Life Environmentally Optimized

Rules for the Classification of Ships with Reinforced Plastic, Aluminium Alloy or Wooden Hulls

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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 authorized 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 certificate on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of 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 right to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorization 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 class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

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

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's clients 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 property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which 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

1. Reference edition

The reference edition of these Rules is the edition effective from 1 July 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 4 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 subdivision and cross-references

3.1 Rule subdivision

The Rules are subdivided into three parts, from A to C.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Each Part consists of:

- **Chapters**
- **Sections**
- **Articles**
- **Sub-articles**
- **Requirements**

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

3.2 Cross-references

Examples: Pt A, Ch 1, Sec 1, [2.2.1]

- **Pt A means Part A of these Tasneef Rules**

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

- **Ch 1 means Chapter 1**

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

- **Sec 1 means Section 1**

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

- [2.2.1] refers to requirement 1, within sub-article [2] of Article [2].

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.

3.3 Cross-references to Tasneef Rules for the Classification of Ships

The Tasneef Rules for the Classification of Ships are referred to with the abbreviated wording “Tasneef Rules”.

For example Part A of the Tasneef Rules means Part A of the Tasneef Rules for the Classification of Ships.

Tasneef®

Life Environmentally Optimized

RULES FOR THE CLASSIFICATION
OF SHIPS WITH REINFORCED PLASTIC,
ALUMINIUM ALLOY OR WOODEN HULLS

Parts **A B C**

Part A	**CLASSIFICATION AND SURVEYS**
Part B	**HULL AND STABILITY**
Part C	**MACHINERY, SYSTEMS AND FIRE PROTECTION**

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RULES FOR THE CLASSIFICATION
OF SHIPS WITH REINFORCED PLASTIC,
ALUMINIUM ALLOY OR WOODEN HULLS

Part A
Classification and Surveys

Chapters **1 2 3 4**

CHAPTER 1
FOREWORD

Section 1 Field of Application of the Rules and General

CHAPTER 2
SURVEYS OF SHIPS WITH REINFORCED PLASTIC HULL

Section 1 Field of application and surveys

CHAPTER 3
SURVEYS OF SHIPS WITH ALUMINIUM ALLOY HULL

Section 1 Field of application and surveys

CHAPTER 4
SURVEYS OF SHIPS WITH WOODEN HULL

Part A
Classification and Surveys

Chapter 1
FOREWORD

SECTION 1 FIELD OF APPLICATION OF THE RULES AND GENERAL

SECTION 1 FIELD OF APPLICATION OF THE TASNEEF RULES AND GENERAL

1 Field of application of the Tasneef Rules

1.1

1.1.1 These Tasneef Rules apply for the purpose of classification of ships with reinforced plastic, aluminium alloy or wooden hull, except for ships for which specific Tasneef Rules are in force, such as, for example, pleasure craft and High Speed Craft (HSC).

Where necessary, in the various parts of the Tasneef Rules, specific conditions relevant to the field of application of the requirements are given.

These Tasneef Rules contain general requirements applicable to all ships and special requirements applicable to passenger ships and fishing vessels . The requirements for cargo ships, for the purpose of assignment of special service notations (except for fishing vessels, which are specifically dealt with in these Tasneef Rules) will be established by Tasneef case by case on the basis of the requirements of Part E of the Tasneef Tasneef Rules for the Classification of Ships.

For the purpose of the assignment of special class notations, the requirements of Part F of the Tasneef Rules for the Classification of Ships are to be complied with, as far as practicable, at Tasneef's discretion, in relation to the navigation and service notations, ship size and hull material.

2 General

2.1 Compliance with statutory Tasneef Rules and regulations

2.1.1 With regard to what is not expressly stated or modified in these Tasneef Rules, for the purpose of classification, the requirements of the Tasneef Rules for the Classification of Ships, as far as applicable, are to be complied with.

The classification of a ship, and more in general, Tasneef's decisions and acts, do not absolve the Interested Party from compliance with any additional and/or more stringent Tasneef Rules and requirements, issued by the Administration of the state whose flag the ship is entitled to fly, and/or of the State of the base port from which the ship operates, and with any other specific provisions issued to this end.

2.2 Abbreviations

2.2.1 Tasneef Rules

In these Tasneef Rules, the wording "Tasneef Rules" is intended to mean the effective Tasneef "Rules for the Classification of Ships"; i. e., when in the text, reference is made to Part A of the Tasneef Rules, reference is to be made to Part A of the Tasneef Rules for the Classification of Ships.

Part A

Classification and Surveys

Chapter 2

SURVEYS OF SHIPS WITH REINFORCED PLASTIC HULL

SECTION 1 FIELD OF APPLICATION AND SURVEYS

SECTION 1 FIELD OF APPLICATION AND SURVEYS

1 Field of application

1.1

1.1.1 The requirements of this Chapter apply to ships with reinforced plastic hull.

For the purpose of classification and surveys, the requirements of Part A of the Tasneef Rules are to be complied with, taking account of the modifications and additions specified in [2], [3] and [4], as far as the frequency and the technical requirements relevant to surveys are concerned.

2 Periodical surveys and relevant frequency, anticipations and postponements

2.1 Surveys in general

2.1.1 For all periodical surveys, the requirements of Part A, Chapter 2, Section 2 of the Tasneef Rules are to be fulfilled. However, in the case of ships more than 15 years old, the frequency of the Bottom survey is subject to special consideration.

3 First Classification Surveys

3.1 First Classification Surveys of ships built under Tasneef supervision

3.1.1 Special inspections are required at the following stages:

a) when the hull lamination starts with the application of gel-coat;

b) before starting the arrangement of internal stiffeners;

c) when the hull is extracted from the mould;

d) when the connection of the hull to the deck starts;

e) before the installation of the dolly, if any;

f) when the core of sandwich structure is arranged.

In addition, during the supervision of the first hull, an inspection of the shipyard is performed in order to verify that it is provided with adequate equipment in relation to the materials used and to the type of manufacture and that the quality of the laminates is ensured.

3.2 First Classification Surveys of ships built without Tasneef supervision

3.2.1 The eligibility for class is evaluated on the basis of the substantial compliance with the applicable Tasneef Rules, with the examination of main drawings and documents and following the outcome of a First Classification Survey specifically carried out with an extension adequate to the individual cases.

Where appropriate, within reasonable limits, a proven service record of satisfactory performance may be used as a criterion of equivalence. Special consideration will be given to ships of recent construction.

For the purpose of classification, it may be required that adequate data for the evaluation of materials, machinery and arrangements in general are made available; such adequate data may consist of the details of specific Tasneef Rules and requirements originally applied but, where appropriate, tests and checks, to be established in the individual cases, may also be required.

4 Periodical hull surveys

4.1 Annual surveys

4.1.1 In the case of hulls made of sandwich type structures, it is to be carefully checked that the parts are not detached from the core. The check is to be performed by hammering the shell and evaluating the differences in the sound heard or by means of checks with non-destructive methods recognized by Tasneef.

4.1.2 The connection between hull and deck is to be carefully checked, in particular when hull and deck are made of different materials.

4.2 Class renewal survey (hull) and bottom survey in dry condition

4.2.1 In addition to the requirements for the Annual surveys given in [4.1], the presence of "osmosis" phenomena in the laminates of the underwater body and/or of cracks in the gel-coat is to be verified.

To this end, the ship is to be made available for the bottom survey in dry condition before the application of any paint, so as to allow a careful visual inspection.

Part A
Classification and Surveys

Chapter 3

SURVEYS OF SHIPS WITH ALUMINIUM ALLOY HULL

SECTION 1 FIELD OF APPLICATION AND SURVEYS

SECTION 1 FIELD OF APPLICATION AND SURVEYS

1 Field of application

1.1

1.1.1 The requirements of this Chapter apply to ships with aluminium alloy hull.

The applicable requirements of Part A of the Tasneef Rules are generally to be complied with, taking account of the modifications and additions specified in [2] and [3], as far as the frequency and the technical requirements relevant to surveys are concerned.

2 Periodical surveys and relevant frequency, anticipations and postponements

2.1 Surveys in general

2.1.1 For all periodical surveys, the requirements of Part A, Chapter 2, Section 2 of the Tasneef Rules are to be fulfilled. However, in the case of ships more than 15 years old, the frequency of the Bottom survey is subject to special consideration.

3 First Classification Surveys

3.1 First Classification Surveys of ships built without Tasneef supervision

3.1.1 The eligibility for class is evaluated on the basis of the substantial compliance with the applicable Tasneef Rules, with the examination of main drawings and documents and following the outcome of a First Classification Survey specifically carried out with an extension adequate to the individual cases.

Where appropriate, within reasonable limits, a proven service record of satisfactory performance may be used as a criterion of equivalence. Special consideration will be given to ships of recent construction.

For the purpose of classification, it may be required that adequate data for the evaluation of materials, machinery and arrangements in general are made available; such adequate data may consist of the details of specific Tasneef Rules and requirements originally applied but, where appropriate, tests and checks, to be established in the individual cases, may also be required.

Part A

Classification and Surveys

Chapter 4

SURVEYS OF SHIPS WITH WOODEN HULL

SECTION 1 FIELD OF APPLICATION AND SURVEYS

SECTION 1 FIELD OF APPLICATION AND SURVEYS

1 Field of application

1.1

1.1.1 The requirements of this Chapter apply to ships with wooden hull.

The applicable requirements of Part A of the Tasneef Rules are generally to be complied with, taking account of the modifications and additions specified in [3.1], [3.2], [3.3] and [3.4], as far as the frequency and the technical requirements relevant to surveys are concerned.

2 Periodical surveys and relevant frequency, anticipations and postponements

2.1

2.1.1 The requirements of Part A, Chapter 2, Section 2 of the Tasneef Rules are to be fulfilled, with the exception of the Bottom survey, which is to be performed one year after the previous survey of the same type for all passenger and cargo ships with wooden hull of 200 gross tonnage and upwards.

3 Periodical hull surveys

3.1 Annual surveys

3.1.1 The ship is to be inspected, as far as practicable at the time of the survey, in order to verify that the hull and its equipment are in a satisfactory and efficient condition and that no significant unapproved modifications or alterations have been made which could affect the class and/or the safety of the ship concerned.

The checks to be performed to this end are to include, inter alia, the following items:

a) the outside shell above the waterline, with particular attention to the butts of shell and sheerstrake planking;

b) weather decks, with particular attention to the butts of waterways, inner waterways and planking;

c) hatchways (coamings, shifting beams, fore and aft covers, etc.), other deck openings (with closing appliances, ventilator coamings, etc.) and bulwarks;

d) deck fittings and appliances, such as bollards, fairleads, guard-rails, ladders, etc.;

e) masts and rigging, and sails, if any (with iron fittings, standing and running rigging, etc.), including lightning conductors;

f) wire equipment - towline, hawsers and warps, and stream-anchor wire (or chain), if required;

g) the windlass and chain-cables as far as accessible;

h) the equipment of anchors and chain-cables;

i) main and auxiliary steering arrangements, with particular attention to the rod and chain gear, if fitted;

j) freeboard marks;

k) the deck outfit, tools and gear;

l) enclosed spaces, as far as accessible at the time of the survey.

For the purpose of the above, survey operations other than those mentioned above, but deemed equivalent by the Tasneef Surveyor in terms of the characteristics and general condition of the ship concerned, may also be carried out.

3.1.2 At alternate Annual surveys, after the second one, in addition to the provisions given in [3.1.1], all enclosed spaces are to be examined by the Tasneef Surveyor in charge to verify their condition.

In the course of the inspection, the following hull structural members are to be examined, in particular: beams, deck girders, pillars, knees, frames (after removal of air-courses and ceiling at the discretion of the Surveyor), breasthooks, deadwoods, keelsons, inner planking (beam shelves, clamps, thick strakes of ceiling, sparring, etc.), with particular attention to the examination of the butts of all longitudinal members.

Fastenings are also to be examined to verify their general condition.

The Surveyor may require a check of the condition of the structure by means of a more extensive specific examination, such as removal of portions of the inner planking and testing of timbers by axe, chisel or other suitable tool.

3.2 Bottom surveys

3.2.1 The survey is to consist of the following checks:

a) Check of the condition of the outside planking and its caulking by means of suitable tests, as deemed necessary by the attending Surveyor, on each side of the ship, amidships and at the ends, in the vicinity of the waterline and near to the keel, with local removal of any metal sheathing, as necessary. When evidence of deterioration is found in the outside planking and its caulking, additional tests are to be made as necessary to determine the extent of renewal of planking or re-caulking required. If it is found that general re-caulking of the outside planking is necessary, the metal sheathing, if any, is to be entirely removed and the outside planking is to be thoroughly cleaned. At the discretion of the Tasneef Surveyor, after re-caulking the metal sheathing is to be renewed either entirely or in the deteriorated areas.

b) Check of the condition of keel, deadwood, stem, stern-post, rudder and associated pintles and gudgeons and all sea openings.

c) Examination of sea connections, of the attachments of valves to the ship shell and of gratings; where the valves fitted to the ship shell are of cast iron, they are to be opened for examination at every Docking Survey; where they are of ductile material, they are to be opened for examination at intervals not exceeding 4 years.

d) Measurement of clearances in the rudder gudgeons and the wear down in the rudder carrier bearing and stern-bush.

Moreover, in the case of a Docking Survey held concurrently with a First Classification or Special Survey, all those checks are to be performed which are required for such surveys and which can only be carried out when the ship is in drydock or on a slipway.

3.3 Class renewal survey No. 1

3.3.1 The survey is to include examination and checks sufficiently extensive to ensure that the structures, systems and equipment of the ship are in good order or are restored to such condition as to allow the ship to operate safely for the new period of class to be assigned.

To this end, the operations listed below, or others deemed equivalent by the Tasneef Surveyor in relation to the characteristics of the ship concerned, are to be performed.

The survey is, however, to include all the operations required in connection with an Annual survey of the hull and a Bottom survey.

3.3.2 All ceiling and limber boards are to be removed; in addition, if considered necessary by the Surveyor, a sufficient amount of the outer shell planking and inner sparring is to be removed to enable a close examination of the frames to be carried out.

3.3.3 Any surfaces in contact with rust are to be well scraped and the outside surface of the shell planking, from the light waterline to the covering boards, is to be well cleaned and scraped.

3.3.4 The condition of fastenings is to be checked and, if considered necessary by the Tasneef Surveyor, a sufficient number of fastenings is to be drawn to enable their condition and that of the adjacent timber to be thoroughly checked. In this connection, particular attention is to be given to iron fastenings, especially in way of the waterline, and fastenings made of copper or yellow metal are to be tested, as far as practicable, and renewed when found to be broken or excessively worn.

3.3.5 The sheerstrake planking is to be tested by drawing a sufficient number of treenails, or by boring if no treenails are fitted; the holes resulting from the latter are subsequently to be closed by treenails or bolts.

3.3.6 If the keel and centre keelson are connected by iron fastenings, a sufficient number of these fastenings is to be drawn to check their condition; where this is impracticable, additional fastenings, as required by the Surveyor, are to be fitted in the connection of keel with centre keelson, of stem and stern-post with aprons and inner stern-posts, and also in the connection of other main structural members.

3.3.7 Particular attention is to be given to the examination of breasthooks, frames, beams (particularly at their ends), knees, hawse timbers, knight heads, transoms and all fore and aft structural members.

3.3.8 If visual examination or testing by sounding and boring reveals rot or decay due to woodworm, the affected areas and adjacent timbers are to be closely inspected and, if necessary for the purpose, additional parts are to be removed in order to decide the extent of renewal required.

3.3.9 Bulwarks, bulwark stays, guard-rails and similar fittings, and superstructures in general are to be examined in order to check their condition.

3.3.10 Anchors and chain-cables are to be examined in accordance with the requirements in Part A, Chapter 3 of the Tasneef Rules applicable to Class renewal surveys of steel ships.

3.3.11 Rudder and steering arrangements are to be carefully examined and, if considered necessary for the purpose, the rudder is to be unshipped; rod and chain gears are to be examined as required for Class renewal surveys of steel ships.

3.4 Class renewal survey No. 2

3.4.1 The requirements for a Class renewal survey No. 1 are to be complied with, together with those in the following subparagraphs [3.4.2] to [3.4.5].

3.4.2 The whole of the internal structure and planking is to be cleaned and scraped.

3.4.3 Particular attention is to be given to the condition of the upper deck or weather decks; planks showing evident signs of wear are to be bored, and renewed either wholly or in part when the deterioration exceeds 20 mm.

3.4.4 The windlass and other items of deck machinery are to be examined and dismantled as deemed necessary by the Tasneef Surveyor.

3.4.5 The anchors and chain-cables are to be examined in accordance with the requirements in Chapter 3 applicable to the Class renewal surveys of steel ships.

3.5 Class renewal survey No. 3

3.5.1 The requirements for Class renewal surveys No. 1 and No. 2 are to be complied with, together with those in the following subparagraphs [3.5.2] and [3.5.3].

3.5.2 Several lengths of covering boards, waterways and inner waterways are to be removed as considered necessary by the Surveyor, in order to carefully check the condition of the timber in way of the ends of beams and frames.

3.5.3 Superstructures and erections are to be scraped, particularly in those positions which are liable to greater deterioration, and parts are to be removed as required for renewal and/or repair.

Life Environmentally Optimized

RULES FOR THE CLASSIFICATION
OF SHIPS WITH REINFORCED PLASTIC,
ALUMINIUM ALLOY OR WOODEN HULLS

Part B
Hull and Stability

Chapters **1 2 3**

CHAPTER 1
REINFORCED PLASTIC HULLS

CHAPTER 2
ALUMINIUM ALLOY HULLS

CHAPTER 3
WOODEN HULLS

Part B
Hull and Stability

CHAPTER 1
REINFORCED PLASTIC HULLS

SECTION 1 DESIGN PRINCIPLES AND STABILITY

1 Design principles

1.1 Applications

1.1.1 The requirements of Part B, Chapter 2 of the Tasneef Rules apply, together with the requirements of:

- Part E, Chapter 11, Section 2, for passenger ships
- Part E, Chapter 20, Section 2, for fishing vessels.

1.1.2 Direct calculations

Tasneef may require direct calculations to be carried out, if deemed necessary according to the provisions of Sec 3, [5].

Such calculations are to be carried out based on structural modelling, loading and checking criteria described in Sec 3, [5]. Calculations based on other criteria may be accepted if deemed equivalent to those laid down by Tasneef.

1.1.3 Units

Unless otherwise specified, the following units are used in the Tasneef Rules:

- thickness of plating, in mm,
- section modulus of stiffeners, in cm^3,
- shear area of stiffeners, in cm^2,
- span and spacing of stiffeners, in m,
- stresses, in N/mm^2,
- concentrated loads, in kN,
- distributed loads, in kN/m or kN/m^2.

1.1.4 Definitions and symbols

The definitions of the following terms and symbols are applicable throughout this Chapter and its Appendices and are not, as a rule, repeated in the different paragraphs. Definitions applicable only to certain paragraphs are specified therein.

"Moulded base line": The line parallel to the summer load waterline, crossing the upper side of keel plate or the top of skeg at the middle of length **L**.

"Hull": The hull is the outer boundary of the enclosed spaces of the craft, except for the deckhouses, as defined below.

"Chine": For hulls that do not have a clearly identified chine, the chine is the hull point at which the tangent to the hull is inclined 50° to the horizontal.

"Bottom": The bottom is the part of the hull between the keel and the chines.

"Main deck": The main deck is the uppermost complete deck of the hull. It may be stepped.

"Side": The side is the part of the hull between the chine and the main deck.

"Castle": A castle is a superstructure extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4% of the local breadth. In general, such a superstructure fitted on the weather deck of the ship is considered as "constituting a step of the strength deck" when it extends within 0,4 **L** amidships for at least 0,15 **L**. Other castles are considered as "not constituting a step of the strength deck".

"Deckhouse": The deckhouse is a decked structure located above the main deck, with lateral walls inboard of the side of more than 4 per cent of the local breadth. Structure located on the main deck and whose walls are not in the same longitudinal plane as the under side shell may be regarded as a deckhouse.

"Cross-deck": For twin-hull craft, the cross-deck is the structure connecting the two hulls.

"Fore end": Hull region forward of 0,9 **L** from the aft perpendicular.

"Deadrise angle α_d": For hulls that do not have a clearly identified deadrise angle, α_d is the angle between the horizontal and a straight line joining the keel and the chine. For catamarans with non-symmetrical hulls (where inner and outer deadrise angles are different), α_d is the lesser angle.

"Aft end": Hull region abaft of 0,1 **L** from the aft perpendicular.

"Midship area": Hull region between 0,3 **L** and 0,7 **L** from the aft perpendicular.

L : Rule length, in m, equal to L_{WL} where L_{WL} is the waterline measured with the craft at rest in calm water and, for SESs, in the off-cushion condition

FP : forward perpendicular, i.e. the perpendicular at the intersection of the waterline at draught **T** and the foreside of the stem

AP : aft perpendicular, i.e. the perpendicular located at a distance **L** abaft of the forward perpendicular

B : the greatest moulded breadth, in m, of the craft

B_w : the greatest moulded breadth, in m, measured on the waterline at draught **T**; for catamarans, B_w is the breadth of each hull

D : depth, in m, measured vertically in the transverse section at the middle of length L from the moulded base line of the hull(s) to the top of the deck beam at one side of the main deck (if the main deck is stepped, **D** will be defined in each separate case at the discretion of Tasneef)

T : draught of the craft, in m, measured vertically on the transverse section at the middle of length **L**, from the moulded base line of the hull(s) to the full load waterline, with the craft at rest in calm water and, for SESs, in the off-cushion condition

Δ : moulded displacement at draught **T**, in sea water (mass density = 1,025 t/m^3), in tonnes

C_B : total block coefficient, defined as follows:

$$C_B = \frac{\Delta}{(1,025 \cdot L \cdot B_W \cdot T)}$$

For catamarans, C_B is to be calculated for a single hull, assuming D equal to one half of the craft's displacement

V : maximum service speed, in knots

g : acceleration of gravity, equal to 9,81 m/s^2

LCG : longitudinal centre of gravity of the craft.

2 Intact stability

2.1 Application

2.1.1 In general the requirements of Part B, Chapter 3 of the Tasneef Rules apply and, for passenger ships, the requirements of Part E, Ch 11, Sec 3 of the Tasneef Rules.

SECTION 2 MATERIAL AND CONSTRUCTION

1 Application and structures

1.1 Application

1.1.1 In general, the requirements in [1.2] apply. Where, according to [1.1.1], the structural strength checks are carried out on the basis of the requirements from Sec 3, [7] to Sec 3, [13], the requirements in [2] and [3] apply.

1.2 Structures

1.2.1 The main raw materials are to be type approved by Tasneef.

It may be accepted as equivalent that main raw materials are individually inspected by Tasneef. In such a case, each batch being used is submitted to tests, the conditions and scope of which are stipulated by the Tasneef Surveyor.

a) **Reinforcement fibres**

Fibres for reinforcement may be textile glass or aramid or carbon fibres or other fibres.

Products laid on a surface, such as size, binder and coupling finish, are to ensure cohesion between fibres and resins.

During manufacturing, the shipyard is to ensure that reinforcement materials are free from scrap matter and without defects, detrimental to their use.

b) **Resins**

Resins are to be capable of withstanding ageing in marine environments and industrial atmospheres.

Resins are to be used within the limits fixed by the Manufacturer. In this respect, the Surveyor may ask for any relevant proof.

c) **Core materials for sandwich laminates**

Expanded foams contributing to sandwich laminate strength are to be of the closed cell type and compatible with the resins used.

Expanded polystyrenes may be used only as filling or buoyancy materials.

d) **Additives**

Fillers and pigments are to affect neither the conditions of polymerisation of the impregnation resin nor its mechanical characteristics. The percentage of both of them is not to exceed, as a rule, 10% of the mass of resin, with a maximum of 2% for thixotropic agents and 5% for flame retarders.

The use of microspheres is subject to special examination.

The type and proportions of catalyst and accelerator are to be adjusted in any case to the conditions of work (production rate) and ambient atmosphere (temperature).

In order to ensure complete curing, the builder is to respect the indications of the resin Manufacturer, particularly for the ratio of catalyst.

e) **Materials for integrated structures**

These are elements entirely covered with laminate, and used for reinforcement, moulding, or as lamination support for stiffeners, for example.

The metals used are to withstand seawater and fuel corrosion; they are to be of good quality and are not to have any influence on resin curing.

They are to undergo appropriate preparation to improve bonding with the resin.

As a rule, wood reinforcements are to be of a plywood type with good seawater resistance. The use of timber is subject to a special examination.

1.2.2 Tests on laminates

The shipyard is to make samples representative of shell materials and if possible of other parts of the structure, taking into account the type and size of ship.

If sister ships are built at the same shipyard, and provided that raw materials are not changed, the frequency of samples for testing is determined by Tasneef.

These test samples are to be submitted to a laboratory approved by Tasneef to undergo mechanical and physico-chemical tests, as defined below.

In general, tests are to be carried out according to the standards indicated below, or other recognized standards previously agreed upon with Tasneef.

These tests are to show that laminate characteristics are at least equivalent to the theoretical values given by direct calculation following the method given in [1.2.3]. Otherwise, supplementary tests may be required.

Tasneef reserves the right to require tests different from those defined below, if particular materials or unusual manufacturing process are used.

Tests are to be carried out on a panel, the composition of which is to be the same as that of a shell plating area, without gel-coat.

Identification of the panel is given by the following elements:

- exact name of the resin, with its specific gravity, elasticity modulus, and breaking stress in curing state,
- description of elementary layers,
- characteristics of the laminate (e.g. layer type, direction),
- direction of the panel in respect of longitudinal axis of the ship and indication of direction for warp and weft for the rovings in respect of the same axis.

Conditioning of laminate panels, preparation of testpieces, dimensional measurement of testpieces and the tests defined below are to be carried out according to recognized standards.

Tests are to be carried out on testpieces taken out of the panel in two perpendicular directions. The number of testpieces for each direction is given by the standard used for the particular test.

For each group of testpieces and for each result, the value to consider is the average obtained from the number of tested pieces, provided that the minimum value is not less than 0,9 times the mean value. Otherwise, the value to consider is determined by Tasneef, taking testing conditions and dispersion of results into account.

Mechanical characteristics are to be obtained from dry testpieces, i.e. not conditioned in water.

In general, the following tests are to be carried out:

- single skin laminates: tensile tests, bending tests (three-point method), measurement of specific gravity and percentage of reinforcement in mass,
- sandwich laminates: bending tests (four-point method), and, for each skin, tensile tests, measurement of specific gravity and percentage of reinforcement in mass.

Bending tests are to be carried out with the load applied either on the gel-coat side or on the opposite side. The choice of the side is to be decided in accordance with Tasneef, so that the failure mode of the testpiece is representative of the case of scantlings of the plating.

Test results are to be shown in a test report, mentioning the tests in a) to c).

a) **Tensile tests**

In general, these tests are to be carried out for single skin laminates and the skins of sandwich laminates.

The applicable standard is:

- ISO 3268.

For each testpiece, the test report is to provide the following information:

- reference of the standard used for the test,
- widths and thicknesses of the testpiece, in mm,
- length between fixed ends, in mm,
- load (in N),
- elongation curve (in mm),
- breaking load, in N,
- tensile breaking stress, in N/mm^2,
- tangential initial elasticity modulus, in N/mm^2,
- other items of information required by the standard, if necessary.

If breaking occurs in several steps, the value taken into account is the first break obtained from the load-elongation curve.

The test report is also to indicate the mean value of the breaking load, breaking tensile strength and tangential initial elasticity modulus.

b) **Bending tests**

In general, bending tests using the three-point method are to be carried out only for the single skin laminates.

The applicable standard is:

- ISO 178.

In general, bending tests using the four-point method are to be carried out only for sandwich laminates.

The applicable standard is:

- ASTM C 393.

For each testpiece, the test report is to provide the following information:

- reference of the standard used for the test,
- widths and thicknesses of the testpiece, in mm,
- length of the span between supports, in mm,
- for the four-point method: location of the points where the load is applied,
- load (in N),
- deflection (in mm) curve,
- breaking load, in N, and failure mode,
- bending breaking strength, in N/mm^2, for single skin laminate tests,
- bending breaking strength of skin and shear breaking strength of core for sandwich laminate tests, both in N/mm^2,
- other items of information required by the standard, if necessary.

If breaking occurs in several steps, the value taken into account is the first break obtained from the load-deflection curve.

The test report is also to indicate the mean value of the breaking load and breaking strength.

c) **Mass density and percentage of reinforcement**

In general, these tests are to be carried out for single skin laminates and the skins of sandwich laminates.

The applicable standards are:

- ASTM D 792,
- ASTM D 3171.

For each testpiece, the test report is to provide the following information:

- reference of the standard used for the test,
- dimensions, in mm, of the testpiece,
- mass of the test-piece, in g,
- mass by unit of area of the testpiece, in g/m^2,
- specific density, in g/m^3,
- mass of reinforcement of the testpiece, in g,
- mass of reinforcement by unit of area, in g/m^2,
- percentage of reinforcement in mass,
- other items of information required by the standard, if necessary.

The test report is also to indicate the mean value of the mass by unit of area, in g/m^2, specific gravity, in g/m^3, mass of reinforcement by unit of area, in g/m^2, and percentage of reinforcement in mass.

1.2.3 Estimation of mechanical characteristics of materials

The meanings of the symbols used below are as follows:

Ψ : content in mass of reinforcement in a layer,

ϕ : content in volume of reinforcement in a layer, defined in (a) below,

μ_0 : vacuum content, equal to 0, if there is no available information,

$\mathbf{E}_1$: Young's modulus of a layer with unidirectional fibres, parallel to fibres, in N/mm², defined in (a) below,

$\mathbf{E}_2$: Young's modulus of a layer with unidirectional fibres, perpendicular to fibres, in N/mm², defined in (a) below,

ν_{12}, ν_{21} : Poisson's ratios of a layer with unidirectional fibres, defined in (a) below,

$\mathbf{G}_{12}$: Coulomb's modulus of a layer with unidirectional fibres, in N/mm², defined in (a) below,

ρ_v : specific gravity of reinforcement, in g/cm³,

ρ_r : specific gravity of resin, in g/cm³,

$\mathbf{E}_{1v}$: Young's modulus of reinforcement in the direction parallel to fibres, in N/mm²,

$\mathbf{E}_{2v}$: Young's modulus of reinforcement in the direction perpendicular to fibres, in N/mm²,

$\mathbf{E}_r$: Young's modulus of resin, in N/mm²,

ν_v : Poisson's ratio of reinforcement,

ν_r : Poisson's ratio of resin,

$\mathbf{G}_r$: Coulomb's modulus of resin, in N/mm², defined in (a) below,

$\mathbf{G}_v$: Coulomb's modulus of the reinforcement, in N/mm², as given in Tab 1.

When there is no available information, the values given in Tab 1 may be considered.

a) **Elementary layer**

The content in volume φ of reinforcement in the layer is given by the formula:

$$\phi = \frac{\psi \cdot (1 - \mu_0)}{\psi + (1 - \psi) \cdot \dfrac{\rho_v}{\rho_r}}$$

Whatever the type of reinforcement used in a particular layer, the elastic characteristics of a layer with unidirectional fibres having the same content of reinforcement as that layer are to be calculated first:

- Young's moduli:

  parallel to fibres

  $$\mathbf{E}_1 = \phi \cdot \mathbf{E}_{1v} + (1 - \phi) \cdot \mathbf{E}_r$$

  perpendicular to fibres

  $$\mathbf{E}_2 = \frac{\mathbf{E}_r}{1 - \nu_r^2} \cdot \frac{1 + 0{,}85 \cdot \phi^2}{(1 - \phi)^{1,25} + \phi \dfrac{\mathbf{E}_r}{\mathbf{E}_{2v}(1 - \nu_r^2)}}$$

- Poisson's ratios:

  $$\nu_{12} = \phi \cdot \nu_v + (1 - \phi) \cdot \nu_r$$

  $$\nu_{21} = \nu_{12} \cdot \frac{\mathbf{E}_2}{\mathbf{E}_1}$$

- Coulomb's modulus:

  $$\mathbf{G}_{12} = \mathbf{G}_r \cdot \frac{1 + 0{,}6 \cdot \phi^{0,5}}{(1 - \phi)^{1,25} + \dfrac{\mathbf{G}_r}{\mathbf{G}_v} \cdot \phi}$$

  where:

  $$\mathbf{G}_r = \frac{\mathbf{E}_r}{2 \cdot (1 + \nu_r)}$$

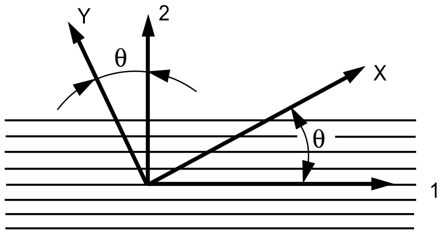
Following any direction that forms an angle θ with the direction of fibres, Young's moduli of the elementary layer become:

$$\frac{1}{\mathbf{E}_x} = \frac{1}{\mathbf{E}_1} \cdot \cos^4\theta + \left(\frac{1}{\mathbf{G}_{12}} - \frac{2\nu_{12}}{\mathbf{E}_1}\right) \cdot \sin^2\theta \cdot \cos^2\theta + \frac{1}{\mathbf{E}_2} \cdot \sin^4\theta$$

$$\frac{1}{\mathbf{E}_y} = \frac{1}{\mathbf{E}_1} \cdot \sin^4\theta + \left(\frac{1}{\mathbf{G}_{12}} - \frac{2\nu_{12}}{\mathbf{E}_1}\right) \cdot \sin^2\theta \cdot \cos^2\theta + \frac{1}{\mathbf{E}_2} \cdot \cos^4\theta$$

The values of E_1, E_2, ν_{12} and G_{12} are calculated as above; directions x and y are defined in Fig 1.

Figure 1



In general, the content in mass of reinforcement in a layer of mat is between 0,25 and 0,35.

Young's modulus of a layer of mat may be estimated from:

$$\mathbf{E}_M = \frac{3}{8} \cdot \mathbf{E}_1 + \frac{5}{8} \cdot \mathbf{E}_2$$

In this formula, the values $\mathbf{E}_1$ and $\mathbf{E}_2$ are those defined above.

Woven rovings may be taffeta, cotton serge, satin, etc., warp and weft balanced or not.

In general, the content in mass of reinforcement in a woven roving reinforced layer is between 0,4 and 0,6, and the content in mass of reinforcement in a unidirectional reinforced layer is between 0,6 and 0,7.

The direction of the warp (direction 1) is to be distinguished from that of the weft (direction 2); the elastic characteristics are:

$$\mathbf{E}_{1R} = \mathbf{k} \cdot \mathbf{E}_1 + (1 - \mathbf{k}) \cdot \mathbf{E}_2$$

$$\mathbf{E}_{2R} = (1 - \mathbf{k}) \cdot \mathbf{E}_1 + \mathbf{k} \cdot \mathbf{E}_2$$

where **k** is the woven balance coefficient equal to the ratio of warp tensile strength to the sum of tensile strengths in warp and weft, $\mathbf{E}_1$ and $\mathbf{E}_2$ being defined above.

