

- l : length of the arm, in m, measured from the shell plating to the centreline of the shaft boss,
- n : shaft revolutions per minute,
- d_{so} : rule diameter, in mm, of the propeller shaft, for carbon steel material, using R_m = 400 N/mm²
- R_{ma} : minimum tensile strength, in N/mm², of arms, with appropriate metallurgical temper.

Boss thickness and length are to be calculated as for the double arm brackets.

3 Sailing yacht appendages and component fastenings

3.1 Keel connection

3.1.1

The typical ratio of the weight of external ballast to light displacement is generally 0,4 ÷ 0,5.

The ballast may be internal or external to the hull.

In the first case, the ballast is to be permanently secured, by clips or equivalent means, to the resistant structures of the hull (floors, frames, etc) but in no case to the plating, on which it is never to bear, so as not to shift even during rolling or pitching.

In the second case, the connection to the hull is to be effected by means of bolts long enough to incorporate the height of the ballast, either wholly or in part; such bolts are to pass through the hull, with a head (or nut and lock nut) at one end and a nut and lock nut at the other, towards the inside of the hull. The surface of the ballast keel head is to be flush with the surface of the hull, the bolt holes are to be fashioned with equipment designed to achieve an almost complete absence of play between bolt and hole, and the locking of the nuts is to be uniform. The nuts are to rest on plates or large washers and to be left uncovered so that they may be easily examined.

The diameter d, in mm, at the bottom of the thread of each keel bolt is given by the following formula:

$$d = 1,60 \times \left[\frac{W \times h_G}{\Sigma li \times \sigma_R}\right]^{0,5}$$

where:

W : is the total weight of the ballast in N ;

h_G : is the distance in mm, from the centroid of the ballast, to the plane attachment of the ballast to the hull ;

σ_R : is the minimum yield strength of the bolt material, N/mm²;

Σli : summation of the distances from the centre of the bolts on side of the keel to the edge of the keel on the other side, in mm.

If there are fewer bolts on one side of the keel, Σli is to be measured from the centroid of the bolts on that side to the edge of the keel on the other side.

Where are fitted bolts on the longitudinal axis of the keel, Σli should be measured from the centre of the bolts to the edge of the keel.

It is to be verified that the arrangement is strong enough to withstand the grounding loads. It is assumed that the conventional grounding loads are the following:

a) Longitudinal grounding loads acting in the aft direction and parallel to the longitudinal hull axis. The load is to be applied to the bottom edge of the keel

   $L_{GL} = 3,1\ \Delta$ (if Lwl $\geq$ 20 m)

   $L_{GL} = 1,60\ \Delta$ (if Lwl $\leq$ 10 m)

b) Vertical grounding load V_{GL} , in tons, acting upward on the bottom of the keel

   $V_{GL} = 1,60\ \Delta$

   It is to be verified that shear stress and primary stress due to the load as indicated in a and b are not more than the value given from the following formula:

   shear stress $\leq 0,70\ \eta_B$

   primary stress $\leq 0,70\ \eta_R$

   where:

   Δ : the maximum displacement of the vessel, in tonnes.

   η_R : minimum shear yield stress of the bolt material, in N/mm².

Where direct calculations are carried out to determine the diameter of bolts, the degree of locking is to be taken into account and a safety factor $\geq$ 3,5 in relation to the ultimate tensile strength and $\geq$ 2 in relation to the yield stress of the bolt material is to be applied.

3.1.2 Chain plates

The plates should be ample in size and well fastened to the structure to distribute the loads.

Many arrangements may be adopted according to the design philosophy.

Basically, the following arrangement could be adopted:

a) Single strap design:

   in this case the chainplates may be fitted internally or externally and by means of bolts. In the case of internal fittings, the bolts are to have large heads; on account of their appearance, washers are not normally fitted on the outside of the hull;

b) Bracket connection

   in this case the chainplate is connected to a plywood bracket by means an angle or flat bar chainplate.

   The chainplate is to be bolted to the bracket. Where possible, the chainplates are to be bolted directly to the bulkhead. Where the chanplate and bolts penetrate, the hull or deck is to be made watertight with a flexible sealant rather than a rigid resin, which may crack under the strain and result in annoying leakage.

   Chainplates are to be generally of mild steel, stainless steel, monel or aluminium. Bolts are to be galvanically compatible with the other materials and are to be sea corrosion-resistant.

   Adequately hull reinforcement is to be provided in way of the chainplates.

3.1.3 Component fastenings

Components can be satisfactorily fastened with bolts, screws or rivets. These fasteners are to be of a corrosion-resistant metal. Bolts, washers, backing plates and fittings are to be of a compatible material. Where chemically incompatible, adequately insulation is to be provided. If the components are to be fitted to a hull structure in sandwich construction with low density core materials, the local hull area is to be replaced with structurally effective inserts in way of bolted connections and fittings. The inserts are to be adequately bonded to the laminate skins and to the adjacent low density core.

Alternatively, the local area can be replaced with monolithic laminate of the same thickness as the sandwich laminate.

4 Stabiliser arrangements

4.1 General

4.1.1 The scantlings, arrangement and efficiency of stabiliser arrangements do not fall within the scope of Classification; nevertheless, the bedplates of the various components, the supporting structures and the watertight integrity are to be examined.

4.2 Stabiliser arrangements

4.2.1 The stabiliser fin machinery is to be supported by adequately reinforced structures.

Drawings are to be submitted for approval showing the position, the supporting structures and the loads transmitted.

4.2.2

The shell plating in way of stabilizer fins shall be adequately reinforced. In the case of fixed type stabiliser fins, the passage to the hull and the components necessary for the operation of the system, supported by adequately reinforced structures are to be arranged in a watertight box with an inspection opening fitted with a watertight cover.

In metal structures, the watertight box shall be at least of the same thickness as the adjacent shell plating. The box shall be well stiffened. For GRP vessels, the scantling of the watertight boxes and their stiffeners will be considered case by case. Where it is not practical to provide a watertight box, particularly because of the restricted inside spaces, the arrangement will be specially considered by Tasneef

4.3 Stabilising tanks

4.3.1 The tank structures are to comply with the requirements for tank bulkheads, taking into account the maximum head that may arise in service.

Where sloshing is foreseeable the scantlings will be the subject of special consideration.

5 Thruster tunnels

5.1 Tunnel wall thickness

5.1.1 The thickness of the tunnel is to be in accordance with the Manufacturer's specifications; in general, the thickness is to be not less than:

- For steel tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 2 mm), and in any case not less than 7 mm.
- For light alloy tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 1 mm), and in any case not less than 8 mm .
- For composite tunnels: the Rule thickness of the adjacent plating increased by 25%; in any case the thickness is to be not less than 8 mm. For tunnels having an inside diameter not more than 300 mm, Tasneef may accept a tunnel thickness equal to that of the adjacent plating provided that in any case the thickness is not less than 8 mm.

5.2 Tunnel arrangement details

5.2.1 The system for connecting the tunnel to the hull depends on the material used for the construction.

5.2.2 The tunnel is to be arranged between two floors of increased height or in a separate watertight compartment.

5.2.3

The thickness of the plating is to be locally increased as stated in Ch 2, Sec 5, or Ch 3, Sec 5 as applicable.

5.2.4 The tunnel is to be connected to the plating by means of full penetration welding.

5.2.5 For tunnels in composite material, the weight of the connecting laminate stiffener is to be equal to the weight of the bottom plating stiffener. The stiffener is to be arranged on both sides of the plating laminate.

Prior to the connecting lamination, the surfaces of the tunnel and the plating concerned are to be suitably cleaned and prepared and the edges of the cuts are to be sealed with resin.

6 Water-jet drive ducts

6.1

6.1.1 The thickness of the duct is to be in accordance with the Manufacturer's specifications and, in general, is to be not less than that of the adjacent plating.

The duct is to be adequately supported, stiffened and fully integrated with the hull structure.

The water-jet drive supporting structures are to be able to withstand the loads induced by the propulsion system in the following conditions:

- maximum thrust ahead
- maximum thrust at the maximum lateral inclination
- maximum reverse thrust (astern speed).

The foregoing loads are to be provided by the water-jet drive Manufacturer and adequately documented.

All hull openings are to be adequately reinforced and to have well rounded corners.

The thickness of the plating in the vicinity of the duct entrance is to be locally increased as stated in [5.2.3].

The Manufacturer is to assess the need to arrange suitable means of protection at the duct opening in order to prevent the ingress of foreign bodies which may damage the internal mechanism.

7 Crane support arrangements

7.1

7.1.1 Crane foundations shall be designed considering the worst combinations of the following loadings:

- maximum load capacity
- the weight of the crane itself;
- wind;
- crane accelerations resulting from the vessel's heel and trim.

Insert plates are to be provided in the deck in way of the crane foundation; in order to avoid concentration of forces, these insert plates are to have suitable dimensions (in respect of the dimensions of the foundation), be suitably prepared and have round corners. The thickness of these inserts is to be in accordance with the Designer's calculations.

A drawing of this arrangement with all the forces acting and the detail of the connection to the deck is to be sent for approval.

SECTION 3 EQUIPMENT

1 General

1.1

1.1.1 The anchoring equipment required in [6] is intended for temporary mooring of a yacht within or near a harbour, or in a sheltered area.

The equipment is therefore not designed to hold a yacht off fully exposed coasts in rough weather or to stop a yacht which is moving or drifting. In such conditions the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated.

The anchoring equipment required in [6] is deemed suitable to hold a yacht 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 will be significantly reduced.

It is assumed that under normal circumstances a yacht will use one anchor only.

2 Anchors

2.1

2.1.1 Anchors are to be manufactured in accordance with Pt D, Ch 4, Sec 1.

2.1.2 *(1/7/2021)*

The mass, per anchor, given in Table 1 applies to "high holding power" anchors. When use is made of normal type anchors, the mass shown in the table is to be multiplied by 1,33.

When "very high holding power" anchors are used, the mass of the anchors may be equal to 70% of that shown in Table 1 for stockless anchors.

The actual mass of each anchor may vary by + or - 7% with respect to that shown in Table 1, provided that the total mass of the two anchors is at least equal to the sum of the masses given in the table.

When 2 anchors are required:

The second anchor is intended as a spare and it is not necessary to carry it as a bower anchor provided that, in the event of the loss of the first anchor, the spare anchor can be readily removed from its position and arranged as a bower anchor.

In this case, the first anchor is to be equipped with at least 70% of the length of chain indicated in table, and the spare anchor with at least 70% of the required length.

When only 1 anchor is required (EN less than 110) and a second is foreseen as a spare, this spare anchor has to have a mass of at least 70% of the main anchor; in this case the chain length is to be at least 65% for EN < 70 and 70% for EN < 110 of the required chain length for the main anchor and also of the spare anchor.

For EN < 280 a maximum of a 90% of the chain length fitted on the spare anchor may be replaced by wire or fiber rope.

The replacement of one anchor fit in place with two anchors both fit in place and used simultaneously is acceptable only in case of EN less than 110.

The anchor required may be replaced by two anchors having each a mass of at least 60% of the mass of the required anchor; the length of each chain line shall not be less than 65% for EN < 70 and 70% for EN < 110 of the total length indicated in the table.

2.1.3 *(1/1/2023)*

The diameters refer to Grade Q1 steel chain cables; where Grade Q2 or Q3 steel studless chain cables are used, the diameters may be reduced guaranteeing the same breaking load as the chain cable corresponding to Grade Q1. (see Pt D, Ch 4, Sec 1, Tab 9); where Grade Q2 or Q3 steel with stud chain cables are used, the diameters may be reduced guaranteeing as per Tab 1.

For HHP and VHHP anchors, grade Q1 chain cables are preferably not to be used and Grade Q2 or Q3 chain cables are generally to be used; in this case the reduction of chain diameter for VHHP may be possible only for chain with stud as per Tab 1.

For yacht of more than 500GT studless chain cables are not allowed.

2.1.4 Test for high holding power anchors approval *(1/1/2019)*

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.

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.

2.1.5 Test for very high holding power anchors approval *(1/1/2019)*

For approval and/or acceptance as a VHHP 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 VHHP 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 VHHP 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.

2.1.6 Specification for test on high holding power and super high holding power anchors *(1/1/2019)*

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 VHHP) 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 VHHP anchors or, when ordinary stockless anchors are not available, HHP and SHHP anchors for testing VHHP 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 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 Chain cables for anchors

3.1

3.1.1 *(1/1/2023)*

Chain cables are to have proportions in accordance with recognised unified standards and to be of the steel grade given in Table 1.

Grade 1 chain cables are generally not to be used in association with "high holding power" and "very high holding power" anchors.

4 Mooring lines

4.1

4.1.1 Mooring lines may be of wire, natural or synthetic fibre, or a mixture of wire and fibre.

Where steel wires are used, they are to be of the flexible type.

Steel wires to be used with mooring winches, where the wire is wound on the winch drum, may be constructed with an independent metal core instead of a fibre core.

The breaking loads shown in Table 1 refer to steel wires or natural fibre ropes.

Where synthetic fibre ropes are adopted, their size will be determined taking into account the type of material used and the manufacturing characteristics of the rope, as well as the different properties of such ropes in comparison with natural fibre ropes.

The equivalence between synthetic fibre ropes and natural fibre ropes may be assessed by the following formula:

$$CR_S = 7,4 \cdot \frac{\delta \cdot CR_M}{CR_M^{1/9}}$$

dove:

δ : elongation to breaking of the synthetic fibre rope, to be assumed not less than 30%;

CR_S : breaking load of the synthetic fibre rope, in kN;

CR_M : breaking load of the natural fibre rope, in kN;

Where synthetic fibre ropes are used, rope diameters under 20 mm are not permitted, even though a smaller diameter could be adopted in relation to the required breaking load.

5 Windlass

5.1

5.1.1 Windlasses are to be power driven and suitable for the size of chain cable and is to have the characteristics below.

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.

A suitable stopping device is to be fitted in order to prevent the anchor from shifting due to movement of the yacht.

5.1.2 *(1/1/2019)*

For vessels having GT equal to or greater than 500, calculations demonstrating compliance with Pt B, Ch 10, Sec 4, [3.7] of the Rules for the Classification of Ships are to be sent to Tasneef for approval together with detailed plans and an arrangement plan showing the following components:

- Shafting
- Gearing
- Brakes
- Clutches.

For chain stoppers and fairled and bollard Pt B, Ch 10, Sec 4, [3.8] and [3.11] of the Rules for the Classification of Ships have to be applied.

5.2 Working test on windlass

5.2.1 The working test of the windlass is to be carried out on board at the presence of the Surveyor.

5.2.2 The test is to demonstrate that the windlass 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.

5.2.3 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 82,5m of chain cable and verifying that the time required for the weighing (excluding the housing of the anchors in the hawse pipe) does not exceed 9 min. Where the depth of water in the trial area is inadequate, or the anchor cable is less than 82,5 m, suitable equivalent simulating conditions will be considered as an alternative.

6 Equipment Number and equipment

6.1

6.1.1 All yacths are to be provided with anchors, chain cables and ropes based on their Equipment Number **EN**, as shown in Table 1.
The equipment Number **EN** is to be calculated as follows:

$$EN = \Delta^{2/3} + 2h \cdot B + 0,1A$$

where:

- Δ : yacht displacement, in tonnes, as defined in Section 1
- h : $a + \Sigma h_n$
  - a : distance, in m, from the summer load waterline amidships to the weather deck
  - h_n : height, in m, at the centreline of each tier n of superstructures or deckhouses having a breadth greater than B/4.
- A : area, in m², in profile view, of the parts of the hull, superstructures and deckhouses above the summer load waterline which are within the length L of the yacht and also have a breadth greater than B/4.

For yachts that have superstructures with the front bulkhead with an angle of inclination aft, the equipment number can be calculated as follows:

$$EN = \Delta^{2/3} + 2\left(aB + \sum b_n h_n \sin\theta_n\right) + 0,1A$$

- θ_n : angle of inclination with the horizontal axis aft of each front bulkhead
- b_n : greatest breadth, in m, of each tier n of superstructures or deckhouses having a breadth greater than B/4.

For **EN** > 1060 the anchors, chain cables and ropes will be fixed by Tasneef depending on the case.

6.1.2 When calculating h, sheer and trim are to be disregarded, i.e. h is to be taken equal to the sum of freeboard amidships plus the height h_n (at the centreline) of each tier of superstructures and deckhouses having a breadth greater than B/4.
Where a deckhouse having a breadth greater than B/4 is above another deckhouse with a breadth of B/4 or less, the upper deckhouse is to be included and the lower ignored.
Screens or bulwarks 1,5 metres or more in height are to be regarded as parts of deckhouses when determining h and A.
In determining the area A, when a bulwark is more than 1,5 metres in height the area above such height is to be included.

6.1.3 A drawing relevant to the equipment number to be sent for approval; the drawing is to contain also information on

- geometrical elements of calculation
- list of equipment;
- construction and breaking load of steel wires;
- material, construction, breaking load and relevant elongation of synthetic ropes.

7 Sailing yachts

7.1

7.1.1 For sailing yachts (with or without auxiliary engine), the value of **EN** is to be calculated using the formula given in [6.1].

Table 1 *(1/7/2020)*

EN		Stockless bower anchors		Chain cables for anchors					Mooring lines		
A<EN≤B		No. **(1)**	Mass per anchor (kg)	Total length (m)	Diameter (mm)				No.	Length (m)**(2)**	Breaking load kN
					Studless chain cable	Chain cables with stud					
A	B					Grade Q1 steel	Grade Q2 steel	Grade Q3 steel			
50	70	1	100	165	11	-	-	-	2	42	26
70	90	1	120	192,5	12,5	11	-	-	2	50	31
90	110	1	140	192,5	12,5	11	-	-	2	62	35
110	130	2	160	220	14,5	14	12,5	-	3	70	35
130	150	2	180	220	14,5	14	12,5	-	3	74	39
150	175	2	200	220	17,5	16	14	11	3	77	43
175	205	2	230	220	17,5	16	14	11	3	80	47
205	240	2	260	220	19	17,5	16	12,5	4	85	51
240	280	2	310	220	19	17,5	16	12,5	4	90	55
280	320	2	360	247,5	20,5	19	17,5	14	4	95	59
320	360	2	410	247,5	22	20,5	17,5	14	4	100	62
360	400	2	460	247,5	24	22	19	16	4	105	70
400	450	2	520	275	-	22	19	16	4	110	78
450	500	2	580	275	-	24	20,5	17	4	110	86
500	550	2	640	275	-	26	22	20,5	4	130	98
550	600	2	700	302,5	-	26	22	20,5	4	130	105
600	660	2	770	302,5	-	28	24	22	4	130	118
660	770	2	840	302,5	-	30	26	24	4	130	126
720	780	2	910	330	-	30	26	24	4	140	138
780	840	2	980	330	-	32	28	24	4	140	150
840	910	2	1060	357,5	-	32	28	24	4	140	160
910	980	2	1150	357,5	-	34	30	26	4	140	173
980	1060	2	1260	357,5	-	36	32	28	4	140	184

(1) See [2.1.2].
(2) Length of each line.

SECTION 4 NON-STRUCTURAL FUEL TANKS

1 General

1.1

1.1.1 Tanks for liquid fuel are to be designed and constructed so as to withstand, without leakage, the dynamic stresses to which they will be subjected. They are to be fitted with internal diaphragms, where necessary, in order to reduce the movement of liquid.

Tanks are to be arranged on special supports on the hull and securely fastened to them so as to withstand the stresses induced by movement of the yacht.

Tanks are to be arranged so as to be accessible at least for external inspection and check of piping.

Where their dimensions permit, tanks are to include openings allowing at least the visual inspection of the interior.

In tanks intended to contain fuel with a flashpoint below 55°C determined using the closed cup test (petrol, kerosene and similar), the above openings are to be arranged on the top of the tank.

Such tanks are to be separated from accommodation spaces by integral gastight bulkheads. Tanks are to be arranged in adequately ventilated spaces equipped with a mechanical air ejector.

Upon completion of construction and fitting of all the pipe connections, tanks are to be subjected to a hydraulic pressure test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

At the discretion of Tasneef leak testing may be accepted as an alternative, provided that it is possible, using liquid solutions of proven effectiveness in the detection of air leaks, to carry out a visual inspection of all parts of the tanks with particular reference to pipe connections.

2 Metallic tanks

2.1 General

2.1.1 Tanks intended to contain diesel oil are to be made of stainless steel, nickel copper, steel or aluminium alloys.

Steel tanks are to be suitably protected internally and externally so as to withstand the corrosive action of the salt in the atmosphere and the fuel they are intended to contain.

The upper part of tanks is generally not to have welded edges facing upwards or be shaped so as to accumulate water or humidity.

To this end, zinc plating may be used, except for tanks intended to contain diesel oil, for which internal zinc plating is not permitted.

Tanks are to be effectively earthed.

2.2 Scantlings

2.2.1 The thickness of metallic tank plating is to be not less than the value t, in mm, given by the following formula:

$$t = 4 \cdot s \cdot (h_S \cdot K)^{0,5}$$

where:

s : stiffener spacing, in m;

h_S : static internal design head, in m, to be assumed as the greater of the following values:

- vertical distance from the pdr (see below) to a point located 2 m above the tank top
- two-thirds of the vertical distance from the pdr to the top of overflow

K : $\frac{235}{R_S}$ where R_S is the minimum yield stress, in N/mm², of the tank material. Where light alloys are employed, the value of R_S to be assumed is that corresponding to the alloy in the annealed condition;

pdr : point of reference, intended as the lower edge of the plate, or, for stiffeners, the centre of the area supported by the stiffener.

In any case the thickness of the tank is to be not less than 2 mm for steel and not less than 3 mm for light alloy.

The section modulus of stiffeners is to be not less than the value Z, in cm³, given by the formula:

$$Z = 4 \cdot s \cdot S^2 \cdot h_S \cdot K$$

where:

S : stiffener span, in m.

3 Non-metallic tanks

3.1 General

3.1.1 Fuel tanks may be made of non-metallic materials.

The materials adopted are to withstand the corrosive action of the fuel to be carried.

The acceptance of non-metallic tanks will be subject to tests on materials (such as after immersion in the fuel to be carried).

3.2 Scantlings

3.2.1

The scantlings of non-metallic tanks will be specially considered by Tasneef on the basis of the characteristics of the material proposed and the results of strength tests performed on a sample.

In general, for tanks made of composite material, the thickness t, in mm, of the plating and the module of stiffeners Z, in cm³, are to be not less, respectively, than the values:

$$t = 6 \cdot s \cdot (h_S \cdot k_{of})^{0,5}$$

$$Z = 15 \cdot s \cdot S^2 \cdot h_S \cdot K_0$$

where:

k_{of} , k_0 : as defined in Ch 4;

s, S, h_S : as defined in [2.2].

In any case, the thickness is to be not less than 8 mm with reinforcement not less than 30% in weight fraction.

The surface of the tanks is to be internally coated with resin capable of withstanding hydrocarbons and externally coated with self-extinguishing resin.

The self-extinguishing characteristic is to be ascertained by a test carried out according to ASTM D635 on specimens having all their surface impregnated with the self-extinguishing resin used. During such test the flame speed is not to exceed 6 cm/min.

4 Tests on tanks

4.1 General

4.1.1 *(1/1/2021)*

Prior to their installation on board, tanks are to be subjected to a hydraulic pressure test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

On the base of additional verifications proposed by the Shipyard (such as NDT) a leak testing with an air pressure as per [4.2.1]. may be accepted by Tasneef as an alternative.

4.1.2 Leak testing

Leak testing is to be carried out by applying an air pressure of 0,15 bar.

Prior to inspection of the tightness of welding, in the case of metallic tanks and pipe connections, it is recommended that the air pressure is raised to 0,2 bar and kept at this level for about 1 hour. The level may then be lowered to the test pressure before carrying out the welding tightness check of the tank and connections by means of a liquid solution of proven effectiveness in the detection of air leaks.

The test may be supplemented by arranging a pressure gauge and checking that the reading does not vary over time.

Leak testing is to be performed before any primer and/or coating is applied. In the case of tanks made of composite material, the test is to be carried out before the surface is externally coated with self-extinguishing resin.

SECTION 5 LOADS

1 General

1.1

1.1.1 The static and dynamic design loads defined in this Section are to be adopted in the formulae for scantlings of hull and deck structures stipulated in Chapters 2, 3 and 4 of Part B.

For yachts of speed exceeding 10 $L^{0,5}$ knots or yachts of unusual shape, additional information may be required in the form of basin test results on prototypes.

Alternative methods for the determination of acceleration and loads may be taken into consideration by Tasneef also on the basis of model tests or experimental values measured on similar yachts, or generally accepted theories.

In such case a report is to be submitted giving details of the methods used and/or tests performed.

Pressures on panels and stiffeners may be considered as uniform and equal to the value assumed in the point of reference pdr as defined in [2.3].

2 Definitions and symbols

2.1 General

2.1.1 The definitions of the following symbols are valid for all of Part B. The meanings of those symbols which have specific validity are specified in the relevant Chapters or Sections.

2.2 Definitions

2.2.1 Displacement yacht

A yacht whose weight is fully supported by the hydrostatic forces.

In general, for the purposes of this Section, a displacement yacht is a craft having $V / L^{0,5} \leq 4$.

2.2.2 Semi-planing yacht

A yacht that is supported partially by the buoyancy of the water it displaces and partially by the dynamic pressure generated by the bottom surface running over the water.

2.2.3 Planing yacht

A yacht in which the dynamic lift generated by the bottom surface running over the water supports the total weight of the yacht.

2.2.4 Chine

In hulls without a clearly visible chine, this is the point of the hull in which the tangent to the hull has an angle of 50° on the horizontal axis.

2.2.5 Bottom

The bottom is that part of the hull between the keel and the chines.

2.2.6 Side Shell

The side shell is that part of the hull between the chine and the highest continuous deck.

2.3 Symbols

2.3.1

β_x : Deadrise of the transverse section under consideration.
In hulls without a clearly visible deadrise, this is the angle formed by the horizontal axis and the straight line joining keel and chine.

Pp_{AV} : Forward perpendicular: perpendicular at the intersection of the full load waterline plane (with the yacht stationary in still water) and the fore side of the stem.

Pp_{AD} : Aft perpendicular: perpendicular at the intersection of the full load waterline plane (with the yacht stationary in still water) and the aft side of the sternpost or transom.

pdc : Design deck, intended as the first deck above the full load waterline, extending for at least 0,6 L and constituting an effective support for side structures.

pdr : Point of reference, intended as the lower edge of the plating panel or the centre of the area supported by the stiffener, depending on the case under consideration.

Δ : Displacement, in t, of the yacht at full load draught T. Where unknown, to be assumed equal to $0,42 \cdot L \cdot B \cdot T$.

C_B : Block coefficient, given by the relationship:

$$C_B = \frac{\Delta}{1,025 L \cdot B \cdot T}$$

C_S : Support contour of the yacht, in m, defined as the transverse distance, measured along the hull, from the chines to 0,5 L. For twin hull yachts, C_S is twice the distance measured along the single hull.

g : Acceleration of gravity = 9,81 m/s^2.

LCG : Longitudinal centre of gravity of the yacht; where unknown, to be taken as located in the section at 0,6 L from the Pp_{AV}.

a_{CG} : Maximum design value of vertical acceleration at LCG, in g, provided by the Designer based on an assessment of the service conditions (speed, significant wave height) envisaged in the design.

V : Maximum service speed, in knots.

3 Design acceleration

3.1 Vertical acceleration at LCG

3.1.1 General

The design vertical acceleration at LCG, a_{CG} (expressed in g), is defined by the Designer and corresponds to the average of the 1% highest accelerations in the most severe sea conditions expected. Generally, it is to be not less than:

$$a_{CG} = S \cdot \frac{V}{L^{0,5}}$$

where S is given by:

$$S = 0,65 C_F$$

where:

$$C_F = 0,2 + [0,6/(V/L^{0,5})] \geq 0,32$$

Values of S reduced to as low as 80% of the foregoing value may be accepted, at the discretion of Tasneef if justified on the basis of the results of model tests or prototype tests.

The sea area to which the aforementioned value refers is defined with reference to the significant wave height H_S which is exceeded for an average of not more than 10% of the year:

- Open-sea service: Hs ≥ 4,0 m;

If the design acceleration cannot be defined by the Designer, the a_{CG} value corresponding to the value of S calculated with the above-mentioned formula is to be assumed.

3.1.2 Longitudinal distribution of vertical acceleration

The longitudinal distribution of vertical acceleration along the hull is given by:

$$a_v = k_v \cdot a_{CG}$$

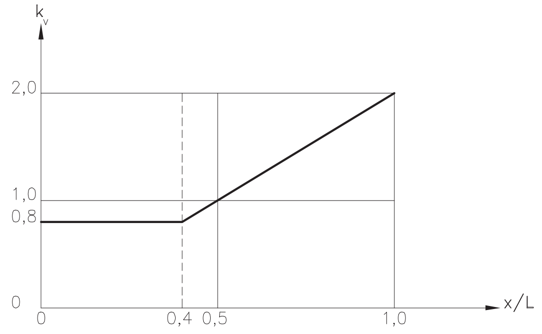
where:

K_V : Longitudinal distribution factor, defined in Fig 1, equal to 2.x/L or 0,8, whichever is the greater, where x is the distance, in m, from the calculation point to the aft perpendicular;

a_{CG} : Design acceleration at LCG (see [3.1]).

Variation of a_V in the trasverse direction may generally be disregarded.

Figure 1



3.2 Transverse acceleration

3.2.1 Transverse acceleration, to be used in direct calculations for yachts with many tiers of superstructure for which significant racking effects are anticipated, is defined on the basis of model tests and full-scale measurements.

In the absence of such results, transverse acceleration, in g, at the calculation point of the yacht may be obtained from:

$$a_t = 2,5 \cdot \frac{H_{sl}}{L} \cdot \left[1 + 5 \cdot \left(1 + \frac{V/L^{0,5}}{6}\right)^2 \cdot \frac{r}{L}\right]$$

where:

H_{sl} : permissible significant wave height, in m, at speed V

r : distance of the calculation point from:
- 0,5 D for monohull yachts
- waterline at draught T, for twin hull.

4 Overall loads

4.1 General

4.1.1 Overall loads are to be used for the check of longitudinal strength of the yacht, as required, in relation to the material of the hull, in Chapters 2, 3 and 4.

4.2 Longitudinal bending moment and shear force

4.2.1 General

The values of the longitudinal bending moment and shear force are given, as a first approximation, by the formulae in [4.2.2]. For large yachts, the results of experimental tank tests may be taken into account.

If the actual distribution of weights along the yacht is known, a more accurate calculation may be performed in accordance with the procedure given in [4.2.3]. Tasneef reserves the right to require calculations to be carried out according to [4.2.3] whenever deemed necessary.

4.2.2 Bending moment and shear force

The total bending moments $M_{bl,H}$, in hogging conditions, and $M_{bl,S}$, in sagging conditions, in kN·m, are the greater of those given by the formulae in a) and b) below.

For yachts of L > 100 m, only the formula in b) is generally to be applied; the formula in a) is to be applied when deemed necessary by Tasneef on the basis of the motion characteristics of the yacht.

The total force T_{bl}, in kN, is given by the formula in c) below.

a) bending moment due to still water loads, wave induced loads and impact loads

$$M_{bl,H} = M_{bl,S} = 0,55 \cdot \Delta \cdot L \cdot (C_B + 0,7) \cdot (1 + a_{CG})$$

where a_{CG} is the vertical acceleration at the LCG, defined in [3.1].

The same value of M_{bl} is taken for a yacht in sagging conditions or in hogging conditions.

b) bending moment due to still water loads and wave induced loads.

$$M_{bl,H} = M_{sH} + 0,95 \cdot S \cdot C \cdot L^2 \cdot B \cdot C_B$$
$$M_{bl,S} = M_{sS} + 0,55 \cdot S \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)$$

where:

$M_{s,H}$: still water hogging bending moment, in kN · m, where not supplied, the following may be assumed for the checks:

$$M_{sH} = 85 \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)10^{-3}$$

$M_{s,S}$: still water sagging bending moment, in kN · m, where not supplied, the following may be assumed for the checks:

$$M_{sS} = 63 \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)10^{-3}$$

S : parameter defined in 3.1.1 to be assumed = 0,21 for displacement yachts

C : 6 + 0,02 L

For the purpose of this calculation, C_B may not be taken less than 0,6.

c) Total shear force

$$T_t = \frac{3,1 \cdot M_{bl}}{L}$$

where M_{bl} is the greater of $M_{bl,H}$ and $M_{bl,S}$ calculated according to a) or b) above, as applicable.

4.2.3 Bending moment and shear force taking into account the actual distribution of weights

a) The distribution of quasi-static bending moment and shear force, due to still water loads and wave induced loads, is to be determined from the difference in weight and buoyancy distributions in sagging and hogging for each loading condition envisaged.

b) For calculation purposes, the following values are to be taken for the design wave:

- wave length, in m:

$$\lambda = L$$

- wave height, in m:

$$h = \frac{L}{15 + \frac{L}{20}}$$

- wave form: sinusoidal.

c) In addition, the increase in bending moment and shear force, due to impact loads in the forebody area, for the sagging condition only, is to be determined as specified below. For the purpose of this calculation, the hull is considered longitudinally subdivided into a number of intervals, generally to be taken equal to 20. For smaller yacht, this number may be reduced to 10 if justified, at Tasneef discretion, on the basis of the weight distribution, the hull forms and the value of the design acceleration a_{CG}.

For twin hull yachts, the following procedure is to be applied to one of the hulls, i.e. the longitudinal distribution of weight forces g_i and the corresponding breadth B_i are to be defined for one hull.

The total impact, in kN, is:

$$F_{SL} = \sum q_{SLi} \cdot \Delta x_i$$

where q_{SLi} is the additional load, per length unit, in kN/m, per x/L ≥ 0,6 (see Fig 2), computed with the following formula:

$$q_{SLi} = p_0 \cdot B_i \cdot \sin\left[2 \cdot \pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right]$$

where:

Δx_i : length of interval, in m

x_i : distance, in m, from the aft perpendicular

B_i : yacht breadth, in m, at the uppermost deck in way of the coordinate x_i; for twin hull yacht, B_i is the maximum breadth of one hull considered at the transverse section considered;

x_i, B_i : to be measured at the centre of interval i

p_0 : maximum hydrodynamic pressure, in kN/m², calculated by the following formula:

$$p_0 = \frac{a_{v1} \cdot G \cdot (r_0 + x_W^2)}{f_{SL} \cdot [r_0^2 + 0,5 \cdot L \cdot (x_{SL} - z_W) - x_{SL} \cdot x_W]} p$$

a_{v1} : design vertical acceleration in way of the forward perpendicular, as defined in [3.3];

G : weight force, in kN, calculated from the following formula:

$$G = \sum g_i \cdot \Delta x_i$$

g_i : weight per unit length, in kN/m, of interval i; for twin hull yachts g_i is defined for one hull;

x_W : distance, in m, of LCG from the midship perpendicular, calculated by the following formula:

$$x_W = \frac{\sum (g_i \cdot \Delta x_i \cdot x_i)}{\sum (x_i \cdot \Delta x_i)} - 0,5 \cdot L$$

r_0 : radius of gyration, in m, of weight distribution, calculated as follows:

$$r_0 = \left(\frac{\sum [g_i \cdot \Delta x_i \cdot (x_i - 0,5\ L)^2]}{\sum (g_i \cdot \Delta x_i)}\right)^{0,5}$$

normally

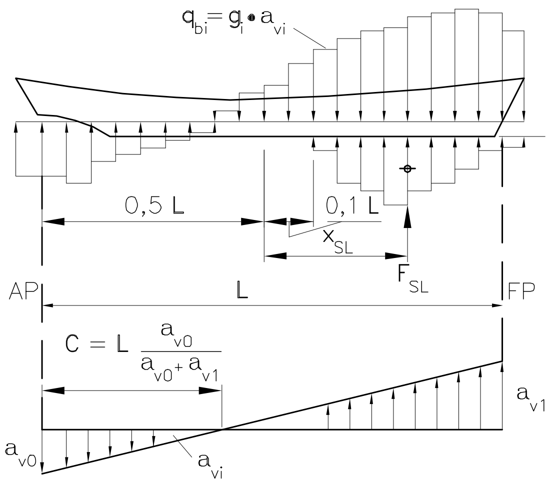
$$0,2 \cdot L < r_0 < 0,25 \cdot L \quad \text{(guidance values)}$$

x_{SL} : distance, in m, from the centre of the surface F_{SL} to the midship perpendicular, calculated from the following formula:

$$x_{SL} = \frac{1}{f_{SL}} \sum (\Delta x_i \cdot x_i \cdot B_i) \cdot \sin\left[2\pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right] - 0,5\ L$$

f_{SL} : $\sum (\Delta x_i \cdot B_i) \cdot \sin\left[2\pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right]$, in m²

Figure 2



d) The resulting load distribution q_{si}, in k/N, for the calculation of the impact induced sagging bending moment and shear force is:

- For x / L < 0,6

$$q_{si} = q_{bi} = g_i \cdot a_{vi}$$

where:

a_{vi} : total dimensionless vertical acceleration at the interval considered, calculated by the following formula:

$$a_{vi} = a_h + a_p \cdot (x_i - 0{,}5\ L)$$

a_h : acceleration due to heaving motion

a_p : acceleration due to pitching motion

a_h e a_p : are relative to g

a_h : $\dfrac{F_{SL}}{G} \cdot \left[\dfrac{r_0^2 - x_{SL} \cdot x_W}{r_0^2 - x_W^2}\right]$

a_p : $\dfrac{F_{SL}}{G} \cdot \left[\dfrac{x_{SL} - x_W}{r_0^2 - x_W^2}\right]$, in m^{-1}

- For x / L ≥ 0,6

$$q_{si} = q_{bi} - q_{SLi}$$

e) The impact induced sagging bending moment and shear force are to be obtained by integration of the load distribution q_{si} along the hull. They are to be added to the respective values calculated according to a) and b) in order to obtain the total bending moment and shear due to still water loads, wave induced loads and impact loads.

4.3 Design total vertical bending moment

4.3.1 The design total vertical bending moment Mt, in kNxm, is to be taken equal to the greater of the values indicated in [4.2.2] a) and b), for planing or semi-planing yachts. For displacement yachts, the value of MT is to be taken equal to the greater of those given in [4.2.2] (b).

4.4 Transverse loads for twin hull yachts

4.4.1 General

For catamarans, the hull connecting structures are to be checked for the load conditions specified in [4.4.2] and [4.4.3] below. These load conditions are to be considered as acting separately.

The design moments and forces given in the following paragraphs are to be used unless other values are verified by model tests, full-scale measurements or any other information provided by the Designer.

For yacht of length L > 65 m or speed V > 45 knots, or for yachts with structural arrangements that do not permit a realistic assessment of stress conditions based on simple models, the transverse loads are to be evaluated by means of direct calculations carried out in accordance with criteria specified in the individual Chapters or other criteria considered equivalent by Tasneef

4.4.2 Transverse bending moment and shear force

The transverse bending moment M_{bt} in kN.m, and shear force T_{bt}, in kN, are given by:

$$M_{bt} = \frac{\Delta \cdot b \cdot a_{CG} \cdot g}{5}$$

$$T_{bt} = \frac{\Delta \cdot a_{CG} \cdot g}{4}$$

where:

b : transverse distance, in m, between the centres of the two hulls;

a_{CG} : vertical acceleration at L_{CG}, defined in [3.1].

4.4.3 Transverse torsional connecting moment

The catamaran transverse torsional connecting moment, in kN.m, is given by:

$$M_{tt} = 0{,}125 \cdot \Delta \cdot L \cdot a_{CG} \cdot g$$

where a_{CG} is the vertical acceleration at L_{CG}, defined in [3.1], which need not be taken greater than 1,0 g for this calculation.

5 Local loads

5.1 General

5.1.1 The following loads are to be considered in determining the scantlings of hull structures:

- impact pressure due to slamming, if expected to occur;
- external pressure due to hydrostatic heads and wave loads;
- internal loads.

External pressure generally determines the scantlings of side and bottom structures, whereas internal loads generally determine the scantlings of deck structures.

Where internal loads are caused by concentrated masses of significant magnitude (e.g. tanks, machinery), the capacity of the side and bottom structures to withstand such loads is to be verified according to criteria stipulated by Tasneef In such cases, the inertial effects due to acceleration of the yacht are to be taken into account.

Such verification is to disregard the simultaneous presence of any external wave loads acting in the opposite direction to internal loads.

5.2 Load points

5.2.1 Pressure on panels and strength members may be considered uniform and equal to the pressure at the following load points:

- for panels:

  lower edge of the plate, for pressure due to hydrostatic head and wave load;
- for strength members:

  centre of the area supported by the element.

Where the pressure diagram shows cusps or discontinuities along the span of a strength member, a uniform value is to be taken on the basis of the weighted mean value of pressure calculated along the length of the member.

5.3 Design pressure for the bottom

5.3.1 Planing and semi-planing yachts

The design pressure p, in kN/m², for the scantlings of structures on the bottom of the hull, plating and stiffeners is to be assumed as equal to the greater of the values p_1 and p_2 defined as follows:.

$$p_1 = 0,24L^{0,5} \cdot \left(1 - \frac{h_0}{2T}\right) + 10 \cdot (h_0 + a \cdot L)$$

$$p_2 = 15 \cdot (1 + a_V) \cdot \frac{\Delta}{L \cdot C_S} \cdot g \cdot F_L \cdot F_1 \cdot F_a$$

h_0 : vertical distance, in m, from the pdr to the full load waterline;

a : coefficient function of the longitudinal position of pdr, equal to:

- 0,036 aft of 0,5 L
- 0,04/(C_B - 0,024) in way of Pp_{AV}
- values for intermediate positions obtained by linear interpolation;

F_L : coefficient given in Fig 3 as a function of the longitudinal position of the pdr;

F_1 : coefficient function of the shape and inclination of the hull to be taken ≥ 0,4 given by:

$$\left(F_1 = \frac{50 - \beta_X}{50 - \beta_{LCG}}\right) \geq 0,4$$

where b_{LCG} is the deadrise angle, in degrees, of the section in way of the L_{CG};

F_a : coefficient given by:

$$F_a = 0,30 - 0,15 \cdot \log\left(\frac{1,43 \cdot A_1 \cdot T}{\Delta}\right)$$

where A_1 is the surface, in m², of the plating panel considered or the surface of the area supported by the stiffener;

a_V : maximum design value of vertical acceleration, in g, at the transverse section considered.

The pressure p_1 is, in any case, not to be assumed as < 10 D.

5.3.2 Displacement yachts *(1/1/2023)*

For the purpose of the evaluation of the design pressure for the bottom, sailing yachts with or without auxiliary engine are also included as displacement yachts.

The pressure p, in kN/m², for the scantlings of hull structures, plating and stiffeners on the bottom of the hull, is to be taken as equal to the value p_1, defined as follows:

$$p_1 = 0,24L^{0,5} \cdot \left(1 - \frac{h_0}{2T}\right) + 10 \cdot (h_0 + a \cdot L)$$

where h_0 and a are as defined in [5.3.1].

The pressure p is, in any case, not to be assumed <10 D.

5.4 Design pressure for the side shell

5.4.1 Planing or semi-planing yachts

The pressure p, in kN/m², for the scantlings of side structures, plating and associated stiffeners is to be taken as equal to the value p_1, defined as follows:

$$p_1 = 66,25 \cdot (a + 0,024) \cdot (0,15L - h_0)$$

The pressure p_1 in any case, not to be assumed as < 10 h_1, where h_1 is as defined in [5.4.2].

For the zones located forward of 0,3 L from the Pp_{AV}, the value p is to be not less than the value p_2 defined as follows:

$$p_2 = C_1\{k_V \cdot [0,6 + \text{sen}\gamma \cdot \cos(90 - \alpha)] + C_2 \cdot L^{0,5} \cdot \text{sen}(90 - \alpha)\}^2$$

where:

a, h_0 : as defined in [5.3.1]

C_1 : coefficient given by Fig 4 as a function of the load surface A, in m², bearing on the element considered; for plating, A = 2,5s is to be taken

C_2 : coefficient given by Fig 5 as a function of C_B and the longitudinal position of the element considered

k_V : $0,625 \cdot L^{1/2} + 0,25V$

α : angle formed at the point considered by the side and the horizontal axis (see Fig 6)

γ : angle formed by the tangent at the waterline, corresponding to the draught T, taken at the point of intersection of the transverse section of the element considered, with the above waterline and the longitudinal straight line crossing the above intersection (see Fig 7).

The value p_2 may, in any case, be assumed as not greater than 0,5p, where p is the design pressure for the bottom as defined in [5.3.1], calculated at the section considered.

5.4.2 Displacement yachts *(1/1/2023)*

For the purpose of the evaluation of the design pressure for the side shell, sailing yachts with or without auxiliary engine are also included as displacement yachts.

The design pressure p, in kN/m², for the scantlings of side structures, plating and associated stiffeners is to be taken as equal to the value p_1 defined as follows:

$$p_1 = 66,25 \cdot (a + 0,024) \cdot (0,15L - h_0)$$

where:

a, h_0 : as defined in [5.3.1]

h_1 : distance, in m, from the pdr to the straight line of the beam of the highest continuous deck.

The pressure p_1 in any case, not to be assumed as $<10\ h_1$.

5.5 Design heads for decks

5.5.1 *(1/7/2021)*

The design heads, h_d in m, for the various decks are shown in Table 1.

Sheltered areas are intended to mean decks intended for accommodation.

The design heads shown in Tab 1 assume a uniformly distributed load with mass density of 0,7 t/m³ and a consequent load per square metre of deck, in kN/m², equal to 6,9 h_d.

Where distributed loads with mass density greater or lower than the above are envisaged, the value h_d will be modified accordingly.

In the case of decks subject to concentrated loads, the scantlings of deck structures (plating and stiffeners) will also need to be checked with the aforementioned loads.

Table 1

Deck	EXPOSED WEATHER AREA		SHELTERED AREA (also partially by deck-houses)
	FWD 0,075 L from FWD PP	AFT 0,075 L from FWD PP	
	h_d	h_d	h_d
Deck below pdc	-	-	0,9
pdc	1,5	1,0	0,9
Decks over pdc	1,2	0,9	0,7

5.6 Design heads for watertight bulkheads

5.6.1 Subdivision bulkheads

The scantlings of subdivision bulkheads, plating and associated stiffeners are to be verified assuming a head h_B equal to the vertical distance, in m, from the pdr to the highest point of the bulkhead.

5.6.2 Tank bulkheads

The scantlings of tank bulkheads, plating and associated stiffeners are to be verified assuming as h_T, in m, the greater of the following values:

- vertical distance from the pdr to a point located at a height h, in m, above the highest point of the tank given by:

  $$h_T = [1 + 0,05(L - 50)]$$

  where the value of L is to be taken no less than 50 m and no greater than 80 m
- 2/3 of the vertical distance from the pdr to the top of the overflow pipe.

Figure 3

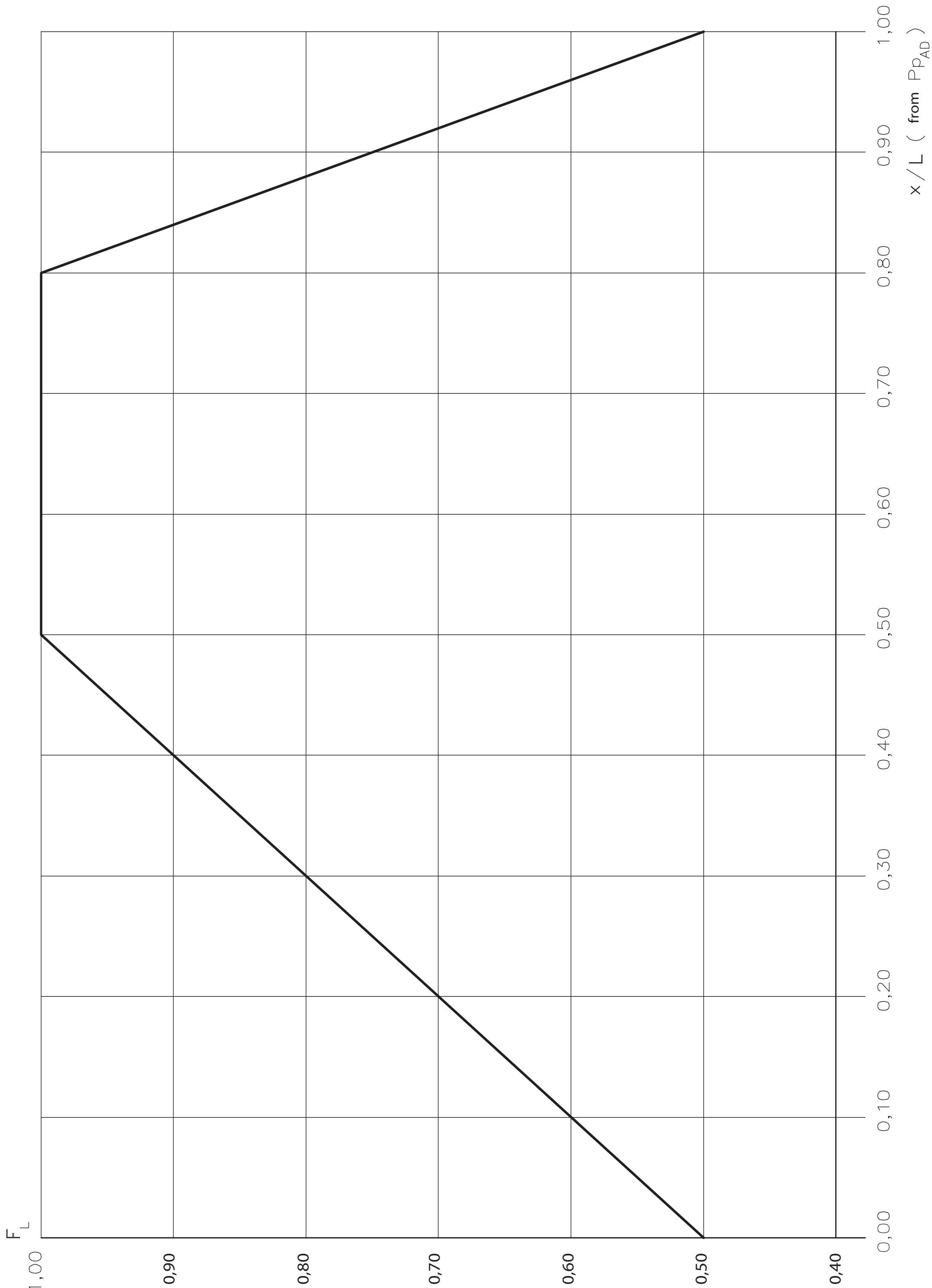

x / L (from PP_AD)
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
F_L
1,00
0,90
0,80
0,70
0,60
0,50
0,40

Figure 4

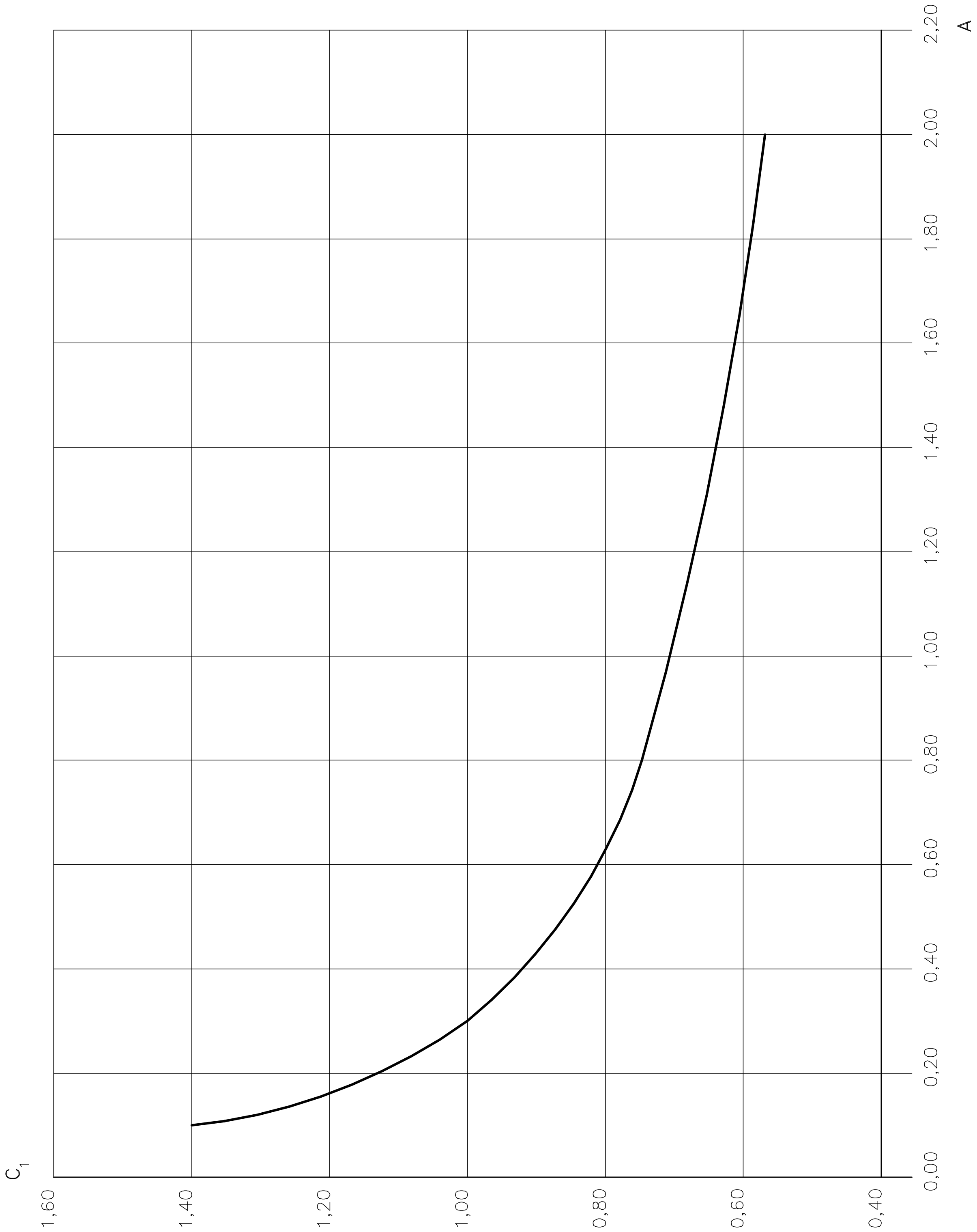

A
C1
0,00
0,20
0,40
0,60
0,80
1,00
1,20
1,40
1,60
1,80
2,00
2,20
1,60
1,40
1,20
1,00
0,80
0,60
0,40

Figure 5

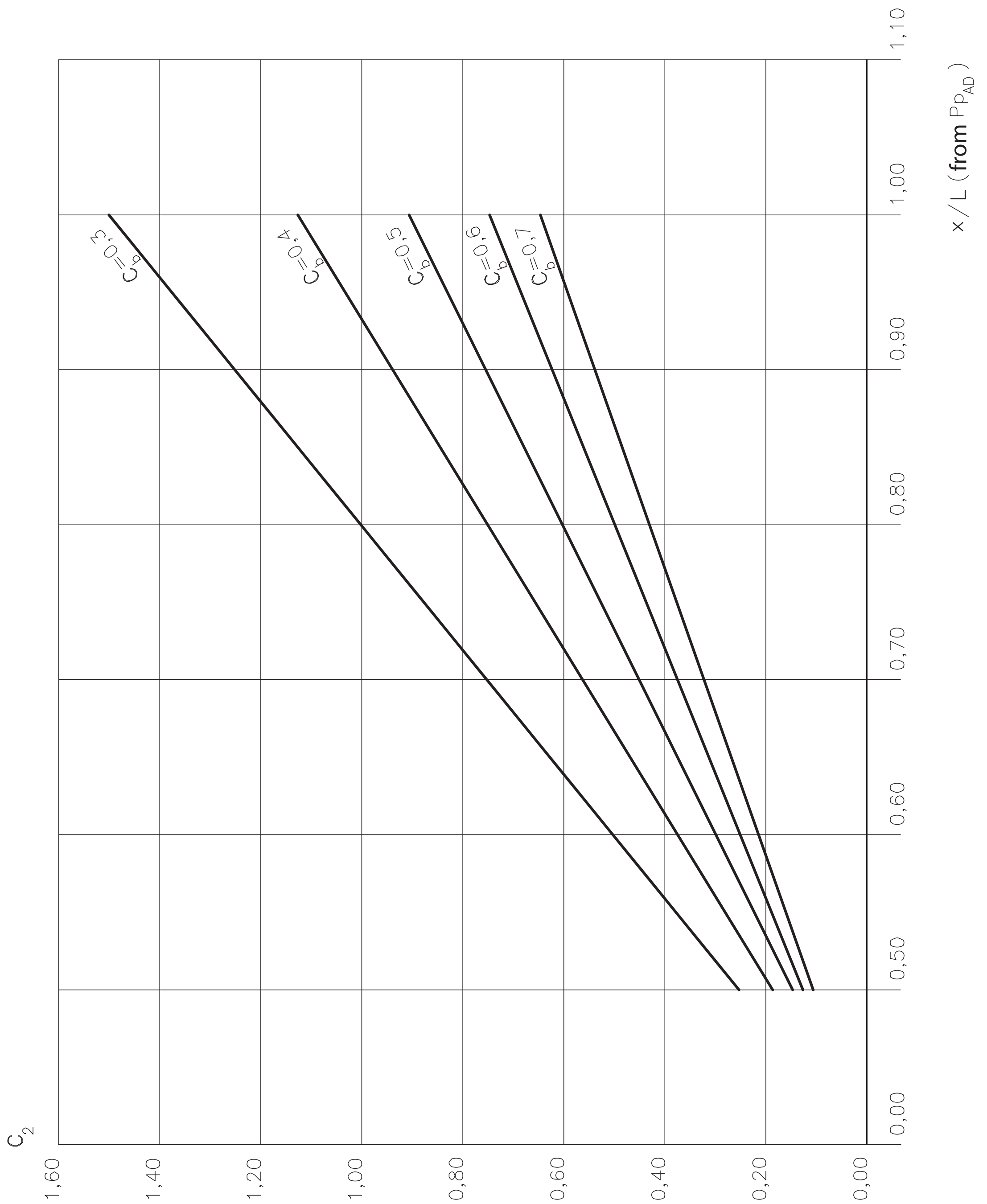

C2
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
0,00
0,50
0,60
0,70
0,80
0,90
1,00
1,10
x / L (from PPAD)
Cb=0,3
Cb=0,4
Cb=0,5
Cb=0,6
Cb=0,7

Figure 6

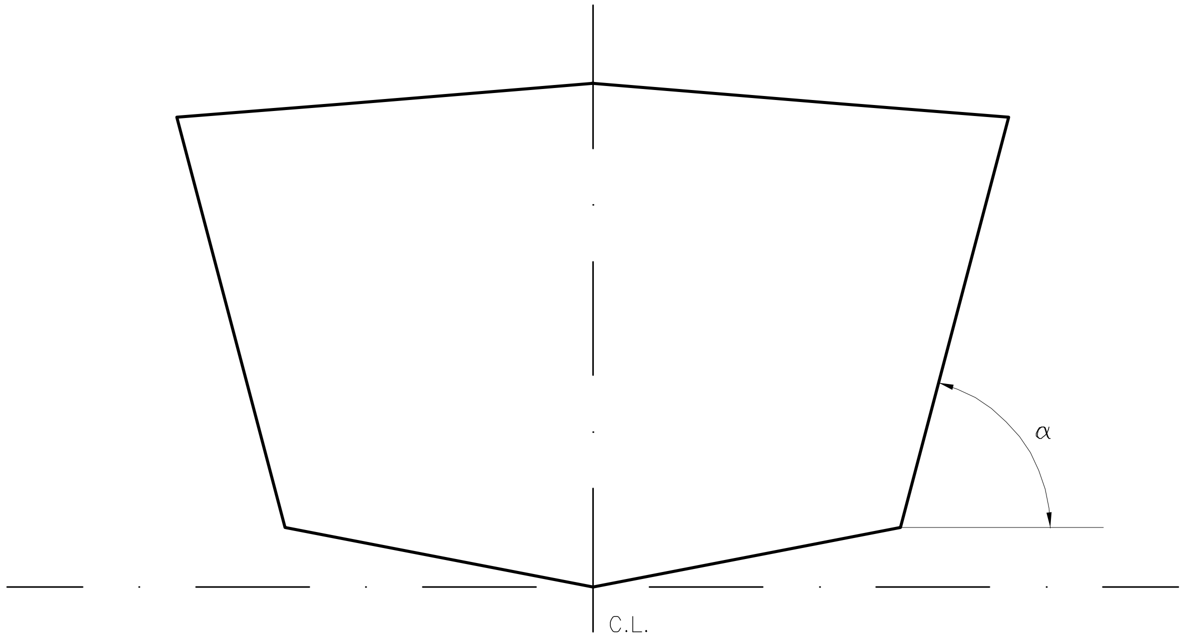
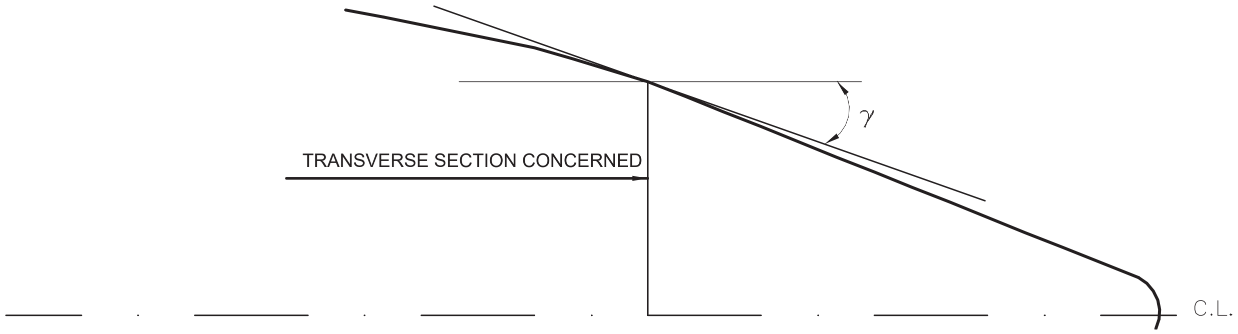


Figure 7



SECTION 6 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 2, Sec 2, [2.3] (see also [1.4.6]

C_R : rudder force, in N, acting on the rudder blade, defined in [2.1.2]

M_{TR} : rudder torque, in N.m, acting on the rudder blade, defined in [2.1.3]

M_B : bending moment, in N.m, in the rudder stock, defined in [3.1.6].

1 General

1.1 Application

1.1.1 Ordinary profile spade rudders *(1/1/2020)*

The requirements of this Section apply to ordinary profile spade 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 *(1/1/2020)*

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 *(1/1/2020)*

The requirements for steering nozzles are given in [10].

1.1.4 Special rudder types *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

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 10.

1.3.3 *(1/1/2020)*

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 *(1/1/2020)*

Rudders made of materials others than steel will be considered by the Society on a case-by-case basis.

1.4.2 *(1/1/2020)*

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 *(1/1/2020)*

The material used for rudder stocks, pintles, keys and bolts is to have a minimum yield stress not less than 200 N/mm^2.

1.4.4 *(1/1/2020)*

The requirements relevant to the determination of scantlings contained in this Section apply to steels having a 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 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} : 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 *(1/1/2020)*

Significant reductions in rudder stock diameter due to the application of steels with 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 *(1/1/2020)*

Welded parts of rudders are to be made of approved rolled hull materials. For these members, the material factor k defined in Ch 2, Sec 2, [2.3] is to be used.

1.5 Welding and design details

1.5.1 *(1/1/2020)*

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.

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 *(1/1/2020)*

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. 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.

1.5.3 *(1/1/2020)*

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].

1.5.4 *(1/1/2021)*

Requirements for welded connections of blade plating to vertical and horizontal webs are given in [7.3.6].

1.5.5 *(1/1/2020)*

Requirements for welding and design details of rudder trunks are described in [8.1].

2 Force and torque acting on the rudder

2.1 Rudder blade without cut-outs

2.1.1 Rudder blade description *(1/1/2020)*

A rudder blade without cut-outs may have trapezoidal or rectangular contour.

2.1.2 Rudder force *(1/1/2020)*

The rudder force C_R is to be obtained, in N, from the following formula:

$$C_R = 132\ n_t\ A\ V^2\ r_1\ r_2\ r_3$$

where:

n_t : yacht's type coefficient, to be taken from 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,

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,

h : mean height, in m, of the rudder area to be taken equal to (see Fig 1):

$$h = \frac{z_3 + z_4 - z_2}{2}$$

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 : Yacht's type coefficient *(1/1/2020)*

Yacht's type	n_t
≥ 500GT	1,00
< 500GT	0,55

Table 2 : Values of coefficient r_2 *(1/1/2020)*

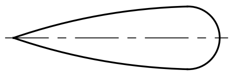
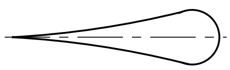
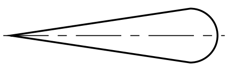
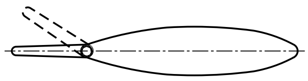
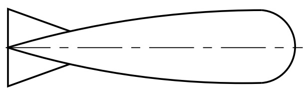
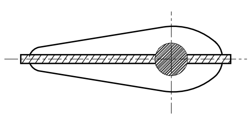
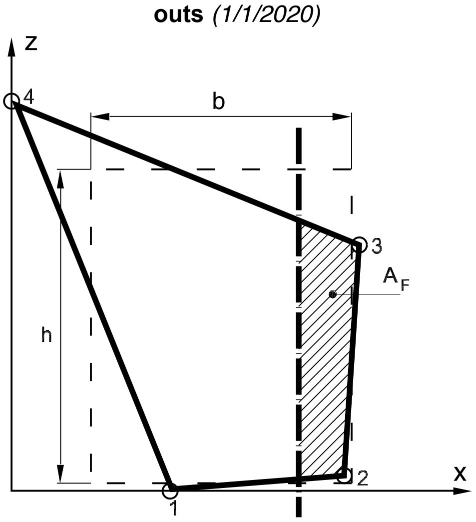
Rudder profile type	r_2 for ahead condition	r_2 for astern condition
NACA 00 - Goettingen 	1,10	0,80
Hollow 	1,35	0,90
Flat side 	1,10	0,90
High lift 	1,70	To be specially considered; if not known: 1,30
Fish tail 	1,40	0,80
Single plate 	1,00	1,00
Mixed profiles (e.g. HSVA)	1,21	0,90

Figure 1 : Geometry of rudder blade without cut-outs *(1/1/2020)*



2.1.3 Rudder torque *(1/1/2020)*

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:

- α = 0,33 for ahead condition,
- α = 0,66 for astern condition,

A_F : area, in m², of the rudder blade portion afore the centreline of rudder stock (see Fig 1).

3 Loads acting on the rudder structure

3.1 General

3.1.1 Loads *(1/1/2020)*

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.

3.1.2 Direct load calculations *(1/1/2020)*

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 [3.1.3].

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 Criteria for direct calculation of the loads acting on the rudder structure *(1/1/2020)*

These requirements 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.

3.1.4 Load calculation *(1/1/2020)*

The loads in 3.1.3 are to be calculated through direct calculations depending on the type of rudder.

They are to be used for the stress analysis required in:

- [4], for the rudder stock,
- [7] for the rudder blade
- [8] for the rudder trunk.

3.1.5 Forces per unit length *(1/1/2020)*

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::

$$p_R = \frac{C_R}{\ell_{10}}$$

3.1.6 Moments and forces *(1/1/2020)*

The loads in 3.1.3 may therefore be obtained from the following formulae (See Fig 2):

- 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:

  $Q_R = C_R$

4 Rudder stock scantlings

4.1 Bending moment

4.1.1 General *(1/1/2021)*

The bending moment M_B in the rudder stock for spade rudders is to be determined according to [3.1.2] through a direct calculation.

4.2 Scantlings

4.2.1 Rudder stock subjected to combined torque and bending *(1/1/2020)*

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:

$\sigma_E \le \sigma_{E,ALL}$

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:

$$\sigma_B = 10^3\frac{10{,}2M_B}{d_{TF}^3}$$

τ_T : torsional stress to be obtained, in N/mm², from the following formula:

$$\tau_T = 10^3\frac{5{,}1M_{TR}}{d_{TF}^3}$$

$\sigma_{E,ALL}$: allowable equivalent stress, in N/mm², equal to:

$\sigma_{E,ALL} = 118/k_1$ N/mm²

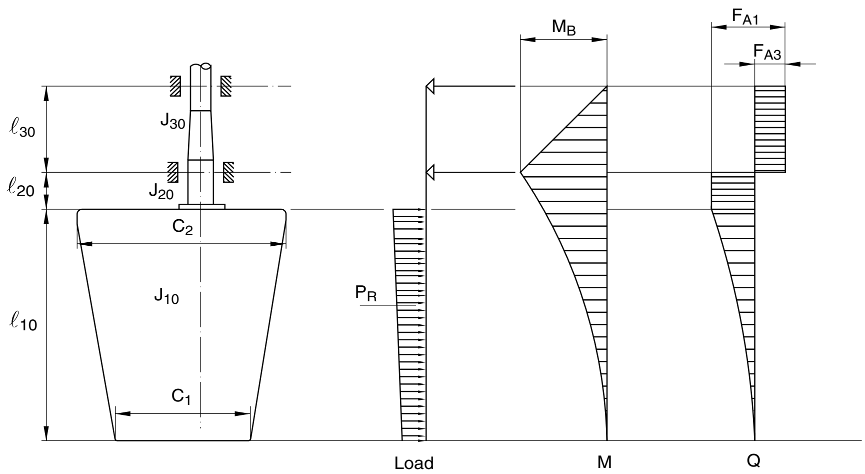
For this purpose, the rudder stock diameter is to be not less than the value obtained, in mm, from the following formula:

$$d_{TF} = 4{,}2(M_{TR}k_1)^{1/3}\left(1 + \frac{4}{3}\left(\frac{M_B}{M_{TR}}\right)^2\right)^{1/6}$$

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, where d_T is the rudder stock diameter subject to torque only calculated as below:

$d_T = 4{,}2\ (M_{TR}\ k_1)^{1/3}$

Figure 2 : Spade rudders *(1/1/2020)*



5 Rudder stock couplings

5.1 Horizontal flange couplings

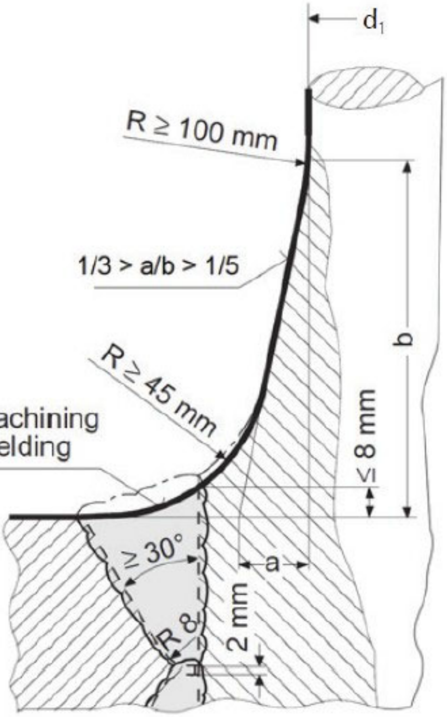
5.1.1 General *(1/1/2020)*

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_{TF} or 45 mm, whichever is the greater.

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 3).

Figure 3 : Welded joints between rudder stock and coupling flange *(1/1/2020)*



5.1.2 Bolts *(1/1/2020)*

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:

$$d_B = 0{,}62\sqrt{\frac{d_{TF}^3 k_{1B}}{n_B e_M k_{1S}}}$$

where:

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) mm^2 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 *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

The requirements in Pt C, Ch 1, Sec 10 apply.

5.2.2 General *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

Cone couplings without hydraulic arrangements for mounting and dismounting the coupling should have a taper on diameter in compliance with the following formula:

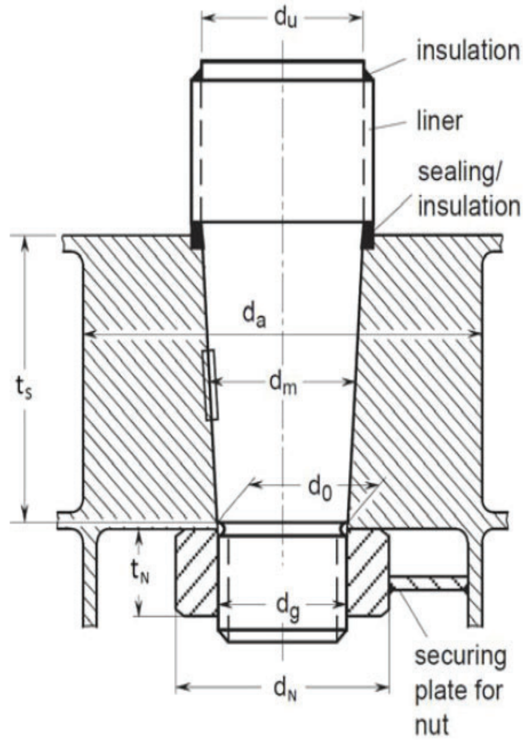
$$\frac{1}{12} \le \frac{d_U - d_0}{t_S} \le \frac{1}{8}$$

where:

d_U, t_S, d_0,: geometrical parameters of the coupling, defined in Fig 4.

The cone shapes are to fit exactly. The coupling length t_S is to be, in general, not less than 1,5d_U.

Figure 4 : Geometry of cone coupling with key *(1/7/2019)*



5.3.3 Dimensions of key *(1/7/2019)*

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 1.145d_T:

d_T : rudder stock diameter, in mm, subject to torque only (see 4.2.1)

d_k : mean diameter of the conical part of the rudder stock, in mm, at the key

R_{eH1} : 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:

where:

R_{eH2} : minimum yield stress of the key, stock or coupling material, in N/m², whichever is the less.

$$a_k = \frac{5Q_F}{d_k R_{eH2}}$$

$$a_k = \frac{10Q_F}{d_k R_{eH2}}$$

5.3.4 Slugging nut *(1/1/2020)*

The cone coupling is to be secured by a slugging nut, whose dimensions are to be in accordance with the following formulae:

$d_G \geq 0,65$ du

$t_N \geq 0,60\ d_G$

$d_N \geq 1,2\ d_0$ and, in any case, $d_N \geq 1,5\ d_G$

where:

d_G, t_N, d_N, d_1, d_0:geometrical parameters of the coupling, defined in Fig 4.

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 4.

5.3.5 Push-up *(1/1/2020)*

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 Pt B, Ch 10, Sec 1, [5.4.3] and [5.4.4] of Tasneef Rules for a torsional moment $Q'_F = 0,5Q_F$.

5.3.6 Rudder torque transmitted entirely by the key *(1/1/2020)*

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:

$$a_S = \frac{35,1Q_F}{d_k R_{eH1}}$$

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:

5.4 Cone couplings between rudder stocks and rudder blades with special arrangements for mounting and dismounting the couplings

5.4.1 General *(1/1/2021)*

See Pt B, Ch 10, Sec 1, [5.4] of Tasneef Rules.

5.5 Vertical flange couplings

5.5.1 *(1/1/2021)*

See Pt B, Ch 10, Sec 1, [5.5] of Tasneef Rules.

5.6 Couplings by continuous rudder stock welded to the rudder blade

5.6.1 *(1/1/2021)*

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 $0,20\ d_{TF}$.

5.6.2 *(1/1/2021)*

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 $0,20\ d_{TF}$.

5.7 Skeg connected with rudder trunk

5.7.1 *(1/1/2020)*

See Pt C, Ch 1, Sec 1, [5.7] of Tasneef Rules.

6 Rudder stock bearings

6.1 General

6.1.1 *(1/7/2021)*

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 3.1.3,

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,

$p_{F,ALL}$: allowable bearing pressure, in N/mm^2, defined in Tab 3.

Values greater than those given in Tab 3 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/mm^2.

The minimum height is to be at least d_m.

Table 3 : Allowable bearing pressure *(1/1/2020)*

Bearing material	$p_{F,ALL}$, in N/mm^2
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70 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.

6.1.2 *(1/1/2020)*

An adequate lubrication of the bearing surface is to be ensured.

6.1.3 *(1/1/2020)*

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.

6.1.4 *(1/1/2020)*

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.

7 Rudder blade scantlings

7.1 General

7.1.1 Application *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

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.

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.

7.2 Strength checks

7.2.1 Bending stresses *(1/1/2020)*

For the generic horizontal section of the rudder blade it is to be checked that the bending stress σ, in N/mm^2, induced by the loads defined in [3.1], is in compliance with the following formula:

$\sigma \le \sigma_{ALL}$

where:

σ_{ALL} : allowable bending stress, in N/mm^2, specified in Tab 4.

Table 4 : Allowable stresses for rudder blade scantlings *(1/1/2020)*

Allowable bending stress σ_{ALL} in N/mm^2	Allowable shear stress τ_{ALL} in N/mm^2	Allowable equivalent stress $\sigma_{E,ALL}$ in N/mm^2
110/k	50/k	120/k

7.2.2 Shear stresses *(1/1/2020)*

For the generic horizontal section of the rudder blade it is to be checked that the shear stress τ, in N/mm^2, induced by the loads defined in [3.1], is in compliance with the following formula:

$\tau \le \tau_{ALL}$

where:

τ_{ALL} : allowable shear stress, in N/mm^2, specified in Tab 4.

7.2.3 Combined bending and shear stresses *(1/1/2020)*

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:

$\sigma_E \le \sigma_{E,ALL}$

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 4.

7.3 Rudder blade plating

7.3.1 Plate thickness *(1/1/2020)*

The thickness of each rudder blade plate panel is to be not less than the value obtained, in mm, from the following formula:

$$t_f = \left(5{,}5 s\beta\sqrt{kT + \frac{C_R 10^{-4}}{A}}\right)\sqrt{k} + 2{,}5$$

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 : moulded draught, in m.

7.3.2 Thickness of the top and bottom plates of the rudder blade *(1/1/2020)*

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 *(1/1/2020)*

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 *(1/1/2020)*

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 for yachts ≥ 500GT
- 6 mm for yachts < 500GT.

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 mainpiece, this is to be replaced by two vertical webs closely spaced, having thickness not less than 1,4 t_f and the thickness of rudder plating to be at least 1,3 t_f. One vertical web only may be accepted provided its thickness is at least twice that of normal webs.

7.3.5 Thickness of side plating and vertical web plates welded to solid part or to rudder flange *(1/1/2021)*

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 [7.3.4].

7.3.6 Welding *(1/1/2020)*

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.

7.4 Connections of rudder blade structure with solid parts in forged or cast steel

7.4.1 General *(1/1/2021)*

See Pt B, Ch 10, Sec 1, [7.4] of Tasneef Rules.

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 *(1/1/2021)*

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 cm³, from the following formula:

$w_S = 1{,}3\, d_{TF}^3\, 10^{-4}$

where d_{TF}, in mm, is to be calculated in compliance with the requirements in [4.2], taken k_1 equal to 1.

7.5.2 Actual section modulus of the connection *(1/1/2020)*

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.

7.5.3 Welding of the rudder blade structure to the rudder blade flange *(1/1/2020)*

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 *(1/1/2020)*

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 1.4 t_f and 1,3 t_f respectively.

7.6 Single plate rudders

7.6.1 Mainpiece diameter *(1/1/2020)*

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 *(1/1/2020)*

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 5).

7.6.3 Arms *(1/1/2020)*

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:

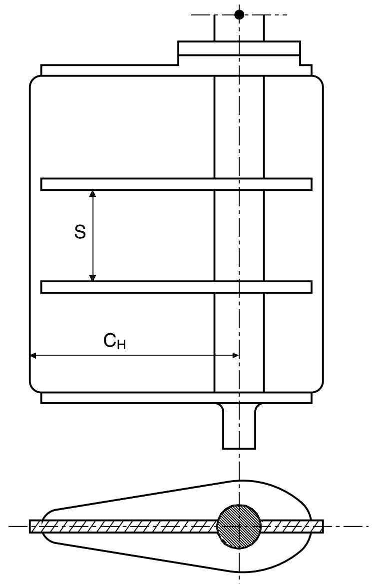
$$Z_A = 0{,}5 s C_H^2 V_{AV}^2 k$$

where:

C_H : horizontal distance, in m, from the aft edge of the rudder to the centreline of the rudder stock (see Fig 5),

s : defined in [7.6.2].

Figure 5 : Single plate rudder *(1/1/2020)*



8 Rudder trunk

8.1 Materials, welding and connection to the hull

8.1.1 *(1/1/2020)*

This requirement applies to both trunk configurations (extending or not below stern frame).

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 2 Sec 2.

In general, the fillet shoulder radius r, in mm, is to be as large as practicable (see Fig 6) and to comply with the following formulae:

r = 60 mm when $\sigma_B \geq 40 / k$ N/mm²,

r = 0,1 d_{TF} when $\sigma_B < 40 / k$ N/mm²,

without being less than 30 mm,

where:

d_{TF} : rudder stock diameter, in mm,

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.

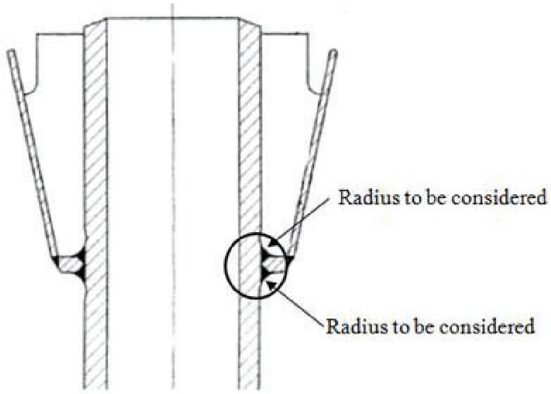
The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel are to be specially considered by the Society.

The rudder trunk is to be of adequate thickness (in general equivalent to the thickness of the hull in that area) and duly connected to the hull to the satisfaction of the Surveyor.

If the rudder stock is lined in way of the trunk bearing (for instance with stainless steel brush), the lining is to be shrunk on.

Figure 6 : Fillet shoulder radius *(1/1/2020)*



8.1.2 Strength check *(1/1/2020)*

Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantling of the trunk are to be such that:

- the equivalent stress σ_E, in N/mm^2, due to bending and shear does not exceed 0,35 R_{EH},
- the bending stress σ_B, in N/mm^2, 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} : yield stress, in N/mm^2, 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 General

9.1.1 *(1/1/2021)*

See Pt B, Ch 1, Sec 10, [9] of Tasneef Rules.

10 Steering nozzles

10.1 General

10.1.1 *(1/1/2021)*

See Pt B, Ch 1, Sec 10, [10] of Tasneef Rules.

11 Azimuth propulsion system

11.1 General

11.1.1 *(1/1/2021)*

See Pt B, Ch 1, Sec 10, [11] of Tasneef Rules.

APPENDIX 1 SIDE DOORS AND STERN DOORS

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 Arrangement

1.2.1 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.

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

1.2.3 Doors are preferably to open outwards.

1.3 Definitions

1.3.1 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 yacht.

1.3.2 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 yacht'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 yacht's structure.

1.3.3 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 *(1/7/2022)*

The design external forces FE and the design internal forces FI, in kN, 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.

For side/stern doors used as platform when in open position, the following design forces are to be taken into consideration in addition to the ones in Tab 1:

- deck loads and sea dynamic forces acting on the platform; and
- buoyancy forces when part of the side/stern door is submerged.

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 Yacht's structure.

3.1.3 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 for side plating, using the door stiffener spacing.

3.2.2 Ordinary stiffeners

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

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.

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 m^2 to be determined on the basis of the load area taking account of the direction of the pressure
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 kN /m
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.
Such above value is to be assumed considering the failure of the lashing of the objects to be carried in the space behind the doors: in such a case Fc is to be assumed not less than the weight in KN of the most heavy object to be carried in the space behind the doors.
However, the value of FC 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 : Design pressure for the side shell (Ch 1, Sec 5, [5.4]) not to be taken less than 25 kN/m^2

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 Scantlings of primary supporting members are generally to be verified through direct calculations on the basis of the design Loads in Table 1 and the strength criteria given in [5].

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 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.

4.1.2 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 [5].

4.2.2 When the securing and supporting devices are equally spaced, the distribution of the forces acting on each device may be obtained by dividing the total design force given in [2.1.1] for the number of the suppoting devices.

For arrangements of securing and supporting devices different from the above, direct calculations may be necessary to asses the distribution of the forces acting on the devices.

Special consideration will be given by Tasneef when the dimension of the opening is significant compared to the depth of the vessel: the distribution of the 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 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 [5].

4.2.4 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 backup brackets.

5 Strength criteria

5.1 Primary supporting members and securing and supporting devices

5.1.1 Plastic reinforced structures

The allowable normal and shear stresses are to be in conformity with the requirements stated in Ch 4, Sec 1, [4].

5.1.2 Steel structures

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 forces defined in [2.1.1], are in compliance with the following formulae:

$\sigma \leq \sigma_{ALL}$

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

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 2, Sec 2, [2.3].

5.1.3 Pins

a) Pins are to be calculated in compliance with the requirements given in [5.1.2]. In general, with reference to the material factor k for pins if a material with R_{eh} >=450 N/mm^2 is used, the value of k may be taken equal to 0,62.

   Pins are to be considered, in general, as a clamped beam.

   The clamped section is to be considered on the side where the actuator system for each pin is fitted.

   In general, the clamped section is provided with two adjacent bearings.

   Such bearings are, in general, fitted on the side door.

   The external bearing is considered the one which is close to the external edge of the side door. The other bearing is considered as the internal bearing.

   Another bearing is provided on the hull side where Force F is considered applied on the beam (pin).

   The Force for each pin is to be calculated taking into consideration the requirements given in [4.2.2] and [4.2.3]

   If the axial clearance (L) between the external bearing on the side door and the bearing on the hull structure is less than 1,5 times the pin diameter (d), the normal stress due to bending moment can be disregarded

   Where the action of the bending moment is to be considered, it is to be equilibrated by the reaction acting on each of the two bearings fitted on the side door. This reaction is obtained dividing the bending moment by the distance between the two bearings.

   In addition, the reaction force is also applied on the external bearing to equilibrate the force (F) applied on the bearing fitted on the ship side.

b) Other arrangements different from those indicated in a) will be considered on a case by case basis.

5.1.4 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:

$\sigma_B = 10\ F/ A_B$

with:

F : Force acting on the relevant bearing

A_B : Projected bearing area, in cm^2 (to be calculated multiplying the internal diameter of the bearing by the axial length of the bearing. In any case, the axial length is to be assumed not more than 1,2 times the internal diameter of the bearing)

$R_{eH,B}$: 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.

5.1.5 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 stress 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 Ch 2, Sec 2, [2.3].

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 with a clear opening area equal to or greater than 10 m^2 are to be provided with closing devices operable from a remote control position above the freeboard deck. This remote control is provided for 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 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) special safety precautions

b) service conditions

c) maintenance.

This manual is to be submitted in duplicate to Tasneef for information.

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.

8 External door testing

8.1

8.1.1 *(1/1/2016)*

External doors are to be tested according to the requirements given in App 2 for watertight doors.

For doors of more than 2 m^2 the hydrostatic test may be waived.

In any case upon completion of installation, external doors are to be checked by a "hose test".

The hose test is to be carried out at a minimum pressure in the hose of not less than 2,0 10^5 Pa and the nozzle is to be applied at a maximum distance of 1,5 m.

The nozzle diameter is to be not less than 12 mm.

APPENDIX 2 WATERTIGHT DOORS AND HATCHES: DESIGN AND TESTING CRITERIA

1 Watertight doors: design and testing criteria

1.1 Field of application

1.1.1

These requirements apply to the design, manufacturing and testing of watertight doors and associated manoeuvring systems.

They are essentially intended for sliding doors, but they are also applicable, as far as for the scantling and hydraulic test are concerned, to hinged doors.

As regards matters not explicitly dealt with in this Section the additional requirements given in Pt C for electrical systems are also to be applied.

1.2 Documentation to be submitted

1.2.1

Prior to starting the actual construction, the Manufacturer shall submit to Tasneef for approval the following drawings, diagrams and specifications, in triplicate:

a) Constructional drawings of the doors and associated accessories (guides, wedges, seals, frame, etc.); the drawings shall contain the constructional details of the components employed and shall indicate, inter alia, the type and characteristics of the materials employed, and the welding details and, for each door, the scantling hydrostatic head and the position on board foreseen for the door itself.

b) Diagrammatic plans of the hydraulic plant for the manoeuvring system. These plans shall indicate all the necessary information for their interpretation and verification and, in particular, the working and design pressures, the delivery of the pumps, the materials employed for the piping and fittings, and the dimensions of the pipes.

c) Constructional drawings of the manoeuvring hydraulic cylinders and of the pressure vessels. These drawings shall be complete with all dimensions and shall indicate, inter alia, the materials employed and any necessary information for their interpretation and verification.

d) Functional diagrams of power circuits, of control circuits from the navigating bridge, of signalling and alarm circuits, including specification of the type and characteristics of the equipment and specification of the electrical protection.

1.3 Scantlings of watertight bulkhead in way of watertight doors

1.3.1 Frames

When the frame is connected to the bulkhead by means of rivets or bolts, a thin heat-resisting seal is to be inserted between the frame and the bulkhead shell to assure watertightness.

Each side of the frame section is to have a moment of inertia J in cm^4, about the axis, through the centre of gravity, parallel to the door plane, not less than that given by the following formula:

$J = 27AB^3h$

where:

A = minor side of the clear door opening on the bulkhead, in m;

B = major side of the clear door opening on the bulkhead, in m;

h = water head resulting from the stability scantling, in m, measured from the door sill; this head is not to be taken less than 2 m.

Any stiffener on the bulkhead, fitted in way of the frame and surrounding the whole opening, together with the attached plating of the bulkhead, may be included in the calculation of the moment of inertia of the frame.

1.3.2 Bulkhead stiffeners

The bulkhead shell around the door opening is to be suitably reinforced by means of stiffeners, both vertical and horizontal.

The distance of such stiffeners from the outer edge of the door frame is generally to be not greater than 300 mm or less than 150 mm, and their scantlings are to be as required for the stiffeners of a watertight subdivision bulkhead, without taking into account the door frame and considering the door in closed position.

In way of the structure of connection of the door manoeuvring cylinder to the bulkhead, suitable local stiffeners are to be fitted, and the thickness of the bulkhead shell is to be increased, or a fastening plate is to be fitted.

1.4 Scantlings of watertight subdivision doors

1.4.1

The scantlings of the door shell and stiffeners, both horizontal and vertical, are to be in conformity with the requirements of Ch 2, Sec 10 for steel bulkheads.

1.5 Seals and wedges of sliding watertight doors

1.5.1 Seals

In general, door seals are to be of metallic material.

However, non-metallic materials may be employed, provided they are suitable for the application.

1.5.2 Wedges

The total number of fixed wedges on the door and on the frame, as well as their scantlings and shape, is to ensure a tightness of the seal such that the water leakage rate during the test does not exceed that stated in [9] .

1.6 Sliding guides and wheels of watertight doors

1.6.1

The guides are to have such a shape as to avoid the lodging of dust, dirt, etc. which could prevent the door from closing.

Guides consisting of a flat vertical bar on which grooved wheels roll for door movement may be considered as satisfying such requirement.

The scantlings of such guides and of the shoulder of the associated grooved wheels are to be such as to ensure a stiffening guaranteeing the closure of the door when subjected to a water head of 1 m.

1.7 Connection of the manoeuvring cylinder to the door

1.7.1

In way of the structure of connection of the manoeuvring cylinder to the door, a fastening plate having approximately the same thickness as the door is to be fitted.

Other types of connection may be considered on a case-by-case basis by Tasneef

1.8 Manoeuvring systems of watertight doors

1.8.1 General

The requirements of this Section apply to the manoeuvring systems of watertight doors which are required to be power-operated sliding type.

As far as other types of watertight doors are concerned, the acceptance of the relevant manoeuvring system will be considered in each case by Tasneef

In these Rules, watertight sliding doors are intended to mean those doors whose manoeuvring is done by means of (electrical or hydraulic) power systems.

1.9 Type, manufacturing and system characteristics

1.9.1

In general, reference is to be made to the applicable requirements for Passenger Ships, as defined in SOLAS Chapter II-1.

Hand operation from above the bulkhead deck and a hydraulic accumulator may be omitted if each door is provided with a dedicated power-pack electrically driven via the emergency switchboard, and control voltage from an emergency battery, and each door may be operated manually locally. Edge strips which stop the door closing on contact are not permitted.

1.9.2

The following requirements apply:

It shall be possible to open and close the door by hand at the door itself from both sides, both by power and by the above-mentioned hand-operated mechanism.

Power systems for power-operated watertight sliding doors shall be separate from any other power system.

Flexible hoses in non-metallic material installed on systems of watertight doors fitted on fire-resistant bulkheads shall be recognised by Tasneef as fire-resistant.

The fluid used shall be chosen considering the temperatures liable to be encountered by the installation during its service.

A single failure in the electrical or hydraulic power-operated systems excluding the hydraulic actuator shall not prevent the hand operation of any door.

A single electrical failure in the power operating or control system of a power-operated sliding watertight door shall not result in a closed door opening.

Watertight door controls, including hydraulic piping and electrical cables, shall be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimise the likelihood of them being involved in any damage which the ship may sustain.

As far as practicable, electrical equipment and components for watertight doors shall be situated above the bulkhead deck and outside hazardous areas and spaces.

The enclosures of electrical components necessarily situated below the bulkhead deck shall provide suitable protection against the ingress of water and, in particular:

a) electric motors, associated circuits and control components are to be protected to IPX7 standard
b) door position indicators and associated circuit components are to be protected to IPX8 standard
c) door movement warning signals are to be protected to IPX6 standard.

Other arrangements for the enclosures of electrical components may be fitted provided Tasneef is satisfied that an equivalent protection is achieved. The water pressure testing of the enclosures protected to IPX8 shall be based on the pressure that may occur at the location of the component during flooding for a period of 36 h.

1.9.3

Hinged doors may be accepted if installed on infrequently used openings in watertight compartments, where a crew member will be in immediate attendance when the door is open at sea. Audible and visual alarms are to be fitted in the wheelhouse.

In any case, for yachts less than 500 GT, hinged doors may be accepted provided that there is an audible and visual alarm on the Bridge indicating when the door is open. The doors are to be kept closed at sea and marked accordingly. A time delay for the alarm may be accepted.

1.10 Workshop testing

1.10.1 Testing of watertight doors

The hydraulic test is aimed at ascertaining the good watertightness of the door when it is subjected to the water head taken for the determination of the scantlings, which is not to be taken less than 2 m.

The test is considered to be satisfactory if the water leakage rate q, l/h, through the door, evaluated in a period not shorter than 1 h, does not exceed the quantity given by the following formula:

$q = h^3 (p+4,57) / 109$

where p is the perimeter of the door clear opening, m, and h is the water head taken for the determination of the scantlings, as defined in [3.1].

However, in the case of doors where the water head taken for the determination of the scantling does not exceed 6,10 m, the q value may be taken equal to 22,5 l/h if this value is greater than that calculated by the above-mentioned formula.

In special cases Tasneef may allow the hydraulic test to be carried out on board, with an agreed case-by-case test procedure.

During the tests, it is to be ascertained with a practical test that the door manoeuvring devices and systems are such as to allow the closure of the door with the ship listed by 15° on either side. The test may be carried out on board.

Moreover, the correct closure of the door, subjected to a water head of 1 m, is also to be ascertained with a practical test.

1.10.2 Testing of the manoeuvring systems

The testing of the manoeuvring systems consists of the following operations:

a) verification of compliance with the approved drawings;

b) testing of valves, pressure vessels (cylinders, tanks, accumulators, etc.), pumps, piping and associated fittings and electrical components in accordance with the relevant Rules;

c) hydrostatic pressure test of the system, at 1,5 times the maximum working pressure;

d) test in the working condition, as far as practical, in order to check the system functioning, safety devices included.

The tests foreseen in items (c) and (d) may be carried out on board.

1.11 Watertight door manoeuvring system tests on board

1.11.1

Watertight door manoeuvring systems are to be tested on board in order to ascertain their compliance with these Rules.

1.11.2

In particular, the following tests are to be carried out:

a) testing of the closure from the navigating bridge, with verification of the time necessary to carry out such closure;

b) testing of the closure of each door from the relevant manoeuvring position above the bulkhead deck, with verification of the time necessary to carry out such closure;

c) testing of opening and closure of each door from each side of the bulkhead, with verification of the time necessary to carry out the closure. The test is to be carried out both with power and with hand operation;

d) verification that the control handles which allow the opening of the door from each side of the bulkhead by power are so arranged as to enable persons passing through the doorway to hold both handles in the open position;

e) verification that, when released, the above-mentioned handles come back automatically to the position which ensures the closure of the door, if the door itself has been previously closed from the navigating bridge;

f) verification that the capacity of the hydraulic accumulators, if fitted, is sufficient to operate the connected doors at least three times, i.e. closed-open-closed, at the pump cut-in pressure;

g) testing of the indication and alarm systems.

1.12 Certification

1.12.1

A test certificate is to be issued for each door.

1.12.2

As an alternative to 12.1 for mass production products, a Type Approval Certificate for watertight doors may be issued.

A Tasneef Type Approval Certificate valid for 3 years can be obtained by the maker by testing a prototype according to the requirements given in [10] and [11].

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with Tasneef on a case-by-case basis.

During the period of the Certificate's validity, and for the next appliances produced of the same type, the tests required by the Rules can be carried out by the maker, who will issue a Certificate of conformity to the prototype.

1.12.3

For the renewal of the Tasneef Type Approval Certificate, the tests that will be carried out are to be specified in a scheme that is to be agreed with Tasneef

2 Hatches, design and testing criteria

2.1 Documentation to be submitted

2.1.1

Prior to starting the actual construction, the Manufacturer shall submit to Tasneef for approval the following drawings, in triplicate:

- constructional drawings of the hatch and associated accessories (guides, wedges, seals, frame, etc.); the drawings shall contain the constructional details of the components employed and shall indicate, inter alia, the type and characteristics of the materials employed, and the welding details and, for each hatch, the scantling hydrostatic head and the position foreseen on board.

2.2 Hatch scantling

2.2.1

For the scantling requirements of the deck hatch, reference is to be made to Pt B, Ch 1, Sec 1 [5.5]

2.3 Testing of Hatch

2.3.1 *(1/7/2021)*

This test shall be performed on each type of prefabricated appliance before its installation on the craft.

A sample of each type of prefabricated appliance shall be tested in a suitable pressure jig for at least 30 min with an outside water pressure of at least:

1,3 p

or

14 KPa

whichever is greater, where:

p is the deck design pressure in kPa corresponding to the deck head h_d specified in Pt B, Ch 1, Sec 5, [5.5].

No leak or permanent deformation of any part of the appliance shall be observed during the test.

Mechanical tests on hinged deck hatches:

Additional tests in conformity with ISO 12216 are to be carried out as for the Unintentional stepping test, Rope Jamming test and Hatch and hinge strength test.

2.3.2

Appliances having already performed successfully in one test do not need to be subjected to the test at lower pressure values.

The above test shall only be performed on a test sample made with the same process as the actual appliance, or on a sample taken from the production line.

These tests shall be repeated if any significant change is made to the manufacturing process or materials.

2.3.3

After performance of the above tests carried out by the appliance Manufacturer, before commercialisation, each appliance shall have its watertightness test on board using the "hose test" method.

The hose test is to be carried out at a minimum pressure in the hose of not less than $2,0 \cdot 10^5$ Pa, and the nozzle is to be applied at a maximum distance of 1,5 m.

The nozzle diameter is to be not less than 12 mm.

2.4 Type Approval Certificate

2.4.1

A Type Approval Certificate is issued after the tests on the prototype according to the above requirements.

The Tasneef Type Approval Certificate is valid for 3 years.The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with Tasneef on a case-by-case basis.

For each appliance, the maker will issue a Certificate of conformity to the prototype.

2.4.2

For the renewal of the Tasneef Type Approval Certificate, the tests that will be carried out are to be specified in a scheme that is to be agreed with Tasneef

2.5 Acceptance of individual products

2.5.1

Individual products can generally be accepted by carrying out the test according to [2.1] to [2.3]. A certificate for the individual product will be issued by Tasneef

Part B
Hull and Stability

Chapter 2
STEEL HULLS

SECTION 1 GENERAL REQUIREMENTS

1 Field of application

1.1

1.1.1 Chapter 2 applies to monohull yachts with a hull made of steel and a length L not exceeding 120 m, with motor or sail power with or without an auxiliary engine.

For yachts made of steel and having length L greater than 120 m, reference is to be made to Tasneef Rules for the Classification of Ships.

Multi-hulls or yachts with unusual shape, proportion and characteristics will be considered case-by-case.

In the examination of constructional plans, Tasneef may take into consideration material distribution and structural scantlings other than those that would be obtained by applying these regulations, provided that structures with longitudinal, transverse and local strength not less than that of the corresponding Rule structure are obtained or provided that such material distribution and structural scantlings are adequate, in the opinion of Tasneef on the basis of direct test calculations of the structural strength (see Pt B, Ch1, Sec 1, [3.1]).

The structural scantlings of displacement yachts of L ≥ 60 m may be arranged by applying the provisions of the Rules for the Classification of Ships.

This Chapter may also be used to check the structural scantlings of hulls made of metals with superior mechanical properties, other than steel, such as titanium and its alloys.

In general the following types are considered usable in the field of pleasure yachts:

- titanium: TiCP2, TiCP3, TiCP4;
- titanium alloys: Ti6AL4V grade 5, Ti5AL2.5Sn grade 6 and Ti3AL2.5V grade 9.

For the scantlings of the plating and stiffeners, a coefficient K, depending on the minimum yield strength of the material used, is to be adopted.

The value of the minimum yield strength is, however, to be not more than 0,7 of the ultimate tensile strength of the material.

Higher values may be adopted, at the discretion of Tasneef on condition that additional buckling strength and fatigue calculations are carried out.

In any case use of these materials is subject to the examination of the technical documentation of the manufacture of the material and the welding processes and tests that will be adopted.

2 Definitions and symbols

2.1 Premise

2.1.1 The definitions and symbols in this Article are valid for all the Sections of this Chapter.

The definitions of symbols having general validity are not normally repeated in the various Sections, whereas the meanings of those symbols which have specific validity are specified in the relevant Sections.

2.2 Definitions and symbols

2.2.1

L : scantling length, in m, on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest;

B : maximum breadth of the yacht, in m, outside frames; in tests of the longitudinal strength of twin hull yachts, B is to be taken as equal to twice the breadth of the single hull, measured immediately below the cross-deck;

D : depth of the yacht, in m, measured vertically in the transverse section at half the length L, from the base line up to the deck beam of the uppermost continuous deck;

T : draft of the yacht, in m, measured vertically in the transverse section at half the length L, from the base line to the full load waterline with the yacht at rest in calm water;

s : spacing of the ordinary longitudinal or transverse stiffener, in m;

Δ : displacement of the yacht outside frames, in t, at draught T;

K : factor as a function of the mechanical properties of the steel used, as defined in Sec 2.

3 Plans, calculations and other information to be submitted

3.1

3.1.1 Table 1 lists the structural plans that are to be presented in advance to Tasneef in triplicate, for examination and approval when required.

The Table also indicates the information that is to be supplied with the plans or, in any case, submitted to Tasneef for the examination of the documentation.

For documentation purposes, a copy of the following plans are to be submitted:

- general arrangement;
- capacity plan;
- lines plan;

Table 1 *(1/1/2016)*

PLAN	CONTAINING INFORMATION RELEVANT TO:
• Midship section	• main dimensions, maximum operating speed V, design acceleration a_{CG} for planing or semi-planing yachts • materials and associated mechanical properties • for yachts having L > 50 m, if mono-hull and L > 40 m, if multi-hull, the maximum still water bending moment is to be indicated • displacement
• Longitudinal and transverse section	
• Plan of the decks	• openings • loads acting, if different from Rule loads
• Shell expansion	• openings
• Structure of the engine room	
• Watertight bulkheads and deep tank bulkheads	• openings • location of overflow
• Structure of stern/side door	• closing appliances
• Superstructures	
• Support structure for crane	• design loads and connections to the hull structures
• Rudder	• materials of all components • calculation speed
• Propeller shaft struts	• material
• Additional plans for sailing yachts: - ballast keel shell expansion showing the adopted throat thickness and other welding characteristics - keel connection details	
• Plan of tank testing **(1)**	
(1) Only for yachts equal to or greater than 500 GT	

If the INWATERSURVEY notation is to be assigned the following plans and information are to be submitted:

- Details showing how rudder pintle and bush clearances are to be measured and how the security of the pintles in their sockets are to be verified with the craft afloat.
- Details showing how stern bush clearances are to be measured with the craft afloat.
- Name and characteristics of high resistant paint, for information only.

3.2

3.2.1

If a builder for the construction of a new vessel of standard design wishes to use drawings already approved for a vessel similar in design and construction and classed with the same class notation and the same navigation, the drawings need not be sent for approval, but the Request for Survey of the vessel is to be submitted together with a list of the drawings the builder wishes to refer to, and copies of the approved drawings are to be sent to Tasneef

It is the builder's responsibility to submit for approval any modification to the approved plans prior to the commencement of any work.

Plan approval of standard design vessels is only valid so long as no applicable Rule changes take place. When the Rules are amended, the plans are to be submitted for new approval.

4 Direct calculations

4.1

4.1.1 As an alternative to those based on the formulae in this Chapter, scantlings may be obtained by direct calculations carried out in accordance with the provisions of Chapter 1 of Part B of these Rules.

Chapter 1 provides schematisations, boundary conditions and loads to be used for direct calculations.

The scantlings are to be such as to guarantee that stress levels do not exceed the allowable values stipulated in the aforementioned Chapter.

4.2

4.2.1 In the case of use of materials with superior mechanical properties, other than steel, such as those indicated in 1.1, the allowable stresses will be stipulated by Tasneef on the basis of such properties and of any further fatigue tests and/or buckling checks which may be required.

5 Bukling strength checks

5.1 Application

5.1.1 Where required, the critical buckling strength of steel plating and stiffeners subject to compressive stresses is to be calculated as specified below.

5.2 Elastic buckling stresses of plates

5.2.1 Compressive stress

The elastic buckling strength, in N/mm², is given by:

$$\sigma_E = 0{,}9 \cdot m_c \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2$$

where:

$m_C = \frac{8,4}{\psi + 1,1}$ for plating with stiffeners parallel to compressive stress

or:

$m_C = c \cdot \left[1 + \left(\frac{a}{b}\right)^2\right]^2 \cdot \frac{2,1}{\psi + 1,1}$ for plating with stiffeners perpendicular to compressive stress

E : Young's modulus, in N/mm², to be taken equal to 2,06 . 10^5N/mm² for steelstructures

t : thickness of plating, in mm

a : shorter side of the plate, in m

b : longer side of the plate, in m

c : coefficient equal to:

- 1,30 when the plating is stiffened by floors or deep girders
- 1,21 when the plating is stiffened by ordinary stiffeners with angle- or T-sections
- 1,10 when the plating is stiffened by ordinary stiffeners with bulb sections
- 1,05 when the plating is stiffened by flat bar ordinary stiffeners.

ψ : ratio between the smallest and largest compressive stresses when the stress presents a linear variation across the plate ($0 \leq \psi \leq 1$).

5.2.2 Shear stress

The elastic buckling stress, in N/mm², is given by:

$$\tau_E = 0{,}9 \cdot m_t \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2$$

where:

$$m_t = 5{,}34 + 4 \cdot \left(\frac{a}{b}\right)^2$$

and E, t, a and b are as defined in (a) above.

5.3 Elastic buckling stresses of stiffeners

5.3.1 Column buckling without rotation of the transverse section

For the column buckling mode (perpendicular to the plane of plating) the elastic buckling stress, in N/mm², is given by:

$$\sigma_E = 0{,}001 \cdot E \cdot \frac{I_a}{A \cdot l^2}$$

E : Young's modulus, in N/mm², to be taken equal to 2,06 . 10^5 N/mm² for steelstructures

I_a : moment of inertia, in cm⁴, of the stiffener, including plate flange

A : cross-sectional area, in cm², of the stiffener, including plate flange

l : span, in m, of the stiffener.

5.3.2 Torsional buckling

For the torsional mode, the elastic buckling stress, in N/mm², is given by:

$$\sigma_E = \frac{\pi^2 \cdot E \cdot I_W}{10^4 \cdot I_p \cdot l^2} \cdot \left(m^2 + \frac{C_K}{m^2}\right) + 0{,}385 \cdot E \cdot \frac{I_t}{I_p}$$

where:

E, I : defined in 5.3.1 above

$$C_K = \frac{C \cdot l^4}{\pi^4 \cdot E \cdot I_W} \cdot 10^6$$

m : number of half-waves, given in Table 2.

Table 2

	0<C<4	4<C<36	36<C<144	(m-1) m<C<m (m+1)
m	1	2	3	m

I_t : St. Venant, moment of inertia of profile, in cm4, without plate flange, equal to:

$\frac{h_w \cdot t_w^3}{3} \cdot 10^{-4}$ for flat bars

or:

$\frac{1}{3} \cdot \left[h_w \cdot t_w^3 + b_f \cdot t_f^3 \cdot \left(1 - 0{,}63 \cdot \frac{t_f}{b_f}\right)\right] \cdot 10^{-4}$

for flanged profile

I_p : polar moment of inertia of profile, in cm⁴, about connection of stiffener to plate, equal to:

$\frac{h_w^3 \cdot t_w}{3} \cdot 10^{-4}$ for flat bars

or:

$\left(\frac{h_w^3 \cdot t_w}{3} + h_w^2 \cdot b_f \cdot t_f\right) \cdot 10^{-4}$ for flanged profiles

I_W : sectional moment of inertia of profile, in cm6, about connection of stiffener to plate, equal to:

$\frac{h_w^3 \cdot t_w^3}{36} \cdot 10^{-6}$ for flat bars

or:

$\frac{t_f \cdot b_f^3 \cdot h_w^2}{12} \cdot 10^{-6}$ for T profiles

$\frac{b_f^3 \cdot h_w^2}{12 \cdot (b_f + h_w)^2} \cdot [t_f \cdot (b_f^2 + 2b_f \cdot h_w + 4h_w^2) + (3t_w \cdot b_f \cdot h_w] \cdot 10^{-6})$

for flanged profiles.

where:

h_W : web height, in mm

t_W : web thickness, in mm

b_f : flange width, in mm

t_f : flange thickness, in mm; for bulb profiles, the mean thickness of the bulb maybe used

C : spring stiffness factor, exerted by supporting plate, equal to:

$$\frac{k_p \cdot E \cdot t^3}{3s \cdot \left(1 + \frac{1{,}33 \cdot k_p \cdot h_w \cdot t^3}{1000 \cdot s \cdot t_w^3}\right)} \cdot 10^{-3}$$

where:

t : plating thickness, in mm,

s : spacing of stiffeners, in m,

k_p : 1 -η_p , not to be taken less than 0,

η_p : σ_a / σ_{Ep}

σ_a : calculated compressive stress in the stiffener

σ_{Ep} : elastic buckling stress of plating as calculated in 5.2.1.

5.3.3 Web buckling

The elastic buckling stress, in N/mm², is given by:

$$\sigma_E = 3{,}8 \cdot E \cdot \left(\frac{t_w}{h_w}\right)^2$$

where:

E : defined in 5.3.1

t_W, h_W : defined in 5.3.2.

5.4 Critical buckling stress

5.4.1 Compressive stress

The critical buckling stress in compression, σ_C, for plating and stiffeners is given by:

$$\sigma_c = \sigma_E \qquad \text{if} \qquad \sigma_E \le \frac{R_{eH}}{2}$$

$$\sigma_c = R_{eH} \cdot \left(1 - \frac{R_{eH}}{4 \cdot \sigma_e}\right) \qquad \text{if} \qquad \sigma_E > \frac{R_{eH}}{2}$$

where:

R_{eH} : minimum yield stress of steel used, in N/mm²

σ_E : elastic buckling stress calculated according to 5.2.1 and 5.3.2.

5.4.2 Shear stress

The critical buckling shear stress τ_C for plating and stiffeners is given by:

$$\tau_c = \tau_E \qquad \text{if} \qquad \tau_E \le \frac{\tau_F}{2}$$

$$\tau_c = \tau_F \cdot \left(1 - \frac{\tau_F}{4 \cdot \tau_e}\right) \qquad \text{if} \qquad \tau_E > \frac{\tau_F}{2}$$

where:

τ_C : 0,58 R_{eh}

R_{eh} : minimum yield stress of steel used, in N/mm²

τ_E : elastic buckling stress calculated according to 5.2.2.

6 General rules for design

6.1

6.1.1 The hull scantlings required in this Chapter are in general to be maintained throughout the length of the hull.

For yachts with length L greater than 50 m, reduced scantlings may be adopted for the fore and aft zones, provided that they are no less than those shown in Table 3.

In such case the variations between the scantlings adopted for the central part of the hull and those adopted for the ends are to be gradual.

In the design, care is to be taken in order to avoid structural discontinuities in particular in way of the ends of superstructures and of the openings on the deck or side of the yacht.

For yachts similar in performance to high speed hulls, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

Such interval is to be suitably reduced in the areas forward of amidships subject to the forces caused by slamming.

7 Minimum thicknesses

7.1

7.1.1 The thicknesses of plating and stiffeners calculated using the formulae in this Chapter is to be not less than the values shown in Table 3.

Lesser thicknesses may be accepted provided that, in the opinion of Tasneef their adequacy in terms of buckling strength and resistance to corrosion is demonstrated.

Where plating and stiffeners contribute to the longitudinal strength of the yacht, their scantlings are to be such as to fulfil the requirements for yacht longitudinal strength stipulated in Sec 4.

8 Corrosion protection

8.1

8.1.1 All steel structures, with the exception of fuel tanks, are to be suitably protected against corrosion.

Such arrangements may consist of coating or, where applicable, cathodic protection.

The structures are to be clean and free from slag before the coating is applied.

8.2

8.2.1 When a primer is used after the preparation of the surfaces and prior to welding, as well as not impairing the latter the composition of the primer is to be compatible with the subsequent layers of the coating cycle.

The coating is to be applied with adequate thickness in accordance with the Manufacturer's specifications.

8.3

8.3.1 Paint or other products containing nitrocellulose or other highly flammable substances are not to be used in machinery or accommodation spaces.

9 Plating attached to griders

9.1 Primary supporting members

9.1.1 The section modulus and the moment of inertia of primary supporting members are to be calculated in association with an effective area $\mathbf{A_S}$, in cm^2, of attached load bearing plating obtained from the following:

$$A_S = 10c \cdot b_F \cdot t_S$$

where:

$$\text{for } \mathbf{S_L}/\mathbf{b_F} < 8 : \mathbf{c} = 0,25 \cdot \left(\frac{\mathbf{S_L}}{\mathbf{b_F}}\right) - 0,016 \cdot \left(\frac{\mathbf{S_L}}{\mathbf{b_F}}\right)^2$$

$$\text{for } \mathbf{S_L}/\mathbf{b_F} \geq 8 : \mathbf{c} = 1$$

where:

Girders : primary supporting members of ordinary stiffeners such as deck girders, beams and web frames, side stringers, vertical and horizontal girders of bulkheads, floors, centre and side bottom girders, and similar.

Ordinary stiffeners: supporting members of shell plating, decks, double bottom or tank top plating, bulkheads, and similar.

$\mathbf{S_L}$: overall length of the girder, in m

$\mathbf{b_F}$: actual width of the load bearing plating, i.e. one-half of the sum of the spaces between parallel stiffeners adjacent to that considered, in m

$\mathbf{t_s}$: mean thickness, in mm, of the attached plating

$\mathbf{A_s}$: area of the attached plating, in cm^2

$\mathbf{t_a}$: web thickness, in mm, in built sections

$\mathbf{d_a}$: web depth in built sections, measured between the inside of the face plate and the inside of the attached plating, in mm

9.2 Ordinary stiffeners

9.2.1 Unless otherwise stated in specific requirements, the section modulus and the moment of inertia of the ordinary stiffeners are to be calcolated in association with an effective load bearing plating having width equal to the spacing of the stiffeners and thickness equal to the mean thickness of the attached plating.

9.3 Special cases

9.3.1 In way of fore and aft regions and, in general, where the web of the section is at an angle α less than 90° to the attached plating, the section modulus shall be calculated taking account of the inclination of the attached plating.

Where the above angle α is less than 75°, the section modulus of the stiffener may be approximately calculated by multiplying the section modulus of the web fitted at right angles to the attached plating by cos (90 - α).

9.4 Calculation of section modulus

9.4.1 Primary supporting members

The section modulus $\mathbf{W_T}$, in cm^3, of a built section with attached plating of area $\mathbf{A_S}$, in cm^2, may be calculated using the following formula:

$$\mathbf{W_T} = \frac{\mathbf{A_p} \cdot \mathbf{d_a}}{10} + \frac{\mathbf{t_S} \cdot \mathbf{d_a^2}}{6000} \cdot \left(1 + \frac{200 \cdot (\mathbf{A_S} - \mathbf{A_p})}{200\mathbf{A_S} + \mathbf{t_a} \cdot \mathbf{d_a}}\right)$$

In cases of symmetrical sections, the section modulus may be calculated as follows:

$$\mathbf{W_T} = \frac{\mathbf{A_P} \cdot \mathbf{d_A}}{10} + \frac{\mathbf{t_a} \cdot \mathbf{d^2}_a}{6000}$$

As a rule $\mathbf{A_S}$ is to be greater than $\mathbf{A_p}$; in this respect, the thickness of the attached plating is to be increased accordingly where necessary.

$\mathbf{A_a}$: web area, in cm^2, in built sections

$\mathbf{b_p}$: face plate width, in mm, in built sections

$\mathbf{A_a}$: face plate area, in cm^2, in built sections

In the case of members located along the edge of openings, the effective area of the attached plating is to be assumed equal to 7/10 of the value of $\mathbf{A_S}$ calculated by assuming $\mathbf{b_F}$ equal to half the distance between the member considered and its adjacent member.

Table 3

Member	Minimum thickness (mm)
Keel, bottom plating	$t_1 = 1,35 \cdot L^{1/3} \cdot K^{0,5}$
Side plating	$t_2 = 1,15 \cdot L^{1/3} \cdot K^{0,5}$
Open strength deck plating	$t_3 = 1,15 \cdot L^{1/3} \cdot K^{0,5}$
Lower and enclosed deck plating	$t_4 = t_3 - 0,5$
1st tier superstructure front bulkhead	$t_5 = t_4$
Superstructure bulkhead	$t_6 = t_5 - 1$
Watertight subdivision bulkhead	$t_7 = t_2 - 0,5$
Tank bulkhead	$t_8 = t_2$
Centre girder	$t_9 = 1,75 \cdot L^{1/3} \cdot K^{0,5}$
Floors and side girders	$t_{10} = 1,30 \cdot L^{1/3} \cdot K^{0,5}$
Tubular pillars	$0,03\ d \cdot K^{0,5} \geq 3,0$ **(1)**
(1) d = diameter of the pillar, in mm	

SECTION 2 MATERIALS

1 General

1.1 Characteristics of materials

1.1.1 The characteristics of the materials to be used in the construction of ships are to comply with the applicable requirements of Part D.

1.1.2 Materials with different characteristics may be accepted, provided their specification (manufacture, chemical composition, mechanical properties, welding, etc.) is submitted to Tasneef for approval.

1.2 Testing of materials

1.2.1 Materials are to be tested in compliance with the applicable requirements of Part D.

1.3 Manufacturing processes

1.3.1 The requirements of this Section presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and the applicable requirements of Part D. In particular:

- parent material and welding processes are to be approved within the limits stated for the specified type of material for which they are intended
- specific preheating may be required before welding
- welding or other cold or hot manufacturing processes may need to be followed by an adequate heat treatment.

2 Steels for hull structure

2.1 Application

2.1.1 Tab 1 gives the mechanical characteristics of steels currently used in the construction of ships.

2.1.2 Higher strength steels other than those indicated in Tab 1 are considered by Tasneef on a case by case basis.

2.1.3 When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, hull scantlings are to be determined taking into account the material factor k defined in [2.3].

2.1.4 Characteristics of steels with specified through thickness properties are given in Pt D, Ch 2, Sec 1, [7].

2.2 Information to be kept on board

2.2.1 A plan is to be kept on board indicating the steel types and grades adopted for the hull structures. Where steels other than those indicated in Tab 1 are used, their mechanical and chemical properties, as well as any workmanship requirements or recommendations, are to be available on board together with the above plan.

2.2.2 It is also recommended that a plan is kept on board indicating the hull structures built in normal strength steel of grades D or E.

Table 1 : Mechanical properties of hull steels

Steel grades	Minimum yield stress R_{eH}, in N/mm^2	Ultimate minimum tensile strength R_m, in N/mm^2
A-B-D-E t ≤ 100mm	235	400 - 520
AH32-DH32-EH32 t ≤ 100mm FH32 t ≤ 50mm	315	440 - 590
AH36-DH36-EH36 t ≤ 100mm FH36 t ≤ 50mm	355	490 - 620
AH40-DH40-EH40 FH40 t ≤ 50mm	390	510 - 650
Note 1: Reference in Part D: Pt D, Ch 2, Sec 1, [2]		

2.3 Material factor k

2.3.1 General

Unless otherwise specified, the material factor k has the values defined in Tab 2, as a function of the minimum guaranteed yield stress R_{eH}.

For intermediate values of R_{eH} , k may be obtained by linear interpolation.

Steels with a yield stress lower than 235 N/mm^2 or greater than 390 N/mm^2 are considered by Tasneef on a case by case basis.

Table 2 : Material factor k

R_{eH} , in N/mm^2	k
235	1
315	0,78
355	0,72
390	0,70

2.4 Grades of steel

2.4.1 For the purpose of the selection of steel grades to be used for the various structural members, the latter are divided into categories (SECONDARY, PRIMARY and SPECIAL), as indicated in Tab 3.

Tab 3 also specifies the classes (I, II and III) of the materials to be used for the various categories of structural members.

2.4.2 Materials are to be of a grade not lower than that indicated in Tab 4 depending on the material class and structural member gross thickness.

2.4.3 For strength members not mentioned in Tab 3, grade A/AH may generally be used.

2.4.4 In specific cases, such as [2.4.5], with regard to stress distribution along the hull girder, the classes required within 0,4L amidships may be extended beyond that zone, on a case by case basis.

2.4.5 The material classes required for the strength deck plating, the sheerstrake and the upper strake of longitudinal bulkheads within 0,4L amidships are to be maintained for an adequate length across the poop front and at the ends of the bridge, where fitted.

Table 3 : Application of material classes and grades

Structural member category	Material class or grade	
	Within 0,4L amidships	Outside 0,4L amidships
SECONDARY: • Longitudinal bulkhead strakes, other than that belonging to the Primary category • Deck plating exposed to weather, other than that belonging to the Primary or Special category • Side plating	I	A / AH
PRIMARY: • Bottom plating (including keel plate) • Strength deck plating, excluding that belonging to the Special category • Continuous longitudinal members above strength deck • Uppermost strake in longitudinal bulkhead	II	A / AH
SPECIAL: • Sheerstrake at strength deck • Stringer plate in strength deck • Deck strake at longitudinal bulkhead • Bilge strake	III	II (I outside 0,6L amidships)

Note 1: Plating materials for sternframes, rudders, rudder horns and shaft brackets are generally to be of grades not lower than those corresponding to class II.
For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders) class III is to be applied.
Note 2: Bedplates of seats for propulsion and auxiliary engines inserted in the inner bottom are to be of class I. In other cases, the steel may generally be of grade A. Different grades may be required by Tasneef on a case-by-case basis.

Table 4 : Material grade requirements for classes I, II and III

Class	I		II		III	
Gross thickness, in mm	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 15	A	AH	A	AH	A	AH
15 < t ≤ 20	A	AH	A	AH	B	AH
20 < t ≤ 25	A	AH	B	AH	D	DH
25 < t ≤ 30	A	AH	D	DH	D	DH
30 < t ≤ 35	B	AH	D	DH	E	EH
35 < t ≤ 40	B	AH	D	DH	E	EH
40 < t ≤ 50	D	DH	E	EH	E	EH

Note 1:“NSS” and “HSS” mean, respectively:
“Normal Strength Steel” and “Higher Strength Steel”.

2.4.6 Rolled products used for welded attachments on hull plating, such as gutter bars and bilge keels, are to be of the same grade as that used for the hull plating in way.

Where it is necessary to weld attachments to the sheerstrake or stringer plate, attention is to be given to the appropriate choice of material and design, the workmanship and welding and the absence of prejudicial undercuts and notches, with particular regard to any free edges of the material.

2.4.7 In the case of grade D plates with a nominal thickness equal to or greater than 36 mm, or in the case of grade DH plates with a nominal thickness equal to or greater than 31 mm, Tasneef may, on a case by case basis, require the impact test to be carried out on each original “rolled unit”, where the above plates:

- either are to be placed in positions where high local stresses may occur, for instance at breaks of poop and bridge, or in way of large openings on the strength deck and on the bottom, including relevant doublings, or
- are to be subjected to considerable cold working.

2.4.8 In the case of full penetration welded joints located in positions where high local stresses may occur perpendicular to the continuous plating, Tasneef may, on a case-by-case basis, require the use of rolled products having adequate ductility properties in the through thickness direction, such as to prevent the risk of lamellar tearing (Z type steel, see Part D).

2.5 Grades of steel for structures exposed to low air temperatures

2.5.1 For ships intended to operate in areas with low air temperatures (-20°C or below), e.g. regular service during winter seasons to Arctic or Antarctic waters, the materials in exposed structures are to be selected based on the design temperature t_D, to be taken as defined in [2.5.2].

2.5.2 The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation, where:

Mean : Statistical mean over observation period (at least 20 years)

Average : Average during one day and night

Lowest : Lowest during one year

Fig 1 illustrates the temperature definition.

For seasonally restricted service, the lowest value within the period of operation applies.

2.5.3 For the purpose of the selection of steel grades to be used for the structural members above the lowest ballast waterline and exposed to air, the latter are divided into categories (SECONDARY, PRIMARY and SPECIAL), as indicated in Tab 5.

Tab 5 also specifies the classes (I, II and III) of the materials to be used for the various categories of structural members.

For non-exposed structures and structures below the lowest ballast waterline, see [2.4].

2.5.4 Materials may not be of a lower grade than that indicated in Tab 6 to Tab 8 depending on the material class, structural member gross thickness and design temperature t_D.

For design temperatures t_D < -55°C, materials will be specially considered by Tasneef on a case by case basis.

2.5.5 Single strakes required to be of class III or of grade E/EH of FH are to have breadths not less than (800+5L) mm, but not necessarily greater than 1800 mm.

Figure 1 : Commonly used definitions of temperatures

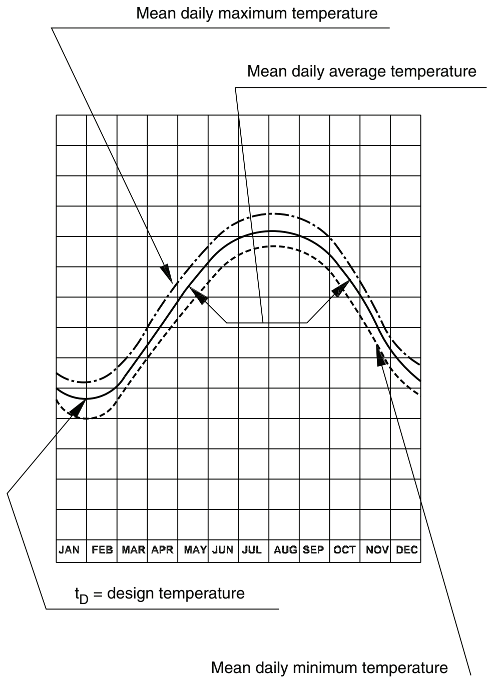


Table 5 : Application of material classes and grades to structures exposed to low air temperatures

Structural member category	Material class	
	Within 0,4L amidships	Outside 0,4L amidships
SECONDARY: Deck plating exposed to weather (in general) Side plating above T_B **(1)** Transverse bulkheads above T_B **(1)**	I	I

(1) T_B is the draught in light ballast condition.