Generally, a layer reinforced with woven rovings may be considered as made of two perpendicular unidirectional layers, and it is possible to apply directly to them the formulae laid down above, taking into account the actual content of reinforcement in the layer.

b) **Single skin laminates**

A laminate is made of n layers. The characteristics of layer i of the laminate are:

$\mathbf{t}_i$: thickness, in mm, regardless of direction, given by

$$t_i = \frac{P_{vi}}{(1-\mu_0)} \cdot \left(\frac{1}{\rho_v} + \frac{1-\psi_i}{\psi_i \cdot \rho_r}\right) \cdot 10^{-3}$$

where P_{vi} is the mass of reinforcement by unit of area in layer i in g/m², and Ψ_i is the content in mass of reinforcement in layer i.

z_i : distance, in mm, from the neutral fibre of layer i to an edge (regardless of direction):

$$z_i = z_{i-1} + \frac{t_{i-1} + t_i}{2}$$

E_i : Young's modulus of layer **i**, in N/mm², assumed to be known and experimentally verified. E_i is the lowest of the values in tension and compression.

The equivalent tensile elasticity modulus E_L, in N/mm², of the multi-layer laminate may be calculated by:

$$E_L = \frac{\sum E_i \cdot t_i}{\sum t_i}$$

The distance of the neutral fibre of the multi-layer laminate is, in mm:

- $V = \frac{\sum E_i \cdot t_i \cdot z_i}{\sum E_i \cdot t_i}$, with regard to the edge of reference,
- $V' = \sum t_i - V$, with regard to the other edge.

Distances d_i from the neutral fibre of each layer to the neutral fibre of the laminate are, in mm:

$$d_i = z_i - V$$

The flexural rigidity of the multi-layer laminate [**EI**], by millimetre of width, in N.mm²/mm

$N \cdot mm^2/mm$ is

$$[EI] = \sum E_i \cdot \left(\frac{t_i^3}{12} + t_i \cdot d_i^2\right)$$

The inertia of the multi-layer laminate, by millimetre of width, in mm⁴/mm, is:

$$[I] = \sum\left(\frac{t_i^3}{12} + t_i \cdot d_i^2\right)$$

The theoretical bending breaking strength of the multi-layer laminate s_{br}, is, in N/mm²:

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]}(1-\mu_0)^2 \cdot 10^{-3}$$

where **k** is equal to:

- 17, for laminates using polyester resin,
- 25, for laminates using epoxy resin.

When the breaking strength of the laminate, given by mechanical tests as stipulated in [1.2.2], is greater than the theoretical calculated value σ_{br}, the breaking strength obtained from tests can be taken into account to increase the preceding value of σ_{br} .

c) **Sandwich laminates**

The inertia and flexural rigidity of sandwich laminates are to be calculated according to (d) and (e) above, taking into account the core as an elementary layer with its own characteristics (thickness and Young's modulus of the core material).

The theoretical bending breaking strength by bending of skins of the sandwich laminate is, in N/mm²

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]}(1-\mu_0)^2 \cdot 10^{-3}$$

where:

[**EI**] : flexural rigidity of the sandwich laminate, in N.mm²/mm $N \cdot mm^2/mm$

[**I**] : inertia of the sandwich laminate, in mm⁴/mm,

μ_0 : vacuum content of skins,

k : coefficient equal to:

- 17,0 for skins using polyester resin,
- 25,0 for skins using epoxy resin,
- 12,5 for skins made of carbon reinforcements and epoxy resins.

When the breaking strength of the laminate by bending of skins, given by mechanical tests as required in [1.2.2], is greater than the theoretical calculated value σ_{br}, the breaking strength obtained from tests can be taken into account to increase the preceding value of σ_{br}.

The shear breaking of a sandwich laminate is to be considered in each individual case, considering the thickness and the shear breaking strength of the core material (see Sec 3, [6.4.3]).

d) **Stiffeners**

In general, the characteristics of the member considered as support only for the lamination of the stiffener are not to be taken into account for estimation of the mechanical characteristics of the stiffener.

Symbols are shown in Tab 2, where l_b is the width of the associated plating, defined in Tab 3.

To supplement the symbols defined in Sec 3, [6.4.4], the following elements are needed:

z_i : distance from the neutral fibres of the three elements, i.e. core, flange and associated plating (index i refers to each one of them), to the outer face of the associated plating, in mm

V : distance from the stiffener neutral fibre to the outer face of the associated plating, in mm:

$$V = \frac{\sum E_i \cdot S_i \cdot z_i}{\sum E_i \cdot S_i}$$

V' : distance from the stiffener neutral fibre to the outer face of the flange, in mm:

$$V' = H - V + t_s + t_b$$

d_i : distances from the neutral fibre of each element to the stiffener neutral fibre, in mm:

$$d_i = z_i - V$$

I_i : specific inertia of each element, in mm⁴.

The rigidity of a stiffener [**EI**], in , N · mm² is:

$$[EI] = \left\lfloor \sum E_i \cdot (I_i + S_i \cdot d_i^2) \right\rfloor$$

The inertia of a stiffener [**I**], in mm^4, is:

$$[I] = \sum (I_i + S_i \cdot d_i^2)$$

The theoretical bending breaking strength of the stiffener σ_{br}, in N/mm^2, is:

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]} \cdot 10^{-3}$$

where **k** is equal to:

- 17, for stiffeners using polyester resin,
- 25, for stiffeners using epoxy resin.

Table 1

		Fibres				Resins	
		E Glass	Aramid	HS Carbon	HM Carbon	Polyester	Epoxy
Mass density in g/cm³		2,54	1,45	1,80	1,90	1,20	1,20
Young's modulus, in N/mm²	Parallel to fibres	73000	130000	230000	370000	3000	2600
	Perpendicular to fibres	73000	5400	15000	6000	-	-
Coulomb's modulus, in N/mm²		30000	12000	50000	20000	-	-
Poisson's ratio		0,25	0,35	0,35	0,35	0,316	0,40

Table 2

Element	Width or height in mm	Thickness in mm	Young's modulus in N/mm²	Cross-Sectional area mm²
Flange	l_s	t_s	E_S	$S_s = t_s \cdot l_s$
Core	H	t_a	E_a	$S_a = t_a \cdot H$
Associated plating	l_b	t_b	E_b	$S_b = t_b \cdot l_b$

Table 3

1		2
R_m = ultimate tensile strength	$= 1278\ G_c^2 - 510\ G_c + 123$	75
E = tensile modulus of elasticity	$= (37\ G_c - 4{,}75)\ 10^3$ **(1)**	6000
R_{mc} = ultimate compressive strength	$= 150\ G_c + 72$ **(1)**	115
E_c = compressive modulus of elasticity	$= (40\ G_c - 6)\ 10^3$	4000
R_{mf} = ultimate flexural strength	$= (502\ G_c^2 + 106{,}8)$ **(2)**	118
E_f = flexural modulus of elasticity	$= (33{,}4\ G_c^2 + 2{,}2)\ 10^3$ **(1)**	5000
R_{mt} = ultimate shear strength	$= 80\ G_c + 38$	58
G = shear modulus of elasticity	$= (1{,}7\ G_c + 2{,}24)\ 10^3$	2665
R_{mti} = ultimate interlaminar shear strength	$= 22{,}5 - 17{,}5\ G_c$	18
- Laminates with unidirectional reinforcements		
R_{mu} = ultimate tensile strength	$= 1900\ G_c^2 - 1500\ G_c + 560$	304
E_u = tensile modulus of elasticity	$= (143\ G_c^2 - 114\ G_c + 42{,}7)\ 10^3$	23100

(1) Formula applicable for $G_c > 0{,}29$; for $G_c = 0{,}29 \div 0{,}25$, the following is required: $E \geq 6000$; $R_{mc} \geq 115$; $E_f \geq 5000$

(2) For $G_c = 0{,}29 \div 0{,}25$, values of R_{mf} less than the values given by such formula are permitted down to a minimum of 85%; therefore, $R_{mf} = 118$ for $G_c = 0{,}25$

2 Materials

2.1 Terminology

2.1.1

a) Reinforced plastic: heterogeneous material consisting of a matrix of thermosetting resin with associated additives and of (generally glass) fibre reinforcements, produced as a laminate through moulding.

b) Resins: of the unsaturated polyester type or possibly epoxide resins.

c) Reinforcement of reinforced plastic: the fibres mentioned in a) for example in the form of mat, woven roving, cloth. The reinforcement may be termed:

- homogeneous, when the fibres are made of the one material (for example glass) for the entire laminate;
- promiscuous, when the fibres of some layers are made of one material and those of others of another;
- hybrid, when the fibres of one or more layers are of two or more different materials.

d) Single-skin laminate: a reinforced plastic material which is generally in the shape of a flat or curved plate, or moulded.

e) Material composed of two single-skin laminates, structurally connected by the interposition of a core of light material.

2.2 Materials making up the laminates

2.2.1 General

All of the materials making up the laminates are to have properties suitable for hull construction in the opinion of the builder. Following examination of the relevant information received, Tasneef may, at its discretion, require specific checks of the laminates to be carried out.

2.2.2 Resins

Resins (see [2.1]) 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 and have mainly the purpose of protecting the laminate from external agents. Orthophthalic gel coat resins are not accepted.

2.2.3 Resin additives

Resin additives (catalysts, accelerators, fillers, colour pigments) are to be compatible with the resins and suitable for the curing process of the latter. Catalysts which initiate the curing process of the resin and accelerators which govern the gelling and setting times are to be such that the resin sets completely in cold conditions in the environmental conditions in which manufacture is carried out.

The inert fillers are not to:

- significantly alter the properties of the resin, with particular regard to the viscosity, and are to be uniformly distributed in the resin itself such that the laminates, in particular those of the fire-retarding type, have the minimum mechanical properties stated in these requirements;
- exceed 13% (including 3% of any thixotropic filler) by weight of the resin or, if less, the maximum amount recommended by the Manufacturer.

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.

2.2.4 Glass fibre and associated products

Glass fibre of type E is to be employed for the following types of products:

M : mat, continuous filament mat or chopped strand mat;

F_s : rovings for chopping;

S : woven roving;

S_u : unidirectional woven roving;

T : cloth;

C : combined products, i.e. made up of more than one type, e.g. M+S.

2.2.5 Other types of fibres and associated products

The use of reinforcements made of aramid type fibres or carbon fibres or hybrid type fibres (e.g. cloth made of carbon and aramid type fibres) is allowed provided that the fibres and associated products comply with the Tasneef "Rules for the type-approval of components of composite materials intended for hull construction".

Other types of fibres may be considered by Tasneef on a case-by-case basis.

2.3 Core materials for sandwich laminates

2.3.1 Such materials are to have the appropriate physical and mechanical properties and resistance to environmental agents for the intended use in accordance with the Tasneef "Rules for the type-approval of components of composite materials intended for hull construction".

2.4 Type approval of materials

2.4.1 For the purposes of the type-approval, materials are to comply with the Tasneef "Rules for the type-approval of components of composite materials intended for hull construction". As far as concerns fire resistance, materials are to be in accordance with specific standards recognised by Tasneef, in particular with the specific Tasneef requirements for the fire protection of reinforced plastic ships.

2.5 Laminates with glass fibre reinforcements and associated characteristics

2.5.1 Terminology

γ_r : density of the resin; standard value = 1,2 g/cm^3;

γ_V : density (of the glass fibres; standard value = 2,56 g/cm^3;

p : mass per area of the reinforcement of a single layer of the laminate (g/m^2);

q : total mass per area of a single layer (g/m^2);

g_c : **p/q** content of glass reinforcement in the layer; the most frequent maximum values of g_c are the following, taking into account that reinforcements are to be "wet" by and compacted in the resin matrix: 0,34 for reinforcements in **M** or F_S; 0,5 for reinforcements in S or T;

P : total mass per area of the reinforcements in the laminate (g/m^2);

Q : total mass per area of the laminate (g/m^2), excluding the surface coating of resin;

G_c : **P/Q** = content of reinforcement in the laminate, between the minimum allowed value of 0,25 and approximately 0,5;

t_i : thickness of a single layer of the laminate, in mm, given by:

$$t_i = 0,33\,p\left(\frac{2,56}{g_c} - 1,36\right) \cdot 10^3$$

t : thickness of the laminate, in mm = sum of the t_i thicknesses.

2.5.2 Mechanical properties of laminates

The minimum mechanical properties of structural laminates of the hull, in N/mm^2, are given by the formulae in Tab 3 as a function of G_c of the laminate as defined in the previous paragraph. These values are based on the most frequently used laminates, i.e. those having G_c = 0,25÷0,34, approximately, in the case of reinforcements in only **M** or F_s, and G_c = 0,30÷0,50, approximately, in the case of reinforcements in different products, e.g. **M** + **S** or **M** + **S** + **T**. In column 2 of the table the values indicated are those given by the specific case of G_c = 0,25, the minimum allowed value of the content of glass reinforcement.

The minimum mechanical properties of the laminates, found in testing in accordance with the provisions of the Tasneef "Rules for the type-approval of components of composite materials intended for hull construction", are to be not less than the values required above.

2.6 Laminates with reinforcement in fibres other than glass and associated characteristics

2.6.1 Laminates with reinforcements in fibres other than glass, described in [2.2], are to have mechanical properties that are in general greater than or at least equal to those given in Tab 3, promiscuous or hybrid reinforcements being employed if necessary for this purpose. Tasneef reserves the right to take into consideration laminates having certain properties lower than those given in the table, and will establish the procedure and criteria for approval.

2.7 Other materials

2.7.1 Materials, other than those dealt with above, employed for hull structural members, for example marine plywood and possibly light alloys or steel, are to have suitable properties for the specific use in the opinion of Tasneef and are not to affect the polymerisation process of the resin.

The use of solid timber in place of marine plywood for the core of laminates is not recommended; however, where it is proposed, its use in each case will be the subject of special consideration by Tasneef.

2.8 Testing of hull laminates

2.8.1 Recognition of shipyards or workshops for hull construction

During the construction of the first hull and upon completion of the checks of the laminate manufacturing processes and of the suitability of the shipyard for hull construction as per Chapter 3, the following testing of the laminates is to be carried out according to the Tasneef "Rules for the type-approval of components of composite materials intended for hull construction".

The relevant tests are to be carried out on specimens taken from samples of the laminate of the bottom of the hull and, if substantially different in composition and content of reinforcement, the laminate of the side and the deck, with measurement of the ultimate tensile strength and the ultimate flexural strength (N/mm^2) together with the associated deflection (mm).

In the case of fire-resistant laminates, those tests required by Tasneef in accordance with the requirements for fire protection (see the specific requirements for the fire protection of reinforced plastic ships) are to be carried out.

Subject to the outcome of the above-mentioned tests, Tasneef reserves the right to require further checks which, in the case of employment of materials that are not type approved, may also include testing of the materials making up the laminates.

2.8.2 Shipyards or workshops already recognised as suitable for hull construction

Shipyards or workshops already recognised as suitable for the construction of hulls in glass fibre reinforced plastic are generally to carry out tests of laminates in the following specific cases:

a) use of values of the coefficients K_o, K_{of} and K'_{of} less than those obtained by the formulae given in Sec 3, [7.5] and in Tab 3;

b) use of special manufacturing processes for laminates, different from those for which the suitability was recognised;

c) use of fibres in promiscuous or hybrid products;

d) when doubts arise or in the event of disagreement.

The type and number of tests, to be performed on samples of laminates identical to those used for construction and manufactured with the same process, are stipulated in relation to the circumstances that determined the need for such testing and taking into account whether or not type approved materials have been used.

3 Hull contruction processes and shipyards or workshops

3.1 General

3.1.1 This Chapter states the general requirements for the construction of hand lay-up or spray lay-up laminates; processes of other types (e.g. by resin transfer, vacuum or pressurised moulding with **M** and continuous filaments) are to be recognised as suitable by Tasneef on an individual basis.

3.2 Moulds

3.2.1 Moulds for the 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.

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.

During construction, provision is to be made to ensure satisfactory access such as to permit the proper carrying out of the laminating.

3.3 Laminating

3.3.1 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 is to be applied to the gel coat itself, is generally not to exceed a mass per area of 300 g/mm^2 and is to be applied through rolling so as to obtain a content of reinforcement, in weight, 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 plans 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 various 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 builder 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, general spray conditions and 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 the 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 builder, 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.

Attention is drawn, in particular, to the importance of ensuring the correct carrying out of joints between panels.

Insert plates of appropriate material to withstand the design loads are to be arranged in way of attachments. Such elements are to be suitably connected to the core material and the surface layer of the laminate.

3.4 Hardening and release of laminates

3.4.1 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. Such interval 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 vessel.

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, this is to be at least 24 hours.

3.5 Defects in the laminates

3.5.1 The manufacturing processes of laminates are to be such as to avoid defects, in particular the following main types: 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.

3.6 Shipyards or workshops

3.6.1 General

Shipyards or workshops for hull construction are to be suitably equipped to provide the required 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 will be ascertained by Tasneef, the responsibility for implementing all measures necessary for the proper carrying out of construction being left to the shipyard.

When it appears from the tests carried out that the shipyard or workshop not only complies with the following requirements but also uses type approved materials (see [2.4]) and internal production control procedures which, in the opinion of Tasneef, are such as to ensure a consistent level of quality, it 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.

3.6.2 Moulding shops

Where hand lay-up or spray lay-up processes are used for the manufacture of laminates, a temperature of between 16°C and 25°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 the 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.

3.6.3 Storage areas for materials

Resins are to be stored in dry, well-ventilated conditions at a temperature of between 10° and 20°C, or in conformity with the Manufacturer's recommendations. 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. in 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 such area in due time so as to reach the temperature of the moulding shop before being used.

3.6.4 Identification and handling of materials

In the phases of reception and handling, the materials are not to suffer contamination or degradation and are at all times to bear adequate identification marks, including those relative to Tasneef type approval. Storage is to be so arranged such 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 Manufacturer has given the hull builder prior written consent.

SECTION 3 DESIGN LOADS AND HULL SCANTLING

1 Application

1.1

1.1.1 In general, the requirements from [2] to [6] apply. However, on the basis of the ship's characteristics and the navigation notation required, Tasneef may accept structural strength checks carried out according to the requirements from [7] to [13].

1.1.2 On the basis of the ship's characteristics and the navigation notation required, Tasneef may require structural strength checks based also on direct calculations.

2 Design acceleration

2.1 Vertical acceleration at LCG

2.1.1 The design vertical acceleration at **LCG**, a_{CG} (expressed in g), is defined by the Designer and corresponds to the average of the 1 per cent 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 a parameter with values as indicated in Tab 1.

Lower **S** values, down to 80 per cent of tabular values, may be accepted, if justified, at Tasneef's discretion. In exceptional cases greater reductions may be accepted, if justified, at Tasneef's discretion, on the basis of model tests and full-scale measurements.

The sea areas referred to in Tab 1 are defined with reference to significant wave heights H_s which are exceeded for an average of not more than 10 percent of the year:

- Open-sea service: $H_s \geq 4,0$ m;
- Restricted open-sea service: 2,5 m $\leq H_s <$ 4,0 m
- Moderate environment service: 0,5 m $< H_s <$ 2,5 m
- Smooth sea service: $H_s \leq 0,5$ m.

If the design acceleration cannot be defined by the Designer, the a_{CG} value corresponding to the appropriate **S** value reported in Tab 1 will be assumed.

For limit operating conditions allowed for by design parameters, see [4].

An acceleration greater than the permissible limits given in Tab 2 for all types of craft may not be adopted for the purpose of defining limit operating conditions.

2.2 Longitudinal distribution of vertical acceleration

2.2.1 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 the greater of 2x/L and 0,8, x being the distance, in m, from aft perpendicular to load point;

a_{CG} : design acceleration at **LCG**, see [2.1.1].

Variation of a_v in the transverse direction may generally be disregarded.

Table 1

Type of service	Open sea **(1)**	Restricted open sea	Moderate environment	Smooth sea
Passenger Ferry Cargo	0,65 · C_F **(2)**	0,20	0,15	0,09
Supply	C_F	0,30	0,23	0,14
Pilot	1,33 · C_F	0,40	0,30	Not applicable
Rescue	1,67 · C_F	0,50	Not applicable	Not applicable

(1) For this condition, **S** is defined for each separate case, at the discretion of Tasneef, depending on the actual service area.
(2) For passenger, ferry and cargo craft, their seaworthiness in this condition is to be ascertained. In general, **S** is not to be lower than the values given in this Table, where: $C_F = 0,2 + [\,0,6 / (V \cdot L^{-0,5})] \geq 0,32$

Figure 1

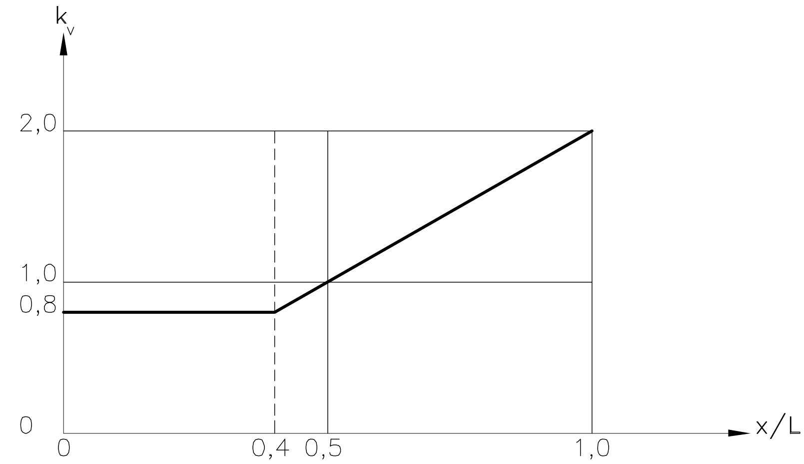


Table 2

Type of service	Limits of a_{CG}, in g
Passenger Ferry Cargo	1,0
Supply	1,5
Pilot	2,0
Rescue	2,5

2.3 Transverse acceleration

2.3.1 Transverse acceleration is defined on the basis of results of model tests and full-scale measurements, considering their characteristic value as specified in [2.4.1].

In the absence of such results, transverse acceleration, in g, at the calculation point of the craft may be obtained from:

$$\mathbf{a_t} = 2{,}5 \cdot \frac{\mathbf{H_{sl}}}{\mathbf{L}} \cdot \left[1 + 5 \cdot \left(1 + \frac{\mathbf{V}/\mathbf{L}^{0{,}5}}{6}\right)^2 \cdot \frac{\mathbf{r}}{\mathbf{L}}\right]$$

where:

H_{sl} : permissible significant wave height, defined in [2.4].

r : distance of the point from:

- 0,5 **D**, for monohull craft
- waterline at draught **T**, for twin-hull craft.

2.4 Assessment of limit operating conditions

2.4.1 "Limit operating conditions" in this paragraph are to be taken to mean sea states (characterized only by their significant wave heights) compatible with the design parameters of the craft, i.e. the sea states in which the craft may operate depending on its actual speed.

Limit operating conditions are used in this chapter only for the purpose of checking the strength of the structure.

Limit operating conditions, taken as a basis for classification, are indicated on the midship section drawing and are to be considered in defining the worst intended conditions and the critical design conditions in Chapter 1. They are defined, at the discretion of Tasneef, on the basis of the results of model tests and full-scale measurements.

It is the Designer's responsibility to provide for a relation between the speed and the significant wave height which provides a maximum vertical acceleration less than the design value.

Model tests are to be carried out in irregular sea conditions with a significant wave height corresponding to the operating conditions of the craft. The scale effect is to be accounted for with an appropriate margin of safety. The characteristic value of acceleration to be assumed corresponds to the average of the 1 per cent highest values obtained during tests. The duration of the tests is, as far as practicable, to be sufficient to guarantee that results are stationary.

Where model test results or full-scale measurements are not available, the formula contained in [2.4.2] may be used to define maximum speeds compatible with design acceleration, depending on sea states having a significant height H_s.

Model tests or full measurements are, in any case, required for SESs or other craft having an active support system. For craft having a speed **V** such that **V/L**0,5 < 3, where model tests or full-scale measurements are not available the results provided by the formula indicated in [2.4.2] are to be supplemented, to Tasneef's satisfaction, by data on the motion characteristics of craft of type and dimensions similar to that under consideration.

On the basis of the formula indicated in [2.4.2], the limit sea state may be defined (characterised by its significant wave height H_{sl}), i.e. the sea state in which the craft may operate at its maximum service speed. During its voyage, whenever the craft encounters waves having a significant height greater than H_{sl}, it must reduce its speed.

It is assumed that, on the basis of weather forecast, the craft does not encounter, within the time interval required for the voyage, sea states with significant heights, in metres, greater than the following:

$$\mathbf{H_{sm}} = 5 \cdot \frac{\mathbf{a_{CG}}}{\mathbf{V}/\mathbf{L}^{0{,}5}} \cdot \frac{\mathbf{L}}{6 + 0{,}14 \cdot \mathbf{L}}$$

where vertical acceleration a_{CG} is defined in [2.1].

At the discretion of Tasneef, a different value of H_{sm} may be assumed on the basis of considerations regarding the characteristics of the intended area of operation, the model test results and the hull structural strength exceeding the minimum level stated in this Sec 3.

For craft with a particular shape or other characteristics, Tasneef reserves the right to require model tests or full-scale measurements to verify results obtained by the formulae.

Tasneef may require an accelerometer to be installed on the craft, in general at **LCG**. The information given by the accelerometer is to be immediately readable at the wheelhouse.

2.4.2 The significant wave height is related to the craft's geometric and motion characteristics and to the vertical acceleration $\mathbf{a}_{CG}$ by the following formula:

$$\frac{H_s}{T} = 3555 \cdot \frac{C_B \cdot a_{CG}}{\left(\frac{V_x}{L^{0,5}}\right)^2 \cdot (50 - \alpha_{dCG}) \cdot \left(\frac{\tau}{16} + 0,75\right)} - 0,084 \cdot \frac{B_W}{T}$$

where:

- H_s : significant wave height,, in m;
- α_{dCG} : deadrise angle, in degrees, at **LCG**, taken to be between 10° and 30°;
- τ : trim angle during navigation, in degrees, taken to be not less than 4°;
- V_x : craft speed, in knots.

If V_x is replaced by the maximum service speed **V** of the craft, the previous formula yields the significant height of the limit sea state, H_{sl}.

This formula may also be used to specify the permissible speed in a sea state characterised by a significant wave height equal to or greater than H_{sl}.

3 Overall loads

3.1 Longitudinal bending moment

3.1.1 General

The values of the longitudinal bending moment are given, as a first approximation, by the formulae in [3.1.2], For large craft, values from models tests may be taken into account.

If the actual distribution of weights along the craft is known, a more accurate calculation may be carried out according to the procedure in [3.1.3]. Tasneef reserves the right to require calculations to be carried out according to [3.1.3] whenever it deems it necessary.

3.1.2 Bending moment

The total bending moments $M_{bl,H}$, in hogging conditions, and $M_{bl,S}$, in sagging conditions, in kN · m, are to be taken as the greatest of those given by the formulae in (a) and (b).

For ships having **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 ship.

The total shear force T_{bl}, in kN, is given by the formula in (c).

a) Bending moment due to still water loads, wave induced loads and impact loads

$$M_{blH} = M_{blS} = 0,55 \cdot \Delta \cdot L \cdot (C_B + 0,7) \cdot (1 + a_{CG})$$

where $\mathbf{a}_{CG}$ is the vertical acceleration at the **LCG**, defined in [2.1].

b) Bending moment due to still water loads and wave induced loads

$$M_{blH} = M_{sH} + 0,19 \cdot \frac{S}{S_0} \cdot C \cdot L^2 \cdot B \cdot C_B$$

$$M_{blS} = M_{sS} + 0,11 \cdot \frac{S}{S_0} \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)$$

where:

- $M_{s,H}$: still water hogging bending moment, in kN · m
- $M_{s,S}$: still water sagging bending moment, in kN · m
- **S** : parameter as indicated in Tab 1, for the considered type of service
- S_0 : parameter as indicated in Tab 1, for "restricted open sea service"
- 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

$$T_{bl} = \frac{3,1 \cdot M_{bl}}{L}$$

where M_{bl} is the greatest of $M_{bl,H}$ and $M_{bl,S}$ calculated according to (a) and (b), as applicable.

3.1.3 Bending moment 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 hogging and sagging for each loading or ballast 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, to be taken, in general, equal to 20.

   For twin-hull craft, the calculation below applies to one of the hulls, i.e. the longitudinal distribution of weight forces $\mathbf{g}_i$ and the corresponding breadth $\mathbf{B}_i$ are to be defined for one hull.

   The total impact force, n kN, is:

$$F_{SL} = \sum q_{SLi} \cdot \Delta x_i$$

where q_{SLi} is the additional load per unit length, in kN/m, for $x/L \geq 0,6$ (see also Fig 2), given by:

$$q_{SLi} = p_0 \cdot B_i \cdot \sin\left[2 \cdot \pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right]$$

where

Δx_i : length of interval, in m

x_i : distance, in m, from the aft perpendicular

B_i : craft breadth, in m, at uppermost deck at x_i; for twin-hull craft, B_i is the maximum breadth of one hull at the considered longitudinal location

x_i and B_i : to be measured at the centre of interval **i**

p_0 : maximum hydrodynamic pressure, in kN/m^2:

$$p_0 = \frac{a_{v1} \cdot G \cdot (r_0 + x_W^2)}{f_{SL} \cdot [r_0^2 + 0,5 \cdot L \cdot (x_{SL} - x_W) - x_{SL} \cdot x_W]}$$

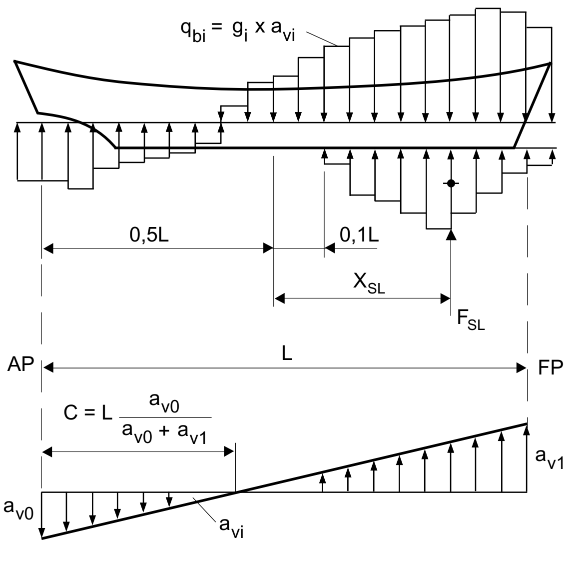
a_{v1} : vertical design acceleration at the forward perpendicular, as defined in [3.3]

G : weight force, in kN:

$$G = \sum g_i \cdot \Delta x_i$$

g_i : weight per unit length, in kN/m, of interval **i**; for twin-hull craft, is to be defined for one hull g_i;

Figure 2



x_W : distance, in m, of **LCG** from the midship perpendicular:

$$x_W = \frac{\sum (g_i \cdot \Delta x_i \cdot x_i)}{\sum (g_i \cdot \Delta x_i)} - 0,5 \cdot L$$

r_0 : radius of gyration, in m, of weight distribution:

$$r_0 = \left(\frac{\sum [g_i \cdot \Delta x_i \cdot (x_i - 0,5\ L)^2]}{\sum (g_i \cdot \Delta x_i)}\right)^{0,5}$$

normally $0,2 \cdot L < r_o < 0,25 \cdot L$ (guidance value)

x_{SL} : distance, in m, of centre of surface F_{SL} from the midship perpendicular, given by:

$$x_{SL} = \frac{1}{f_{SL}} \sum (\Delta x_i \cdot x_i \cdot B_i) \cdot \sin\left[2\pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right] - 0,5\ L$$

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 m^2

d) The resulting load distribution q_{si} , in kN/m, for the calculation of the impact induced sagging bending moment and shear force is:

1) For $x / L < 0,6$

$$q_{si} = q_{bi} = g_i \cdot a_{vi}$$

where:

a_{vi} : total dimensionless vertical acceleration at interval **i**:

$$a_{vi} = a_h + a_p \cdot (x_i - 0,5\ L)$$

a_h : acceleration due to heaving motion

a_p : acceleration due to pitching motion

a_h and a_p: are relative to **g**

a_h= : $\frac{F_{SL}}{G} \cdot \left[\frac{r_0^2 - x_{SL} \cdot x_W}{r_0^2 - x_W^2}\right]$

a_p= : $\frac{F_{SL}}{G} \cdot \left[\frac{x_{SL} - x_W}{r_0^2 - x_W^2}\right]$, in m^{-1}

2) For $x / L \geq 0,6$

$$q_{si} = q_{bi} - q_{SLi}$$

e) The impact induced sagging bending moment and shear force are obtained by integration of the load distribution q_{si} along the hull. They are to be added to the respective values calculated according to (i) in order to obtain the total bending moment and shear force due to still water loads, wave induced loads and impact loads.

3.2 Twin-hull craft transverse loads

3.2.1 General

For twin-hull craft, the hull connecting structures are to be checked for load conditions specified in [3.2.2] and [3.2.3] below. These load conditions are to be considered as acting separately. 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 (see [2.4.1], Requirements for model tests).

For craft with length $L > 65$ m or speed $V < 45$ knots, or for craft 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 [5] or other criteria considered equivalent by Tasneef.

3.2.2 Transverse bending moment and shear force

The transverse bending moment $\mathbf{M}_{bt}$, in KN · m, and shear force $\mathbf{T}_{bt}$, in KN · m, are given by:

$$\mathbf{M}_{bt} = \frac{\Delta \cdot \mathbf{b} \cdot \mathbf{a}_{CG} \cdot \mathbf{g}}{5}$$

$$\mathbf{T}_{bt} = \frac{\Delta \cdot \mathbf{a}_{CG} \cdot \mathbf{g}}{4}$$

where:

b : transverse distance, in m, between the centres of the two hulls;

$\mathbf{a}_{CG}$: vertical acceleration at LCG, defined in [2.1].

3.2.3 Transverse torsional connecting moment

The twin-hull transverse torsional connecting moment, in kN · m, about a transverse axis is given by:

$$\mathbf{M}_{tt} = 0{,}125 \cdot \Delta \cdot \mathbf{L} \cdot \mathbf{a}_{CG} \cdot \mathbf{g}$$

where $\mathbf{a}_{CG}$ is the vertical acceleration at LCG, defined in [2.1], which need not to be taken greater than 1,0 g for this calculation.

3.3 Small waterplane area twin-hull (SWATH) craft-Forces

3.3.1 Side beam force

The design beam side force, in kN, (see Fig 3) is given by:

$$\mathbf{F}_Q = 12{,}5 \cdot \mathbf{T} \cdot \Delta^{2/3} \cdot \mathbf{d} \cdot \mathbf{L}_S$$

where:

d : $1{,}55 - 0{,}75 \cdot \tanh\left(\frac{\Delta}{11000}\right)$

$\mathbf{L}_S$: $2{,}99 \cdot \tanh\lambda - 0{,}725$

λ : $\dfrac{0{,}137 \cdot \mathbf{A}_{lat}}{\mathbf{T} \cdot \Delta^{1/3}}$

$\mathbf{A}_{lat}$: lateral area, in m², projected on a vertical plane, of one hull with that part of strut or struts below waterline at draught T.