(2) Plating at corners of large hatch openings to be considered on a case by case basis. Class III or grade E/EH to be applied in positions where high local stresses may occur.

Note 1: Plating materials for sternframes, rudder horns, rudders and shaft brackets are to be of grades not lower than those corresponding to the material classes in [2.4].

Structural member category	Material class	
	Within 0,4L amidships	Outside 0,4L amidships
PRIMARY: Strength deck plating **(2)** Continuous longitudinal members above strength deck Longitudinal bulkhead above T_B **(1)**	II	I
SPECIAL: Sheerstrake at strength deck Stringer plate in strength deck Deck strake at longitudinal bulkhead	III	II
(1) T_B is the draught in light ballast condition. **(2)** Plating at corners of large hatch openings to be considered on a case by case basis. Class III or grade E/EH to be applied in positions where high local stresses may occur. **Note 1:**Plating materials for sternframes, rudder horns, rudders and shaft brackets are to be of grades not lower than those corresponding to the material classes in [2.4].		

2.6 Grades of steel within refrigerated spaces

2.6.1 For structural members within or adjacent to refrigerated spaces, when the design temperature is below 0°C, the materials are to be of grades not lower than those indicated in Tab 9, depending on the design temperature, the structural member gross thickness and its category (as defined in Tab 3).

2.6.2 Unless a temperature gradient calculation is carried out to assess the design temperature and the steel grade in the structural members of the refrigerated spaces, the temperatures to be assumed are specified below:

- temperature of the space on the uninsulated side, for plating insulated on one side only, either with uninsulated stiffening members (i.e. fitted on the uninsulated side of plating) or with insulated stiffening members (i.e. fitted on the insulated side of plating)
- mean value of temperatures in the adjacent spaces, for plating insulated on both sides, with insulated stiffening members, when the temperature difference between the adjacent spaces is generally not greater than 10 °C (when the temperature difference between the adjacent spaces is greater than 10°C, the temperature value is stipulated by Tasneef on a case by case basis)
- in the case of non-refrigerated spaces adjacent to refrigerated spaces, the temperature in the non-refrigerated spaces is to be conventionally taken equal to 0°C.

2.6.3 Situations other than those mentioned in [2.6.1] and [2.6.2] or special arrangements will be considered by Tasneef on a case by case basis.

2.6.4 Irrespective of the provisions of [2.6.1], [2.6.2] and Tab 9, steel having grades lower than those required in [2.4], Tab 3 and Tab 4, in relation to the class and gross thickness of the structural member considered, may not be used.

Table 6 : Material grade requirements for class I at low temperatures

Gross thickness, in mm	-20°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	A	AH	B	AH	D	DH	D	DH
10 < t ≤ 15	B	AH	D	DH	D	DH	D	DH
15 < t ≤ 20	B	AH	D	DH	D	DH	E	EH
20 < t ≤ 25	D	DH	D	DH	D	DH	E	EH
25 < t ≤ 30	D	DH	D	DH	E	EH	E	EH
30 < t ≤ 35	D	DH	D	DH	E	EH	E	EH
35 < t ≤ 45	D	DH	E	EH	E	EH	ϕ	FH
45 < t ≤ 50	E	EH	E	EH	ϕ	FH	ϕ	FH
Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel". **Note 2:**"ϕ" = not applicable.								

Table 7 : Material grade requirements for class II at low temperatures

Gross thickness, in mm	-20°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	B	AH	D	DH	D	DH	E	EH
10 < t ≤ 20	D	DH	D	DH	E	EH	E	EH
20 < t ≤ 30	D	DH	E	EH	E	EH	ϕ	FH
30 < t ≤ 40	E	EH	E	EH	ϕ	FH	ϕ	FH
40 < t ≤ 45	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
45 < t ≤ 50	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ

Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel".
Note 2:"ϕ" = not applicable.

Table 8 : Material grade requirements for class III at low temperatures

Gross thickness, in mm	-20°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	D	DH	D	DH	E	EH	E	EH
10 < t ≤ 20	D	DH	E	EH	E	EH	ϕ	FH
20 < t ≤ 25	E	EH	E	EH	ϕ	FH	ϕ	FH
25 < t ≤ 30	E	EH	E	EH	ϕ	FH	ϕ	FH
30 < t ≤ 35	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
35 < t ≤ 40	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
40 < t ≤ 50	ϕ	FH	ϕ	FH	ϕ	ϕ	ϕ	ϕ

Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel".
Note 2:"ϕ" = not applicable.

Table 9 : Material grade requirements for members within or adjacent to refrigerated spaces

Design temperature, in °C	Gross thickness, in mm	Structural member category	
		Secondary	Primary or Special
$-10 \le t_D < 0$	t ≤ 20	B / AH	B / AH
	20 < t ≤ 25	B / AH	D / DH
	t > 25	D / DH	E / EH
$-25 \le t_D < -10$	t ≤ 15	B / AH	D / DH
	15 < t ≤ 25	D / DH	E / EH
	t > 25	E / EH	E / EH
$-40 \le t_D < -25$	t ≤ 25	D / DH	E / EH
	t > 25	E / EH	E / EH

3 Steels for forging and casting

3.1 General

3.1.1 Mechanical and chemical properties of steels for forging and casting to be used for structural members are to comply with the applicable requirements of Part D.

3.1.2 Steels of structural members intended to be welded are to have mechanical and chemical properties deemed appropriate for this purpose by Tasneef on a case-by- case basis.

3.1.3 The steels used are to be tested in accordance with the applicable requirements of Part D.

3.2 Steels for forging

3.2.1 For the purpose of testing, which is to be carried out in accordance with the applicable provisions of Part D, the above steels for forging are assigned to class 1 (see Pt D, Ch 2, Sec 3, [1.2]).

3.2.2 Rolled bars may be accepted in lieu of forged products, after consideration by Tasneef on a case by case basis.

In such case, compliance with the provisions of Pt D, Ch 2, Sec 1, relevant to the quality and testing of rolled parts accepted in lieu of forged parts, may be required.

3.3 Steels for casting

3.3.1 Cast parts intended for stems, sternframes, rudders, parts of steering gear and deck machinery in general may be made of C and C-Mn weldable steels of quality 1, having tensile strength R_m = 400 N/mm^2 or 440 N/mm^2, in accordance with the applicable requirements of Pt D, Ch 2, Sec 4.

Items which may be subjected to high stresses may be required to be of quality 2 steels of the above types.

3.3.2 For the purpose of testing, which is to be carried out in accordance with Pt D, Ch 2, Sec 4, [1.11], the above steels for casting are assigned to class 1 irrespective of their quality.

3.3.3 The welding of cast parts to main plating contributing to hull strength members is considered by Tasneef on a case by case basis.

Tasneef may require additional properties and tests for such casting, in particular impact properties which are appropriate to those of the steel plating on which the cast parts are to be welded and non-destructive examinations.

3.3.4 Heavily stressed cast parts of steering gear, particularly those intended to form a welded assembly and tillers or rotors mounted without key, are to be subjected to non-destructive examination to check their internal structure.

4 Other materials and products

4.1 General

4.1.1 Other materials and products such as parts made of iron castings, where allowed, products made of copper and copper alloys, rivets, anchors, chain cables, cranes, masts, derrick posts, derricks, accessories and wire ropes are generally to comply with the applicable requirements of Part D.

4.1.2 The use of plastics or other special materials not covered by these Rules is considered by Tasneef on a case by case basis. In such cases, Tasneef states the requirements for the acceptance of the materials concerned.

4.1.3 Materials used in welding processes are to comply with the applicable requirements of Part D.

4.2 Iron cast parts

4.2.1 As a rule, the use of grey iron, malleable iron or spheroidal graphite iron cast parts with combined ferritic/perlitic structure is allowed only to manufacture low stressed elements of secondary importance.

4.2.2 Ordinary iron cast parts may not be used for windows or sidescuttles; the use of high grade iron cast parts of a suitable type will be considered by Tasneef on a case by case basis.

SECTION 3 WELDING AND WELD CONNECTIONS

1 General

1.1 Application

1.1.1

The requirements of this Section apply to 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 Tasneef 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 to the welding of hull structural steels or aluminium alloys of the types considered in Part D or other types accepted as equivalent by Tasneef

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

Welding consumables and welding procedures adopted are to be approved by Tasneef

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.

The approval of the welding procedure is not required in the case of manual metal arc welding with approved covered electrodes, except in the case of one side welding on refractory backing (ceramic).

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 Tasneef 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.

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

Manual and semi-automatic welding is to be performed by welders certified by Tasneef 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 assistance for and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

1.4.4 NDE operators

Non-destructive tests are to be carried out by qualified personnel, certified by Tasneef or by recognised bodies in compliance with appropriate standards.

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 ensure 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 2, Sec 1, 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 Tasneef

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 Tasneef on a case by case basis; tests as deemed necessary (for example, transverse impact tests) may be required by Tasneef

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.

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 connection 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 Tasneef are adopted.

Connections different from the above may be accepted by Tasneef 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 Tasneef

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

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 Tasneef on a case-by-case basis.

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:

$$\frac{p}{d} \leq \varphi$$

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.

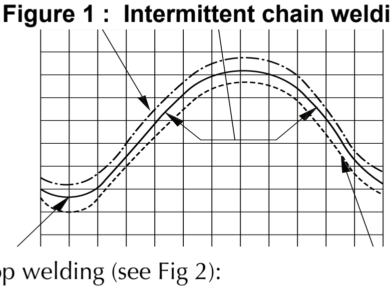
In addition, the following limitations are to be complied with:

- chain welding (see Fig 1):

  $d \geq 75$ mm

  $p\text{-}d \leq 200$ mm

Figure 1 : Intermittent chain welding



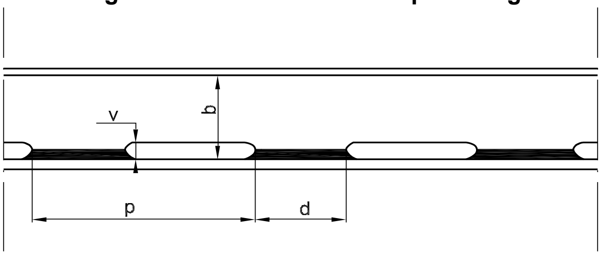
- scallop welding (see Fig 2):

  $d \geq 75$ mm

  $p\text{-}d \leq 150$ mm

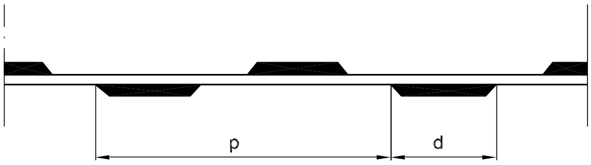
  $v \leq 0,25b$, without being greater than 75 mm

Figure 2 : Intermittent scallop welding



- staggered welding (see Fig 3):
  d ≥ 75 mm
  p-2d ≤ 300 mm
  p ≤ 2d for connections subjected to high alternate stresses.

Figure 3 : Intermittent staggered welding



2.3.5 Throat thickness of fillet weld T connections

The throat thickness, in mm, of fillet weld T connections is to be obtained from the following formula:

$$t_T = w_F t \frac{p}{d}$$

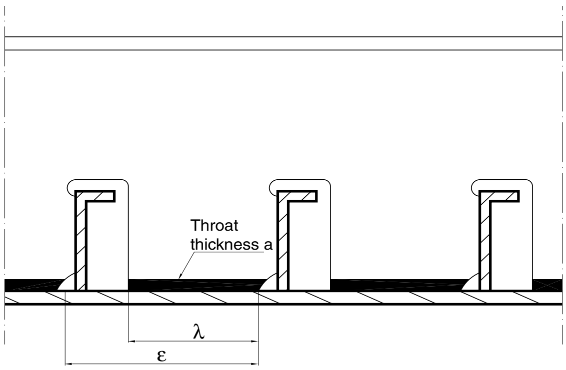
where:

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;

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 Tasneef to be increased, depending on the results of structural analyses.

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 ≤ t ≤ 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

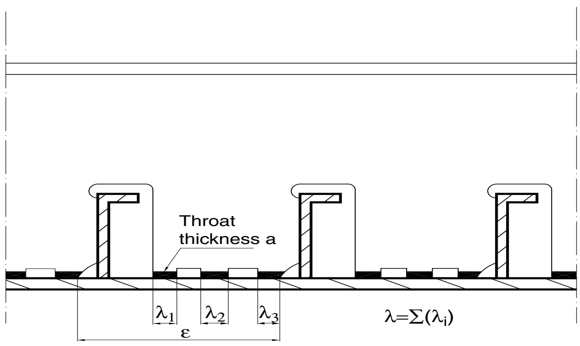


Table 2 : Welding factors w_F and coefficient φ for the various hull structural connections

Hull area	Connection of	Connection to		w_F (1)	φ (2) (3) CH	φ (2) (3) SC	φ (2) (3) 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
	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	ordinary stiffeners	side and plating		0,13	3,5	3,0	4,6	ST 260
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
Bulkheads	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				

Hull area	Connection of	Connection to		w_F (1)	φ (2) (3) CH	φ (2) (3) SC	φ (2) (3) ST	p_1, in mm (see [2.3.6]) (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
	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
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				

Hull area	Connection			w_F **(1)**	φ **(2)** **(3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
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

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 $0{,}35 t_W$, where t_W is the web gross thickness, in mm.

Where primary supporting member web stiffeners are welded to ordinary stiffener face plates, in certain cases Tasneef may require the above throat thickness, in mm, to be obtained from the following formula:

$$t_T = \frac{4(p_S + p_W)s\ell\left(1 - \dfrac{s}{2\ell}\right)}{u + v\left(\dfrac{c + 0{,}2d}{b + 0{,}2d}\right)}$$

where:

p_S, p_W : Still water and wave pressure, respectively, in kN/m², 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 of	Connection to		w_F (1)	φ (2) (3) CH	φ (2) (3) SC	φ (2) (3) ST	p_1, in mm (see [2.3.6]) (3)
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 extending 20% of the span from the span ends. Where end brackets are fitted, ends means the area extending 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

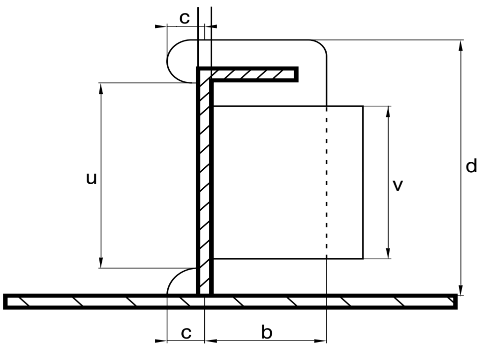


Table 4 : Required throat thickness

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 Tasneef

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 Tasneef 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

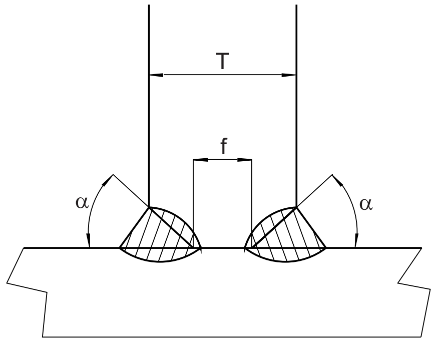


Figure 8 : Partial penetration weld

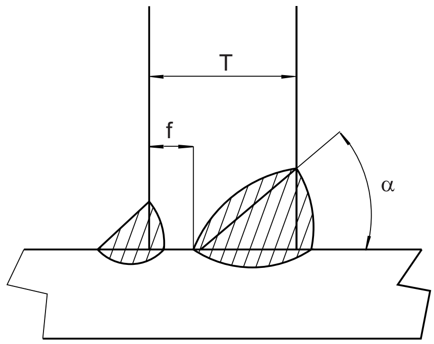


Figure 9 : Full penetration weld

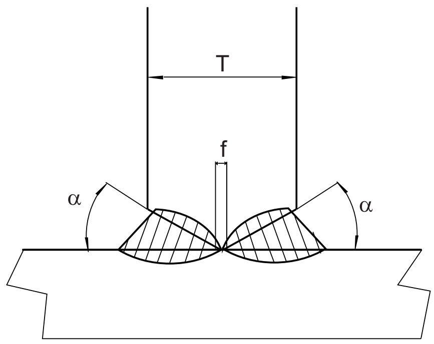
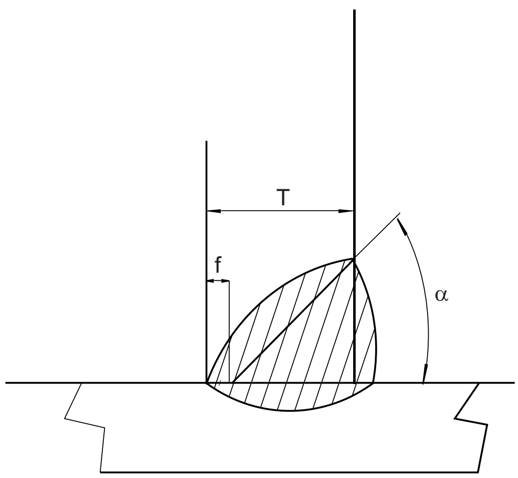


Figure 10 : Full penetration weld



2.6 Slot welding

2.6.1 General

Slot welding may be adopted in very specific cases subject to the special agreement of Tasneef (e.g. for doublers).

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 Tasneef 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 Tasneef 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 Tasneef 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 2, Sec 7, [9], 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 Tasneef 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 Tasneef

Shop primers are to be approved by Tasneef 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.

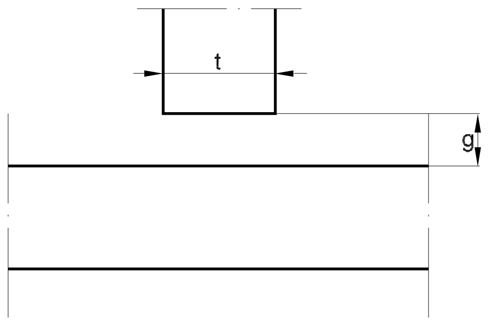
4.3.5 Gap in fillet weld T connections

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 4 mm.

Figure 11 : Gap in fillet weld T connections



4.3.6 Plate misalignment in butt connections

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 3 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.

Tasneef may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

Figure 12 : Plate misalignment in butt connections

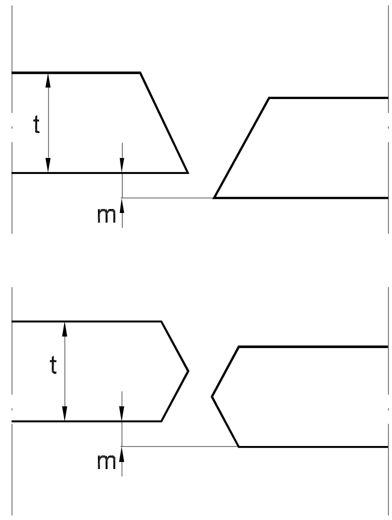
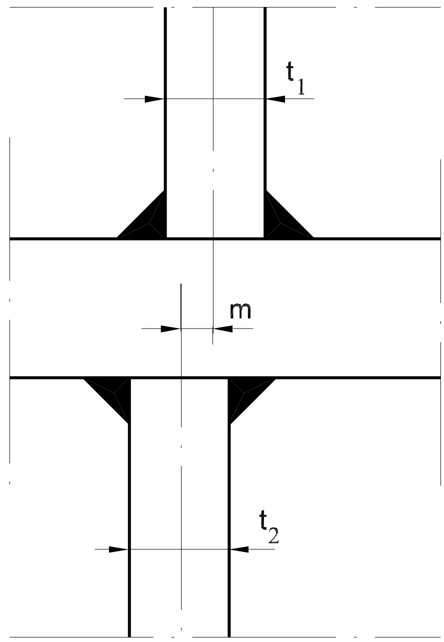


Figure 13 : Misalignment in cruciform connections



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 Tasneef 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 Tasneef on a case-by-case basis, taking into account any detailed information on the size and position of welds and the stresses on the zones concerned, both during vessel launching and with the vessel 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 sternframes), 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 in other specified requirements, in excess of the permitted tolerances and found during construction, are to be repaired as agreed with Tasneef 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 Tasneef 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 Tasneef

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 Tasneef 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 of 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 Tasneef requirements, the approved plans and the Surveyor's instructions.

6.2.4 Tasneef 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.

7 End connections of ordinary stiffeners

7.1

7.1.1 Where ordinary stiffeners are continuous through primary supporting members, they are to be connected to the web plating so as to ensure proper transmission of loads, e.g. by means of one of the connection details shown in Fig 14 to Fig 17.

Connection details other than those shown in Fig 14 to Fig 17 may be considered by Tasneef on a case-by-case basis.

Figure 14 : End connection of ordinary stiffener without collar plate

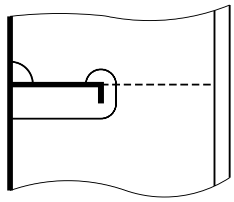


Figure 15 : End connection of ordinary stiffener with collar plate

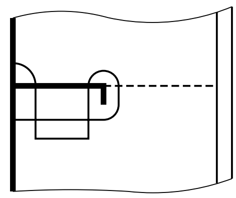


Figure 16 : End connection of ordinary stiffener with one large collar plate

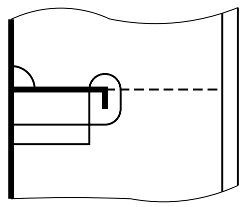
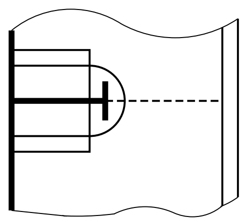


Figure 17 : End connection of ordinary stiffener with two large collar plates



In all the above connections, the radius of all the scallops in the primary member around the stiffener is to be at least 20 mm.

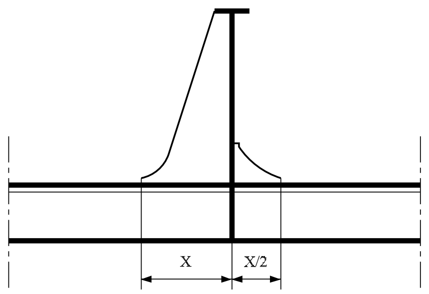
The extension of the collar plate above the primary member is to be at least 3 t, where t is the thickness of the collar plate.

7.1.2 Where ordinary stiffeners are cut at primary supporting members, brackets are to be fitted to ensure the structural continuity.

The net thickness of brackets is to be not less than that of ordinary stiffeners. Brackets with net thickness, in mm, less than $15L_b$, where L_b is the length, in m, of the free edge of the end bracket, are to be flanged or stiffened by a welded face plate. The net sectional area, in cm^2, of the flanged edge or face plate is to be at least equal to $10L_b$.

7.1.3 Where necessary, Tasneef may require backing brackets to be fitted, as shown in Fig 18 in order to improve the fatigue strength of the connection.

Figure 18 : End connection of ordinary stiffener with backing bracket



8 End connections of primary supporting members

8.1 Bracketed end connections

8.1.1 Arm lengths of end brackets are to be equal, as far as practicable.

As a general rule, the height of end brackets is to be not less than that of the primary supporting member.

8.1.2 The thickness of the end bracket web is generally to be not less than that of the primary supporting member web.

8.1.3 The scantlings of end brackets are generally to be such that the net section modulus of the primary supporting member with end brackets is not less than that of the primary supporting member at mid-span.

8.1.4 The width, in mm, of the face plate of end brackets is to be not less than $50(L_b+1)$, where L_b is the length, in m, of the free edge of the end bracket.

Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

8.1.5 Stiffening of end brackets is to be designed such that it provides adequate buckling web stability.

As guidance, the following prescriptions may be applied:

- where the length L_b is greater than 1,5 m, the web of the bracket is to be stiffened;
- the net sectional area, in cm², of web stiffeners is to be not less than 16,5l, where l is the span, in m, of the stiffener;
- tripping flat bars are to be fitted to prevent lateral buckling of web stiffeners. Where the width of the symmetrical face plate is greater than 400 mm, additional backing brackets are to be fitted.

8.2 Bracketless end connections

8.2.1 As a general rule, in the case of bracketless crossing between primary supporting members (see Fig 19), the thickness of the common part of the web is to be not less than the value obtained, in mm, from the following formula:

$$t = 15{,}75\frac{W}{\Omega}$$

where:

w : the lesser of w1 and $w_{2,MAX}$

w1 : gross section modulus, in cm³, of member 1

$w_{2,MAX}$: the greater value, in cm³, of the gross section moduli of members 2 and 3

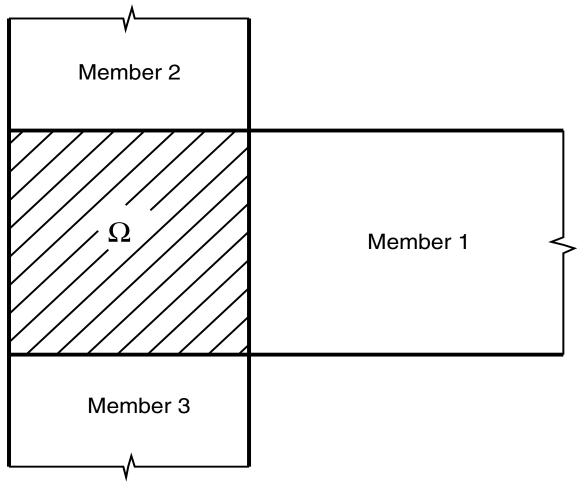
Ω : Area, in cm², of the common part of members 1, 2 and 3.

In the absence of one of members 2 and 3 shown in Fig 19, the value of the relevant gross section modulus is to be taken equal to zero.

8.2.2 In no case may the thickness calculated according to 8.2.1 be less than the smallest web net thickness of the members forming the crossing.

8.2.3 In general, the continuity of the face plates is to be ensured.

Figure 19 : Bracketless end connections of primary supporting members



9 Cut-outs and holes

9.1

9.1.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the depth of cut-outs is to be not greater than 50% of the depth of the primary supporting member.

9.2

9.2.1 Where openings such as lightening holes are cut in primary supporting members, they are to be equidistant from the face plate and corners of cut-outs and, in general, their height is to be not greater than 20% of the web height.

9.3

9.3.1 Openings may not be fitted in way of toes of end brackets.

9.4

9.4.1 Over half of the span of primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

At the ends of the span, the length of openings is to be not greater than 25% of the distance between adjacent openings.

9.5

9.5.1 The cut-out is to be reinforced in accordance with to one of the solutions shown in Fig. 20 to Fig. 22:

- continuous face plate (Solution 1): see Fig 20
- straight face plate (Solution 2): see Fig 21
- compensation of the opening (Solution 3): see Fig 22
- combination of the above solutions.

Other arrangements may be accepted provided they are supported by direct calculations submitted to Tasneef for review.

Figure 20 : Stiffening of large openings in primary supporting members - Solution 1

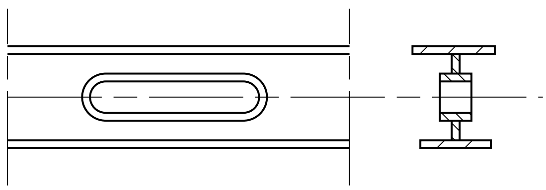


Figure 21 : Stiffening of large openings in primary supporting members - Solution 2

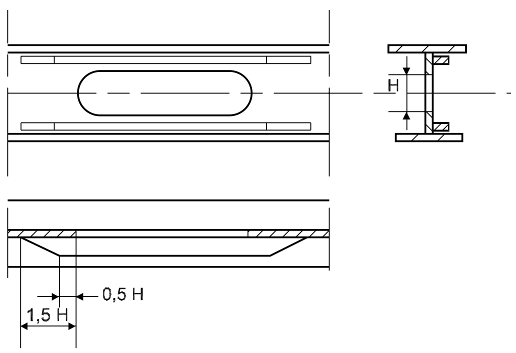
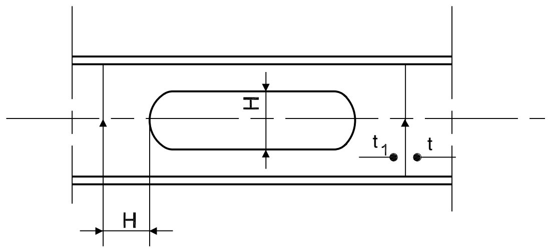


Figure 22 : Stiffening of large openings in primary supporting members - Solution 3 (inserted plate)



10 Stiffening arrangement

10.1

10.1.1 Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 100t, where t is the web net thickness, in mm, of the primary supporting member.

In general, the web stiffeners of primary supporting members are to be spaced not more than 110t apart.

10.2

10.2.1 As a general rule, tripping brackets (see Fig 23) welded to the face plate may be fitted:

at every fourth spacing of ordinary stiffeners, without exceeding 4 m

- at the toe of end brackets
- at rounded face plates
- in way of cross ties
- in way of concentrated loads.

Where the width of the symmetrical face plate is greater than 400 mm, backing brackets are to be fitted in way of the tripping brackets.

10.3

10.3.1 In general, the width of the primary supporting member face plate is to be not less than one tenth of the depth of the web, where tripping brackets are spaced as specified in 10.2.

10.4

10.4.1 The arm length, in m, of tripping brackets is to be not less than the greater of the following values, in m:

$$d = 0{,}38b$$

$$d = 0{,}85b\sqrt{\frac{s_t}{t}}$$

where:

b : Height, in m, of tripping brackets, shown in Fig 23

s_t : Spacing, in m, of tripping brackets

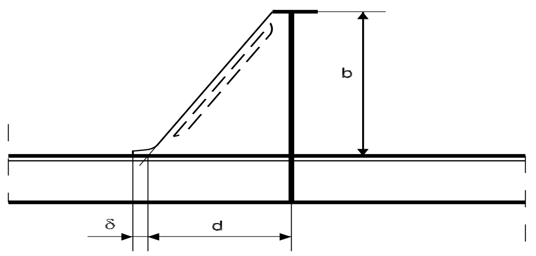
t : Net thickness, in mm, of tripping brackets.

It is recommended that the bracket toe should be designed as shown in Fig 23.

10.5

10.5.1 Tripping brackets with a net thickness, in mm, less than $15L_b$ are to be flanged or stiffened by a welded face plate.

Figure 23 : Primary supporting member: web stiffener in way of ordinary stiffener



11 Riveted connections

11.1

11.1.1 When riveted connections are employed, the mechanical properties of the rivets are to be indicated on the plans.

Tasneef may, at its discretion, require shear, tensile and compression tests to be carried out on representative specimens of riveted connections.

11.2

11.2.1 When rivets are used to connect materials of different types, precautions are to be taken against electrolytic corrosion.

Whenever possible, the arrangements are to be such as to enable inspection in service without the need to remove coverings, etc.

12 Sealed connections

12.1

12.1.1 Where a sealing product is used to ensure airtight or watertight integrity, product information is to be submitted together with evidence of its previous successful use.

SECTION 4 LONGITUDINAL STRENGTH

1 General

1.1

1.1.1 The structural scantlings prescribed in Chapter 2 are also intended for the purposes of the longitudinal strength of a yacht having length L less than 50 m for monohull yachts or 40 m for catamarans and openings on the strength deck of limited size.

For yachts of greater length and/or openings of size greater than the breadth B of the hull and extending for a considerable part of the length of the yacht, calculation of longitudinal strength is required.

1.2

1.2.1 To this end, longitudinal strength calculations are to be carried out considering the load and ballast conditions for both departure and arrival.

2 Bending stresses

2.1

2.1.1 In addition to satisfying the minimum requirements stipulated in the individual Sections of this Chapter, the scantlings of members contributing to the longitudinal strength of monohull yachts and catamarans are to achieve a section modulus of the midship section at the bottom and the deck such as to guarantee stresses not exceeding the allowable values.

Therefore:

$$\sigma_f \le f \cdot \sigma_s \quad N/mm^2$$

$$\sigma_p \le f \cdot \sigma_s \quad N/mm^2$$

where:

$$\sigma_f = \frac{M_T}{1000\ W_f} \quad N/mm^2$$

$$\sigma_p = \frac{M_T}{1000\ W_p} \quad N/mm^2$$

W_f, W_p : section modulus, in m^3, at the bottom and the deck, respectively, of the transverse section

M_T : design total vertical bending moment defined in Ch 1, Sec 5

f : 0,80 for planing yachts

f : 0,72 for displacement yachts

σ_s : mimimum yield stress of the material, in N/mm^2.

2.2

2.2.1 The compressive value of normal stresses is not to exceed the value of the critical stresses for plates and stiffeners calculated in Article 5 of Sec 1.

2.3

2.3.1 The moment of inertia J of the midship section, in m^4, is to be not less than the value given by the following formulae.

For planing yachts:

$$J = 5,32 \cdot M \cdot 10^{-6}$$

For displacement yachts:

$$J = 5,90 \cdot M \cdot 10^{-6}$$

3 Shear stresses

3.1

3.1.1 *(1/7/2022)*

The shear stresses in every position along the length L are not to exceed the allowable values; in particular.

$$\frac{T_t}{A_t} \cdot 10^{-3} \le \frac{f \cdot \sigma_s}{\sqrt{3}}$$

where:

T_t : total shear, in kN, defined in Ch 1

σ_s, f : defined in 2

A_t : actual shear area of the transverse section, in m^2, to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings.

4 Calculation of the section modulus

4.1

4.1.1 In the calculation of the modulus and inertia of the midship section, all the continuous members, plating and longitudinal stiffeners are generally to be included, provided that they extend for at least 0,4 L amidships.

SECTION 5 PLATING

1 Definitions and symbols

1.1

1.1.1

s : spacing of longitudinal or transverse ordinary stiffener, in m

p : scantling pressure, in kN/m^2, given in Ch 1, Sec 5

K : factor defined in Sec 2 of this Chapter.

2 Keel

2.1 Sheet steel keel

2.1.1 The keel plating is to have a width b_{CH}, in mm, throughout the length of the yacht, not less than the value obtained by the following equation:

$$b_{CH} = 4,5 \cdot L + 600$$

and a thickness not less than that of the adjacent bottom plating increased by 2 mm.

2.2 Solid keel

2.2.1

The height and thickness of the keel, throughout the length of the yacht, are to be not less than the values h_{CH} and t_{CH}, in mm, calculated with the following equations:

$$h_{CH} = 1,5 \cdot L + 100$$

$$t_{CH} = (0,35 \cdot L + 6) \cdot K^{0,5}$$

Lesser heights and thicknesses may be accepted provided that the effective area of the section is not less than that of the Rule section.

Lesser heights and thicknesses may also be acceptable if a centre girder is placed in connection with the solid keel.

3 Bottom and bilge

3.1

3.1.1

Bottom plating is the plating up to the chine or to the upper turn of the bilge.

The thickness of the bottom plating and the bilge is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 8 \cdot s \cdot (T \cdot K)^{0,5}$$

where:

k_1 : 0,11, assuming $p=p_1$

: 0,07, assuming $p=p_2$.

k_a : coefficient as a function of the ratio S/s given in Table 1 below, where S is the greater dimension of the plating, in m.

k_2 : curvature correction factor given by 1-(h/s) to be taken not less than 0,7 where h is the distance, in mm, measured perpendicularly from the chord s to the highest point of the arc of plating between the two supports (see Fig 1).

The thickness of the plating of the bilge is, in any event, to be taken as not less than the greater of the thicknesses of the bottom and side.

Sheet steel of plating in way of the propeller shaft struts, tunnel thruster attachment and in the vicinity of the water-jet drive duct entrance is to have a thickness, in mm, not less than the value t_e given by:

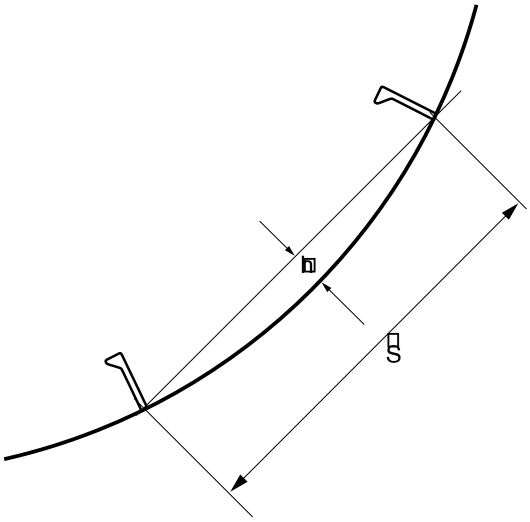
$$t_e = (0,05 \cdot L + 6) \cdot K^{0,5}$$

and, in any event, equal to the thickness of the bottom increased by 50%.

Table 1

S/s	K_a
1	17,5
1,2	19,6
1,4	20,9
1,6	21,6
1,8	22,1
2,0	22,3
>2	22,4

Figure 1



4 Sheerstrake

4.1

4.1.1 In yachts having L > 50 a sheerstrake plate of height h, in mm, not less than 0,025 L and thickness not less than the greater of the values of the plating of the side and the stringer plate is to be fitted.

In the case of sidescuttles or windows or other openings arranged on the sheerstrake plate, the thickness is to be increased sufficiently as necessary in order to compensate for such openings.

In way of the ends of the bridge, the thickness of the sheerstrake is to be adequately increased.

5 Side

5.1

5.1.1 The thickness of side plating is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 6,5 \cdot s \cdot (T \cdot K)^{0,5}$$

where k_1, k_2 and k_a are as defined in 3.1.

5.2

5.2.1 The thickness of the transom is to be no less than that required for the bottom, for the part below the waterline, or for the side, for the part above the waterline.

In the event of water-jet drive systems, the thickness of the transom will be the subject of special consideration.

6 Openings in the shell plating

6.1

6.1.1 Sea intakes and other openings are to be well rounded at the corners and located, as far as possible, outside the bilge strakes and the keel. Arrangements are to be such as to ensure continuity of strength in way of openings.

An increase in the thickness of the local plating may be required where the openings are of unusual dimensions.

6.2

6.2.1 Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects. In any event, such openings are to be located well clear of welded connections.

6.3

6.3.1 The internal walls of sea intakes are to have external plating thickness increased by 1 mm, but not less than 6 mm.

7 Local stiffeners

7.1

7.1.1 The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the stem, propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

7.2

7.2.1 Where the aft end is shaped such that the bottom plating aft has a large flat area, Tasneef may require the local plating to be increased and/or reinforced with the fitting of additional stiffeners.

7.3

7.3.1 The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements.

The thickness is to be not less than 1,25 times that of the adjacent plating but no greater than that of the keel.

8 Cross-deck bottom plating

8.1

8.1.1 The thickness is to be taken, the stiffener spacing s being equal, no less than that of the side plating.

Where the gap between the bottom and the waterline is so small that local wave impact phenomena are anticipated, an increase in thickness and/or additional internal stiffeners may be required.

SECTION 6 SINGLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a single bottom, which may be of either longitudinal or transverse type.

1.2 Longitudinal structure

1.2.1 The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The floors may be supported by girders, which in turn may be supported by transverse bulkheads, or by the sides of the hull.

1.2.2 A centre girder is to be fitted.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.2.3 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

1.2.4 Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

1.3 Transverse structure

1.3.1 The transverse framing consists of ordinary stiffeners arranged transversely (floors) and placed at each frame supported by girders, which in turn are supported by transverse bulkheads or reinforced floors.

1.3.2 A centre girder is to be fitted.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.3.3 In way of the propeller shaft struts, the rudder horn and the ballast keel, additional floors are to be fitted with sufficiently increased scantlings.

1.3.4 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to be fitted as a continuation of the existing girders outside the engine room.

1.3.5 Floors of increased scantlings are to be fitted in way of reinforced frames at the sides and reinforced beams on the weather deck. Any intermediate floors are to be adequately connected to the ends.

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m^2, given in Ch 1

K : coefficient defined in Sec 2 of this Chapter.

3 Longitudinal type structure

3.1 Bottom longitudinals

3.1.1 The section modulus of longitudinal stiffeners is to be not less than the value Z, in cm^3, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 0,83 assuming $p=p_1$

: 0,36 assuming $p=p_2$

S : conventional span of the longitudinal stiffener, in m, equal to the distance between floors.

The bottom longitudinal stiffeners are preferably to be continual through the transverse members. Where they are to be interrupted in way of a transverse watertight bulkhead, brackets are to be provided at the ends.

3.2 Floors

3.2.1 The section modulus of the floors at the centreline of the span S is to be not less than the value Z_M, in cm^3, calculated with the following formula.

$$Z_M = k_1 \cdot b \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b : half the distance, in m, between the two floors adjacent to that concerned

S : conventional floor span equal to the distance, in m, between the two supporting members (sides, girders, keel with a dead rise edge > 12°).

In the case of a keel with a dead rise edge $\leq$ 12° but > 8°, the span S is always to be calculated considering the distance between girders or sides; the modulus Z_M may, however, be reduced by 40%.

If a side girder is fitted on each side with a height equal to the local height of the floor, the modulus may be reduced by a further 10%.

3.3 Girders

3.3.1 Centre girder

When the girder forms a support for the floor, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b_{PC} : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b'_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b'_{PC} : half the distance, in m, between the two side girders if present, or equal to B/2 in the absence of side girders

S : distance between the floors.

3.3.2 Side girders

When the side girder forms a support for the floor, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder concerned

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b'_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b'_{PL} : half the distance, in m, between the two adjacent girders or between the side and the adjacent girder

S : distance between the floors.

4 Transverse type structures

4.1 Ordinary floors

4.1.1 The section modulus for ordinary floors is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

S : conventional span in m, of the floor equal to the distance between the members which support it (girders, sides).

4.2 Centre girder

4.2.1 The section modulus of the centre girder is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1,22 assuming $p=p_1$

: 0,75 assuming $p=p_2$

b_{PC} : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders

S : conventional span of the centre girder, equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

4.3 Side girders

4.3.1 The section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 4.2

b_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder adjacent to that concerned

S : conventional girder span equal to the distance, in m, between the two members which support it (transverse bulkheads, floors).

5 Constructional details

5.1

5.1.1 The centre girder and side girders are to be connected to the stiffeners of the transom by means of suitable fittings.

The face plate of the girders may be gradually reduced to reach the dimensions of that of the transom stiffeners.

SECTION 7 DOUBLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.1.2 *(1/7/2021)*

The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead in the machinery space, or as near thereto as practicable, is requested for yachts of L > or = 50 m.

On yachts of L > 61 m a double bottom is to be fitted outside the machinery space extending, as far as practicable, forward to the collision bulkhead and aft to the after peak bulkhead.

On yachts of L > 76 m the double bottom is to extend, as far as this is practicable, throughout the length of the yacht.

The double bottom is to extend transversely to the side so as to protect the bottom in the bilge area, as far as possible.

The double bottom may be avoided if the vessel satisfies what required in Ch.II-1 part B-2 Regulation 9 SOLAS'74 as amended. For yachts of less than 80 m in load line length, the alternative arrangements to provide a level of safety may be limited to compartments not having a double bottom or having a double bottom arrangement not in line with what required below. In these cases compliance with the bottom damage standard may be carried out assuming that the damage will only occur between the transverse watertight bulkheads in compartments not having a double bottom or having a double bottom not in line with what below.

1.1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.

The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of Tasneef

1.1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2 Minimum height

2.1

2.1.1 The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value h_{DF}, in mm, obtained from the following formula:

$$h_{df} = 28B + 32(T + 10)$$

The height of the double bottom is, in any event, to be not less than 700 mm. For yachts less than 50 m in length, Tasneef may accept reduced height.

3 Inner bottom plating

3.1

3.1.1 *(1/1/2019)*

The thickness of the inner bottom plating is to be not less than the value t_1, in mm,calculated with the following formula:

$$t_1 = (0,04L + 5s + 1)k^{0,5}$$

where:

s : spacing of the ordinary stiffeners, in m.

For yachts of length L ≤ less than 50 m, the thickness is to be maintained throughout the length of the hull.

For yachts of length L > or = 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquids, the thickness of the top is also to comply with the provisions of Sec 10.

4 Centre girder

4.1

4.1.1

A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness, in mm, of the centre girder is to be not less than the following value t_{pc}:

$$t_{pc} = (0,008 h_{df} + 2) k^{0,5}$$

5 Side girders

5.1

5.1.1 Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

5.2

5.2.1 Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height no less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6 Floors

6.1

6.1.1

The thickness of floors t_m, in mm, is to be not less than the following value:

$$t_m = (0,008 h_{df} + 0,5) k^{0,5}$$

Watertight floors are also to have thickness not less than that required in Sec 10 for tank bulkheads.

6.2

6.2.1 When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be arranged in longitudinally framed double bottoms in the following locations:

- under bulkheads and pillars
- outside the machinery space at an interval no greater than 2 m
- in the machinery space under the bedplates of main engines
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7 Bracket floors

7.1

7.1.1 *(1/1/2019)*

At each frame between solid floors, bracket floors consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating are to be arranged and attached to the centre girder and the margin plate by means of flanged brackets with a width of flange not less than 1/10 of the double bottom depth.

The frame section modulus Z_c, in cm^3, is to be not less than:

$$Z_c = k_1 \cdot s \cdot S^2 \cdot p \cdot K$$

where:

k_1	:	0,83 assuming $p=p_1$
	:	0,36 assuming $p=p_2$
S	:	frame span, in m, equal to the distance between the mid-spans of the brackets connecting the frame/reverse frame.

The reverse frame section modulus is to be not less than 85% of the frame section modulus.

Where tanks intended for liquids are arranged above the double bottom, the frame and reverse frame section moduli are to be no less than those required for tank stiffeners as stated in Sec 10.

8 Bottom and inner bottom longitudinals

8.1

8.1.1 *(1/1/2019)*

The section modulus of bottom stiffeners is to be no less than that required for single bottom longitudinals stipulated in Sec 6.

The section modulus of inner bottom stiffeners is to be no less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquids are arranged above the double bottom, the section modulus of longitudinals is to be no less than that required for tank stiffeners as stated in Sec 10.

9 Bilge keel

9.1 Arrangement, scantlings and connections

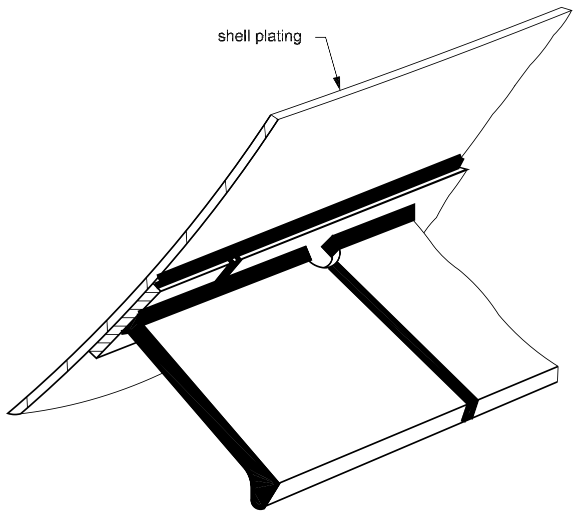
9.1.1 Arrangement

Where installed, bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The ends of the bilge keel are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

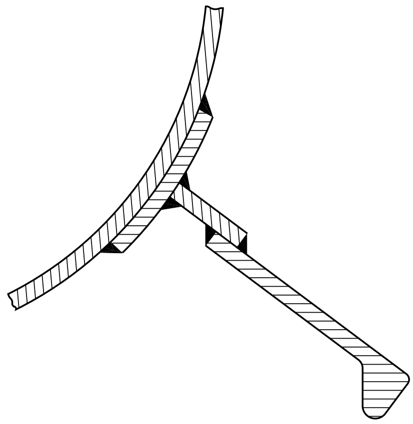
The arrangement shown in Fig 1 is recommended.

Figure 1 : bilge keel arrangement



The arrangement shown in Fig 2 may also be accepted

Figure 2 : bilge keel arrangement



9.1.2 Materials

The bilge keel and the intermediate flat are to be made of steel with the same yield stress and grade as that of the bilge strake.

9.1.3 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm.

9.2 Bilge keel connection

9.2.1 The intermediate flat, through which the bilge keel is connected to the shell, 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.

SECTION 8 SIDE STRUCTURES

1 General

1.1

1.1.1 This Section lays down the criteria for the scantlings of the reinforcement structures of the side, which may be of longitudinal or transverse type.

The longitudinal type structure consists of ordinary stiffeners placed longitudinally, supported by reinforced frames, generally spaced not more than 2 m apart, or by transverse bulkheads.

The transverse type structure is made up of ordinary reinforcements placed vertically (frames), which may be supported by reinforced stringers, by decks, by flats or by the bottom structures.

Reinforced frames are to be provided in way of the mast and the ballast keel, in sailing yachts, in the machinery space and in general in way of large openings on the weather deck.

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m², defined in Part B, Ch 1, Sec 5;

K : factor defined in Sec 2 of this Chapter.

3 Ordinary stiffeners

3.1 Transverse frames

3.1.1 The section modulus of the frames is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 0,67 assuming $p=p_1$

: 0,56 assuming $p=p_2$

S : conventional frame span, in m, equal to the distance between the supporting members.

The ordinary frames are to be well connected to the elements which support them, in general made up of a beam and a floor.

3.2 Longitudinal stiffeners

3.2.1 The section modulus of the side longitudinals is to be not less than the value Z, in cm³, calculated with the following formula:

The section modulus of the frames is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 0,83 assuming $p=p_1$

: 0,36 assuming $p=p_2$

S : conventional span of the longitudinal, in m, equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads.

4 Reinforced beams

4.1 Reinforced frames

4.1.1 The section modulus of the reinforced frames is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot K_{CR} \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1 assuming $p=p_1$

: 0,7 assuming $p=p_2$

K_{CR} : 0,9 for reinforced frames which support longitudinal ordinary stiffeners, or reinforced stringers;

: 0,4 for reinforced frames which do not support ordinary stiffeners;

s : spacing, in m, between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned;

S : conventional span, in m, equal to the distance between the members which support the reinforced frame.

4.2 Reinforced stringers

4.2.1 The section modulus of the reinforced stringers is to be not less than the value Z, in cm³,calculated with the following formula:

$$Z = k_1 \cdot K'_{CR} \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 4.1

K'_{CR} : • 0,9 for reinforced stringers which support vertical ordinary stiffeners (frames);
• 0,4 for reinforced stringers which do not support vertical ordinary stiffeners;

s : spacing,in m, between the reinforced stringers or 0,5 D in the absence of reinforced stringers or decks;

S : conventional span, in m, equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames.

5 Frame connections

5.1 General

5.1.1 End connections of frames are to be bracketed.

5.1.2 Tweendeck frames are to be bracketed at the top and welded or bracketed at the bottom to the deck.

In the case of bulb profiles, a bracket may be required to be fitted at the bottom.

5.1.3 Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

6 Scantling of brackets of frame connections

6.1

6.1.1 As a general rule, for yachts of length greater than 50 m, the following scantlings may be adopted:

6.1.2 Upper brackets of frames

The arm length of upper brackets connecting frames to deck beams is to be not less than the value obtained, in mm, from the following formula:

$$d = \phi\sqrt{\frac{w + 30}{t}}$$

where:

ϕ: coefficient equal to:

- for unflanged brackets:
  $\phi = 48$
- for flanged brackets:
  $\phi = 43{,}5$

w : required section modulus of the stiffener, in cm3, given in 6.1.3 and 6.1.4 and depending on the type of connection,

t : bracket net thickness, in mm.

6.1.3 For connections of perpendicular stiffeners located in the same plane (see Fig 1) or connections of stiffeners located in perpendicular planes (see Fig 2), the required section modulus is to be taken equal to:

$w = w_2$ if $w_2 \le w_1$

$w = w_1$ if $w_2 > w_1$

where w_1 and w_2 are the required section moduli of stiffeners, as shown in Fig 1 and Fig 2.

6.1.4 For connections of frames to deck beams (see Fig 3), the required section modulus is to be taken equal to:

- for bracket "A":

  $w_A = w_1$ if $w_2 \le w_1$

- for bracket "B":

  $w_B = w'_1$ need not to be greater then w_1

where w_1, w'_1 and w_2 are the required section moduli of stiffeners, as shown in Fig 3.

Figure 1 : Connections of perpendicular stiffeners in the same plane

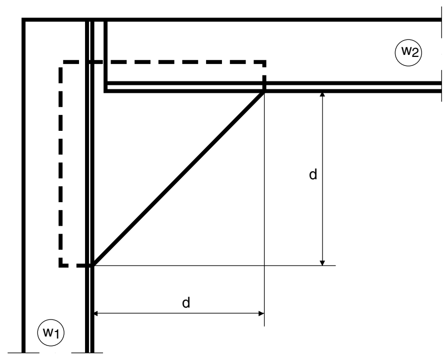


Figure 2 : Connections of stiffeners located in perpendicular planes

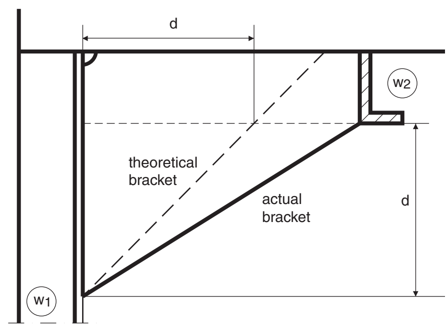
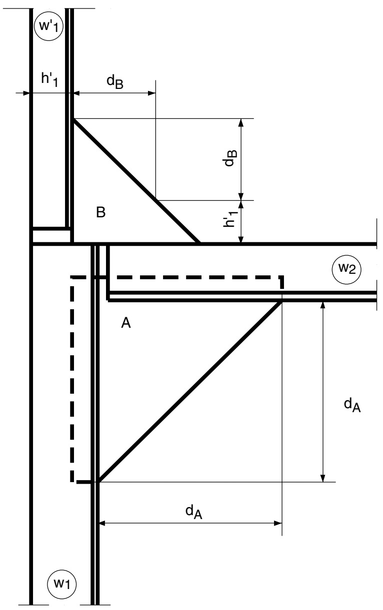


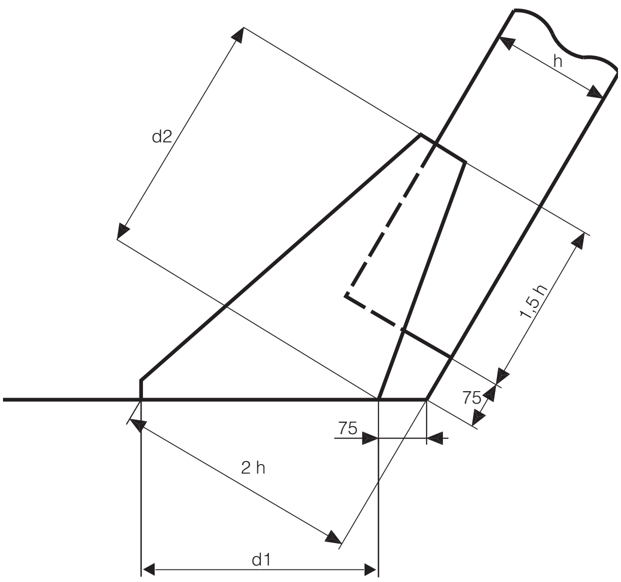
Figure 3 : Connections of frames to deck beam



6.2 Lower brackets of frames

6.2.1 In general, frames are to be bracketed to the inner bottom or to the face plate of floors as shown in Fig 4.

Figure 4 : Lower brackets of frames



6.2.2 The arm lengths d1 and d2 of lower brackets of frames are to be not less than the value obtained, in mm, from the following formula:

$$d = \phi\sqrt{\frac{w+30}{t}}$$

where:

ϕ: coefficient equal to:

- for unflanged brackets:
  $\phi = 50$
- for flanged brackets:
  $\phi = 45$

w : required section modulus of the frame, in cm^3,

t : bracket thickness, in mm.

6.2.3 Where the bracket thickness, in mm, is less than 15 L_b , where L_b is the length, in m, of the bracket free edge, the free edge of the bracket is to be flanged or stiffened by a welded face plate.

The sectional area, in cm^2, of the flange or the face plate is to be not less than $10L_b$.

SECTION 9 DECKS

1 General

1.1

1.1.1 This Section lays down the criteria for the scantlings of decks, plating and reinforcing or supporting structures.

The reinforcing and supporting structures of decks consist of ordinary reinforcements, beams or longitudinal stringers, laid transversely or longitudinally, supported by lines of shoring made up of systems of girders and/or reinforced beams, which in turn are supported by pillars or by transverse or longitudinal bulkheads.

Reinforced beams together with reinforced frames are to be placed in way of the masts in sailing yachts.

In sailing yachts with the mast resting on the deck or on the deckhouse, a pillar or bulkhead is to be arranged in way of the mast base.

2 Definitions and symbols

2.1

2.1.1

pdc : calculation deck, meaning the first deck above the full load waterline, extending for at least 0,6 L and constituting an efficient support for the structural elements of the side; in theory, it is to extend for the whole length of the yacht;

s : spacing of transverse or longitudinal ordinary stiffeners, in m;

h : scantling height, in m, the value of which is given in Part B, Ch 1, Sec 5;

K : factor defined in Sec 2 of this Chapter.

3 Deck plating

3.1 Weather deck

3.1.1 The thickness of the weather deck plating, considering that said deck is also a strength deck, is to be not less than the value t, in mm, calculated with the following formula:

$$t = 1,9 \cdot s \cdot (L \cdot K)^{0,5}$$

In yachts having L> or = 50 m, a stringer plate is to be fitted with width b, in m, not less than 0,025 L and thickness t, in mm, not less than the value given by the formula:

$$t = 2,4 \cdot s \cdot (L \cdot K)^{0,5}$$

The stringer plate of increased thickness may be waived if the thickness adopted for the deck is greater than Rule thickness.

3.2 Lower decks

3.2.1 *(1/1/2023)*

The thickness of decks below the weather deck intended for accommodation spaces is to be not less than the value calculated with the formula:

$$t = 1,15 \cdot s \cdot (L \cdot K)^{0,5}$$

Where the deck is a tank top, the thickness of the deck is, in any event, to be not less than the value calculated with the formulae given in Sec 10 for tank bulkhead plating.

4 Stiffening and support structures for decks

4.1 Ordinary stiffeners

4.1.1 The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value Z, in cm^3, calculated with the following formula:

$$Z = 7,5 \cdot C_1 \cdot s \cdot S^2 \cdot K \cdot h$$

where:

C_1 : 1,44 for weather deck longitudinals
: 0,63 for lower deck longitudinals
: 0,56 for beams.

S : conventional span, in m, equal to the distance between the two supporting members.

4.2 Reinforced beams

4.2.1 The section modulus for girders and for ordinary reinforced beams is to be not less than the value Z, in cm^3, calculated with the following equation:

$$Z = 4,75 \cdot b \cdot S^2 \cdot K \cdot h$$

where:

b : average width of the strip of deck resting on the beam, in m. In the calculation of b, any openings are to be considered as non-existent

S : conventional span of the reinforced beam, in m, equal to the distance between the two supporting members (pillars, other reinforced beams, bulkheads).

4.3 Pillars

4.3.1 *(1/1/2019)*

Pillars are, in general, to be made of tubes. In tanks intended for liquids, open section pillars are to be fitted.

The section area of pillars is to be not less than the value A, in cm^2, given by the formula:

$$A = \frac{Q}{12,5 - 0,045\lambda}$$

where:

Q : load resting on the pillar, in kN, calculated with the following formula:

$$Q = 6,87 \cdot A \cdot h$$

where:

A : area of the part of the deck resting on the pillar, in m^2.

h : scantling height, defined in [2.1.1].

λ : the ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

4.3.2 Pillar connections *(1/1/2016)*

Heads and heels of pillars are to be attached to the surrounding structure by means of brackets and insert plates so that the loads are well distributed.

Insert plates may be replaced by doubling plates, except in the case of pillars which may also work under tension such as those in tanks.

As an alternative, brackets or insert plates may be avoided provided that the local verification of compressive stress shows acceptable results.

Pillars are to be attached at their heads and heels by continuous welding.

Pillars are to be connected to the inner bottom at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

SECTION 10 BULKHEADS

1 General

1.1

1.1.1 *(1/1/2016)*
The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Chapter 1.

2 Symbols

2.1

2.1.1

s : spacing between the stiffeners, in m

S : conventional span, equal to the distance, in m, between the members that support the stiffener concerned

h_B, h_T : as defined in Part B, Ch 1, Sec 5

K : as defined in Ch 2, Sec 2.

3 Plating

3.1

3.1.1 The watertight bulkhead plating is to have a thickness not less than the value t_S, in mm, calculated with the following formula:

$$t_S = k_1 \cdot s \cdot (h \cdot K)^{0,5}$$

The coefficient k_1 and the scantling height h have the values indicated in Table 1.

Table 1

Bulkhead	k_1	h (m)
Collision bulkhead	4,35	h_B
Watertight bulkhead	3,8	h_B
Deep tank bulkhead	4,25	h_T

4 Stiffeners

4.1 Ordinary stiffeners

4.1.1 The section modulus of ordinary stiffeners is to be not less than the value Z, in cm^3, calculated with the following formula:

$$Z = 7,5 \cdot s \cdot S^2 \cdot h \cdot c \cdot K$$

The values of the coefficient c and of the scantling height h are those indicated in Table 2.

4.2 Reinforced beams

4.2.1 The horizontal webs of bulkheads with vertical ordinary stiffeners and reinforced stiffeners in the bulkheads with horizontal ordinary stiffeners are to have a section modulus not less than the value Z, in cm^3, calculated with the following formula:

$$Z = C_1 \cdot b \cdot S^2 \cdot h \cdot K$$

C_1 : 6, for subdivision bulkheads

: 10, for tank bulkheads

b : width, in m, of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener

h : scantling height indicated in Table 2.

Table 2

Bulkhead	h (m)	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Deep tank bulkhead	h_T	1

5 General arrangement

5.1

5.1.1 The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

5.2

5.2.1 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

6 Non-tight bulkheads

6.1 Non-tight bulkheads not acting as pillars

6.1.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

6.2 Non-tight bulkheads acting as pillars

6.2.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- two frame spacings, when the frame spacing does not exceed 0,75 m,
- one frame spacing, when the frame spacing is greater than 0,75 m.

SECTION 11 SUPERSTRUCTURES

1 General

1.1

1.1.1 First tier superstructures or deckhouses are intended as those situated on the uppermost exposed continuous deck of the yacht, second tier superstructures or deckhouses are those above, and so on.

Where the distance from the hypothetical freeboard deck to the full load waterline exceeds the freeboard that can hypothetically be assigned to the yacht, the reference deck for the determination of the superstructure tier may be the deck below the one specified above, see Ch 1, Sec 1, [4.3.2].

When there is no access from inside superstructures and deckhouses to 'tweendecks below, reduced scantlings with respect to those stipulated in this Section may be accepted at the discretion of Tasneef

2 Boundary bulkhead plating

2.1

2.1.1

The thickness of the boundary bulkheads is to be not less than the value t, in mm, calculated with the following formula:

$$t = 8 \cdot s \cdot (K \cdot h)^{0,5}$$

s : spacing between the stiffeners, in m

h : conventional scantling height, in m, the value of which is to be taken not less than that indicated in Table 1

K : factor defined in Sec 2.

In any event, the thickness t is to be not less than the values shown in Sec 1, Tab 3.

Table 1

Type of bulkhead	h (m)
1^{st} tier front	1,5
2^{nd} tier front	1,0
Other bulkheads wherever situated	1,0

3 Stiffeners

3.1

3.1.1 *(1/7/2022)*

The stiffeners of the boundary bulkheads are to have a section modulus not less than the value Z, in cm3, calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where:

h : conventional scantling height, in m, defined in [2.1.1]

K : factor defined in Sec 2

s : spacing of the stiffeners, in m

S : span of the stiffeners, equal to the distance, in m, between the members supporting the stiffener concerned.

4 Superstructure decks

4.1 Plating

4.1.1

The superstructure deck plating is to be not less than the value t, in mm, calculated with the following formula:

$$t = 10 \cdot s \cdot (K \cdot h)^{0,5}$$

where:

s : spacing of the stiffeners, in m

K : factor defined in Sec 2.

h : conventional scantling height, in m, defined in Ch 1, Sec 5, [5.5].

In any event, the thickness t is to be not less than the values shown in Sec 1, Tab 3.

4.2 Stiffeners

4.2.1

The section modulus Z, in cm^3, of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where:

s : spacing of the stiffeners, in m

S : conventional span of the stiffener, equal to the distance, in m, between the supporting members

h : conventional scantling height, in m, defined in Ch 1, Sec 5, [5.5].

K : factor defined in Sec 2.

Reinforced beams (beams, stringers) and ordinary pillars are to have scantlings as stated in Sec 9.

Part B
Hull and Stability

Chapter 3
ALUMINIUM HULLS

SECTION 1 GENERAL REQUIREMENTS

1 Field of application

1.1

1.1.1 Chapter 3 of Section B applies to monohull yachts with hulls made of aluminium alloy and a length L not exceeding 90 m, with motor or sail power with or without auxiliary engines.

Multi-hulls or hulls with a greater length will be considered case-by-case.

In the examination of constructional plans, Tasneef may take into consideration material distribution and structural scantlings other than those that would be obtained by applying these regulations, provided that structures with longitudinal, transverse and local strength not less than that of the corresponding Rule structure are obtained or provided that such material distribution and structural scantlings prove adequate, in the opinion of Tasneef on the basis of direct test calculations of the structural strength.

The formulae indicated in this Chapter are based on use of an aluminium alloy having yield strength, in the welded condition, $R_{p\ 0,2}$ = 110 N/mm^2 (corresponding to a permanent elongation of 0,2%).

The scantlings of structures made with light alloys having different values of yield strength are obtained taking into account coefficient K as defined in Section 2.

2 Definitions and symbols

2.1 Premise

2.1.1 The definitions and symbols in this Article are valid for all the Sections of this Chapter.

The definitions of symbols having general validity are not normally repeated in the various Sections, whereas the meanings of those symbols which have specific validity are specified in the relevant Sections.

2.2 Definitions and symbols

2.2.1

L : scantling length, in m, on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest;

B : maximum breadth of the yacht, in m, outside frames; in tests of the longitudinal strength of twin hull yachts, B is to be taken as equal to twice the breadth of the single hull, measured immediately below the cross-deck;

D : depth of the yacht, in m, measured vertically in the transverse section at half the length L, from the base line up to the deck beam of the uppermost continuous deck;

T : draught of the yacht, in m, measured vertically in the transverse section at half the length L, from the base line to the full load waterline with the yacht at rest in calm water;

s : spacing of the longitudinal or transverse ordinary stiffener, in m;

Δ : displacement of the yacht outside frames, in t, at draught T;

K : factor as a function of the mechanical properties of the aluminium alloy used, as defined in Sec 2.

3 Plans, calculations and other information to be submitted

3.1

3.1.1 Table 1 lists the structural plans that are to be presented in advance to Tasneef in triplicate, for examination and approval when required.

The table also indicates the information that is to be supplied with the plans or, in any case, submitted to Tasneef for the examination of the documentation.

For documentation purposes, copies of the following plans are to be submitted:

- general arrangement;
- capacity plan;
- lines plan;

Table 1 *(1/1/2016)*

PLAN	CONTAINING INFORMATION RELEVANT TO:
• Midship section	• main dimensions, maximum operating speed V, design acceleration a_{CG} (for planing or semi-planing yachts) • materials and associated mechanical properties • for yacht with L > 40 m, if multi-hull, or L > 50 m if mono-hull, state the maximum vertical bending moment in still water • development
• Longitudinal and trasversal section	
• Plan of the decks	• openings • loads acting, if different from Rule loads
• Shell expansion	• openings
• Structure of the engine room	
• Watertight bulkheads and deep tank bulkheads	• openings • location of air outlets
• Structure of stern/side door	• closing appliances
• Superstructures	• openings • location of overflow
• Support structure for crane	• design loads and connections to the hull structures
• Rudder	• materials of all components • calculation speed
• Propeller shaft struts	• material
• Additional plans for sailing yachts: - ballast keel shell expansion showing the adopted throat thickness and other welding characteristics - keel connection details	
• Plan of tank testing **(1)**	
(1) Only for yachts equal to or greater than 500 GT	

If the **INWATERSURVEY** notation is to be assigned, the following plans and information are to be submitted:

- Details showing how rudder pintle and bush clearances are to be measured and how the security of the pintles in their sockets is to be verified with the craft afloat.
- Details showing how stern bush clearances are to be measured with the craft afloat.
- Name and characteristics of high resistant paint, for information only.

3.2

3.2.1 If a Builder for the construction of a new vessel of a standard design wishes to use drawings already approved for a vessel similar in design and construction and classed with the same class notation and the same navigation, the drawings need not be sent for approval, but the request for survey for the vessel is to be submitted enclosed with a list of the drawings the Builder wishes to refer to, and copies of the approved drawings are to be sent to Tasneef

It is the Builder's responsibility to submit for approval any modification to the approved plans prior to the commencement of any work.

Plan approval of standard design vessels is only valid so long as no applicable Rule changes take place. When the Rules are amended, the plans are to be submitted for new approval.

4 Direct calculations

4.1

4.1.1 As an alternative to those based on the formulae in this Chapter, scantlings may be obtained by direct calculations carried out in accordance with the provisions of Chapter 1 of Part B of these Rules.

Chapter 1 provides schematisations, boundary conditions and loads to be used for direct calculations.

The scantlings are to be such as to guarantee that stress levels do not exceed the allowable values stipulated in the aforementioned Chapter.

5 General rules for design

5.1

5.1.1 The hull scantlings required in this Chapter are in general to be maintained throughout the length of the hull.

For yachts with length L equal to or greater than 50 m, reduced scantlings may be adopted for the fore and aft zones, provided that, with particular regard to plating, they are no less than those shown in Table 2.

In such case the variations between the scantlings adopted for the central part of the hull and those adopted for the ends are to be gradual.

In the design, care is to be taken in order to avoid structural discontinuities in particular in way of the ends of superstructures and of the openings on the deck or side of the yacht.

For yachts similar in performance to high speed craft, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

Such interval is to be suitably reduced in the areas forward of amidships subject to the forces caused by slamming.

6 Minimum thicknesses

6.1

6.1.1 In general, the thicknesses of plating stiffeners and cores of reinforced beams is to be not less than the minimum values shown in Table 2.

Lesser thicknesses may be accepted provided that, in the opinion of Tasneef their adequacy in terms of buckling strength and resistance to corrosion is demonstrated.

Where plating and stiffeners contribute to the longitudinal strength of the yacht, their scantlings are to be such as to fulfil the requirements for yacht longitudinal strength stipulated in Sec 4.

Table 2

Member	Minimum thickness (mm)
Keel, bottom plating	$t_1 = 1,75 \cdot L^{1/3} \cdot K^{0,5}$
Side plating	$t_2 = 1,50 \cdot L^{1/3} \cdot K^{0,5}$
Open strength deck plating	$t_3 = 1,50 \cdot L^{1/3} \cdot K^{0,5}$
Lower and enclosed deck plating	$t_4 = t_3 - 0,5$
1st tier superstructure front bulkhead	$t_5 = t_1$
Superstructure bulkhead	$t_6 = t_5 - 1,5$
Watertight subdivision bulkhead	$t_7 = t_2 - 0,5$
Tank bulkhead	$t_8 = t_2$
Centre girder	$t_9 = 2,3 \cdot L^{1/3} \cdot K^{0,5}$
Floors and side girders	$t_{10} = 1,70 \cdot L^{1/3} \cdot K^{0,5}$
Tubular pillars	$t_{11} = 0,05\ d$ **(1)**
(1) d = diameter of the pillar, in mm	

7 Plating attached to griders

7.1 Primary supporting members

7.1.1 *(1/1/2020)*

The section modulus and the moment of inertia of primary supporting members are to be calculated in association with an effective area A_S, in cm², of attached load bearing plating obtained from the following:

$$A_S = 10c \cdot b_F \cdot t_S$$

where:

$$\text{for } \mathbf{S}_L/\mathbf{b}_F < 8 : \mathbf{c} = 0,25 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right) - 0,016 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right)^2$$

$$\text{for } \mathbf{S}_L/\mathbf{b}_F \geq 8 : \mathbf{c} = 1$$

where:

Girders : primary supporting members of ordinary stiffeners such as deck girders, beams and web frames, side stringers, vertical and horizontal girders of bulkheads, floors, centre and side bottom girders, and similar.

Ordinary stiffeners: supporting members of shell plating, decks, double bottom or tank top plating, bulkheads, and similar.

$\mathbf{S}_L$: overall length of the girder, in m

$\mathbf{b}_F$: actual width of the load bearing plating, i.e. one-half of the sum of the spaces between parallel stiffeners adjacent to that considered, in m

$\mathbf{t}_s$: mean thickness, in mm, of the attached plating

$\mathbf{A}_s$: area of the attached plating, in cm²

$\mathbf{t}_a$: web thickness, in mm, in built sections

$\mathbf{d}_a$: web depth in built sections, measured between the inside of the face plate and the inside of the attached plating, in mm

7.2 Ordinary stiffeners

7.2.1 *(1/1/2020)*

Unless otherwise stated in specific requirements, the section modulus and the moment of inertia of the ordinary stiffeners are to be calcolated in association with an effective load bearing plating having width equal to the spacing of the stiffeners and thickness equal to the mean thickness of the attached plating.

7.3 Special cases

7.3.1 *(1/1/2020)*

In way of fore and aft regions and, in general, where the web of the section is at an angle a less than 90° to the attached plating, the section modulus shall be calculated taking account of the inclination of the attached plating.

Where the above angle α is less than 75°, the section modulus of the stiffener may be approximately calculated by multiplying the section modulus of the web fitted at right angles to the attached plating by cos (90 - α).

7.4 Calculation of section modulus

7.4.1 Primary supporting members *(1/1/2020)*

The section modulus $\mathbf{W}_T$, in cm³, of a built section with attached plating of area $\mathbf{A}_S$, in cm², may be calculated using the following formula:

$$W_T = \frac{A_p \cdot d_a}{10} + \frac{t_S \cdot d_a^2}{6000} \cdot \left(1 + \frac{200 \cdot (A_S - A_p)}{200 A_S + t_a \cdot d_a}\right)$$

In cases of symmetrical sections, the section modulus may be calculated as follows:

$$W_T = \frac{A_P \cdot d_A}{10} + \frac{t_a \cdot d^2{}_a}{6000}$$

As a rule A_S is to be greater than A_p; in this respect, the thickness of the attached plating is to be increased accordingly where necessary.

A_a : web area, in cm², in built sections

b_p : face plate width, in mm, in built sections

A_a : face plate area, in cm², in built sections

In the case of members located along the edge of openings, the effective area of the attached plating is to be assumed equal to 7/10 of the value of A_S calculated by assuming b_F equal to half the distance between the member considered and its adjacent member.

SECTION 2 MATERIALS, CONNECTIONS AND STRUCTURE DESIGN PRINCIPLES

1 Materials and connections

1.1 General requirements

1.1.1 Materials to be used in hull and equipment construction, in delivery condition, are to comply with these requirements or with specific requirements applicable to individual cases; they are to be tested in compliance with the applicable provisions. Quality and testing requirements for materials covered here are outlined in the relevant Tasneef Rules.

These requirements presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and the relevant Tasneef provisions. The latter, in particular, may include requirements concerning welding operations and techniques and other manufacturing processes (e.g., specific preheating before welding and/or welding or other cold or hot manufacturing processes followed by an appropriate heat treatment).

Welding processes are to be approved for the specified type of material for which they are intended and with limits and conditions as stated in the applicable Tasneef requirements.

1.2 Aluminium alloy hull structures

1.2.1 The designation of aluminium alloys used here complies with the numerical designation used in RRIAD (Registration Record of International Alloy Designation).

The characteristics of aluminium alloys to be used in the construction of aluminium craft are to comply with the relevant requirements of Tasneef Rules.

As a rule, series 5000 aluminium-magnesium alloys (see Tab 1) or series 6000 aluminium-magnesium-silicon alloys (see Tab 2) are to be used.

Table 1

SERIES 5000 WROUGHT ALUMINIUM ALLOYS FOR WELDED CONSTRUCTION (Rolled products: Plates and Sections) Guaranteed mechanical characteristics **(1)**				
Alloy **(2)**	Temper **(3)**	Dimensions in mm	Minimum guaranteed yield stress $R_{p\,0,2}$ at 0,2% N/mm²	Minimum guaranteed tensile strength R_m N/mm²
5083 (Plates)	0 or H111	$t \le 6$ $t > 6$	125 115	275 275
5083 (Sections)	0 or H111	All thicknesses	110	270
5086 (Plates)	0 or H111	All thicknesses	100	240
5086 (Sections)	0 or H111	All thicknesses	95	240
5754	0 or H111	$t \le 6$ $t > 6$	80 70	190 190
5454	0 or H111	All thicknesses	85	215
5454	F	All thicknesses	100	210

(1) The guaranteed mechanical characteristics in this Table correspond to general standard values. For more information, refer to the minimum values guaranteed by the product supplier.
(2) Other grades or tempers may be considered, subject to Tasneef agreement.
(3) 0 : annealed
H111: roller levelled after annealing
F: as fabricated.
(4) See [1.5.1].

Table 2

SERIES 6000 WROUGHT ALUMINIUM ALLOYS FOR WELDED CONSTRUCTION (Rolled products: Plates and Sections) Guaranteed mechanical characteristics **(1)**				
Alloy **(2)**	Temper **(3)**	Dimensions in mm	Minimum guaranteed yield stress $R_{p\,0,2}$ a 0,2% N/mm²	Minimum guaranteed tensile strength R_m N/mm²
6005 A (Open Sections)	T5 or T6	**t** ≤ 6 6< **t** ≤ 10 10 < **t** ≤ 25	225 215 200	270 260 250
6005 A (Closed Sections)	T5 or T6	**t** ≤ 6 6< **t** ≤ 25	215 200	255 250
6061 (Sections)	T6	**t** ≤ 25	240	260
6082 (Sections)	T6	**t** ≤ 15	250	290

(1) The guaranteed mechanical characteristics in this Table correspond to general standard values. For more information, refer to the minimum values guaranteed by the product supplier.
(2) Other grades or tempers may be considered, subject to Tasneef agreement.
(3) T5 : artificially aged
T6 : solution heat treated and artificially aged.

The use of series 6000 alloys or extruded plates, for parts which are exposed to sea water atmosphere, will be considered in each separate case by Tasneef also taking into account the protective coating applied.

The list of aluminium alloys given in Tab 1 and Tab 2 is not exhaustive. Other aluminium alloys may be considered, provided the specification (manufacture, chemical composition, temper, mechanical properties, welding, etc) and the scope of application are submitted to Tasneef for review.

In the case of welded structures, alloys and welding processes are to be compatible and appropriate, to the satisfaction of Tasneef and in compliance with the relevant Rules.

For forgings or castings, requirements for chemical composition and mechanical properties will be defined in each separate case by Tasneef

In the case of structures subjected to low service temperatures or intended for other particular applications, the alloys to be employed will be defined in each separate case by Tasneef which will state the acceptability requirements and conditions.

Unless otherwise specified, Young's modulus for aluminium alloys is equal to 70000 N/mm² and Poisson's ratio equal to 0,33.

1.3 Extruded plating

1.3.1 Extrusions with built-in plating and stiffeners, referred to as extruded plating, may be used.

In general, the application is limited to decks and deckhouses. Other uses may be permitted at the discretion of Tasneef

Extruded plating is preferably to be oriented so that the stiffeners are parallel to the direction of main stresses.

Connections between extruded plating and primary members are to be given special attention.

1.4 Tolerances

1.4.1 The under-thickness tolerances of plates and rolled sections are to be in accordance with Tab 3.

The under-thickness tolerances of extruded plating are to be in accordance with Tab 4.

The responsibility for maintaining the required tolerances lies with the Manufacturer, who is also to inspect the surface condition.

1.5 Influence of welding on mechanical characteristics

1.5.1 Welding heat input lowers locally the mechanical strength of aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111) or by heat treatment (series 6000).

Consequently, where necessary, a drop in mechanical characteristics of welded structures is to be considered in the heat-affected zone, with respect to the mechanical characteristics of the parent material.

The heat-affected zone may be taken to extend 25 mm on each side of the weld axis.

Aluminium alloys of series 5000 in 0 condition (annealed) or in H111 condition (annealed flattened) are not subject to a drop in mechanical strength in the welded areas.

Aluminium alloys of series 5000 other than condition 0 or H111 are subject to a drop in mechanical strength in the welded areas. The mechanical characteristics to consider are, normally, those of condition 0 or H111. Higher mechanical characteristics may be taken into account, provided they are duly justified.

Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas. The mechanical characteristics to be considered are, normally, to be indicated by the supplier.

Table 3

As-built thickness **t**, in mm	Under-thickness tolerance, in mm
$\mathbf{t} \le 8$	0,3
$8 < \mathbf{t} \le 12$	0,5
$12 < \mathbf{t} \le 20$	0,7
$\mathbf{t} > 20$	1

Table 4

As-built thickness **t**, in mm	Under-thickness tolerance, in mm
$\mathbf{t} \le 6$	0,3
$6 < \mathbf{t} \le 10$	0,4

1.6 Material factor K for scantlings of structural members made of aluminium alloy

1.6.1

The value of the material factor K to be introduced into formulae for checking scantlings of structural members, given in this Chapter and the various Appendices, is determined by the following equation:

$$\mathbf{K} = \frac{110}{\eta \cdot \mathbf{R}_{p0,2}}$$

where:

$\mathbf{R}_{p0,2}$: is the minimum guaranteed yield stress, in N/mm², of the parent material in delivery condition

$\mathbf{R'}_{p0,2}$: is the minimum guaranteed yield stress, in N/mm², of metal in welded condition, i.e.:

- condition 0 or H111 for series 5000 alloys (see [1.5])
- to be indicated by the supplier for series 6000 alloys (see [1.5]).

η : is the joint coefficient for the welded assembly, corresponding to the aluminium alloy considered, given in Tab 5 (for series 5000 other than condition 0 or H11, and series 6000 to be calculated by knowing $R'_{p0,2}$)

β : is the coefficient of metallurgical efficiency, having the same physical mean of η. When $\mathbf{R'}_{p0,2}$ is not available, coefficient η is to be taken equal β, given in Tab 6

For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in annealed or welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

In the case of welding of two different aluminium alloys, the material factor **K** to be considered for the scantlings of welds is to be the greater material factor of the aluminium alloys of the assembly.

Table 5 : Joint coefficient for aluminum alloys

Aluminium alloys	η
Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1
Alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$\mathbf{R'}_{p\,0,2}/\mathbf{R}_{p\,0,2}$
Aluminium alloys hardened by heat treatment (series 6000)	$\mathbf{R'}_{p\,0,2}/\mathbf{R}_{p\,0,2}$

(1) When no information is available, coefficient η is to be taken equal to the metallurgical efficiency coefficient ß defined in Tab 6.

Note 1:

$\mathbf{R'}_{p0,2}$: minimum guaranteed yield stress, in N/mm², of metal in welded condition.

Table 6 : Aluminum alloys Metallurgical efficiency coefficient ß

Aluminium alloys	Temper condition	Gross thickness, in mm	β
6005 A (Open sections)	T5 or T6	$t \le 6$	0.45
		$t > 6$	0,40
6005 A (Closed sections)	T5 or T6	All	0,50
6061 (Sections)	T6	All	0,53
6082 (Sections)	T6	All	0,45

1.7 Fillet welding

1.7.1 The effective length, in mm, of the weld beads is given by:

$$\mathbf{d}_e = \mathbf{d} - 20$$

where **d** is the actual length, in mm, of the weld bead.

1.8 Riveted connections for aluminium alloy hulls

1.8.1 Use of rivets for connecting structures is limited, in principle, only to members which do not contribute to the overall strength of the hull. Exceptions are to be supported by experimental evidence or good in-service performance.

The conditions for riveted connection acceptability are to be individually stated in each particular case, depending on the type of member to be connected and the rivet material.

Whenever riveted connections are to be employed, a detailed plan, illustrating the process as well as the dimensions and location of rivets and holes, together with the mechanical and metallurgical properties of the rivets, is to be submitted for approval.

Tasneef may, at its discretion, require tension, compression and shear tests to be carried out on specimens of riveted connections constructed under the same conditions as during actual hull construction, to be witnessed by a Tasneef Surveyor.

Tasneef reserves the right to accept the results of tests performed by recognised bodies or other Societies.

1.9 Welded connections

1.9.1 General requirements

For welding, the requirements in Ch 2, Sec 3 apply. In particular, these provisions make the adoption of welding procedures dependent on their previous qualification by Tasneef In addition, individual builders are to hold an authorisation by Tasneef to use these procedures, employing welders qualified by Tasneef

1.9.2 Accessibility and edge preparation

For correct execution of welded joints, sufficient accessibility is necessary, depending on the welding process adopted and the welding position.

Edge cutting, to be carried out in general by machining, is to be regular and without burrs or cuts.

The structural parts to be welded as well as those adjacent, even if they have been previously pickled, are to be cleaned carefully before welding, using suitable mechanical means, such as stainless steel wire brushes, so as to eliminate oxides, grease or other foreign bodies which could give rise to welding defects.

Edge preparation, alignment of joints, spot-welding methods and root chipping are to be appropriate to the type of joint and welding position, and comply with Tasneef requirements for the welding procedures adopted.

1.9.3 Inspections

Inspections of welded connections by Tasneef Surveyors are, in general, those specified in (a) to (e) below. The extent of inspection will be defined by Tasneef on a case-by-case basis.

a) Inspection of base materials for compliance with the requirements in this Article and of structures with the approved plans.

b) Inspection of the use and application conditions of welding procedures for compliance with those approved and verification that qualified welders are employed.

c) Visual examination of edge preparations, root chipping and execution of welds in way of structural connections.

d) Examination of radiographs of welded joints (radiographing is to be performed, if necessary, depending on the extent of the examinations), and inspection of performance of the ultrasonic or magnetic particle examinations which may be required.

e) Inspection of any repairs, to be performed with procedures and inspection methods at the discretion of the Tasneef Surveyor.

Irrespective of the extent of such inspections, it is the responsibility of the builder to ensure that the manufacturing procedures, processes and sequences are in compliance with the relevant Tasneef requirements, approved plans and sound working practice. For this purpose, the shipyard is to have its own production control organisation.

1.9.4 Welding processes for light alloys

In general, the welding of the hull structures is to be performed with the MIG (metal-arc inert gas) and TIG (tungsten-arc inert gas) processes using welding consumables recognised as suitable for the base material to be used. Welding processes and filler materials other than those above will be individually considered by Tasneef at the time of approval of welding procedures.

For authorisation to use welding procedures in production, the following details are to be stated:

a) grade and temper of parent and filler materials

b) weld execution procedures: type of joint (e.g. butt-joint, fillet joint); edge preparation (e.g. thicknesses, bevelling, right angle edges); welding position (e.g. flat, vertical, horizontal) and other parameters (e.g. voltage, amperage, gas flow capacity)

c) welding conditions (e.g. cleaning procedures of edges to be welded, protection from environmental atmosphere)

d) special operating requirements for butt-joints, for example for plating: welding to be started and completed on end pieces outside the joint, back chipping, arrangements for repairs consequent to possible arc restarts

e) type and extent of controls during production.

1.10 Corrosion protection - Heterogeneous steel/aluminium alloy assembly

1.10.1 Connections between aluminium alloy parts, and between aluminium alloy and steel parts, if any, are to be protected against corrosion by means of coatings applied by suitable procedures agreed by Tasneef

In any case, any direct contact between steel and aluminium alloy is to be avoided (e.g. by means of zinc or cadmium plating of the steel parts and application of a suitable coating on the corresponding light alloy parts).

Any heterogeneous jointing system is subject to Tasneef agreement.

The use of transition joints made of aluminium/steel-clad plates or profiles is subject to Tasneef agreement.

Transition joints are to be type approved.

Qualifications tests for welding procedures are to be carried out for each joint configuration.

2 Structure design principles

2.1 Protection against corrosion

2.1.1 Scantlings stipulated in Sec 3 and Sec 4 assume that the materials used are chosen and protected in such a way that the strength lost by corrosion is negligible.

2.1.2 The shipyard is to give Tasneef a document specifying all the arrangements made to protect the material against corrosion at the construction stage: coating types, number and thickness of layers, surface preparation, application conditions, control after completion, anodic protection, etc.

2.1.3 This document is also to include maintenance arrangements to be made in service to restore and maintain the efficiency of this protection, whatever the reasons for its weakening, and whether or not incidental.

All such maintenance operations are to be listed in a book shown to the Tasneef Surveyor in charge upon request.

2.2 Rounding-off

2.2.1 Values for thickness as obtained from formulae are to be rounded off to the nearest standard value, without such a reduction exceeding 3 per cent.

SECTION 3 DESIGN LOAD AND HULL SCANTLINGS

1 Design loads

1.1 Application

1.1.1 The requirements in Ch 1, Sec 5, [3], Ch 1, Sec 5, [4], and Ch 1, Sec 5, [5] apply.

2 Hull scantlings

2.1

2.1.1 This Article stipulates requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members). The loads acting on such structures are to be calculated in accordance with Ch 1, Sec 5.

In general, for craft with length **L** > 65 m or speed **V** > 45 knots, the scantlings of transverse structures are to be verified also by direct calculations carried out in accordance with Ch 3, Sec 1, [4].

For all other craft, Tasneef may, at its discretion and as an alternative to the requirements of this Article, accept scantlings for transverse structures of the hull based on direct calculations in accordance with Ch 3, Sec 1, [4].

2.2 Definitions and symbols

2.2.1 "**Rule bracket**" - A bracket with arms equal to **l**/8, **l** being the span of the connected stiffener. Where the bracket connects two different types of stiffeners (frame and beam, bulkhead web and longitudinal stiffener, etc.), the value of **l** is to be that of the member with the greater span, or according to criteria specified by Tasneef

t : thickness, in mm, of plating and deck panels;

Z : section modulus, in cm³, of stiffeners and primary supporting members;

s : spacing of stiffeners, in m, measured along the plating;

l : overall span of stiffeners, in m, i.e. the distance between the supporting elements at the ends of the stiffeners (see Fig 4);

S : conventional scantling span of primary supporting members, in m, to be taken as given in the examples in Fig 5. Special consideration is to be given to conditions different from those shown. In no case is **S** to be less than 1,1 S_0, S_0 being the distance between the internal ends of the conventional brackets as indicated in Fig 5 or, if there are no brackets, between the ends of the members;

b : actual surface width of the load bearing on primary supporting members; for usual arrangements $b = 0,5 \cdot (l_1 + l_2)$, where l_1 and l_2 are the spans of stiffeners supported by the primary supporting member;

p : design pressure, in kN/m², calculated as defined in Ch 1, Sec 5, [5];

σ_{am} : permissible normal stress, in N/mm²;

τ_{am} : permissible shear stress, in N/mm²;

K : material factor defined in Sec 2, [1.6];

e : σ_p / σ_{bl}, ratio between permissible and actual hull girder longitudinal bending stresses (see [2.4]);

σ_p : maximum admissible stress, in N/mm², as defined in [2.4.1];

σ_{bl} : longitudinal bending stress, in N/mm², as defined in [2.4.1];

μ : $\left(1,1 - 0,5 \cdot \left(\frac{s}{l}\right)\right)^{0,5}$

, which is not to be taken greater than 1,0.

2.3 Overall strength

2.3.1 Longitudinal strength

In general, the scantlings resulting from local strength calculations in this Article are such as to ensure adequate longitudinal strength of the hull girder for the craft.

Specific longitudinal strength calculations are to be carried according to the requirements of Sec 4.

2.3.2 Transverse strength of twin hull craft

The equivalent Von Mises stresses obtained for load conditions in Ch 1, Sec 5, [4.4.2] and Ch 1, Sec 5, [4.4.3] are not to exceed 75/**K** N/mm².

The compressive values of normal stresses and the shear stresses are not to exceed the values of critical stresses for plates and stiffeners calculated according to [2.4].

In general, the bottom of the cross-deck is to be constituted by continuous plating for its entire longitudinal and transverse extension. Alternative solutions may, however, be examined by Tasneef on the basis of considerations pertaining to the height of the cross-deck above the waterline and to the motion characteristics of the craft.

In the special case of twin hull craft, when the structure connecting both hulls is formed by a deck with single plating stiffened by n reinforced beams, the normal and shear stresses in the beams for the load condition in Ch 1, Sec 5, [4.4.3] can be calculated as indicated in [2.4.3].

For craft with **L** > 65 m or speed **V** > 45 knots, or for those craft whose structural arrangements do not permit a realistic assessment of stress conditions based on simple models, the transverse strength is to be checked by means of direct calculations carried out in accordance with the criteria specified in Ch 3, Sec 1, [4].

2.3.3 Transverse strength in the special case of twin hull craft when the structure connecting both hulls is formed by a deck with single plate stiffened by n reinforced beams

See Fig 6; G is the centre of the stiffnesses $\mathbf{r}_i$ of the n beams. Its position is defined by:

$$\mathbf{a} = \frac{\sum \mathbf{r}_i \cdot \mathbf{x}_i}{\sum \mathbf{r}_i}$$

where:

a : the abscissa, in m, of the centre G with respect to an arbitrarily chosen origin 0 $\mathbf{r}_i$

r_i : $\dfrac{12 \cdot \mathbf{E}_i \cdot \mathbf{I}_i}{\mathbf{S}_i^3} \cdot 10^6$, in N/m

$\mathbf{E}_i$: Young's modulus, in N/mm², of the beam **i**

$\mathbf{I}_i$: bending inertia, in m⁴, of the beam **i**

$\mathbf{S}_i$: span, in m, of the beam **i** between the inner faces of the hulls

$\mathbf{x}_i$: abscissa, in m, of the beam **i** with respect to the origin 0.

If $\mathbf{F}_i$, in N, is the force taken over by the beam **i**, the deflection $\mathbf{y}_i$, in m, of the hull in way of the beam **i**, is:

$$\mathbf{y}_i = \frac{\mathbf{F}_i \cdot \mathbf{S}_i^3 \cdot 10^{-6}}{12 \cdot \mathbf{E}_i \cdot \mathbf{I}_i} = \frac{\mathbf{F}_i}{\mathbf{r}_i} = \mathbf{d}_i \cdot \omega$$

$\mathbf{d}_i$: $\mathbf{x}_i$ - **a**, abscissa, in m, of the beam **i** in relation to **G**

ω : rotation angle, in rad, of one hull in relation to the other around a transverse axis passing through **G**.

Considering that the transverse torsional moment (see Ch 1, Sec 3, [3.2.3])

$$\mathbf{M}_{tt} = \mathbf{F}_i \cdot \mathbf{d}_i \cdot 10^{-3}$$

the formula for ω may be obtained as follows:

$$\omega = \frac{\mathbf{M}_{tt}}{\sum \mathbf{r}_i \cdot \mathbf{d}_i^2} \cdot 10^3$$

As $\mathbf{M}_{tt}$, $\mathbf{r}_i$ and $\mathbf{d}_i$ are known, and ω thus deduced, the force $\mathbf{F}_i$, in N, the bending moment $\mathbf{M}_i$, in N · m, and the corresponding normal and shear stresses can be evaluated in each beam:

$$\mathbf{F}_i = \omega \cdot \mathbf{r}_i \cdot \mathbf{d}_i$$

$$\mathbf{M}_i = \mathbf{F}_i \cdot \mathbf{S}_i / 2$$

Note 1: Beams calculated by the above method are assumed to be fixed in each hull as beams in way of bulkheads inside hulls. For this hypothesis to be correct, the beams are to extend over the whole breadth of both hulls and their stiffness is to be kept the same over the entire span inside and outside the hulls.

Figure 1 : Examples of conventional spans of ordinary stiffeners

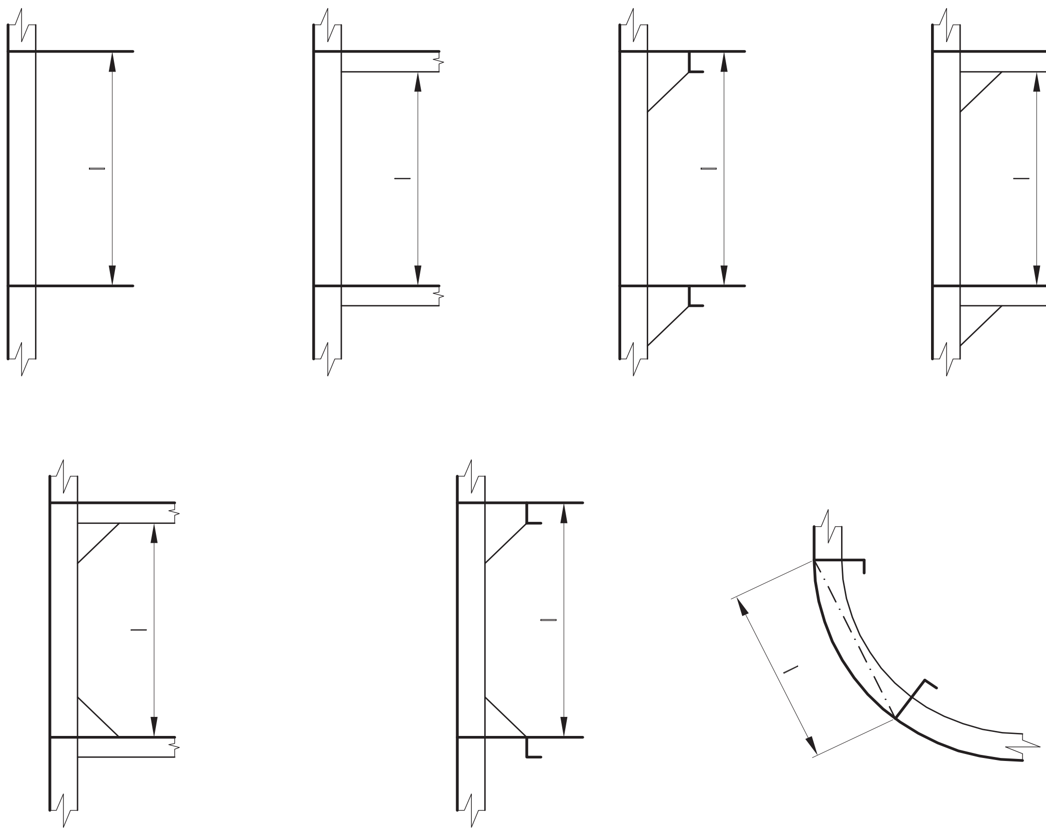


Figure 2 : Examples of conventional spans of primary supporting members

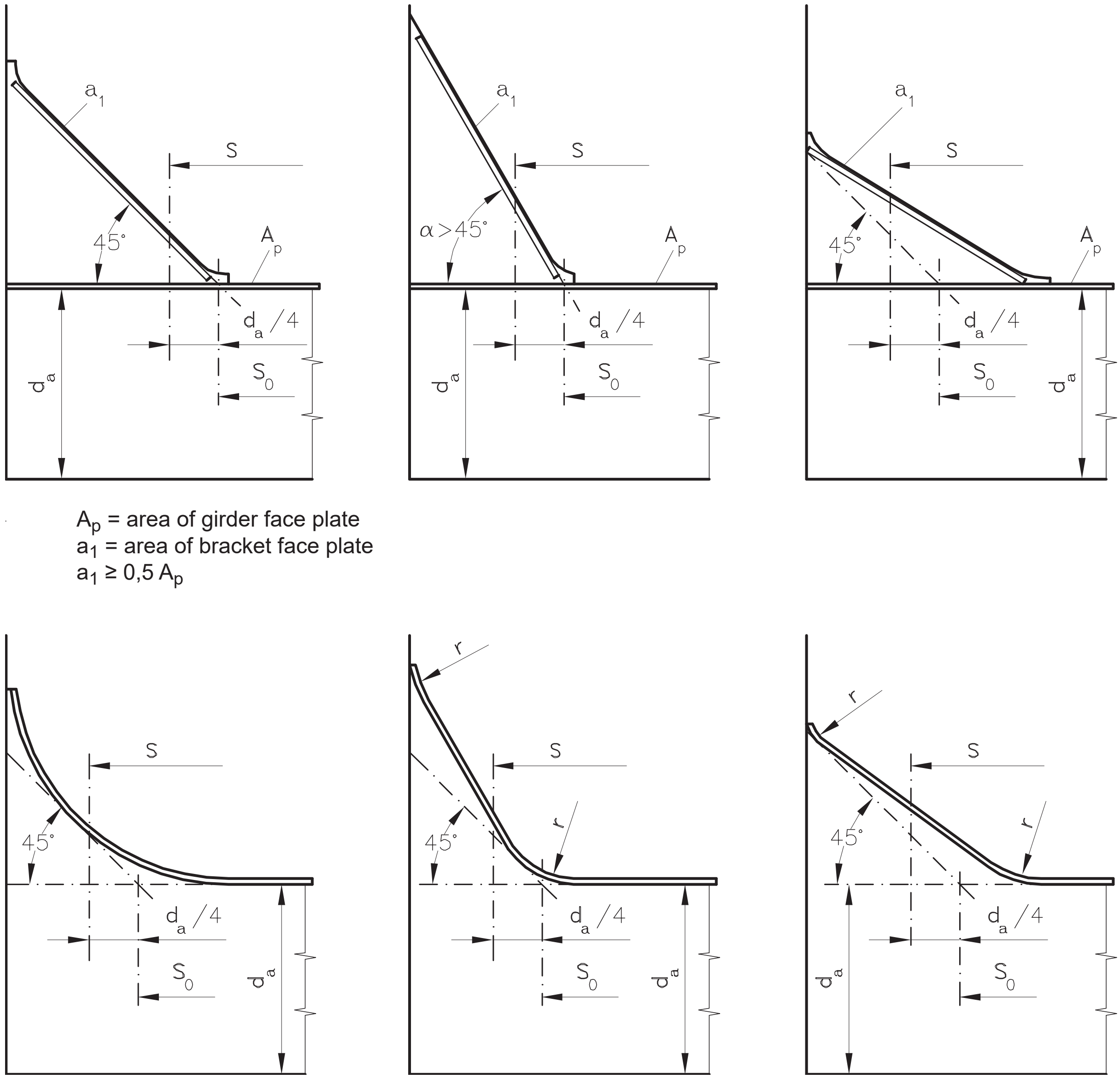
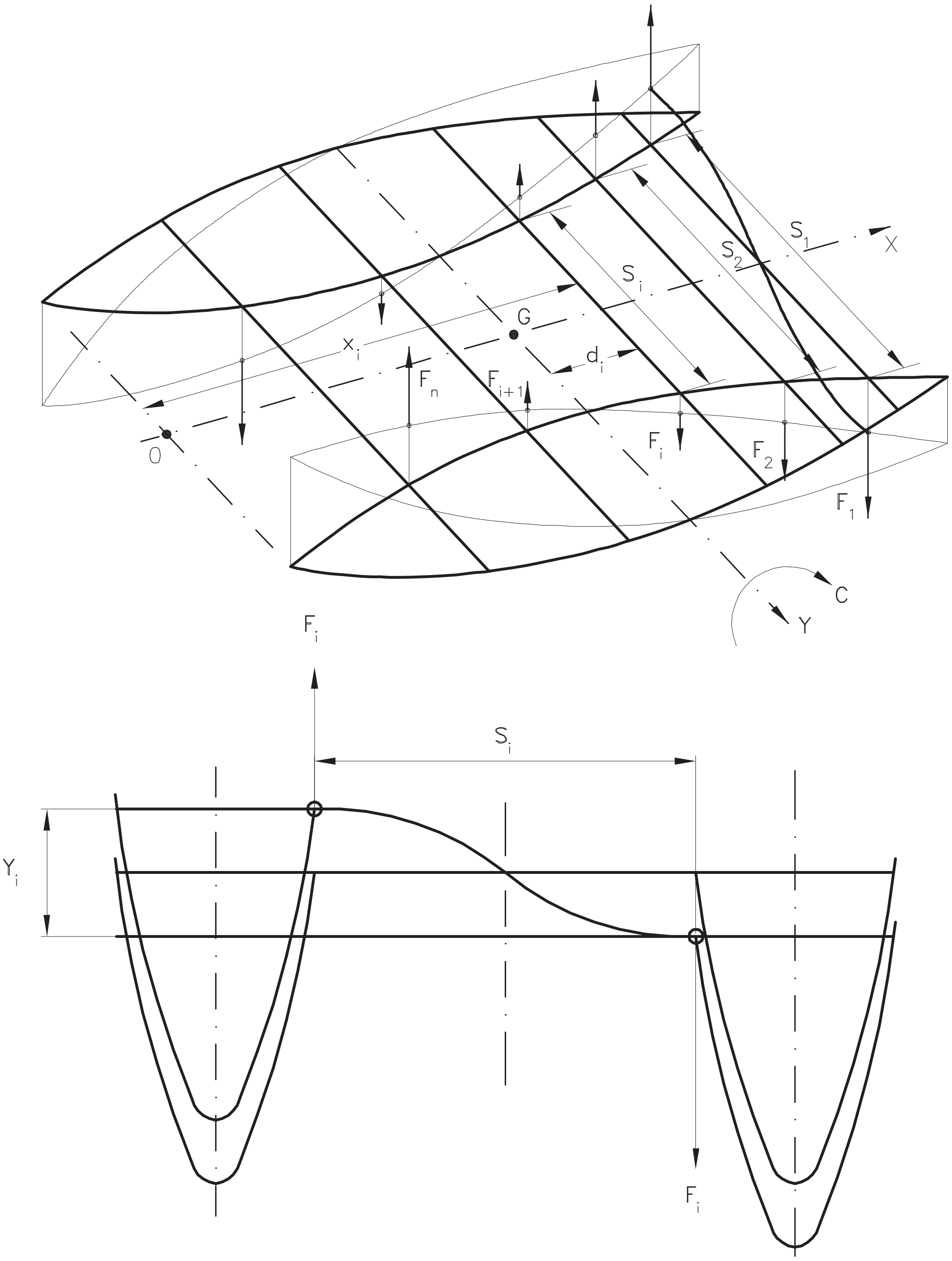


Figure 3



2.4 Buckling strength of aluminium alloy structural members

2.4.1 Application

These requirements apply to aluminium alloy plates and stiffeners subjected to compressive loads, to calculate their buckling strength.

2.4.2 Elastic buckling stresses of plates

a) **Compressive stress**

The elastic buckling stress, in N/mm², is given by:

$$\sigma_E = 0{,}9 \cdot \mathbf{m}_c \cdot E \cdot \varepsilon \cdot \left(\frac{\mathbf{t}}{1000 \cdot \mathbf{a}}\right)^2$$

where:

$\mathbf{m}_c$: coefficient equal to:

$(1 + \gamma^2)^2$ for uniform compression $(\psi) = 1$;

$1 + \frac{\gamma}{\gamma_1}(\mathbf{m}_1 - 1)$, for compression-bending stress

$(0 \le \psi \le 1)$, if $(\gamma < \gamma_1)$

$\frac{2,1}{1,1 + \psi} \cdot (1 + \gamma^2)^2$, for compression-bending stress

$(0 \le \psi \le 1)$ if $\gamma \ge \gamma_1$

m₁ : $\frac{2,1}{1,1 + \psi} \cdot (1 + \gamma_1^2)^2$

t : plate thickness, in mm,

E : Young's modulus, in N/mm^2, to be taken equal to $0,7 \cdot 10^5$ N/mm^2;

a : shorter side of plate, in m;

c : unloaded side of plate, in m;

d : loaded side of plate, in m;

Ψ : ratio between smallest and largest compressive stress in the case of linear variation across the panel $(0 \le \Psi \le 1)$;

γ : $\frac{\mathbf{c}}{\mathbf{d}}$, to be not greater than 1;

γ_1 : $\left(\frac{\left(4 - \frac{1,1 + \psi}{0,7}\right)^{0,5} - 1}{3}\right)^{0,5}$

ε : coefficient equal to:

- 1, for edge **d** stiffened by a flat bar or bulb section, and $\gamma \ge 1$
- 1,1, for edge **d** stiffened by angle- or T-section, and $\gamma \ge 1$
- 1,1, for edge **d** stiffened by flat bar or bulb section, and $\gamma < 1$
- 1,25, for edge **d** stiffened by angle- or T-section, and $\gamma < 1$

b) **Shear stress**

The elastic buckling stress, in N/mm^2, is given by:

$$\tau_E = 0,9 \cdot \mathbf{m}_t \cdot \mathbf{E} \cdot \left(\frac{\mathbf{t}}{1000 \cdot \mathbf{a}}\right)^2$$

where:

$\mathbf{m_t}$: $5,34 + 4 \cdot \left(\frac{\mathbf{a}}{\mathbf{b}}\right)^2$

E, **t** and **a** are given in (a)

b : longer side of plate, in m.

2.4.3 Critical buckling stress

a) **Compressive stress**

The critical buckling stress, in N/mm^2, is given by:

$$\sigma_c = \sigma_E \quad \text{if} \quad \sigma_E \le \frac{\mathbf{R}_{p0,2}}{2}$$

$$\sigma_c = \mathbf{R}_{p0,2} \cdot \left(1 - \frac{\mathbf{R}_{p0,2}}{4 \cdot \sigma_E}\right) \quad \text{if} \quad \sigma_E > \frac{\mathbf{R}_{p0,2}}{2}$$

where:

$\mathbf{R}_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm^2, in delivery condition

σ_E : elastic buckling stress calculated according to [2.4.2], (a) above.

b) **Shear stress**

The critical buckling stress, in N/mm^2, is given by:

$$\tau_c = \tau_E \quad \text{if} \quad \tau_E \le \frac{\tau_F}{2}$$

$$\tau_c = \tau_F \cdot \left(1 - \frac{\tau_F}{4 \cdot \tau_E}\right) \quad \text{if} \quad \tau_E > \frac{\tau_F}{2}$$

where:

τ_F : $\frac{\mathbf{R}_{p0,2}}{3^{0,5}}$

$\mathbf{R}_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm^2, in delivery condition

τ_E : elastic buckling stress calculated according to [2.5.2], (b).

2.4.4 Axially loaded stiffeners

a) **Elastic flexural buckling stress**

The elastic flexural buckling stress, in N/mm^2, is given by:

$$\sigma_E = 69,1 \cdot \left(\frac{\mathbf{r}}{1000 \cdot \mathbf{c}}\right)^2 \cdot \mathbf{m} \cdot 10^4$$

where:

r : $10\left(\frac{\mathbf{I}}{\mathbf{S} + \phi \cdot \mathbf{t} \cdot 10^{-2}}\right)^{0,5}$ gyration radius, in mm,

I : moment of inertia of the stiffener, in cm^4, calculated with a plate flange of width equal to φ

φ : smaller of:
$800 \cdot \mathbf{a}$
$200 \cdot \mathbf{c}$

S : area of the cross-section of the stiffener, in cm^2, excluding attached plating

m : coefficient depending on boundary conditions:

- 1, for a stiffener simply supported at both ends,
- 2, for a stiffener simply supported at one end and fixed at the other end,
- 4, for a stiffener fixed at both ends.

b) **Local elastic buckling stresses**

The local elastic buckling stresses, in N/mm^2, are given by:

- for flat bars:

$$\sigma_E = 55 \cdot \left(\frac{\mathbf{t}_w}{\mathbf{h}_w}\right)^2 \cdot 10^3$$

- built-up stiffeners with symmetrical flange:

$$\sigma_E = 27 \cdot \left(\frac{\mathbf{t}_w}{\mathbf{h}_w}\right)^2 \cdot 10^4 \text{ web}$$

$$\sigma_E = 11 \cdot \left(\frac{\mathbf{t}_f}{\mathbf{b}_f}\right)^2 \cdot 10^4 \text{ flange}$$

where:

$\mathbf{h_w}$: web height, in mm,

$\mathbf{t_w}$: web thickness, in mm,

$\mathbf{b_f}$: flange width, in mm,

$\mathbf{t_f}$: flange thickness, in mm.

c) **Critical buckling stress**

The critical buckling stress, in N/mm², is given by:

$$\sigma_c = \sigma_E \quad \text{if} \quad \sigma_E \le \frac{\eta \cdot \mathbf{R}_{p0,2}}{2}$$

$$\sigma_c = \eta \cdot \mathbf{R}_{p0,2} \cdot \left(1 - \frac{\eta \cdot \mathbf{R}_{p0,2}}{4 \cdot \sigma_E}\right) \quad \text{if} \quad \sigma_E > \frac{\eta \cdot \mathbf{R}_{p0,2}}{2}$$

where:

$\mathbf{R}_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm², in delivery condition

η : joint coefficient for the welded assembly, defined in Sec 2, [1.6]

σ_E : either overall elastic buckling stress or local elastic buckling stress calculated according to (a) and (b) above, whichever is the lesser.

SECTION 4 LONGITUDINAL STRENGTH

1 General

1.1

1.1.1 The structural scantlings prescribed in Chapter 3 are also intended for the purposes of the longitudinal strength of a yacht having length L not exceeding 45 m for monohull or 40 m for catamarans and openings on the strength deck of limited size.

For yachts of greater length and/or openings of size greater than the breadth B of the hull and extending for a considerable part of the length of the yacht, calculation of the longitudinal strength is required.

1.2

1.2.1 To this end, longitudinal strength calculations are to be carried out considering the load and ballast conditions for both departure and arrival.

2 Bending stresses

2.1

2.1.1 In addition to satisfying the minimum requirements stipulated in the individual Chapters of these Rules, the scantlings of members contributing to the longitudinal strength of monohull yachts and catamarans are to achieve a section modulus of the midship section at the bottom and the deck such as to guarantee stresses not exceeding the allowable values.

Therefore:

$$\sigma_f \le f \cdot \sigma_s \quad N/mm^2$$

$$\sigma_p \le f \cdot \sigma_s \quad N/mm^2$$

where:

$$\sigma_f = \frac{M_T}{1000\ W_f} \quad N/mm^2$$

$$\sigma_p = \frac{M_T}{1000\ W_p} \quad N/mm^2$$

W_f, W_p : section modulus, in m^3, at the bottom and the deck, respectively, of the transverse section

M_T : design total vertical bending moment defined in Ch 1, Sec 5.

f : 0,80 for planing yachts

f : 0,72 for displacement yachts

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

2.2

2.2.1 The compressive value of normal stresses is not to exceed the value of the critical stresses for plates and stiffeners calculated in Sec 3, [2.4.3].

2.3

2.3.1 The moment of inertia J of the midship section, in m^4, is to be not less than the value given by the following formulae:

$J = 16 \cdot M_T \cdot 10^{-6}$ for planing yachts

$J = 18 \cdot M_T \cdot 10^{-6}$ for displacement yachts

3 Shear stresses

3.1

3.1.1 *(1/7/2022)*

The shear stresses in every position along the length L are not to exceed the allowable values; in particular.

$$\frac{T_t}{A_t} \cdot 10^{-3} \le \frac{f \cdot \sigma_s}{\sqrt{3}}$$

where:

T_t : total shear stress, in kN, defined in Ch 1, Sec 5

σ_s, f : defined in [2]

A_t : actual shear of the transverse section, in m^2, to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings.

4 Calculation of the section modulus

4.1

4.1.1 In the calculation of the modulus and inertia of the midship section, all the continuous members, plating and longitudinal stiffeners are generally to be included, provided that they extend for at least 0,4 L amidships.

SECTION 5 PLATING

1 Definitions and symbols

1.1

1.1.1

s : spacing of longitudinal or transverse ordinary stiffener, in m;

p : scantling pressure, in kN/m², given in Ch 1, Sec 5;

K : factor defined in Sec 2 of this Chapter.

2 Keel

2.1 Sheet keel

2.1.1 *(1/1/2021)*

The keel plating is to have a width b_{CH}, in mm, throughout the length of the yacht, not less than the value obtained by the following equation:

$$b_{CH} = 4,5 \cdot L + 600$$

and a thickness not less than that of the adjacent bottom plating increased by 2 mm.

2.2 Solid keel

2.2.1

The height and thickness of the keel, throughout the length of the yacht, are to be not less than the values h_{CH} and t_{CH}, in mm, calculated with the following equations:

$$h_{CH} = 1,5 \cdot L + 100$$

$$t_{CH} = (0,35 \cdot L + 6) \cdot K^{0,5}$$

Lesser heights and thicknesses may be accepted provided that the effective area of the section is not less than that of the Rule section.

Lesser heights and thicknesses may also be acceptable if a centre girder is placed in connection with the solid keel.

3 Bottom and bilge

3.1

3.1.1

Bottom plating is the plating up to the chine or to the upper turn of the bilge.

The thickness of the bottom plating and the bilge is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 11 \cdot s \cdot (T \cdot K)^{0,5}$$

where:

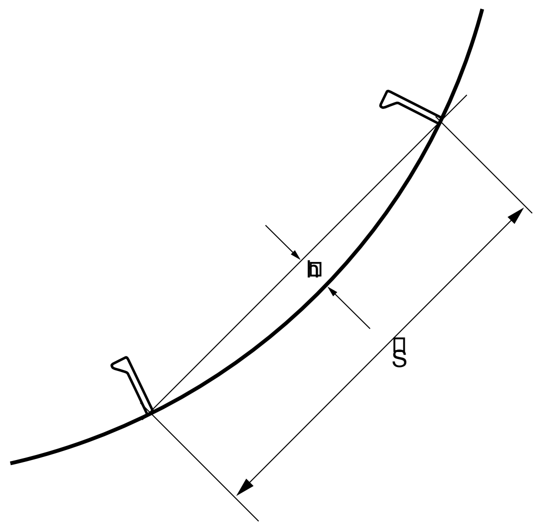
k_1 : 0,15, assuming $p=p_1$

: 0,10, assuming $p=p_2$.

k_a : coefficient as a function of the ratio S/s given in Table 1 below, where S is the greater dimension of the plating, in m.

k_2 : curvature correction factor given by 1-h/s to be taken not less than 0,7, where h is the distance, in mm, measured perpendicularly from the chord s to the highest point of the arc of plating between the two supports (see Figure 1).

Figure 1



The thickness of the plating of the bilge is, in any event, to be taken as not less than the greater of the thicknesses of the bottom and side.

Sheet steel of plating in way of the propeller shaft struts, tunnel thruster attachment and in the vicinity of the water-jet drive duct entrance is to have a thickness, in mm, not less than the value t_e given by:

$$t_e = 1,3 \cdot (0,05 \cdot L + 6) \cdot K^{0,5}$$

and, in any event, equal to the thickness of the bottom increased by 50%.

Table 1

S/s	K_a
1	17,5
1,2	19,6
1,4	20,9
1,6	21,6
1,8	22,1
2,0	22,3
>2	22,4

4 Sheerstrake

4.1

4.1.1 In yachts having L > or = 50 m, a sheerstrake plate of height h, in mm, not less than 0,025 L and thickness not less than the greater of the values of the plating of the side and the stringer plate is to be fitted.

In the case of sidescuttles or windows or other openings arranged on the sheerstrake plate, the thickness is to be increased sufficiently as necessary in order to compensate for such openings.

In way of the ends of the bridge, the thickness of the sheerstrake is to be adequately increased.

5 Side

5.1

5.1.1 The thickness of side plating is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 10 \cdot s \cdot (T \cdot K)^{0,5}$$

where k_1, k_2 and k_a are as defined in 3.1.

5.2

5.2.1 The thickness of the transom is to be no less than that required for the bottom, for the part below the waterline, or for the side, for the part above the waterline.

In the event of water-jet drive systems, the thickness of the transom will be the subject of special consideration.

6 Openings in the shell plating

6.1

6.1.1 Sea intakes and other openings are to be well rounded at the corners and located, as far as possible, outside the bilge strakes and the keel. Arrangements are to be such as to ensure continuity of strength in way of openings.

6.2

6.2.1 Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects. In any event, such openings are to be located well clear of welded connections.

6.3

6.3.1 The internal walls of sea intakes are to have external plating thickness increased by 2 mm, but not less than 6 mm.

7 Local stiffeners

7.1

7.1.1 The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the stem, propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

7.2

7.2.1 Where the aft end is shaped such that the bottom plating aft has a large flat area, Tasneef may require the local plating to be increased and/or reinforced with the fitting of additional stiffeners.

7.3

7.3.1 The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements.

The thickness is to be not less than 1,25 that of the adjacent plating but no greater than that of the keel.

8 Cross Deck bottom plating

8.1

8.1.1 The thickness is to be taken, the stiffener spacing s being equal, no less than that of the side plating.

Where the gap between the bottom and the waterline is reduced so that local wave impact phenomena are anticipated, an increase in thickness and/or additional internal stiffeners may be required.

SECTION 6 SINGLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a single bottom, which may be of either longitudinal or transverse type.

1.2 Longitudinal structure

1.2.1 The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The floors may be supported by girders, which in turn may be supported by transverse bulkheads, or by the sides of the hull.

1.2.2 A centre girder is to be fitted.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.2.3 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

1.2.4 Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

1.3 Transverse structure

1.3.1 The transverse framing consists of ordinary stiffeners arranged transversely (floors) and placed at each frame supported by girders, which in turn are supported by transverse bulkheads or reinforced floors.

1.3.2 A centre girder is to be fitted.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.3.3 In way of the propeller shaft struts, the rudder horn and the ballast keel, additional floors are to be fitted with sufficiently increased scantlings.

1.3.4 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to be fitted as a continuation of the existing girders outside the engine room.

1.3.5 Floors are to be fitted in way of reinforced frames at the sides and reinforced beams on the weather deck. Any intermediate floors are to be adequately connected to the ends.

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m², given in Chapter 1;

K : coefficient defined in Sec 2.

3 Longitudinal type structure

3.1 Bottom longitudinals

3.1.1 The section modulus of longitudinal stringers is to be not less than the value Z, in cm², calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1,6 assuming $p=p_1$

: 0,7 assuming $p=p_2$

S : conventional span of the longitudinal stiffener, in m, equal to the distance between floors.

The bottom longitudinal stringers are preferably to be continual through the transverse members. Where they are to be interrupted in way of a transverse watertight bulkhead, brackets are to be provided at the ends.

3.2 Floors

3.2.1 The section modulus of the floors at the centreline of the span S is to be not less than the value Z_M, in cm³, calculated with the following formula.

$$Z_M = k_1 \cdot b \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [3.1]

b : half the distance, in m, between the two floors adjacent to that concerned

S : conventional floor span equal to the distance, in m, between the two supporting members (sides, girders, keel with a dead rise edge > 12°).

In the case of a keel with a dead rise edge ≤ 12° but > 8° the span S is always to be calculated considering the distance between girders or sides; the modulus ZM may, however, be reduced by 40%.

If a side girder is fitted on each side with a height equal to the local height of the floor, the modulus may be reduced by a further 10%.

3.3 Girders

3.3.1 Centre girder

When the girder forms a support for the floor, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [3.1]

b_{PC} : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b'_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [3.1].

b'_{PC} : half the distance, in m, between the two side girders if present, or equal to B/2in the absence of side girders

S : distance between the floors.

3.3.2 Side girders

When the side girder forms a support for the floor, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in 3.1

b_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder concerned

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b'_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [3.1]

b'_{PL} : half the distance, in m, between the two adjacent girders or between the side and the adjacent girder

S : distance between the floors, in m.

4 Transverse type structures

4.1 Ordinary floors

4.1.1 The section modulus for ordinary floors is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [3.1]

S : conventional span in m, of the floor equal to the distance between the members which support it (girders, sides).

4.2 Centre girder

4.2.1 The section modulus of the centre girder is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 2,32 assuming $p=p_1$

: 1,43 assuming $p=p_2$

b_{PC} : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders

S : conventional span of the centre girder, equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

4.3 Side girders

4.3.1 The section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in[3.1]

b_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder adjacent to that concerned

S : conventional girder span equal to the distance, in m, between the two members which support it (transverse bulkheads, floors).

5 Constructional details

5.1

5.1.1 The centre girder and side girders are to be connected to the stiffeners of the transom by means of suitable fittings.

The face plate of the girders may be gradually reduced to reach the dimensions of that of the transom stiffeners.

SECTION 7 DOUBLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.1.2 *(1/7/2021)*

The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead in the machinery space, or as near thereto as practicable, is requested for yachts of L > or = 50 m.

On yachts of L > 61 m a double bottom is to be fitted outside the machinery space extending, as far as possible, forward to the collision bulkhead and aft to the after peak bulkhead.

On yachts of L > 76 m the double bottom is to extend, as far as possible, throughout the length of the yacht.

The double bottom is to extend transversely to the side so as to protect the bottom in the bilge area, as far as possible.

The double bottom may be avoided if the vessel satisfies what required in Ch.II-1 part B-2 Regulation 9 SOLAS'74 as amended. For yachts of less than 80 m in load line length, the alternative arrangements to provide a level of safety may be limited to compartments not having a double bottom or having a double bottom arrangement not in line with what required below. In these cases compliance with the bottom damage standard may be carried out assuming that the damage will only occur between the transverse watertight bulkheads in compartments not having a double bottom or having a double bottom not in line with what below.

1.1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.

The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of Tasneef

1.1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2 Minimum height

2.1

2.1.1 The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value h_{DF}, in mm, obtained from the following formula:

$$h_{df} = 28B + 32(T + 10)$$

The height of the double bottom is, in any event, to be not less than 700 mm. For yachts less than 50 m in length, Tasneef may accept reduced height.

3 Inner bottom plating

3.1

3.1.1 *(1/1/2019)*

The thickness of the inner bottom plating is to be not less than the value t_1, in mm, calculated with the following formula:

$$t_1 = 1,4(0,04L + 5s + 1)k$$

where:

s : spacing of the ordinary stiffeners, in m.

For yachts of length L less than 50 m, the thickness is to be maintained throughout the length of the hull.

For yachts of length L > or = 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquids, the thickness of the top is also to comply with the provisions of Sec 10.

4 Centre girder

4.1

4.1.1

A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness of the centre girder is to be not less than the following value t_{pc}, in mm:

$$t_{pc} = 1,4(0,008\,h_{df} + 2)k$$

5 Side girders

5.1

5.1.1 Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

5.2

5.2.1 Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height no less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6 Floors

6.1

6.1.1 *(1/1/2023)*

The thickness of floors t_m, in mm, is to be not less than the following value:

$$t_m = (0,008\,h_{df} + 0,5) \cdot k^{0,5}$$

Watertight floors are also to have thickness not less than that required in Sec. 10 for tank bulkheads.

6.2

6.2.1 When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be arranged in longitudinally framed double bottoms in the following locations.

- under buklheads and pillars
- outside the machinery space at an interval no greater than 2 m
- in the machinery space under the bedplates of main engines
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7 Bracket floors

7.1

7.1.1 *(1/1/2019)*

At each frame between solid floors, bracket floors consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating are to be arranged and attached to the centre girder and the margin plate by means of flanged brackets with a width of flange not less than 1/10 of the double bottom depth.

The frame section modulus Z_c, in cm^3, is to be not less than:

$$Z_c = k_1 \cdot s \cdot S^2 \cdot p \cdot K$$

where:

k_1	:	1,6 assuming $p=p_1$
	:	0,68 assuming $p=p_2$
S	:	frame span, in m, equal to the distance between the mid-spans of the brackets connecting the frame/reverse frame.

The reverse frame section modulus is to be not less than 85% of the frame section modulus.

Where tanks intended for liquids are arranged above the double bottom, the frame and reverse frame section moduli are to be no less than those required for tank stiffeners as stated in Sec 10.

8 Bottom and inner bottom longitudinals

8.1

8.1.1 *(1/1/2019)*

The section modulus of bottom stiffeners is to be no less than that required for single bottom longitudinals stipulated in Sec 6.

The section modulus of inner bottom stiffeners is to be no less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquids are arranged above the double bottom, the section modulus of longitudinals is to be no less than that required for tank stiffeners as stated in Sec 10.