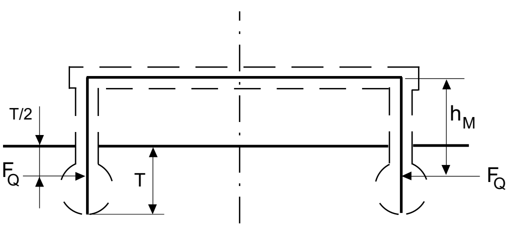
The lateral pressure, in kN/m², acting on one hull is given by:

$$\mathbf{p}_Q = \frac{\mathbf{F}_Q}{\mathbf{A}_{lat}}$$

The distribution of the lateral force $\mathbf{F}_Q$ can be taken as constant over the effective length $\mathbf{L}_e = \mathbf{A}_{lat} / \mathbf{T}$, in m. The constant lateral force per unit length, in kN/m, is thus given by:

$$\mathbf{q}_Q = \frac{\mathbf{F}_Q}{\mathbf{L}_e}$$

Figure 3



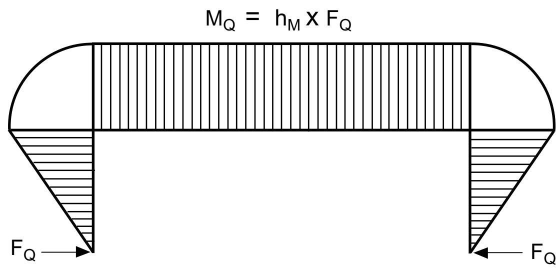
3.3.2 Bending moment

The corresponding design bending moment, in KN · m, is given by:

$$\mathbf{M}_Q = \mathbf{h}_M \cdot \mathbf{F}_Q$$

$\mathbf{h}_M$: half the draught T plus the distance from the waterline at draught T to the midpoint of the cross-deck structure (see Fig 4), in m.

Figure 4



4 Local loads

4.1 Introduction

4.1.1 Design loads defined in this Article are to be used for the resistance checks provided for in [6] to obtain scantlings of structural elements of hull and deckhouses.

Such loads may be integrated or modified on the basis of the results of model tests or fullscale measurements. Model tests are to be carried out in irregular sea conditions with significant wave heights corresponding to the operating conditions of the craft. The scale effect is to be accounted for by an appropriate margin of safety.

The characteristic value to be assumed is defined as the average of the 1 per cent highest values obtained during testing. The length of the test is, as far as practicable, to be sufficient to guarantee that statistical results are stationary.

4.2 Loads

4.2.1 General

The following loads are to be considered in determining scantlings of hull structures:

- impact pressures due to slamming, if expected to occur;
- sea pressures due to hydrostatic heads and wave loads;
- internal loads.

External pressure generally determines scantlings of side and bottom structures; internal loads generally determine 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 craft 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.

4.2.2 Load points

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; geometrical centre of the panel, for impact pressure.
- 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.

4.3 Impact pressure on the bottom

4.3.1 If slamming is expected to occur, the impact pressure, kN/m², considered as acting on the bottom is not less than:

$$p_{sl} = 70 \cdot \frac{\Delta}{S_r} \cdot K_1 \cdot K_2 \cdot K_3 \cdot a_{CG}$$

where:

Δ : displacement, in tonnes (see [2.4]). For twin hull-craft, Δ in the above formula is to be taken as half of the craft displacement.

S_r : reference area, m²:

$$S_r = 0{,}7 \cdot \frac{\Delta}{T}$$

For twin-hull craft, D in the above formula is to be taken as half the craft displacement.

K_1 : longitudinal bottom impact pressure distribution factor (Fig 5):

$0{,}5 + x/L$, for $x/L < 0{,}5$

$1{,}0$, for $0{,}5 \le x/L \le 0{,}8$

$3{,}0 - 2{,}5 \cdot x/L$, for $x/L > 0{,}8$

where **x** distance, in m, from aft perpendicular to load point

K_2 : factor accounting for impact area

$$K_2 = 0{,}455 - 0{,}35 \cdot \frac{u^{0{,}75} - 1{,}7}{u^{0{,}75} + 1{,}7}$$

where

u : $100 \cdot \frac{s}{S_r}$

s : area, m², supported by the element (plating, stiffener, floor or girder). For plating, the supported area is the spacing between the stiffeners multiplied by their span, without taking for the latter more than three times the spacing between the stiffeners.

where:

$K_2 \ge 0{,}50$, for plating

$K_2 \ge 0{,}45$, for stiffeners

$K_2 \ge 0{,}35$, for girders and floors.

K_3 : $(70 - \alpha_d)/(70 - \alpha_{dCG})$

factor accounting for shape and deadrise of the hull, where α_{dCG} is the deadrise angle, in degrees, measured at **LCG**; values taken for α_d and α_{dCG} are to be between 10° and 30°.

a_{CG} : design vertical acceleration at LCG, defined in [2].

4.4 Impact pressure on bottom of cross-deck and internal sides (for twin-hull craft)

4.4.1 Slamming on bottom of the cross-deck (wet deck) is assumed to occur if the distance, in m, between the waterline at draught **T** and the wet deck is less than Z_{wd}, where:

Z_{wd} : $0{,}05 \cdot L$, if $L \le 65$ m

Z_{wd} : $3{,}25 + 0{,}0214 \cdot (L - 65)$, if $L > 65$ m

In such a case, the impact pressure, in kN/m², considered as acting on the wet deck is not less than:

$$p_{sl} = 3 \cdot K_2 \cdot K_{CD} \cdot V \cdot V_{sl} \cdot \left(1 - 0{,}85\frac{H_A}{H_S}\right)$$

where:

K_2 : as defined in [4.3]

K_{CD} : longitudinal wet deck impact pressure distribution factor (Fig 6):

$0{,}5 \cdot (1{,}0 - x/L)$ for $x/L < 0{,}2$

$0{,}4$ for $0{,}2 \le x/L \le 0{,}7$

$6{,}0 \cdot x/L - 3{,}8$ for $0{,}7 < x/L \le 0{,}8$

$1{,}0$ for $x/L > 0{,}8$

x : distance, in m, from aft perpendicular to load point.

V : ship's speed, in knots,

H_a : air gap, in m

V_{SL} : relative impact velocity, in m/s, given by:

$$V_{SL} = \frac{4 \cdot H_S}{L^{0{,}5}} + 1$$

H_S : significant wave height, in m.

If slamming is considered to occur on the wet deck, the impact pressure on the internal sides is obtained by interpolation between the pressure considered as acting on the bottom and the pressure P_{SL} at wet deck.

If the wet deck at a transverse section considered is not parallel to the design waterline the impact pressure P_{SL} will be considered in each separate case by Tasneef.

4.5 Sea pressures

4.5.1 The sea pressure, in kN/m², considered as acting on the bottom and side shell is not less than p_{smin}, defined in Tab 3, or less than:

$$p_s = 10 \cdot \left[T + 0{,}75 \cdot S - \left(1 - 0{,}25 \cdot \frac{S}{T}\right) \cdot z\right], \text{ for } z \le T$$

$$p_s = 10 \cdot (T + S - z), \text{ for } z > T$$

where:

z : vertical distance, in m, from the moulded base line to load point; **z** is to be taken positively upwards.

S : as given, in m, in Tab 3 with C_B taken not greater than 0,5

Between midship area and fore end (0,5 < **x**/**L** < 0,9), p_s varies in a linear way as follows:

$$p_s = p_{sFP} - (2{,}25 - 2{,}5 \cdot x/L) \cdot (p_{sFP} - p_{sM})$$

where p_{sFP} is the sea pressure at fore end and p_{sM} the sea pressure in the midship area.

Table 3

	S	$p_{s,\,min}$
$x/L \geq 0{,}9$	$T \leq 0{,}36 \cdot a_{CG} \cdot \frac{L^{0{,}5}}{C_B} \leq 3{,}5 \cdot T$	$20 \leq \frac{L+15}{2} \leq 35$
$x/L \leq 0{,}5$	$T \leq 0{,}60 \cdot a_{CG} \cdot L^{0{,}5} \leq 2{,}5 \cdot T$	$10 \leq \frac{L-5}{2} \leq 25$

4.6 Sea pressures on front walls of the hull

4.6.1 The pressure, kN/m^2, considered as acting on front walls of the hull (in the case of a stepped main deck), not located at the fore end, is not less than

$$p_{sf} = 6 \cdot \left[1 + \frac{x_1}{2 \cdot L(C_B + 0{,}1)}\right](1 + 0{,}045 \cdot L - 0{,}38 \cdot z_1)$$

where:

x_1 : distance, in m, from front walls to the midship perpendicular (for front walls aft of the midship perpendicular, $x_1 = 0$)

z_1 : distance, in m, from load point to waterline at draught **T**.

Where front walls are inclined backwards, the pressure calculated above can be reduced to

$$p_{sF} \cdot \sin^2\alpha$$

where α is the angle in degrees between front wall and deck.

p_{sF} is not less than 6,5 + 0,06 **L**.

For front walls located at the fore end, the pressure p_{sF} will be individually considered by Tasneef.

4.7 Sea pressures on deckhouses

4.7.1 The pressure, kN/m^2, considered as acting on walls of deckhouses is not less than

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

where:

K_{su} : coefficient equal to:

- 6,0, for front walls of a deckhouse located directly on the main deck not at the fore end
- 5,0, for unprotected front walls of the second tier, not located at the fore end
- $1{,}5 + 3{,}5 \cdot \frac{b}{B}$ (with $3 \leq K_{su} < 5$)

  for sides of deckhouses b = breadth, in m, of considered deckhouse
- 3, for the other walls

x_1 : distance, in m, from front walls or from wall elements to the midship perpendicular (for front walls or side walls aft of the midship perpendicular, $x_1 = 0$)

z_1 : distance, in m, from load point to waterline at draught **T**.

The minimum values of p_{su}, in kN/m^2, to be considered are:

- for the front wall of the lower tier:

  $p_{su} = 6{,}5 + 0{,}06 \cdot L$
- for the sides and aft walls of the lower tier:

  $p_{su} = 4$
- for the other walls or sides:

  $p_{su} = 3$

For unprotected front walls located at the fore end, the pressure p_{su} will be individually considered by Tasneef.

4.8 Deck loads

4.8.1 General

The pressure, in kN/m^2, considered as acting on decks is given by the formula

$$p_d = p(1 + 0{,}4 \cdot a_v)$$

where:

p : uniform pressure due to the load carried, in kN/m^2. Minimum values are given in [4.8.2] to [4.8.6];

a_v : design vertical acceleration, defined in [2].

Where decks are intended to carry masses of significant magnitude, including vehicles, the concentrated loads transmitted to structures are given by the corresponding static loads multiplied by $(1 + 0{,}4 \cdot a_v)$.

Figure 5

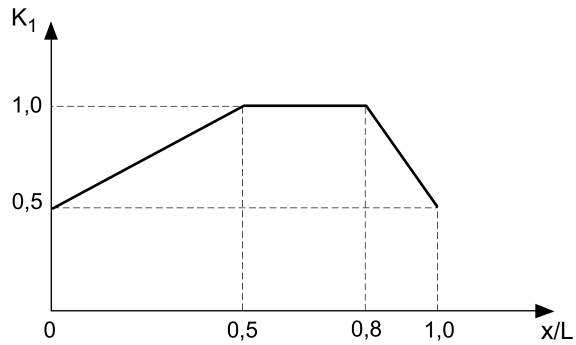
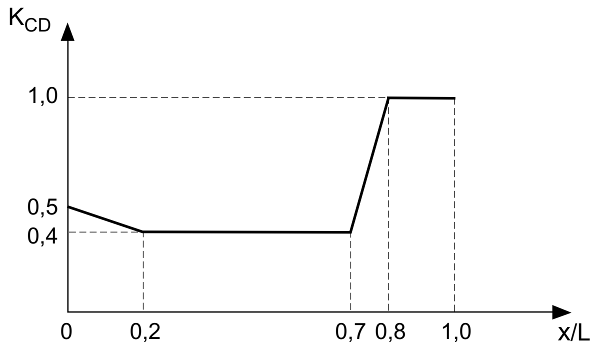


Figure 6



4.8.2 Weather decks and exposed areas

a) For weather decks and exposed areas without deck cargo if:

- $z_d \le 2$ m $p = 6{,}0$ kN/m²
- 2 m $< z_d < 3$ m $p = 12 - 3 \cdot z_d$ kN/m²
- $z_d \ge 3$ m $p = 3{,}0$ kN/m²

where z_d is the vertical distance, in m, from deck to waterline at draught T.

p can be reduced by 20% for primary supporting members and pillars under decks located at least 4 m above the waterline at draught **T**, excluding embarkation areas.

b) For weather decks and exposed areas with deck cargo if:

- $z_d \le 2$ m, $p = p_c + 2$ kN/m², with $p_c \ge 4$ kN/m²
- 2 m $< z_d < 3$ m, $p = p_c + 4 - z_d$ kN/m²

  with $p_c \ge 8 - 2 \cdot z_d$ kN/m²
- $z_d \ge 3$ m, $p = p_c + 1$ kN/m²

  with $p_c \ge 2$ kN/m²

p_c : uniform pressure due to deck cargo load, in kN/m², to be defined by the Designer with the limitations indicated above.

4.8.3 Shelter decks

They are decks which are not accessible to the passengers and which are not subjected to the sea pressures. Crew can access such decks with care and taking account of the admissible load, which is to be clearly indicated. Deckhouses protected by such decks may not have direct access to 'tween-deck below. For shelter decks

$p = 1{,}3$ kN/m²

A lower value may be accepted, at the discretion of Tasneef, provided that such a value as well as the way of access to the deck are clearly specified by and agreed upon with the Owner.

4.8.4 Enclosed accommodation decks

a) For enclosed accommodation decks not carrying goods:

$p = 3{,}0$ kN/m²

p can be reduced by 20 per cent for primary supporting members and pillars under such decks.

b) For enclosed accommodation decks carrying goods:

$p = p_c$

The value of p_c is to be defined by the Designer, but taken as not less than 3,0 kN/m².

4.8.5 Enclosed cargo decks

For enclosed cargo decks other than decks carrying vehicles

$p = p_c$

where p_c is to be defined by the Designer, but taken as not less than 3,0 kN/m².

For enclosed cargo decks carrying vehicles, the loads are defined in [4.8.7].

4.8.6 Platforms of machinery spaces

For platforms of machinery spaces

$p = 15{,}0$ kN/m²

4.8.7 Enclosed decks carrying vehicles

The scantlings of the structure of enclosed decks carrying vehicles are to be determined by taking into account only the concentrated loads transmitted by the wheels of vehicles, except in the event of supplementary requirements from the Designer.

The scantlings under racking effects of the primary structure of decks carrying vehicles are to be the greater of the following cases:

- scantlings determined under concentrated loads transmitted by the wheels of vehicles,
- scantlings determined under a uniform load p_c taken not less than 2,5 kN/m². This value of p_c may be increased if the structural weight cannot be considered as negligible, in the opinion of Tasneef.

4.9 Pressures on tank structures

4.9.1 The pressure, in kN/m², considered as acting on tank structures is not less than the greater of

$$p_{t1} = 10 \cdot h_1 \cdot \rho \cdot (1 + 0{,}4 \cdot a_v) + 100 \cdot p_v$$

$$p_{t2} = 10 \cdot h_2$$

where:

h_1 : distance, in m, from load point to tank top

h_2 : distance, in m, from load point to top of overflow or to a point located 1,5 m above the tank top, whichever is greater

ρ : liquid density, in t/m³ (1,0 t/m³ for water)

p_v : setting pressure, in bars, of pressure relief valve, when fitted.

4.10 Pressures on subdivision bulkheads

4.10.1 The pressure, in kN/m², considered as acting on subdivision bulkheads is not less than

$$p_{sb} = 10 \cdot h_3$$

where:

h_3 : distance, in m, from load point to bulkhead top.

5 Direct calculations

5.1 General

5.1.1 When deemed necessary by Tasneef, direct calculations of the hull structural scantlings are to be carried out, on the basis of the most advanced calculation techniques.

When performing direct calculations, the loads specified in [2] to [4] are generally to be applied. Where, in the case of ships of special design for which, in the opinion of Tasneef, these requirements are deemed inappropriate, loads calculated according to other criteria are to be adopted.

6 Scantlings

6.1 Introduction

6.1.1 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 the provisions of [4].

In general, for craft with length **L** > 65 m or speed **V** > 45 knots, the scantlings of transverse structures are to be verified by direct calculations carried out.

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.

6.2 Definitions

6.2.1 In addition to the definitions in Sec 1, the following is to be considered:

Superstructure - in this Article, a decked structure located above the uppermost continuous deck, extending from side to side of the craft, or with the side plating not inboard of the shell plating by more than 4 per cent of the local breadth.

6.3 Longitudinal strength

6.3.1 General

This Article gives the criteria to be used for the longitudinal strength calculation of monohull ships more than 24 m in length.

For multihulls, the strengths due to longitudinal bending, transverse bending and torsion are to be examined individually by Tasneef.

The longitudinal strength of monohull craft more than 65 m in length is to be checked.

The longitudinal strength of monohull craft more than 24 m and less than 65 m in length is to be checked when the following conditions are not simultaneously satisfied:

- $\mathbf{L/D} \le \mathbf{r}_2$
- no longitudinal members located at more than 0,04 **D** above the strength deck at side
- in any transverse section of strength deck, the sum of the breadths of openings is less than:

$$\mathbf{b} = \frac{65-\mathbf{L}}{40}\cdot\mathbf{B}$$

Values of $\mathbf{r}^2$ factor are given in Tab 4 depending on the type of service of the craft.

In general, the strength deck is the uppermost continuous complete deck or the uppermost superstructure deck contributing to the longitudinal strength, if any.

- The deck number n of a superstructure of length equal to or greater than $5\cdot\mathbf{N}\cdot\mathbf{H}$ in length and located in the midship region, can be taken as the strength deck in way of the considered transverse section where **H** is the mean height, in m, of the ’tween deck.
- If such a deck is not considered as the strength deck, arrangements are to be made so that this deck does not participate in the longitudinal strength of the ship.
- Ships with shell openings such that the length of openings is greater than half the length of the shell are to be individually examined by Tasneef.

The section moduli at bottom, at the strength deck and at the top of longitudinal members located above the strength deck, if any, calculated according to [6.3.2] below, are not to be less than the value defined in [6.3.3] below.

Table 4

Type of service	$\mathbf{r}_2$
Open sea and restricted open sea	16,5
Moderate environment	18,0
Smooth sea	22,0

6.3.2 Calculation of section modulus

The data given in Tab 5 for plating and [6.3] for longitudinals are necessary for calculation of the midship section modulus.

Where there is a sandwich member, the two skins of the laminate are to be taken into account only with their own characteristics. The cores are taken into account if they offer longitudinal continuity and appreciable strength against axial tension-compression.

For each transverse section within the midship region, the section modulus, in m³, is given by:

$$\mathbf{W} = \frac{1}{\mathbf{E_p}}\cdot\left[\mathbf{C'}\cdot\mathbf{P}+\frac{\mathbf{C'}}{6}\cdot\mathbf{A}\cdot\left(1+\frac{\mathbf{F}-\mathbf{P}}{\mathbf{F}+0,5\cdot\mathbf{A}}\right)\right]\cdot 10^{-3}$$

where:

P : $\mathbf{t_p}\cdot\mathbf{B}\cdot\mathbf{E_p}+\mathbf{n_p}\cdot(\mathbf{l_{ps}}\cdot\mathbf{t_{ps}}\cdot\mathbf{E_{ps}}+\mathbf{t_{pa}}\cdot\mathbf{H_{pa}}\cdot\mathbf{E_{pa}})$

A : $2[\mathbf{t_m}\cdot\mathbf{l_m}\cdot\mathbf{E_m}+\mathbf{n_m}\cdot(\mathbf{t_{ms}}\cdot\mathbf{l_{ms}}\cdot\mathbf{E_{ms}}+\mathbf{t_{ma}}\cdot\mathbf{H_{ma}}\cdot\mathbf{E_{ma}})]$

F : $\mathbf{t_f}\cdot\frac{\mathbf{B}}{2}\cdot\mathbf{E_f}+\mathbf{n_f}\cdot(\mathbf{l_{fs}}\cdot\mathbf{t_{fs}}\cdot\mathbf{E_{fs}}+\mathbf{t_{fa}}\cdot\mathbf{H_{fa}}\cdot\mathbf{E_{fa}})$

$\mathbf{t_p}$, $\mathbf{t_m}$, $\mathbf{t_f}$, $\mathbf{E_p}$, $\mathbf{E_m}$, $\mathbf{E_f}$: see Tab 5.

$\mathbf{t_{ps}}$, $\mathbf{t_{ms}}$, $\mathbf{t_{fs}}$, $\mathbf{E_{ps}}$, $\mathbf{E_{ms}}$, $\mathbf{E_{fs}}$, $\mathbf{l_{ps}}$, $\mathbf{l_{ms}}$, $\mathbf{l_{fs}}$, $\mathbf{t_{pa}}$, $\mathbf{t_{ma}}$, $\mathbf{t_{fa}}$, $\mathbf{E_{pa}}$, $\mathbf{E_{ma}}$,

$\mathbf{E_{fa}}$, $\mathbf{H_{pa}}$, $\mathbf{H_{ma}}$, $\mathbf{H_{fa}}$, $\mathbf{n_p}$ $\mathbf{n_m}$, $\mathbf{n_f}$: see Tab 6.

$\mathbf{l_m}$, **C’** : see also Fig 7.

Table 5

	Deck	Side shell	Bottom
Mean thickness, in mm	t_p	t_m	t_f
Young's modulus, in N/mm²	E_p	E_m	E_f

6.3.3 Rule section modulus

The midship section modulus at the strength deck, at the bottom and above the strength deck, if any, is not to be less, in m³, than:

$$W_m = 11 \cdot \alpha \cdot r_1 \cdot F \cdot L^2 \cdot B \cdot (C_B + 0{,}7) \cdot 10^{-6}$$

where:

r_1 : value in Tab 7

a= : $\dfrac{L}{r_2 \cdot D}$ **but** not less than 1

F : $(118 - 0{,}36 \cdot L) \cdot \dfrac{L}{1000}$

r_2 : value in Tab 4.

6.3.4 Bending longitudinal stress

The bending stress, in N/mm², due to the longitudinal bending moment is given by the formula:

$$\sigma_{bl} = \frac{M_{bl}}{W} \cdot 10^{-3}$$

where M_{bl} is the total bending moment, defined in [3.1], and W, is the actual value of the midship section modulus, in m³, either at bottom or at the deck.

6.4 Structural scantlings - General

6.4.1 Main principles

a) General

Scantlings are given for the midship region and end regions. In intermediate regions, scantlings are to vary gradually from the midship region to the end regions.

Plating and stiffener scantlings are determined by the fact that the sum of stress due to local design loads and longitudinal bending of the hull (if applicable) is to be less than the corresponding allowable stress of the material, i.e. the breaking strength divided by a safety factor, defined below.

Scantlings may be increased where the structure is likely to be subjected to particular forces, for instance due to:

- very high speed,
- nature or uneven distribution of its loading, such as concentrated loads,
- particular conditions of operation, construction or design.

When design assumptions not covered by these Rules or unusual structural arrangements are provided, the proposed scantlings are to be backed by direct calculations carried out with an agreed method, and submitted to Tasneef for examination.

In such cases, the shipyard is to provide, to the satisfaction of Tasneef, all information needed to verify the calculation.

In addition to the cases explicitly foreseen by these Rules, subject to justifications submitted for examination, Tasneef may consider scantlings and structural arrangements, other than those derived from the application of these Rules, provided they take special account of:

- calculation method or a method for the determination of stresses offering a high level of accuracy; calculation data and all information necessary for their assessment are to be submitted to Tasneef,
- development of the applied techniques, the builder's practical experience and the means he uses to ensure an appropriate level of quality and building consistency,
- satisfactory behaviour in service of the type of hull structure concerned,
- particular loading cases.

b) Bottom - Side shell boundary for catamarans

For the structure of a catamaran, the inner walls of which are nearly vertical, the limit between bottom and side shell inside the two hulls is to be taken at the level of chine for external walls, as defined in Sec 1, [1.1.4].

c) Safety factors

The safety factor **SF** is equal to the ratio between the breaking strength (bending or shear) and the allowable stress for a material.

The safety factor to be considered for allowable bending stresses of plating and stiffeners is given in Tab 8.

The safety factor to be considered for allowable shear stress of core material of sandwiches and of web primary stiffener is given in Tab 9.

For ships of unusual construction and/or with special service conditions, another value of the safety factor can be defined in accordance with the yard, which is to justify the new safety factor.

Table 6

		Deck	Side shell (1 side)	Bottom
Flange	Thickness, in mm	t_{ps}	t_{ms}	t_{fs}
	Young's modulus, in N/mm²	E_{ps}	E_{ms}	E_{fs}
	Breadth, in mm	l_{ps}	l_{ms}	l_{fs}
Web	Thickness equivalent to **I** section, in mm	t_{pa}	t_{ma}	t_{fa}
	Young's modulus, in N/mm²	E_{pa}	E_{ma}	E_{fa}
	Height, in m	H_{pa}	H_{ma}	H_{fa}
	Number of longitudinals	n_p	n_m	n_f

Figure 7

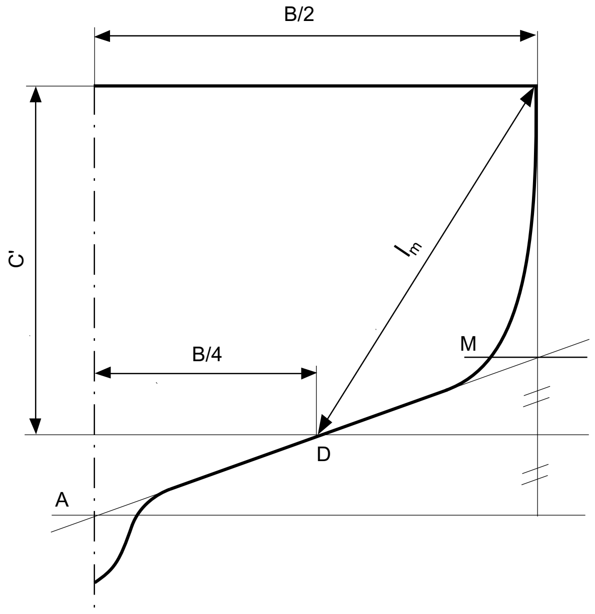


Table 7

Type of service	r_1
Open sea and restricted open sea	1
Moderate environment	0,96
Smooth sea	0,92

Table 8

	SF
General	6
Members subject to impact load	4,5
Transverse watertight bulkheads	5
Sides and ends of superstructures and deckhouses	4
Members subject to the test pressure p_e	4

Table 9

		SF
Core of sandwich	General	3
	Sandwiches subject to impact load	2,5
Web of primary members	General	5
	Stiffeners subject to impact load	3,5
	Stiffeners on transverse watertight bulkhead	4
	Stiffeners of sides and ends of superstructures and deckhouses	3
	Stiffeners calculated with the test pressure p_e	3

6.4.2 Single skin laminates

a) **General**

The bending stress, in N/mm², of the laminate is to be multiplied by the following reduction factor K_s:

$$k_s = \mu_1 \cdot \alpha \cdot r_c^2$$

where:

μ_1 : factor equal to:

- 1 if $l \geq 2 \cdot s$
- $1 - 1,5 \cdot \left(1 - \frac{l}{2 \cdot s}\right)^2$ if $s < l < 2 \cdot s$
- $0,625$ if $l \leq s$

where:

l : span of stiffener, in m

s : length, in m, as defined in Fig 8 or Fig 9

α : $1 - 3 \cdot \left(\frac{a}{s}\right) \cdot \left(1 - \frac{a}{s}\right)$

in the case of shell plating with ω stiffeners (see Fig 8) α is not to be taken less than 0,4; **a** is the length, in m, shown in Fig 8.

$\mathbf{r_c}$: $1 - 0{,}8 \cdot \frac{\mathbf{f}}{\mathbf{s}}$

without being less than 0,85, where **f**, in m, is shown in Fig 9.

In the case of unstiffened shell plating with a large curvature, a relevant study of the stress is to be submitted to Tasneef for examination.

b) **Scantlings of single skin laminates**

The minimum thicknesses of the single skin laminate plates are not to be, as a rule, less than the following values:

- $1{,}5 \cdot (\mathbf{L} + 10)^{0{,}5}$

  for bottom and bilge plates,

- $1{,}25 \cdot (\mathbf{L} + 10)^{0{,}5}$

  for shell plating,

- $(\mathbf{L} + 10)^{0{,}5}$

  for other plating.

Lower values can be considered if a justification is submitted to Tasneef.

The bending stress, in N/mm², due to the design pressure **p** (defined in [4]) is given by the formula:

$$\sigma_d = \mathbf{k_s} \cdot \frac{\mathbf{V}}{[\mathbf{I}]} \cdot \frac{\mathbf{p} \cdot \mathbf{s}^2}{12} \cdot 10^3$$

where:

V : maximum distance of the neutral axis of the laminate, in mm, as defined in Sec 2, [1.2.3](b)

[**I**] : inertia of the laminate, by mm of width, in mm⁴/mm, as defined in Sec 2, [1.2.3](b).

The bending stress due to the design pressure σ_d is given by the following formula:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

σ_{br} : breaking bending strength of the laminate, as defined in Sec 2, [1.2.3](b),

σ_{bl} : bending stress due to the total bending moment, as defined in [6.3.4].

σ_{bl} is to be equal to zero for all plates of ships of less than 24 m in length and for longitudinal framed plates and all plates at ends of other ships.

SF : safety factor, as defined in [6.4.1].

The bending stress σ_{de}, in N/mm², calculated for the test pressure $\mathbf{p_e}$ is to be:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

The bending deflection, due to design pressure **p** (see [4]), of a sandwich laminate between stiffeners is not to be greater than about 1% of the stiffener spacing. The total deflection, in mm, of a sandwich laminate, fixed on its edges, is given by the formula:

$$\mathbf{f} = \frac{\mu_2}{384} \cdot \frac{\mathbf{p} \cdot \mathbf{s}^4}{[\mathbf{EI}]} \cdot 10^9$$

where:

[**EI**] : rigidity of the sandwich laminate, for 1 mm width, in $\mathbf{N} \cdot \mathbf{mm}^2/\mathbf{mm}$

μ_2 : 1, for $\mathbf{l} \geq 2 \cdot \mathbf{s}$

$1 - 2{,}1 \cdot \left(1 - \frac{\mathbf{l}}{2 \cdot \mathbf{s}}\right)^2$ for $\mathbf{s} < \mathbf{l} < 2 \cdot \mathbf{s}$

0,475, for $\mathbf{l} \leq \mathbf{s}$

Figure 8

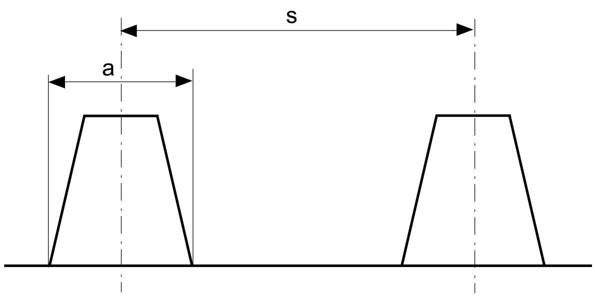
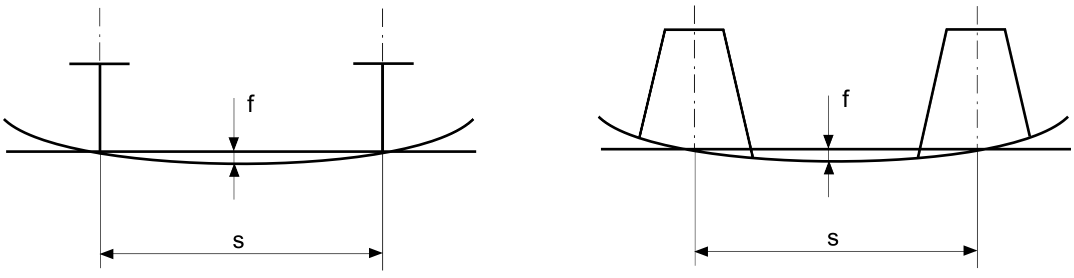


Figure 9



6.4.3 Sandwich laminates

a) **General**

See [6.4.2] (a).

b) **Scantlings of sandwich laminates**

The minimum thicknesses of each skin of sandwich laminate plates are in general not to be less than the following values:

- $0,6 \cdot (\mathbf{L} + 10)^{0,5}$

  , for bottom and bilge plates,

- $0,5 \cdot (\mathbf{L} + 10)^{0,5}$

  , for shell plating,

- $0,4 \cdot (\mathbf{L} + 10)^{0,5}$

  , for other plating.

Lower values can be considered if a justification is submitted to Tasneef.

The bending stress, in N/mm^2, due to the design pressure **p** (defined in [4]) is equal to:

$$\sigma_d = k_s \cdot \frac{V}{[I]} \cdot \frac{p \cdot s^2}{12} \cdot 10^3$$

where:

V : maximum distance of the neutral axis of the sandwich, in mm, as defined in Sec 2, [1.2.3](c).

[I] : inertia of the sandwich, by mm width, in mm^4/mm, as defined in Sec 2, [1.2.3] (c).

The bending stress due to design pressure σ_d is to be such that:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

σ_d : breaking bending strength of the sandwich, as defined in Sec 2, [1.2.3] (c),

σ_{bl} : bending stress due to the total bending moment, as defined in [6.4.4] σ_{bl} is to be equal to zero for all plates of ships of less than 24 m in length and for longitudinal framed platings and all plates at ends of other ships.

SF : Safety factor, as defined in [6.4.1].

The bending stress σ_{de}, in N/mm^2, calculated for the test pressure $\mathbf{p}_e$ is to be such that:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

The shear stress, in N/mm^2, due to the design pressure **p**, is to be:

$$\tau_d = \frac{p \cdot s}{2 \cdot t_a}$$

where $\mathbf{t}_a$ is the thickness of the core, in mm.

The shear stress due to the design pressure is to be such that:

$$\tau_d < \frac{\tau_{br}}{SF}$$

where:

τ_{br} : shear breaking strength of the core material, in N/mm^2,

SF : safety factor, as defined in [6.4.1].

The sum of the bending and shear deflections, due to the design pressure **p** (see [4]), of a sandwich laminate between stiffeners is not to be greater than about 1% of the stiffener spacing. The total deflection, in mm, of a sandwich laminate, fixed on its edges, is given by the formula:

$$f = \frac{\mu_2}{384} \cdot \frac{p \cdot s^4}{[EI]} \cdot 10^9 + \frac{\mu_3}{8} \cdot \frac{p \cdot s^2}{t_a \cdot G} \cdot 10^3$$

where:

[EI] : rigidity of the sandwich laminate, for 1 mm width, in N · mm^2/mm, as defined in Sec 2, [1.2.3] (b)

$\mathbf{t}_a$: core thickness, in mm

G : shear modulus of the core material, in N/mm^2

μ_2 : factor defined in [6.4.2] (b)

μ_3 : 1, for $l \geq 2 \cdot s$

$1 - 1,8 \cdot \left(1 - \frac{l}{2 \cdot s}\right)^2$, for $s < l < 2 \cdot s$

0,550, for $l \leq s$

6.4.4 Stiffeners

a) **General**

The Rule values of stiffener stresses take account of the width $\mathbf{l}_b$ of the attached plating, defined below:

- for primary stiffeners, $\mathbf{l}_b$ is the smaller of the two values:

  s or 0,2 **l**, stiffener **L**,

  s or 0,2 **l** + **a**, stiffener Ω,

  where **a** is defined in [6.4.2],

- for ordinary stiffeners, $\mathbf{l}_b$ is equal to the spacing **s** between stiffeners.