9 Bilge keel

9.1 Arrangement, scantlings and connections

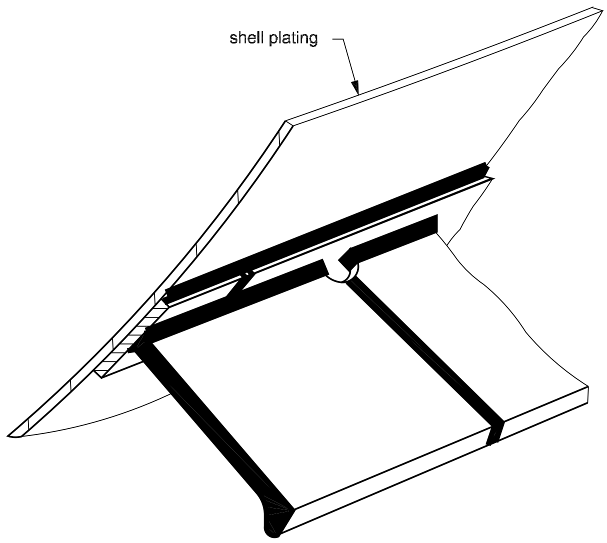
9.1.1 Arrangement

Where installed, bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The ends of the bilge keel are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

The arrangement shown in Fig 1 is recommended.

Figure 1 : Bilge keel arrangement



The arragement shown in Fig 2 may also be accepted.

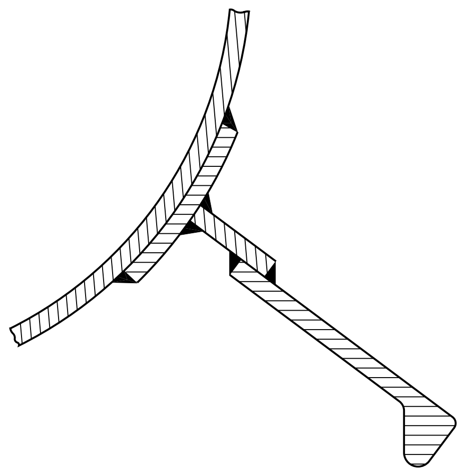
9.1.2 Materials

The bilge keel and the intermediate flat are to be made of the same alloy as that of the bilge strake.

9.1.3 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm.

Figure 2 : Bilge keel arrangement



9.2 Bilge keel connection

9.2.1 The intermediate flat, through which the bilge keel is connected to the shell, 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.

SECTION 8 SIDE STRUCTURES

1 General

1.1

1.1.1 This Section lays down the criteria for the scantlings of the reinforcement structures of the side, which may be of longitudinal or transverse type.

The longitudinal type structure consists of ordinary stiffeners placed longitudinally supported by reinforced frames, generally spaced not more than 2 m apart, or by transverse bulkheads.

The transverse type structure is made up of ordinary reinforcements placed vertically (frames), which may be supported by reinforced stringers, by decks, by flats or by the bottom structures.

Reinforced frames are to be provided in way of the mast and the ballast keel, in sailing yachts, in the machinery space and in general in way of large openings on the weather deck.

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m², defined in Part B, Ch 1, Sec 5 ;

K : factor defined in Sec 2.

3 Ordinary stiffeners

3.1 Transverse frames

3.1.1 The section modulus of the frames is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1,27 assuming $p=p_1$

: 1 assuming $p=p_2$

S : conventional frame span, in m, equal to the distance between the supporting members.

The ordinary frames are to be well connected to the elements which support them, in general made up of a beam and a floor.

3.2 Longitudinal stiffeners

3.2.1 The section modulus of the side longitudinals is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1,6 assuming $p=p_1$

: 0,7 assuming $p=p_2$

S : conventional span of the longitudinal, in m, equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads.

4 Reinforced beams

4.1 Reinforced frames

4.1.1 The section modulus of the reinforced frames is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K_{CR} \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : 1 assuming $p=p_1$

: 0,7 assuming $p=p_2$

K_{CR} : 1,92 for reinforced frames which support longitudinal ordinary stiffeners, or reinforced stringers;

: 0,86 for reinforced frames which do not support ordinary stiffeners;

s : spacing between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned;

S : conventional span, in m, equal to the distance between the members which support the reinforced frame.

4.2 Reinforced stringers

4.2.1 The section modulus of the reinforced stringers is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K'_{CR} \cdot s \cdot S^2 \cdot K \cdot p$$

where:

k_1 : defined in [4.1]

K_{CR} : 1,92 for reinforced stringers which support vertical ordinary stiffeners (frames);

: 0,86 for reinforced stringers which do not support vertical ordinary stiffeners;

s : spacing between the reinforced stringers or 0,5 D in the absence of other reinforced stringers or decks;

S : conventional span, in m, equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames.

5 Frame connections

5.1 General

5.1.1 End connections of frames are to be bracketed.

5.1.2 'Tweendeck frames are to be bracketed at the top and welded or bracketed at the bottom to the deck.

In the case of bulb profiles, a bracket may be required to be fitted at the bottom.

5.1.3 Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

6 Scantling of brackets of frame connections

6.1

6.1.1 As a general rule, for yachts of length greater than 50 m, the following scantlings may be adopted:

6.1.2 Upper brackets of frames

The arm length of upper brackets connecting frames to deck beams is to be not less than the value obtained, in mm, from the following formula:

$$d = \varphi\sqrt{\frac{w + 30}{t}}$$

where:

φ : coefficient equal to:

- for unflanged brackets:

  $\varphi = 48$

- for flanged brackets:

  $\varphi = 43,5$

w : required net section modulus of the stiffener, in cm³, given in [6.1.3] and [6.1.4] and depending on the type of connection,

t : bracket net thickness, in mm.

6.1.3 For connections of perpendicular stiffeners located in the same plane (see Fig 1) or connections of stiffeners located in perpendicular planes (see Fig 2), the required section modulus is to be taken equal to:

$w = w_2$ if $w_2 \le w_1$

$w = w_1$ if $w_2 > w_1$

where w_1 and w_2 are the required net section moduli of stiffeners, as shown in Fig 1 and Fig 2.

6.1.4 For connections of frames to deck beams (see Fig 3), the required section modulus is to be taken equal to:

- for bracket "A":

  $w_A = w_1$ if $w_2 \le w_1$

  $w_A = w_2$ if $w_2 > w_1$

- for bracket "B":

  $w_B = w'_1$ need not be greater than w_1

where w_1, w'_1 and w_2 are the required net section moduli of stiffeners, as shown in Fig 3.

Figure 1 : Connections of perpendicular stiffeners in the same plane

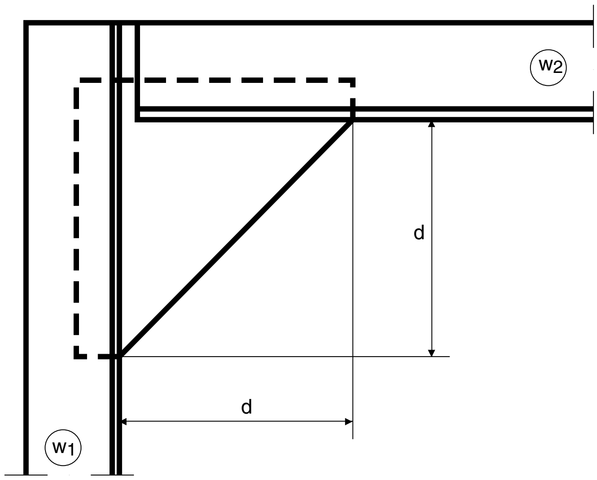


Figure 2 : Connections of stiffeners located in perpendicular planes

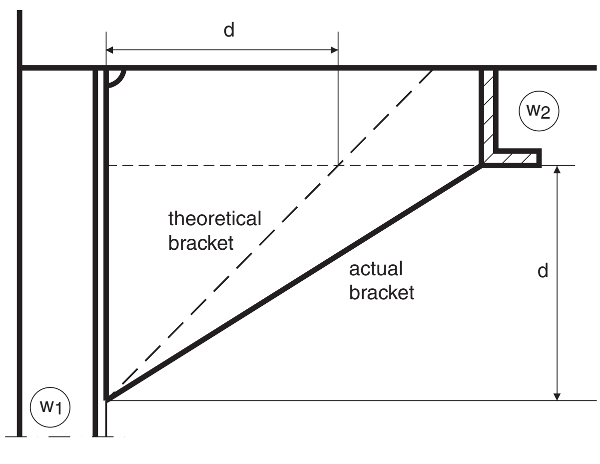


Figure 3 : Connections of frames to deck beams

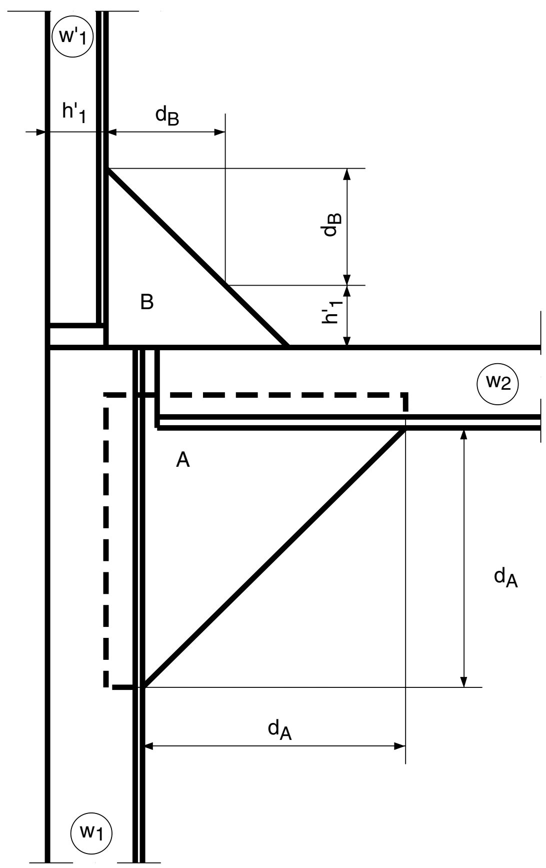
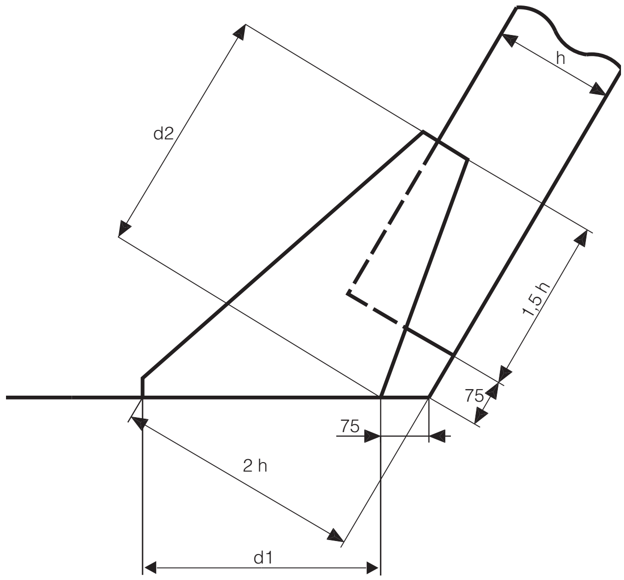


Figure 4 : Lower brackets of main frames



6.2 Lower brackets of frames

6.2.1 In general, frames are to be bracketed to the inner bottom or to the face plate of floors as shown in Fig 4.

6.2.2 The arm lengths d_1 and d_2 of lower brackets of frames are to be not less than the value obtained, in mm, from the following formula:

$$d = \varphi \sqrt{\frac{w + 30}{t}}$$

where:

- φ : coefficient equal to:
  - for unflanged brackets: $\varphi = 50$
  - for flanged brackets: $\varphi = 45$
- w : required net section modulus of the frame, in cm³,
- t : Bracket net thickness, in mm.

6.2.3 Where the bracket thickness, in mm, is less than 15Lb , where Lb is the length, in m, of the bracket free edge, the free edge of the bracket is to be flanged or stiffened by a welded face plate.

The sectional area, in cm², of the flange or the face plate is to be not less than 10Lb.

SECTION 9 DECKS

1 General

1.1

1.1.1 This Section lays down the criteria and formulae for the scantlings of decks, plating and reinforcing or supporting structures.

The reinforcing and supporting structures of decks consist of ordinary reinforcements, beams or longitudinal stringers, laid transversely or longitudinally, supported by lines of shoring made up of systems of girders and/or reinforced beams, which in turn are supported by pillars or by transverse or longitudinal bulkheads.

Reinforced beams together with reinforced frames are to be placed in way of the masts in sailing yachts.

In sailing yachts with the mast resting on the deck or on the deckhouse, a pillar or bulkhead is to be arranged in way of the mast base.

2 Definitions and symbols

2.1

2.1.1

pdc : calculation deck, meaning the first deck above the full load waterline, extending for at least 0,6 L and constituting an efficient support for the structural elements of the side; in theory, it is to extend for the whole length of the yacht;

s : spacing of transverse or longitudinal ordinary stiffeners, in m;

h : scantling height, in m, the value of which is given in Part B, Ch 1, Sec 5;

K : factor defined in Sec 2.

3 Deck plating

3.1 Weather deck

3.1.1 The thickness of the weather deck plating, considering that said deck is also a strength deck, is to be not less than the value t, in mm, calculated with the following formula:

$$t = 2,5 \cdot s \cdot (L \cdot K)^{0,5}$$

In yachts having L > or = 50 m a stringer plate is to be fitted with width b, in m, not less than 0,025 L and thickness t, in mm, not less than the value given by the formula:

$$t = 3,1 \cdot s \cdot (L \cdot K)^{0,5}$$

The stringer plate of increased thickness may be waived if the thickness adopted for the deck is greater than Rule thickness.

3.2 Lower decks

3.2.1 The thickness of decks below the weather deck intended for accommodation spaces is to be not less than the value calculated with the formula:

$$t = 1,5 \cdot s \cdot (L \cdot K)^{0,5}$$

Where the deck is a tank top, the thickness of the deck is, in any event, to be not less than the value calculated with the formulae given in Sec 10 for tank bulkhead plating.

4 Stiffening and support structures for decks

4.1 Ordinary stiffeners

4.1.1 The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value Z, in cm^3, calculated with the following equation:

$$Z = 14 \cdot C_1 \cdot s \cdot S^2 \cdot K \cdot h$$

where:

C_1 : 1,44 for weather deck longitudinals
: 0,63 for lower deck longitudinals
: 0,56 for beams.

4.2 Reinforced beams

4.2.1 The section modulus for girders and for ordinary reinforced beams is to be not less than the value Z, in cm^3, calculated with the following equation:

$$Z = 9 \cdot b \cdot S^2 \cdot K \cdot h$$

where:

b : average width of the strip of deck resting on the beam, in m. In the calculation of b, any openings are to be considered as non-existent

S : conventional span of the reinforced beam, in m, equal to the distance between the two supporting members (pillars, other reinforced beams, bulkheads).

4.3 Pillars

4.3.1 *(1/1/2019)*

Pillars are, in general, to be made of tubes. In tanks intended for liquids, open section pillars are to be fitted.

The section area of pillars is to be not less than the value A, in cm^2, given by the formula:

$$A = \frac{1,6Q}{12,5 - 0,045\lambda}$$

where:

Q : load resting on the pillar, in kN, calculated with the following formula:

$$Q = 6,87 \cdot A \cdot h$$

where:

A : area of the part of the deck resting on the pillar, in m^2.

h : scantling height, defined in [2.1.1].

λ : the ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

4.3.2 Pillar connections *(1/1/2016)*

Heads and heels of pillars are to be attached to the surrounding structure by means of brackets and insert plates so that the loads are well distributed.

Insert plates may be replaced by doubling plates, except in the case of pillars which may also work under tension such as those in tanks.

As an alternative, brackets or insert plates may be avoided provided that the local verification of compressive stress shows acceptable results.

Pillars are to be attached at their heads and heels by continuous welding.

Pillars are to be connected to the inner bottom at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

SECTION 10 BULKHEADS

1 General

1.1

1.1.1 *(1/1/2016)*

The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Chapter 1.

2 Symbols

2.1

2.1.1

s : spacing between the stiffeners, in m

S : conventional span, equal to the distance, in m, between the members that support the stiffener concerned

h_B, h_T : as defined in Pt B, Ch 1, Sec 5

K : as defined in Ch 2, Sec 2.

3 Plating

3.1

3.1.1 The watertight bulkhead plating is to have a thickness not less than the value t_S, in mm, calculated with the following formula:

$$t_S = k_1 \cdot s \cdot (h \cdot K)^{0,5}$$

The coefficient k_1 and the scantling height h have the values indicated in Tab 1.

Table 1

Bulkhead	k_1	h (m)
Collision bulkhead	5,6	h_B
Watertight bulkhead	4,9	h_B
Deep tank bulkhead	5,5	h_T

4 Stiffeners

4.1 Ordinary stiffeners

4.1.1 The section modulus of ordinary stiffeners is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = 14 \cdot s \cdot S^2 \cdot h \cdot c \cdot K$$

The values of the coefficient c and of the scantling height h are those indicated in Tab 2.

4.2 Reinforced beams

4.2.1 The horizontal webs of bulkheads with vertical ordinary stiffeners and reinforced stiffeners in the bulkheads with horizontal ordinary stiffeners are to have a section modulus not less than the value Z, in cm ³, calculated with the following formula:

$$Z = C_1 \cdot b \cdot S^2 \cdot h \cdot K$$

where:

C_1 : 11,4 for watertight bulkheads

: 19 for deep tank bulkheads

b : width, in m, of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener

h : scantling height indicated in Tab 2.

Table 2

Bulkhead	h (m)	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Deep tank bulkhead	h_T	1

5 General arrangement

5.1

5.1.1 The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

5.2

5.2.1 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

6 Non-tight bulkheads

6.1 Non-tight bulkheads not acting as pillars

6.1.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

6.2 Non-tight bulkheads acting as pillars

6.2.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- two frame spacings, when the frame spacing does not exceed 0,75 m,
- one frame spacing, when the frame spacing is greater than 0,75 m.

SECTION 11 SUPERSTRUCTURES

1 General

1.1

1.1.1 First tier superstructures or deckhouses are intended as those situated on the uppermost exposed continuous deck of the yacht, second tier superstructures or deckhouses are those above, and so on.

Where the distance from the hypothetical freeboard deck to the full load waterline exceeds the freeboard that can hypothetically be assigned to the yacht, the reference deck for the determination of the superstructure tier may be the deck below the one specified above, see Ch 1, Sec 1, [4.3.5].

When there is no access from inside superstructures and deckhouses to 'tweendecks below, reduced scantlings with respect to those stipulated in this Section may be accepted at the discretion of Tasneef

2 Boundary bulkhead plating

2.1

2.1.1

The thickness of the boundary bulkheads is to be not less than the value t, in mm, calculated with the following formula:

$$t = 8 \cdot s \cdot (K \cdot h)^{0,5}$$

s : spacing between the stiffeners, in m

h : conventional scantling height, in m, the value of which is to be taken not less than that indicated in Table 1

K : factor defined in Sec 2.

In any event, the thickness t is to be not less than the values shown in Sec 1, Tab 2.

Table 1

Type of bulkhead	h (m)
1st tier front	1,5
2nd tier front	1,0
Other bulkheads wherever situated	1,0

3 Stiffeners

3.1

3.1.1 The stiffeners of the boundary bulkheads are to have a section modulus not less than the value Z, in cm³, calculated with the following formula:

$$Z = 6,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where:

h : conventional scantling height, in m, defined in [2.1.1]

K : factor defined in Sec 2

s : spacing of the stiffeners, in m

S : span of the stiffeners, equal to the distance, in m, between the members supporting the stiffener concerned.

4 Superstructure decks

4.1 Plating

4.1.1

The superstructure deck plating is to be not less than the value t, in mm, calculated with the following formula:

$$t = 10 \cdot s \cdot (K \cdot h)^{0,5}$$

where:

s : spacing of the stiffeners, in m

K : factor defined in Sec 2

h : conventional scantling height, in m, defined in Ch 1, Sec 5, [5.5].

In any event, the thickness t is to be not less than the values shown in Sec 1, Tab 2.

4.2 Stiffeners

4.2.1

The section modulus Z, in cm³, of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated with the following formula:

$$Z = 6,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where:

s : spacing of the stiffeners, in m

S : conventional span of the stiffener, equal to the distance, in m, between the supporting members

K : factor defined in Sec 2

h : conventional scantling height, in m, defined in Ch 1, Sec 5, [5.5].

Reinforced beams (beams, stringers) and ordinary pillars are to have scantlings as stated in Sec 9.

Part B
Hull and Stability

Chapter 4
REINFORCED PLASTIC HULLS

SECTION 1 GENERAL REQUIREMENTS

1 Field of application

1.1

1.1.1 Chapter 4 of Section B applies to monohull yachts with hulls made of composite materials and a length L not exceeding 60 m, with motor or sail power with or without auxiliary engines.

Multi-hulls or hulls with a greater length will be considered case-by-case.

In the examination of constructional plans, Tasneef may take into consideration material distribution and structural scantlings other than those that would be obtained by applying these regulations, provided that structures with longitudinal, transverse and local strength not less than that of the corresponding Rule structure are obtained or provided that such material distribution and structural scantlings prove adequate, in the opinion of Tasneef on the basis of direct test calculations of the structural strength (see Pt B, Ch 1, Sec 1, [3.1]).

2 Definitions and symbols

2.1 Premise

2.1.1 The definitions and symbols in this Article are valid for all the Sections of this Chapter.

The definitions of symbols having general validity are not normally repeated in the various Sections, whereas the meanings of those symbols which have specific validity are specified in the relevant Sections.

2.2 Symbols

2.2.1

γ_r : density of the resin; standard value 1,2 g/cm^3;

γ_v : density of the fibres; standard value for glass fibres 2,56 g/cm^3;

p : mass per area of the reinforcement of a single layer, in g/m^2;

q : total mass per area of a single layer of the laminate, in g/m^2;

g_c : p/q = content of reinforcement in the layer; for laminates in glass fibre the most frequent maximum values of gc are the following, taking into account that reinforcements are to be "wet" by the resin matrix and compacted therein: 0,34 for reinforcements in mat or cut filaments, 0,5 for reinforcements in woven roving or cloth;

P : total mass per area of reinforcements in the laminate, in g/m^2;

Q : total mass per area of the laminate, in gm^2, excluding the surface coating of resin;

G_c : P/Q = content of reinforcement in the laminate; for laminates with glass fibre reinforcements the value of G_C is to be not less than 0,30;

t_i : thickness of a single layer of the laminate, in mm. In the case of glass reinforcements such thickness is given by:

$$t_i = 0,33p\left(\frac{2,56}{g_c} - 1,36\right)$$

p being expressed in kg/m^2;

t_F : Σt_i = total thickness of the laminate.

2.3 Definitions

2.3.1

Reinforced plastic : a composite material consisting mainly of two components, a matrix of thermosetting resin and of fibre reinforcements, produced as a laminate through moulding;

Reinforcements : reinforcements are made up of an inert resistant material matrix of thermosetting resin and of fibre reinforcements, encapsulated in the matrix (resin) to increase its resistance and rigidity. The reinforcements usually consist of glass fibres or other materials, such as aramid or carbon type fibres;

Single-skin laminate : reinforced plastic material with, in general, the shape of a flat or curved plate, or moulded.

Sandwich laminate : material composed of two single-skin laminates, structurally connected by the interposition of a core of light material.

3 Plans, calculations and other information to be submitted

3.1

3.1.1

Plans with the scantlings, the layout and the major structures of the hull are to be submitted to Tasneef for examination sufficiently in advance of commencement of the laminating of the hull.

The plans are to indicate the scantlings and the minimum mechanical properties of the laminates as well as the percentage in mass of the reinforcement in the laminate.

In general, the following plans are to be sent for examination in triplicate.

- the midship section and the transverse sections with the main dimensions of the construction shown and, for constructions with an engine, the design speed and the design acceleration a_{CG};
- longitudinal & transverse section and relevant typical connection details;
- deck plan;
- construction of the bottom, floors, girders;
- double bottom;
- lamination schedule;
- watertight and subdivision bulkheads;
- superstructures;
- engine and auxiliary foundations.
- structure of stern/side door and relevant closing appliances;
- support structure for crane with design loads;
- for sailing yachts ballast keel plating inclusive of the lamination schedule and keel connection details.

The above-mentioned plans are also to contain the associated lamination details, the percentage in mass of the reinforcement, the type of resin, the core material characteristics, the sandwich construction process and the type of structural adhesive used (if any). In the case of reinforcements other than glass, the minimum mechanical properties of the laminate are to be indicated.

A list of all materials used in the construction including the commercial name and the relevant characteristics of each component such as gel coat, resin, fibre reinforcement, core material, fire retardant additives or resins, adhesive, core bonding materials, details of the process of sandwich construction and details of the materials used for granting reserve of buoyancy (and method of installation) is to be sent with the initial submission of the plans and a copy of this list is to be provided to the attending Surveyor.
The list above is for guidance purposes only; in particular, the same plan may be relative to one or more of the subjects indicated.

Furthermore, for documentation purposes, copies of the following plans are to be submitted:

- general arrangement;
- capacity plan;
- lines plan;

If the **INWATERSURVEY** notation is to be assigned, the following plans and information are to be submitted:

- Details showing how rudder pintle and bush clearances are to be measured and how the security of the pintles in their sockets is to be verified with the craft afloat.
- Details showing how stern bush clearances are to be measured with the craft afloat.
- Name and characteristics of high resistant paint, for information only.

3.2

3.2.1 If a Builder for the construction of a new vessel of a standard design wants to use drawings already approved for a vessel similar in design and construction and classed with the same class notation and the same navigation, the drawings may not be sent for approval , but the Request of Survey for the vessel shall be submitted enclosed to a list of the drawings the Builder wants to refer to and copy of the approved drawings are to be sent to Tasneef

It's the Builder responsibility to submit for approval any modification to the approved plans prior to the commencement of any work.

Plan approval of standard design vessels is only valid so long as no applicable Rule changes take place. When the Rules are amended, the plans are to be submitted for new approval.

4 Direct calculations

4.1

4.1.1 As an alternative to those based on the formulae in this Chapter, scantlings may be obtained by direct calculations carried out in accordance with the provisions of Ch 1, Sec 1 of these Rules.

Chapter 1 provides schematisations, boundary conditions and loads to be used for direct calculations.

The scantlings of the various structures are to be such as to guarantee that stress levels do not exceed the allowable values stipulated in Tab 1. The values in column 1 are to be used for the load condition in still water, while those in column 2 apply to dynamic loads.

Table 1

Member	Allowable stresses	
	1	2
Keel, bottom plating	0,4 σ	0, 8 σ
Side plating	0,4 σ	0,8 σ
Deck plating	0,4 σ	0,8 σ
Bottom longitudinals	0,6 σ_t	0,9 σ_t
Side longitudinals	0,5 σ_t	0,9 σ_t
Deck longitudinals	0,5 σ_t	0, 9 σ_t
Floors and girders	0,4 σ_t	0,8 σ_t
Frames and reinforced side stringers	0,4 σ_t	0,8 σ_t
Reinforced beams and deck girders	0,4 σ_t	0,8 σ_t

Note 1:
σ(N/mm^2): the ultimate bending strength for single-skin laminates; the lesser of the ultimate tensile strength and the ultimate compressive strength for sandwich type laminates. In this case the shear stress in the core is to be no greater than 0,5 R_t where R_t is the ultimate shear strength of the core material;
σ_t(N/mm^2): the ultimate tensile strength of the laminate.

5 General rules for design

5.1

5.1.1 The hull scantlings required in this Chapter are in general to be maintained throughout the length of the hull.

For yachts with length L greater than 30 m, reduced scantlings may be adopted for the fore and aft zones.

In such case the variations between the scantlings adopted for the central part of the hull and those adopted for the ends are to be gradual.

In the design, care is to be taken in order to avoid structural discontinuities in particular in way of the ends of superstructures and of the openings on the deck or side of the yacht.

For high speed hulls, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

Such spacing is to be suitably reduced in the areas forward of amidships subject to the forces caused by slamming.

5.2 Minimum thicknesses

5.2.1 *(1/1/2019)*

The thicknesses of the laminates of the various main members of the hull calculated using the formulae in this Chapter are to be not less than the values, in mm, in Table 2.

Table 2

Member	Single-skin laminate	Sandwich laminate **(1)**
Keel, bottom plating	5,5	4,5/3,5
Side plating	5	4/3
Inner bottom plating	5	4,5/3,5
Strength deck plating	4	3/2
Lower deck plating	3	2/2
Subdivision bulkhead plating	2,5	2/2
Tank bulkhead plating	4,5	4/3
Side superstructures	2,5	2/2
Front superstructures	3	2,5/2,5
Girders-floors	-	2/2
Any stiffeners	-	2 **(2)**

(1) The first value refers to the external skin, the second refers to the internal skin

(2) Intended to refer to the thickness of the layers encapsulating the core

The minimum values shown are required for laminates consisting of polyester resins and glass fibre reinforcements.

For laminates made using reinforcements of fibres other than glass (carbon and/or aramid, glass and aramid), lower minimum thicknesses than those given in Table 2 may be accepted on the basis of the principle of equivalence.

In such case, however, the thickness adopted is to be adequate in terms of buckling strength.

This thickness is, in any case, to be submitted to Tasneef for approval.

6 Construction

6.1 Principles of building

6.1.1 Definitions

The stiffeners with the lowest spacing are defined in this Chapter as ordinary stiffeners.

Depending on the direction of ordinary stiffeners, a structure is made of one of the following systems:

- longitudinal framing,
- transverse framing.

Ordinary stiffeners are supported by structural members, defined as primary stiffeners, such as:

- keelsons or floors,
- stringers or web frames,
- reinforced beams or deck stringers.

6.1.2 General provisions

The purpose of this item [6.1.2] is to give some recommended structural details. However, they do not constitute a requirement; different details may be proposed by builders and agreed upon by Tasneef provided that builders give justifications, to be defined in each special case.

Arrangements are to be made to ensure the continuity of longitudinal strength:

- in areas with change of stiffener framing,
- in areas with large change of strength,
- at connections of ordinary and primary stiffeners.

Arrangements are to be made to ensure the continuity of transverse strength in way of connections between hulls of catamarans and axial structure.

Structure discontinuities and rigid points are to be avoided; when the strength of a structural element is reduced by the presence of an attachment or an opening, proper compensation is to be provided.

Openings are to be avoided in highly stressed areas, in particular at ends of primary stiffeners, and for webs of primary stiffeners in way of pillars.

If necessary, the shape of openings is to be designed to reduce stress concentration.

In any case, the corners of openings are to be rounded.

Connections of the various parts of a hull, as well as attachment of reinforcing parts or hull accessories, can be made by moulding on the spot, by bonding separately moulded, or by mechanical connections.

Bulkheads and other important reinforcing elements are to be connected to the adjacent structure by corner joints (see Fig 1) on both sides, or equivalent joints.

The mass per m^2 of the corner joints is to be at least 50% of the mass of the lighter of the two elements to be fitted, and at least 900 g/m^2 of mat or its equivalent.

The width of the layers of the corner joints is to be worked out according to the principle given in Fig 1.

The connection of the various parts of the hull, as well as connection of reinforcing members to the hull, can be made by adhesives, subject to special examination by Tasneef

6.1.3 Plates

The edges of the reinforcements of one layer are not to be juxtaposed but to overlap by at least 50 mm; these overlaps are to be offset between various successive layers.

Prefabricated laminates are fitted by overlapping the layers, preferably with chamfering of edges to be connected.

The thickness at the joint is to be at least 15% higher than the usual thickness.

Changes of thickness for a single-skin laminate are to be made as gradually as possible and over a width which is, in general, not to be less than thirty times the difference in thickness, as shown in Fig 2.

The connection between a single-skin laminate and a sandwich laminate is to be carried out as gradually as possible over a width which is, in general, not to be less than three times the thickness of the sandwich core, as shown in Fig 3.

a) **Deck-side shell connection**

   This connection is to be designed both for the bending stress shown in Fig 4, caused by vertical loads on deck and horizontal loads of sea water, and for the shear stress caused by the longitudinal bending.

   In general, the connection is to avoid possible loosening due to local bending, and ensure longitudinal continuity. Its thickness is to be sufficient to keep shear stresses acceptable.

   Fig 5 to Fig 8 give examples of deck-side shell connections.

b) **Bulkhead-hull connection**

   In some cases, this connection is needed to distribute the local load due to the bulkhead over a sufficient length of hull. Fig 9 and Fig 10 give possible solutions. The scantlings of bonding angles are determined according to the loads acting upon the connections.

   The builder is to pay special attention to connections between bulkheads of integrated tanks and structural members.

c) **Passages through hull**

   Passages of metal elements through the hull, especially at the level of the rudder stock, shaft brackets, shaft line, etc., are to be strongly built, in particular when subjected to alternating loads.

   Passages through the hull are to be reinforced by means of a plate and counterplate connected to each other.

d) **Passages through watertight bulkheads**

   The continuous omega or rectangle stiffeners at a passage through a watertight bulkhead are to be watertight in way of the bulkhead.

e) **Openings in deck**

   The corners of deck openings are to be rounded in order to reduce local stress concentrations as much as possible, and the thickness of the deck is to be increased to maintain the stress at a level similar to the mean stress on the deck.

   The reinforcement is to be made from a material identical to that of the deck.

6.1.4 Stiffeners

Primary stiffeners are to ensure structural continuity.

Abrupt changes in web height, flange breadth and cross-sectional area of web and flange are to be avoided.

In general, at the intersection of two stiffeners of unequal sizes (longitudinals with web frames, floors, beams or frames with stringers, girders or keelsons), the smallest stiffeners (longitudinals or frames) are to be continuous, and the connection between the elements is to be made by corner joints according to the principles defined in [6.1.2].

Fig 11 to Fig 13 give various examples of stiffeners.

Connections between stiffeners are to ensure good structural continuity. In particular, the connection between deck beam and frame is to be ensured by means of a flanged bracket. However, some types of connections without bracket may be accepted, provided that loads are light enough. In this case, stiffeners are to be considered as supported at their ends.

6.1.5 Pillars

Connections between metal pillars subject to tensile loads and the laminate structure are to be designed to avoid tearing between laminate and pillars.

Connections between metal pillars subject to compressive loads and the laminate structure are to be carried out by mean of intermediate metal plates. The welding of the pillar to the metal plate is to be carried out before fitting of the plate on board the vessel.

Fig 13 gives the principle for connection between the structure and pillars subject to compressive loads.

6.1.6 Engine seating

The engine seating is to be fitted on special girders suitably positioned between floors, which locally ensure sufficient strength in relation to pressure and weight loads.

Fig 15 gives an example of possible seating.

Figure 1

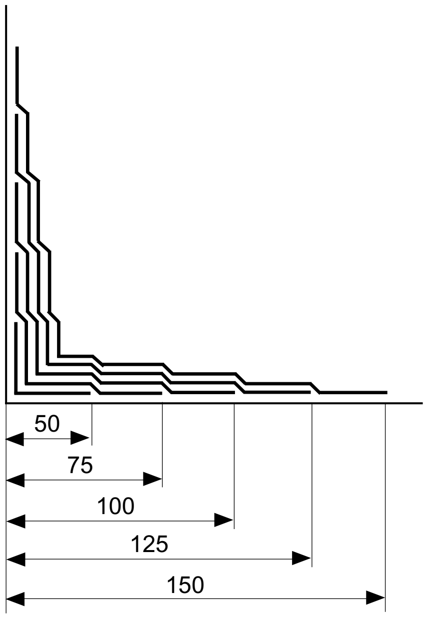


Figure 2

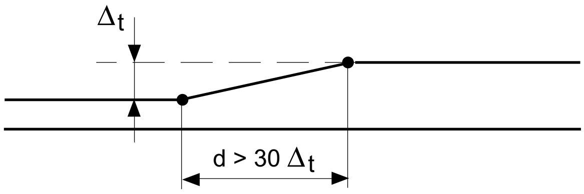


Figure 3

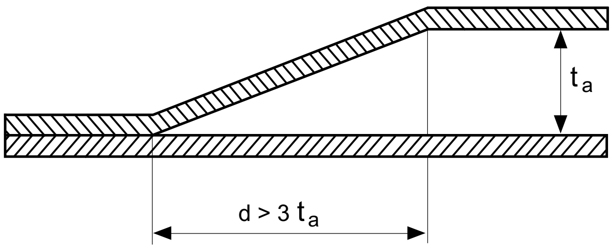


Figure 4

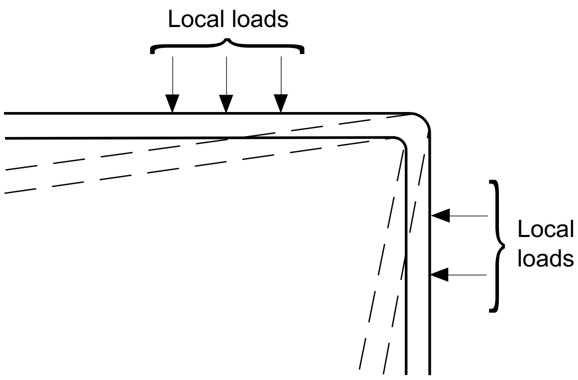


Figure 5

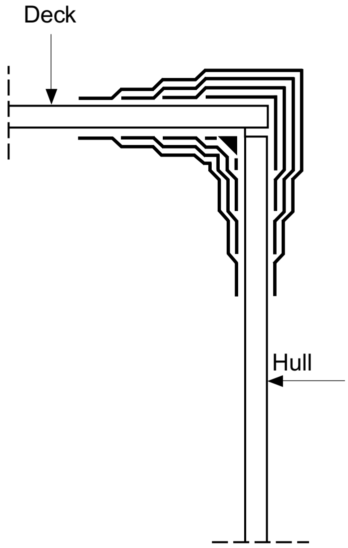


Figure 6

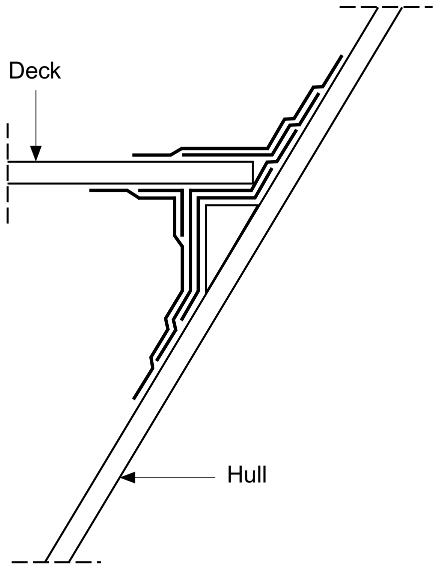


Figure 7

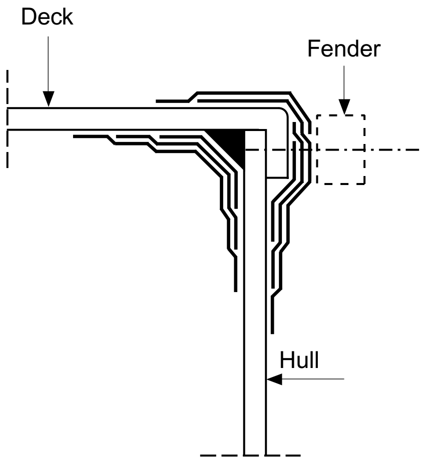


Figure 8

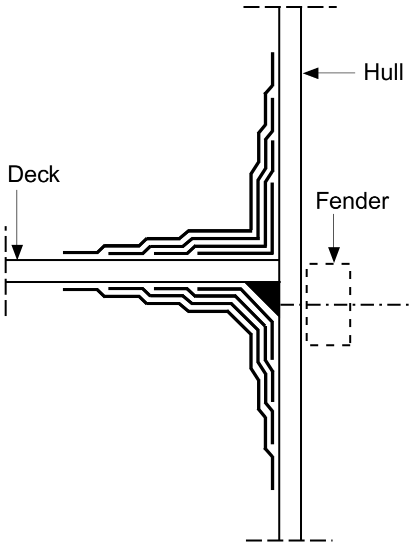


Figure 9

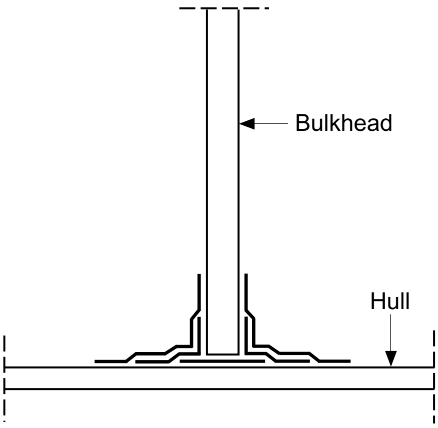


Figure 10

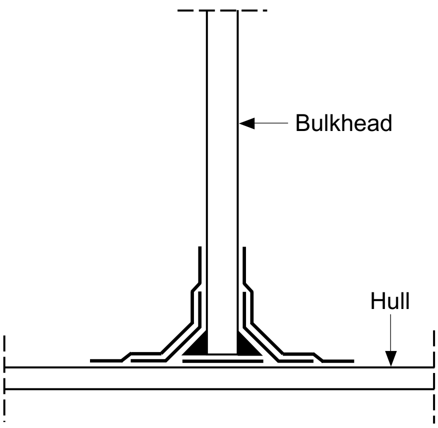


Figure 11

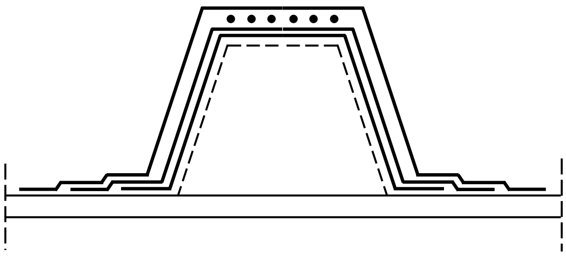


Figure 12

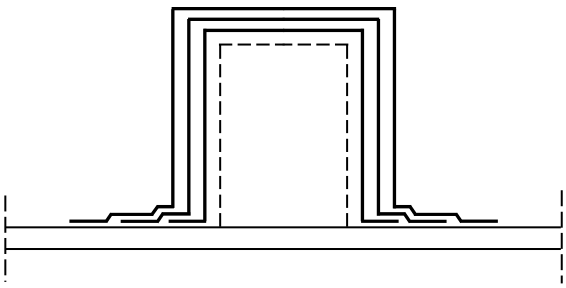


Figure 13

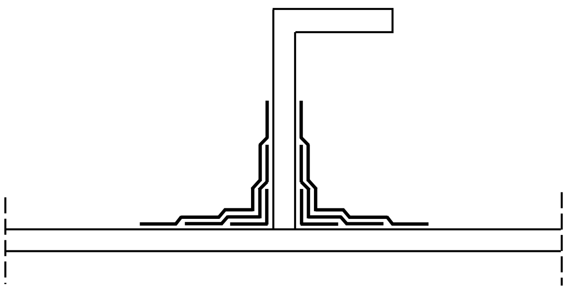


Figure 14

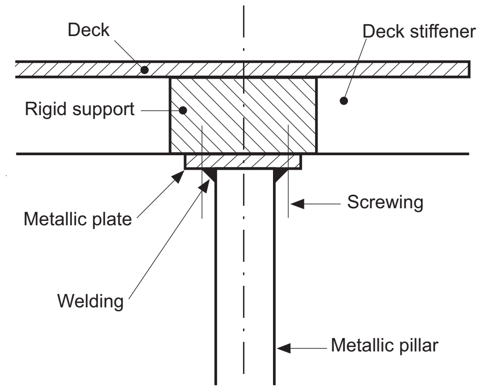
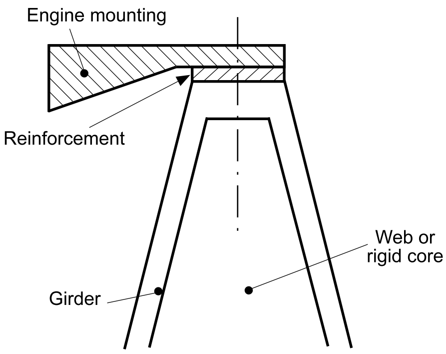


Figure 15



6.2 Engine exhaust

6.2.1 Engine exhaust discharge arrangements made of laminates are to be of the water injection type with a normal service temperature of approximately 70° C and a maximum temperature not exceeding 120° C.

6.2.2 The resins used for the lamination are to be type approved and to have adequate resistance to heat and to chemical agents as well as a high deflection temperature.

As a general rule, the exhaust ducts are to be internally coated with two layers of mat of 600 g/m^2 laminated with vinylester resin; a flame-retardant or self-extinguishing polyester resin having a thickness not less than 1,5 mm with a low deflection at high temperature may be accepted. Details of these resins are to be enclosed with the list required in [3.1.1] and general characteristics are to be reported on the relevant drawings.

6.2.3 Additives or pigments which may impair the mechanical properties of the resin are not to be used.

6.3 Tanks for liquids

6.3.1 Structural tanks are to be intended to contain fuel oil or lube oil. No integral tanks are to contain gasoline. Integral tanks may be of single-skin laminates and sandwich construction.

For single-skin laminates and sandwich construction tanks the following requirements are to be applied:

- the final ply of the laminate is to be covered with fibreglass chopped strand mat of heavy weight (at least 600 gr/m^2). Alternatively, the internal thickness of the tanks is to be not less than 10 mm;
- the internal surface of the tanks is to have a heavy resin coat, which may incorporate a light fibre tissue, as a barrier to prevent any undue absorption by the laminate. This may be carried out with the use of special resin (isophaltic type) resistant to hydrocarbons. Alternatively, a suitable thickness of gel coat is to be applied;
- stiffeners are not to penetrate the tank boundaries so that, in the event of a fracture of the laminate or frame, the oil will not travel some distance along the continuous glass fibres due to a capillary action. Accordingly, the tank is to be isolated by means of diaphragms made of laminates to form the final internal barrier layer against oil absorption;
- the outer surfaces of the tanks are to be coated with a fire-retardant paint or resin.

  In addition for sandwich construction tanks the following requirements are to be applied:
- the cores are to be end grain balsa or closed cell polyvinylchloride foam;
- each balsa block is to be individually set with the space around it filled with resin.

6.3.2 Mechanical tests are to be carried out on samples of the laminate "as is" and after immersion in the fuel oil at ambient temperature for a week. After the immersion the mechanical properties of the laminate are to be not less than 80% of the value of the sample "as is". For scantling calculations the mechanical characteristics obtained by the mechanical tests are to be assumed.

6.3.3 Where the tank is formed by plywood bulkhead, its surface is to completely protected against the ingress of liquid by means of a layer of laminate of at least 4 mm in thickness.

6.3.4 *(1/1/2021)*

Tanks, complete with all pipe connections, are to be subjected to a hydraulic pressure test with a head above the tank top equal to h, as defined in Ch 1, Sec 5, or to the overflow pipe, whichever is the greater.

On the base of additional verifications proposed by the Shipyard (such as NDT) a leak testing with an air pressure as per [4.2.1]. may be accepted by Tasneef as an alternative.

7 Plating attached to griders

7.1 Primary supporting members

7.1.1 *(1/1/2020)*

The section modulus and the moment of inertia of primary supporting members are to be calculated in association with an effective area A_S, in cm^2, of attached load bearing plating obtained from the following:

$$A_S = 10c \cdot b_F \cdot t_S$$

where:

$$\text{for } \mathbf{S}_L / \mathbf{b}_F < 8 : \mathbf{c} = 0,25 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right) - 0,016 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right)^2$$

$$\text{for } \mathbf{S}_L / \mathbf{b}_F \geq 8 : \mathbf{c} = 1$$

where:

Girders : primary supporting members of ordinary stiffeners such as deck girders, beams and web frames, side stringers, vertical and horizontal girders of bulkheads, floors, centre and side bottom girders, and similar.

Ordinary stiffeners: supporting members of shell plating, decks, double bottom or tank top plating, bulkheads, and similar.

$\mathbf{S}_L$: overall length of the girder, in m

b_F : actual width of the load bearing plating, i.e. one-half of the sum of the spaces between parallel stiffeners adjacent to that considered, in m

t_s : mean thickness, in mm, of the attached plating

A_s : area of the attached plating, in cm^2

t_a : web thickness, in mm, in built sections

d_a : web depth in built sections, measured between the inside of the face plate and the inside of the attached plating, in mm

7.2 Ordinary stiffeners

7.2.1 *(1/1/2020)*

Unless otherwise stated in specific requirements, the section modulus and the moment of inertia of the ordinary stiffeners are to be calcolated in association with an effective load bearing plating having width equal to the spacing of the stiffeners and thickness equal to the mean thickness of the attached plating.

7.3 Special cases

7.3.1 *(1/1/2020)*

In way of fore and aft regions and, in general, where the web of the section is at an angle a less than 90° to the attached plating, the section modulus shall be calculated taking account of the inclination of the attached plating.

Where the above angle α is less than 75°, the section modulus of the stiffener may be approximately calculated by multiplying the section modulus of the web fitted at right angles to the attached plating by cos (90 - α).

SECTION 2 MATERIALS

1 General

1.1

1.1.1 In addition to those in this Section, provisions regarding the characteristics and test and quality control procedures for the manufacture of composite materials are also specified in Part D, Ch 6.

1.1.2 The basic laminate considered in this Chapter is composed of an unsaturated resin, in general polyester, and of glass fibre reinforcements in the form of mat alternated with woven roving. The construction may consist of a single-skin laminate, a sandwich laminate, or a combination of both.

The reinforcement contained in the laminate is not less than 30% by weight; it is laid-up by hand, by mechanical pre-impregnation, or by spraying.

Laminates having a different composition or special systems of lay-up will be considered by Tasneef on a case-by-case basis upon submission of technical documentation illustrating details of the procedure.

All of the materials making up the laminates are to have properties suitable for marine use in the opinion of the Manufacturer. The products used in the production of the laminates, whether single-skin or sandwich (resins, reinforcements, stiffeners, cores, etc.), are to be type approved by Tasneef any structural parts in plywood are to be made with material type approved by Tasneef At the discretion of the latter, material type approved by other recognised Societies may be accepted.

2 Definitions and terminology

2.1

2.1.1

Mat	:	Reinforcements made up of regularly distributed filaments on the flat with no particular orientation and held together by a bond so as to form a mat that can be rolled up. The filaments may be cut to a predetermined length or continuous.
Roving	:	Made up of parallel filaments.
Woven Roving	:	Made from the weaving of roving. Due to their construction they have continuous filaments. Woven rovings of different types exist and can be differentiated by: the type of roving used in warp and weft, the name of the distribution per unit of length, respectively in warp and weft.
Mat-woven roving	:	Combined reinforcement made up of a layer of mat with cut filaments superimposed on a layer of woven roving by stitching or bonding.
Hybrid	:	Reinforcement having fibres of two or more different types; a typical example is that of glass fibre with aramid type fibre.
Unidirectional	:	Reinforcement made up of fibres that follow only one direction without interweaving.
Biaxial	:	Reinforcement made up of fibres that follow two directions (0°-90°), without interweaving.
Quadriaxial	:	Reinforcement made up of parallel fibres in the direction of filling and warp (0°, 90°) and in two oblique directions (± 45°).

3 Materials of laminates

3.1 Resins

3.1.1 Resins used are to be type approved by Tasneef for marine use.

Resins may be for laminating, i.e. form the matrix of laminates, or for surface coating (gel coat); the latter are to be compatible with the former, having mainly the purpose of protecting the laminate from external agents.

Polyester-orthophthalic type gel coat resins are not permitted. In the case of a hull constructed with a sandwich laminate on a male mould, the water resistance of the external surface will be the subject of special consideration.

Resins are to have the capacity for "wetting" the fibres of the laminate and for bonding them in such a way that the laminate has suitable mechanical properties and, in the case of glass fibre, not less than those indicated in 3.6.

The resins used are in general of the polyester, polyestervinylester or epoxide type; in any case, the resin is to have an ultimate elongation of not less than 3,0% if on the surface and 2,5% if in the laminate.

Compliant resins used in different structural applications are, as a general rule, always to be adopted in conjunction with over bonding lamination. The acceptance of structural fillets of compliant resins alone, without over bonding lamination, will be subject to special consideration after analysis of test results submitted by the Manufacturer demonstrating equivalent strength to over bonding laminates.

Resins are to be used within the limits and following the instructions supplied by the Manufacturer.

3.1.2 Resins additives

Resin additives (catalysts, accelerators, fillers, wax additives and colour pigments) are to be compatible with the resins and suitable for their curing process. Catalysts which initiate the curing process of the resin and the accelerators which govern the gelling and setting times are to be such that the resin sets completely in the environmental conditions in which manufacture is carried out. The Manufacturer's recommendations for the level of catalyst and accelerator to be mixed into the resins are to be followed.

The inert fillers are not to significantly alter the properties of the resin, with particular regard to the viscosity, and are to be carefully distributed in the resin itself in such a way that the laminates have the minimum mechanical properties stated in these requirements.

Such fillers are not to exceed 13% (including 3% of any thixotropic filler) by weight of the resins.

The colour pigments are not to affect the polymerisation process of the resin, are to be added to the resin as a coloured paste and are not to exceed the maximum amount (in general 5%) recommended by the Manufacturer. The thixotropic fillers of the resins for surface coating are not to exceed 3% by weight of the resin itself.

Details of the resins additives are to be enclosed in the list required in Sec 1, [3.1.1].

3.1.3 Flame-retardant additives

Where the laminate is required to have fire-retarding or flame-retardant characteristics, details of the proposed arrangements are to be submitted for examination.

Where additives are adopted for this purpose, they are to be used in accordance with the Manufacturer's instructions.

The results of tests performed by independent laboratories verifying the required characteristics are to be submitted.

Where fire-retarding or flame-retardant characteristics are required by the flag Administration, such properties are to be approved by the relevant Administration, or by Tasneef when authorised by the former.

Details of flame-retardant additives are to be enclosed in the list required in Sec 1, [3.1.1].

3.2 Reinforcements

3.2.1 General

All fibre reinforcements are to be type approved by Tasneef The reinforcements used and their characteristics are to be enclosed with the list required in Sec 1, [3.1.1].

The reinforcements taken into consideration in these requirements are mainly of fibres of three types: glass fibre, aramid type fibre and carbon type fibre.

The use of hybrid reinforcements obtained by coupling the above-mentioned fibres is also foreseen.

Structures can be obtained using reinforcements of one or more of the above-mentioned materials.

In the latter case the laminates may be made in alternate layers, i.e. made up of layers of one material or using hybrid reinforcements.

In any event, the manufacturing process is to be approved in advance by Tasneef and to this end a technical report is to be sent illustrating the processes to be followed and the materials (resins, reinforcements, etc.) used.

Reinforcements made of materials other than the preceding may be taken into consideration on a case-by-case basis by Tasneef which will stipulate the conditions for their acceptance.

The materials are to be free from imperfections, discoloration, foreign bodies, moisture and other defects and stored and handled in accordance with the Manufacturer's recommendations.

3.2.2 Glass fibre

The glass generally used for the manufacture of reinforcements is that called type "E", having an alkali content of not more than 1%, expressed in Na_2O.

Reinforcements manufactured in "S" type glass may also be used.

Such reinforcements are to be used for the lamination in hull resin matrices, with the procedure foreseen by the Manufacturer, such that the laminates have the same mechanical properties required in the structural calculations and for "E" type glass, these not being less than those indicated in item [4].

Reinforcements in glass fibre are generally foreseen in the form of: continuous filament or chopped strand mat, roving, unidirectional woven roving and in combined products i.e. made up of both mat and roving.

3.2.3 Aramid type fibres

Reinforcements in aramid type fibres are generally used in the form of roving or cloth of different weights (g/m^2).

Such reinforcements can be used in the manufacture of hulls either alone or alternated with layers of mat or roving of "E" type glass.

Hybrid reinforcements, in which the aramid type fibres are laid at the same time, in the same layer as "E" type glass fibres or carbon type fibres, may also be used.

3.2.4 Carbon-graphite fibres

Carbon-graphite type fibres means those which are at present called "carbon" type, used in the form of products suitable to be incorporated as reinforcements by themselves or together with other materials like glass fibres or aramid type fibres, in resin matrices for the construction of structural laminates.

3.3 Core materials for sandwich laminates

3.3.1 Core materials are to be type approved by Tasneef these materials are to be used in accordance with the Manufacturer's instructions and the method used in the sandwich construction is to be forwarded for information purposes enclosed with the list required in Sec 1, [3.1.1].

The materials considered in these requirements are rigid expanded foam plastics and balsa wood.

Particular care is to be given to the handling of these materials, which is to be in accordance with the Mnufacturer's recommendations.

The use of other materials will be taken into consideration on a case-by-case basis by Tasneef which will decide the conditions for acceptance on the basis of a criterion of equivalence.

Polystyrene can only be used as buoyancy material.

3.3.2 "Rigid expanded foam plastics" means expanded polyurethane (PUR) and polyvinyl chloride (PVC).

These materials, just like other materials used for cores, are to be of the closed-cell type, to be resistant to environmental agents (salt water, fuel oils, lube oils) and to have a low absorption of water.

Furthermore, they are to maintain a good level of resistance up to the temperature of 60°C and, if worked in non-rigid sheets made up of small blocks, the open weave backing and the adhesive are to be compatible and soluble in the resin of the laminate.

3.3.3 Balsa wood is to be chemically treated against attacks by parasites and mould and oven dried immediately after cutting.

Its humidity is to be no greater than 12%; if worked in non-rigid sheets made up of small blocks, the open weave backing and the adhesive are to be compatible and soluble in the resin of the laminate.

The balsa wood is to be laid-up with its grain at right-angles to the fibres in the surface laminates.

3.3.4 The ultimate tensile strength of the core materials is to be not less than the values indicated in Table 1. Such characteristic is to be ascertained by tests; in any case, core materials for laminates having an ultimate tensile strength < 0,4 N/mm^2 are not acceptable.

3.3.5 For the construction of sandwich structures with dry vacuum bagging techniques, core bonding paste is to be used; the characteristics are to be enclosed in the list as per Sec 1, [3.1.1]. The construction procedures of such sandwich structures will be subject to special consideration.

Table 1

Material	Density (kg/m^3)	Minimum shear strength (N/mm^2)
Balsa end-grain	104	1,6
	144	2,5
PVC, cross-linked	80	0,9
	100	1,4
PVC, linear	80-96	1,2
Polyurethane	90	0,5

3.4 Adhesive and sealant material

3.4.1 These materials are to be accepted by Tasneef before use. Details are to be submitted enclosed with the list required in Sec 1, [3.1.1].

3.5 Plywood

3.5.1 Plywood for structural applications is to be marine plywood type approved by Tasneef

Where it is used for the core of reinforcements or sandwich structures, the surfaces are to be suitably treated to enable the absorption of the resin and the adhesion of the laminate.

3.6 Timber

3.6.1 The use of timber is subject to special consideration by Tasneef In general, the Designer will be required to indicate on the drawings submitted the assumed characteristics such as strength and density.

3.7 Repair compounds

3.7.1 Materials used for repairs are to be accepted by Tasneef before use.

For acceptance purposes, the Manufacturer is to submit full product details and user instructions, listing the types of repair for which the system is to be used.

Depending on the proposed uses, Tasneef may require some tests.

3.8 Type approval of materials

3.8.1 Recognition by Tasneef of the suitability for use (type approval) of materials for hull construction may be requested by the Manufacturer. The type approval of resins, fibre products of single-skin laminates and core materials of sandwich laminates is carried out according to the requirements set out in the relevant Tasneef Rules.

Table 2 lists the typical mechanical properties of fibres commonly used for reinforcements.

4 Mechanical properties of laminates

4.1 General

4.1.1 The minimum mechanical properties, in N/mm^2, of laminates made with reinforcements of "E" type glass fibre may be obtained from the formulae given in Table 3 as a function of GC of the laminate as defined in Section 1.

These values are based on the most frequently used laminates made up of reinforcements of mat and roving type.

In the above-mentioned table, the values indicated are those corresponding to G_C = 30, the minimum value allowed of the content of glass reinforcement.

The minimum mechanical properties of the glass laminates found in testing, as a function of G_C, are to be no less than the values obtained from the formulae in the above-mentioned table.

Laminates with reinforcements of fibres other than glass, described in 3.2, are to have mechanical properties that are in general greater than or at least equal to those given in Table 3, the reinforcement content being equal. Tasneef reserves the right to take into consideration possible laminates having certain properties lower than those given in

Table 3, and will establish the procedures and criteria for approval on a case-by-case basis.

The scantlings indicated in this Chapter are based on the values of the mechanical properties of a laminate made with reinforcements in "E" type glass, with a reinforcement content equal to 0,30.

Whenever the mechanical properties of the reinforcement are greater than those mentioned above, the scantlings may be modified in accordance with the provisions of 4.2.1 below.

The mechanical properties and the percentage of reinforcement are to be ascertained, for each yacht built, from tests on samples taken preferably from the hull or, alternatively, having the same composition and prepared during the lamination of the hull (for the tests to be carried out, see Pt D, Ch 6, Sec 3).

Table 2

	Specific gravity	Tensile modulus of elasticity N/mm^2	Shear modulus of elasticity N/mm^2	Poisson's ratio
E Glass	2,56	69000	28000	0,22
S Glass	2,49	69000	**(1)**	0,20
R Glass	2,58	**(1)**	**(1)**	**(1)**
Aramid	1,45	124000	2800	0,34
LM Carbon	1,8	230000	**(1)**	**(1)**
IM Carbon	1,8	270000	**(1)**	**(1)**
HM Carbon	1,8	300000	**(1)**	**(1)**
VHM Carbon	2,15	725000	**(1)**	**(1)**
(1) Values supplied by the Manufacturer and agreed upon with Tasneef prior to use				

Table 3

1		2
R_m = ultimate tensile strength	$= 1278\ G^2_c - 510\ G_c + 123$	85
E = tensile modulus of elasticity	$= (37\ G_c - 4,75)\ .\ 10^3$	6350
R_{mc} = ultimate compressive strength	$= 150\ G_c + 72$	117
E_c = compressive modulus of elasticity	$= (40\ G_c - 6)\ .\ 10^3$	6000
R_{mf} = ultimate flexural strength	$= (502\ G^2_c + 107)$	152
E_t = flexural modulus of elasticity	$= (33,4\ G^2_c + 2,2)\ .\ 10^3$	5200
R_{mt} = ultimate shear strength	$= 80\ G_c + 38$	62
G = shear modulus of elasticity	$= (1,7\ G_c + 2,24)\ .\ 10^3$	2750
R_{mti} = ultimate interlaminar shear strength	$= 22,5 - 17,5\ G_c$	17

The values of the mechanical properties are to be no less than those used for the scantling of the structures.

Where certain values are in fact found to be lower than those used for the scantlings, but no lower than 85% of the latter, Tasneef reserves the right to accept the laminate subject to any conditions for acceptance it may stipulate.

4.1.2 Mechanical properties of carbon fibre laminates

For carbon fibre laminates the following mechanical properties indicated in Table 4 may be assumed.

Table 4

Mechanical Properties	N/mm²
E = tensile module of elasticity (0° or 90° direction)	$75000\ G_C - 6730$
Rm = ultimate tensile strength (0° or 90° direction)	$740\ G_C - 65$
Rmc = ultimate compressive strength (0° or 90° direction)	$460\ G_C - 40$
R_{mf} = ultimate flexural strength	$Rmf = \frac{2,5Rm}{\left(1 + \frac{Rm}{Rmc}\right)}$
Rmtc = ultimate interlaminar shear strength	35 Mpa

The above properties are reserved for hand laminated, woven roving and cross-plied 0/90 reinforcement high-strength carbon fibre.

For unidirectional reinforcement the following mechanical properties are to be considered.