Cutouts for the passage of ordinary stiffeners are to be as small as possible. As a rule, the depth of cutouts is not to be greater than half the web height of the primary stiffener.

b) **Scantlings**

The bending stress σ_d, in N/mm^2, due to the design pressure **p** (defined in [4]) is given by the formula:

$$\sigma_d = \varepsilon \cdot \frac{p \cdot s \cdot l^2}{12} \cdot \frac{V}{[I]} \cdot 10^6$$

where:

ε : 1, if the stiffener is fixed at its ends, 1,5, in other cases.

V : distance from the stiffener neutral axis to the flange, in mm, as defined in Sec 2, [1.2.3] (d)

[I] : inertia of the stiffener, in mm^4, as defined in Sec 2, [1.2.3] (d).

The bending stress due to the design pressure σ_d, is to be:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

σ_{br} : breaking bending strength of the stiffener, as defined in [6.4.1].

σ_{bl} : bending stress due to the total bending moment, as defined in [6.3.4]. σ_{bl} is to be equal to zero for all stiffeners of ships of less than 24 in length and for stiffeners not contributing to the longitudinal strength and all stiffeners at ends, for other ships

SF : Safety factor, as defined in [6.4.1].

The shear stress, in N/mm², due to the design pressure p (defined in [4]) is given by the formula:

$$\tau_d < \frac{\mathbf{p} \cdot \mathbf{s} \cdot \mathbf{l}}{2 \cdot \mathbf{S_a}} \cdot 10^3$$

where $\mathbf{S}_a$is the total web cross-sectional area, in mm².

For primary stiffeners, the shear stress due to the design pressure is to be:

$$\tau_d < \frac{\tau_{br}}{SF}$$

where:

τ_{br} : shear breaking strength, in N/mm², of the laminate farming the web of the primary stiffener. If a precise value of τ_{br} obtained from tests or other agreed method is not available, τ_{br} is equal to 60 N/mm²,

SF : Safety factor, as defined in [6.4.1].

The bending stress σ_{de}, in N/mm², calculated for the test pressure $\mathbf{p}_e$ is to be such that:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

For primary stiffeners the shear stress τ_{de}, in N/mm², calculated for the testing pressure $\mathbf{p}_e$, is to be:

$$\tau_{de} < \frac{\tau_{br}}{SF}$$

6.5 Bottom structure

6.5.1 Application

The requirements of this item [6.5] apply to single or double-bottom structures with longitudinal or transverse framing.

The requirements of this article are to be used for the scantlings of the main structural members located between the keel and the chine, as defined in Sec 1, [1.1.4] and also [6.4.1] (b) for catamarans.

The requirements of this article apply also to structural members of the vault of catamarans.

6.5.2 General arrangements

In general, a continuous centreline girder is to be provided over the full length of the ship.

In the engine room additional girders are to be fitted in order to provide sufficient structural strength. Unless otherwise specified, the shipyard is to submit the supporting structure to the engine builder for agreement on rigidity and arrangements.

Floors are to be continuous between the centreline keelson and the bilge.

A floor or a girder is to be provided under each line of pillars.

Main engines and thrust blocks are to be secured to the hull structure by seatings with adequate strength to withstand forces transmitted by the propulsive installation.

When solid ballast is fitted, it is to be securely positioned. If necessary, intermediate floors may be fitted for the purpose.

For each floor or keelson web, the height thickness ratio is not to exceed 25.

Provision is to be made for the free passage of water from all parts of the bottom to the suctions, taking into account the pumping rate required.

6.5.3 Plating scantlings

Plating scantlings are to be calculated in accordance with [6.4.2] and [6.4.3].

The width of the keel plate, in m, is not to be less than 0,6 + 0,01 **L**.

6.5.4 Stiffener scantlings

Stiffener scantlings are to be calculated in accordance with [6.4.4].

For the scantlings of a bottom girder, its span **l** is to be measured:

- between transverse bulkheads, if the keelson can be considered as a support, i.e if its height is at least 1,5 times the height of the floors in the centreline, and its moment at least twice the moment of the floors in the centreline,
- between floors, if the keelson is intercostal, its height not exceeding the floor height.

For the scantlings of a floor, its span l is to be measured:

- between side shell plates, if the bottom is flat and supporting bottom girders or longitudinal bulkheads do not exist,
- between side shell plating and keel, in the case of pronunced sections if supporting bottom girders or longitudinal bulkheads do not exist,
- between side shell plating and keelson, side shell plating and bulkhead, or bulkhead and bulkhead, if longitudinal bulkheads or keelson exist, the scantlings and the span of which are such that they can be considered as a support.

For ships with a dead rise of floors, the floor span is to be measured from the ship centreline, when the angle of the dead rise of floor is greater than:

- 20° in the case of built-in floor at side,
- 10° in the case of supported floor at side.

This being so, the floor moment is to be calculated in accordance with [6.4.4], with $\varepsilon = 1{,}1$.

When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of the stiffeners, taking relative stiffnesses into account, is to be submitted.

6.5.5 Single-bottom structure

Side girders are to be fitted. In general, their spacing is not to exceed 2,5 m.

Centre and side girders are to be extended as far aft and forward as practicable.

Where side girders are fitted in lieu of the centre girder, overlap is to be adequately extended, and additional stiffening of the centre bottom may be required.

Flanges of bottom girders and floors are to be connected.

For ships more than 40 m in length with transverse framed bottom, longitudinal stiffeners connected to floors are to be fitted between bottom girders, within the midship region. The mean spacing of longitudinal members is not to exceed 1,4 m.

6.5.6 Double-bottom structure

In general, the height of the double bottom is not to be less than $0,1 \cdot \mathbf{L}^{0,5}$.

Side girders are to be fitted. In general, their spacing is not to exceed 4,2 m.

See also [6.5.5] above.

6.6 Side shell structure

6.6.1 Application

The requirements of this Article apply to transversely or longitudinally framed side shell structure.

The requirements of this article are to be used for the scantlings of the main structural members located between the chine, as defined in Sec 1, [1.1.4], and the highest continuous deck.

The requirements of this article apply to structural members of inner walls of catamarans (see [6.4.1] (b)).

6.6.2 General arrangements

In the case of longitudinal framing, the web frames are to be located in way of floors.

In the case of transverse framing, the section modulus of the web frames located in the engine room is to be not less than 4 times that of adjacent frames, and the cross-sectional area of these web frames is to be not less than twice that of adjacent frames.

In the case of transverse framing, frames are to be fitted at each frame space. The scantlings of main and 'tween deck frames are not to be less than those of frames located immediately above.

In general, stringers are required if the span of main and 'tween deck frames is greater than 4 m.

Web frames are to be fitted in way of beams at hatch ends.

The flanges of stringers and web frames are to be connected if necessary.

6.6.3 Plating scantlings

Plating scantlings are to be calculated in accordance with [6.4.2] and [6.4.3].

The width of the sheerstrake, in m, is not to be less than:

$$\mathbf{b} = 0,715 + 0,425 \cdot \frac{\mathbf{L}}{100}$$

Unless otherwise specified, the thickness of the sheerstrake is not to be less than that of the adjacent side shell plating.

The thickness of the sheerstrake is to be increased by 40%, in way of breaks in long superstructures occurring within the midship 0,5 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

The thickness of the sheerstrake is to be increased by 30%, in way of breaks in long superstructures occurring outside the midship 0,5 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

The thickness of the sheerstrake is to be increased by 15%, in way of breaks in short superstructures occurring within the midship 0,5 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

6.6.4 Stiffener scantlings

Stiffeners scantlings are to be calculated in accordance with [6.4.4].

For the scantlings of a stringer, its span **l** is to be measured:

- between transverse bulkheads if the stringer can be considered as a support or if there is no vertical web,
- between vertical webs if the stringer is intercostal and cannot be considered as a support between transverse bulkheads.

For the scantlings of a vertical web frame, its span **l** is to be measured:

- 'tween decks or between deck and bottom, if there are no stringers or if stringers are intercostal,
- between deck and stringer, bottom and stringer or between stringers if stringers can be considered as a support between transverse bulkheads.

When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of stiffeners, taking relative stiffnesses into account, is to be submitted.

6.7 Deck structure

6.7.1 Application

The requirements of this article apply to transversely or longitudinally framed deck structure.

The requirements of this article are to be used for the scantlings of the main structural members of the strength deck, lower and platform decks, accommodation decks and the decks of superstructures and deckhouses.

6.7.2 General arrangements

In the case of longitudinal framing, the beams are to be located in way of the vertical web frames of side shell.

In the case of transverse framing, the beams are to be, in general, fitted at every frame, in line with side shell stiffeners.

In the case of a vertical break for the strength deck, the continuity of strength is to be ensured by a tapered structure of the two decks within a length between 2 and 5 frame spaces.

The transverse strength of ships with large deck openings is to be considered in each case.

In the area of openings, the continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

Hatch girders and reinforced beams are to be fitted in way of hatch openings.

The flanges of girders and reinforced beams are to be connected, if necessary.

In the case of concentrated loads on decks (e.g. pillars, winches, davits), direct calculations are to be carried out taking into account simultaneous design pressure and concentrated loads.

6.7.3 Plating scantlings

Plating scantlings are to be calculated in accordance with [6.4.2] and [6.4.3].

The width of the stringer plate, in m, is not to be less than:

$$\mathbf{b} = 0{,}005 \cdot (\mathbf{L} + 70)$$

The thickness of the stringer plate is to be increased by 40%, in way of breaks of long superstructures occurring within the midship 0,5 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

The thickness of the stringer plate is to be increased by 30%, in way of breaks of long superstructures occurring outside the midship 0,5 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

The thickness of the stringer plate is to be increased by 15%, in way of breaks of short superstructures occurring within the midship 0,6 **L**, over a length of about one sixth of the ship breadth on each side of the superstructure end.

6.7.4 Stiffener scantlings

Stiffeners scantlings are to be calculated in accordance with [6.4.4].

For the scantlings of a girder, its span **l** is to be measured:

- between transverse bulkheads, if the girder can be considered as a support, i.e if its height is at least 1,5 times the height of the floors in the centreline, and its moment at least twice the moment of the floors in the centreline
- between deck beams, if the girder is intercostal and used to prevent tripping instability of deck beams.

For the scantlings of a deck beam, its span **l** is to be measured:

- between side shell plates, if there are no girders which can be considered as a support or if there are no longitudinal bulkheads
- between side shell plating and bulkhead or girder, or between bulkheads or girders if there are longitudinal bulkheads or girders, the scantlings and span of which are such that they can be considered as a support.

Hatch beams and hatch girders are to be of reinforced scantlings, to take the interrupted stiffeners into account.

The scantlings of hatch beams and girders are not to be less than those obtained in accordance with [6.4.4], changing **s** to take into account the effective supported areas.

When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of stiffeners taking relative stiffnesses into account is to be submitted.

6.7.5 Deck covers

The scantlings of deck cover plating are to be determined in accordance with [6.4.2] and [6.4.3].

The scantlings of the deck cover stiffeners are to be calculated in accordance with [6.4.4], the span **l** of the stiffener being measured:

- between the two edges of the cover, if the stiffener can be considered as a support for this dimension,
- between perpendicular stiffeners, if the stiffener is considered as intercostal.

In the case of deck cover with a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of stiffeners taking into account the relative stiffenesses is to be submitted.

6.8 Bulkhead structures

6.8.1 Application

The requirements of this article are to be used for the scantlings of the main structural members of:

- transverse or longitudinal watertight bulkheads,
- transverse or longitudinal tank bulkheads,
- transverse or longitudinal wash bulkheads,
- cofferdam bulkheads,
- shaft tunnel bulkheads.

6.8.2 General provisions

The scantlings of tank bulkheads which are also Rule bulkheads are not to be less than those required for a watertight bulkhead.

Where bulkheads do not extend up to the uppermost continuous deck (such as the after peak bulkhead), suitable strengthening is to be provided in the extension of the bulkhead.

Bulkheads are to be stiffened in way of deck girders.

Floors are to be fitted in the double bottom, in way of plane transverse bulkheads.

The scantlings of stiffeners on the horizontal part of stepped bulkheads are to be calculated as for beams.

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; crossbars are to be provided to support the cut-off stiffeners.

Provision is to be made to avoid the buckling of large accommodation bulkheads without stiffeners.

6.8.3 Plating scantlings

Plating scantlings are to be calculated in accordance with [6.4.2] and [6.4.3].

6.8.4 Stiffener scantlings

Stiffeners scantlings are to be calculated in accordance with [6.4.4].

For the scantlings of a stringer, its span **l** is to be measured:

- between side shell plates, between longitudinal bulkheads or between side shell plating and longitudinal bulkhead, for stringers of transverse bulkheads considered as a support,

- between transverse bulkheads, for stringers of longitudinal bulkheads considered as a support,
- between vertical webs, for stringers whose scantlings are such that they cannot be considered as a support.

For the scantlings of a vertical web, its span **l** is to be measured:

- between decks or between deck and bottom if the vertical web can be considered as a support,
- between horizontal stiffeners if scantlings of the vertical web are such that it cannot be considered as a support.

When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of stiffeners taking relative stiffnesses into account is to be submitted.

6.8.5 Watertight doors

The strength of a watertight door is not to be less than that of the adjacent bulkhead.

In the calculation of the scantlings of stiffeners of watertight door, stiffeners are to be considered as supported at ends.

6.9 Superstructure and deckhouse structures

6.9.1 Application

The requirements of this article apply to the structure of superstructures and deckhouses framed transversely and longitudinally.

6.9.2 General provisions

Reduction in scantlings may be granted for:

- deckhouses not protecting openings in the freeboard and superstructure decks,
- deckhouses located above the third tier.

These reductions are to be individually examined by Tasneef.

Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, pillars or other equivalent system.

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

All openings cut in the sides or decks of superstructures and deckhouses are to be stiffened and have well rounded corners. Continuous stiffeners are to be fitted below and above doors or similar openings. Where necessary, compensation for large openings may be required.

Side plating at the ends of superstructures is to be tapered into the bulwark or sheerstrake of the strength deck. Where a raised deck is fitted, this arrangement is to extend over a three-frame space.

Access openings cut in sides of enclosed superstructures are to be fitted with watertight doors, permanently attached.

The structure and attachment system of these doors are to be arranged so that the strength remains equivalent to that of a non-pierced bulkhead.

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

As a rule, the spacing of stiffeners on sides of superstructures and deckhouses is to be the same as that of beams on supporting decks.

Partial bulkheads or webs are to be arranged to support the sides and ends of superstructures and deckhouses. Scantlings of these web frames are to be individually considered.

Sides of deckhouses are to be strengthened in way of lifeboats and the top plating is to be reinforced in way of lifeboat davits.

Special attention is to be paid to the transfer of vertical loads between decks.

6.9.3 Plating scantlings

Plating scantlings are to be calculated in accordance with [6.4.2] and [6.4.3].

When the superstructure deck is the strength deck, the scantlings of the sides of superstructures are to be determined as for the side shell plates.

The plating thickness of sides of long superstructures is to be increased by 25% over a length of about one sixth of the ship breadth on each end of the superstructure.

6.9.4 Stiffener scantlings

Stiffener scantlings are to be calculated in accordance with [6.4.4].

Scantlings of side stiffeners of superstructures and deckhouses need not exceed those of side stiffeners of the tier immediately below, based on the same span and spacing.

Tasneef reserves the right to require a special examination of superstructure frames:

- where the decks at ends of the considered frame are not stiffened in the same way,
- where the frame span exceeds 4 m,
- for passenger ships.

In the case of a superstructure or deckhouse contributing to longitudinal strength, the vertical stiffeners between windows on the sides are to be individually examined.

6.10 Principles of building

6.10.1 Definitions

The stiffeners with the lower 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.

6.10.2 General provisions

The purpose of this item [6.10.2] is to give some structural details which may be recommended. 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 structure 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 10) on both sides, or equivalent joint.

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 10.

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.

6.10.3 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 11.

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 12.

a) **Deck-side shell connection**

   This connection is to be designed both for the bending stress shown in Fig 13, caused by vertical loads on deck and horizontal loads of seawater, 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 14 to Fig 17 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 18 and Fig 19 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 hull should 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.

6.10.4 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 [6.10.2].

Fig 20 to Fig 22 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.

6.10.5 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 ship.

Fig 22 gives the principle for connection between the structure and pillars subject to compressive loads.

6.10.6 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 24 gives an example of possible seating.

Figure 10

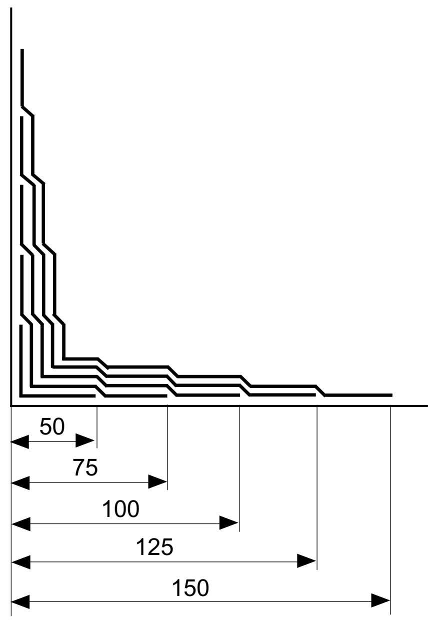


Figure 11

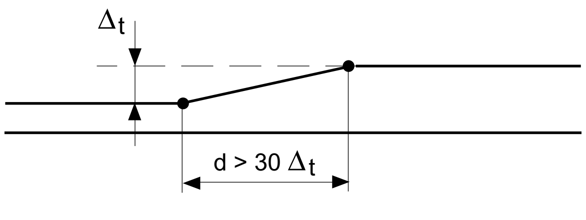


Figure 12

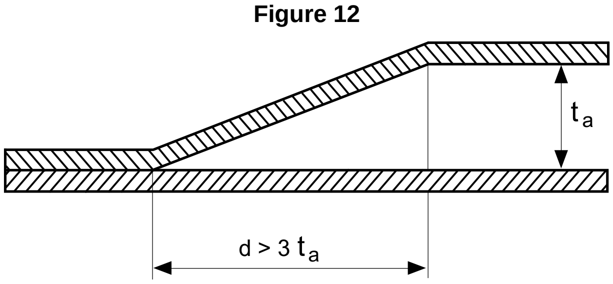


Figure 13

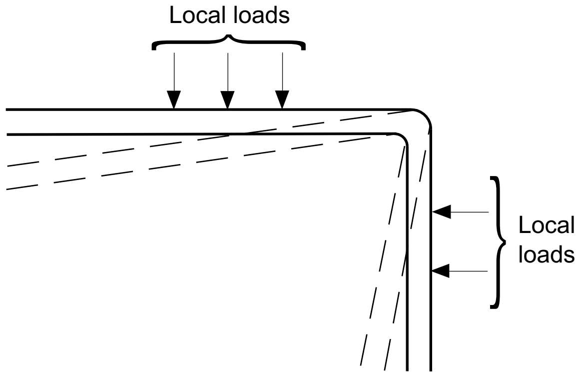


Figure 14

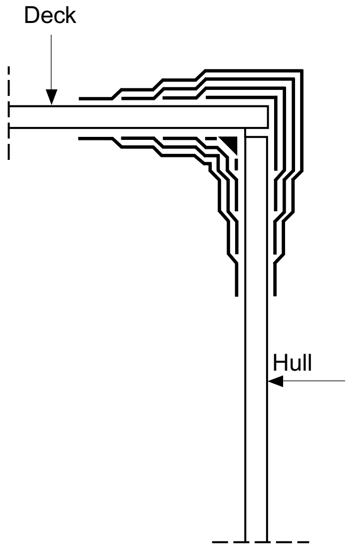


Figure 15

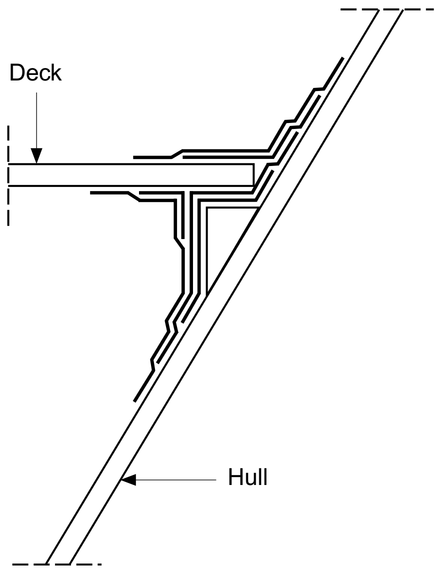


Figure 16

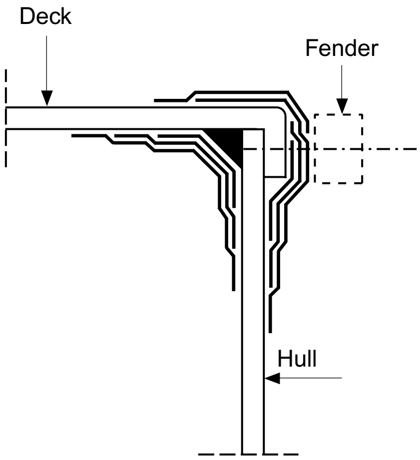


Figure 17

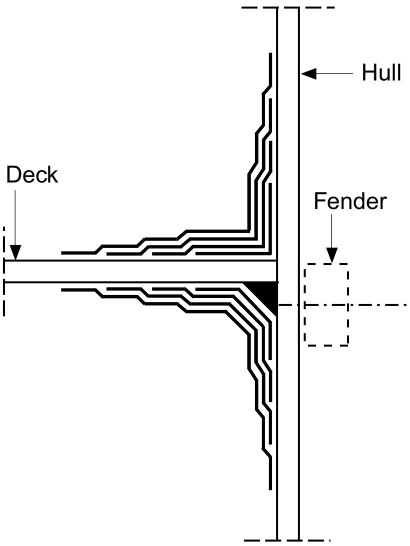


Figure 18

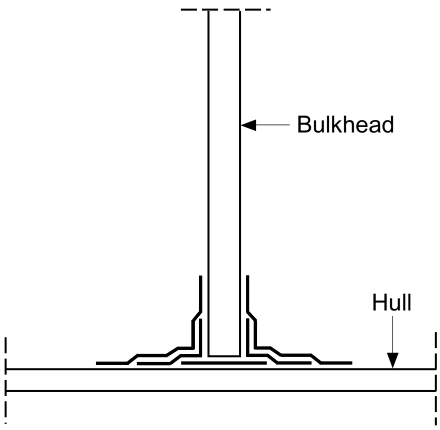


Figure 19

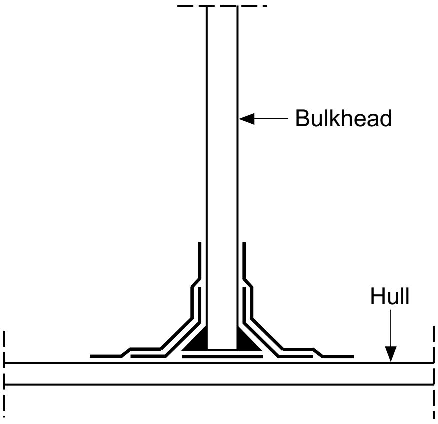


Figure 20

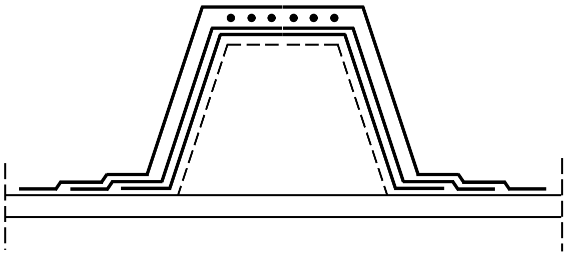


Figure 21

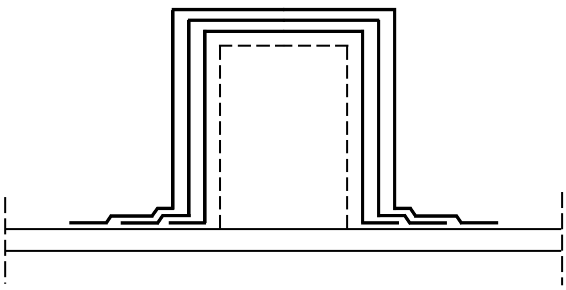


Figure 22

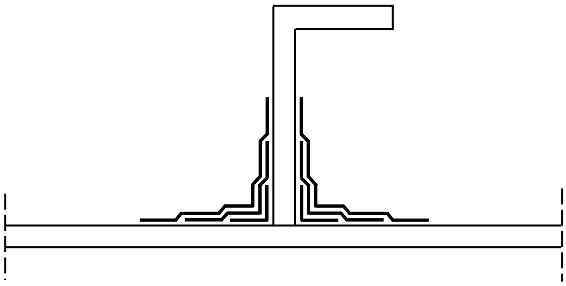


Figure 23

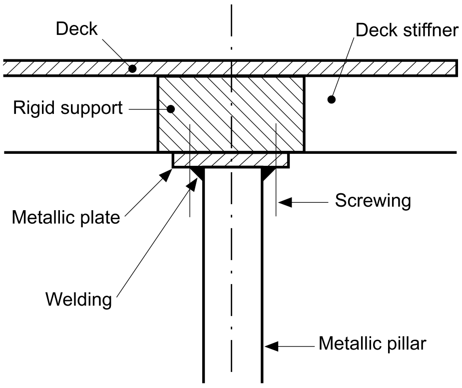
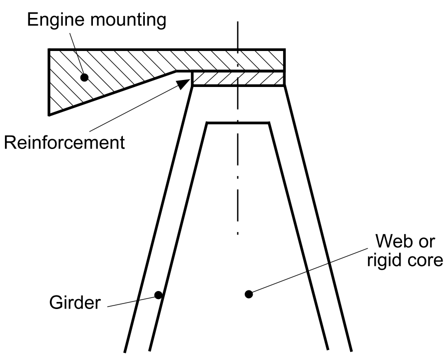


Figure 24



7 General requirements for structural scantlings

7.1 Terminology

7.1.1 The following definitions and symbols are valid throughout these Rules, except where otherwise stated.

s : spacing, in metres, of ordinary stiffeners of plating; in the case of sections of Ω type, the value of **s** is given, for the calculation of the plating thicknesses, by the distance between the inner edges of the two adjacent sections;

$\mathbf{s_r}$: reference spacing of ordinary stiffeners given, in metres, by:

$$\mathbf{s_r} = (2,3\mathbf{L} + 460) \cdot 10^{-3}$$

where **L** = length of the hull defined in Sec 1, [1.1.4]

S : conventional overall scantling span of a girder, in metres, to be assumed equal to the distance between the supporting elements at the ends of the beam;

b : actual width, in metres, of the load-bearing plating;

Z : Rule section modulus, in cm^3, of a girder in association with a width of plating having conventional breadth equal to **s** or, for primary supporting members, equal to **b**;

$\mathbf{K_0}$, $\mathbf{K_{of}}$, $\mathbf{K'_{0f}}$: coefficients relative to materials, given in [7.5];

$\mathbf{K_{V1}}$, $\mathbf{K_{V2}}$, $\mathbf{K'_{V3}}$ and $\mathbf{K_{V4}}$:coefficients for "high speed" hulls, given in [7.7].

7.2 Size and distribution of hull structural scantlings, type of structure and structural continuity

7.2.1 Hull structural scantlings and service of the ship

The structural scantlings established in these Rules may be reduced in the case of ships classed for restricted service, at Tasneef's discretion.

7.2.2 Distribution of structural scantlings

The hull scantlings required in these Rules are to extend for the entire length of the hull without reductions at the fore and aft ends, unless otherwise stated in specific cases below.

7.2.3 Type of structure

Hull structure is conventionally divided into the following types:

- longitudinal, when the ordinary stiffeners consist mainly of longitudinals on the bottom, sides and weather deck, supported by transverse webs constituted by floors, side frames and deck frames or by equivalent transverse bulkheads. The spacing of webs is generally required to be not greater than approximately 2 m (except for high speed hulls, for which see [7.7]) or, for hulls having **L** > 6 m, not greater than 2,5 m;
- transverse, when the ordinary stiffeners consist mainly of floors, side frames and deck beams.

Transverse structure is permitted, as a rule, for hulls which are not high speed hulls and which are of limited length, i.e. **L** not exceeding 20 m.

7.2.4 Structural continuity

In designing the ship, special attention is to be given in order to prevent any structural discontinuity; to this end, the variation in scantlings and structures, such as in way of openings in strength decks, is to be gradual.

7.3 Longitudinal strength

7.3.1 The structural scantlings in these Rules are intended as being adequate also for the purpose of hull longitudinal strength in the case of ships having **L** ≤ 30 m and openings in decks of limited breadth as specified below.

Therefore, the calculation of the section modulus, in cm^3, of the midship section with respect to the bottom, $\mathbf{W_f}$, and with respect to the deck, $\mathbf{W_p}$, is requested only for the following hulls, unless it is deemed necessary by Tasneef also in other cases:

- hulls having **L** > 30 m
- hulls having any **L** and the above openings with breadth greater than 0,3 **L** of the local breadth of the deck
- hulls having any **L** and unconventional form.

7.4 Direct calculations

7.4.1 Direct calculations of the hull structural scantlings are to be carried out, on the basis of the most modern technology, in those cases deemed necessary by Tasneef.

With regard to the loads acting on the structures and to the load conditions, the relevant requirements of Part B, Chapter 5 of the Rules concerning ordinary ships are generally adopted, except in the case of ships of special design for which, in the opinion of Tasneef, these Rules are inappropriate and require modification or for which other criteria are to be adopted.

7.5 Coefficients for the scantlings of structures relative to the mechanical properties of laminates

7.5.1 The values of the coefficients K_o and K_{of} that appear in the formulae of the hull structural scantlings in these Rules refer to single-skin laminates with glass fibre reinforcements and are given by:

$$+ K_0 = (75 / R_m)$$

$$K_{0f} = \sqrt{118 / R_{mf}}$$

where R_m and R_{mf} are, in N/mm², the values of the ultimate tensile and flexural strengths given by the formulae in Sec 2, Tab 3 or, for tested laminates, the values obtained in the tests.

Therefore, in the case of laminates having G_c = 0,25 (minimum permitted) $K_o = K_{of} = 1$ is to be assumed.

The values K_o and K_{of} are to be assumed not less than 0,5 and 0,7, except for specific cases assessed by Tasneef on the basis of the tests performed.

The values of K_o and K_{of} of single-skin laminates with reinforcements in fibres other than glass, or with promiscuous or hybrid reinforcements, are determined using formulae (1) with:

R_m : the lower of the ultimate tensile strength and the ultimate compressive strength, in N/mm²

R_{mf} : ultimate flexural strength, in N/mm².

For the thickness of surface sandwich laminates the requirements stated above apply, as appropriate, taking however the coefficient $K'_{of} = \sqrt{75 / R_m}$ instead of K_{of}.

7.6 Mass of reinforcement fibres in laminates

7.6.1 The mass per area, in kg/m², requested for the glass fibres in a laminate is obtained from the following formula:

$$P_r = \frac{3,07}{(2,56 / G_c) - 1,36} \cdot t$$

where G_c is the content of fibres in the laminate, defined in Sec 2, [2.5.1], and **t** is the thickness, in mm, of the laminate itself prescribed in the requirements for structural scantlings given later in this Section. Therefore, P_r is the Rule value of the mass per area of the reinforcements.

For laminates with reinforcements in fibres other than glass, or with promiscuous or hybrid reinforcements, the mass per area of the reinforcements and the thickness **t** of the laminates are to be equal or equivalent to those measured on the panels used for mechanical tests.

7.7 Coefficients for scantlings and type of structure of high speed hulls

7.7.1 "High speed hulls" is intended to mean those propelled by an engine for which the ratio

$$\alpha = V / \sqrt{L}$$

is greater than 3,6 where **V** is the maximum design speed, in knots, and **L** is the length of the hull, in metres, on the load waterline, defined in Sec 1, [1.1.4]. The most commonly found design characteristics of such hulls are given below **by way of example for the purpose of information only**

L : 10 ÷ 30 m

D : (0,15 ÷ 0,18)**L**

B : (1,6 ÷ 2,2)**D**

T : (0,3 ÷ 0,55)**D**

α : 3,6° ÷ 11°

$V \leq$ 35 knots

B_c : (0,7÷ 0,8) **B** = breadth, in metres, between the chines in the transverse section located 0,65 **L** from the aft perpendicular

β : 12°÷ 18° = dead rise of the bottom in way of B_c

Δ_p : $(0,11L^2 - 11) + 24$ = design displacement at the full load, in tonnes.

The hull structure is, as a rule, to be longitudinal with spacing of longitudinals and side webs limited to a maximum of 1,5 s_r and 2 s_r, where s_r = reference frame spacing.

The coefficients which appear in the following structural scantling formulae are:

- K_{v1}, relative to the thickness of bottom plating;
- K_{v2}, relative to the thickness of side plating;
- K_{v3}, relative to the modulus **Z** of the bottom longitudinals and floors;
- K_{v4}, relative to the modulus **Z** of the side longitudinals and side webs.

The values of these coefficients are given by the following formulae but, in any event, are not to be taken less than 1:

K_{v1} : $0,34\sqrt{\alpha} + 0,35$

K_{v2} : $(0,024\,\alpha + 0,91)(1,018 - 0,0027\,L)$

K_{v3} : $0,36\,\alpha - 0,3$

K_{v4} : K_{v2}

The above formulae are deemed appropriate up to values of **V** = 35 knots, and α = 11°. This value of α corresponds to the Froude number 1,8 given by the ratio $V / \sqrt{gL}$

where

g : gravity acceleration = 9,81 m/s²;

V : speed, in m/s;

L : length as defined above.

For greater values of **V** (as a rule not exceeding 31 m/s (60 knots), the above coefficients are to be considered only for guidance.

For hulls having $\alpha < 3{,}6°$ the coefficients defined above are all assumed equal to 1.

7.8 Structures with sandwich construction

7.8.1 General requirements

The scantlings of sandwich type structures laid down in [7.8.2] are established using a criterion of equivalence with respect to those of structures with single-skin laminates.

Any other criteria may, however, be taken into consideration by Tasneef in each case on the basis of direct calculations of the structural scantlings.

7.8.2 Scantlings of sandwich laminates

The thickness of both surface laminates of the sandwich is, as a rule, to be not less than 0,6 of the thickness of the single-skin laminate calculated with the relevant formula given in the following chapters, using $\mathbf{s}/\mathbf{s}_r = 1$ and $\mathbf{K}_{of} = 1$. Each of the thicknesses is then to be corrected by multiplying by $\mathbf{K'}_{of}$ (see [7.5]), but is to be taken, as a rule, not less than 2,5 mm.