Table 5

Mechanical Properties	Parallel to the fibres	Perpendicular to the fibres
E = tensile module of elasticity	$151500\ G_C - 15750$	$8025\ G_C^2 - 3150\ G_C + 3300$
Rm = ultimate tensile strength	$1500\ G_C - 150$	$38\ G_C^2 - 15\ G_C + 15$
Rmc = ultimate compressive strength	$820\ G_C - 82$	$1126\ G_C^2 - 45\ G_C + 45$
R_{mf} = ultimate flexural strength	$\frac{2,5Rm}{\left(1 + \frac{Rm}{Rmc}\right)}$	$\frac{2,5Rm}{\left(1 + \frac{Rm}{Rmc}\right)}$
Rmti = ultimate interlaminar shear strength	$230\ G_C^2 - 180\ G_C + 60$	$230\ G_C^2 - 180\ G_C + 60$

The glass content G_C may be assumed according to the following.

Table 6

Type of ply reinforcement	Open mould		Vacuum bag
	Simple Surface	Complex surface	
Chopped strand mat sprayed up	0,22	0,17	0,28
Chopped strand mat hand lay-up	0,22	0,17	0,28
Woven roving	0,40	0,28	0,50
Roving-mat combination	[0,46 - 0,18 x Q] - 0,08	[0,35 - 0,11 x Q] - 0,08	[0,56 - 0,22 x Q] - 0,08
Multidirectional fabric	0,41	0,30	0,50
Unidirectional fabric	0,46	0,32	0,57

$$Q = \frac{\text{Total mass of mat}}{\text{Total mass of glass in laminate (Mat + Woven Roving)}}$$

The total thickness, in mm, of the laminate may be calculated with the following formula:

$$t = \frac{Q}{2,160}\left(\left(\frac{1,8}{Gc}\right) - 0,6\right)$$

where Q is in kg/m².

In order to determine the total content G_C of the laminate of n ply, the following formula may be applied:

$$G_C = \frac{q1 + q2 + q3 + ...qn}{\frac{q1}{gc1} + \frac{q2}{gc2} + \frac{q3}{gc3} + ...\frac{qn}{gcn}}$$

where:

q : is the mass in kg/m² of the single ply;

G_c : is the glass content of the single ply.

4.2 Coefficients relative to the mechanical properties of laminates

4.2.1 The values of the coefficients Ko and Kof relative to the mechanical properties of the laminates that appear in the formulae of the structural scantlings of the hull in this Chapter are given by:

$$K_o = 85/R_m$$

$$K_{of} = \left(\frac{152}{R_{mf}}\right)^{0,5}$$

where R_m and R_{mf} are the values, in N/mm², of the ultimate tensile and flexural strengths of the laminate. Such values may be calculated with the formulae in Table 3 for glass fibre reinforcements or obtained from mechanical tests on samples of the laminate for other types of laminate.

Therefore, in the case of laminates with glass fibre having G_C = 30 (minimum allowed), it is to be assumed that:

$$K_o = 1$$

$$K_{of} = 1$$

The values K_o and K_{of} are to be taken as not less than 0,5 and 0,7, respectively, except in specific cases considered by Tasneef on the basis of the results of tests carried out.

SECTION 3 CONSTRUCTION AND QUALITY CONTROL

1 Shipyards or workshops

1.1 General

1.1.1 All constructions are to be built using materials and working processes approved or accepted by Tasneef

The builder is to obtain approval or acceptance for the materials he uses; furthermore, it is the builder's responsibility to ensure that all the materials are used in accordance with the Manufacturer's instructions and recommendations.

Shipyards or workshops for hull construction are to be suitably equipped to provide the necessary working environment according to these requirements, which are to be complied with for the recognition of the shipyard or workshop as suitable for the construction of hulls in reinforced plastic. This suitability is to be ascertained by a Tasneef Surveyor, the responsibility for the fulfilment of the requirements specified below as well as all other measures for the proper carrying out of construction being left to the shipyard or workshop.

When it emerges from the tests carried out that the shipyard or workshop complies with the following provisions, uses type approved materials, and has a system of production and quality control that satisfies the Tasneef Rules, so as to ensure a consistent level of quality, the shipyard or workshop may obtain from Tasneef a special recognition of suitability for the construction of reinforced plastic hulls.

The risks of contamination of the materials are to be reduced as far as possible; separate zones are to be provided for storage and for manufacturing processes. Alternative arrangements of the same standard may be adopted.

Compliance with the requirements of this Section does not exempt those in charge of the shipyard or workshop from the obligation of fulfilling all the hygiene requirements for work stipulated by the relevant authorities.

1.2 Moulding shops

1.2.1 Where hand lay-up or spray lay-up processes are used for the manufacture of laminates, a temperature of between 16° and 32°C is to be maintained in the moulding shop during the lay-up and polymerisation periods. Small variations in temperature may be allowed, at the discretion of the Tasneef Surveyor, always with due consideration being given to the resin Manufacturer's recommendations. Where moulding processes other than those mentioned above are used, the temperatures of the moulding shop are to be established accordingly.

The relative humidity of the moulding shop is to be kept as low as possible, preferably below 70%, and in any case lower than the limit recommended by the resin Manufacturer. Significant changes in humidity, such as would lead to condensation on moulds and materials, are to be avoided.

Instruments to measure the humidity and temperature are to be placed in sufficient number and in suitable positions. If necessary, due to environmental conditions, an instrument capable of providing a continuous readout and record of the measured values may be required.

Ventilation systems are not to cause an excessive evaporation of the resin monomer and draughts are to be avoided.

The work areas are to be suitably illuminated. Precautions are to be taken to avoid effects on the polymerisation of the resin due to direct sunlight or artificial light.

1.3 Storage areas for materials

1.3.1 Resins are to be stored in dry, well-ventilated conditions at the temperature recommended by the resin Manufacturer. If the resins are stored in tanks, it is to be possible to stir them at a frequency for a length of time indicated by the resin Manufacturer. When the resins are stored outside the moulding shop, they are to be brought into the shop in due time to reach the working temperature required before being used.

Catalysts and accelerators are to be stored separately in clean, dry and well-ventilated conditions in accordance with the Manufacturer's recommendations.

Fillers and additives are to be stored in closed containers that are impervious to dust and humidity.

Reinforcements, e.g. glass fibre, are to be stored in dust-free and dry conditions, in accordance with the Manufacturer's recommendations. When they are stored outside the cutting area, the reinforcements are to be brought into the latter in due time so as to reach the temperature of the moulding shop before being used.

Pre-impregnated reinforcements are to be stored in an area set aside for the purpose. The quality control documentation is to keep a record of the storage and depletion of the stock of such reinforcements.

Materials for the cores of sandwich type structures are to be stored in dry areas and protected against damage; they are to be stored in their protective covering until they are used.

1.4 Identification and handling of materials

1.4.1 In the phases of reception and handling the materials are not to suffer contamination or degradation and are to bear adequate identification marks at all times, including those relative to Tasneef type approval. Storage is to be so arranged that the materials are used, whenever possible, in chronological order of receipt. Materials are not to be used after the Manufacturer's date of expiry, except when the latter has given the hull builder prior written consent.

2 Hull construction processes

2.1 General

2.1.1 The general requirements for the construction of hand lay-up or spray lay-up laminates are set out below; processes of other types (e.g. by resin transfer, vacuum or pressurised moulding with mat and continuous filaments) are to be individually recognised as suitable by Tasneef

2.2 Moulds

2.2.1 Moulds for production of laminates are to be constructed with a suitable material which does not affect the resin polymerisation and are to be adequately stiffened in order to maintain their shape and precision in form. They are also not to prevent the finished laminate from being released, thus avoiding cracks and deformations.

During construction, provision is to be made to ensure satisfactory access such as to permit the proper carrying out of the laminating.

Moulds are to be thoroughly cleaned, dried and brought to the moulding shop temperature before being treated with the mould release agents, which are not to have an inhibiting effect on the gel coat resin.

2.3 Laminating

2.3.1 The gel coat is to be applied by brush, roller or spraying device so as to form a uniform layer with a thickness of between 0,4 and 0,6 mm. Furthermore, it is not to be left exposed for longer than is recommended by the Manufacturer before the application of the first layer of reinforcement.

A lightweight reinforcement, generally not exceeding a mass per area of 300 g/m^2, is to be applied to the gel coat itself by means of rolling so as to obtain a content of reinforcement not exceeding approximately 0,3.

In the case of hand lay-up processing, the laminates are to be obtained with the layers of reinforcement laid in the sequence indicated in the approved drawings and each layer is to be thoroughly "wet" in the resin matrix and compacted to give the required weight content.

The amount of resin laid "wet on wet" is to be limited to avoid excessive heat generation.

Laminating is to be carried out in such a sequence that the interval between the application of layers is within the limits recommended by the resin Manufacturer.

Similarly, the time between the forming and bonding of structural members is to be kept within these limits; where this is not practicable, the surface of the laminate is to be treated with abrasive agents in order to obtain an adequate bond.

When laminating is interrupted so that the exposed resin gels, the first layer of reinforcement subsequently laid is to be of mat type.

Reinforcements are to be arranged so as to maintain continuity of strength throughout the laminate. Joints between the sections of reinforcement are to be overlapped and staggered throughout the thickness of the laminate.

In the case of simultaneous spray lay-up of resin and cut fibres, the following requirements are also to be complied with:

- before the use of the simultaneous lay-up system, the Manufacturer is to satisfy himself of the efficiency of the equipment and the competence of the operator;
- the use of this technique is limited to those parts of the structure to which sufficiently good access may be obtained so as to ensure satisfactory laminating;
- before use, the spray lay-up equipment is to be calibrated in such a way as to provide the required fibre content by weight; the spray gun is also to be calibrated, according to the Manufacturer's instruction manual, such as to obtain the required catalyst content, the general spray conditions and the appropriate length of cut fibres. Such length is generally to be not less than 35 mm for structural laminates, unless the mechanical properties are confirmed by tests; in any event, the length of glass fibres is to be not less than 25 mm;
- the calibration of the lay-up system is to be checked periodically during the operation;
- the uniformity of lamination and fibre content is to be systematically checked during production.

The manufacturing process for sandwich type laminates is taken into consideration by Tasneef in relation to the materials, processes and equipment proposed by the Manufacturer, with particular regard to the core material and to its lay-up as well as to details of connections between prefabricated parts of the sandwich laminates themselves. The core materials are to be compatible with the resins of the surface laminates and suitable to obtain strong adhesion to the latter (Manufacturer's instructions to be followed).

Attention is drawn, in particular, to the importance of ensuring the correct carrying out of joints between panels.

Where rigid core materials are used, then dry vacuum bagging techniques are to be adopted. Particular care is to be given to the core bonding materials and to the holes provided to ensure efficient removal of air under the core. Bonding paste is to be visible at these holes after vacuum bagging.

2.4 Hardening and release of laminates

2.4.1 On completion of the laminating, the laminate is to be left in the mould for a period of time to allow the resin to harden before being removed. This period may vary, depending on the type of resin and the complexity of the laminate, but is to be at least 24 hours, unless a different period is recommended by the resin Manufacturer.

The hull, deck and large assemblies are to be adequately braced and supported for removal from the moulds as well as during the fitting-out period of the yacht.

After the release and before the application of any special post-hardening treatment, which is to be examined by Tasneef the structures are to be stabilised in the moulding environment for the period of time recommended by the resin Manufacturer. In the absence of recommendations, the period is to be at least 24 hours.

2.5 Defects in the laminates

2.5.1 The manufacturing processes of laminates are to be such as to avoid defects, such as in particular: surface cracks, surface or internal blistering due to the presence of air bubbles, cracks in the resin for surface coating, internal areas with non-impregnated fibres, surface corrugation, and surface areas without resin or with glass fibre reinforcements exposed to the external environment.

Any defects are to be eliminated by means of appropriate repair methods to the satisfaction of the Tasneef Surveyor.

Dimensions and tolerances are to conform to the approved construction documentation.

2.5.2 The responsibility for maintaining the required tolerances rests with the builder.

Monitoring and random checking by the Surveyor does not absolve the builder from this responsibility.

2.6 Checks and tests

2.6.1 Checks and tests are to be arranged during the lamination process by the hull builder, in accordance with the relevant quality system, and by the Tasneef Surveyor.

The hull builder is to maintain a constant check on the laminate.

Any defects found are to be eliminated immediately.

In general the following checks and tests are to be carried out:

a) check of the mould before the application of the release agent and of the gel coat;

b) check of the thickness of the gel coat and the uniformity of its application;

c) check of the resin and the amount of catalyst, accelerator, hardener and various additives;

d) check of the uniformity of the impregnation of reinforcements, their lay-up and superimposition;

e) check and recording of the percentage of the reinforcement in the laminate;

f) checks of any post-hardening treatments;

g) general check of the laminate before release from the mould;

h) check and recording of the laminate hardness before release from the mould;

i) check of the thickness of the laminate which, in general, is not to differ by more than 15% from the thickness indicated in approved structural plans;

j) mechanical tests on laminates taken from the hull or prepared during the lamination of the hull (in accordance with Pt D, Ch 6, Sec 3).

The thicknesses of the laminates are, in general, to be measured at not less than ten points, evenly distributed across the surface.

The above-mentioned checks and tests are to be carried out, as a rule, in the presence of a Tasneef Surveyor; where the shipyard has a system of production organisation and quality control certified by Tasneef the checks may be carried out directly by the shipyard without the presence of a Tasneef Surveyor.

2.6.2 Where ultrasonic thickness gauges are used, relevant tools are to be calibrated against an identical laminate (of measured thickness).

2.6.3 As a general rule, a method of validating the complete laminate thickness is to be agreed between the builder and the Surveyor.

SECTION 4 LONGITUDINAL STRENGTH

1 General

1.1

1.1.1

The structural scantlings prescribed in Chapter 4 are also intended as appropriate for the purposes of the longitudinal hull strength of a yacht having length L not exceeding 40 m for monohull yachts or 35 m for catamarans and openings on the strength deck of limited size.

For yachts of greater length and/or openings of size greater than the breadth B of the hull and extending for a considerable part of the length of the yacht, a test of the longitudinal strength is required.

1.2

1.2.1 To this end, longitudinal strength calculations are to be carried out considering the load and ballast conditions for both departure and arrival.

As a guide, the criteria used by Tasneef for tests of longitudinal hull beam strength are shown below.

2 Bending stresses

2.1

2.1.1 In addition to satisfying the minimum requirements stipulated in the individual Chapters of these Rules, the scantlings of members contributing to the longitudinal strength of monohull yachts and catamarans are to achieve a section modulus of the midship section at the bottom and the deck such as to guarantee stresses not exceeding the allowable values.

Therefore:

$\sigma_f \leq f\sigma_l$

$\sigma_p \leq f\sigma_l$

where:

$$\sigma_f = \frac{M_T}{1000\ W_f}\ \ N/mm^2$$

$$\sigma_p = \frac{M_T}{1000\ W_p}\ \ N/mm^2$$

W_f, W_p : section modulus, in m^3, at the bottom and the deck, respectively, of the transverse section

M_T : design total vertical bending moment defined in Ch 1, Sec 5

f : 0,33 for planing yachts

f : 0,25 for displacement yachts

σ_l : the lesser of the values of ultimate tensile and ultimate compressive strength, in N/mm^2, of the bottom and deck laminate.

2.2

2.2.1 In order to limit the flexibility of the hull structure, the moment of inertia J of the midship section, in m^4, is generally to be not less than the value given by the following formulae:

$J = 200 \cdot M_T \cdot 10^{-6}$ for planing vessesls

$J = 230 \cdot M_T \cdot 10^{-6}$ displacement yachts.

2.3 Calculation of strength modulus

2.3.1 Reference is to be made to Table 1 for plating and Table 2 for longitudinals for calculation of the midship section modulus.

Table 1

	Deck	Side shell	Bottom
Mean thickness, in mm	t_p	t_m	t_f
Young's modulus, in N/mm^2	E_p	E_m	E_f

Where there is a sandwich member, the two skins of the laminate are to be taken into account for the purposes of the longitudinal strength only with their own characteristics. The cores may be taken into account only if they offer longitudinal continuity and appreciable strength against axial tension-compression.

For each transverse section within the midship region, the section modulus, in m^3, is given by:

$$W_p = \frac{1}{E_p} \cdot \left[C' \cdot P + \frac{C'}{6} \cdot A \cdot \left(1 + \frac{F-P}{F+0{,}5 \cdot A}\right)\right] \cdot 10^{-3}$$

$$W_f = \frac{1}{E_f} \cdot \left[C' \cdot P + \frac{C'}{6} \cdot A \cdot \left(1 + \frac{F-P}{F+0{,}5 \cdot A}\right)\right] \cdot 10^{-3}$$

where:

P : $t_p \cdot B \cdot E_p + n_p \cdot (l_{ps} \cdot t_{ps} \cdot E_{ps} + t_{pa} \cdot H_{pa} \cdot E_{pa})$

A : $2[t_m \cdot l_m \cdot E_m + n_m \cdot (t_{ms} \cdot l_{ms} \cdot E_{ms} + t_{ma} \cdot H_{ma} \cdot E_{ma})]$

F : $t_f \cdot \frac{B}{2} \cdot E_f + n_f \cdot (l_{fs} \cdot t_{fs} \cdot E_{fs} + t_{fa} \cdot H_{fa} \cdot E_{fa})$

t_p, t_m, t_f, E_p, E_m, E_f: values defined in Table 1

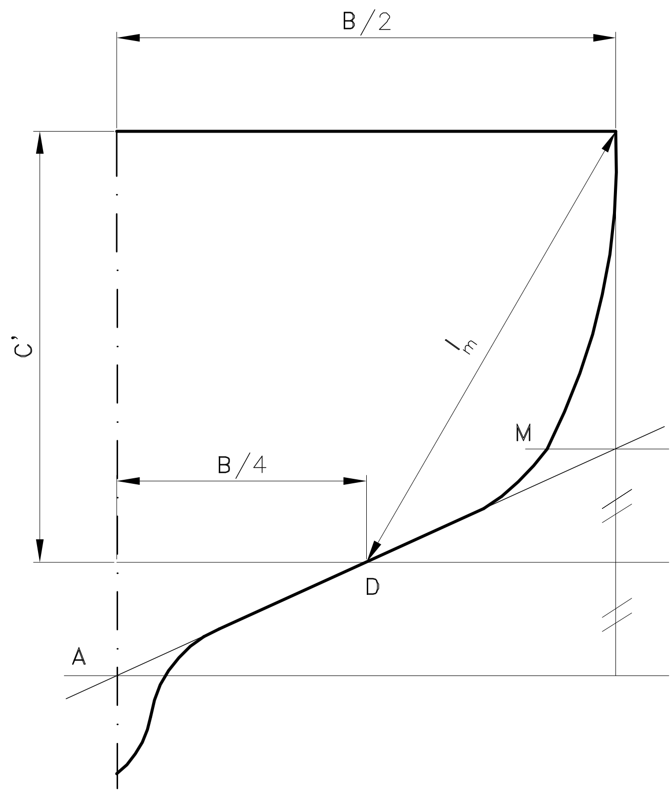
t_{ps}, t_{ms}, t_{fs}, E_{ps}, E_{ms}, E_{fs}, l_{ps}, l_{ms}, l_{fs}, t_{pa}, t_{ma}, t_{fa}, E_{pa}, E_{ma}, E_{fa}, H_{pa}, H_{ma}, H_{fa}, n_p, n_m, n_f: values defined in Table 2

l_m, C' : length, in m, defined in Figure 1.

Table 2

		Deck	Side shell	Bottom
Flange	Mean thickness, in mm	t_{ps}	t_{ma}	t_{fs}
	Young's modulus, in N/mm²	E_{ps}	E_{ma}	E_{fs}
	Breadth in mm	l_{ps}	l_{ms}	l_{fs}
Web	Equivalent thickness in Section I, in mm	t_{pa}	t_{ma}	t_{fa}
	Young's modulus, in N/mm²	E_{pa}	E_{ma}	E_{fa}
	Height in mm	H_{pa}	H_{ma}	H_{fa}
	Number of longitudinals	n_p	n_m	n_f

Figure 1



3 Shear stresses

3.1

3.1.1 The shear stresses in every position along the length L are not to exceed the allowable values; in particular.

$$\frac{T_t}{A_t} \cdot 10^{-3} \le f \cdot \tau$$

where:

T_t : total shear stress in kN defined in Ch 1, 5.4

f : defined in 2

τ : shear stress of the laminate, in N/mm²

A_t : actual shear area of the transverse section, in m², to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings.

SECTION 5 EXTERNAL PLATING

1 General

1.1

1.1.1 Bottom and side plating may be made using both single-skin laminate and sandwich structure.

When the two solutions are adopted for the hull, a suitable taper is to be made between the two types.

Bottom plating is the plating up to the chine or to the upper turn of the bilge.

When the side thickness differs from the bottom thickness by more than 3 mm, a transition zone is to be foreseen.

2 Definitions and symbols

2.1

2.1.1

S : larger dimension of the plating panel, in m

s : spacing of the longitudinal or transverse ordinary stiffener, in m

p : scantling pressure, in kN/m², given in Ch 1, Sec 5

K_{of}, K_o : factors defined in Sec 2 of this Chapter.

3 Keel

3.1

3.1.1 The keel is to extend the whole length of the yacht and have a breadth b_{CH}, in mm, not less than the value obtained by the following formula:

$$b_{CH} = 30L$$

The thickness of the keel is to be not less than the value t_{CH}, in mm, obtained by the following formula:

$$t_{CH} = 1,4t$$

t being the greater of the values t_1 and t_2, in mm, calculated as specified in 5 assuming the spacing s of the corresponding stiffeners.

When calculating s, dead rise edge ≥ 12° is considered as a stiffener.

The thickness t_{CH} is to be gradually tapered transversely to the thickness of the bottom and, in the case of hulls having a U-shaped keel, the thickness of the keel is to extend transversely, as indicated in Fig 2 b) in Sec 1, tapering with the bottom plating.

In yachts with sail and ballast keel, the thickness of the keel for the whole length of the ballast keel is to be increased by 30%; this increase is to extend longitudinally to fore and aft of the ballast for a suitable length.

When the hull is laminated in halves, the keel joint is to be carried out as shown in Fig 5 in Sec 1 or in a similar way.

4 Rudder horn

4.1

4.1.1 When the rudder is of the semi-spade type, such as Type I B shown in Ch 1, Sec 2, Fig 2, the relevant rudder horn is to have dimensions and thickness such that the moment of inertia J, in cm, and the section modulus Z, in cm³, of the generic horizontal section of the same skeg, with respect to its longitudinal axis, are not less than the values given by the following formulae:

$$J = \frac{A \cdot h^2 \cdot V^2}{36} 10^{-3}$$

$$Z = \frac{A \cdot h \cdot V^2}{55}$$

where:

A : the rudder area, in m², acting on the horn;

h : the vertical distance, in mm, from the skeg section to the lower edge of the pintle (rudder heel);

V : maximum design speed of the yacht, in knots.

5 Bottom plating

5.1

5.1.1 The thickness of bottom plating is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_a \cdot s \cdot k_{of} \cdot p^{0,5}$$

$$t_2 = 16 \cdot s \cdot k_{of} \cdot D^{0,5}$$

where:

k_1 : 0,26, when assuming $p=p_1$

: 0,15, when assuming $p=p_2$.

k_a : coefficient as a function of the ratio S/s given in Table 1.

The thickness of the plating of the bilge is, in any event, to be taken as not less than the greater of the thicknesses of the bottom and side.

The minimum bottom shell thickness is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

If the plating has a pronounced curve, as for example in the case of the hulls of sailing yachts, the thickness calculated with the formulae above may be reduced multiplying by (1 - f/s), f being the distance, in m, between the connecting beam and the two extremities of the plating concerned and the surface of the plating itself. This reduction may not be assumed less than 0,70.

In sailing yachts with or without auxiliary engines in way of the ballast keel, when the width of the latter is greater than that of the keel, the thickness of the bottom is to be increased to the value taken for the keel.

Table 1

S/s	K_a
1	17,5
1,2	19,6
1,4	20,9
1,6	21,6
1,8	22,1
2,0	22,3
>2	22,4

6 Side plating and sheerstrake plating

6.1

6.1.1 A sheerstrake plate of height h, in mm, not less than 0,025 L and thickness t_c, in mm, not less than the value in the following formula is to be fitted:

$$t_c = 1,30t$$

where t is the greater of the thicknesses t_1 and t_2, calculated as stated in 6.2 below.

6.2 Side plating

6.2.1 The thickness of side plating is to be not less than the greater of the values t_1 and t_2, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_a \cdot s \cdot k_{of} \cdot p^{0,5}$$

$$t_2 = 12 \cdot s \cdot k_{of} \cdot D^{0,5}$$

where k_1 and k_a are as defined in 5.1.

7 Openings in the shell plating

7.1

7.1.1 Sea intakes and other openings are to be well rounded at the corners and located, as far as possible, outside the bilge strakes and the keel. Arrangements are to be such as to ensure continuity of strength in way of openings.

The edges of openings are to be suitably sealed in order to prevent the absorption of water.

7.2

7.2.1 Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects.

7.3

7.3.1 The internal walls of sea intakes are to have external plating thickness increased by 2 mm, but not less than 6 mm.

8 Local stiffeners

8.1

8.1.1 The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the propulsion engine bedplates, stem (the thickness is not required to be greater than that of the keel in this case), propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

8.2

8.2.1 Where the aft end is shaped such that the bottom plating aft has a large flat area, Tasneef may require the local plating to be increased and/or reinforced with the fitting of additional stiffeners.

8.3

8.3.1 The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements as indicated in 3.1.1.

8.4

8.4.1 The thickness of the transom is to be not less than that of the side plating for the portion above the waterline, or less than that of the bottom for the portion below the waterline.

Where water-jets or propulsion systems are fitted directly to the transom, the scantlings of the latter will be the subject of special consideration.

In such case a sandwich structure with marine plywood core of adequate thickness is recommended.

9 Cross-deck bottom plating

9.1

9.1.1 The thickness is to be taken, the stiffener spacing s being equal, no less than that of the side plating.

Where the gap between the bottom and the waterline is so small that local wave impact phenomena are anticipated, an increase in thickness and/or additional internal stiffeners may be required.

SECTION 6 SINGLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a single bottom, which may be of either longitudinal or transverse type.

1.2 Longitudinal structure

1.2.1 A centre girder is to be fitted. In the case of a keel with a dead rise > 12°, the centre girder may be omitted but in such case the fitting of a longitudinal stringer is required.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.2.2 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

1.2.3 Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

1.3 Transverse structure

1.3.1 The transverse framing consists of ordinary stiffeners arranged transversely (floors) and placed at each frame supported by girders, which in turn are supported by transverse bulkheads or reinforced floors.

1.3.2 A centre girder is to be fitted. In the case of a keel with a dead rise > 12°, the centre girder may be omitted but in such case the fitting of a longitudinal stringer is required.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.3.3 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

1.3.4 Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

1.3.5 Floors are to be fitted in way of reinforced frames at the sides and reinforced deck beams.

Any intermediate floors are to be adequately connected to the ends

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m², given in Ch 1, Sec 5;

K_o : coefficient defined in Sec 2 of this Chapter.

3 Longitudinal type structure

3.1 Bottom longitudinals

3.1.1 The section modulus of longitudinal stringers is to be not less than the value Z, in cm², calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : 1,5 assuming $p=p_1$

: 1 assuming $p=p_2$

S : conventional span of the longitudinal stiffener, in m, equal to the distance between floors.

3.2 Floors

3.2.1 The section modulus of the floors at the centreline of the span S is to be not less than the value Z_M, in cm³, calculated with the following formula.

$$Z_M = k_1 \cdot b \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : 2,4 assuming $p = p_1$

1,2 assuming $p = p_2$

b : half the distance, in m, between the two floors adjacent to that concerned

S : conventional floor span equal to the distance, in m, between the two supporting members (sides, girders, keel with a dead rise edge > 12°).

In the case of a U-shaped keel or one with a dead rise edge ≤12° but > 8° the span S is still to be calculated considering the distance between girders or sides; the modulus Z_M may, however, be reduced by 40%.

If a side girder is fitted on each side with a height equal to the local height of the floor, the modulus may be reduced by a further 10%.

3.3 Girders

3.3.1 Centre girder

When the girder forms a support for the floor, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.2
- b'_{PC} : half the distance, in m, between the two side girders if supporting or equal to B/2 in the absence of supporting side girders
- S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b'_{PC} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.1
- b'_{PC} : half the distance, in m, between the two side girders if present, or equal to B/2 in the absence of side girders
- S : distance between the floors.

3.3.2 Side girders

When the side girder forms a support for the floor, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b'_{PL} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.2
- b'_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder concerned
- S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b'_{PL} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.1
- b'_{PL} : half the distance, in m, between the two adjacent girders or between the side and the adjacent girder
- S : distance between the floors, in m.

4 Transverse type structures

4.1 Ordinary floors

4.1.1 The section modulus for ordinary floors is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.1
- S : conventional span in m, of the floor equal to the distance between the members which support it (girders, sides).

4.2 Centre girder

4.2.1 The section modulus of the centre girder is to be not less than the value Z_{PC}, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.2
- b_{PC} : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders
- S : conventional span of the centre girder, equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

4.3 Side girders

4.3.1 The section modulus is to be not less than the value Z_{PL}, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K_o \cdot p$$

where:

- k_1 : defined in 3.2
- b_{PL} : half the distance, in m, between the two adjacent girders or between the side and the girder adjacent to that concerned
- S : conventional girder span equal to the distance, in m, between the two members which support it (transverse bulkheads, floors).

5 Constructional details

5.1

5.1.1 The centre girder and side girders are to be connected to the stiffeners of the transom by means of suitable fittings.

SECTION 7 DOUBLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.1.2 *(1/7/2021)*

The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead of the machinery space, or as near thereto as practicable, is requested for yachts of L > or = 50 m.

The double bottom may be avoided if the vessel satisfies what required in Ch.II-1 part B-2 Regulation 9 SOLAS'74 as amended. For yachts of less than 80 m in load line length, the alternative arrangements to provide a level of safety may be limited to compartments not having a double bottom or having a double bottom arrangement not in line with what required below. In these cases compliance with the bottom damage standard may be carried out assuming that the damage will only occur between the transverse watertight bulkheads in compartments not having a double bottom or having a double bottom not in line with what below.

1.1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.

The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of Tasneef

1.1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

The edges of the holes are to be suitably sealed in order to prevent the absorption of liquid into the laminate.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2 Minimum height

2.1

2.1.1 The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value h_{dF}, in mm, obtained from the following formula:

$$h_{df} = 28B + 32(T + 10)$$

The height of the double bottom is, in any event, to be not less than 700 mm. For yachts less than 50 m in length, Tasneef may accept reduced height.

3 Inner bottom plating

3.1

3.1.1 *(1/1/2019)*

The thickness of the inner bottom plating is to be not less than the value t_1, in mm, calculated with the following formula:

$$t_1 = 1,3(0,04L + 5s + 1)k_{of} \text{ for single-skin laminate}$$

$$t_1 = (0,04L + 5s + 1)k_{of} \text{ for sandwich laminate}$$

where:

- s : spacing of the ordinary stiffeners, in m
- k_{of} : coefficients for the properties of the material defined in Sec 2.

For yachts of length L less than 50 m, the thickness is to be maintained throughout the length of the hull.

For yachts of length L > or = 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquids, the thickness of the top is also to comply with the provisions of Sec 10.

4 Centre girder

4.1

4.1.1 A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness, in mm, of the core of a sandwich type centre girder is to be not less than the following value t_{pc}:

$t_{pc} = (0,125L + 3,5)k_{of}$

where k_{of} is defined in Sec 2.

Where a single-skin laminate is used for the centre girder, the thickness is to be not less than twice that defined above.

5 Side girders

5.1

5.1.1 Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

Watertight girders are to have thickness not less than that required in Sec 10 for tank bulkheads

5.2

5.2.1 Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height no less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6 Floors

6.1

6.1.1 Te thickness t_m, in mm, of the core of sandwich type floors is to be not less than the following value:

$t_m = (0,125L + 1,5)k_{of}$

where k_{of} is defined in Sec. 2.

Where a single-skin laminate is used for floors, the thickness is to be not less than twice that calculated above.

Watertight floors are also to have thickness not less than that required in Sec 10 for tank bulkheads.

6.2

6.2.1 When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be arranged in longitudinally framed double bottoms in the following locations:

- under buklheads and pillars
- outside the machinery space at an interval no greater than 2 m
- in the machinery space under the bedplates of main engines
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7 Bottom and inner bottom longitudinals

7.1

7.1.1 *(1/1/2019)*

The section modulus of bottom stiffeners is to be no less than that required for single bottom longitudinals stipulated in Sec 6.

The section modulus of inner bottom stiffeners is to be no less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquids are arranged above the double bottom, the section modulus of longitudinals is to be no less than that required for tank stiffeners as stated in Sec 10.

SECTION 8 SIDE STRUCTURES

1 General

1.1

1.1.1 *(1/1/2019)*

Where tanks intended for liquids are arranged above the double bottom, the section modulus of longitudinals is to be no less than that required for tank stiffeners as stated in Sec 10.

The longitudinal type structure consists of ordinary stiffeners placed longitudinally supported by reinforced frames, generally spaced not more than 2 m apart, or by transverse bulkheads.

The transverse type structure is made up of ordinary reinforcements placed vertically (frames), which may be supported by reinforced stringers, by decks, by flats or by the bottom structures.

Reinforced frames are to be provided in way of the mast and the ballast keel, in sailing yachts, in the machinery space and in general in way of large openings on the weather deck.

2 Definitions and symbols

2.1

2.1.1

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m², defined in Pt B, Ch 1, Sec 5 ;

K_o : factor defined in Sec 2 of this Chapter.

3 Ordinary stiffeners

3.1

3.1.1 The section modulus of the frames is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : 1,75 assuming $p=p_1$

: 1,1 assuming $p=p_2$

S : conventional frame span, in m, equal to the distance between the supporting members.

The ordinary frames are to be well connected to the elements which support them, in general made up of a beam and a floor.

3.2 Longitudinals

3.2.1 The section modulus of the side longitudinals is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : 1,9 assuming $p=p_1$

: 1 assuming $p=p_2$

S : conventional span of the longitudinal, in m, equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads.

4 Reinforced beams

4.1 Reinforced frames

4.1.1 The section modulus of the reinforced frames is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K_{CR} \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : 1 assuming $p=p_1$

: 0,7 assuming $p=p_2$

K_{CR} : 2,5 for reinforced frames which support longitudinal ordinary stiffeners, or reinforced stringers;

: 1,1 for reinforced frames which do not support ordinary stiffeners;

s : spacing, in m, between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned;

S : conventional span, in m, equal to the distance between the members which support the reinforced frame.

4.2 Reinforced stringers

4.2.1 The section modulus of the reinforced stringers is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K'_{CR} \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

k_1 : defined in 4.1

K_{CR} : 2,5 for reinforced stringers which support ordinary vertical stiffeners (frames);

: 1,1 for reinforced stringers which do not support ordinary vertical stiffeners;

s : spacing, in m, between the reinforced stringers or 0,5 D in the absence of other reinforced stringers or decks;

S : conventional span, in m, equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames.

SECTION 9 DECKS

1 General

1.1

1.1.1 This Section lays down the criteria for the scantlings of decks, plating and reinforcing or supporting structures.

The reinforcing and supporting structures of decks consist of ordinary reinforcements, beams or longitudinal stringers, laid transversely or longitudinally, supported by lines of shoring made up of systems of girders and/or reinforced beams, which in turn are supported by pillars or by transverse or longitudinal bulkheads.

Reinforced beams together with reinforced frames are to be placed in way of the masts in sailing yachts.

In sailing yachts with the mast resting on the deck or on the deckhouse, a pillar or bulkhead is to be arranged in way of the mast base.

2 Definitions and symbols

2.1

2.1.1

pdc : calculation deck, meaning the first deck above the full load waterline, extending for at least 0,6 L and constituting an efficient support for the structural elements of the side; in theory, it is to extend for the whole length of the yacht;

s : spacing of transverse or longitudinal ordinary stiffeners, in m;

h_B, h_T : scantling height, in m, the value of which is given in Pt B, Ch 1, Sec 5;

K_o, K_{of} : factor defined in Sec 2;

L_1 : scantling length, in m, to be assumed not less than 15 m.

3 Deck plating

3.1 Weather deck

3.1.1 The thickness of the weather deck plating, considering that said deck is also a strength deck, is to be not less than the value t, in mm, calculated with the following formula:

$$t = 0,15 \cdot k_a \cdot s \cdot k_{of} \cdot L_1^{0,5}$$

On yachts of L > 30 m a stringer plate is to be fitted with width b, in m, not less than 0,025 L and thickness t, in mm, not less than the value given by the formula

$$t = 0,2 \cdot k_a \cdot s \cdot k_{of} \cdot L_1^{0,5}$$

where k_a is defined in 5.1 in Sec 5 and L_1 is the length of the scantling, to be assumed not less than 15 m.

3.2 Lower decks

3.2.1 The thickness of decks below the weather deck intended for accommodation spaces is to be not less than the value calculated with the formula:

$$t = 0,13 \cdot k_a \cdot s \cdot k_o \cdot L_1^{0,5}$$

where k_a is defined in Sec 5, [5.1].

Where the deck is a tank top, the thickness of the deck is, in any event, to be not less than the value calculated with the formulae given in Sec 10 for tank bulkhead plating.

4 Stiffening and support structures for decks

4.1 Ordinary stiffeners

4.1.1 The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value Z, in cm^3, calculated with the following equation:

$$Z = 14 \cdot s \cdot S^2 \cdot h \cdot k_o \cdot C_1$$

where:

C_1 : 1 for weather deck longitudinals
: 0,63 for lower deck longitudinals
: 0,56 for beams.

4.2 Reinforced beams

4.2.1 The section modulus for girders and for ordinary reinforced beams is to be not less than the value Z, in cm^3, calculated with the following equation:

$$Z = 15 \cdot b \cdot S^2 \cdot h \cdot k_o$$

where:

b : average width of the strip of deck resting on the beam, in m. In the calculation of b, any openings are to be considered as non-existent

S : conventional span of the reinforced beam, in m, equal to the distance between the two supporting members (pillars, other reinforced beams, bulkheads).

4.3 Pillars

4.3.1 Pillars are, in general, to be made of steel or aluminium alloy tubes, and connected at both ends to plates supported by efficient brackets which allow connection to the hull structure by means of bolts. Details are to be sent for approval.

The section area of pillars is to be not less than the value A, in cm², given by the formula:

$$A = \frac{Q \cdot C}{12,5 - 0,045\lambda}$$

where:

Q : load resting on the pillar, in kN, calculated with the following formula:

$$Q = 6,87 \cdot A \cdot h$$

where:

A : area of the part of the deck resting on the pillar, in m².

h : scantling height, defined in [2.1.1].

λ : the ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

C : 1 for steel pillars

: 1,6 for aluminium alloy pillars.

4.3.2 Pillars are to be fitted on main structural members. Wherever possible, deck pillars are to be fitted in the same vertical line as pillars above and below, and effective arrangements are to be made to distribute the load at the heads and heels of all pillars.

4.3.3 The attachment of pillars to sandwich structures is, in general, to be through an area of single-skin laminate. Where this is not practicable and the attachment of the pillar has to be by through bolting through a sandwich structure then a wood or other suitable solid insert is to be fitted in the core in way.

SECTION 10 BULKHEADS

1 General

1.1

1.1.1 The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Chapter 1 of Part B.

The scantlings indicated in this Section refer to bulkheads made of reinforced plastic both in single-skin and in sandwich type laminates.

Whenever bulkheads, other than tank bulkheads, are made of wood, it is to be type approved marine plywood and the scantlings are to be not less than those indicated in Chapter 5 of Part B.

Pipes or cables running through watertight bulkheads are to be fitted with suitable watertight glands.

2 Symbols

2.1

2.1.1

s : spacing between the stiffeners, in m

S : conventional span, equal to the distance, in m, between the members that support the stiffener concerned

h_s, h_B : as defined in Pt B, Ch 1, Sec 5

k_o, k_{of} : as defined in Sec 2 of this Chapter.

3 Plating

3.1

3.1.1 The watertight bulkhead plating is to have a thickness not less than the value t_S, in mm, calculated with the following formula:

$$t_S = k_1 \cdot s \cdot k_{of} \cdot h^{0,5}$$

The coefficient k_1 and the scantling height h have the values indicated in Table 1.

Table 1

Bulkhead	k_1	h (m)
Collision bulkhead	5,8	h_B
Watertight bulkhead	5,0	h_B
Deep tank bulkhead	5,3	h_T

4 Stiffeners

4.1 Ordinary stiffeners

4.1.1 The section modulus of ordinary stiffeners is to be not less than the value Z, in cm^3, calculated with the following formula:

$$Z = 13,5 \cdot s \cdot S^2 \cdot h \cdot c \cdot k_o$$

The values of the coefficient c and of the scantling height h are those indicated in Table 2.

4.2 Reinforced beams

4.2.1 The horizontal webs of bulkheads with ordinary vertical stiffeners and reinforced stiffeners in the bulkheads with horizontal ordinary stiffeners are to have a section modulus not less than the value Z, in cm^3, calculated with the following formula:

$$Z = C_1 \cdot b \cdot S^2 \cdot h \cdot k_o$$

where:

C_1 : 10,7 for subdivision bulkheads

: 18 for tank bulkheads

b : width, in m, of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener

h : scantling height indicated in Table 2.

Table 2

Bulkhead	h (m)	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Deep tank bulkhead	h_T	1

5 Tanks for liquids

5.1

5.1.1 See Sec 1, [6.3].

SECTION 11 SUPERSTRUCTURES

1 General

1.1

1.1.1 First tier superstructures or deckhouses are intended as those situated on the uppermost exposed continuous deck of the yacht, second tier superstructures or deckhouses are those above, and so on.

Where the distance from the hypothetical freeboard deck to the full load waterline exceeds the freeboard that can hypothetically be assigned to the yacht, the reference deck for the determination of the superstructure tier may be the deck below the one specified above, see Ch 1, Sec 1, [4.3.2].

When there is no access from inside superstructures and deckhouses to 'tweendecks below, reduced scantlings with respect to those stipulated in this Section may be accepted at the discretion of Tasneef

2 Boundary bulkhead plating

2.1

2.1.1 The thickness of the boundary bulkheads is to be not less than the value t, in mm, calculated with the following formula:

$$t = 3,7 \cdot s \cdot K_{Of} \cdot h^{0,5}$$

s : spacing between the stiffeners, in m

h : conventional scantling height, in m, the value of which is to be taken not less than that indicated in Table 1

K_{of} : factor defined in Sec 2.

Table 1

Type of bulkhead	h (m)
1st tier front	1,5
2nd tier front	1,0
Other bulkheads wherever situated	1,0

In any event, the thickness t is to be not less than the values shown in Table 2 of Sec 1 of this Chapter.

3 Stiffeners

3.1

3.1.1 The stiffeners of the boundary bulkheads are to have a section modulus not less than the value Z, in cm^3, calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K_o$$

where:

h : conventional scantling height, in m, defined in 2 .1

K_o : factor defined in Sec 2

s : spacing of the stiffeners, in m

S : span of the stiffeners, equal to the distance, in m, between the members supporting the stiffener concerned.

4 Superstructure decks

4.1 Plating

4.1.1 The superstructure deck plating is to be not less than the value t, in mm, calculated with the following formula:

$$t = 3,7 \cdot s \cdot K_{Of} \cdot h^{0,5}$$

where:

s : spacing of the stiffeners, in m

K_{of} : factor defined in Sec 2

h : conventional scantling height, in m, defined in 2.1.

4.2 Stiffeners

4.2.1 The section modulus Z, in cm^3, of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K_o$$

where:

S : conventional span of the stiffener, equal to the distance, in m, between the supporting members

s, h, K_o : as defined in 3.1

Reinforced beams (beams, stringers) and ordinary pillars are to have scantlings as stated in Sec 9.

SECTION 12 SCANTLINGS OF STRUCTURES WITH SANDWICH CONSTRUCTION

1 Premise

1.1

1.1.1 The sandwich type laminate taken into consideration in this Section is made up of two thin laminates in reinforced plastic bonded to a core material with a low density and low values for the mechanical properties.

The core material is, in general, made up of balsa wood, plastic foam of different densities or other materials (honeycomb) which deform easily under pressure or traction but which offer good resistance to shear stresses.

The thicknesses of the two skins are negligible compared to the thicknesses of the core.

The thickness of the core is to be not less than 6 times the minimum thickness of the skins.

The thicknesses of the two skins are to be approximately equal; the thickness of the external skin is to be no greater than 1,33 times the net thickness of the internal skin.

The moduli of elasticity of the core material are negligible compared to those of the skin material.

Normal forces and flexing moments act only on the external faces, while shear forces are supported by the core .

The scantlings indicated in the following Articles of this Section are considered valid assuming the above-mentioned hypotheses.

The scantlings of sandwich structures obtained differently and/or with core materials or with skins not corresponding to the above-mentioned properties will be considered case-by-case on the principle of equivalence, on submission of full technical documentation of the materials used and any tests carried out.

2 General

2.1 Laminating

2.1.1 Where the core material is deposited above a prefabricated skin, as far as practicable the former is to be applied after the polymerisation of the skin laminate has passed the exothermic stage.

2.1.2 Where the core is applied on a pre-laminated surface, even adhesion is to be ensured.

2.1.3 When resins other than epoxide resins are used, the layer of reinforcement in contact with the core material is to be of mat.

2.1.4 Prior to proceeding with glueing of the core, the latter is to be suitably cleaned and treated in accordance with the Manufacturer's instructions.

2.1.5 Where the edges of a sandwich panel are to be connected to a single-skin laminate, the taper of the panel is not to exceed 30°.

In zones where high density or plywood insert plates are arranged, the taper is not to exceed 45°.

2.2 Vacuum bagging

2.2.1 Where the vacuum bagging system is used, details of the procedure are to be submitted for examination.

The number, scantlings and distribution of venting holes in the panels are to be in accordance with the Manufacturer's instructions.

The degree of vacuum in the bagging system both at the beginning of the process and during the polymerisation phase is not to exceed the level recommended by the Manufacturer, so as to avoid phenomena of core evaporation and/or excessive monomer loss.

2.3 Constructional details

2.3.1 In general the two skins, external and internal, are to be identical in lamination and in resistance and elasticity properties.

In way of the keel, in particular in sailing yachts with a ballast keel, in the zone where there are hull appendages, such as propeller shaft struts and rudder horns, in way of the connection to the upper deck and in general where connections with bolts are foreseen, as a rule, single-skin laminate is to be used.

The use of a sandwich laminate in these zones will be carefully considered by Tasneef bearing in mind the properties of the core and the precautions taken to avoid infiltration of water in the holes drilled for the passage of studs and bolts.

The use of sandwich laminates is also ill-advised in way of structural tanks for liquids where fuel oils are concerned.

Such use may be accepted by increasing the thickness of the skin in contact with the liquid, as indicated in Section 10.

3 Symbols

3.1

3.1.1

S : conventional span of the strip of sandwich laminate equal to the minimum distance, in m, between the structural members supporting the sandwich (bulkheads, reinforced frames);

p : scantling pressure, in kN/m², as defined in Pt B, Ch 1, Sec 5;

h : scantling height, in m, given in Pt B, Ch 1, Sec 5;

R_{to} : ultimate tensile strength, in N/mm², of the external skin;

R_{ti} : ultimate tensile strength, in N/mm², of the internal skin;

R_{co} : ultimate compressive strength, in N/mm², of the external skin;

R_{ci} : ultimate compressive strength, in N/mm², of the internal skin;

τ : ultimate shear strength, in N/mm², of the core material of the sandwich;

h : net height, in mm, of the core of the sandwich.

4 Minimum thickness of the skins

4.1

4.1.1 The thickness of the skin laminate is to be sufficient to obtain the section modulus prescribed in the following Articles; furthermore, it is to have a value, in mm, not less than that given by the following formulae:

a) Bottom

$$t_o = 0,50 \cdot (2,2 + 0,25L)$$

$$t_i = 0,40 \cdot (2,2 + 0,25L)$$

b) Side and weather deck

$$t_o = 0,45 \cdot (2,2 + 0,25L)$$

$$t_i = 0,35 \cdot (2,2 + 0,25L)$$

where:

t_o : thickness of the external laminate of the sandwich

t_i : thickness of the internal laminate of the sandwich.

Thicknesses less than the minimums calculated with the above formulae, though not less than those in Table 2, may be accepted provided they are sufficient in terms of buckling strength.

In the case of a sandwich structure with a core in balsa wood or polyurethane foam and other similar products, the critical stress σ_{CR}, in N/mm², given by the following formula, is to be not less than 1,1 σ_C:

$$\sigma_{CR} = 0,4 \cdot \frac{(E_F \cdot E_A \cdot G_A)^{1/3}}{1 - \nu^2}$$

where:

E_F : compressive modulus of elasticity of the laminate of the skin considered, in, in N/mm²;

E_A : compressive modulus of elasticity of the core material of the skin considered, in N/mm²;

G_A : shear modulus of elasticity of the core material, in N/mm²;

σ_C : actual compressive strength on the skin considered, in N/mm²

ν : Poisson coefficient of the laminate of the skin considered.

5 Bottom

5.1

5.1.1 The section moduli Z_{So} and Z_{Si}, in cm³, corresponding to the external and internal skins, respectively, of a strip of sandwich of the bottom 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$Z_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

where:

k_1 : 1,6 assuming $p=p_1$

: 0,4 assuming $p=p_2$

The moment of inertia of a strip of sandwich 1 cm wide is to be not less than the value I_S, in cm⁴, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where:

R : the greater of the ultimate compressive strengths of the two skins, in N/mm²;

E_S : the mean of the four values of the compressive and tensile moduli of elasticity of the two skins, in N/mm²;

Z : Z_{So} or Z_{Si}, in cm³, whichever is the greater.

The net height of the core h_a, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{k_1 \cdot p \cdot S}{\tau}$$

where:

k_1 : 0,5 assuming $p=p_1$

: 0,2 assuming $p=p_2$

6 Side

6.1

6.1.1 The section moduli Z_{So} and Z_{Si}, in cm³, corresponding to the external and internal skins, respectively, of a strip of sandwich of the side 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$Z_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

where:

k_1 : 1,6 assuming $p=p_1$

: 0,4 assuming $p=p_2$

The moment of inertia of a strip of sandwich of the side 1 cm wide is to be not less than the value I_S, in cm^4, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where R and E_S are as defined in [5]:

The net height of the core h_a, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{k_1 \cdot p \cdot S}{\tau}$$

where:

k_1 : 0,5 assuming $p=p_1$

: 0,2 assuming $p=p_2$

7 Decks

7.1

7.1.1 The section moduli Z_{So} and Z_{Si}, in cm^3, corresponding to the external and internal skins, respectively, of a strip of sandwich of the deck 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{co}}$$

However, the modulus Z_{So} may be assumed not greater than that required for the side in [6.1], having the same conventional span S as defined in [3.1.1].

$$Z_{Si} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{ti}}$$

The moment of inertia of a strip of sandwich 1 cm wide is to be not less than the value I_S, in cm^4, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where R and E_S are as defined in [5].

The net height of the core h_a, in mm, is to be not less than the value given by the following formula:

$$h_a = \frac{7 \cdot h \cdot S}{\tau}$$

8 Watertight bulkheads and boundary bulkheads of the superstructure

8.1

8.1.1 *(1/7/2020)*

The scantlings shown in this Article apply both to subdivision bulkheads and to tank bulkheads.

They may also be applied to boundary bulkheads of the superstructure assuming for h the relevant value indicated in Ch 4, Sec 11.

The section modulus Z_S, in cm^3, and the moment of inertia I_S, in cm^4, of a strip of sandwich 1 cm wide are to be not less than the values given by the following formulae:

$$Z_S = 15 \cdot h \cdot S^2 \cdot \frac{1}{R}$$

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where:

R : the greater of the ultimate compressive strengths of the two skins, in N/mm^2;

E_S : the mean of the values of the compressive moduli of elasticity of the two skins, in N/mm^2;

The net height of the core h_a, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{7 \cdot h \cdot S}{\tau}$$

SECTION 13 STRUCTURAL ADHESIVES

1 General

1.1

1.1.1

Structural adhesives are to be used according to the Manufacturer's specifications. The details of the structural adhesives are to be enclosed in the list required in Ch 1, Sec 1, [3.1.1].

The above-mentioned information is to include the material data sheet containing all the details of the structural adhesive.

The process for the application of the adhesive is to be submitted and is to include:

- The maximum bond line thickness;
- Surface preparation and cleanliness of the surface to be bonded;
- Handling, mixing, application and curing requirements of the structural adhesive;
- Non-destructive test methods and acceptability criteria for any defects found;
- Remedial work in order to rectify excessive unevenness of the faying surface or local undulations;
- Details relevant to the level of training required for the personnel involved in the application of structural adhesives.

Details listed in the material data sheet are to be specified in the construction plan submitted for approval.

1.1.2 For hull for which structural adhesives are used, a special class notation will be assigned as indicated in Part A.

1.2

1.2.1 *(1/1/2021)*

The structural adhesives are to have the following properties:

a) The adhesive is to be compatible with the lamination resin;

b) It is recommended that the elastic modulus of the adhesive is should be compatible with the elastic modulus of the GRP skin: this means that the ratio between the two elastic moduli shall be such as to avoid stress concentration in the skin substrate when a longitudinal shear force is applied to the joint;

c) The mechanical properties of the adhesive are to be rapidly achieved. That means no use of screws or bolts is necessary to hold the substrate together while the adhesive cures;

d) A greater safety factor (ratio of failure strain to actual strain) than the one of the adjacent structure is to result;

e) The minimum shear strength obtained from a lap-shear test is to be not less than 7 N/mm². All failures of test samples are to be either cohesive or fibre tear.

f) The type approval of structural materials is issued by Tasneef subject to the satisfactory outcome of the following test carried out on the basis of a testing scheme agreed with Tasneef

   1) Lap-shear static test to be performed according to ASTM D3165 Standard using FRP substrates; the shear strength is to be achieved on:
      - 5 samples at the room temperature of 23° C ;
      - 5 samples at the room temperature of 23° C after exposure to 5 cycles of laboratory ageing according to ASTM D1183 Standard;

      Requirements to be complied with: the average of the results obtained after conditioning according to ASTM D1183 is to be not less than 85% of the average of the results without conditioning.

   2) Peel-static test to be performed according to ASTM D3807 Standard using FRP substrates; the strength properties are to be achieved on:
      - 5 samples at the room temperature of 23° C;
      - 5 samples at the room temperature of 23° C after exposure to 5 cycles of laboratory ageing according to ASTM D1183 Standard.

      Requirements to be complied with: the average of the results obtained after conditioning according to ASTM D1183 is to be not less than 85% of the average of the results without conditioning.

   3) Lap-shear fatigue dynamic test to be performed according to ASTM D3166 Standard using substrates that can be metallic; the shear strength is to be achieved on:
      - 5 samples at the room temperature of 23 °C after exposure to 2 cycles of laboratory ageing according to ASTM D1183 Standard.

      Requirements to be complied with: the sample shall withstand without breaks the fatigue tests carried out at a frequency declared by the Manufacturer normally not less than 10 Hz, generally applying a sinusoidal load of with maximum 50% and minimum of 5% of the static shear strength for 1,000,000 cycles.

   For adhesive used only for the gluing of glazing different testing criteria and conditions may be agreed with Tasneef

   The validity of the type approval is 5 years.

2 Design criteria for bonded connection

2.1

2.1.1 In general the shear stress at the inner surface of the plating is to be calculated by direct calculations according to the requirements of Ch 1, Sec 5. In general, the calculation of the flange connection between the internal reinforcement and the plating is to be carried out as indicated in this paragraph.

A typical stiffener/plating connection is shown in the following Fig 1:

The linear load due to the bending moment calculated at the inner surface plating can be obtained from the following formula:

$$Q_p = \frac{P \times (E \times A)_p \times Y_p}{(E \times I)_{sp}}$$

where:

Q_p : is the linear load in N/mm applied to the inner surface of the plating and due to the bending moment ;

P= 500 x p x s x S: is the total load in N applied to the panel of dimension (Sxs) and due to the design pressure as calculated according to items Ch 1, Sec 5, [5.3] and Ch 1, Sec 5, [5.4];

$ExA=E_p \times b \times t_p$;

where:

E_p: is the inplane elastic modulus of the plating in N/mm²;

b: is the width of the plate associated with the stiffener, in mm;

t_p : is the thickness of the associated plate, in mm ;

Y_p: is the distance from the centroid of the associated plate to the neutral axis, in mm ;

$(ExI)_{sp}$:is the flexural rigidity of the composite element (stiffener and plating) combined around the neutral axis, in N/mm²;

The shear stress for the jointing adhesive for plating can be calculated with the following formula:

$$\tau_p = \frac{Q_p}{b}(N/mm^2)$$

It is to be verified that τ_p is not greater than 20% of the nominal bond shear strength as indicated by the Manufacturer's adhesive. For guidance, Tab 1 indicates some data regarding the nominal shear strength and the allowable design stress for certain structural adhesives.

Figure 1

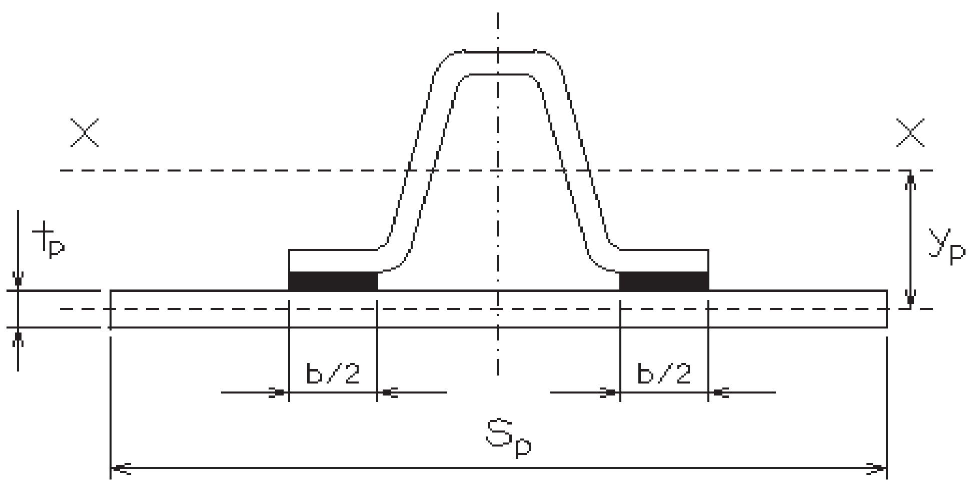


Table 1

Adhesive	Nominal bond shear strength [N/mm²]	Allowable design stress [N/mm²]
Cold-cured epoxy	28	5,2
Polyester or vinylester resin or paste	14	3,5
Epoxy type paste	41	8,5

Part B
Hull and Stability

Chapter 5
WOOD HULLS

SECTION 1 MATERIALS

1 Suitable timber species

1.1

1.1.1 The species of timber suitable for construction are listed in Table 1 together with the following details:

- commercial and scientific denomination;
- natural durability and ease of impregnation;
- average physical-mechanical characteristics at 12% moisture content.

The durability classes are relative to the solid timber's resistance to moulds.

The suitability for use in the various hull structures is given in Table 2.

The same species are suitable for the fabrication of marine plywood and lamellar structures in accordance with the provisions of Article 2 below.

The use of timber species other than those stated in Table 1 may be accepted provided that the characteristics of the species proposed are as similar as possible to those of one of the species listed.

2 Timber quality

2.1 Planking

2.1.1 The timber is to be well-seasoned, free from sapwood and any noxious organisms (moulds, insects, larvae, bacteria, etc.) which might impair its durability and structural efficiency.

The moisture content at the time of use is to be not greater than 20% (according to the method UNI 8939 Planking - Check of batch moisture content).

Knots may be tolerated when they are intergrown, provided that their diameter is less than 1/5 of the dimension parallel to such diameter, measured on the section of the knot. The grain is to be straight (the maximum admissible inclination in relation to the longitudinal axis of the piece is equal to a ratio of 1:10).

Note 1: Timber with the above characteristics corresponds roughly to Class 1 of UNI 8198 (Conifer planking - Classification on the basis of mechanical resistance).

2.2 Marine plywood and lamellar structures

2.2.1 The suitable timber species and criteria for the use of alternative species are listed in Table 1.

For marine plywood, the elevated temperatures reached during drying and pressing rule out the possibility of survival of insects and larvae in the finished panels. Moreover, this factor contributes in enabling the marine plywood to have a lower moisture content than that of solid timber of the same species in the same ambient conditions, rendering it less prone to attacks of mould.

Therefore, assuming the same species of timber, the durability of marine plywood is greater than that of solid timber.

In any case, the thickness of the individual layers constituting the plywood or the lamellar structure is to be reduced in direct proportion to the durability of the species used; the maximum recommended thicknesses are listed in Table 1.

The minimum number of plywood layers used in the construction is 3 for thicknesses not greater than 6 mm and 5 for greater thicknesses.

The marine plywood adopted for hull construction and structural parts in general is to be type tested by Tasneef in accordance with the relevant regulations.

2.3 Certification and checks of timber quality

2.3.1 The quality of timber, plywood and lamellar structures is to be certified as complying with the provisions of 2.1 and 2.2 by the builder to the Tasneef Surveyor, who, in the event of doubts or objections, will verify the circumstances by performing appropriate checks.

Such certification is to refer to the checks carried out during building survey in the yard, relative to the following characteristics:

a) for solid timber: mass density and moisture content;

b) for plywood and lamellar structures: glueing test.

Such checks are not required for Quality Assurance material certified by Tasneef in pursuance of the relevant regulations.

2.4 Mechanical characteristics and structural scantlings

2.4.1 The structural scantlings indicated in this Chapter apply to timber with the following density δ, in kg/m^3, at a moisture content not exceeding 20%:

- bent frames: $\delta = 720$
- non-bent frames keel and stem: $\delta = 640$
- shell and deck planking, shelves and clamps, stringers and beams: $\delta = 560$.

The scantlings given in the following Articles may be modified as a function of the density of the timber employed and its moisture content, in accordance with the relationship:

$$S_1 = S / K$$

$$K = \frac{\delta_e}{\delta} + (U - U_e) \cdot 0,02$$

S_1 : corrected section (or linear dimension)

S : Rule section (or linear dimension), obtained in accordance with this Chapter

δ : density of the timber species (or plywood) used;

δ_e : standard density of the timber species of reference;

U : standard moisture content percentage (20% for solid timber, 15% for plywood or lamellar structures);

U_e : maximum expected moisture content balance for the part considered, in service conditions.

Reductions in scantlings exceeding those obtained using the formulae above may be accepted on the basis of the mechanical base characteristics of the timber, plywood or lamellar structures actually employed.

Table 1 : Basic physical/mechanical characteristics of timbers for construction

Commercial name	Origin **(1)**	Botanical name **(2)**	Mass density (kg/m³)	Natural durability **(3)**	Ease of impregation **(3)**	Mechanical characteristics **(4)**			
						R_f (N/mm²)	E_f (N/mm²)	R_c (N/mm²)	R_t (N/mm²)
DOUSSIE	Africa	Afzelia spp	800	A	4	114	16000	62	14,0
IROKO	Africa	Chlorophora excelsa	650	A/B	4	85	10000	52	12,0
KHAYA	Africa	Khaya spp	520	C	4	74	9600	44	10,0
MAKORE’	Africa	Tieghemella spp	660	A	4	86	9300	50	11,0
MAHOGANY	America	Swietenia spp	550	B	4	79	10300	46	8,5
OKOUME’	Africa	Aucoumea Kleineana	440	D	3	51	7800	27	6,7
ELM	Europe	Ulmus spp	650	D	2/3	89	10200	43	11,0
OAK	Europe	Quercus robur e Q. petraea	710	B	4	125	15600	68	13,0
SAPELE	Africa	Entandrophragma cylindricum	650	C	3	105	12500	56	15,7
SIPO	Africa	Entandrophragma utile	640	B/C	3/4	100	12000	53	15,0
TECK	Asia	Tectona grandis	680	A	4	100	10600	58	13,0
WHITE OAK	America	Quercus spp	730	B/C	4	120	15000	65	12,6
CHESTNUT	Europe	Castanea spp	600	B	4	59	8500	37	7,4
CEDAR (Western Red)	America	Thuja plicata	380	B/C	3	51	7600	31	6,8
DOUGLAS FIR	America	Pseudotsuga menziesil	500	C/D	3/4	85	13400	50	7,8
LARCH	Europe	Larix decidua	550	C/D	3/4	89	12800	52	9,4

Abbreviations:

Natural durability
- A = very durable
- B = durable (maximum permissible thickness for the fabrication of marine plywood 5 mm)
- C = not very durable (maximum permissible thickness for the fabrication of marine plywood 2,5 mm)
- D = not durable (maximum permissible thickness for the fabrication of marine plywood 2 mm)

Ease of treatment for impregnation
- 1 = permeable
- 2 = not very resistant
- 3 = resistant
- 4 = very resistant

Note

(1) Area of natural growth
(2) Unified botanical name (spp = different species)
(3) Level of natural durability and ease of treatment for impregnation according to Standard EN 350/2
(4) Mechanical characteristics with 12% moisture content, source: Wood Handbook: wood as an engineering material - 1987, USDA
- Ultimate flexural strength R_f (strength concentrated amidships)
- Bending modulus of elasticity E_f (strength concentrated amidships)
- Ultimate compression strength R_c (parallel to the grain)
- Ultimate shear strength R_t (parallel to the grain).

Table 2 : Guide for selections of construction timbers

	SPECIES OF TIMBER										
STRUCTURAL ITEM	Douglas	Cedar(red)	Iroko	Larch	Makore	Mahorgany	Elm english	White oak	Oak	Sapeli	Teak
Keel, hog, sternpost, deadwoods			II		II	II	II	II	II	III	I
Stern					II	II	II	II	II	III	I
Bilge stringer	III			II				II		III	I
Beam shelves, clamps waterways	III		II	II				II	II	III	I
Floors					II	II	II	II	II		I
Frames grown or web frames				II **(2)**	II			II **(1)**	II **(1)**	III	I
Frames, bent frames								II **(1)**	II **(1)**		
Planking below water-line	III		II	II		II		II	II	III	I
Planking above water-line	III		II	III		II		II		III	I
Deck planking	II	III	II								I
Beams, bottom girders	II			II	II **(2)**	II **(2)**		II **(1)**	II **(1)**		I
Brackets vertical				II				II **(1)**	II		
Bracket horizontal				II				I	I		
Gunwale margin planks			II			II		II	II		

Note

(1) The timber concerned may be employed either in natural or laminated form.

(2) The timber may be employed only in laminated form.

Suitability of timber for use:

I = very suitable

II = fairly suitable

III = hardly suitable

SECTION 2 FASTENINGS, WORKING AND PROTECTION OF TIMBER

1 Fastenings

1.1

1.1.1 Glues for timber fastenings are to be of resorcinic or phenolic type, i.e. durable and water-resistant in particular.

Ureaformaldehyde glues may only be used in well-ventilated parts of the hull not subject to humidity.

Glues are to be used according to the Manufacturer's instructions on timber with moisture content not exceeding 15-18% or, for urea-type glues, 12,5-15%.

The parts to be glued are to be carefully prepared and cleaned and, in particular, all traces of grease are to be removed.

Where rivets, screws and bolts are not made of material recognised as suitable for resisting corrosion from the marine environment, they are to be hot galvanised in accordance with a recognised standard. In the absence of such standard, after rivets, screws and bolts have been hot galvanised and subsequently machine finished, the protective zinc coating on their surfaces is to remain intact.

Through bolts are to be clinched on washers, or tightened by a nut, also on washers. Nuts and washers are to be of the same material as that of the bolts.

Where connecting bolts go through shell planking or keel, they are to have heads packed with cotton or other suitable material.

Where screw fastenings are used for planking, the threading is to penetrate the support frame for a distance equal to the planking thickness.

1.2

1.2.1 The use of suitable glues in place of mechanical connections will be the subject of special consideration by Tasneef

In general, such replacement of fastening methods will be accepted subject to the satisfactory outcome of tests, on representative samples of the joints, conducted with procedures stipulated on the basis of the type of glue, the type of connection and any previous documented applications.

In any event, Tasneef reserves the right to require a minimum number of mechanical connections.

2 Timber working

2.1

2.1.1 Timber working is to be appropriate to the species and hardness of the timber, as well as to the type of hull construction, e.g. grown or web frames, lamellar structures, board or plywood planking.

Lamellar structure is generally employed for bent structural parts, with lamellas as continuous as possible or with scarf joints and normally glued before bending.

The lamellas are generally to be made using the same species of timber.

The lamellas are to be arranged with their fibres parallel to the length of the element to be constructed.

3 Protection

3.1

3.1.1 Inaccessible surfaces of internal hull structures are to be treated with a suitable wood preservative according to the Manufacturer's instructions and compatible with the glues, varnishes and paints employed. The timber of the internal bottom of the hull is to be smeared with oil or varnish; any synthetic resins used as coating are to be applied to dry timber with the utmost care.

All cut edges of plywood are to be sealed with glue, paint or other suitable products such as to prevent the penetration of moisture along the end-grain.

SECTION 3 BUILDING METHODS FOR PLANKING

1 Shell planking

1.1 Simple skin

1.1.1 Planks are to be arranged such that strake butts are at least 1,20 metres apart from those of adjacent strakes and at least three continuous strakes separate two butts arranged on the same frame.

The butts of garboards are to be arranged clear of those in the keel, and the butts of the sheerstrake are to be arranged clear of those of the waterway.

Butts may be strapped or scarfed, and wooden straps are to have thickness equal to that of the planking, width so as to overlap adjacent strakes by at least 12 mm and length as necessary for the connection while leaving a space for water drainage between the strap edge and the frame.

Scarfs are to have length not less than 5 times the planking thickness, to be centred on the frames and to be connected by means of glueing and pivoting.

1.2 Double diagonal skin

1.2.1 This consists of an inner skin of thickness not exceeding 0,4 of the total thickness and an outer skin arranged longitudinally.

1.3 Double longitudinal skin

1.3.1 This consists of an inner and outer skin, arranged such that the seams of the outer skin fall on the middle of the planks of the inner skin.

The inner skin is to have thickness not exceeding 0,4 of the total thickness and to be connected to the frames by means of screws or nails and to the outer skin by means of screws or through bolts. The outer skin is, in turn, to be connected to the frames by means of through bolts. When frames other than laminated frames are employed, the use of screws is permitted. A suitable elastic compound layer is to be arranged between the two skins.

1.4 Laminated planking in several cold-glued layers

1.4.1 The construction of cold moulded laminated planking is to be effected in loco at a constant temperature.

It is therefore of the utmost importance that the Manufacturer should be equipped with adequate facilities for this type of construction.

The planks forming the laminate are to be of width and thickness adequate for the shape of the hull; the width is generally not to exceed 125 mm.

The number of layers is to be such as to obtain the required thickness.

1.5 Plywood planking

1.5.1 Plywood planking consists of panels as large as practicable in relation to the shape of the hull. The butts are to be suitably staggered from each other and from machinery foundations.

The connection of seams is to be achieved by means of glue and bolts; the connection of butts is to be effected by means of scarfs or straps. Scarfs are to have length not less than 8 times the thickness and, where effected in situ, to be backed by straps, at least 10 times as wide as the thickness, glued and fastened.

The strap connection is to be effected using straps of the same plywood.

1.6 Double skin with inner plywood and outer longitudinal strakes

1.6.1 This consists of two layers: one internal of plywood, arranged as described in 1.5, the other external, formed by planks in longitudinal strakes arranged as described in 1.3. The plywood thickness is to be not less than 0,4 of the total thickness.

1.7 Fastenings and caulking

1.7.1 Butt-straps on shell planking (see Figure 1) are to be connected by means of through bolts of the scantlings given in Tab 1 for the connection of planking to frames, and are to be proportionate in number to the width a of panels, as follows:

- $a < 100$ mm
  3 bolts at each end of plank
- $100 \leq a < 100$ mm
  4 bolts at each end of plank
- $200 \leq a < 250$ mm
  3 bolts at each end of plank.

The number and scantlings of bolts to be used for connection of planking to frames are given in Tab 1.

The following types of connection are to be adopted:

- Type I framing: all through fastenings;
- Type II framing with grown or laminated frames: through bolts in way of bilge stringers or side longitudinals, wood screws for other connections;
- Type II framing with metal frames: all connections formed by through bolts with nuts;
- Type III framing: connections as above depending on whether bent, grown, laminated or steel frames are concerned.

All fastenings for strengthened frames in way of masts are to be through fastenings.

When plywood planking is adopted, it is to be connected to frames by means of nails or screws spaced 75 mm apart and with diameters as given in Tab 2.

Planks of shell planking, if not glued, are to have caulked seams and butts.

1.8 Sheathing of planking

1.8.1 When use is made of reinforced plastic or synthetic resin sheathing, the hull is to be prepared by carefully levelling every joint and filling every bolt hole with suitable compounds after adequate sinking of the bolts. The protective sheathing is to cover keel, false keel and deadwood as far as practicable, prior to the fitting of external ballast in the keel, where envisaged.

When sheathing is applied, the moisture content of the timber is to be as low as possible.

2 Deck planking

2.1 Planking

2.1.1 The butts of planks of two contiguous strakes are to be spaced at least 1,20 metres apart; two plank butts on the same beam are to be separated by at least three strakes of continuous planking.

Butts are to be set onto a beam and may be simple or scarfed.

2.2 Plywood

2.2.1 Plywood panels are to be as long as possible. The butts are to be arranged clear of those of adjacent panels and are to be strapped or otherwise set onto a strong beam. Longitudinal joints are to be set onto longitudinal structures of sufficient width for the connection. All joints are to be sealed watertight.

2.3 Plywood sheathed with laid deck

2.3.1 The butts of plywood panels are to be in accordance with the specifications given in 2.2.1, while the distribution of plank butts is to comply with the provisions of 2.1.1.

2.4 Longitudinal planking

2.4.1 When longitudinal planking is adopted, each plank is to be fastened to beams by means of a wood screw or lateral nail. In addition, each plank may be connected to that adjacent by means of a glued, sunk-in strip.

Plywood planking is to be glued and riveted to beams, or otherwise fastened by means of screws with pitch not less than 75 mm and diameter in accordance with that shown in Tab 1.

2.5 Caulking

2.5.1 Wood planking is to be caulked or made watertight by the application of a suitable elastic compound.

Wooden dowels used to cover bolt holes are to be glued.

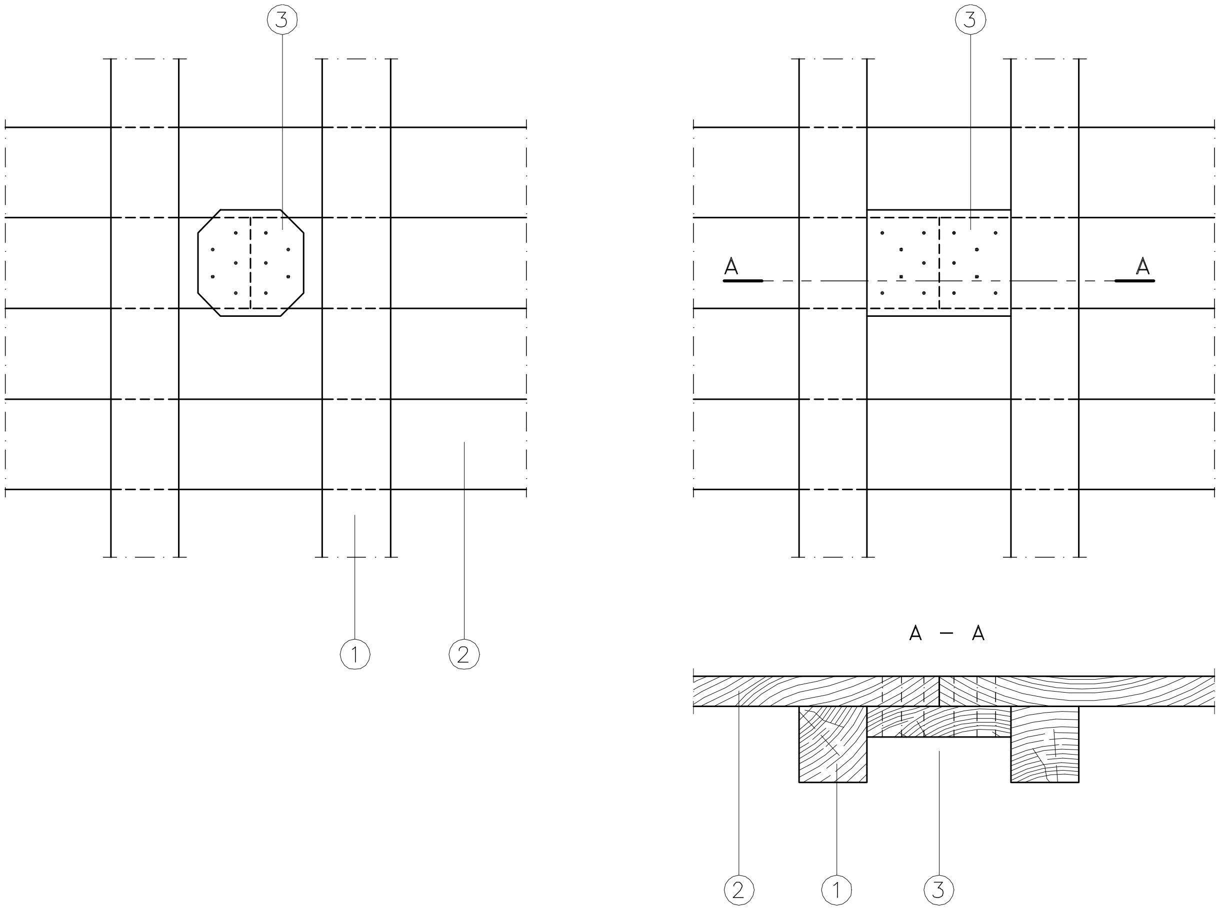
Table 1 : Connections of shell and deck planking - scantlings of fastenings

Thickness of planking mm	SHELL PLANKING				DECK PLANKING		NUMBER OF FASTENINGS PER PLANK				
	Grown frame: laminated, or steel frames			Bent frames	Wood screws diameter mm	Bolts with nuts diameter mm	Width a of plank mm				
	diameter			diameter							
	bolts with nuts mm	wood screws mm	Copper nails mm	copper nails mm			**a** < 100	100 ≤ **a** <150	150 ≤ **a** <180	180 ≤ **a** <205	205 ≤ **a** <225
18	4,5	5	4,5	2,5	4,5	4,5	2	2	3	3	3
20	4,5	5	5	3	5	4,5	2	2	3	3	3
22	6	5	6,5	3,5	5	6	2	2	3	3	3
24	6	5	6,5	3,5	5,5	6	2	2	3	3	3
26	7	5,5	6,5	3,5	5,5	6	1	2	2	3	3
28	7	5,5	6,5	4,5	5,5	6	1	2	2	3	3
30	7	5,5	6,5	4,5	5,5	6	1	2	2	3	3
32	8	6,5	7,5	5	6,5	8	1	2	2	3	3
34	8	6,5	7,5	5,5	6,5	8	1	2	2	3	3
36	8	7	7,5	5,5	6,5	8	1	2	2	2	3
38	8	7	7,5	5,5	7	8	1	2	2	2	3
40	9	8	9,5	6	7	8	1	2	2	2	3
42	9	8	9,5	6	7	9	1	2	2	2	3
44	10	8	9,5	-	8	9	1	2	2	2	3
46	12	8,5	11	-	8	10	1	2	2	2	3
48	12	8,5	11	-	8	10	1	2	2	2	3
50	14	10	12,5	-	8,5	12	1	2	2	2	3
52	14	10	12,5	-	8,5	12	1	2	2	2	3

Table 2 : Connections of shell and deck planking in plywood

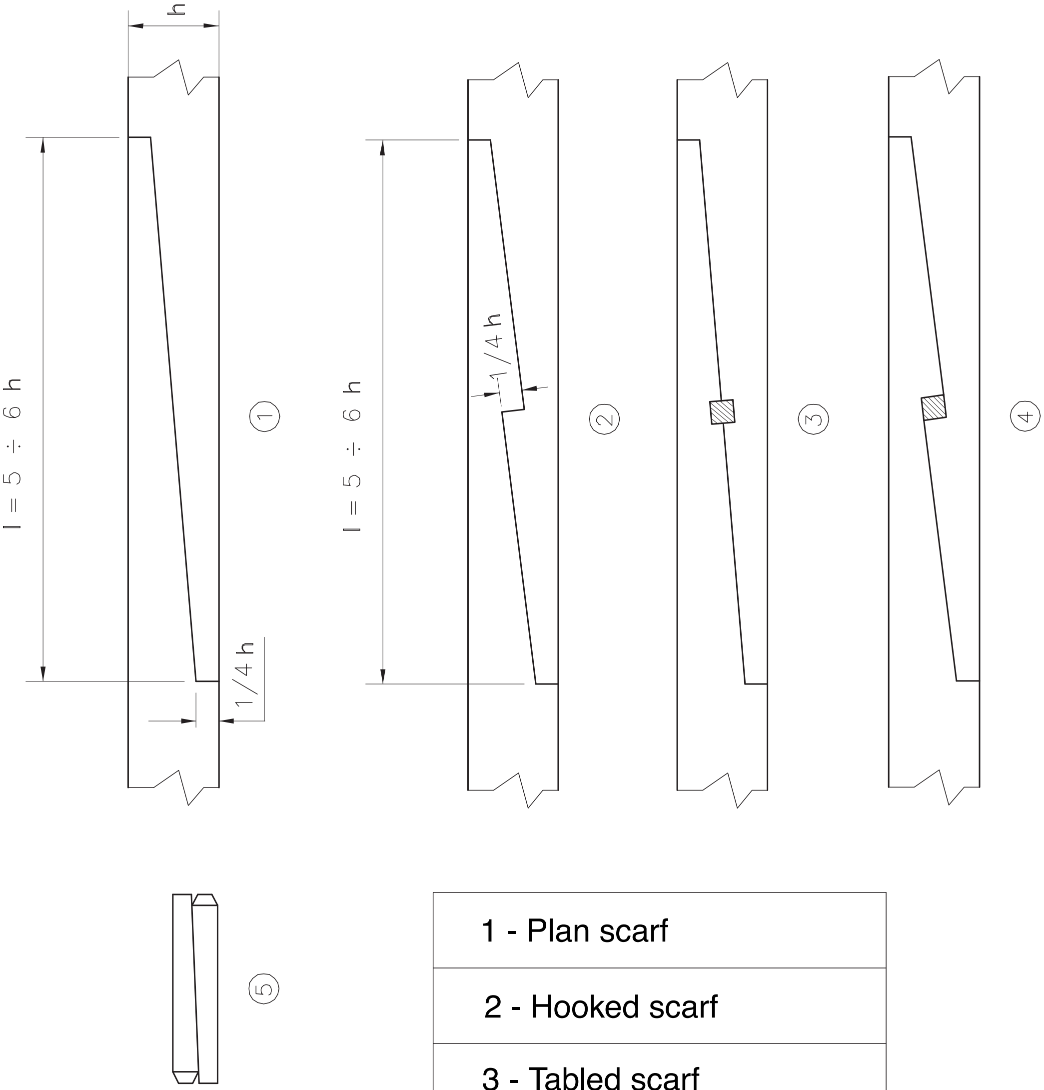
Thickness of plywood	OVERLAP OF SEAMS shell and deck planking, on keel, stringers, shelves, or carlings mm		Width of butt-straps mm		DIAMETER OF FASTENINGS	
					Wood screws mm	Copper nails mm
6 8 10	25 28 32	single fastening	150 175 200	single fastening	4,5 5 5	3,5 3,5 4,5
12 14 16	35 35 45		225 250 280		5,5 5,5 5,5	4,5 5 5
18 20 22	45 50 50	double fastenings	350 350 350	double fastenings	6,5 6,5 6,5	5 5,5 6
24 26	60 60		380 380		7 7	6,5 6,5

Figure 1 : Butt-straps on shell planking



1 - Frame	
2 - Shell planking	
3 - Butt - strap	

Figure 2 : Usual types of scarf-joints



1 - Plan scarf
2 - Hooked scarf
3 - Tabled scarf
4 - Tabled hooked scarf
5 - Double wedges

SECTION 4 STRUCTURAL SCANTLINGS OF SAILING YACHTS WITH OR WITHOUT AUXILIARY ENGINES

1 General

1.1

1.1.1 The scantlings in this Section apply to hulls of length **L** not exceeding 30 metres with round bottom of shape similar to that shown in Fig 1 and Fig 2, and fitted with fixed ballast or drop keel. Subject to Tasneef authorisation the value of the structural scantlings for yachts more than 30 metres but not more than 40 metres in length may be calculated by linear interpolation of the results for yachts not more than 30 metres, given in this Section.

Yachts of length **L** exceeding 30 metres or hull shapes other than the above will be considered in each case on the basis of equivalence criteria.

2 Keel

2.1

2.1.1 The scantlings of wooden keels are given in Tab1.

The keel thickness is to be maintained throughout the length, while the width may be gradually tapered at the ends so as to be faired to the stem and the sternpost.

The breadth of the rabbet on the keel for the first plating strake is to be at least twice the thickness and not less than 25 mm.

The wooden keel is to be made of a minimum number of pieces; scarf joints may be permitted with scarf 6 times as long as the thickness and tip 1/4 to 1/7 of the thickness of the hooked or tabled type, if bolted, or of the plain type, if glued. It is recommended that scarfs should not be arranged near mast steps or ends of engine foundation girders.

Where the keel is cut for the passage of a drop keel, the width is to be increased.

Where the mast is stepped on the keel, it is to be arranged aft of the forward end of the ballast keel. Where this is not practicable, effective longitudinal stiffeners are to be arranged extending well forward and aft of the mast step and effectively connected to the keel.

Bolted scarfs are to be made watertight by means of softwood stopwaters.

3 Stempost and sternpost

3.1

3.1.1 The stempost is to be adequately scarfed to the keel and increased in width at the heel as necessary so as to fit the keel fairing.

Stempost scantlings are given in Tab 1.

The sternframe is shown in Fig 3 and sternpost scantlings are given in Tab 1.

The lower portion of the sternpost is to be tenoned or otherwise attached to the keel. The connection is completed by a stern deadwood and a large bracket fastening together false keel, keel and post by means of through bolts.

The counter stern is to be effectively connected to the sternpost; where practicable, such connection is to be effected by scarfs with through bolts.

The cross-sectional area of the counter stern at the connection with the sternpost is to be not less than that of the latter; such area may be reduced at the upper end by 25%.

4 Frames

4.1 Types of frames

4.1.1 Bent frames

Bent frames consist of steam warped listels. Their width and thickness are to be uniform over the whole length; the frames are to be in one piece from keel to gunwale and, where practicable, from gunwale to gunwale, running continuous above the keel.

Table 1 : Keel, Stempost, Sternpost

: Length L m	Keel		Stempost				Sternpost	
			at heel		at head			
	Width mm	Depth mm	Width mm	Depth mm	Width mm	Depth mm	Depth mm	Depth mm
24	435	240	240	240	190	190	190	190
26	455	255	255	255	200	200	200	200
28	470	270	270	270	215	215	215	215
30	480	290	290	290	230	230	230	230

4.1.2 Grown frames

Grown frames consist of naturally curved timbers connected by means of scarfs, or butted and strapped. Their width is to be uniform, while their depth is to be gradually tapered from heel to head.

The length of scarfs is to be not less than 6 times the width, and they are to be glued.

4.1.3 Laminated frames

Laminated frames consist of glued wooden layers. The glueing may take place before forming where the latter is slight; otherwise it should be carried out in situ or be prefabricated by means of suitable strong moulds.

4.1.4 Metal frames

Steel frames consist of angles properly curved and bevelled such that the flange to planking is closely fayed to the same planking.

4.2 Framing systems and scantlings

4.2.1 The admissible framing systems and the frame scantlings are indicated in Tables 2 and 3:

Type I : all equal frames, of the bent type;

Type II : all equal frames, of grown, laminated or steel angle type;

Type III : frames of scantlings as required for Type II, but alternated with one, two or three bent frames.

These types are hereafter referred to, respectively, as Type III_1, Type III_2, Type III_3.

When a frame spacing other than that specified in the Table is adopted, the section modulus of the frame is to be modified proportionally. For wooden rectangular sections, a being the width and b the height of the Rule section for the spacing s, a_1 and b_2 the actual values for the assumed spacing s_1, it follows that:

$$a_1\ b_1^2 = a \cdot b^2\ \frac{s_1}{s}$$

The width of frames is to be not less than that necessary for the fastening; their depth is in any case to be assumed as not less than 2/3 of the width, except where increased width is required for local strengthening in way of masts.

The table scantlings, duly modified where necessary for the specific gravity of the timber and for the frame spacing, are to be maintained for 0,6 of the hull length amidships; outside such zone, the following reductions may be applied:

- for bent or laminated frames: 10% in width,
- for grown frames: 20% in width throughout the length of the frame, and 20% in depth of the head,
- metal frames: 10% in thickness.

Frames may have a reduction in strength of 25% where cold laminated planking is adopted in situ, in accordance with the provisions of 8.

Frames are to be properly shaped so as to fit the planking perfectly.

Where no floors are arranged, the frames are to be wedged into and fastened at the heels of the centreline structural member of the hull.

When internal ballast supported by the frames is arranged, the latter are to be increased in scantlings.

Frames adjacent to masts are to be strengthened on each side as follows, or equivalent arrangements are to be provided.

- Type I framing

  Three grown frames are to be fitted, with scantlings as required for Type II framing, but with constant depth equal to that indicated in Tab 3 for the heel. Such frames are to be arranged instead of alternate bent frames. Otherwise, six consecutive bent frames with a cross-section increased by 60% in respect of that shown in the above-mentioned table may be fitted.

- Type II framing

  Three grown frames are to be fitted, with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned table and constant depth. Such frames are to be alternated with ordinary grown frames. If alternate frames are adopted, they are to be stiffened by reverse frames of scantlings as prescribed for the reverse frames of plate floors.

- Type III framing

  Three grown frames with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned table, and constant depth, are to be arranged at Rule spacing, with one or two intermediate bent frames. If steel frames are adopted, three are to be stiffened by reverse frames with scantlings as required for the frames of plate floors, and arranged with one or two intermediate bent frames.

Where, in way of the mast, a sufficiently strong bulkhead is provided, such increased frames may be reduced in number to two.

5 Floors

5.1 General

5.1.1 Floors may be made of wood or metal (steel or aluminium alloy).

- Wooden floors, as a rule, may only be employed in association with grown frames and are to be flanked by them.
- Metal floors are employed in association with either bent, grown or laminated frames, and are arranged on the internal profile of the frames.
- Angle floors may be employed with either bent, grown or laminated frames, and may be arranged as shown in Tab 1. When they are arranged with a flange inside, an angle lug is to be fitted in way of the throat, for the connection to the wooden keel (see the above table).
- Plate floors may be employed in association with either grown or angle frames (see the above-mentioned table). The internal edge is to be provided with a reverse angle or a flange; in the latter case, the thickness is to be increased by 10%.

5.2 Arrangement of floors

5.2.1 Where Type I framing with bent frames is adopted (see Tables 2 and 3), floors are to be fitted inside 0,6 L amidships as follows.

- on every second frame if the hull depth does not exceed 2,75 metres and on every frame in hulls of greater depth;
- on every second frame inside 0,6 L amidships, and outside such area over an extent corresponding to the length on the waterline;
- on every third frame elsewhere.

Where Type III framing is adopted, a floor is to be fitted in way of every grown, laminated or angle frame. Where one or two intermediate bent frames are arranged, and the depth D exceeds 2,40 metres, floors are to be fitted on bent frames located inside 0,6 L amidships.

Where three intermediate bent frames are arranged, a floor is to be fitted on the central frame.

5.3 Scantlings and fastenings

5.3.1 The scantlings of floors are given in Tables 4 and 5.

At the hull ends, the length of arms need not exceed one third of the frame span.

Wooden floors are to be made of suitably grained or laminated timber, and their height at the ends is to be not less than half the height of the throat.

Where the ballast keel bolts cross wooden floors, the width of the latter at the throat is to be locally increased, if necessary, so as to be not less than three and a half times the diameter of the bolt.

Table 2 : Frames

Depth D_1 mm **(1)**	TYPE I Bent frames only			TYPE II Grown frames, or laminated frames, or steel frames only							
					Grown frames			Laminated frames		Steel frames	
	spacing mm	width mm	depth mm	spacing mm	width mm	depth mm at heel	depth mm at head	width mm	depth mm	Section modulus cm^3	Scantlings mm **(2)**
3,00	215	57	40	305	61	74	53	81	52	3,1	50x50x5
3,20	225	62	43	322	68	83	58	93	59	4,4	60x30x6
3,40	235	67	46	340	75	91	68	103	66	6	65x50x7
3,60	245	72	49	355	81	100	80	117	74	7,9	75x50x6
3,80	255	77	52	375	87	112	92	122	84	10,2	80x60x7
4,00	265	82	55	390	94	124	100	131	94	12,5	90x60x7
4,20	-	-	-	408	100	140	117	143	102	14,5	90x60x8

(1) For hulls fitted with external ballast in the keel, 0,75 D_1, may be assumed in place of 0,75 D_1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D_1.
(2) The scantlings of bars are given for guidance purposes.
Solution I is only applicable where D_1 does not exceed 3,60 metres.
The frame spacing is intended as that measured amidships of the frame widths.

Table 3 : Frames

Depth D_1 mm **(1)**	TYPE III Main frames (grown or laminated) alternated with bent frames				
	Spacing between main frames and intermediate frames			Bent frames	
	1 bent frame mm	2 bent frames mm	3 bent frames mm	length mm	depth mm
3,00	515	620	695	43	33
3,20	560	650	730	45	35
3,40	590	690	770	48	39
3,60	620	725	800	50	43
3,80	650	765	840	53	47
4,00	680	800	870	56	51
4,20	-	-	-	-	-

(1) For hulls fitted with external ballast in the keel, 0,75 D_1, may be assumed in place of 0,75 D_1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D_1.
Solution I is only applicable where D_1, does not exceed 3,60 metres.
The frame spacing is intended as that measured amidships of the frame widths.

Table 4 : Frames

Depth D_1 mm (1)	FLOORS ON BENT FRAMES					Plate floors on grown or steel floors	
	Length of arms mm	forged		steel angle floors (2)			
		at throat mm	at the ends mm	section modulus cm^3	scantlings mm	for 2/3 L amidships mm	outside 2/3 L amidships mm
3,00	430	29x15	24x6	1,4	40x40x4	300x5	200x4
3,20	465	31x16	25x6	1,4	40x40x4	320x5	220x4
3,40	495	33x17	27x6	1,5	40x40x4	330x5	230x4
3,60	530	35x17	28x6	1,5	40x40x4	340x6	240x4
3,80	-	-	-	-	-	345x6	245x4
4,00	-	-	-	-	-	350x6	250x4
4,20	-	-	-	-	-	360x6	260x4

(1) For hulls fitted with external ballast in the keel, 0,75 D_1 may be assumed in place of D_1, può essere assunto 0,75 D_1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D_1.
(2) The scantlings of angle floors are given for guidance purposes.

Table 5 : Frames

Depth D_1 mm (1)	FLOORS ON GROWN OR LAMINATED FRAMES							
	Length of arms		forged floors		wooden floors		steel angle floors (2)	
	for 3/5 L amidships mm	outside 3/5 L amid-ships mm	at throat mm	at the ends mm	width mm	depth mm	section modulus cm^3	scantlings mm
3,00	580	430	56x22	50x12	51	135	2,40	45x45x5
3,20	610	460	60x24	52x13	56	148	3,60	50x50x6
3,40	650	500	64x26	54x14	60	160	5,70	55x55x8
3,60	680	530	69x28	56x16	64	170	6,90	60x60x8
3,80	720	560	73x30	58x17	70	180	6,90	60x60x8
4,00	750	590	77x31	61x18	75	190	9,00	65x65x9
4,20	780	620	80x31	63x20	80	200	10,0	70x70x9

(1) For hulls fitted with external ballast in the keel, 0,75 D_1, may be assumed in place of 0,25 circa. where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D_1.
(2) The scantlings of angle floors are given for guidance purposes.

Lugs for the connection of angle or plate floors to the wooden keel, if penetrated by the ballast keel bolts, are to have a flange width at least three times the diameter of the bolt and thickness equal to that of the plate floor plus 2,5 mm..

At the end of the hull, when frames are continuous through the centre structure, floors need not be fitted; whenever practicable, however, the frames are to be attached to the centre structure by means of three through bolts.

Floors are to be connected to frames by at least three bolts for arms with length l < 250 mm and at least 6 bolts for greater l; for diameters of bolts, see Table 10.

6 Beam shelves, beam clamps in way of masts, bilge stringers

6.1 Beam shelves

6.1.1 The cross-sectional area of beam shelves through 0,6 L amidships is to be not less than that indicated in Table 6. Outside such zone, the cross-section may be gradually decreased to reach, at the end, a value equal to 75% of that shown.

The cross-section to be considered is to be inclusive of the dappings for fixing of beams.

Where beam shelves are made of two or more pieces, the connection is to be effected by means of glued scarfs adequately arranged so as to be staggered in respect of the sheerstrake, waterway and bracket joints.

Scarfs are generally arranged vertically.

When the weather deck is not continuous owing to the presence of raised decks, the shelf is to extend to the hull end or, alternatively, stiffeners are to be fitted to prevent excessive discontinuity due to the interruption of the deck. The scantlings of frames may be required to be increased.

Where angle frames are employed, reverse lugs are to be fitted in order to allow connection to the beam shelf. When Type III framing is adopted, the shelf is to rest on the bent frames with interposition of suitable chocks.

The shelves are to be connected to each frame by a through bolt for heights ≤ 180 mm and by two through bolts for greater heights. If metal frames are adopted, bolting of the shelf is to be effected on a reverse lug. For bolt scantlings, see Table 10.

6.2 Beam clamps in way of masts

6.2.1 In way of masts, a beam clamp is to be arranged, of length approximately equal to the hull breadth in the same position.

Such clamp, with cross-section equal to approximately 75% of that required for shelves, may be arranged so that its wider side is faying to the beams and leaning against the shelf or, alternatively, it may be arranged below the shelf.

6.3 Bilge stringers

6.3.1 In hulls with Type I or Type III framing, a bilge stringer is to be arranged, having cross-section for 0,6 L amidships not less than that given in Table 6. Outside such zone, the cross-section may be decreased to reach, at the ends, a value equal to 75% of that required.

The greater dimension of the stringer is to be arranged against the frames.

When the stringer is built of two or more pieces, these are to be connected by means of glued scarfs parallel to the planking. Such scarfs are to be properly staggered in the port and starboard stringers and arranged clear of the joints of other longitudinal elements.

Where angle frames are adopted, these are to be connected to the stringer by means of a reverse lug.

When Type III framing is adopted, chocks are to be fitted for the connection between stringer and intermediate bent frames.

In lieu of a bilge stringer, two side stringers having cross-section equal to 60% of that required for the bilge stringer may be fitted.

6.4 End breasthooks

6.4.1 The beam shelves and the stringers are to be connected to each other at the hull ends, and with the centreline structure, by means of suitable breasthooks or brackets.

In hulls with exceptionally raked ends, such breasthooks are to be given adequate attention.

7 Beams

7.1 Scantlings of beams

7.1.1 The scantlings of beams are given in Table 7. Where the spacing adopted is other than that shown in the table, the scantlings, following correction as necessary for the weight of the timber employed, are to be modified in accordance with the following relationship:

$$a_1\ b_1^2\ =\ a \cdot b^2\ \frac{s^1}{s}$$

where a and b are the width and height of the Rule cross-section, a_1 and b_2 are the width and height of the modified section, s is the Rule spacing, and s_1 the assumed spacing.

Laminated beams may be reduced in width by 15%.

Strong beams are to be fitted in way of openings which cause more than two beams to be cut and in way of masts, when deemed necessary by Tasneef

Table 6 : Beam shelves and bilge stringers

Length **L** (m)	Cross-sectional area of beam shelves cm^2	Cross-sectional area of bilge stringers cm^2
24	190	140
26	220	160
28	250	175
30	280	190

Table 7 : Beams

Length of beam m	Spa-cing mm	ORDINARY BEAMS FOR 3/5 L AMIDSHIPS			ORDINARY BEAMS OUTSIDE 3/5 L AMIDSHIPS, HALF BEAMS			STRONG BEAMS		
		Widt h mm	Depth		Width mm	Depth		Width. mm	Depth	
			at mid-beam mm	at beam ends mm		at mid-beam mm	at beam ends mm		at mid-beam mm	at beam ends mm
3,00	350	45	72	50	39	54	43	61	81	61
3,50	390	51	80	57	47	61	48	72	91	72
4,00	430	57	90	63	48	67	53	78	101	78
4,50	480	62	99	69	52	74	57	85	111	85
5,00	520	68	106	75	57	80	62	93	120	93
5,50	560	72	114	80	59	87	65	98	128	98
6,00	600	78	121	86	62	95	69	107	136	107
6,50	640	83	129	92	64	103	71	116	144	116
7,00	680	86	132	96	67	113	74	128	156	128
7,50	720	95	146	105	69	125	76	140	168	140

Table 8 : Vertical knees of beams

Length of beams m	Number **(1)** of knees on each side	LENGTH OF ARMS		FORGED KNEES		STEEL ANGLE KNEES		PLATE KNEES thickness mm
		for 3/5 L amidships mm	outside 3/5 L amidships mm	at throat mm	at the ends mm	scantlings **(2)** mm	section modulus cm^3	
3,00	5	400	320	34x17	30x7	40x40x5	1,70	4
3,50	6	440	350	41x20	37x7	50x50x5	3,00	4
4,00	7	490	390	48x23	42x8	55x55x5	4,30	4
4,50	8	530	420	53x26	46x9	60x60x6	5,90	5
5,00	9	570	450	57x28	49x10	75x50x6	7,50	5
5,50	10	610	490	62x30	52x11	75x50x7	9,30	5
6,00	10	650	520	67x32	54x12	90x60x7	11,50	6
6,50	11	700	560	72x34	55x14	90x60x8	14,00	6
7,00	12	740	590	78x35	57x16	100x65x7	16,00	6
7,50	12	780	620	81x37	58x17	100x65x8	19,00	7

(1) The number of knees is given on the basis of the maximum breadth B of the hull, using the column for the length of beam.
(2) The scantlings of angles are only given as indications.

7.2 End attachments of beams

7.2.1 Beams are to be dovetailed on the shelf. When plywood deck planking is employed, in place of the dovetail a simple dapping may be adopted, having depth not less than 1/4 of the beam depth; in this case, the beam is to be fastened to the shelf by means of a screw or pin.

Vertical knees are to be fitted, to the extent required in Table 8, to strong beams and to suitably distributed ordinary beams. Each arm of the knees is to be connected to the shelf and the frame by means of 4 bolts, which need not go through the planking, with a diameter as shown in Table 10.

Bulkheads of adequate scantlings, connected to the beam and frame, can be considered as substitutes for knees.

At the ends of the hull, the length of knee arms may be not more than one third of the span of the beam or frame.

In the above-mentioned table, the scantlings of forged plate knees are given; the depth at the throat is to be not less than 1,6 h for naturally curved wooden knees and not less than 1,4 h for laminated wooden knees, h being the depth at heel of a grown frame.

Horizontal knees are to be fitted in way of hatch-end beams and beams adjacent to mast wedgings. These knees need not be arranged when plywood deck planking is adopted.

7.3 Local strengthening

7.3.1 The beams and decks are to be locally strengthened at the attachments of halliards, bollards and cleats, at skylight ends, and in way of foundations of winches.

In way of mast weldings, four strong beams are to be fitted, with scantlings as prescribed in Table 7, but constant section equal to that indicated for amidships. The beams are to be arranged, as far as practicable, in proximity of the web frames dealt with in 4.2.

All openings on deck are to be properly framed so as to constitute an effective support for half beams.

7.4 Lower deck and associated beams

7.4.1 In hulls with depth measured from the upper side of the wooden keel to the weather deck beam at side $\geq$ 3, metres, a lower deck or cabin deck is to be arranged and fitted with beams having scantlings not less than 60% of those of the weather deck.

When the depth, measured as specified above, exceeds 4,3 metres, vertical knees are to be arranged no smaller in scantlings than prescribed in Table 8 as a function of the beam span, and in number equal to half of those required for the weather deck.

8 Planking

8.1 Shell planking

8.1.1 The basic thickness of shell planking is given in Table 9.

Such thickness is to be modified as follows.

If the frame spacing is other than that indicated in Table 2, the thickness is to be increased where there is greater spacing, or may be reduced where there is smaller spacing, by:

- 6 mm for every 100 mm of difference if Type I framing is adopted;
- 4 mm for every 100 mm of difference if Type II or III framing is adopted.

After correction for spacing as indicated above, and for the weight of the timber, where necessary, the planking thickness may be reduced: by 10% if arranged in diagonal or longitudinal double skin; by 10% if laminated and cold moulded in situ, when the frames are reduced in scantlings by 25% in respect of the value given in Table 2; the thickness may be decreased by 25% where the frames have not been reduced in respect of the requirements of the table.

When plywood is employed, the thickness may be reduced in relation to the type of framing adopted; the maximum reduction permitted is 25%.

Sheathing of the hull is not required; where envisaged, e.g. in copper or reinforced plastics, it will be considered by Tasneef on a case-by-case basis (see Sec 6, [1.8]).

8.2 Deck planking

8.2.1 Deck planking may be:

- constituted by planks parallel to the gunwale limited by a stringer board at side and by a kingplank at the centreline;
- plywood;
- plywood with associated planks as above.

The thickness of the deck is given in Table 9 and is subject to the following modifications:

- if the beam spacing is other than that indicated in Table 7, the thickness is to be modified by 3 mm for every 100 mm of variation in spacing;
- if plywood is employed, the thickness may be reduced by 30%;
- if plywood is adopted in association with planking, the specific mass of the plywood/planking assembly is to be not less than 430 kg/m³, and the combined thickness may be reduced by 30%. In addition, the plywood thickness is to be not less than 30% of the combined thickness, or less than 6,5 mm; when the planking thickness is less than 19 mm, the seams are to be made watertight by the application of a suitable elastic compound approved by Tasneef

A further reduction of 1,5 mm may be applied to the deck thickness when the deck is sheathed with nylon, reinforced plastics or other approved coverings.

The fixed fittings on deck, in particular winches, windlasses, ballards and fairleads, are to be well secured on suitable basements and isolated by means of coatings of appropriate materials. Before applying such insulating materials to the basements, the timber is to be protected by suitable preservative solutions or paints.

Guardrail stanchions are to be fastened by at least two pins, one of which is to be a through pin.

Table 9 : Planking - basic thickness

Length L m	Shell and deck planking mm	Deck planking in deckhouses and coachroofs mm	Coamings of coachroofs mm
24	45,5	26	36
26	47,5	27	36
28	50	28	36
30	52	29	36

Table 10 : Floor fastenings

Depth of yacht D m	Diameter of bolts			
	at throat		in the arms	
	Grown, or laminated, or steel frames mm	Bent frames mm	Grown, or laminated, or steel frames mm	Bent frames mm
≤2,4	12	8	8	8
2,6	12	9	9	8
2,8	14	10	10	8
3	14	12	12	8
3,2	16	12	12	9
3,4	18	14	14	9
3,6	20	14	14	9
3,8	20	-	14	-
4	20	-	16	-
4,2	22	-	16	-
FASTENINGS OF LONGITUDINAL STRUCTURES				
Length of yacht L m	Diameter of bolts			
	Centreline structures of yachts mm	Scarfs and breasthook arms mm	Beam shelves and beam knees mm	
24	20	14	11	
26	20	14	11	
28	22	16	12	
30	22	18	14	

8.3 Superstructures - Skylights

8.3.1 When coachroofs are adopted, the opening on deck is to be well framed and the coaming on the weather deck is to be not less in thickness than that required in Table 9.

The coachroof deck is to have sheathing as prescribed in Table 9, though such sheathing may be reduced in thickness in accordance with the specifications in 8.2 for the weather deck. If the beam spacing is other than that indicated in Table 5, the thickness is to be modified by 3 mm for every 100 mm of difference in spacing.

When deckhouses are adopted, they are to have a coaming fastened to the beams and carlings by means of through bolts.

The structure of deckhouses is to be similar to that required for coachroofs. Depending on their size, deckhouses are to be adequately stiffened to the satisfaction of Tasneef

Deck openings for skylights are to be well framed and provided with shutters of adequate thickness.

8.4 Masts and rigging

8.4.1 Each yacht is to be provided with masts, rigging and sails sufficient in number and in good condition. The scantlings of masts and rigging are left to the experience of builders and shipowners. Care will be taken by the Tasneef Surveyor, however, in verifying that the attachments of shrouds and stays to the hull are such as to withstand at least twice the load expected on such rigging.

The mast step is to be of strong construction, and is to be extended so as not to be connected to the transverse and longitudinal framing of the bottom of the hull. The wedging on deck is to be provided with watertight means.

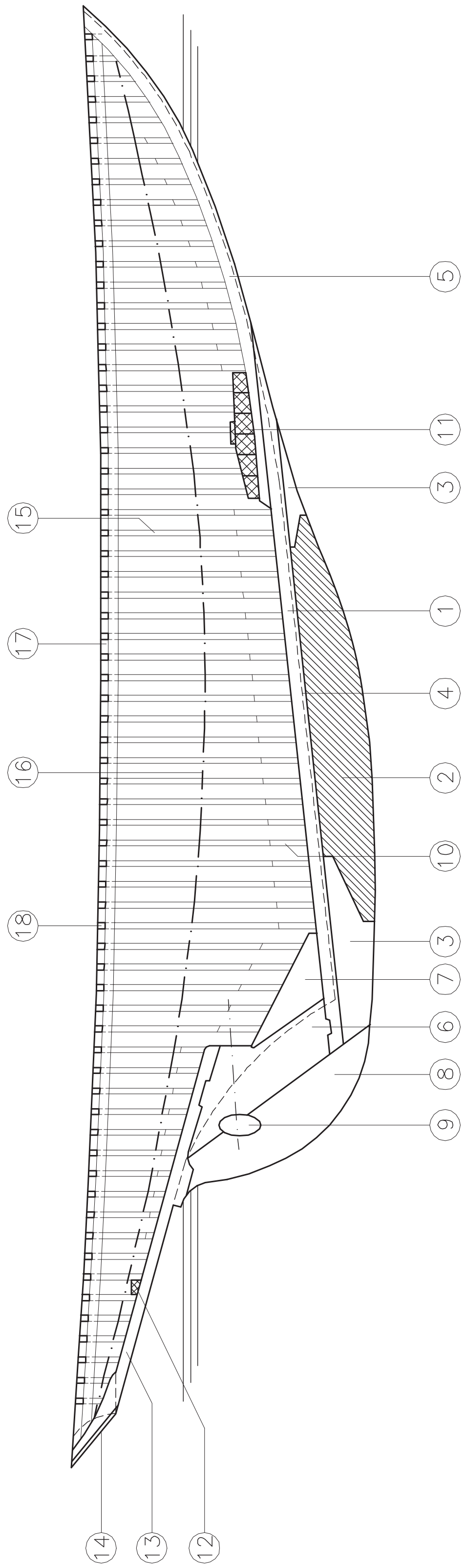
When the mast rests on deck, the underlying structure is to be strengthened in way such as to avoid giving way. If the mast rests on a coachroof, the hull is to be strengthened in way by means of a bulkhead or a stiffened frame.

For shrouds and stays in wire and not in rod, the breaking loads of wires in galvanised steel 160 UNI 4434, in spiral shape, 1x19 wires (col. 1) and in stainless steel AISI 316 18/10 (ASTM-A 368-55), in spiral shape, 1x19 wires (col. 2) are included below for information purposes.

Table 11

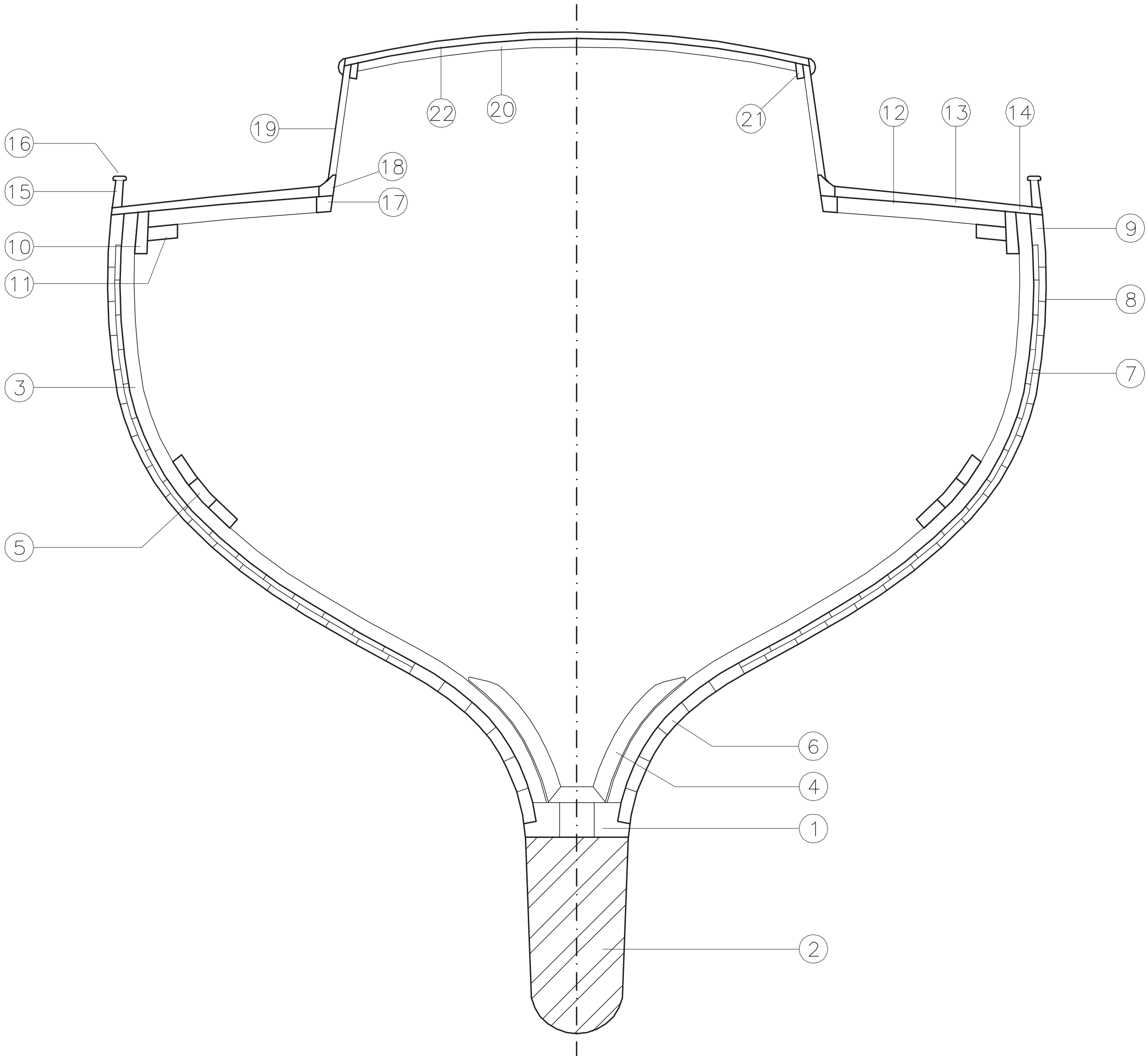
Diameter (mm)	Metallic cross-section (mm^2)	Breaking load kN	
		Col. 1	Col. 2
3	5,37	7,75	7,36
4	9,55	13,73	13,73
5	14,2	21,10	20,60
6	21,5	30,90	29,43
7	29,2	41,60	40,22
8	38,2	54,94	52,97
10	59,7	65,73	83,39
12	86,0	122,63	117,72

Figure 1 : Sailing yachts - Constructional profile



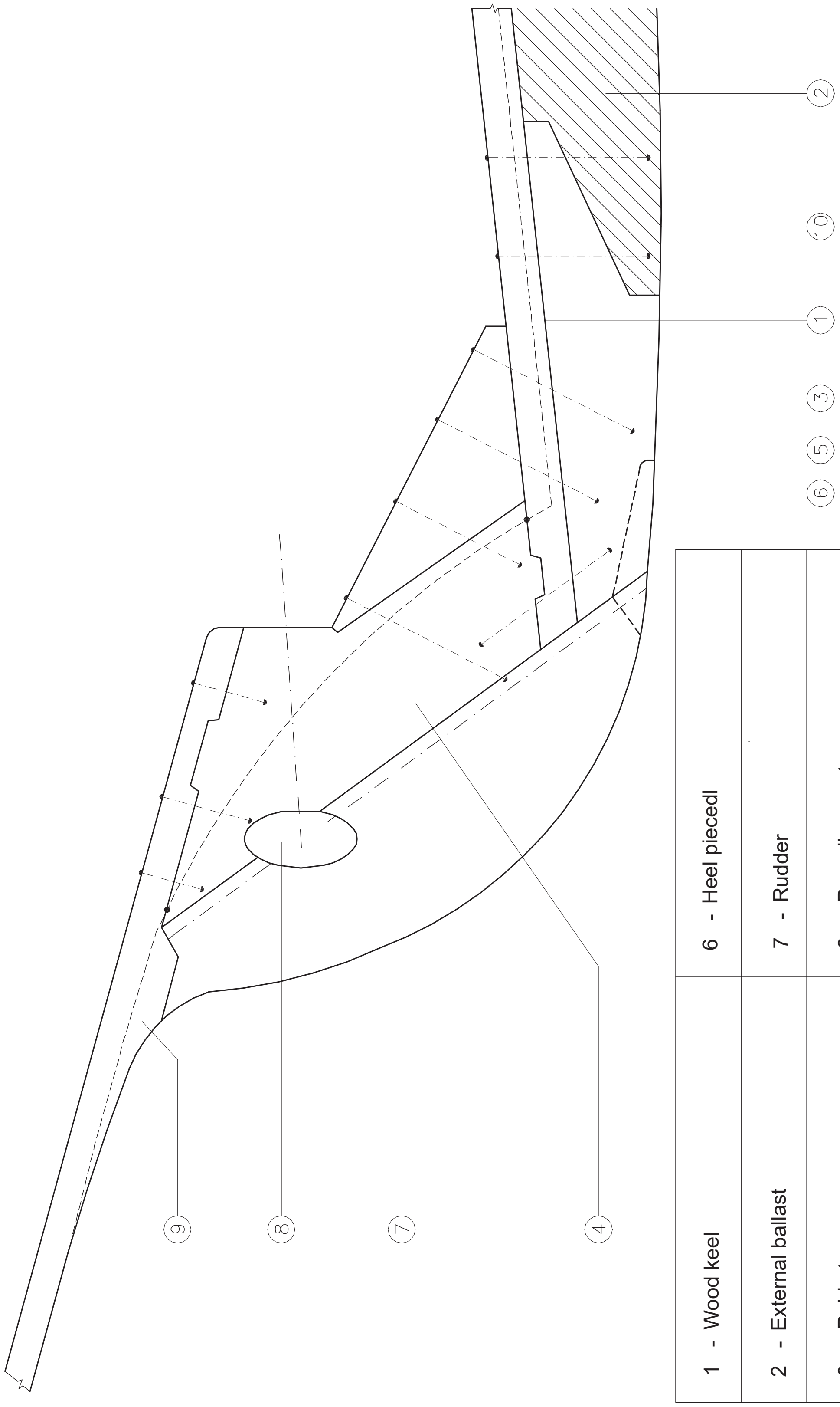
1 - Wood keel	7 - Knee	13 - Stern counter
2 - External ballast	8 - Rudder	14 - Upper stern
3 - Hog	9 - Propeller aperture	15 - Frames
4 - Rabbet	10 - Floors	16 - Stringers
5 - Stempost	11 - Mainmast step	17 - Shelves
6 - Sternpost	12 - Mizzen step	18 - Beams

Figure 2 : Midship section



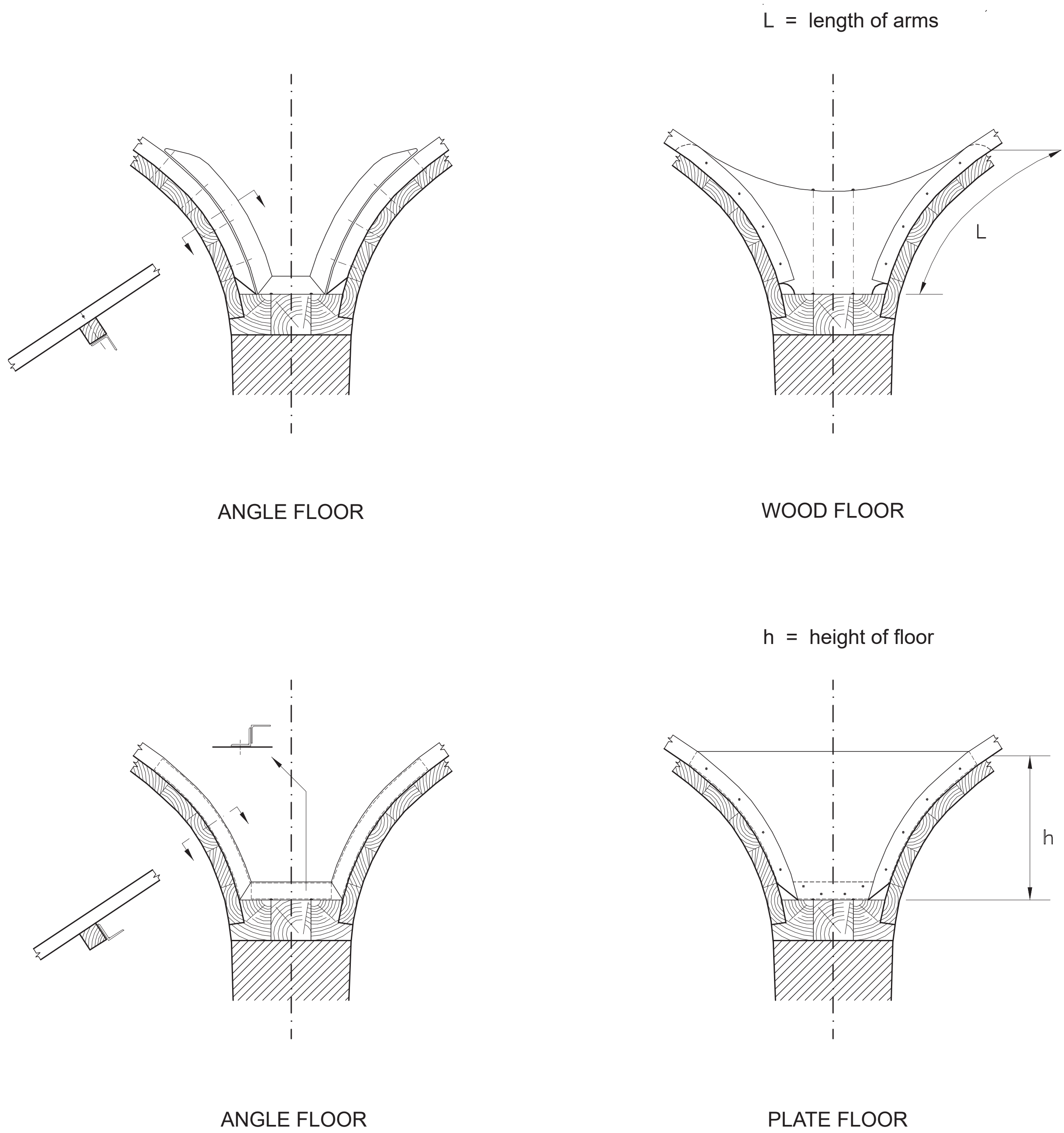
1 - Wood keel	9 - Sheerstrake	17 - Carling
2 - Ballast	10 - Shelf	18 - Coaming "Coachroof"
3 - Frame	11 - Beam clamp	19 - Side planking "Coachroof"
4 - Floor	12 - Half beams	20 - Beam "Coachroof"
5 - Stringers	13 - Deck planking	21 - Shelf "Coachroof"
6 - Bottom simple planking	14 - Waterway	22 - Top "Coachroof"
7 - Planking inner skin	15 - Seam	
8 - Planking outer skin	16 - Stay seam	

Figure 3 : Sternframe



1 - Wood keel	6 - Heel piecedl
2 - External ballast	7 - Rudder
3 - Rabbet	8 - Propeller aperture
4 - Sternpost	9 - Stern counter
5 - Knee	10 - Hog

Figure 4 : Typical floors



SECTION 5 STRUCTURAL SCANTLINGS OF MOTOR YACHTS

1 General

1.1

1.1.1 The scantlings in this Section apply to yachts of length $L \le 35$ metres with chine hulls of the type shown in Figures 1 and 2 and speed not exceeding 40 knots. Subject to Tasneef authorisation the value of the structural scantlings for yachts more than 35 metres but not more than 45 metres in length may be calculated by linear interpolation of the results for yachts not more than 35 metres, given in this Section.

For yacht which differ substantially from the above as regards dimensions and/or speed, or yachts with round keels, the scantlings are determined by equivalence criteria.

2 Keel - stempost

2.1

2.1.1 The minimum breadth of the keel and the aggregate cross-sectional area of keel and hog frame are given in Table 1.

Such scantlings are to be maintained up to the stem end, while they may be reduced by 30% at the stern end.

Where they are made from a number of pieces, the keel and hog frame are to be scarfed. The scarfs are to be 6 times the thickness and of hooked or tabled type, if bolted, or of plain type, if glued; the length may be reduced to not less than 4 times the thickness where the scarf is bolted and glued.

The keel scarfs are to be spaced not less than 1,5 metres apart from those of the hog frame.

Stempost scantlings are given in Tab 1 and a typical sternframe is shown in Fig 3.

3 Transom

3.1

3.1.1 In chine hulls, the sternpost is replaced by a transom.

The transom structure consists of a frame having profile parts with a cross-section not less than 120% of bottom frames, side frames or beams; moreover, the structure's vertical stiffeners, arranged in way of keel and bottom girders, are to have a cross-section with a height equal to that of the side frames and width increased by 50%.

The stiffeners above are generally to be spaced not more than 600 mm apart.

The thickness of transom planking is to be equal to that given in Tab 2 (col. 2), with any modifications required in accordance with those specified for shell planking.

4 Floors and frames

4.1 General

4.1.1 The ordinary framing of the hull is divided into three parts:

- bottom frames, comprising those between the keel and the chine stringers;
- side frames, comprising those between the chine stringers and the waterways;
- beams.

The bottom frames, generally made of two pieces, one port and one starboard of the keel, are butted in way of the centreline and connected by means of a double plywood floor.

The side frames are in one piece connected to the bottom frames by means of double plywood brackets.

The beams are connected to the side frames by means of double plywood brackets.

Table 1 : Keel and stempost

Lenght m	KEEL Minimum breadth mm	 Cross-section of keel or keel and hog **(1)** cm²	STEMPOST Width at heel and at head mm	 Cross-section at heel cm²	 Cross-section at head cm²
1	2	3	4	5	6
24	230	413	230	413	289
26	245	462	245	462	324
28	260	516	260	516	361
30	280	570	280	570	399

(1) Where there is no hog frame, a reduction in keel area of 10% in respect of that prescribed may be permitted. A keel cross-section reduced such as to be not less than 0,85 of that given in col. 3 may be accepted provided that the difference is compensated by an increased cross-section of girders.

4.2 Bottom and side frames

4.2.1 Frame scantlings are given in Tables 3, 4 and 5, where three different types of frames are considered:

Type I : solid or laminated frames, of constant scantlings throughout the length of the hull;

Type II : solid or laminated frames, alternated with one or two bent frames. Only the former are connected by means of floors and brackets; the scantlings are as prescribed for Type I frames;

Type III : solid or laminated frames, associated with bent longitudinals; this type of framing is to be associated with double-skin cross planking or cold moulded laminated multi-layer planking or, alternatively, with plywood planking.