The minimum section modulus, in cm^3/cm, of a section of 1 cm width of the sandwich is given by:

$$\mathbf{Z}_s = \frac{\mathbf{Z}}{\mathbf{s}_r}$$

where:

Z : section modulus, in cm^3, of the reinforcement (presuming the associated strip of plating to be single-skin laminate), to be obtained from the relevant formula given in the following chapters, assuming $\mathbf{s} = \mathbf{s}_r$ and span equal to the minimum distance between the structural members supporting the sandwich. The relevant absolute Rule minimum value is not to be taken into account in the calculation of **Z**.

The minimum section modulus, $\mathbf{W}_1$ o $\mathbf{W}_2$, in cm^3/cm, of a given sandwich is to be $\geq \mathbf{Z}_s$.

The minimum value of the flexural modulus of stiffness **EJ**, in $N/mm^2 \cdot cm^4/cm$, of a sandwich is not prescribed; however, for guidance, it is suggested that the value of **J**, in cm^4/cm, should not be less than that obtained from the following relation:

$$\mathbf{J} = 2,4 + \mathbf{Z}_s^{\ 3}$$

The ultimate shear strength $\mathbf{R}_t$, in N/mm^2, of the core material of a sandwich is to be at least equal to 0,4 and in such case the height **h**, in cm, of the sandwich is given by:

$$\mathbf{h} = 7,5(\sqrt{\mathbf{Z}_s} - 0,45)$$

where:

h : $\mathbf{t}_c + 0{,}5\ (\mathbf{t}_1 + \mathbf{t}_2)$, $\mathbf{t}_c$ being the height of the core of the sandwich, in cm, and $\mathbf{t}_1$ and $\mathbf{t}_2$ being the thickness of each of the two surface sandwich laminates, in cm. The absolute minimum value of **h** is, as a rule, to be not less than 0,8 cm.

$\mathbf{Z}_s$: section modulus defined above.

The value of **h** is reduced linearly for core materials which have $\mathbf{R}_t > 0{,}4\ N/mm^2$.

8 Keel; stem and sternpost or sternframe (transom); rudder horn; propeller shaft brackets

8.1 Keel

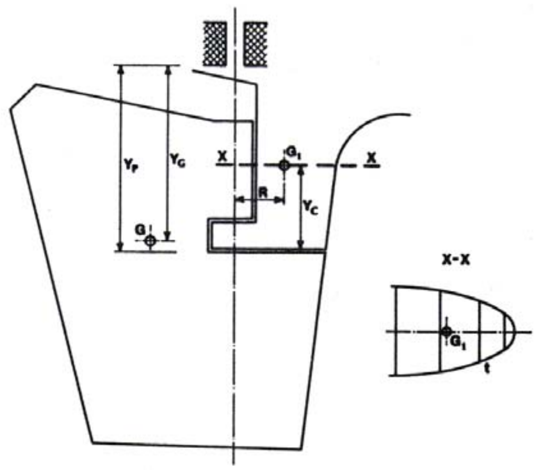
8.1.1 The keel is to have width not less than 0,05 **L** and thickness $\mathbf{t}_{ch}$, in mm, at least equal to the greatest of the following values:

- thickness of the bottom plating of the hull;
- $\mathbf{t}_{ch} = 1{,}4\ \mathbf{t}_1$ where $\mathbf{t}_1$ = thickness of the bottom plating given in [7.2] (using $\mathbf{s} = \mathbf{s}_r$ in the formula) in the case of a U-shaped keel or of a bottom with a dead rise ≥ 12° or of a plate keel with centre vertical girder;
- $\mathbf{t}_{ch} = 2\ \mathbf{t}_1$ in the case of a plate keel, or with a dead rise less than 12°, without centre vertical girder.

The thickness $\mathbf{t}_{ch}$ is to be gradually tapered to the thickness of the bottom and, in the case of hulls having a U-shaped keel, $\mathbf{t}_{ch}$ is to extend transversally to the bottom plating with adequate tapering.

When the hull is prefabricated in two halves, the keel joint is to be carried out with adequate overlapping of the layers of reinforcement on both sides of the bottom.

Figure 25



G : centroid of the rudder

$\mathbf{G}_1$: centroid of the sect. **X** - **X** of the rudder horn

8.2 Stem and sternpost or sternframe (transom)

8.2.1 The stem and the sternpost are to have thickness not less than:

- $\mathbf{t}_{ch}$, extending up to the full load waterline;
- $\mathbf{t}_1$ (given by the formula in [7.2], using $\mathbf{s} = \mathbf{s}_r$ and $\mathbf{K}_{V1} = 1$) extending up to the above-mentioned waterline as far as the deck or edge

The thickness $\mathbf{t}_s$, in mm, of the transom is to be not less than the value $\mathbf{t}_2$ for the side plating of the hull given in [9.3] using $\mathbf{K}_{V2} = 1$. When outboard or stern drive engines are fitted, the thickness $\mathbf{t}_s$ is to be suitably increased or, alternatively, a structure with double plating and a core in plywood may be used such that, in the opinion of the Designer, the strength of the transom is adequate in relation to the weight and output of the engines.

8.3 Rudder horn

8.3.1 Rudder horns of semi-spade rudders are to be adequately dimensioned in relation to the force acting on the pintle.

For rudders with one pintle only, this condition is generally satisfied when the generic section X - X has:

- section modulus **Z** with respect to the longitudinal axis, in cm^3,
- area **a** of the figure bounded by the rudder's external contour, in cm^2,
- average thickness **t** of the rudder shell, in cm, such as to satisfy the following relation:

$$\frac{0,1\mathbf{A}\mathbf{p}\mathbf{Y}_G}{\mathbf{Y}_p}\left(\frac{\mathbf{Y}_C}{\mathbf{Z}}+\sqrt{\frac{\mathbf{Y}_C^2}{\mathbf{Z}^2}+\frac{\mathbf{R}^2}{\mathbf{t}^2\mathbf{a}^2}}\right)\leq 0,15$$

where:

A : the total rudder area, in m^2

p : external pressure on the rudder, in kN/m^2, given by:
$\mathbf{p} = 9,8\,\mathbf{K}_0\,(\mathbf{V}+3)^2 \times 10^{-3}$ where:

- **K** : 8,75 for rudders inside the propeller jet
  7,35 for rudders outside the propeller jet
- **V** : speed of the ship, in knots
- **R** : distance from the centroid of the section considered of the rudder horn to the centreline of the rudder stock, in cm
- $\mathbf{Y}_g$, $\mathbf{Y}_p$, $\mathbf{Y}_c$: distances, in cm, shown in Fig 25.

The connection of the rudder horn to the hull will be subject to special consideration by Tasneef on a case-by-case basis.

8.4 Propeller shaft brackets

8.4.1 For double arm or single arm propeller shaft brackets made of steel or other metal, the requirements in Part B, Chapter 10, Sec 3 of the Rules apply.

9 Bottom, side and deck plating

9.1 General

9.1.1 The thickness of external and deck plating given by the requirements in this Chapter is to be increased as far as necessary such as to ensure the hull longitudinal strength, when prescribed (see [7.3]).

9.2 Bottom plating

9.2.1

The thickness $\mathbf{t}_1$ of bottom plating, in mm, is to be not less than:

$$\mathbf{t}_1 = 3,9\frac{\mathbf{s}}{\mathbf{s_r}}\sqrt{\mathbf{L}-3}\,\mathbf{K}_{of}\mathbf{K}_{V1}$$

or less than the thickness of side plating or, in any case, less than 3 mm, where:

L : length of the hull defined in Sec 1, [1.1.4];

s and $\mathbf{s}_r$: spacing defined in [7.1];

$\mathbf{K}_{of}$: coefficient relative to the mechanical properties of the laminate of bottom plating, defined in [7.5];

$\mathbf{K}_{V1}$: coefficient relative to high speed hulls defined in [7.7]

The thickness of the bottom is to extend transversally up to not less than 150 mm above the full load waterline and, in any case, beyond the chine in the case of chine units.

9.3 Side and sheerstrake plating

9.3.1 The thickness $\mathbf{t}_2$ of side and sheerstrake plating, in mm, is to be not less than:

$$\mathbf{t}_2 = 3\frac{\mathbf{s}}{\mathbf{s_r}}\sqrt{\mathbf{L}-3}\,\mathbf{K}_{of}\mathbf{K}_{V2}$$

or, in any case, less than 3 mm.

For hulls having **L** > 15, however, the sheerstrake is to be fitted with a height, in mm, at least equal to 0,025 **L** and thickness $\mathbf{t}_c$ not less than $\mathbf{t}_2$ or $4,2(\mathbf{s}/\mathbf{s_r})\sqrt{\mathbf{L}-3}\,\mathbf{K}_{of}\mathbf{K}_{V2}$

9.4 Local thickness increases in external plating

9.4.1 Bottom and side in way of openings and fore and aft end structure

The thickness of bottom and side plating is to be gradually increased with respect to that given in the requirements above, in way of:

- any large openings in such plating;
- fore and aft end structure of the hull and similar structure, such as sternpost or sternframe, propeller shaft boss, rudder horn, propeller shaft brackets;
- ends of castles, as provided for in [13].

9.4.2 Plating of the bottom forward

For the thickness of the plating of the bottom forward, see [11].

9.5 Deck plating

9.5.1 The thickness $\mathbf{t}_3$, in mm, of weather deck plating, including the stringer, is to be not less than:

$$\mathbf{t}_3 = 2,8\frac{\mathbf{s}}{\mathbf{s_r}}\sqrt{\mathbf{L}-3}\,\mathbf{K}_{of}$$

or, in any case, less than 3 mm.

For hulls having **L** > 15, however, the stringer plate is to be fitted having width at least equal to 0,025 **L** and thickness not less than:

$$t = 3,9\frac{s}{s_r}\sqrt{L-3}K_{of}$$

For hulls having deck openings of breadth ≥ 0,3 of the local breadth of the deck itself, the thickness of the plating at the sides of the opening is to be increased such as to compensate for the area of deck missing, taking into account any longitudinals and, when required, the provisions regarding hull longitudinal strength.

In any event, deck openings are to be well rounded at the corners.

The thickness **t**, in mm, of decks below the weather deck intended for accommodation spaces is to be not less than:

$$t = 2,1\frac{s}{s_r}\sqrt{L-3}K_{of}$$

Decks intended for other purposes will be examined by Tasneef on a case-by-case basis taking into account the loads bearing on them.

For superstructure decks, see [13].

10 Bottom, side and deck structures

10.1 Single bottom structures

10.1.1 Longitudinal structure

The section modulus **Z**, in cm³, of bottom longitudinals is given by:

$$Z = 20sS^2hK_oK_{V3}$$

where:

h : height of the hull **D**, to be assumed in any case at least equal to **L**/(5 + 0,1 **L**) where **L** = length of the hull.

The value of **Z** is, in any event, to be assumed not less than 20 cm³.

10.1.2 The section modulus **Z**, in cm³, of reinforced floors in way of the centreline of the span is given by:

$$Z = 22sS^2hK_oK_{V3}$$

where:

h : height defined in [10.1.1].

S : span, to be assumed not less than 1 m

s : spacing, in m, in general to be assumed not greater than 3 s_r, except for high speed hulls (see [7.7]).

10.1.3 The centre girder is generally to be fitted, except in the case of a U-shaped keel or of a dead rise edge ≤ 12°. Its height is to be not less than the local height of the floors and its section modulus **Z**, in cm³, is to be not less than 60 (L - 4).

Side girders are to be fitted such that the distance between them or to the mid-span of the hull or to the bilge plating does not exceed 2,5 m. Side girders are also to have:

- height in general not less than the local height of the floors;
- section modulus, in cm³, not less than $Z = 23sS^2hK_oK_{V3}$ where **s** = half the distance between the two longitudinals adjacent to the girder

However, when the girders form a support for the floors, the section modulus is to be not less than:

$$Z = 22bS^2hK_oK_{V3}$$

where:

b : half the distance, in m, between the two girders adjacent to that considered, except when only the centre girder is fitted, in which case **b** = half the total breadth of the hull.

S : girder span, in m, equal to the distance between two transverse bulkheads or between two supporting transverse structures of equivalent strength, to be taken not less than 1 m.

10.1.4 Additional floors are to be arranged in way of engine seating girders, propeller shaft struts, the rudder horn and other structures subjected to local loads.

10.1.5 Transverse structure

Ordinary floors are to be fitted at each frame and are to have a section modulus at mid-span, in cm³, not less than:

$$Z = 22sS^2hK_oK_{V3}$$

For additional floors, the requirements in [10.1.1] apply.

10.1.6 For girders, the requirements in [10.1.3] apply.

10.2 Double bottom structures

10.2.1 The structural scantlings of the double bottom are to comply with the requirements in [12], when the double bottom is intended to contain liquids; in any case, such scantlings are to be not less than the following, which refer to longitudinally framed double bottoms:

- thickness, in mm, of the inner bottom:

$$t = 3,1\frac{s}{s_r}\sqrt{L-3}K_o$$

- girders: scantlings given in [10.1.1]
- side longitudinals: section modulus **Z** given in [10.1.1]
- inner bottom longitudinals: section modulus **Z** = 0,8 of the **Z** of side longitudinals, using K_{V3} = 1
- floors: section modulus Z given in [10.1.2].

The scantlings of any transversely framed double bottoms will be examined by Tasneef on a case-by-case basis.

10.3 Side hull structures

10.3.1 Applicability

The requirements in [10.3]apply to hulls with one deck, i.e. the weather deck, or to hulls with two or more decks below the weather deck which are located below the draught **T** at full load of the ship.

The scantlings of side hull structures in cases other than the above, for example in way of any castles above the weather deck, will be considered by Tasneef in each case on the basis of the loads acting on such structures, as laid down in Part B, Chapter 5 of the Rules.

10.3.2 Longitudinal structure

The section modulus, in cm³, of side longitudinals is given by:

$$Z = 20 s S^2 h K_o K_{V4}$$

where:

h : 0,65 **D** or, if greater, **h** = 0,65 **L**/(5 + 0,1 **L**) for longitudinals of ships with one deck and for longitudinals below the lower deck of ships with two decks, while for 'tweendeck longitudinals on ships with two decks **h** = 60% of the above value.

The value of **Z** is to be assumed in any case not less than 15 cm³.

10.3.3 The section modulus, in cm³, of side webs is given by:

$$Z = 22 s S^2 h K_o K_{V4}$$

where:

h : value given in [10.3.2]

S : span, to be assumed not less than 1 m.

10.3.4 Transverse structure

The section modulus, in cm³, of ordinary frames is to be not less than:

$$Z = 20 s S^2 h$$

where **h** is given in [10.3.2].

Ordinary frames are to be well connected to the corresponding floor and to the corresponding beam, such as to achieve an appropriate end connection.

10.3.5 The section modulus, in cm³, of side webs and reinforced stringers is given by:

$$Z = 22 b S^2 h$$

Side webs are, as a rule, to be arranged at a spacing not greater than 5 frame spaces on hulls having height **D** > 2,5 m.

10.4 Deck structures

10.4.1 General requirements

Deck structures are intended to mean those consisting of stiffeners which may be transverse (beams) or longitudinal, generally supported by systems of primary supporting members (girders and/or transverse webs), which in turn are supported by pillars.

The pillars of the various decks are to be fitted in the same vertical line, wherever possible. Other solutions, such as girders supported by cantilevers, will be given special consideration by Tasneef in each individual case.

Pillars or equivalent additional structures are to be fitted under heavy, concentrated loads.

For the structure of forward decks and associated pillars, see also [11].

10.4.2 Symbols and associated requirements

h : conventional cargo height, in metres, on one deck

K_1 : coefficient relative to the zone of the deck considered.

- for ships having **L** > 20 m, the values of **h** and K_1 are as follows:
  - For exposed deck spaces:
    - weather deck of ships with one deck and in the area forward of 0,12 **L** from the forward perpendicular of ships with decks below the weather deck: **h** = 1,5; K_1 = 1,9
    - weather deck abaft 0,12 **L** from the forward perpendicular of ships with decks below the weather deck: **h** = 1,4; K_1 = 1,9
    - forecastle deck forward of 0,12 **L** from the forward perpendicular: **h** = 1,5; K_1 = 1,5
  - castle decks elsewhere: **h** = 1,3; K_1 = 1,5
  - deckhouse deck: **h** = 1,2; K_1 = 1,35
  - for unexposed deck spaces:
    - deck intended for cargo: **h** = h_c; K_1 = 1 where h_c = 'tweendeck height to be assumed, for the purpose of the calculation, not less than 2 m and, for flats in machinery spaces, equal to 2,5 m;
  - deck intended for accommodation:
  - weather deck and castle deck **h** = 1,3; K_1 = 1,5; decks below: **h** = 0,8; K_1 = 1
  - deckhouse deck: **h** = 1,2; K_1 = 1,35
  - for ships having **L** ≤ 20m, the values of **h** and K_1 stated above are reduced to 70%.

K_2 : 0,007 **L** + 0,3, to be assumed in any event not less than 0,7;

γ_0 : conventional cargo mass density on one deck, equal to 0,7 t/m³ and corresponding to the unit load q_o = 0,7 **h** t/m² resting on the deck itself;

γ : mass density, in t/m³, of the cargo it is intended to transport on one deck; when $\gamma > \gamma_0$ the values of **h** and K_1 stated above are to be increased in direct proportion.

10.4.3 Longitudinal structure

The longitudinals are to have a cross-sectional area sufficient, together with the deck plating to which they are connected, to achieve the midship section modulus (when required) and to have a section modulus, in cm³, not less than:

$$Z = 18 s S^2 h K_1 K_2 K_0$$

or less than 12 cm³.

If, however, the longitudinals are fitted on a deck other than the strength deck, the value of **Z** is to be reduced to 60%.

10.4.4 The transverse webs supporting the longitudinals are to be located in way of the side webs and are to have a section modulus, in cm³, not less than:

$$\mathbf{Z} = 22\mathbf{bS}^2\mathbf{hK}_0$$

10.4.5 Transverse structure

The ordinary beams are to have a section modulus, in cm³, not less than:

$$\mathbf{Z} = 17\mathbf{sS}^2\mathbf{hK}_1\mathbf{K}_2\mathbf{K}_0$$

10.4.6 The girders supporting the beams are to have a section modulus, in cm³, not less than:

$$\mathbf{Z} = 18\mathbf{bS}^2\mathbf{hK}_0$$

10.4.7 Concentrated loads

When a concentrated load acts on a deck, the section modulus of the supporting structures is to be increased, with respect to that determined using the above formulae, on the basis of the relevant requirements in Part B, Chapter 5, Sec 6 of the Rules. If necessary, adequate pillars are also to be fitted.

10.4.8 Pillars

The minimum section area **A**, in cm², of a steel pillar is given by:

$$\mathbf{A} = \frac{\mathbf{Q}}{12,5 - (0,045(\mathbf{l}/\mathbf{r}))}$$

where:

l : length of the pillar, in cm

r : minimum radius of gyration of the pillar cross-section, in cm

Q : load resting on the pillar, in kN , to be obtained from the formula:

$$\mathbf{Q} = 6,87\mathbf{Fh}_0 + 9,81\mathbf{W}$$

where:

F : area of the deck resting on the pillar, in m²

W : load from pillars above, if any, or any other concentrated load, in kN.

The formula from which **A** is calculated refers to solid pillars of steel having tensile strength **R** = 400÷490 N/mm², to pillars consisting of seamless pipes made of steel having tensile strength **R** = 440÷540 N/mm² and to built-up tubular or prismatic pillars made of steel having tensile strength **R** = 400÷490 N/mm².

Where materials having characteristics other than those above are used, the required area may be modified in accordance with Tasneef.

In general, the thickness of tubular or closed section pillars is to be not less than 1/35 of the nominal diameter or larger side of the section.

The thickness of the face plate of built-up pillars is to be not less than 1/18 of the unsupported width of the face plate.

Structural connections ensuring an efficient load distribution are to be fitted at the ends of pillars.

11 Aft and fore end hull structures

11.1 Strengthening of the bottom forward

11.1.1 In the area between 0,05 **L** and 0,25 **L** from the forward perpendicular, the thickness of the plating of the flat bottom is to be increased, in general by 20% with respect to that required in [9]; moreover:

- if the bottom structure is longitudinally framed, the reinforced floors are to be closely spaced and, in general, fitted at intervals not exceeding two frame spaces;
- in the event of transverse framing, on the other hand, additional intermediate girders are to be fitted between those required in [10].

11.2 Side supports aft of the fore peak

11.2.1 If the side structure in the area between the collision bulkhead and 0,15 **L** from the forward perpendicular is transversely framed, stringers are to be arranged in such area in line with the side longitudinals of the fore peak.

11.3 Forward deck structures

11.3.1 The girders and transverse webs of the weather deck and of the forecastle in the area forward of 0,075 **L** from the forward perpendicular are to have a small span, preferably achieved by means of closely spaced supporting pillars, and a spacing generally not exceeding 2 m.

11.4 Fore peak

11.4.1 The type of framing inside the peak is generally to be the same as that adopted abaft the peak such as to ensure adequate structural continuity.

In those areas where the shape of the hull body is narrower, the floors are to be of increased height with respect to that of the floors in the midship section, such that the angle of incidence with the frame is as large as possible.

When longitudinal framing is adopted, the spacing of floors, frames and transverse webs is generally not to exceed three frame spaces.

The reinforced structures of the flat, if any, and of the central longitudinal bulkhead (e.g. beams and vertical webs) are to be aligned with both the reinforced deck beams and the side webs of the sides of the hull.

12 Hull subdivision bulkheads and tanks for liquids

12.1 Hull subdivision bulkheads

12.1.1 The thickness **t**, in mm, of a single-skin laminate bulkhead and the section modulus **Z**, in cm³, of the associated vertical or horizontal stiffeners are given by the following formulae:

t : $12\mathbf{s}\sqrt{\mathbf{h}_1}\mathbf{K}_{\mathbf{of}}$

and, in any case, not less than 2,5 mm;

Z : $18\mathbf{sS}^2\mathbf{h}_2\mathbf{K}_0$

where:

h_1 : vertical distance, in m, from the lower edge of the area of bulkhead considered to the highest point of the bulkhead;

h_2 : vertical distance, in m, from the mid-point of the vertical stiffener, or from the horizontal stiffener, to the highest point of the bulkhead;

s : spacing, in m, between the stiffeners or reinforced beams.

The value of **Z** may be reduced by 20% when the stiffeners are fitted with end brackets.

The collision bulkhead is to be dimensioned in accordance with the provisions of [12.2].

In the case of corrugated bulkheads made in single-skin laminates, the value of s to be assumed for the calculation of **Z** is equal to the spacing of the corrugation and the value of s to be assumed for the calculation of **t** is equal to the larger side of the corrugation.

The boundary connection of a bulkhead is to be carried out by means of two angle bars.

Bulkheads made in sandwich type laminates or of marine plywood are to have scantlings and connections equivalent to those stipulated above.

12.2 Tanks for liquids

12.2.1 General

Tanks intended to contain drinking or fresh water may be "structural tanks", i.e. tanks forming parts of the hull structures. Tanks intended to contain fuel oil or lubricating oil are generally to be metal tanks separated from any other hull structures, in compliance with the requirements in the specific requirements for fire protection of reinforced plastic ships.

Tanks made of glass fibre may be accepted by Tasneef provided that they comply with the requirements in Part C, Ch 1, App 4 of the Rules.

Structural tanks intended to contain fuel oil or lubricating oil are to be made of single-skin laminates.

Tanks are to be insulated from other hull spaces by means of diaphragms, made of laminates, fitted inside the stiffeners (longitudinal and/or transverse), so that, in the event of the stiffener laminate breaking, the liquid may not flow outside the tank through the stiffener.

Sandwich type laminates may be accepted by Tasneef on a case-by-case basis, provided that the thickness of the laminate internal skin that is in contact with the liquid is not less than 8 mm and that diaphragms are fitted for the purpose of insulating the tank from the other hull spaces.

Tanks intended to contain fuel oil or lubricating oil may be accepted by Tasneef, provided that flame-resistance tests are carried out on laminates, in accordance with the relevant Tasneef requirements. These tests may be omitted if the laminate thickness is not less than 12 mm for plating or 6 mm for stiffeners and if the laminate is covered on the internal skin (inside the tank) by a hydro-carbide resistant resin and on the external skin (outside the tank) by a self-extinguishing resin.

In any case, mechanical tests are to be carried out on laminate samples after immersion in fuel oil at ambient temperature for a week. The mechanical property values of the laminate after immersion are to be not less than 80% of those of the sample before immersion.

For each enclosed space, the total volume of a tank is to be not greater than 6 m^3.

12.2.2 Scantlings

The thickness **t**, in mm, of a single-skin laminate bulkhead and the section modulus **Z**, in cm^3, of the associated vertical or horizontal stiffeners are given by:

where:

$$t = 18 s \sqrt{h_3} K_{of}$$

$$z = 36 s h_4 s^2 K_0$$

where:

h_3 : height **h_1** defined in [10.1] or height equal to half the distance from the lower edge of the bulkhead to the air pipe of the tank, whichever is the greater;

h_4 : height **h_2** defined in [10.1], or height equal to half the distance from the mid-span of the stiffener to the air pipe of the tank, whichever is the greater;

s : spacing, in m, between the stiffeners or reinforced beams.

Hull structures forming the top and bottom of a tank are to be dimensioned in accordance with these requirements whenever the latter are more stringent than those pertaining to such structures.

Boundary connections of bulkheads are to be carried out by means of two angle bars, one on each side and each having:

- side of width 50 mm for the first layer plus 40 mm for each 1000 g/m^2 of the subsequent layers;
- thickness = 0,5 t_{min}, where t_{min} is the lesser thickness of the layers to be connected, but in any case thickness not less than 3,5 mm.

12.2.3 Divisional bulkheads

If a tank extends from side to side of the hull, a longitudinal watertight or wash bulkhead is to be fitted at mid-span.

12.2.4 Cofferdams and drainage

Fuel oil tanks are to be separated from fresh water tanks by means of cofferdams.

As an alternative to such cofferdams, a simple chamber with a drainage channel may be used to collect any leakage.

Where leakage of liquid fuel may occur, for example in way of pumps, heaters, etc., screens, drainage channels or other suitable means are to be provided to drain such leakage to special wells.

12.3 Tests

12.3.1 As far as tests are concerned, the requirements in Part B, Ch 12, Sec 3 of the Rules apply.

12.4 Other bulkheads

12.4.1 Complete or partial bulkheads, other than those dealt with above, which are fitted in place of hull structures are to have scantlings equivalent to those prescribed in these Rules for such structures.

13 Superstructures

13.1 General

13.1.1 Designation of superstructures

First tier superstructures are intended as those situated on the weather deck, second tier superstructures are those immediately above, and so on.

If, however, the freeboard of the ship in respect of the weather deck, at 0,5 **L**, is greater than 1,8 m, for the purpose of structural scantlings the superstructures situated on such deck are termed second tier, those immediately above are termed third tier, and so on.

13.1.2 Materials

This item [13] stipulates the structural scantlings for reinforced plastic superstructures. The use of other material, for example aluminium alloys, and the associated scantlings will be taken into consideration by Tasneef on the basis of the requirements for the use of such material for hull construction.

13.2 Structural scantlings

13.2.1 Conventional scantling height

The conventional scantling height, which appears in the formulae for the structural scantlings of superstructures dealt with below, is equal, for hulls having **L** ≤ 30 m, to the following values:

h : 1,5 m for exposed front 1st tier bulkhead

h : 1,2 m for other superstructure bulkheads.

For hulls having **L** > 30 m, the value of **h** is determined using the relevant requirements of Part B of the Rules.

13.2.2 Boundary bulkheads and decks

a) **Thickness of boundary bulkheads**

The thickness **t**, in mm, of such bulkheads, including the sides of castles not constituting a step of the strength deck and excluding those of castles constituting a step of the strength deck, is to be not less than:

$$t = 7s\sqrt{h}K_{of}$$

and, in any case, not less than 3 mm, where:

s : spacing of the vertical or ordinary stiffeners of the plating

h : conventional scantling height defined above.

b) **Boundary bulkhead vertical stiffeners**

Except where otherwise stated in [13.2.3], the section modulus of boundary bulkhead vertical stiffeners is to be not less than **Z**, in cm^3:

$$z = 6sS^2hK_o$$

and, in any case, not less than 15 cm^3, where:

S : overall span of the vertical stiffener, in m.

The section modulus of the frames and longitudinals of castles not constituting a step of the strength deck is to be calculated using the formulae in [9] and [10]; in any event, the section modulus to be assumed is not to be less than that of the vertical stiffeners.

c) **Deck thickness**

Except where otherwise stated in [13.2.3], the deck plating thickness **t**, in mm, is to be not less than:

$$t = c_1(11{,}5s + 0{,}03L + 5{,}8)K_{of}$$

and, in any case, not less than 3 mm, where:

c_1 : 1 for bridge and forecastle

0,9 for poop

0,7 for deckhouse

0,6 for superstructures of hulls having **L**<15 m.

d) **Deck structures**

Deck structures (beams, girders) are to have scantlings in accordance with [10].

13.2.3 Special superstructures

a) **Sides and deck of castle constituting a step of the strength deck**

Castles constituting a step of the strength deck, defined in Sec 1, [1.1.4], are to have the scantlings stipulated in:

- [9] for side and deck plating
- [10] for side and deck structures

If necessary, such scantlings are to be increased to achieve the midship section modulus, when required.

b) **Deckhouses of considerable dimensions**

The scantlings of deckhouses are given in [13.2.2]; nevertheless, for deckhouses having average breadth ≥ 0,5 **B** and extending in length more than 0,15 **L** within 0,4 **L** amidships, it is necessary to:

- verify that the deck scantlings are such that the midship section modulus, when required, in way of the deckhouse is at least equal to that which would be obtained if the deckhouse did not exist;
- strengthen the sides of the deckhouse with transverse corrugations or with vertical web frames or transverse partial bulkheads;
- ensure that all the windows and openings have well rounded corners.

13.3 Hull strengthening at ends of castles

13.3.1 Application

The requirements specified in [13.3] apply to hulls having **L** ≥ 30 m.

13.3.2 Castles constituting a step of the strength deck

Where an end bulkhead of a castle which constitutes a step of the strength deck falls within 0,4 **L** amidships, the following thickness increases are required:

- the sheerstrake of the supporting deck is to be increased by 50%;
- the stringer of the supporting deck is to be increased by 25%;
- the castle side plating is to be increased by 25%.

Where the above bulkhead falls outside 0,4 **L** amidships, the increases given above may be reduced at the discretion of Tasneef.

13.3.3 Castles not constituting a step of the strength deck

Where a bulkhead of a castle which does not constitute a step of the strength deck falls within 0,4 **L** amidships, the following thickness increases are required:

- the sheerstrake and stringer of the supporting deck are to be increased by 20%;
- the side plating of an end castle extending for 0,25 **L** or more is also to be increased by 20%.

Where an end bulkhead of a castle which does not constitute a step of the strength deck falls outside 0,4 **L** amidships, the increases given above may be reduced, or waived if the end bulkhead falls outside 0,6 **L** amidships.

13.4 Bulwarks

13.4.1 As a rule, bulwarks are to:

- have thickness not less than 90% of that of the sides of the hull within 0,4 **L** amidships;
- be supported by vertical stiffeners (stays) spaced not more than 1 m apart and connected to the deck by means of two angle bars;
- have the upper edge longitudinally strengthened, increasing the mass per area (g/m^2) of the reinforcement of the laminate or adopting an equivalent solution.

14 Scantlings of masts and fishing equipment (e. g. crutches and frames for trawling fishery)

14.1 Design loads

14.1.1 The design loads to be assumed for the strength check of masts and fishing equipment are the following:

- the weights of masts and other arrangements to lift the nets
- the cargo weight, to be assumed equal to maximum breaking load of winches.

14.1.2 Adequate safety coefficients are to be used in the design of the supporting structure of fishing equipment, taking account of operational conditions and wave effects.

14.2 Strength check

14.2.1 Stress calculations for structural members

Stresses on structural members of masts and fishing equipment are to be obtained by direct stress calculations, using the design loads specified in [14.1].

14.2.2 Yield strength check

The combined Von Mises stresses on structural members of masts and fishing equipment are to satisfy the following condition:

$$\sigma_E \leq 0,5\,\mathbf{R_{eH}}$$

where:

σ_E : combined Von Mises stress, in N/mm^2, to be obtained by direct calculations

R_{eH} : minimum yield strength, in N/mm^2, of material, as defined in Part B, Ch 4, Sec 1, [2] of the Tasneef Rules.

14.2.3 Buckling strength check

The buckling strength of structural members of masts and fishing equipment is to be checked in compliance with the provisions of Part B, Chapter 7 or 8 of the Tasneef Rules, as applicable.

SECTION 4 HULL OUTFITTING

1 Propeller shaft brackets

1.1 General

1.1.1 For certain ships, the propeller shafting is extended to the propeller bearings clear of the main hull.

Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

1.2 Shaft brackets

1.2.1 The scantlings of bracket arms are to be calculated as indicated below. For high-powered ships, Tasneef may require direct calculations to be carried out.

Bracket arms are to be attached to deep floors or girders of increased thickness, and the shell plating is to be increased in thickness and suitably stiffened, at the discretion of Tasneef. The thickness of the palm connecting the arms to the hull, if any, is to be not less than $0,2 \cdot \mathbf{d}_S$, where:

$\mathbf{d}_S$: Rule diameter, in mm, of the propeller shaft, calculated with the actual mechanical characteristics.

The arm is to be connected to the hull by means of through bolts, fitted with nut and lock nut, in way of the internal hull structures suitably stiffened at the discretion of Tasneef.

The arms of V-shaft brackets are to be perpendicular, as far as practicable.

The bearing length of the shaft bracket boss, in mm, is to be not less than $3 \cdot \mathbf{d}_S$.

The thickness, in mm, of the shaft bracket boss after boring operation is to be not less than:

$$\mathbf{t_b} = 0,2 \cdot \mathbf{d_s} \cdot (\mathbf{k}_1 + 0,25)$$

where:

$\mathbf{K}_1$: $\mathbf{R}_{ms}/\mathbf{R}_{mb}$,

$\mathbf{R}_{ms}$: minimum tensile strength, in N/mm², of the propeller shaft,

$\mathbf{R}_{mb}$: minimum tensile strength, in N/mm², of the shaft bracket boss, with appropriate metallurgical temper.

Each arm of V-shaft brackets is to have a cross-sectional area, in mm², of not less than:

$$\mathbf{S} = 87,5 \cdot 10^{-3} \cdot \mathbf{d}_{so}^2 \cdot \left(\frac{1600 + \mathbf{R_{ma}}}{\mathbf{R_{ma}}}\right)$$

where:

$\mathbf{d}_{SO}$: Rule diameter, in mm, of the propeller shaft, for carbon steel material,

$\mathbf{R}_{ma}$: minimum tensile strength, in N/mm², of arms, with appropriate metallurgical temper.

Single-arm shaft brackets are to have a section modulus at ship plating level, in cm³, of not less than:

$$\mathbf{W} = \frac{30}{\mathbf{R_{ma}}} \cdot 10^{-3} \cdot \mathbf{l} \cdot \mathbf{d}_{so}^2 \cdot (\mathbf{n} \cdot \mathbf{d}_{so})^{0,5}$$

where:

$\mathbf{l}$: length of the arm, in m, measured from the shell plating to the centreline of the shaft boss,

$\mathbf{n}$: shaft revolutions per minute.

Moreover, the cross-sectional area of the arm at the boss is not to be less than 60% of the cross-sectional area at shell plating.

1.3 Plated bossing

1.3.1 Where the propeller shafting is enclosed within a plated bossing, the aft end of the bossing is to be adequately supported.

The scantlings of end supports are to be individually considered. Supports are to be designed to transmit loads to the main structure.

End supports are to be connected to at least two deep floors of increased thickness, or connected to each other within the ship.

Stiffening of the boss plating is to be individually considered. At the aft end, transverse diaphragms are to be fitted at every frame and connected to floors of increased scantlings. At the fore end, web frames spaced not more than four frames apart are to be fitted.

2 Waterjets

2.1

2.1.1 The supporting structures of waterjets are to be able to withstand the loads thereby generated in the following conditions:

- maximum ahead thrust;
- maximum thrust at maximum lateral inclination;
- maximum reversed thrust (going astern).

Information on the above loads is to be given by the waterjet Manufacturer, supported by documents.

The shell thickness in way of nozzles, as well as the shell thickness of the tunnel, is to be individually considered. In general, such thicknesses are to be not less than 1,5 times the thickness of the adjacent bottom plating.

SECTION 5 RUDDERS

1 Application

1.1

1.1.1 The requirements of Pt B, Ch, 10, Sec 1 of the Tasneef Rules apply except for those relevant to the rudder horn, for which the requirements in Sec 3, [8.3] apply.

SECTION 6 EQUIPMENT

1 Equipment Number

1.1 Cargo ships, except fishing vessels, and passenger ships

1.1.1 The equipment of the ship is to be as stipulated in Tab 1 based on the Equipment Number EN given in the requirements of Part B, Ch 10, Sec 4 of the Tasneef Rules. Alternatively, Tasneef, taking into account the specific service and operational area for which the ship is classed, may accept arrangements other than those above, following a request with grounds from the Interested Parties.

1.2 Fishing vessels

1.2.1 The equipment is to comply with the requirements of Part B, Ch 20, Sec 3, [5] of the Tasneef Rules.

2 Anchors

2.1

2.1.1 The mass per anchor given in Tab 1 applies to normal type anchors and may be reduced to 75% of that shown when high holding power anchors are used.

Anchors are generally to be arranged in hawse pipes or, in any event, so that the chain cables can be easily and rapidly paid out. The chafing lips, and in any case the zone at the shell and deck, are to have radius adequate to the diameter of the chain cable; in general, this is to be not less than 8 times the diameter of the chain cable.

3 Chain cables and ropes

3.1

3.1.1 The chain cable diameters shown in Tab 1 refer to chain cables made of mild steel, grade Q1. The total length of chain cable for the anchor may be provided using a length of at least 10 m, having the required diameter, connected at one end to the anchor and at the other to a wire or natural fibre rope having the required chain cable length and breaking load at least equal to that of the chain cable.

If synthetic fibre ropes are used to replace both the chain cable and the mooring and/or warping lines, the breaking load is to be calculated as stated in Part B, Ch 10, Sec 4 of the Tasneef Rules.

4 Windlass

4.1

4.1.1 The windlass is to be suitable for the size of chain cable and is generally to be power driven; this is a requirement, in any case, for ships having gross tonnage > 200.

Table 1

Equipment number EN	Number of anchors	Mass of each anchor (kg)	Chain Cable			Lines		
			Diameter (mm)		Total length (m)	Breaking load (kN)		Length (m)
			studless	with stud		warping	mooring	
30	2	28	9,5	-	110	31	18	60
40	2	48	11	-	110	46	21	65
50	2	58	11	-	165	60	24	70
60	2	78	12,5	-	165	71	26	75
70	2	99	14	-	165	80	28	80
80	2	117	14	12,5	190	88	30	85
90	2	133	16	12,5	190	94	33	88
100	2	149	17,5	14	190	99	35	92
110	2	156	17,5	14	220	104	37	97
120	2	167	19	16	220	108	38	102
130	2	177	19	16	220	112	39	104
140	2	187	19	16	220	114	40	107
150	2	195	20,5	17,5	220	116	41	110
160	2	205	20,5	17,5	220	118	42	113

Note 1: When the calculated EN is intermediate between two values given in the Table, the masses of the anchors and the breaking loads of the lines may be obtained by linear interpolation; the other elements are to be assumed based on the higher EN.
Note 2: Natural or synthetic fibre ropes with diameter under 20 mm are not permitted.
Note 3: The breaking loads of the lines refer to steel wires or natural fibre ropes. For synthetic fibre ropes, the breaking load is to be determined in accordance with Part B, Chapter 10, Sec 4 of the Tasneef Rules.

SECTION 7 TESTING

1 Application

1.1

1.1.1 The requirements in Pt B, Ch 12, Sec 3 of the Tasneef Rules apply.

Part B
Hull and Stability

Chapter 2
ALUMINIUM ALLOY HULLS

Symbols used in chapter 2

FP_{LL} : "forward freeboard perpendicular". The forward freeboard perpendicular is to be taken at the forward end of the length L_{LL} and is to coincide with the foreside of the stem on the waterline on which the length L_{LL} is measured.

AP_{LL} : "after freeboard perpendicular". The after freeboard perpendicular is to be taken at the after end of the length L_{LL}.

SECTION 1 DESIGN PRINCIPLES AND STABILITY

1 Application

1.1

1.1.1 The requirements in Ch 1, Sec 1 apply.

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	Metallurgical efficiency coefficient β **(4)**
5083 (Plates)	0 o H111	$t \le 6$ $t > 6$	125 115	275 275	1 1
5083 (Sections)	0 o H111	All thicknesses	110	270	1
5086 (Plates)	0 o H111	All thicknesses	100	240	1
5086 (Sections)	0 o H111	All thicknesses	95	240	1
5754	0 o H111	$t \le 6$ $t > 6$	80 70	190 190	1 1
5454	0 o H111	All thicknesses	85	215	1
5454	F	All thicknesses	100	210	1

(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's agreement.
(3) 0 : annealed
H111: roller levelled after annealing
F: as fabricated.
(4) See [1.5.1].

Table 2

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 $\mathbf{R}_{p\,0,2}$ a 0,2% N/mm²	Minimum guaranteed tensile strength $\mathbf{R}_m$ N/mm²	Metallurgical efficiency coefficient β **(4)**	Alloy **(2)**
6005 A (Open Sections)	T5 or T6	**t** ≤ 6 6< **t** ≤ 10 10 < **t** ≤ 25	225 215 200	270 260 250	4043 **t** ≤ 6 6< **t** ≤ 20	0,40
6005 A (Closed Sections)	T5 or T6	**t** ≤ 6 6< **t** ≤ 25	215 200	255 250	5356 6< **t** ≤ 20	0,5
6060 (Sections) **(3)**	T5	**t** ≤ 6 6< **t** ≤ 25	150 130	190 180	4043, **t** ≤ 8 5356, **t** ≤ 8	0,6 0,65
6061 (Sections)	T6	**t** ≤ 25	240	260	5356 4043	0,53 0,53
6082 (Sections)	T6	**t** ≤ 15	250	290	4043, **t** ≤ 20 5356, **t** ≤ 20	0,45 0,45
6106 (Sections)	T5	**t** ≤ 6	195	240	4043, **t** ≤ 10 5356, **t** ≤ 10	0,57

(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's agreement.
(3) 6060 alloy is not to be used for structural members sustaining impact loads (e.g. bottom longitudinals). The use of alloy 6106 is recommended in such cases.
(4) T5 : artificially aged
T6 : solution heat treated and artificially aged.
(5) See [1.5.1].

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
$t \le 8$	0,3
$8 < t \le 12$	0,5
$12 < t \le 20$	0,7
$t > 20$	1

Table 4

As-built thickness **t**, in mm	Under-thickness tolerance, in mm
$t \le 6$	0,3
$6 < t \le 10$	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:

$$K = \frac{100}{\eta \cdot R_{p0,2}}$$

where:

$R_{p0,2}$: is the minimum guaranteed yield stress, in N/mm², of the parent material in delivery condition

η : is the joint coefficient for the welded assembly, corresponding to the aluminium alloy considered, given in Tab 5

$R'_{p0,2}$: 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]).

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

Alloys	η
- Aluminium alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1
- Aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$R'_{p\,0,2}/R_{p\,0,2}$
- Aluminium alloys hardened by heat treatment (series 6000)	$R'_{p\,0,2}/R_{p\,0,2}$ **(1)**

(1) Should no information be available, coefficient η is to be taken as the coefficient of metallurgical efficiency defined in Tab 1 and Tab 2, without being less than 0,4 or more than 0,6.

1.7 Fillet welding

1.7.1 The effective length, in mm, of the weld beads is given by:

$$d_e = d - 20$$

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 recognized bodies or other Societies.

1.9 Welded connections

1.9.1 General requirements

For welding, the requirements of the relevant Tasneef Rules 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 authorization 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 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 organization.

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 recognized 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 authorization 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's agreement.

The use of transition joints made of aluminium/steel-cladded plates or profiles is subject to Tasneef's 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 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 LOADS AND HULL SCANTLINGS

1 Design loads

1.1 Application

1.1.1 The requirements in Ch 1, Sec 3, [2], Ch 1, Sec 3, [3], and Ch 1, Sec 3, [4] 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 3, [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 1, Sec 3, [5].

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 1, Sec 3, [5].

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 cm^3, 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 $\mathbf{S}_0$, $\mathbf{S}_0$ 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 $\mathbf{b} = 0{,}5 \cdot (\mathbf{l}_1 + \mathbf{l}_2)$, where $\mathbf{l}_1$ and $\mathbf{l}_2$ are the spans of stiffeners supported by the primary supporting member;

p : design pressure, in kN/m^2, calculated as defined in Ch 1, Sec 3, [4];

σ_{am} : permissible normal stress, in N/mm^2;

τ_{am} : permissible shear stress, in N/mm^2;

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/mm^2, as defined in [2.4.1];

σ_{bl} : longitudinal bending stress, in N/mm^2, as defined in [2.4.1];

μ : $\left(1{,}1 - 0{,}5 \cdot \left(\frac{\mathbf{s}}{\mathbf{l}}\right)\right)^{0{,}5}$

, which is not to be taken greater than 1,0.

2.3 Minimum thicknesses

2.3.1 In general, the thicknesses of plating, stiffeners and primary supporting members are to be not less than the minimum values.

Lesser thicknesses may be accepted provided that their adequacy in relation to strength against buckling and collapse is demonstrated to the satisfaction of Tasneef. Adequate provision is also to be made to limit corrosion.

Table 1

Element	Minimum thickness (mm)
Shell plating: - Bottom shell plating - Side shell plating	 $1,35 \cdot \mathbf{L}^{1/3} \geq 2,5$ $1,15 \cdot \mathbf{L}^{1/3} \geq 2,5$
Deck plating	2,5
Bulkhead plating	2,5
Deckhouse side shell plating	2,5

2.4 Overall strength

2.4.1 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 required for each of the following cases:

- craft with length, **L** > 24 m;
- craft whose hull geometry suggests significant bending moments in still water with the craft at rest;
- craft with large openings on the strength deck

Longitudinal strength calculations are, as a rule, to be carried out for the hull transverse section where the bending moment is maximum.

Longitudinal stress, in N/mm², in each point of the structures contributing to the craft longitudinal strength is obtained from the following equations:

- at bottom:

$$\sigma_{bl} = \frac{M_{bl}}{W_b} \cdot 10^{-3}$$

- at main deck:

$$\sigma_{bl} = \frac{M_{bl}}{W_d} \cdot 10^{-3}$$

- at height **z** above the bottom:

$$\sigma_{bl} = M_{bl} \cdot \left[\frac{1}{W_b} - \left(\frac{1}{W_b} + \frac{1}{W_d}\right) \cdot \frac{z}{D}\right] \cdot 10^{-3}$$

where:

M_{bl} : total bending moment, in kN · m, defined in Ch 1, Sec 3, [3.1].

W_b, W_d : section modulus, in m³, respectively at bottom and main deck at the stress calculation point of the craft section under consideration. In the section modulus calculation, all the elements contributing to longitudinal strength are to be considered, including long deckhouses, as appropriate.

The values of stress σ_{bl} are not to exceed σ_p, with $\sigma_p = 70/K$ N/mm².

Moreover, the compressive values of σ_p are not to exceed the values of critical stresses for plates and stiffeners calculated according to [2.5].

2.4.2 Transverse strength of twin-hull craft

The equivalent Von Mises stresses obtained for load conditions in Ch 1, Sec 3, [3.2.2] and Ch 1, Sec 3, [3.2.3] 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 [2.5].

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 3, [3.2.3] 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 1, Sec 3, [5].

2.4.3 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 r_i of the n beams. Its position is defined by:

$$a = \frac{\sum r_i \cdot x_i}{\sum r_i}$$

where:

a : the abscissa, in m, of the centre G with respect to an arbitrarily chosen origin 0 r_i

r_i : $\frac{12 \cdot E_i \cdot I_i}{S_i^3} \cdot 10^6$, in N/m

E_i : Young's modulus, in N/mm², of the beam **i**

I_i : bending inertia, in, in m⁴, of the beam **i**

S_i : span, in m, of the beam **i** between the inner faces of the hulls

x_i : abscissa, in m, of the beam **i** with respect to the origin 0.

If F_i, in N, is the force taken over by the beam **i**, the deflection y_i, in m, of the hull in way of the beam **i**, is:

$$y_i = \frac{F_i \cdot S_i^3 \cdot 10^{-6}}{12 \cdot E_i \cdot I_i} = \frac{F_i}{r_i} = d_i \cdot \omega$$

d_i : 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])

$$M_{tt} = \sum F_i \cdot d_i \cdot 10^{-3}$$

the formula for ω may be obtained:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3$$

As M_{tt}, r_i and d_i are known, and ω thus deduced, the force F_i, in N, the bending moment M_i, in N · m, and the corresponding normal and shear stresses can be evaluated in each beam:

$$F_i = \omega \cdot r_i \cdot d_i$$

$$M_i = F_i \cdot S_i / 2$$

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 steffners

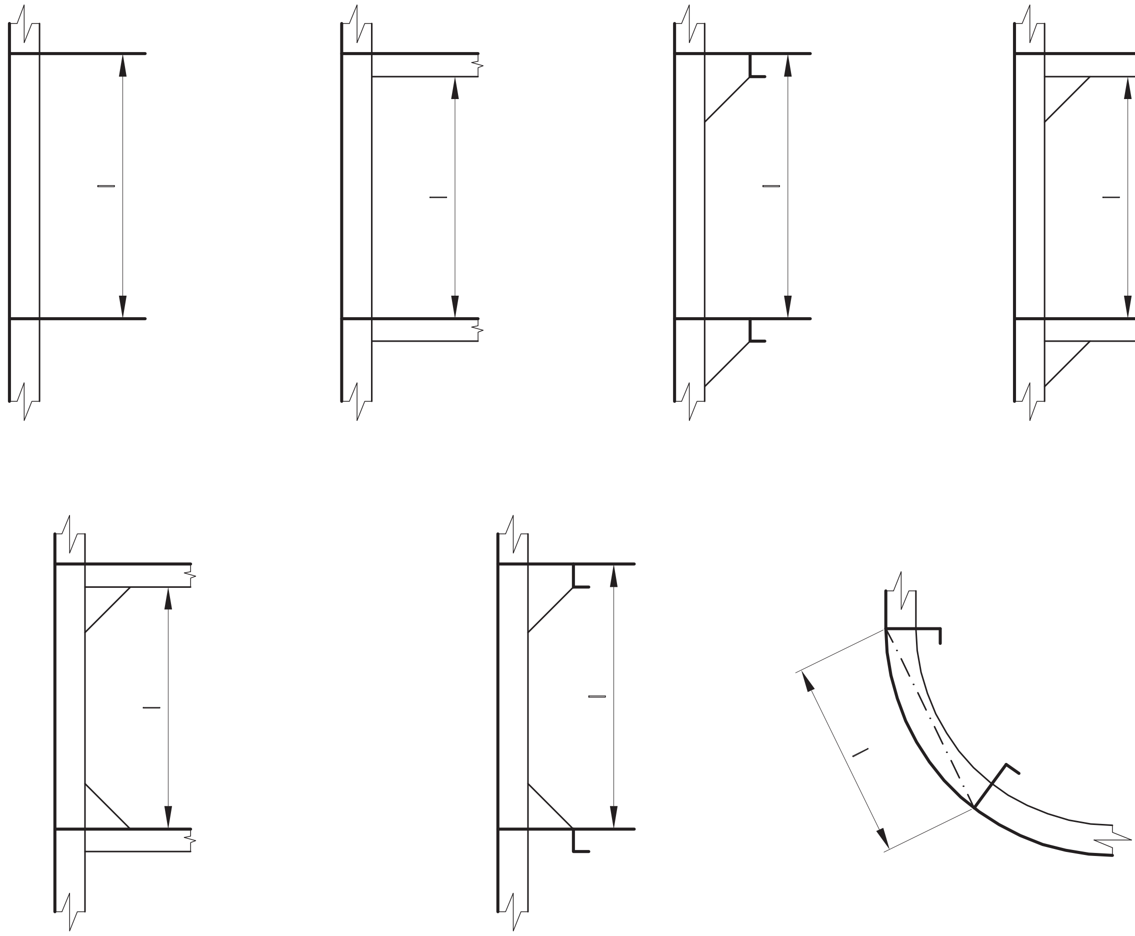
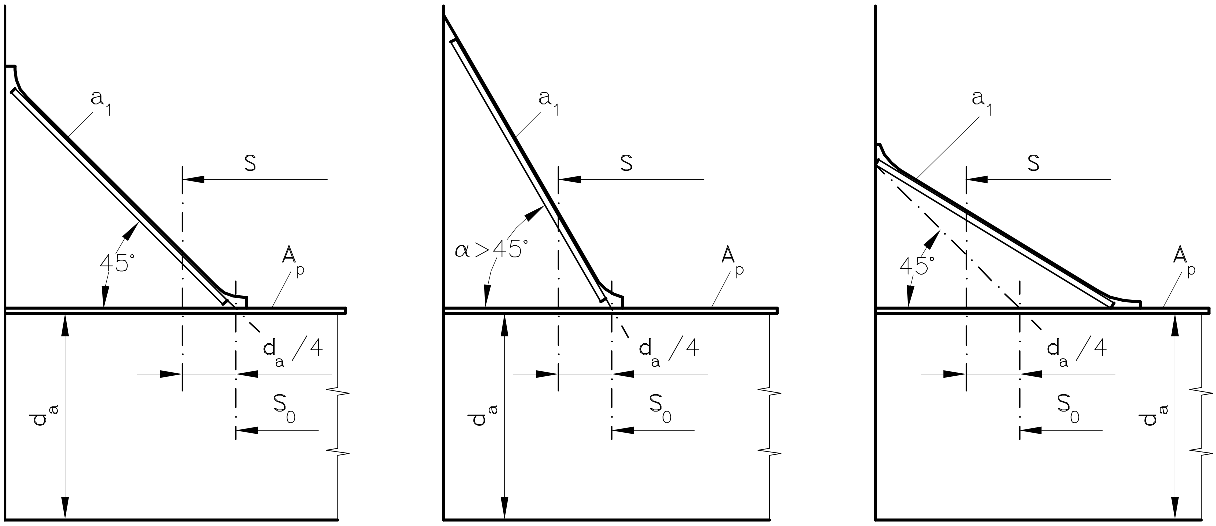


Figure 2 : Examples of conventional spans of primary supporting members



A_p = area of girder face plate
a_1 = area of bracket face plate
$a_1 \geq 0,5\ A_p$

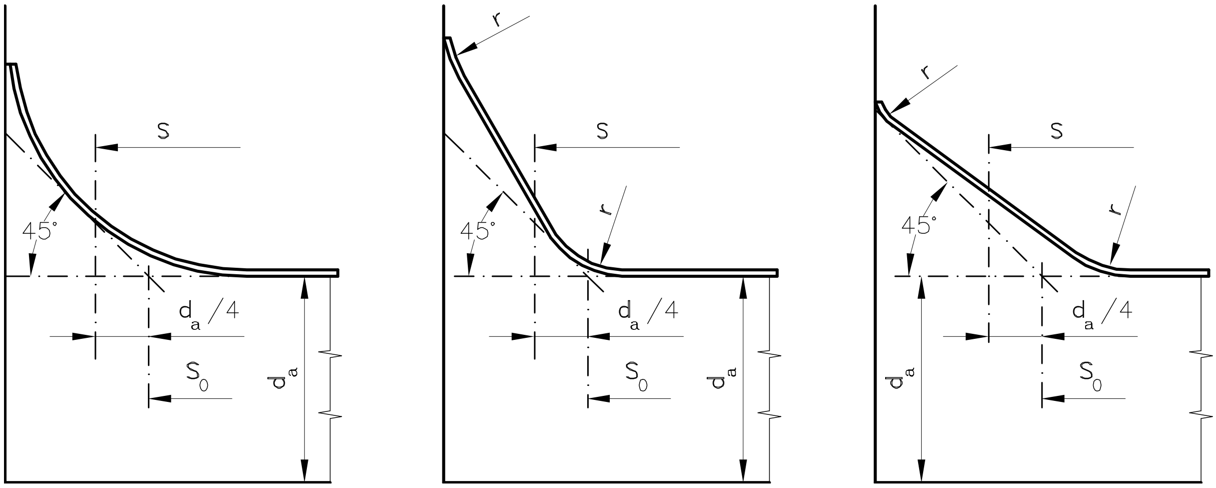
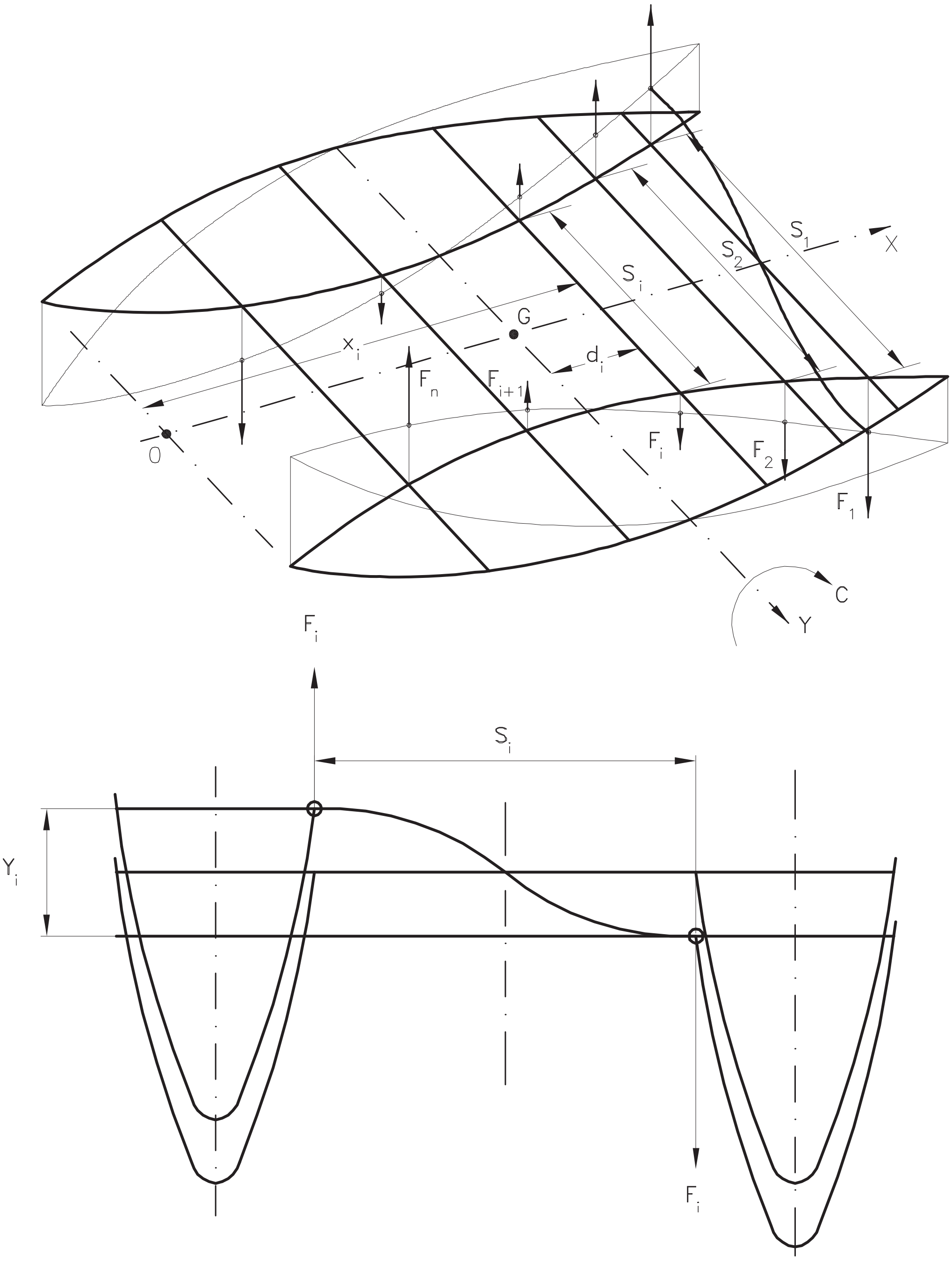


Figure 3



2.5 Buckling strength of aluminium alloy structural members

2.5.1 Application

These requirements apply to aluminium alloy plates and stiffeners subjected to compressive loads, to calculate their buckling strength.

2.5.2 Elastic buckling stresses of plates

a) **Compressive stress**

The elastic buckling stress, in N/mm², is given by:

$$\sigma_E = 0{,}9 \cdot \mathbf{m_c} \cdot \varepsilon \cdot \left(\frac{\mathbf{t}}{1000 \cdot \mathbf{a}}\right)^2$$

where:

m : 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** $\gamma \ge \gamma_1$

m_1 : $\frac{2,1}{1,1 + \psi} \cdot (1 + \gamma_1^2)^2$

t : plate thickness, in mm,

E : Young's modulus, in N/mm², to be taken equal to $0,7 \cdot 10^5$ N/mm²;

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 at 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/mm², 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:

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.

2.5.3 Critical buckling stress

a) **Compressive stress**

The critical buckling stress, in N/mm², 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:

$R_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm², in delivery condition

σ_E : elastic buckling stress calculated according to [2.5.2], (a) above.

b) **Shear stress**

The critical buckling stress, in N/mm², 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 : $\frac{\mathbf{R}_{p0,2}}{3^{0,5}}$

$R_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm², in delivery condition

τ_E : elastic buckling stress calculated according to [2.5.2], (b).

2.5.4 Axially loaded stiffeners

a) **Elastic flexural buckling stress**

The elastic flexural buckling stress, in N/mm², 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 cm⁴, 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 cm², 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 one,
- 4, for a stiffener fixed at both ends.

b) **Local elastic buckling stresses**

The local elastic buckling stresses, in N/mm², 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:

h_w : web height, in mm,

t_w : web thickness, in mm,

b_f : flange width, in mm,

t_f : flange thickness, in mm.

c) **Critical buckling stress**

The critical buckling stress, in N/mm², is given by:

$$\sigma_c = \sigma_E \quad \text{if} \quad \sigma_E \le \frac{\eta \cdot R_{p0,2}}{2}$$

$$\sigma_c = \eta \cdot R_{p0,2} \cdot \left(1 - \frac{\eta \cdot R_{p0,2}}{4 \cdot \sigma_E}\right) \quad \text{if} \quad \sigma_E > \frac{\eta \cdot R_{p0,2}}{2}$$

where:

$R_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm², in delivery conditions

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.

2.6 Plating

2.6.1 Formula

The thickness, in mm, required for the purposes of resistance to design pressure, is given by the formula:

$$t = 22{,}4 \cdot \mu \cdot s \cdot \left(\frac{p}{\sigma_{am}}\right)^{0,5}$$

Pressure **p**, in kN/m², and permissible stress σ_{am}, in N/mm², are defined in requirements stipulated in [2.6.3] to [2.6.8] for the various parts of the hull.

2.6.2 Keel

The thickness of keel plating is to be not less than that required for adjacent bottom plating.

This requirement may be waived in the case of special arrangements for dry-docking of craft of unusual hull design in the opinion of Tasneef.

2.6.3 Bottom shell and bilge plating

The minimum required thickness is to satisfy the requirements of the formula in [2.6.1] under the following two conditions:

a) p = impact pressure p_{sl} on the bottom as defined in Ch 1, Sec 3, [4.3] (in the case of slamming on the bottom), where σ_{am} = 95/**K** N/mm²

b) p = sea pressure p_s defined in Ch 1, Sec 3, [4.5], where σ_{am} = 85/**K** N/mm_2

The thickness of bilge plating is not, in any case, to be less than that of the bottom and side adjacent, whichever is the greater.

The thickness of plates connected to the stern frame, or in way of propeller shaft brackets, is to be at least 1,5 times the thickness of the adjacent plating.

In craft fitted with a bow thruster, the thickness of the connection with the housing of such propeller will be considered individually by Tasneef.

2.6.4 Sea intakes and other openings

Sea intakes and other openings are to be well rounded at the corners and located, as far as practicable, well clear of sharp edges.

Sea chests are to have scantlings as for watertight tank bulkheads (see [2.10]) taking a design pressure p_t, in kN/m², equal to:

$$p_t = p_s + 0{,}5 \cdot p_{sl}$$

where p_s and p_{sl} are as defined in Ch 1, Sec 3, [4.5] and Ch 1, Sec 3, [4.3] respectively.

2.6.5 Plating of side shell and front walls

The minimum required thickness is given by the formula in [2.6.1], assuming:

- **p** = sea pressure p_s defined in Ch 1, Sec 3, [4.5], for side shell plating;
- **p** = sea pressure $p_{s\,f}$ defined in Ch 1, Sec 3, [4.6], for front wall plating;
- σ_{am} = 85/**K** N/mm².

If front walls are located at the fore end of the hull, the pressure $p_{s\,f}$ (see Ch 1, Sec 3, [4.6]) and the allowable stresses will be considered individually by Tasneef.

The thickness of the sheerstrake is to be not less than that of the side or stringer plate.

At the ends of deckhouses, the thickness of the sheerstrake is to be suitably increased.

Where side scuttles or windows or other openings are located on the sheerstrake, the thickness is to be increased to compensate for the openings.

2.6.6 Plating of cross-deck bottom and internal sides of twin-hull craft

The minimum required thickness for the bottom of the cross-deck is given by the formula in [2.6.1], assuming:

a) **p** = deck pressure p_{sl} as defined in Ch 1, Sec 3, [4.4];
   - σ_{am} = 95/**K** N/mm²

b) **p** = sea pressure p_s as defined in Ch 1, Sec 3, [4.5];
   - σ_{am} = 85/**K** N/mm²

Moreover, the thickness of internal sides may be intermediate between that of the bottom of hulls and the bottom of the cross-deck. In any case, it is to be no less than that required in [2.6.1] for external sides.

2.6.7 Deck plating

The minimum required thickness is given by the formula in [2.6.1], assuming:

- **p** = deck pressure p_d as defined in Ch 1, Sec 3, [4.8];
- σ_{am} = 85/**K** N/mm².

The thickness, in mm, of decks intended for the carriage of vehicles is to be not less than the value calculated by the formula:

$$t = f \cdot (c \cdot P \cdot K)^{0,5}$$

where:

f : coefficient equal to 5,6

c : coefficient given in Tab 2 as a function of the dimensions **u** and **v** of the tyre print (see Fig 4)

p : static load on the tyre print, in kN, increased by $(1 + 0{,}4 \cdot a_v)$

Table 2 : Coefficient c as a function of u and v

b / s	u / s → v / u ↓	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
1	0,5	0,242	0,174	0,138	0,113	0,094	0,080	0,077	0,060	0.052	0,045
	1	0,222	0,160	0,122	0,099	0,079	0,066	0,055	0,045	0.037	0,030
	2	0,198	0,134	0,098	0,073	0,053	-	-	-	-	-
	3	0,175	-	-	-	-	-	-	-	-	-
1,4	0,5	0,228	0,189	0,158	0,128	0,111	0,096	0,083	0,073	0,064	0,056
	1	0,217	0,177	0,143	0,116	0,098	0,082	0,070	0,060	0.051	0,043
	2	0,196	0,153	0,119	0,092	0,072	0,058	0,046	-	-	-
	3	0,178	0,134	0,100	0,072	-	-	-	-	-	-
≥ 2,5	0,5	0,232	0,196	0,163	0,135	0,117	0,100	0,087	0,077	0,067	0,059
	1	0,219	0,184	0,150	0,123	0,105	0,088	0,076	0,066	0.056	0,048
	2	0,199	0,161	0,129	0,101	0,082	0,067	0,055	0,046	0,037	0,031
	3	0,185	0,142	0,108	0,083	0,064	0,051	0,038	0,028	0,019	0,012

a_v : design vertical acceleration, defined in Ch 1, Sec 3, [2].

Where there are double wheels, the tyre print consists of both.

The Designer is to supply details of tyre pressure, wheel dimensions, loads on wheels and tyre print dimensions. Where this information is not available, an approximate value of the thickness, in mm, may be obtained from the following formula:

$$t = f_1 \cdot C_1 \cdot (P_1 \cdot K)^{0,5}$$

where:

f_1 : coefficient equal to 0,38

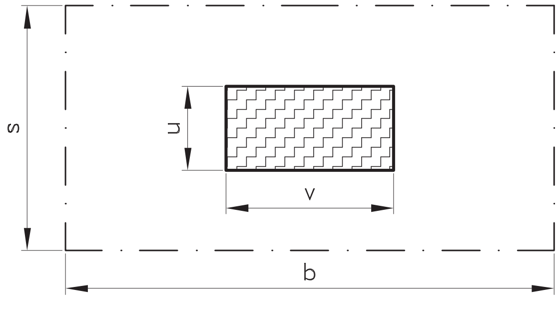
C_1 : coefficient equal to:
- 3,60, for vehicles with 4 wheels per axle
- 4,45, for vehicles with 2 wheels per axle

P_1 : static axle load, in kN, increased by $(1 + 0,4 \cdot a_v)$

a_v : design vertical acceleration, as defined in Ch 1, Sec 3, [2].

The thickness of areas of watertight decks or flats forming steps in watertight bulkheads or the top or the bottom of a tank is also to comply with the provisions of [2.10].

Figure 4



2.6.8 Plating of deckhouse boundary walls

The minimum required thickness is given by the formula in [2.6.1], assuming:

- p = sea pressure p_{su} as defined in Ch 1, Sec 3, [4.7];
- $\sigma_{am} = 85/K$ N/mm².

Openings (doors, windows) are to be well rounded at the corners.

Where there is no access from inside deckhouses to 'tweendecks below or where one of the boundary walls concerned is in a particularly sheltered position, reduced scantlings compared with those above may be accepted, at the discretion of Tasneef.