4.3 Floors

4.3.1 The floors connecting bottom frames (see [4.1]) are to have thickness equal to half that required for the latter, extend at the yacht's centreline to a height not less than twice that prescribed for the heel of such frames and overlap the frames by a distance not less than 2,5 times their depth so as to constitute an effective connection by means of glue and clenched bolts. The space between the two floors above the frames is to be fitted with a chock; alternatively, the frames may be shaped so as to have, at the centreline, a depth above the keel equal to that required for the heel of the frames. For floors, see Fig 4.

4.4 Frame and beam brackets

4.4.1 The connection of bottom frames to side frames and of the latter to beams is to be achieved be means of double brackets similar to those described for floors, but overlapping both frames and beams by a distance not less than twice their respective depths (see Figures 5 and 6).

In lieu of the brackets above, the frame-beam connection may be effected by simply overlapping, preferably dovetailing the beam on the shelf (with glueing and pivoting), and provided that transverse bulkheads are arranged, with spacing not exceeding approximately 2 metres, so as to constitute main transverse strengthening elements of the hull, and that no superstructure is arranged on the weather deck.

Table 2 : Shell and deck planking

Lenght L m	SHELL PLANKING Type I and II framing mm	 Type III framing mm	Weather deck planking mm	Deck of superstructures (quarterdeck, deckhouses, coachroofs, trunks) mm
1	2	3	4	5
24	32	28,5	32	21
26	34	30	34	21
28	36	32	36	21
30	37,5	33,5	37,5	21

Table 3 : Frames

Depth D m	TYPE I FRAMING (EITHER GROWN OR LAMINATED FRAMES ONLY)										
	Spac-ing of web mm	BETWEEN KEEL AND CHINE					BETWEEN CHINE AND DECK				
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width. mm	depth		width. mm	depth mm	width mm	depth		width. mm	depth mm
			at heel mm	at head mm				at heel mm	at head mm		
3,0	322	35	127	116	35	93	35	103	90	35	85
3,1	340	39	140	127	39	104	39	117	108	39	94
3,3	355	44	148	135	44	113	44	122	110	44	103
3,5	375	50	162	148	50	125	50	131	115	50	114
3,7	390	55	178	162	55	135	55	143	123	55	125
3,9	408	60	200	182	60	157	60	156	130	60	143

Table 4 : Frames

Depth D mm	TYPE II FRAMING (EITHER GROWN OR LAMINATED FRAMES WITH BENT FRAMES IN BETWEEN)				
	Spacing between main frames and alternate frames			Bent frames	
	one bent frame mm	two bent frames mm	three bent frames mm	width mm	depth mm
3,0	560	650	730	36	25
3,1	590	690	770	38	27
3,3	620	725	800	40	30
3,5	-	-	-	-	-
3,7	-	-	-	-	-
3,9	-	-	-	-	-

5 Side girders and longitudinals

5.1

5.1.1 On bottom frames, at least two continuous girders are to be fitted each side, with a cross-section not less than 90 cm^2.

Such girders, continuous over bottom frames, are to be connected to the bottom planking by means of chocks between frames, set on a bent longitudinal continuous through the floors and connected to the planking. The chocks and the bent longitudinal may be omitted, but in such case the bottom planking thickness given in Tab 2 is to be augmented such as to achieve a cross-section throughout the bottom increased by at least half that of the longitudinals.

A similar longitudinal, but with a cross-section reduced to 0,65 of those described above and not fastened to the planking, is to be fitted on side frames.

Such longitudinal may be omitted where Type III framing is adopted.

Table 5 : Frames

Depth D m	TYPE III FRAMING (GROWN OR LAMINATED FRAMES OR BENTWOOD LONGITUDINALS)										
	Spacing of web mm	BETWEEN KEEL AND CHINE					BETWEEN CHINE AND DECK				
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width mm	depth		width mm	depth mm	width mm	depth		width mm	depth mm
			at heel mm	at head mm				at heel mm	at head mm		
3,0	640	37	148	126	37	92	37	104	94	37	84
3,1	680	41	160	136	41	103	41	112	106	41	93
3,3	710	46	176	150	46	112	46	122	110	46	103
3,5	750	52	192	163	52	124	52	135	115	52	113
3,7	780	58	208	176	58	135	58	146	122	58	123
3,9	820	62	232	197	62	156	62	160	129	62	142

Table 6 : Frames

Depth D m	TYPE III FRAMING (GROWN OR LAMINATED FRAMES OR BENTWOOD LONGITUDINALS)				
	BENTWOOD LONGITUDINALS				
	spacing mm	between keel and chine		between chine and deck	
		width mm	depth mm	width mm	depth mm
3,0	285	45	30	45	25
3,1	300	48	33	48	27
3,3	315	50	36	50	30
3,5	330	53	39	53	33
3,7	345	55	42	55	36
3,9	360	58	45	58	39

6 Beams

6.1

6.1.1 The arrangement of beams is generally to be carried out as follows:

- for hulls with Type I framing: beams on every frame;
- for hulls with Type II or III framing: beams in way of solid or laminated frames, with bracket connection and intermediate beams, without brackets, let into the shelf.

Beams are to have width equal to that of the frames to which they are connected and section modulus, in cm3, not less than:

$Z_1 = K_1 \cdot a \cdot s$

At the ends of large openings, beams are to be fitted having a section modulus, in cm^3, not less than:

$Z_2 = K_2 \cdot a \cdot s$

where:

Z_1,Z_2 : section modulus of beams without planking contribution, in cm^3

a : width of beams, in cm

s : beam spacing, in m

K_1,K_2 : coefficient given by Tab 7 as a function of the beam span.

Where laminated beams are arranged, the section moduli Z_1 and Z_2 may be reduced to 0,85 of those indicated above.

Table 7

Beam span (m)	Coefficients for calculation of beam section modulus			
	K_1		K_2	
	At the centreline	At the ends	At the centreline	At the end
≤2	14,3	6,43	23	11,4
2,5	18	8,5	31	15,1
3	22,2	10,7	38,6	17,7
3,5	24,7	12,5	43,6	22,2
4	28,3	13,9	48,7	23,6
4,5	30,6	14,9	52,5	25,2
5	32,4	16,3	56,8	27,7
5,5	35,1	17,1	60	28,7
6	36,9	18,1	63,5	31,8
6,5	38,7	19,5	70	35
7	39,6	20,5	73,5	40,2
7,5	40,5	23	81	45,4

7 Beam shelves and chine stringers

7.1

7.1.1 The cross-sectional area of beam shelves and chine stringers is to be not less than that given by Tab 8 below as a function of L and to have the ratio h/t < 3, where h is the depth and t the thickness of the bar.

The cross-section of shelves and stringers is to be considered as inclusive of the dappings for beam and frame ends.

Table 8

Length L of the hull (m)	Cross-sectional area of beam shelves (cm^2)	Cross-sectional area of chine stringers (cm^2)
24	95	112
26	110	128
28	125	140
30	140	152
32	155	164
35	177	182

8 Shell planking

8.1 Thickness of shell planking

8.1.1 The basic thickness of shell planking is given in Table 2.

If the frame spacing is other than that shown in Table 3, the planking thickness is to be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced:

- by 10% if a diagonal or longitudinal double-skin planking is adopted;
- by 15% if composite planking constituted by inner plywood skin and one or two outer longitudinal diagonal strakes is adopted;
- by 25% if laminated planking (i.e. at least three cold-moulded layers) or plywood is adopted.

Moreover, the plywood thickness is to be not less than 30% of the total thickness or less than 6 mm.

Yachts with speed > 25 knots are to have bottom frames (floors and longitudinals) stiffened in respect of the scantlings in this Section and planking thickness increased as follows (for deadrise = 25°) in respect of the values in Table 2:

- speed from 26 to 30 knots: 5%
- speed from 31 to 35 knots: 10%
- speed from 36 to 40 knots: 15%.

When the deadrise is between 25° and 30° and outer longitudinal strakes are fitted on the bottom planking, the above increase in thickness may be reduced but is generally to be no less than half of the percentage values above.

9 Deck planking

9.1 Weather deck

9.1.1 Deck planking may be constituted by planks flanked by a stringer board at side and by a kingplank at the centreline. Such planking may be solely plywood or plywood with associated planking arranged as described above.

The thickness of deck planking is given in Tab 2. If the beam spacing is other than that prescribed in [4.2], the planking thickness is to be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced by 30% if plywood or plywood associated with planking is employed.

Moreover, the plywood thickness is to be not less than 30% of the total thickness or less than 6 mm.

9.2 Superstructure decks

9.2.1 The thickness of planking of superstructure decks is given in Tab 2.

Such thickness is subject to the reductions and increases for weather deck planking as provided for in [9.1].

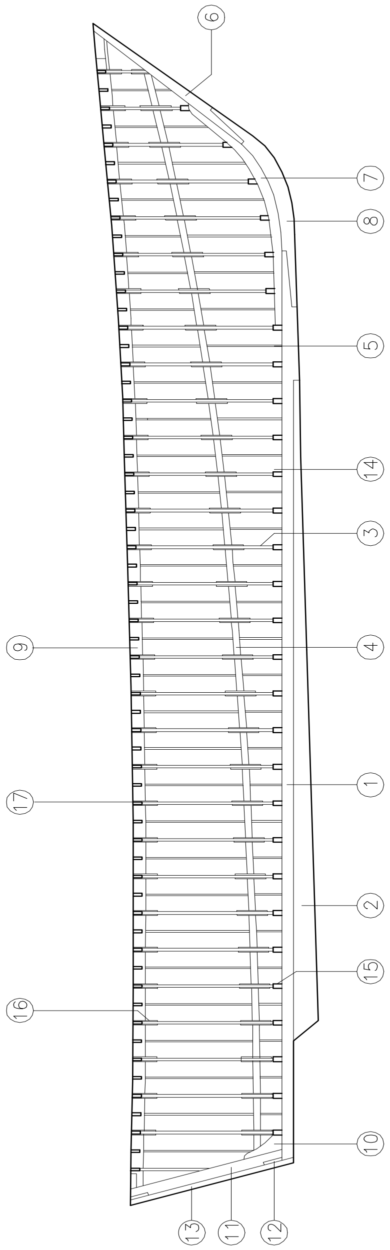
9.3 Lower deck

9.3.1 In hulls with depth, measured between the upper keel side and the weather deck beam, greater than or equal to 3,10 metres, a lower or cabin deck is to be arranged, with beams having a section modulus not less than 60% of that prescribed in Article 6 for weather deck beams and effectively fastened to the sides by means of a shelf with a ross sectional area not less than 2/3 of that required in Table 8.

When the depth, as measured above, exceeds 4,30 metres, the fastening of beams to side is to be completed by means of plywood brackets arranged at least at every second beam and having scantlings as prescribed in [4.4].

The scantlings of the deck planking are to be not less than those required in [9.2].

Figure 1 : Motor yachts - Constructional profile



1 - Keel	7 - Apron	13 - Transom frame
2 - Hog	8 - Stem	14 - Chine knees
3 - Grown frame	9 - Shelf	15 - Floors
4 - Chine stringer	10 - Knee	16 - Beam knees
5 - Bent frame	11 - Transom stiffeners	17 - Beam
6 - Stempost	12 - Transom frame	

Figure 2 : Midship section

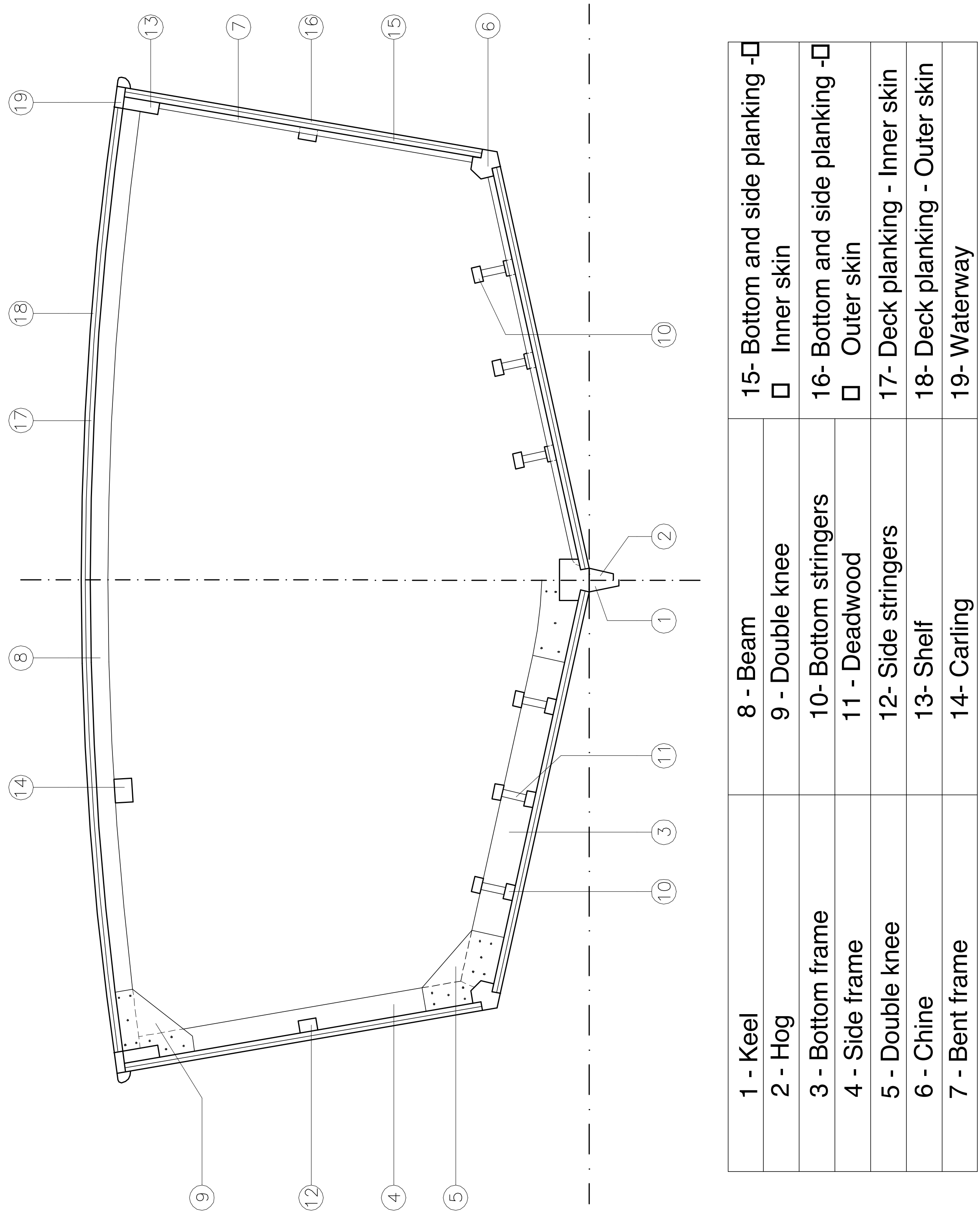


Figure 3 : Stem

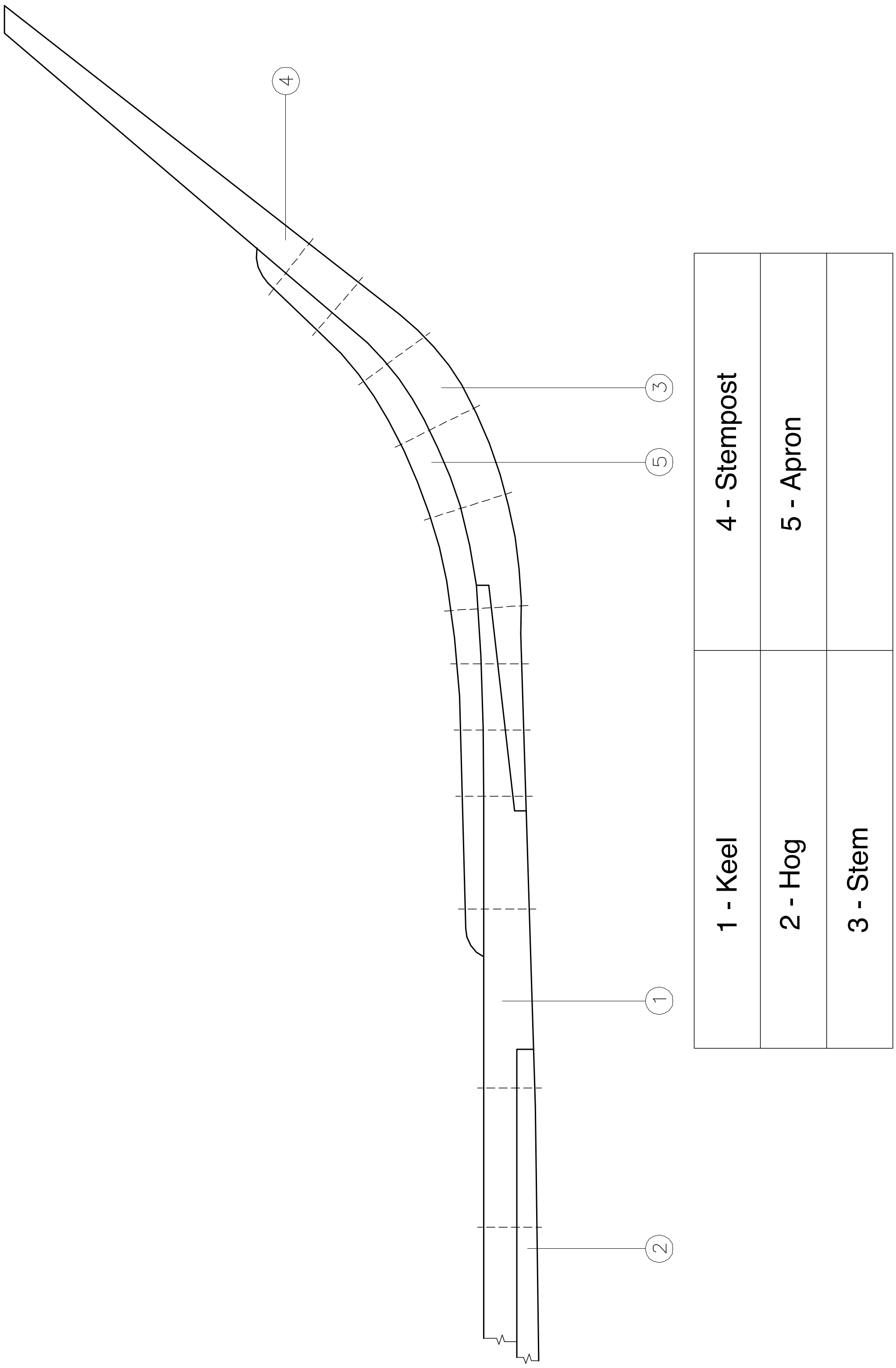
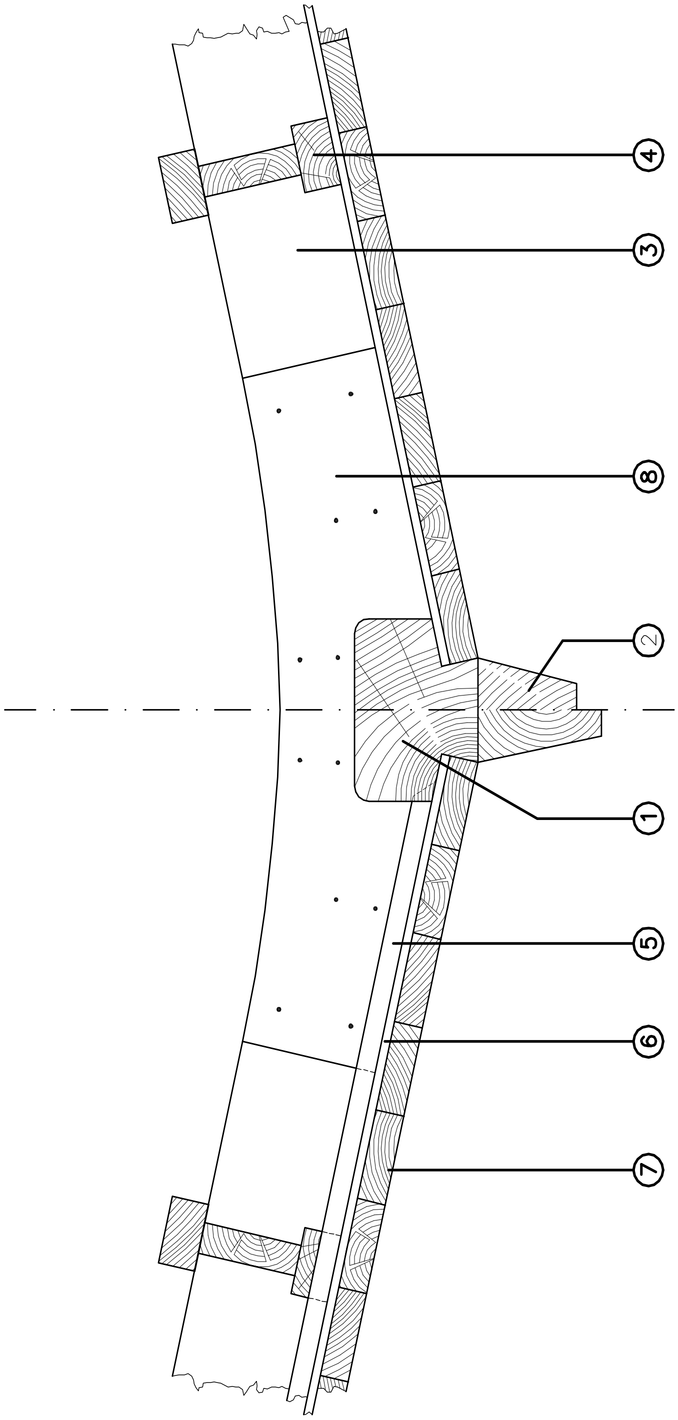
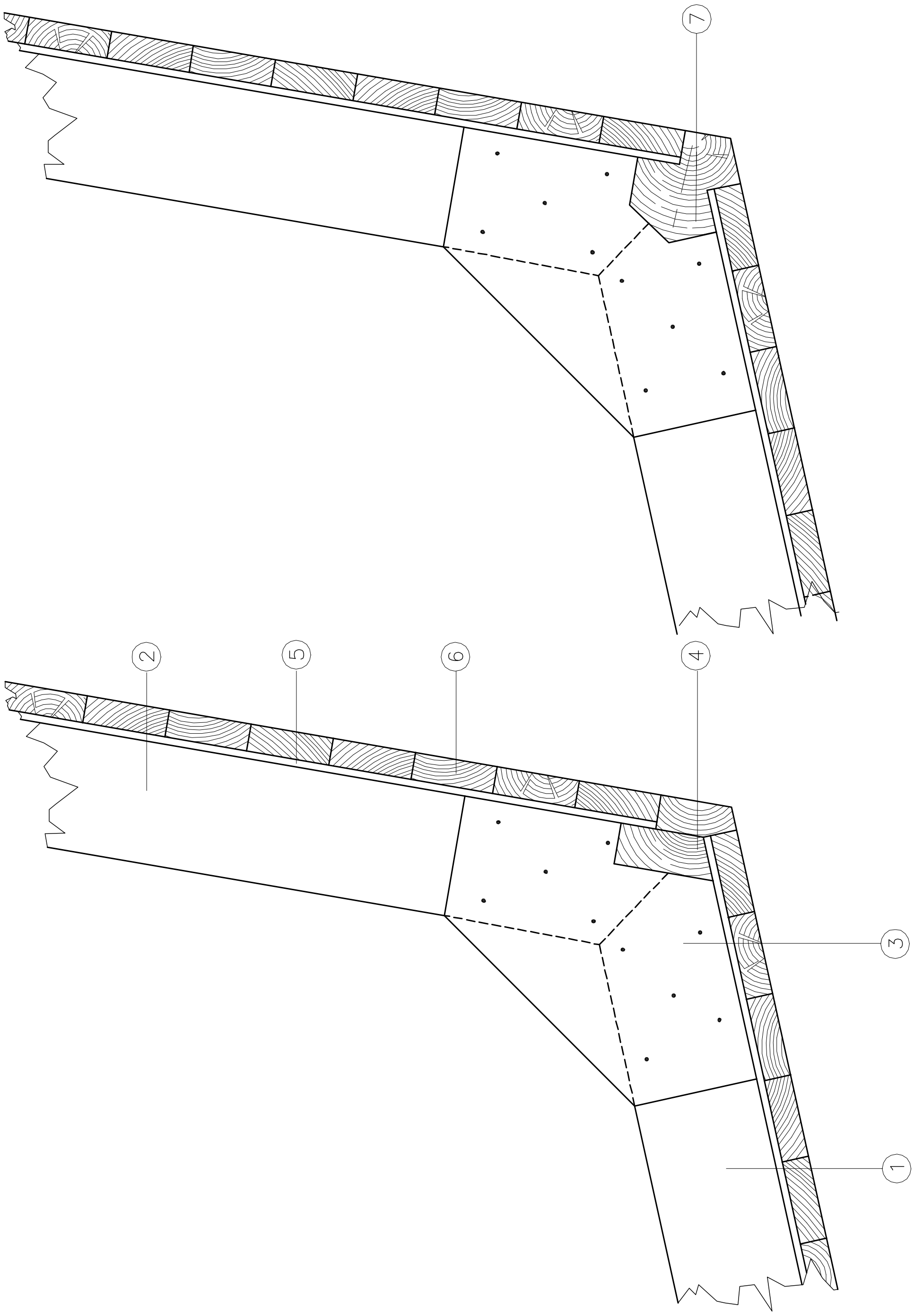


Figure 4 : Detail of floor



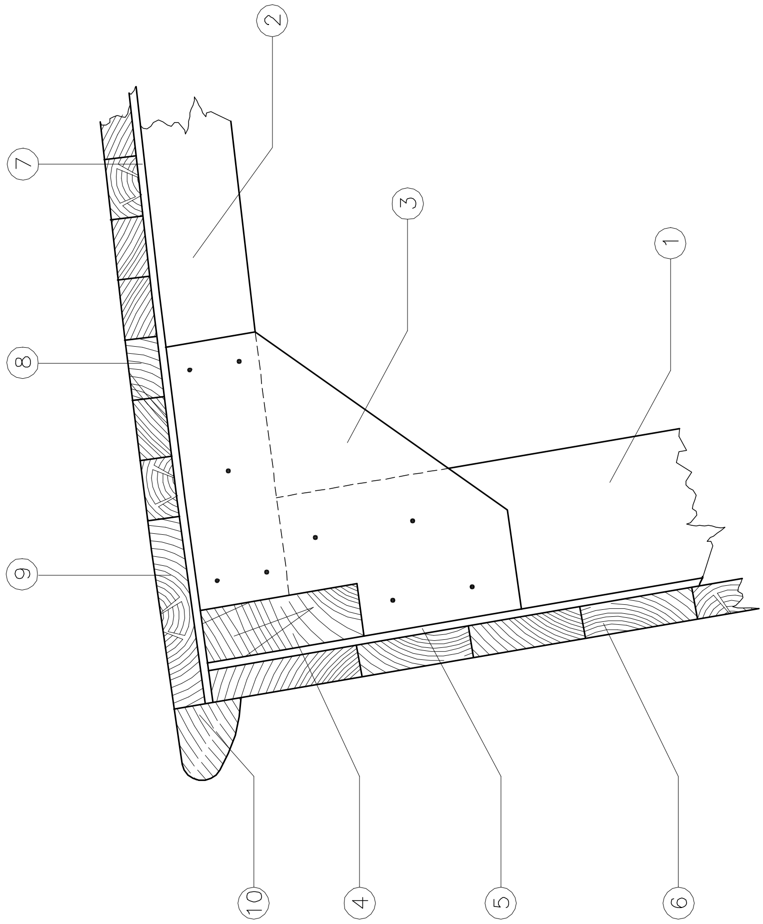
1 - Keel	4 - Bottom stringer	7 - Planking - Outer skin
2- Hog	5 - Bent frame	8 - Double floor
3 - Bottom frame	6 - Planking - Inner skin	

Figure 5 : Detail of floor



1 - Bottom frame	5 - Planking - Inner skin
2 - Side frame	6 - Planking - Outer skin
3 - Double knees	7 - Chine
4 - Chine stringer	

Figure 6 : Detail of gunwale connection



1 - Side frame	6 - Hull planking - Outer skin
2 - Beam	7 - Deck planking - Inner skin
3 - Double knees	8 - Deck planking - Outer skin
4 - Shelf	9 - Waterway
5 - Hull planking - Inner skin	10 - Rubbing piece

SECTION 6 WATERTIGHT BULKHEADS, LINING, MACHINERY SPACE

1 Wooden bulkheads

1.1

1.1.1 Wooden watertight bulkheads normally consist of plywood boards of adequate thickness in relation to the hull size and the spacing and strength of stiffeners. Glues for timber fastenings are to be of resorcinic or phenolic type, i.e. durable and water-resistant in particular.

As regards the number of watertight bulkheads, attention is drawn to the provisions of Chapter I of Part B.

The plywood, normally arranged in vertical panels, is to be scarfed or strapped in way of vertical stiffeners.

Connection to the hull is to be effected by means of a grown or laminated frame and made watertight by packing where necessary.

2 Steel bulkheads

2.1

2.1.1 Steel watertight bulkheads are to be of thickness as shown in Table 1 as a function of the spacing of stiffeners and the height of the bulkhead.

The scantlings are given on the assumption that the lowest strake is horizontal and subsequent strakes vertical. When all strakes are horizontal, the thickness of the third and higher strakes may be decreased by a maximum of 0,5 mm per strake so as to reach a reduction of 25%, in respect of the table thickness, for the highest strake.

If the spacing is other than that shown in the table, the thickness is to be modified by 0,5 mm for every 100 mm of difference in spacing. The spacing of vertical stiffeners is not to exceed 600 mm for the collision bulkhead.

The scantlings of vertical stiffeners, in cm^3, without end connections are to be not less than:

$$Z = (4,2 + 4h)s \cdot S^2$$

where:

- Z : section modulus of vertical stiffener with associated strip of plating one spacing wide, in cm^3
- h : distance from midpoint of stiffener to top of bulkhead, in m
- s : spacing of vertical stiffeners, in m
- S : aggregate span of vertical stiffeners.

The connection of the bulkhead to planking is to be effected on grown or laminated frames, and provided with watertight packing where necessary.

Bulkheads are to be caulked or made watertight by means of suitable gaskets. On completion, any watertight bulkheads and doors are to be tested using a strong jet of water.

3 Internal lining of hull and drainage

3.1

3.1.1 Where ceilings or internal linings are arranged, they are to be fitted so as to be, as far as practicable, easily removable for maintenance and painting of the underlying structures. Linings are to allow sufficient ventilation of air spaces between them and planking.

Limber holes are to be provided in the bottom structures such as to allow the drainage of bilge liquids into suction wells.

4 Machinery space structures

4.1

4.1.1 The scantlings of floors, web frames and foundation girders are to be adequate for the weight, power and type of machinery; their suitability and that of associated connections is to be satisfactory with particular regard to engine running and navigation tests when required by these Rules.

Table 1 : Watertight steel bulkheads

Height of bulkhead mm	Spacing of vertical stiffeners mm	Thickness of lower strake mm	Thickness of other strakes mm
≤2,40	375	4	3,5
2,60	390	5	4,5
2,80	410	5	4,5
3,00	425	5,5	5
3,20	440	5,5	5
3,40	460	5,5	5
3,60	475	6	5,5
3,80	490	6	5,5
4,00	510	6	5,5
4,20	525	6	5,5
4,40	540	6,5	6
4,60	560	6,5	6
4,80	575	6,5	6
5,00	590	6,5	6

Part B
Hull and Stability

Chapter 6
STABILITY

SECTION 1 STABILITY

1 General

1.1

1.1.1 This Section outlines the minimum requirements for intact stability for both motor and sailing vessels.

This Section deals with the standards for intact stability.

1.1.2 An intact stability standard proposed for assessment of a vessel type not covered by the standards defined in this Section is to be submitted to Tasneef for approval at the earliest opportunity.

1.1.3 If used, permanent ballast is to be located in accordance with a plan approved by Tasneef and in a manner that prevents shifting of position. Permanent ballast is not to be removed from the yacht or relocated within the vessel without the approval of Tasneef Permanent ballast particulars are to be noted in the yacht's stability booklet. Attention is to be paid to local or global hull strength requirements arising from the fitting of additional ballast.

2 Intact Stability Standards

2.1 Motor vessels

2.1.1 Monohull Vessels *(1/1/2019)*

The curves of static stability for seagoing conditions are to meet the following criteria:

a) the area under the righting lever curve (GZ curve) is not to be less than 0,055 metre-radians up to 30º angle of heel and not less than 0,09 metre-radians up to 40º angle of heel, or the angle of downflooding, if this angle is less;

b) the area under the GZ curve between the angles of heel of 30º and 40º or between 30º and the angle of downflooding if this is less than 40º, is not to be less than 0.03 metre-radians;

c) the righting lever (GZ) is to be at least 0,20 metres at an angle of heel equal to or greater than 30º;

d) the maximum GZ is to occur at an angle of heel preferably exceeding 30º but not less than 25º;

e) after correction for free surface effects, the initial metacentric height (GM) is not to be less than 0,15 metres;

f) in the event that the vessel's intact stability standard fails to comply with the criteria defined in a) to e), Tasneef may be consulted for the purpose of specifying alternative but equivalent criteria;

g) crowding of passengers;

The angle of heel on account of crowding of passengers to one side is not to exceed 10° and in any event the freeboard deck is not to be immersed.

2.1.2 Multi-hulls

The curves of statical stability for seagoing conditions are to meet the following criteria:

a) the area under the righting lever curve (GZ curve) is not to be less than 0,075 metre-radians up to an angle of 20º when the maximum righting lever (GZ) occurs at 20º and not less than 0,055 metre-radians up to an angle of 30º when the maximum righting lever (GZ) occurs at 30º or above. When the maximum GZ occurs at angles between 20º and 30º the corresponding area under the GZ curve A_{req} is to be taken as follows:

A_{req}={0,055 + 0,002(30 - θ_{max}) metre radians;

where θ_{max} is the angle of heel in degrees at which the GZ curve reaches its maximum.

b) the area under the GZ curve between the angles of heel of 30º and 40º, or between 30º and the angle of downflooding if this is less than 40º, is not to be less than 0,03 metre-radians;

c) the righting lever (GZ) is to be at least 0,20 metres at an angle of heel where it reaches its maximum;

d) the maximum GZ is to occur at an angle of heel not less than 20º;

e) after correction for free surface effects, the initial metacentric height (GM) is not to be less than 0,15 metres;

f) if the maximum righting lever (GZ) occurs at an angle of less than 20º, approval of the stability is to be considered by Tasneef as a special case.

2.1.3 For the purpose of assessing whether the stability criteria are met, GZ curves are to be produced for the loading conditions applicable to the operation of the vessel.

2.1.4 Superstructures

a) The buoyancy of enclosed superstructures complying with regulation 3(10)(b) of the ICLL may be taken into account when producing GZ curves.

b) Superstructures, the doors of which do not comply with the requirements of Regulation 12 of ICLL, are not to be taken into account.

2.1.5 High Speed Vessels

In addition to the criteria above, Designers and builders are to address the following hazards which are known to effect vessels operating in planing modes or those achieving relatively high speeds:

a) directional instability, often coupled to roll and pitch instabilities;

b) bow diving of planing vessels due to dynamic loss of longitudinal stability in calm seas;

c) reduction in transverse stability with increasing speed in monohulls;

d) porpoising of planing monohulls being coupled with pitch and heave oscillations;

e) generation of capsizing moments due to immersion of chines in planing monohulls (chine tripping).

2.1.6 Monohull Vessels operating as Short Range Yachts *(1/1/2017)*

Where Short Range Yachts are unable to meet the criteria above, the following criteria may be used:

a) the area under the righting lever curve (GZ curve) should not be less than 0.07 metre-radians up to 15° angle of heel, when maximum GZ occurs at 15°, and 0.055 metre-radians up to 30° angle of heel, when maximum GZ occurs at 30° or above. Where the maximum GZ occurs at angles of between 15° and 30°, the corresponding area under the GZ curve, A_{req} should be taken as follows: - A_{req} = 0.055 + 0.001(30o - θ_{max}) metre.radians where θ_{max} is the angle of heel, in degrees, where the GZ curve reaches its maximum;

b) the area under the GZ curve between the angles of heel of 30° and 40° or between 30° and the angle of downflooding if this is less than 40o, should not be less than 0.03 metre-radians;

c) the righting lever (GZ) should be at least 0.20 metres at an angle of heel equal to or greater than 30°;

d) the maximum GZ should occur at an angle of heel not less than 15°

e) after correction for free surface effects, the initial metacentric height (GM) should not be less than 0.15 metres.

2.2 Sailing vessels

2.2.1 Monohull

a) Curves of static stability (GZ curves) are to be produced or at least the Loaded Departure with 100% consumables and the Loaded Arrival with 10% consumables.

b) The GZ curves required by a) should have a positive range of not less than 90º. For vessels of more than 45 m, a range of less than 90º may be considered but may be subject to agreed operational criteria.

c) In addition to the requirements of b), the angle of steady heel is to be greater than 15 degrees (see figure). The angle of steady heel is obtained from the intersection of a 'derived wind heeling lever' curve with the GZ curve required by a).

In the figure:

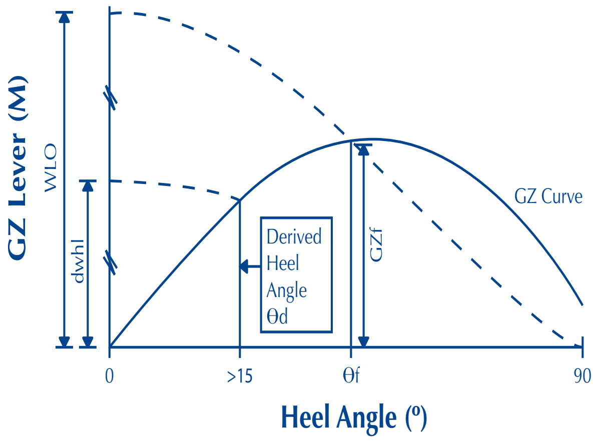
'dwhl' = the 'derived wind heeling lever' at any angle θ

$$dwhl = 0,5 \times WLO \times Cos^{1,3}\theta$$

where:

$$WLO = \frac{GZ_f}{Cos^{1,3}\theta_f}$$

Figure 1



Noting that:

WLO is the magnitude of the actual wind heeling lever at 0º which would cause the vessel to heel to the 'downflooding angle' θ_f or 60º, whichever is the lesser.

GZ_f is the lever of the vessel's GZ at the downflooding angle (θ_f) or 60º, whichever is the lesser.

θ_d is the angle at which the 'derived wind heeling' curve intersects the GZ curve. (If θ_d is less than 15º the vessel will be considered as having insufficient stability).

θ_f the 'downflooding angle' is the angle of heel causing immersion of the lower edge of openings having an aggregate area, in square metres, greater than:

$$\frac{\Delta}{1500}$$

where Δ = vessel's displacement in tonnes.

All regularly used openings for access and ventilation are to be considered when determining the downflooding angle. No opening, regardless of size, which may lead to progressive flooding is to be immersed at an angle of heel of less than 40º. Air pipes to tanks can, however, be disregarded.

If, as a result of immersion of openings in a superstructure, a vessel cannot meet the required standard, those superstructure openings may be ignored and the openings in the weather deck used instead to determine θ_f. In such cases the GZ curve is to be derived without the benefit of the buoyancy of the superstructure.

It might be noted that provided the vessel complies with the requirements of [2.1.1], [2.1.2] and [2.1.3] and is sailed with an angle of heel which is no greater than the 'derived angle of heel', it should be capable of withstanding a wind gust equal to 1,4 times the actual wind velocity (i.e. twice the actual wind pressure) without immersing the 'down-flooding openings' or heeling to an angle greater than 60º.

2.2.2 Multi-hull

a) Curves of static stability in both roll and pitch are to be prepared for at least the Loaded Arrival with 10% consumables. The VCG is to be obtained by one of the three methods listed below:

1) inclining of complete craft in air on load cells, the VCG being calculated from the moments generated by the measured forces, or

2) separate determination of weights of hull and rig (comprising masts and all running and standing rigging), and subsequent calculation assuming that the hull VCG is 75% of the hull depth above the bottom of the canoe body, and that the VCG of the rig is at half the length of the mast (or a weighted mean of the lengths of more than one mast), or

3) detailed calculation of the weight and CG position of all components of the vessel, plus a 15% margin of the resulting VCG height above the underside of canoe body.

b) If naval architecture software is used to obtain a curve of pitch restoring moments, then the trim angle is to be found for a series of longitudinal centre of gravity (LCG) positions forward of that necessary for the design waterline. The curve can then be derived as follows:

GZ in pitch = CG' x cos (trim angle)

$$\text{trim angle} = \tan^{-1}\left(\frac{T_{FP} - T_{AP}}{L_{BP}}\right)$$

where:

CG' = shift of LCG forward of that required for design trim, measured parallel to base line

T_{FP} = draught at forward perpendicular

T_{AP} = draught at aft perpendicular

L_{BP} = length between perpendiculars

Approximations to maximum roll or pitch moments are not acceptable.

c) Data is to be provided to the user showing the maximum advised mean apparent wind speed appropriate to each combination of sails, such wind speeds being calculated as the lesser of the following:

$$v_w = 1,5\sqrt{\frac{LM_R}{A'_S h \cos\phi_R + A_D b}}$$

or

$$v_w = 1,5\sqrt{\frac{LM_P}{A'_S h \cos\phi_P + A_D b}}$$

where:

v_w = maximum advised apparent wind speed (knots)

LM_R = maximum restoring moment in roll (N-m)

LM_p = limiting restoring moment in pitch (N-m), defined as the pitch restoring moment at the least angle of the following:

1) angle of maximum pitch restoring moment, or

2) angle at which foredeck is immersed

3) 10º from design trim

A'_S = area of sails set including mast and boom (square metres)

h = height of combined centre of effort of sails and spars above the waterline

f_R = heel angle at maximum roll righting moment (in conjunction with LMR)

f_P = limiting pitch angle used when calculating LMP (in conjunction with LMP)

A_D = plan area of the hulls and deck (square metres)

b = distance from centroid of AD to the centreline of the leeward hull

This data are to be accompanied by the note:

In following winds, the tabulated safe wind speed for each sail combination should be reduced by the boat speed.

d) If the maximum safe wind speed under full fore-and-aft sail is less than 27 knots, it is to be demonstrated by calculation using annex D of ISO 12217-2 (2002) that, when inverted and/or fully flooded, the volume of buoyancy, expressed in cubic metres (m3), in the hull, fittings and equipment is greater than:

1.2 x (fully loaded mass in tonnes)

thus ensuring that it is sufficient to support the mass of the fully loaded vessel by a margin. Allowance for trapped bubbles of air (apart from dedicated air tanks and watertight compartments) is not to be included.

e) The maximum safe wind speed with no sails set calculated in accordance with c) above is to exceed 36 knots.

f) Trimarans used for unrestricted operations are to have sidehulls each having a total buoyant volume of at least 150% of the displacement volume in the fully loaded condition.

g) The stability information booklet is to include information and guidance on:

1) the stability hazards to which these craft are vulnerable, including the risk of capsizing in roll and/or pitch;

2) the importance of complying with the maximum advised apparent wind speed information supplied;

3) the need to reduce the tabulated safe wind speeds by the vessel speed in following winds;

4) the choice of sails to be set with respect to the prevailing wind strength, relative wind direction, and sea state;

5) the precautions to be taken when altering course from a following to a beam wind.

h) In vessels required to demonstrate the ability to float after inversion (according to c) above), an emergency escape hatch is to be fitted to each main inhabited watertight compartment such that it is above both upright and inverted waterlines.

2.3 Element of Stability

2.3.1 Unless otherwise specified, the lightship weight, vertical centre of gravity (KG) and longitudinal centre of gravity (LCG) of a vessel are to be determined from the results of an inclining experiment.

2.3.2 An inclining experiment is to be conducted in accordance with a detailed standard which is approved by Tasneef and in the presence of a Tasneef Surveyor.

2.3.3 The inclining experiment and the lightweight check are to be conducted in accordance with the provisions of App 1.

2.3.4 The report of the inclining experiment and the lightship particulars derived are to be approved by Tasneef prior to their use in stability calculations.

2.3.5 For sister vessels, in order to verify the stability documentation the following procedure is to be applied:

a) the shipyard declares that a yacht is dealt with as a prototype.

   An inclining experiment is to be carried out on this firts vessel (prototype) and, on the basis of the results, a full stability booklet is to be prepared, taking into account the Rule stability requirements.

   The above documents are to be examined and approved.

b) In the case of a declared sister vessel (same hull, machinery, subdivision, general arrangement and furniture, as far as reasonable), a lightweight survey is to be carried out instead of an inclining test, provided that:

   1) the yacht is built by the same shipyard;
   2) the same drawings are used;
   3) when the sister vessel is built, the light ship displacement difference in comparison to the prototype is not greater than ± 2-3%;
   4) a sister vessel statement is communicated to Tasneef thus formalising the request to waive the inclining experiment for the sister yacht.

Should a yacht be declared a sister vessel of a prototype, the following documentation is to be sent for approval:

a) lightship weight report (duly signed by the attending Tasneef Surveyor and by the shipyard representative);

b) stability booklet as photocopy of the prototype, only updated for the general description (vessel’s name, port of registry, flag, etc).

2.4 Stability Documents

2.4.1 A vessel is to be provided with a stability information booklet for the Master, which is to be approved by Tasneef

2.4.2 The stability information booklet is to be contain the information specified in App 2.

2.4.3 A vessel with previously approved stability information which undergoes a major refit or alterations is to be subjected to a complete reassessment of stability and provided with newly approved stability information.

A major refit or major alteration is one which results in a change in the lightship weight of 2% and above, and/or a change in the longitudinal centre of gravity of 1% and above (measured from the aft perpendicular), and/or an increase in the calculated vertical centre of gravity of 0,25% and above (measured from the keel).

2.4.4 Sailing vessels are to have, readily available, a copy of the Curves of Maximum Steady Heel Angle to Prevent Downflooding in Squalls, or in the case of a multi-hull, the values of maximum advised mean apparent windspeed, for the reference of the watchkeeper. This is to be a direct copy taken from that contained in the approved stability booklet.

2.4.5 The overall sail area and spar weights and dimensions are to be as documented in the vessel's stability information booklet. Any rigging modifications that increase the overall sail area, or the weight/dimensions of the rig aloft, are to be accompanied by an approved update of the stability information booklet.

APPENDIX 1 INCLINING TEST AND LIGHTWEIGHT CHECK

1 General

1.1 General conditions of the yacht

1.1.1 *(1/1/2020)*

Prior to the test, Tasneef Surveyor is to be satisfied of the following:

a) the weather conditions are to be favourable;

b) the yacht is to be moored in a quiet, sheltered area free from extraneous forces, such as to allow unrestricted heeling. The yacht is to be positioned in order to minimise the effects of possible wind, stream and tide;

c) the ship is to be upright however, with inclining weights in the initial position, up to 0,5° of list is acceptable.

The actual trim and deflection of keel, if practical, are to be considered in the hydrostatic data. In order to avoid excessive errors caused by significant changes in the water plane area during heeling, hydrostatic data for the actual trim and the maximum anticipated heeling angles are to be checked beforehand and the trim is to be taken not more than 1% of the length between perpendiculars.

Otherwise, hydrostatic data and sounding tables are to be available for the actual trim.

d) cranes, derrick, lifeboats and liferafts capable of inducing oscillations are to be secured;

e) main and auxiliary boilers, pipes and any other system containing liquids are to be filled;

f) the bilge and the decks are to be thoroughly dried;

g) preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim.

The shape of the tank is to be such that the free surface effect can be accurately determined and remains almost constant during the test. All cross connections are to be closed;

h) the weights necessary for the inclination are to be already on board, located in the correct place;

i) all work on board is to be suspended and crew or personnel not directly involved in the inclining test are to leave the yacht;

j) the yacht is to be as complete as possible at the time of the test. The number of weights to be removed, added or shifted is to be limited to a minimum. Temporary material, tool boxes, staging, sand, debris, etc on board are to be reduced to an absolute minimum.

2 Inclining weights

2.1

2.1.1 The total weight used is preferably to be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side. Tasneef may, however, accept a smaller inclination angle for large yachts provided that the requirement on pendulum deflection or U-tube difference in height specified in [3] is complied with. Test weights are to be compact and of such a configuration that the VCG (vertical centre of gravity) of the weights can be accurately determined. Each weight is to be marked with an identification number and its weight. Recertification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, is to be available during the inclining test to shift weights on the deck in an expeditious and safe manner. Water ballast and people are generally not acceptable as inclining weight.

2.1.2 Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by Tasneef is required. The following conditions are to be met:

a) inclining tanks are to be wall-sided and free of large stringers or other internal members that create air pockets;

b) tanks are to be directly opposite to maintain the yacht's trim;

c) specific gravity of ballast water is to be measured and recorded;

d) pipelines to inclining tanks are to be full. If the yacht's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used;

e) blanks are to be inserted in transverse manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control is to be maintained during the test;

f) all inclining tanks are to be manually sounded before and after each shift;

g) vertical, longitudinal and transverse centres are to be calculated for each movement;

h) accurate sounding/ullage tables are to be provided. The yacht's initial heel angle is to be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard) are to be used when establishing the initial heel angle;

i) verification of the quantity shifted may be achieved by a flowmeter or similar device;

j) the time to conduct the inclining is to be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of wind shifts over long periods of time.

3 Pendulums

3.1

3.1.1 The use of three pendulums is recommended but a minimum of two are to be used to allow identification of bad readings at any one pendulum station. However, for yachts of a length equal to or less than 30 m, only one pendulum may be accepted. They are each to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, to each side of upright, of at least 10 cm. To ensure that recordings from individual instruments are kept separate, it is suggested that the pendulums should be physically located as far apart as practical.

The use of an inclinometer or U-tube is to be considered in each separate case. It is recommended that inclinometers or other measuring devices should only be used in conjunction with at least one pendulum.

4 Means of communication

4.1

4.1.1 Efficient two-way communications are to be provided between central control and the weight handlers and between central control and each pendulum station. One person at a central control station is to have complete control over all personnel involved in the test.

5 Documentation

5.1

5.1.1 *(1/1/2019)*

The person in charge of the inclining test is to have available a copy of the following plans at the time of the test:

a) hydrostatic curves or hydrostatic data;

b) general arrangement plan of decks, holds, inner bottoms;

c) capacity plan showing capacities and vertical and longitudinal centres of gravity of tanks. When water ballast is used as inclining weights, the transverse and vertical centres of gravity for the applicable tanks are to be available for each angle of inclination;

d) tank sounding tables;

e) draught mark locations;

f) docking drawing with keel profile and draught mark corrections, if available.

6 Calculation of the displacement

6.1

6.1.1 The following operations are to be carried out for the calculation of the displacement:

a) draught mark readings are to be taken at aft, midship and forward, at starboard and port sides;

b) the mean draught (average of port and starboard reading) is to be calculated for each of the locations where draught readings are taken and plotted on the yacht's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot is to yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/draughts are to be taken again;

c) the specific gravity of the sea water is to be determined. Samples are to be taken from a sufficient depth of the water to ensure a true representation of the sea water and not merely surface water, which could contain fresh water from run-off of rain. A hydrometer is to be placed in a water sample and the specific gravity read and recorded. For large yachts, it is recommended that samples of the sea water should be taken forward, midship and aft, and the readings averaged. For small yachts, one sample taken from midship is sufficient. The temperature of the water is to be taken and the measured specific gravity corrected for deviation from the standard, if necessary;

d) A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site. Correction is necessary if specific gravity is measured when the sample temperature differs from the temperature at the time of the inclining test. Where the value of the average calculated specific gravity is different from that reported in the hydrostatic curves, adequate corrections are to be made to the displacement curve;

e) all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the yacht's trim and the position of air pipes;

f) it is to be checked that the bilge is dry, and an evaluation of the liquids which cannot be pumped, remaining in the pipes, boilers, condenser, etc., is to be carried out;

g) the entire yacht is to be surveyed in order to identify all items which need to be added, removed or relocated to bring the yacht to the lightship condition. Each item is to be clearly identified by weight and location of the centre of gravity;

h) the possible solid permanent ballast is to be clearly identified and listed in the report.

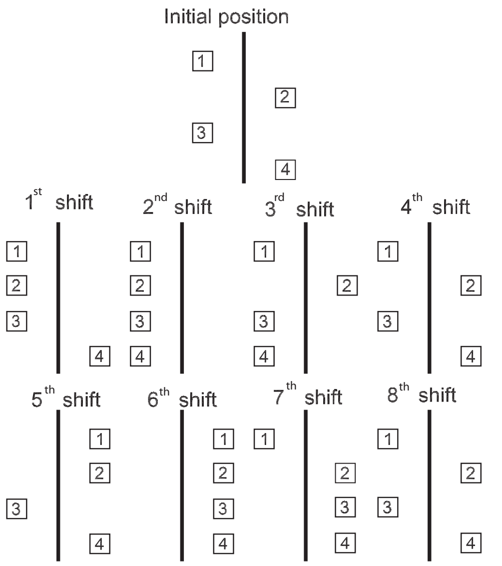
7 Inclining procedure

7.1

7.1.1

The standard test generally employs eight distinct weight movements as shown in Fig 1.

Figure 1



The weights are to be transversely shifted, so as not to modify the yacht's trim and vertical position of the centre of gravity.

After each weight shifting, the new position of the transverse centre of gravity of the weights is to be accurately determined.

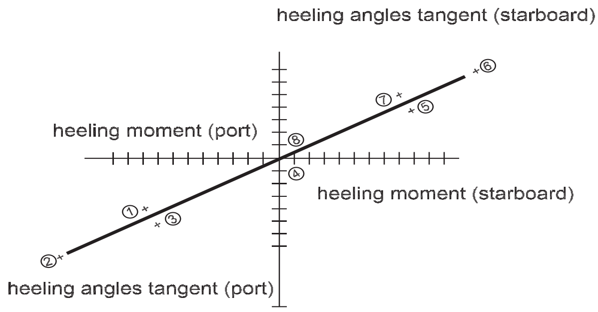
After each weight movement, the distance the weight was moved (centre to centre) is to be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph as shown in Fig 2.

The pendulum deflection is to be read when the yacht has reached a final position after each weight shifting.

During the reading, no movements of personnel are allowed.

For yachts with a length equal to or less than 30 m, six distinct weight movements may be accepted.

Figure 2



8 Lightweight check

8.1

8.1.1 An inclining test for an individual yacht may be dispensed with by Tasneef on a case-by-case basis, provided that basic stability data are available from the inclining test of a sister yacht and a satisfactory lightweight check is performed in order to prove that the sister yacht corresponds to the prototype yacht.

APPENDIX 2 STABILITY INFORMATION BOOKLET

1 Information to be included

1.1 General

1.1.1 A stability information booklet is a stability manual, to be approved by Tasneef which is to contain sufficient information to enable the Master to operate the yacht in compliance with the applicable requirements contained in the Rules.

1.2 List of information

1.2.1 The following information is to be included in the stability information booklet:

a) a general description of the yacht, including:
   - the yacht's name and Tasneef classification number
   - the yacht type and service notation
   - the class notations
   - the yard, the hull number and the year of delivery
   - the flag, the port of registry, the international call sign
   - the moulded dimensions
   - the design draft
   - the displacement corresponding to the above-mentioned draughts;

b) clear instructions on the use of the booklet;

c) general arrangement and capacity plans indicating the assigned use of compartments and spaces (stores, accommodation, etc.);

d) a sketch indicating the position of the draught marks referred to the yacht's perpendiculars;

e) hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the yacht, curves or tables corresponding to such range of trim. A clear reference relevant to the sea density, in t/m^3, is to be included as well as the draught measure (from keel or underkeel);

f) cross curves (or tables) 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;

g) tank sounding tables or curves showing capacities, centre of gravity, and free surface data for each tank;

h) lightship data from the inclining test, including lightship displacement, centre of gravity co-ordinates, place and date of the inclining test, as well as Tasneef approval details specified in the inclining test report. It is recommended that a copy of the approved test report be enclosed with the stability information booklet. Where the above-mentioned information is derived from a sister yacht, the reference to this sister yacht is to be clearly indicated, and a copy of the approved inclining test report relevant to this sister yacht is to be included;

i) standard loading conditions and examples for developing other acceptable loading conditions using the information contained in the booklet;

j) intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surface effect, GZ values and curve when applicable, reporting a comparison between the actual and the required values), which are to be available for each of the above-mentioned operating conditions;

k) information on loading restrictions when applicable;

l) information about openings (location, tightness, means of closure), pipes or other progressive flooding sources;

m) information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable;

n) any other necessary guidance for the safe operation of the yacht;

o) a table of contents and index for each booklet.

2 Loading conditions

2.1

2.1.1 The standard loading conditions to be included in the stability information booklet are:

a) yacht in the fully loaded departure condition, with full stores and fuel and the full number of guests;

b) lightship condition;

c) yacht in the fully loaded arrival condition, with only 10% stores and fuel remaining and the full number of guests.

Such loading cases are considered as a minimum requirement and additional loading cases may be included as deemed necessary or useful.

See also Ch 1, Sec 1, [5.14.4].

3 Stability curve calculation

3.1 General

3.1.1 Hydrostatic and stability curves are normally prepared on a designed trim basis. However, where the operating trim or the form and arrangement of the yacht are such that change in trim has an appreciable effect on righting arms, such change in trim is to be taken into account.

The calculations are to take into account the volume to the upper surface of the deck sheathing.

3.2 Superstructures and deckhouses which may be taken into account

3.2.1 Enclosed superstructures complying with the International Load Line Convention (ILLC) may be taken into account.

The second tier of similarly enclosed superstructures may also be taken into account. Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in the ILCC.

Where deckhouses comply with the above conditions, except that no additional exit is provided to a deck above, such deckhouses are not to be taken into account; however, any deck openings inside such deckhouses are to be considered as closed even where no means of closure are provided.

Deckhouses, the doors of which do not comply with the requirements in the ILCC, are not to be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of the ILCC. Deckhouses on decks above the freeboard deck are not to be taken into account, but openings within them may be regarded as closed. Superstructures and deckhouses not regarded as enclosed may, however, be taken into account in stability calculations up to the angle at which their openings are flooded (at this angle, the static stability curve is to show one or more steps, and in subsequent computations the flooded space is to be considered non-existent).

Trunks may be taken into account. Hatchways may also be taken into account having regard to the effectiveness of their closures.

3.3 Angle of flooding

3.3.1 In cases where the yacht would sink due to flooding through any openings, the stability curve is to be cut short at the corresponding angle of flooding and the yacht is to be considered to have entirely lost its stability.

Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes are not to be considered as open if they submerge at an angle of inclination more than 30°. If they submerge at an angle of 30° or less, these openings are to be assumed open if Tasneef considers this to be a source of significant progressive flooding; therefore, such openings are to be considered on a case-by-case basis.

4 Effects of free surfaces of liquids in tanks

4.1 General

4.1.1 For all loading conditions, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks.

4.2 Consideration of free surface effects

4.2.1 Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition.

Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. Free surface effects for small tanks may be ignored under the condition in [4.8].

4.3 Categories of tanks

4.3.1 Tanks which are taken into consideration when determining the free surface correction may be one of two categories:

a) Tanks with fixed filling level (e.g. liquid cargo, water ballast). The free surface correction is to be defined for the actual filling level to be used in each tank;

b) Tanks with variable filling level (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquid cargo and water ballast during liquid transfer operations).

Except as permitted in [4.6], the free surface correction is to be the maximum value attainable among the filling limits envisaged for each tank, consistent with any operating instructions.

4.4 Consumable liquids

4.4.1 In calculating the free surface effect in tanks containing consumable liquids, it is to be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account is to be that where the effect of free surface is the greatest.

4.5 Water ballast tanks

4.5.1 Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surface effect is to be calculated to take account of the most onerous transitory stage relating to such operations.

4.6 GMo and GZ curve corrections

4.6.1 The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately.

In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0 degrees angle of heel according to the categories indicated in [4.3].

The righting lever curve may be corrected by any of the following methods:

a) Correction based on the actual moment of fluid transfer for each angle of heel calculated; corrections may be calculated according to the categories indicated in [4.3];

b) Correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of heel calculated; corrections may be calculated according to the categories indicated in [4.3].

c) Correction based on the summation of M_{fs} values for all tanks taken into consideration, as specified in [4.3].

Whichever method is selected for correcting the righting lever curve, only that method is to be presented in the yacht's stability information booklet. However, where an alternative method is described for use in manually calculated loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, are to be included.

4.7 Free surface moment

4.7.1 The values for the free surface moment at any inclination in metre-tonnes for each tank may be derived from the formula:

$$M_{fs} = v b \rho k \delta^{0,5}$$

where:

v : Tank total capacity, in m^3

b : Tank maximum breadth, in m

ρ : Mass density of liquid in the tank, in t/m^3

k : Dimensionless coefficient to be determined from Tab 5 according to the ratio b/h. The intermediate values are determined by interpolation.

δ : Tank block coefficient, equal to:

$$\delta = \frac{v}{b l h}$$

l : Tank maximum length, in m

h : Tank maximum height, in m.

4.8 Small tanks

4.8.1 Small tanks which satisfy the following condition using the values of k corresponding to an angle of inclination of 30° need not be included in the correction:

$$\frac{M_{fs}}{\Delta_{min}} < 0,01\,m$$

where:

Δ_{min} : Minimum yacht displacement, in t, calculated at dmin

dmin : Minimum mean service draught, in m, of yacht without cargo, with 10% stores and minimum water ballast, if required.

4.9 Remainder of liquid

4.9.1 The usual remainder of liquids in the empty tanks need not to be taken into account in calculating the corrections, providing the total of such residual liquids does not constitute a significant free surface effect.

Table 1 : Value of coefficient k for calculating free surface corrections

$$k = \frac{\sin\theta}{12}\cdot\left(1+\frac{(\tan\theta)^2}{2}\right)\cdot\frac{b}{h}\ , \qquad \text{where} \qquad \cot\theta \geq \frac{b}{h}$$

$$k = \frac{\cos\theta}{8}\cdot\left(1+\frac{\tan\theta}{b/h}\right)-\frac{\cos\theta}{12\cdot(b/h)^2}\cdot\left(1+\frac{(\cot\theta)^2}{2}\right)\ , \qquad \text{where} \qquad \cot\theta < \frac{b}{h}$$

θ b/h	5°	10°	15°	20°	30°	40°	45°	50°	60°	70°	75°	80°	85°	θ b/h
20	0,11	0,12	0,12	0,12	0,11	0,10	0,09	0,09	0,09	0,05	0,04	0,03	0,02	20
10	0,07	0,11	0,12	0,12	0,11	0,10	0,10	0,09	0,07	0,05	0,04	0,03	0,02	10
5,0	0,04	0,07	0,10	0,11	0,11	0,11	0,10	0,10	0,08	0,07	0,06	0,05	0,04	5,0
3,0	0,02	0,04	0,07	0,09	0,11	0,11	0,11	0,10	0,09	0,08	0,07	0,06	0,05	3,0
2,0	0,01	0,03	0,04	0,06	0,09	0,11	0,11	0,11	0,10	0,09	0,09	0,08	0,07	2,0
1,5	0,01	0,02	0,03	0,05	0,07	0,10	0,11	0,11	0,11	0,11	0,10	0,10	0,09	1,5
1,0	0,01	0,01	0,02	0,03	0,05	0,07	0,09	0,10	0,12	0,13	0,13	0,13	0,13	1,0
0,75	0,01	0,01	0,01	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,16	0,75
0,5	0,00	0,01	0,01	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,23	0,5
0,3	0,00	0,00	0,01	0,01	0,01	0,02	0,03	0,03	0,05	0,11	0,19	0,27	0,34	0,3
0,2	0,00	0,00	0,00	0,01	0,01	0,01	0,02	0,02	0,04	0,07	0,13	0,27	0,45	0,2
0,1	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,02	0,04	0,06	0,14	0,53	0,1