For unprotected front walls located at the fore end, the pressure p_{su} and allowable stresses will be considered individually by Tasneef.

2.7 Ordinary stiffeners

2.7.1 General

This Article states the requirements to be complied with for ordinary stiffeners of the bottom, sides, decks and, for twin-hull craft, the cross-deck and internal sides.

The section modulus Z, in cm³, and the shear area A_t, in cm², required for the purpose of supporting the design pressure transmitted by the plating, are given by the following formulae:

$$Z = 1000 \cdot \frac{l^2 \cdot s \cdot p}{m \cdot \sigma_{am}}$$

$$A_t = 5 \cdot \frac{l \cdot s \cdot p}{\tau_{am}}$$

where m is a coefficient depending on the type of stiffener and on whether there are Rule brackets at the end of each individual span. The values of m are indicated in Tab 3.

The pressure **p**, in kN/m², and allowable stresses σ_{am} and τ_{am}, in N/mm², are defined in [2.7.2] to [2.7.6] for the various regions of the hull.

These formulae are valid for stiffeners whose web is perpendicular to the plating, or forms an angle to the plating of less than 15°.

In the case of stiffeners whose web forms an angle $\alpha > 15°$ to the perpendicular to the plating, the required modulus and shear area may be obtained from the same formulae, dividing the values of **Z** and A_t by cos α .

The section modulus of ordinary stiffeners is to be calculated in association with an effective width of plating equal to the spacing of the stiffeners, without exceeding 20 per cent of the span.

The web thickness is to be not less than:

- 1/15 of the depth, for flat bars;
- 1/35 of the depth, for other sections

and the thickness of the face plate is to be not less than 1/20 of its width.

The ends of ordinary stiffeners are, in general, to be connected by means of Rule brackets to effective supporting structures.

Ends without brackets are accepted at the penetrations of primary supporting members or bulkheads by continuous stiffeners, provided that there is sufficient effective welding section between the two elements. Where this condition does not occur, bars may be accepted instead of the brackets, at the discretion of Tasneef.

In general, the resistant weld section A_w, in cm², connecting the ordinary stiffeners to the web of primary members, is not to be less than:

$$A_w = \phi \cdot p \cdot s \cdot l \cdot K \cdot 10^{-3}$$

where:

- ϕ : coefficient as indicated in Tab 4
- **p** : design pressure, in kN/m², acting on the secondary stiffeners, defined in [2.7.2] to [2.7.6] for various hull regions
- **s** : spacing of ordinary stiffeners, in m
- **l** : span of ordinary stiffeners, in m
- **K** : greater material factor of ordinary stiffener and primary member, defined in Sec 2, [1.6].

For aluminium alloys, when calculating the resistant connecting weld section, the fillet weld length d_e, in mm, is to be determined as follows (see case 1 and 2 in Tab 4):

- case 1: $d_e = d - 20$ where **d**, in mm, is the length of the weld
- case 2: for extruded T stiffeners, the lesser of $d_e = b - 20$ and $d_e = 4 \cdot t$, where **b**, in mm, is the flange width of the ordinary stiffener and **t**, in mm, is the web thickness of the primary member.

Table 3

Type of stiffener	m
Continuous longitudinal stiffeners without Rule brackets at the ends of span	12
Longitudinal and transverse stiffeners with Rule brackets at the ends of span	19
Longitudinal and transverse stiffeners with Rule brackets at one end of span	15
Non-continuous longitudinal stiffeners and transverse stiffeners without Rule brackets at the ends of span	8

Table 4

Case	Weld	ϕ
1	Parallel to the reaction on primary member	200
2	Perpendicular to the reaction on primary member	160

2.7.2 Bottom and bilge stiffeners

Both single and double bottoms are generally to be longitudinally framed.

The section modulus, shear area and welding section required for bottom and bilge stiffeners are given by the formulae in [2.7.1], assuming:

a) **p** = impact pressure p_{sl} if occurring on the bottom as defined in Ch 1, Sec 3, [4.3], where $\sigma_{am} = 70/K$ N/mm² $\tau_{am} = 90/K$ N/mm²;

b) **p** = sea pressure p_s defined in Ch 1, Sec 3, [4.5], where:

- stiffeners contributing to the longitudinal strength:

  $\sigma_{am} = 70 \cdot C_A/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

- stiffeners not contributing to the longitudinal strength:

  $\sigma_{am} = 70/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

where C_A is given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

Table 5

x/L	C_A
$x/L < 0{,}1$	1
$0{,}1 \le x/L \le 0{,}3$	$1 + 0{,}5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 1\right)$
$0{,}3 < x/L < 0{,}7$	$1,3 - \frac{1}{e}$
$0{,}7 \le x/L \le 0{,}9$	$1 - 0{,}5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 9\right)$
$x/L > 0,9$	1

Note 1: The value of C_A is to be taken less than or equal to 1.

Bottom longitudinals are preferably continuous through the transverse elements. Where they are interrupted at a transverse watertight bulkhead, continuous brackets are to be positioned through the bulkhead so as to connect the ends of longitudinals.

2.7.3 Side and front wall stiffeners

The section modulus, shear area and welding section are given by the formulae in [2.7.1], assuming:

- **p** = sea pressure p_s as defined in Ch 1, Sec 3, [4.5], for side stiffeners;
- **p** = sea pressure $p_{s\,f}$ as defined in Ch 1, Sec 3, [4.6], for front wall stiffeners;
- side stiffeners contributing to the longitudinal strength:

  $\sigma_{am} = 70 \cdot C_A/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;
- side stiffeners not contributing to the longitudinal strength and front wall stiffeners:

  $\sigma_{am} = 70/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

  where C_A is given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

For unprotected front walls located at the fore end, the pressure p_{sf} (see Ch 1, Sec 3, [4.6]) and allowable stresses will be considered individually by Tasneef.

2.7.4 Stiffeners of cross-deck bottom and internal sides of twin-hull craft

The section modulus, shear area and welding section for bottom stiffeners of the cross-deck are given by the formulae in [2.7.1], assuming:

a) **p** = impact pressure p_{sl} as defined in Ch 1, Sec 3, [4.4]
$\sigma_{am} = 85/K$ N/mm²
$\tau_{am} = 45/K$ N/mm²;

b) **p** = sea pressure p_s as defined in Ch 1, Sec 3, [4.5],

- stiffeners contributing to the longitudinal strength:

  $\sigma_{am} = 70 \cdot C_A/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;
- stiffeners not contributing to the longitudinal strength:

  $\sigma_{am} = 70/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

where C_A is given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

Internal side stiffeners may have characteristics intermediate between those of the bottom of the hull and those of the bottom of the cross-deck. In any case, such characteristics are not to be less than those required in [2.7.3] for external sides.

2.7.5 Deck stiffeners

The section modulus, shear area and welding section are given by the formulae in [2.7.1], assuming:

- **p** = deck pressure p_d as defined in Ch 1, Sec 3, [4.8];
- stiffeners contributing to the longitudinal strength:

  $\sigma_{am} = 70 \cdot C_A/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;
- stiffeners not contributing to the longitudinal strength:

  $\sigma_{am} = 70/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

  where C_A is given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

Where there are concentrated loads of significant magnitude, deck stiffeners are to be adequately strengthened. In particular, stiffeners of decks intended for the carriage of vehicles are to be able to support the concentrated loads transmitted by the wheels, including inertia effects.

In this case, the structural check is, in general, to be carried out adopting the static model of the continuous girder on several supports (formed by primary supporting members) and considering the most severe vehicle loading arrangement for deck stiffeners. The normal and shear stresses thus calculated are not to exceed the allowable limits defined above.

The ordinary stiffeners of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of [2.10].

Where longitudinals are interrupted in way of watertight bulkheads or reinforced transverse structures, the continuity of the structure is to be maintained by means of brackets penetrating the transverse element. Tasneef may allow double brackets welded to the transverse element, provided that special provision is made for the alignment of longitudinals, and full penetration welding is used.

2.7.6 Stiffeners of deckhouse boundary walls

The section modulus, shear area and welding section are given by the formulae in [2.7.1], assuming:

- **p** = sea pressure p_{su} as defined in Ch 1, Sec 3, [4.7];

  $\sigma_{am} = 70/K$ N/mm²

  $\tau_{am} = 45/K$ N/mm²;

If unprotected front walls are located at the fore end, the pressure $\mathbf{p}_{su}$ and the allowable stresses will be considered individually by Tasneef.

Any front or side wall vertical stiffeners of first tier deckhouses are to be connected, by means of brackets at the ends, to strengthening structures for decks or adjacent sides.

Longitudinal stiffeners are to be fitted on the upper and lower edges of large openings in the plating. The openings for doors are, in general, to be stiffened all the way round.

Where there is no access from inside deckhouses to 'tweendecks below, or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted, at the discretion of Tasneef.

2.8 Primary supporting members

2.8.1 General

This section gives the requirements to be complied with for primary supporting members of the bottom, sides, decks and, for twin-hull craft, the cross-deck.

The primary supporting members (floors, frames, beams) are to form continuous transverse frames. In general, the stiffened frame spacing, in mm, is not to exceed:

$1200 + 10 \cdot \mathbf{L}$

without being greater than 2 m.

Primary supporting members with spacing other than that defined above may be required for specific parts of the hull (e.g. machinery space, under pillars) as stipulated in the provisions below.

The section modulus $\mathbf{Z}$, in cm^3, and shear area $\mathbf{A}_t$, in cm^2, required to support the design pressure transmitted by the ordinary stiffeners are given by the following formulae:

$$\mathbf{Z} = 1000 \cdot \frac{\mathbf{S}^2 \cdot \mathbf{b} \cdot \mathbf{p}}{\mathbf{m} \cdot \sigma_{am}}$$

$$\mathbf{A}_t = 5 \cdot \frac{\mathbf{S} \cdot \mathbf{b} \cdot \mathbf{p}}{\tau_{am}}$$

where:

m : coefficient which depends on support conditions at the ends of the girder span, generally assumed to be:

- 10, for floors, bottom girders, side frames, deck beams and girders, vertical webs of superstructures;
- 12, for side stringers.

In special circumstances, a different value may be taken for **m**, at the discretion of Tasneef.

The pressure **p**, in kN/m^2, and allowable stresses σ_{am} and τ_{am}, in N/mm^2, are defined in [2.8.2] to [2.8.6] for various parts of the hull.

The above formulae are applicable where reinforced structures are not of the grillage type. Otherwise, the scantlings of reinforced structures will be stipulated by means of direct calculations performed on the basis of criteria agreed upon with Tasneef.

The section modulus of primary supporting members is to be calculated in association with attached plating, according to criteria specified by Tasneef.

For steel stiffeners, the following geometric ratios are to be satisfied:

- the web thickness is to be not less than 1/80 of web depth;
- the face plate thickness is to be not less than 1/30 of face plate breadth (1/15 for face plates which are not symmetrical with respect to the web).

2.8.2 Floors and girders of single bottom

The section modulus and shear area are given by the formulae in [2.8.1], for the following two conditions:

a) **p** = impact pressure $\mathbf{p}_{sl}$ if occurring on the bottom as defined in Ch 1, Sec 3, [4.3] (when slamming on the bottom occurs), where: $\sigma_{am} = 70/\mathbf{K}$ N/mm^2

$\tau_{am} = 45/\mathbf{K}$ N/mm^2;

b) **p** = sea pressure $\mathbf{p}_s$ as defined in Ch 1, Sec 3, [4.5], where:

- aluminium alloy floors:

  $\sigma_{am} = 70/\mathbf{K}$ N/mm^2

  $\tau_{am} = 45/\mathbf{K}$ N/mm^2;

- aluminium alloy girders:

  $\sigma_{am} = 70 \cdot \mathbf{C}_A/\mathbf{K}$ N/mm^2

  $\tau_{am} = 45/\mathbf{K}$ N/mm^2;

where $\mathbf{C}_s$ and $\mathbf{C}_A$ are given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

Floors are to be positioned in way of side and deck transverses. Intermediate floors may also be fitted provided that they are adequately connected at the ends.

Manholes and other openings are not to be located at the ends of floor or girder spans, unless shear stress checks are carried out in such areas.

Floors are to be fitted in machinery spaces, generally at every frame, and additional stiffeners are to be provided in way of machinery and pillars.

In way of main machinery seatings, girders are to be positioned extending from the bottom to the foundation plate of main engines.

A girder is generally to be fitted centreline for dry-docking. The height of such a girder is to be not less than that of floors amidships and the thickness not less than the value **t**, in mm, obtained from the formula:

$$\mathbf{t} = (0{,}07 \cdot \mathbf{L} + 2{,}5) \cdot \mathbf{K}^{0{,}5}$$

The girder is to be fitted with a continuous face plate above the floors, its area not less than the value $\mathbf{A}_p$, in cm^2, given by:

$$\mathbf{A}_p = 0{,}5 \cdot \mathbf{L} \cdot \mathbf{K}$$

In hulls with a longitudinally framed bottom and width **B** > 8 m, side girders are also to be positioned in such a way as to divide the floor span into approximately equal parts. In twin-hull craft, **B** is to be taken as the width of a single-hull. The thickness of the web may be assumed to be equal to that of the centre girder less 1 mm, and the area of the face plate may be reduced to 60% of that of the centre girder. Where side girders are intended to support floors, a structural check of their scantlings is to be carried out as deemed necessary by Tasneef.

2.8.3 Primary supporting members of sides and front walls

The section modulus and shear area are given by the formulae in [2.8.1], assuming:

- **p** = sea pressure $\mathbf{p}_s$ as defined in Ch 1, Sec 3, [4.5], for primary members of sides;
- **p** = sea pressure $\mathbf{p}_{s\,f}$ as defined in Ch 1, Sec 3, [4.6], for primary members of front walls;

  $\sigma_{am} = 70/\mathbf{K} - \sigma_a$ N/mm²;

  $\tau_{am} = 45/\mathbf{K}$ N/mm²;

σ_a is the stress induced by the normal force in side transverses due to deck loads transmitted by deck beams.

For unprotected front walls located at the fore end, the pressure $\mathbf{p}_{sf}$ (see Ch 1, Sec 3, [4.6]) and allowable stresses will be considered individually by Tasneef.

2.8.4 Primary supporting members of the cross-deck and internal sides of twin-hull craft

In the most common case of cross-deck structures constituted by transverse stiffener plates enclosed between lower plating and a deck, and connected at the ends to reinforced hull structures, the scantlings are determined by transverse strength checks aimed at ensuring an adequate connection between the hulls (see [2.4]).

Where the cross-deck is formed by multiple structures, each of the latter is also to be checked for the effect of local loads, in accordance with the following provisions.

The section modulus and shear area required for transverse structures of the cross-deck are given by the formulae in [2.8.1], for the following two conditions:

a) lower structures of the cross-deck:
   - **p** = impact pressure $\mathbf{p}_{sl}$ as defined in Ch 1, Sec 3, [4.4]:
     $\sigma_{am} = 85/\mathbf{K}$ N/mm²;
     $\tau_{am} = 45/\mathbf{K}$ N/mm²;

b) cross-deck structures supporting decks:
   - **p** = deck pressure $\mathbf{p}_d$ as defined in Ch 1, Sec 3, [4.8];
     $\sigma_{am} = 70/\mathbf{K}$ N/mm²;
     $\tau_{am} = 45/\mathbf{K}$ N/mm²;

Where the lower structure of the cross-deck also supports a deck, such a structure is to be checked separately for conditions (a) and (b).

The section modulus and shear area required for side transverses of internal sides are given by the formulae in [2.8.1], for condition (a) above.

2.8.5 Primary supporting members of decks

In the absence of concentrated loads transmitted to the primary supporting member by pillars or other primary supporting members, the section modulus and shear area required for deck transverses and deck girders supporting longitudinals and beams, respectively, are given by the formulae in [2.8.1], assuming:

- **p** = deck pressure $\mathbf{p}_d$ as defined in Ch 1, Sec 3, [4.8];
- steel deck transverses:

  $\sigma_{am} = 70/\mathbf{K}$ N/mm²;
  $\tau_{am} = 45/\mathbf{K}$ N/mm²;
- aluminium alloy deck transverses:
  $\sigma_{am} = 70 \cdot \mathbf{C}_A/\mathbf{K}$ N/mm²
  $\tau_{am} = 45/\mathbf{K}$ N/mm²;

where $\mathbf{C}_s$ and $\mathbf{C}_A$ are given by Tab 5 as a function of the distance **x**, in m, from the calculation point of section modulus to the after perpendicular.

The primary members of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of [2.10].

When there are concentrated loads of significant magnitude (e.g. transmitted by pillars or other primary members or due to the carriage of vehicles), deck girders are to be adequately strengthened.

In this case the structural check is generally to be carried out by using the static model of a beam with partial clamping at its ends (clamping coefficient = 0,30).

The allowable stresses stipulated above are to be considered.

The beam section is to be kept constant over its length.

At the discretion of Tasneef, calculations based on different static models may be accepted, depending on the structural typology adopted.

2.8.6 Primary supporting members of deckhouse boundary walls

The section modulus and shear area are given by the formulae in [2.8.1], assuming:

- **p** = see pressure $\mathbf{p}_{su}$ as defined in Ch 1, Sec 3, [4.7];

  $\sigma_{am} = 70/\mathbf{K}$ N/mm²;

  $\tau_{am} = 45/\mathbf{K}$ N/mm²;

For unprotected front walls located at the fore end, the pressure $\mathbf{p}_{su}$ and allowable stresses will be considered individually by Tasneef.

Where there is no access from inside deckhouses to 'tweendecks below or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted at the discretion of Tasneef.

2.9 Pillars made of aluminium alloys

2.9.1 Loads on pillars

Where pillars are aligned, the compressive load **Q**, in kN, is equal to the sum of loads supported by the pillar considered and those supported by the pillars located above, multiplied by a weighting factor.

The weighting factor depends on the relative position of each pillar with respect to that considered.

This coefficient is equal to:

- 1,000, for the pillar considered
- 0,9, for the pillar immediately above (first pillar of the line)
- 0,810 = $(0,9)^2$, for the following pillar (second pillar of the line)
- 0,729 = $(0,9)^3$, for the third pillar of the line
- in general, $(0,9)^n$, for the pillar of the n[th] line, but not less than $(0,9)^7 = 0,478$.

2.9.2 Critical stress for overall buckling of pillars

For global buckling behaviour of pillars made of aluminium alloy, the critical stress, σ_c, in N/mm², is given by the formula:

$$\sigma_c = \frac{\eta \cdot R_{p0,2}}{0,85 + 0,25 \cdot \left(\frac{f \cdot l}{r}\right)} \cdot C$$

where:

η : joint coefficient for the welded assembly, as given in Sec 2, [1.6]

$R_{p0,2}$: minimum guaranteed yield stress of aluminium alloy used, in N/mm², in delivery condition

C : coefficient as given in Fig 5:

$$\frac{1}{1 + \lambda + [(1 + \lambda)^2 - 0,68 \cdot \lambda]^{0,5}}$$

for alloys without heat treatment

$$\frac{1}{1 + \lambda + [(1 + \lambda)^2 - 3,2 \cdot \lambda]^{0,5}}$$

for alloys with heat treatment

λ : $\frac{\eta \cdot R_{p0,2}}{\sigma_E}$

σ_E : $\frac{69,1}{(f \cdot l / r)^2}$

l : length of pillar, in m

r : $\left(\frac{I}{A}\right)^{0,5}$, minimum radius of gyration, in cm, of the pillar cross-section

I : minimum moment of inertia, in cm⁴, of the pillar cross-section

A : area, in cm², of the pillar cross-section

f : coefficient given in Fig 7 depending on the conditions of fixing of the pillar.

2.9.3 Critical stress for local buckling of pillars

For local buckling behaviour of pillars made of aluminium alloy, the admissible stress σ_{cl}, in N/mm², is given by the formula:

$$\sigma_{cl} = 2 \cdot \eta \cdot R_{p0,2} \cdot C$$

where:

C : coefficient as defined in previous item

λ : $\frac{\eta \cdot R_{p0,2}}{\sigma_{El}}$

η : joint coefficient for the welded assembly, as defined in Sec 2, [1.6].

σ_{El} : stress defined below.

For tubular pillars with a rectangular cross-section, the stress σ_{El}, in N/mm², is given by:

$$\sigma_{El} = 252000 \cdot \left(\frac{t}{b}\right)^2$$

where:

b : greatest dimension of the cross-section, in mm

t : plating thickness, in mm.

For tubular pillars with a circular cross-section, the stress σ_{El}, in N/mm², is given by:

$$\sigma_{El} = 43000 \cdot \frac{t}{D}$$

where:

D : outer diameter, in mm,

t : plating thickness, in mm.

For pillars with T cross-sections, the stress, σ_{El}, in N/mm², is the lesser of the following values:

$$\sigma_{El} = 252000 \cdot \left(\frac{t_w}{h_w}\right)^2$$

$$\sigma_{El} = 105000 \cdot \left(\frac{t_f}{b_f}\right)^2$$

where:

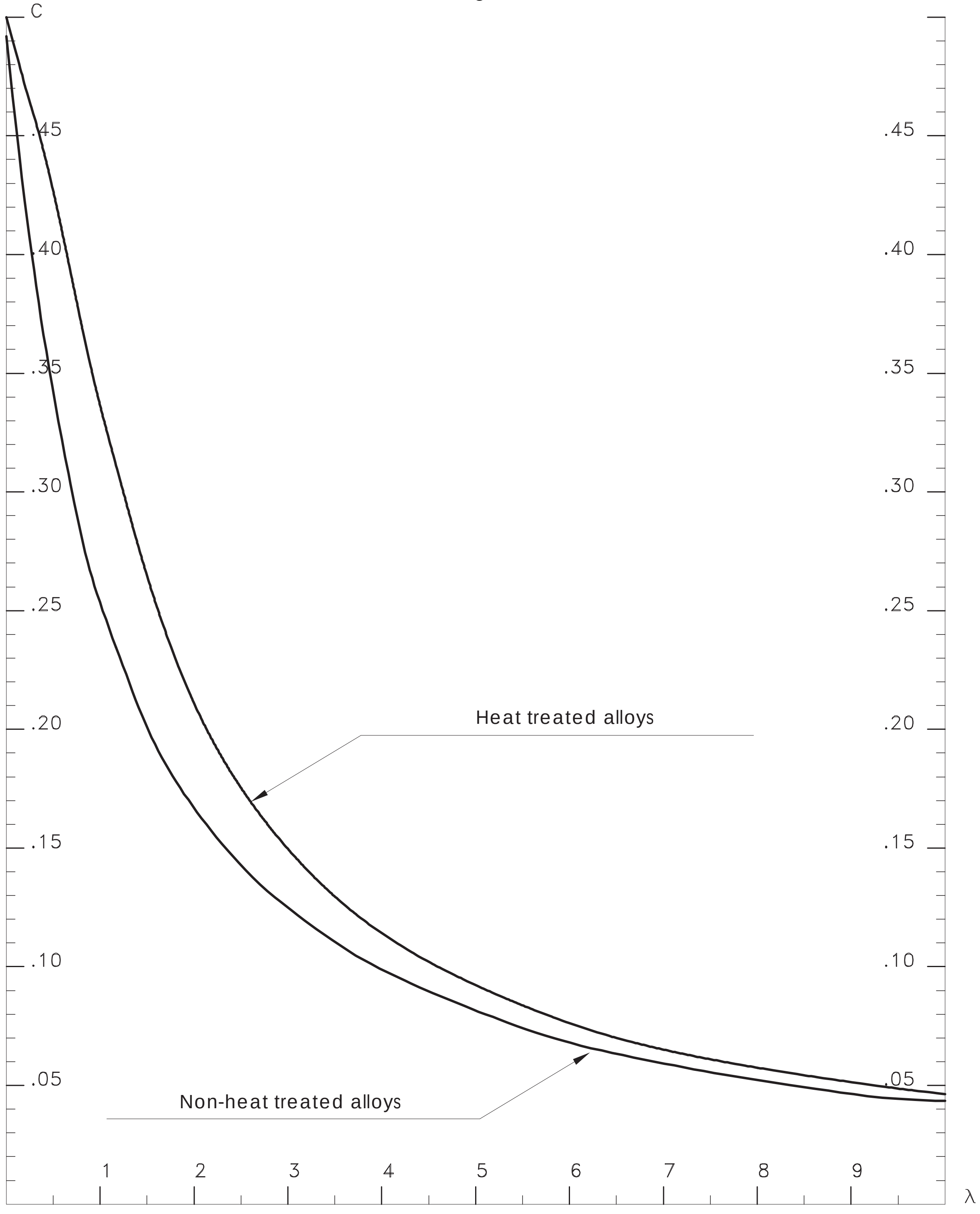
t_w : web thickness, in mm,

h_w : web height, in mm,

t_f : thickness of face plate, in mm,

h_f : width of face plate, in mm.

Figure 5



2.9.4 Scantlings of pillars

The scantlings of pillars are to comply with the following requirements:

$\sigma \leq \sigma_c$

$\sigma \leq \sigma_{cl}$

where:

- σ : $10 \cdot \mathbf{Q}/\mathbf{A}$, compressive stress, in N/mm², in the pillar due to load **Q**, **A** being the cross-sectional area, in cm², of the pillars
- σ_c : overall buckling critical stress, as defined in [2.9.2]
- σ_{cl} : local buckling critical stress, as defined in [2.9.3]

The maximum allowable axial load, in kN, is the smaller of the following values:

$$P_c = \sigma_c \cdot A \cdot 10^{-1}$$

$$P_{cl} = \sigma_{cl} \cdot A \cdot 10^{-1}$$

2.10 Tank bulkheads

2.10.1 General

Hollow profiles are not permitted as tank walls or in tanks for flammable liquids.

2.10.2 Plating

The required thickness, in mm, is given by the formula:

$$t = 22{,}4 \cdot f_m \cdot \mu \cdot s \cdot \left(\frac{p_t}{\sigma_{am}}\right)^{0{,}5}$$

where:

- f_m : coefficient depending on the material equal to 0,75
- p_t : design pressure, in kN/m², as defined in Ch 1, Sec 3, [4.9]
- σ_{am} : 85/**K** N/mm².

2.10.3 Ordinary stiffeners

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [2.7.1], assuming:

- **p** : design pressure p_t as defined in Ch 1, Sec 3, [4.9]
- **m** : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 3

σ_{am} = 70/**K** N/mm²

τ_{am} = 45/**K** N/mm²

2.10.4 Primary supporting members

The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in [2.8.1] assuming:

- **p** : design pressure p_t as defined in Ch 1, Sec 3, [4.9]
- **m** : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10

σ_{am} = 70/**K** N/mm²

τ_{am} = 45/**K** N/mm²

2.10.5 Corrugated bulkheads

The thickness and section modulus of corrugated bulkheads, calculated as stated in [2.10.2], [2.10.3] and [2.10.4] are to be increased by 10% and 20%, respectively

The section modulus W_C, in cm³, of a corrugation may be derived from the following formula:

$$W_C = d \cdot t \cdot (3 \cdot b + c) / 6000$$

where the symbols are as shown in Fig 7 and are expressed in mm. In no case is the angle φ to be less than 40°.

2.11 Subdivision bulkheads

2.11.1 Plating

The required thickness, in mm, is given by the formula:

$$t = 22{,}4 \cdot f_m \cdot \mu \cdot s \cdot \left(\frac{p_{sb}}{\sigma_{am}}\right)^{0{,}5}$$

where:

- f_m : coefficient depending on the material equal to 0,70
- p_{sb} : design pressure, in kN/mm², as defined in Ch 1, Sec 3, [4.10]
- σ_{am} : 95/**K** N/mm²

The thickness of the collision bulkhead is to be calculated from the formula given above, multiplied by 1,15.

2.11.2 Ordinary stiffeners

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [2.7.1], assuming:

- **p** : design pressure p_{sb} as defined in Ch 1, Sec 3, [4.10]
- **m** : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 3

σ_{am} = 95/**K** N/mm²

τ_{am} = 55/**K** N/mm²

The section modulus, shear area and welding section required for the ordinary stiffeners of the collision bulkhead are to be calculated as above, considering σ_{am} and τ_{am} divided, respectively, by 1.15 and 1.05.

2.11.3 Primary supporting members

The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in [2.8.1], assuming:

- **p** : design pressure p_{sb} as defined in Ch 1, Sec 3, [4.10]
- **m** : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10

σ_{am} = 95/**K** N/mm²

τ_{am} = 55/**K** N/mm²

The section modulus, shear area and welding section required for the primary supporting members of the collision bulkhead are to be calculated as above, considering σ_{am} and τ_{am} divided, respectively, by 1,3 and 1,2.

2.11.4 Corrugated bulkheads

The thickness and section modulus of corrugated bulkheads, calculated as stated in [2.11.1], [2.11.2] and [2.11.3] are to be increased by 10% and 20%, respectively.

The section modulus of a corrugation is to be calculated as indicated in [2.10.5].

2.12 Non-tight bulkheads

2.12.1 The thickness of plating of non-tight bulkheads which do not act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 900 mm apart.

Vertical stiffeners are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in cm^3 given by the formula:

$$Z = 2 \cdot s \cdot S^2$$

The thickness of plating of non-tight bulkheads which act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 750 mm apart.

Vertical stiffeners are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in cm^3 given by the formula:

$$Z = 2{,}65 \cdot s \cdot S^2$$

In addition, each vertical stiffener, in association with a width of plating equal to 50 times the plating thickness, is to comply with the requirements for pillars given in [2.9], the load supported being determined in accordance with the same provisions.

In the case of tanks extending from side to side, a wash bulkhead is generally to be fitted amidships; with plating thickness not less than 3 mm and strengthened by vertical stiffeners.

2.13 Independent prismatic tanks

2.13.1 The required thickness for the plating of independent prismatic tanks, in mm, is given by the formula:

$$t = 1{,}25 \cdot f_m \cdot s \cdot \mu \cdot (p_t \cdot K)^{0{,}5}$$

where:

- f_m : coefficient depending on the material, equal to 1,45
- p_t : design pressure, in kN/mm^2, as defined in Ch 1, Sec 3, [4.9]

In no case is the thickness to be less than 3,5 mm.

The section modulus required for stiffeners, in cm^3, is given by the formula:

$$Z = 0{,}4 \cdot f'_m \cdot s \cdot l^2 \cdot p_t \cdot K$$

where:

- f'_m : coefficient depending on the material, equal to 2,15.

The connections to reinforced hull structures of independent tanks are to be able to withstand the dynamic loads induced by the tank weight and the acceleration a_v of the craft (see Ch 1, Sec 3, [2]).

It is recommended that stiffener plates should be arranged so as to prevent undue movement of the liquid.

2.14 Scantlings of masts and fishing equipment (e. g. crutches and frames for trawling fishery)

2.14.1 The requirements of Ch 1, Sec 3, [14] apply.

Figure 6

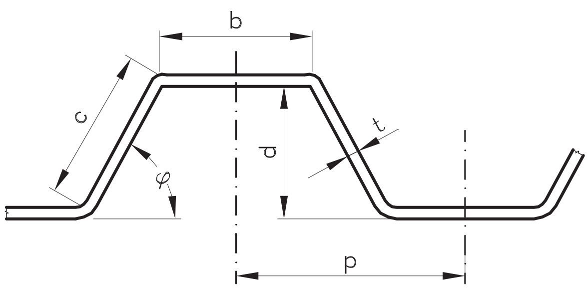
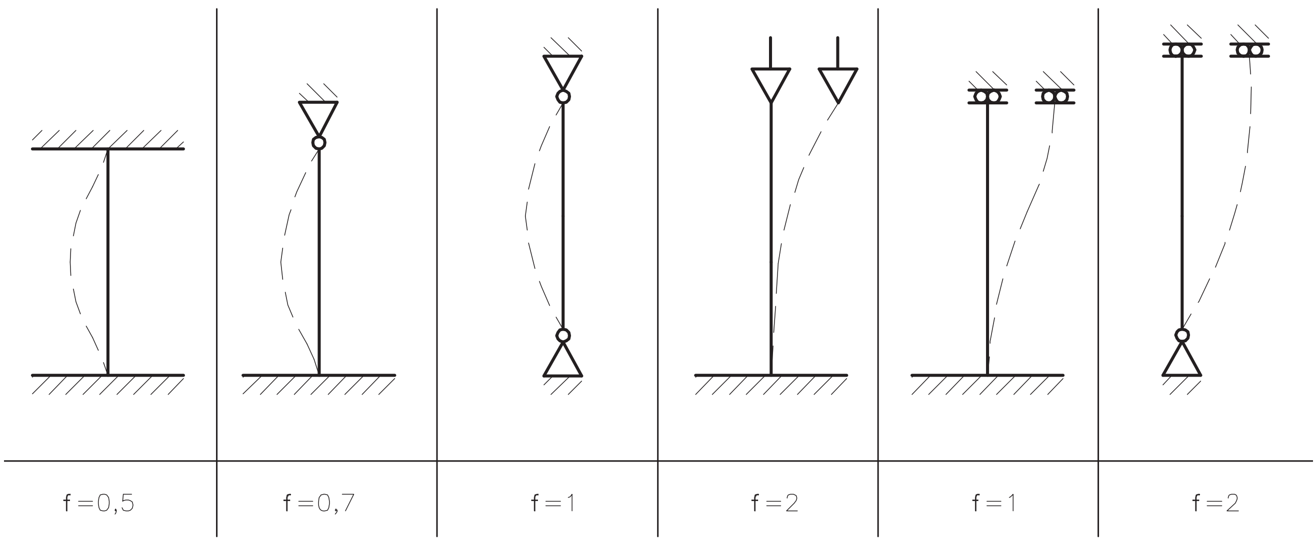


Figure 7



SECTION 4 HULL OUTFITTING

1 Application

1.1

1.1.1 The requirements in Ch 1, Sec 4 apply.

SECTION 5 RUDDERS, EQUIPMENT AND TESTING

1 Rudders

1.1 Application

1.1.1 The requirements in Pt B, Ch 10, Sec 1 of the Tasneef Rules apply.

2 Equipment

2.1 Application

2.1.1 The requirements in Pt B, Ch 10, Sec 4 of the Tasneef Rules apply.

3 Testing

3.1 Application

3.1.1 The requirements in Pt B, Ch 12, Sec 3 of the Tasneef Rules apply.

Part B
Hull and Stability

Chapter 3
WOODEN HULLS

SECTION 1 DESIGN PRINCIPLES AND STABILITY

1 Design principles

1.1 Application

1.1.1 The requirements of Part B, Chapter 2 of the Tasneef Rules apply, together with the requirements of:

- Part E, Ch 11, Sec 2, for passenger ships;
- Part E, Ch 20, Sec 2, for fishing vessels.

2 Stability

2.1 Application

2.1.1 The requirements of Ch 1, Sec 1 apply.

SECTION 2 MATERIALS

1 Suitable timber species

1.1

1.1.1 The species of timber suitable for construction are listed in Tab 1 together with the following details:

- commercial and scientific name;
- 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 Tab 2.

The same species are suitable for the fabrication of marine plywood and lamellar structures in accordance with the provisions of item [2] below.

The use of timber species other than those stated in Tab 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 Tab 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 Tab 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.

For the construction of ships for which the Maltese Cross ✠ is not requested, marine plywood not type tested by Tasneef may be accepted at the latter's discretion, provided that it is certified by the Manufacturer and is satisfactorily subjected to the glueing test in accordance with the EN 314 standard and to mechanical tests (breaking, flexural and tensile tests).

3 Certification and checks of timber quality

3.1

3.1.1 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.

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 impregnation. **(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
MAKORÈ	Africa	Tieghemella spp	660	A	4	86	9300	50	11,0
MAOGANY	America	Swietenia spp	550	B	4	79	10300	46	8,5
OKOUMÈ	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
SAPELI	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

Abbreviation

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

Notes

(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).

4 Mechanical characteristics and structural scantlings

4.1

4.1.1 The structural scantlings indicated in this Chapter apply to timber with the following density δ, in kg/m³, 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 this Chapter may be modified as a function of the density δ_e of the timber employed and its moisture content, in accordance with the relationship:

$$S_1 = S / K$$

$$K = \frac{\delta_e}{\delta} + (U - U_e) \cdot 0,02$$

where:

- S_1 : corrected section (or linear dimension);
- S : Rule section (or linear dimension), obtained in accordance with this Chapter;
- δ_e : density in kg/m³ of the timber species (or plywood) used;
- δ : standard density of the timber species;
- 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 2 : Guide for selections of construction timbers

Commercial name → Structural element ↓	Douglas fir	Cedar (red)	Iroko	Larch	Makore	Mahogany	Elm English	White oak	Oak	Sapeli	Teak
Keel, hog, stern-post, dead-woods			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		I
Grown or web frames				II **(2)**	II			II **(1)**	II **(1)**	III	I
Bent frames								II **(1)**	II **(1)**		
Planking below waterline	III		II	II		II		II	II	III	I
Planking above waterline	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
Vertical brackets				II				II **(1)**	II		
Horizontal brackets				II				I	I		
Gunwale, margin planks			II			II		II	II		

Notes
(1) The timber concerned may be employed either in the natural or in the laminated form.
(2) The timber may be employed only in the laminated form.

Suitability of timber for use:
I = very suitable
II = fairly suitable
III = not very suitable.

SECTION 3 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.

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.

For bent parts, suitable thicknesses are to be chosen such as to avoid excessive stresses during 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 4 STRUCTURAL SCANTLINGS

1 General

1.1

1.1.1 The scantlings in this Chapter apply to ships of length **L** ≤ 30 metres with a chine hull of the type shown in Fig 1 and Fig 6 and speed not exceeding 40 knots.

For ships which substantially differ from the above as regards dimensions and/or speed, or for ships 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 Tab 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 from those of the hog frame.

Stempost scantlings are given in Tab 1 and a typical stern-frame is shown in Fig 2.

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 specified for shell planking.

Table 1 : Keel and stempost

Length **L**	KEEL		STEMPOST		
	Minimum breadth	Cross-section of keel or keel and hog **(1)**	Width at heel and at head	Cross-section at heel	Cross-section at head
m	mm	cm^2	mm	cm^2	cm^2
1	2	3	4	5	6
14	140	189	140	189	132
16	160	228	160	228	160
18	175	270	175	270	189
20	195	312	195	312	218
22	210	360	210	360	252
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.

Table 2 : Shell and deck planking

Length **L** m	SHELL PLANKING		Weather deck planking mm	Deck of superstructures (quarterdecks, deckhouses, coachroofs, trunks) mm
	Type I and II framing mm	Type III framing mm		
1	2	3	4	5
14	21,5	17,5	21,5	17,5
16	25	21	25	19
18	27	24	27	21
20	29	25	29	21
22	31	27	31	21
24	32	28,5	32	21
26	34	30	34	21
28	36	32	36	21
30	37,5	33,5	37,5	21

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.

4.2 Bottom and side frames

4.2.1 Frame scantlings are given in Tab 3, 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.

Table 3 : Frames

Depth **D** m	A) TYPE I FRAMING (EITHER GROWN OR LAMINATED FRAMES ONLY)									
	spacing of web mm	BETWEEN KEEL AND CHINE					BETWEEN CHINE AND DECK			
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width mm	depth at heel mm	depth at head mm	width mm	depth mm	width mm	depth at heel mm	depth at head mm	width mm	depth mm
1,9	237	24	60	54	24	47	24	50	44	24	43
2,1	255	26	72	65	26	56	26	60	55	26	51
2,3	270	28	82	75	28	61	28	70	63	28	56
2,5	288	30	96	88	30	71	30	81	74	30	65
2,7	305	32	112	102	32	82	32	93	84	32	75
2,9	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

Depth D mm	B) TYPE II FRAMING (EITHER GROWN OR LAMINATED FRAMES WITH BENT FRAMES IN BETWEEN)				
	Spacing between main frames and intermediate frames			Bent frames	
	one bent frame mm	two bent frames mm	three bent frames mm	width mm	depth mm
1,9	410	520	590	26	17
2,1	446	540	620	30	19
2,3	460	570	640	31	20
2,5	490	590	670	33	22
2,7	515	620	695	34	23
2,9	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	-	-	-	-	-

Depth D m	C) 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		
1,9	470	25	69	58	25	46	25	48	44	25	43
2,1	510	27	83	70	27	55	27	58	54	27	50
2,3	540	29	97	82	29	62	29	68	65	29	56
2,5	570	31	113	96	31	70	31	79	74	31	64
2,7	610	34	130	110	34	82	34	91	82	34	74
2,9	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

Depth D m	D) 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
1,9	210	33	20	33	17
2,1	225	37	23	37	19
2,3	240	39	25	39	20
2,5	255	41	27	41	22
2,7	270	43	28	43	23
2,9	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

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 vessel's centreline to a height not less than twice that required 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 3.

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 Fig 4 and Fig 5).

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.

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 30 cm^2 where $\mathbf{L} \leq 14$ m, not less than 90 cm^2 where $\mathbf{L} \geq 20$ m, and intermediate values when **L** is between 14 and 20 m.

For ships having $\mathbf{L} \geq 15$ m, 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 5 is to be increased 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 of hulls having $\mathbf{L} \geq 14$ m.

Such longitudinal may be omitted where Type III framing is adopted.

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 cm^3, not less than:

$$\mathbf{Z}_1 = \mathbf{K}_1 \cdot \mathbf{a} \cdot \mathbf{s}$$

At the ends of large openings, beams are to be fitted having a section modulus, in cm^3, not less than:

$$\mathbf{Z}_2 = \mathbf{K}_2 \cdot \mathbf{a} \cdot \mathbf{s}$$

where:

$\mathbf{Z}_1$, $\mathbf{Z}_2$: section modulus of beams without planking contribution, in cm^3

a : width of beams, in cm

s : beam spacing, in cm

$\mathbf{K}_1$, $\mathbf{K}_2$: coefficient given by Tab 4 as a function of the beam span.

Where laminated beams are arranged, the section modulus $\mathbf{Z}_1$ and $\mathbf{Z}_2$ may be reduced to 0,85 of those indicated above.

Table 4

Beam span (m)	Coefficients for calculation of beam section modulus			
	$\mathbf{K}_1$		$\mathbf{K}_2$	
	At the centreline	At the end	At the centreline	At the end
1,2	9,4	4,26	17,1	8,7
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 5 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 5

Length **L** of the hull (m)	Cross-sectional area of beam shelves (cm^2)	Cross-sectional area of chine stringers (cm^2)
14	45	52
16	55	64
18	65	72
20	75	84
22	85	96
24	95	112
26	110	128
28	125	140
30	140	152

8 Shell planking

8.1 Thickness of shell planking

8.1.1 The basic thickness of shell planking is given in Tab 2.

If the frame spacing is other than that shown in Tab 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.

Vessels with speed > 25 knots are to have bottom frames (floors and longitudinals) stiffened in respect of the scantlings in this Article and planking thickness increased as follows (for deadrise ≤ 25°) in respect of the values in Tab 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 generally not 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 Tab 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 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 [6] for weather deck beams and effectively fastened to the sides by means of a shelf with a cross-sectional area not less than 2/3 of that required in Tab 5.

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].

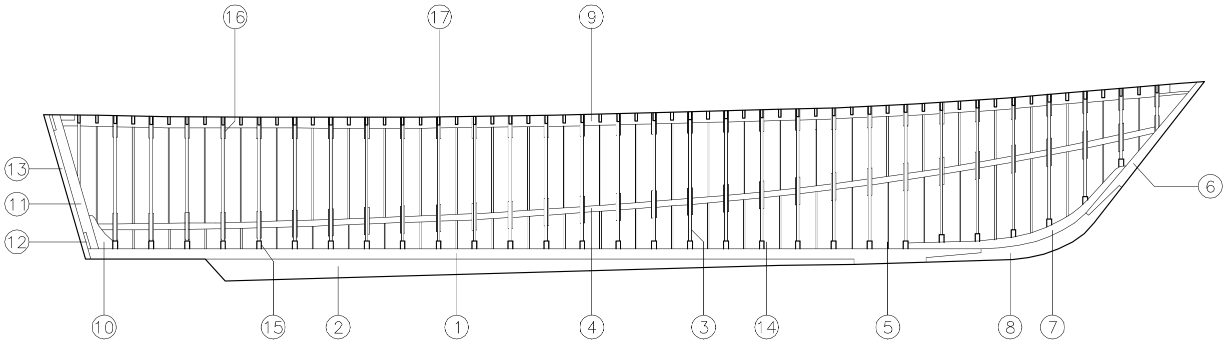
The scantlings of the deck planking are to be not less than those required in [9.2].

10 Scantlings of masts and rigging for fishing (e.g. crutches and frames for trawls)

10.1

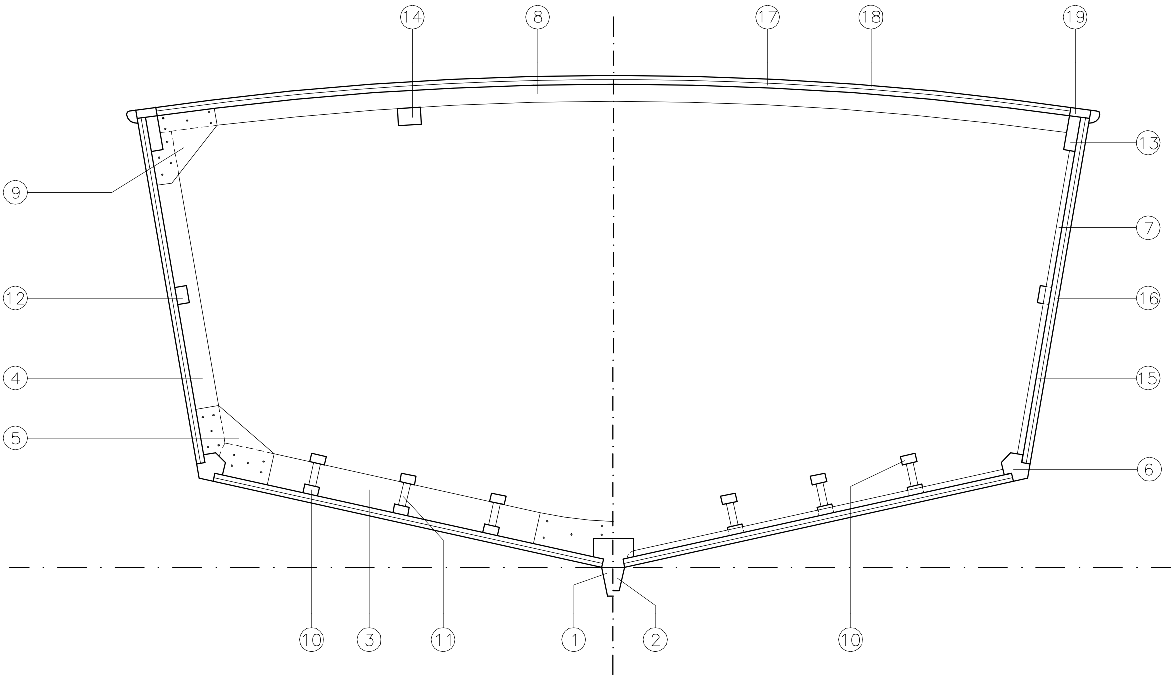
10.1.1 The requirements of Ch 1, Sec 3, [14] apply.

Figure 1 : Scantling plan - longitudinal section



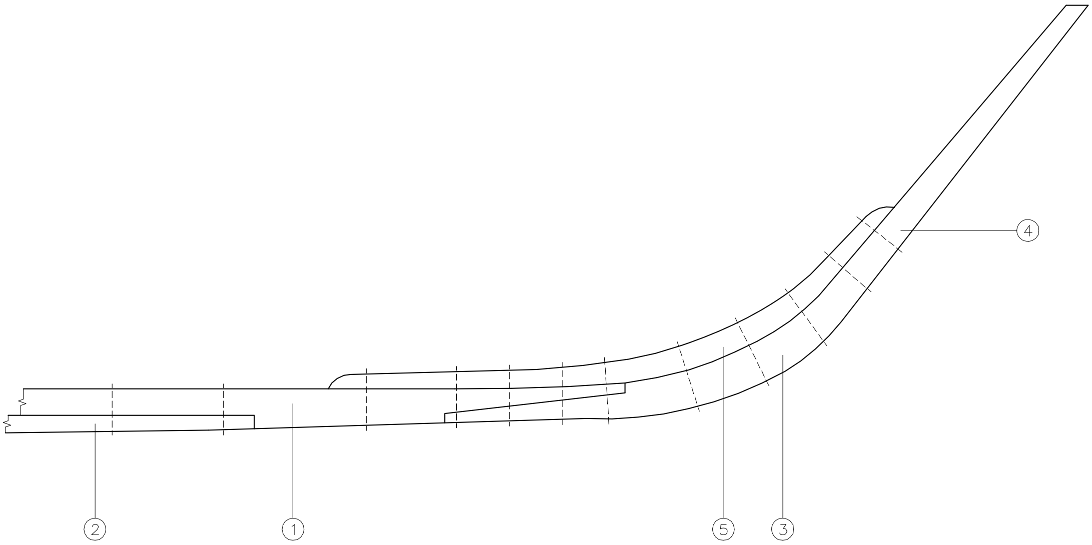
1 - Keel	7 - Apron	13 - Transom planking
2 - Hog	8 - Stem	14 - Chine knees
3 - Grown frame	9 - Shelf	15 - Floors
4 - Chine stringer	10 - Knee	16 - Beam knees
5 - Bent frame	11 - Transom stiffeners	17 - Beam
6 - Stempost	12 - Transom frame	

Figure 2 : Midship section



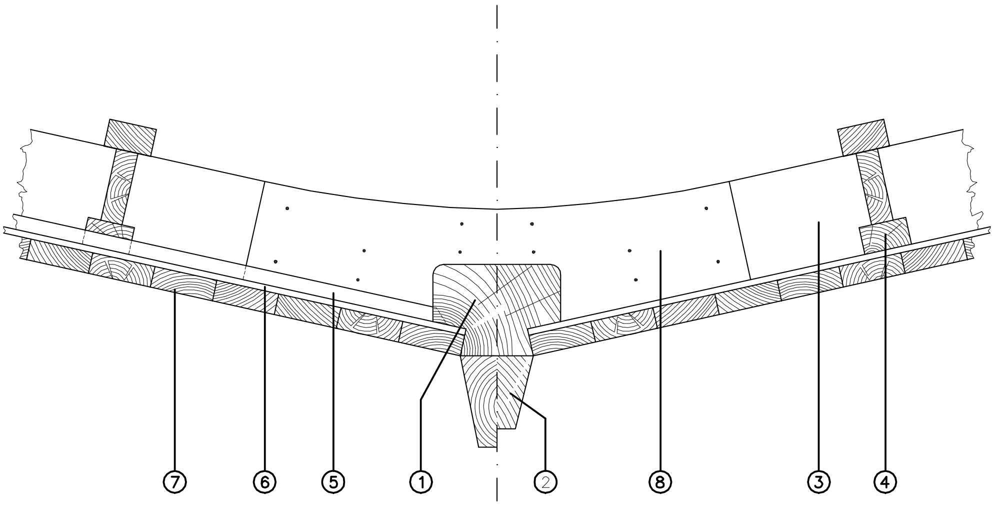
1 - Keel	8 - Beam	15- Bottom and side planking - Inner skin
2 - Hog	9 - Double knee	
3 - Bottom frame	10- Bottom stringers	16- Bottom and side planking - Outer skin
4 - Side frame	11 - Deadwood	
5 - Double knee	12- Side stringers	17- Deck planking - Inner skin
6 - Chine	13- Shelf	18- Deck planking - Outer skin
7 - Bent frame	14- Carling	19- Waterway

Figure 3 : Stem



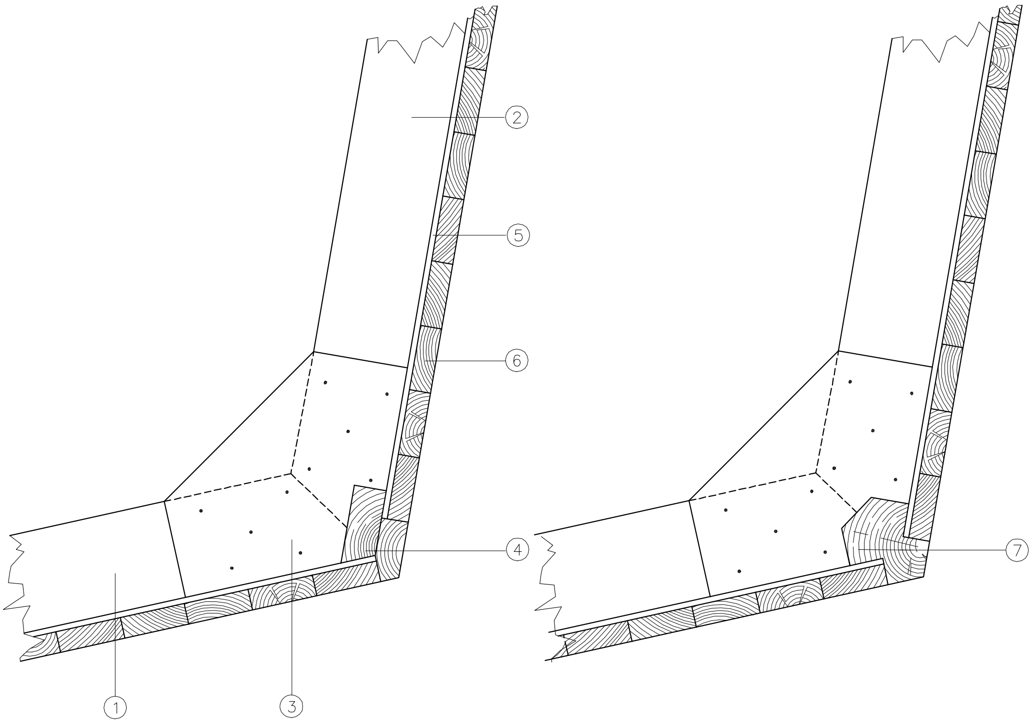
1 - Keel	4 - Stempost
2 - Hog	5 - Apron
3 - Stem	

Figure 4 : Detail of floor



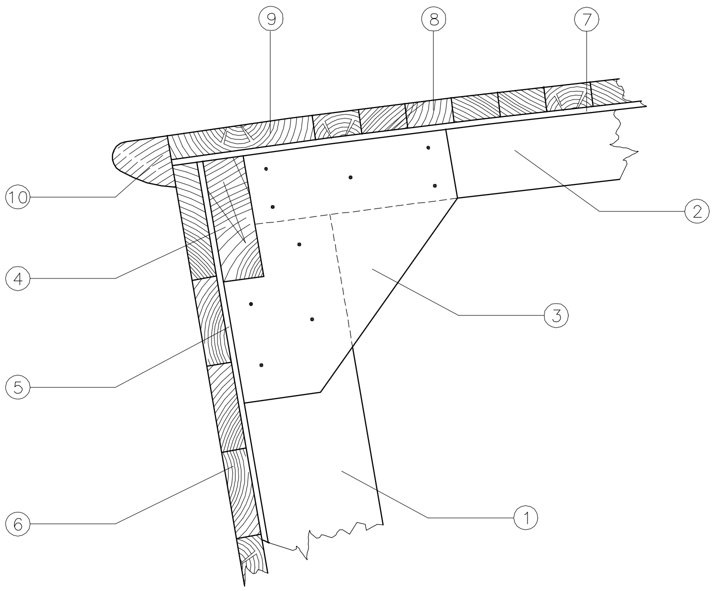
1 - Keel	4 - Bottom stringer	7 - Planking - Outer skin
2- Hog	5 - Bent frame	8 - Double floor
3 - Bottom frame	6 - Planking - Inner skin	

Figure 5 : Details of chine



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 5 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 Part B, Chapter 2 of the Rules.

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 Tab 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:

$$\mathbf{Z} = (4,2 + 4\mathbf{h})\mathbf{s} \cdot \mathbf{S}^2$$

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, in m.

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 : Steel watertight bulkheads

Height of bulkhead mm	Spacing of vertical stiffeners mm	Thickness of lower strake mm	Thickness of plate mm
1,60	310	3	2,5
1,80	325	3	3
2,00	340	3,5	3
2,20	360	4	3,5
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

SECTION 6 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.

The inner skin is to be connected to the frames by means of screws or nails and the outer skin is to be connected to the frames by means of bolts or screws and to the inner skin by means of clenched bolts. A cloth impregnated with oil or other suitable plastic material is to be arranged between the two skins.

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 loco, 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 Fig 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 ≤ **a** ≤ 100 mm

  4 bolts at each end of plank
- 200 ≤ **a** < 250 mm

  5 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.

Table 1 : Connections of sheel and deck planking - scantlings of fastenings

Thickness of planking mm	SHELL PLANKING				DECK PLANKING		NUMBER OF FASTENINGS PER PLANK				
	Grown, 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** <250	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

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 with associated planking

2.3.1 The butts of plywood panels are to be in accordance with the specifications given in [2.2], while the distribution of plank butts is to comply with the provisions of [2.1].

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 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

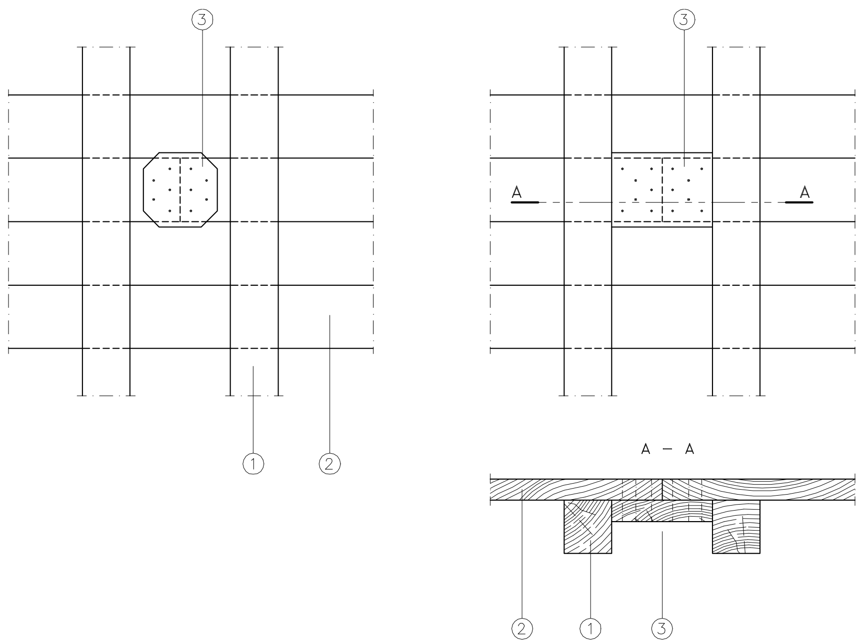
2.5.1 Wood planking is to be caulked or made watertight by the application of a suitable elastic compound.

Wooden dowels used to cover bolt holes are to be glued.

Table 2 : Connections of shell and deck planking in plywood

Thickness of plywood mm	OVERLAP OF SEAMS		Width of butt-straps mm		DIAMETER OF FASTENINGS	
	shell and deck planking, on keel, stringers, shelves, or carlings mm				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 fastening	350 350 350	double fastening	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

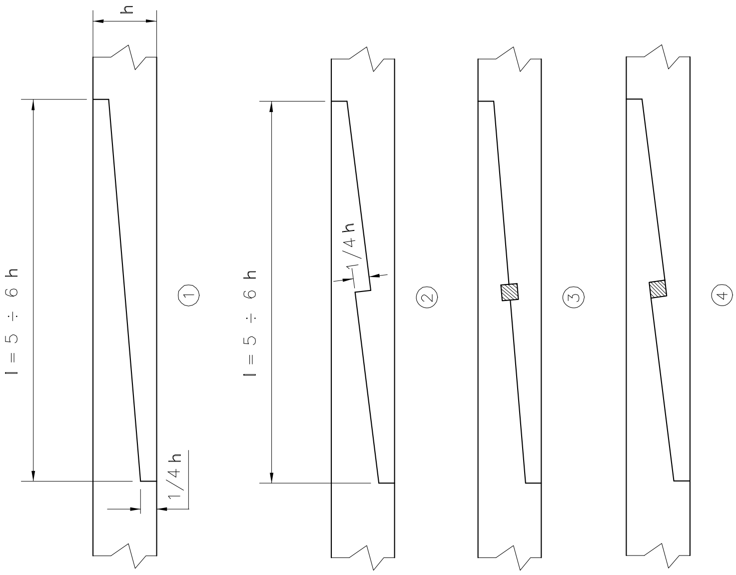


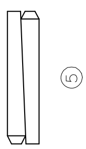
1 - Frame

2 - Shell planking

3 - Butt - strap

Figure 2 : Usual types of scarf joints





1 - Plain scarf
2 - Hooked scarf
3 - Tabled scarf
4 - Tabled hooked scarf
5 - Double wedges

SECTION 7 RUDDERS

1 Application

1.1

1.1.1 The requirements of Part B, Ch 10, Sec 1 of the Tasneef Rules apply.

SECTION 8 EQUIPMENT

1 Application

1.1

1.1.1 The requirements of Ch 1, Sec 6 apply.

SECTION 9 TESTS

1 Application

1.1

1.1.1 The requirements of Part B, Ch 12, Sec 3 of the Tasneef Rules apply.

Rules for the Classification of Ships with Reinforced Plastic, Aluminium Alloy or Wooden Hulls

Part C

Machinery, Systems and Fire Protection

Chapters 1 2

CHAPTER 1
MACHINERY, ELECTRICAL INSTALLATIONS AND AUTOMATION

Section 1 Machinery

Section 2 Electrical Installations

Section 3 Automation

CHAPTER 2
FIRE PROTECTION

Part C

Machinery , Systems and Fire Protection

Chapter 1

MACHINERY, ELECTRICAL INSTALLATIONS AND AUTOMATION

SECTION 1 MACHINERY

1 Application

1.1

1.1.1 The requirements of Part C, Chapter 1 of the Tasneef Rules generally apply; the additional requirements of Part E, Ch 11, Sec 4 and Part E, Ch 20, Sec 4 of the Tasneef Rules apply for passenger ships and fishing vessels, respectively.

For bilge systems of passenger ships, instead of the additional requirements of Part E, Ch 11, Sec 4 of the Tasneef Rules, the requirements of Part C, Ch 1, Sec 10 of the Tasneef Rules generally apply with the modifications or additions given in [2] and [3].

As far as the independent fuel oil tanks are concerned, in addition to compliance with Part C, Ch 1, App 4 of the Tasneef Rules, all the spaces of ships with wooden hull containing tanks or installations for fuel oil are to be suitably protected to avoid fuel oil soaking.

2 Bilge systems of passenger ships subject to buoyancy subdivision regulations

2.1 General arrangement of bilge system

2.1.1 The bilge pumps and their sources of power are to be so arranged that, in the event of damage to any one compartment, at least one bilge pump and its source of power will be available for use.

2.1.2 The bilge main and associated valves are to be located outside the assumed extent of conventional damage penetration.

Similarly, all bilge suction branches leading from the various spaces are to be arranged, to the extent that this is possible, outside the assumed extent of conventional damage penetration. In any case, all bilge suctions are to be fitted with non-return valves so as to prevent the flooding of undamaged compartments in the event that any one compartment is flooded.

2.1.3 The collision bulkhead may be pierced below the margin line by not more than one pipe serving the fore peak, provided that such pipe is fitted with a screw-down valve capable of being operated from above the bulkhead deck and the valve chest is secured inside the fore peak to the collision bulkhead.

Tasneef may, however, authorise the fitting of such valve on the other side of the collision bulkhead provided that the valve is readily accessible under all service conditions and that the space in which it is located is not a cargo space.

The aforesaid screw-down valve is to be equipped with a device indicating whether it is open or closed. The valve is to be of steel, bronze or other ductile material deemed suitable by Tasneef; valves of ordinary cast iron or similar materials are not acceptable.

3 Bilge systems of passenger ships not subject to buoyancy subdivision regulations

3.1 General arrangement of bilge system

3.1.1 All bilge suctions are to be fitted with non-return valves.

For penetrations of the collision bulkhead, the same requirements apply as in [2.1.3].

3.2 Diameter of bilge piping and capacity of bilge pumps of ships of gross tonnage not exceeding 25 and engaged on voyages in the course of which the ship is not more than six miles from the shore and not more than one hour from a safe haven or port

3.2.1 The internal diameter d, in mm, of the bilge main and the bilge suction branches leading from the various compartments is to be not less than that calculated according to the following formula:

$$\mathbf{d} = 0{,}85\ \mathbf{L} + 25$$

where

L = length of the ship measured between the perpendiculars, in m, taken at the extremities of the deepest subdivision load line.

However, the actual internal diameter defined above may be rounded off to the nearest standard size acceptable to Tasneef (in any case it is to be not more than 5 mm less than that obtained from the formula).

The capacity of each bilge pump is to be not less than that given by the following formula:

$$\mathbf{Q} = 0{,}00565\,\mathbf{d}^2$$

where

Q = capacity of the bilge pump in m^3/h

d = rule inner diameter of the bilge main, in mm, calculated with the above formula.

SECTION 2 ELECTRICAL INSTALLATIONS

1 Application

1.1

1.1.1 The requirements of Part C, Chapter 2 of the Tasneef Rules generally apply; the requirements of Pt E, Ch 11 Sec 5 and Pt E, Ch 20, Sec 5 of the Tasneef Rules apply for passenger ships and fishing vessels, respectively.

Moreover, for ships with reinforced plastic or wooden hull, the requirements of this Section apply.

2 Earthing

2.1 Earthing connections

2.1.1 Where earthing connection is required, a conductor is to be provided with the function of collector connected to a specific earthing plate.

2.2 Earthing plate

2.2.1 The earthing plate is to be a plate, free from paint, having a thickness of at least 2 mm and a surface area not less than 0,25 m^2, fixed to the hull below the lowest waterline so as to remain fully submerged in any listing or heeling condition.

2.2.2 The earthing plate is to be made of copper or other conductive material, compatible with sea water and having a surface area such as to give a resistance equivalent to that of a copper earthing connection. The formation of electrochemical couples with other immersed metallic materials, which could cause electrolytic corrosion, is to be avoided.

3 Protection against lightning for ships with reinforced plastic or wooden hull

3.1 General

3.1.1 A protection system against lightning is to be provided on ships with reinforced plastic or wooden hull.

3.1.2 The protection system against lightning is to include air terminals, down conductors and earth terminations.

3.1.3 Metallic masts and metallic structural elements may constitute part or the whole of the protection system.

3.1.4 Metallic equipment may act as natural down conductors and is to be connected to the protection system.

3.1.5 The electrical resistance between the air terminal and the earth termination is not to exceed 0,02 Ω.

3.1.6 The down conductor joints are to be accessible and located or protected so as to minimize the risk of accidental damage. They are to be made by means of rivets or compression clamps. Compression clamps may be of copper or copper alloys and should preferably be of the notched contact type and securely tightened. No welded connection is allowed.

3.1.7 The protection system against lightning is to be installed so as to minimize the risk of induction voltages in the electric cables due to the passage of lightning currents.

3.1.8 When the ship is in drydock or on a slipway, suitable means are to be provided to connect the protection system against lightning to the earthing system of drydock or slipway. The conductors for this connection are to have a length as short as practicable and a cross section not smaller than that electrically equivalent to 100 mm^2 of copper.

3.2 Air terminals

3.2.1 Each non-metallic mast is to be provided with an air terminal (see Note 1)

Note 1: The positioning of air terminals on the ship masts may be effected taking into account the protection angle method specified in the CEI 81-1 standard.

3.2.2 The air terminal is to consist of a conductive bar, made of copper or copper alloy, having a diameter not less than 12 mm, and a height of at least 300 mm above the top of the mast. Other materials may be used, such as, for example, stainless steel or steel bars protected against corrosion, provided that they meet the requirements in [3.1.7]. The material is to be resistant to sea water.

3.3 Down conductors

3.3.1 Down conductors are to consist of a small plate or cable made of copper or copper alloy. Other materials may be used, such as, for example, stainless steel or steel bars protected against corrosion, provided that they meet the requirements in [3.1.7]. The material is to be resistant to sea water.

3.3.2 Copper down conductors are to have a cross section not less than 70 mm^2, be securely fixed to the structure and run as far as practicable on a straight line between the air terminal and the earth termination. Direction changes, where necessary, are to have a minimum radius of at least 10 times the equivalent conductor diameter.

3.4 Earth terminations

3.4.1 Earth terminations are to be constructed and installed as specified in [2.2].

3.4.2 Earth terminations are to be additional to and separate from the earthing plate, mentioned in [2.2].

4 Electrolytic corrosion

4.1 General

4.1.1 Metallic parts in contact with sea water, such as valves, pipes, engine casings, etc., not otherwise protected against electrolytic corrosion, are to be electrically connected to a copper conductor having the function of collector, connected in turn to sacrificial anodes.

SECTION 3 AUTOMATION

1 Application

1.1

1.1.1 The requirements of Part C, Chapter 3 of the Tasneef Rules generally apply.

Part C

Machinery, Systems and Fire Protection

Chapter 2

FIRE PROTECTION

SECTION 1 REQUIREMENTS APPLICABLE TO PASSENGER SHIPS AND CARGO SHIPS INCLUDING FISHING VESSELS

SECTION 1 REQUIREMENTS APPLICABLE TO PASSENGER SHIPS AND CARGO SHIPS INCLUDING FISHING VESSELS

1 General

1.1 Application

1.1.1 This Section applies to ships with reinforced plastic, aluminium alloy or wooden hull when classification is requested for:

a) Passenger ships, with the restrictions specified in [2];

b) Cargo ships (excluding tankers) and fishing vessels, with the restrictions specified in [3].

1.2 Documentation to be submitted

1.2.1 The general arrangement plan is to be submitted to Tasneef by the interested parties, in two copies, for information.

2 Requirements applicable to passenger ships

2.1 General and application

2.1.1 Ships with aluminium alloy hull are to comply, as far as applicable, with the requirements of Part C, Chapter 4 of the Tasneef Rules.

2.1.2 Ships with reinforced plastic or wooden hull, engaged on domestic voyages in the course of which it is at no time more than 20 miles from the line of coast, where shipwrecked persons can land, corresponding to the medium tide height, are to comply, as far as applicable, with the requirements of Part C of the Tasneef Rules and have to satisfy the following conditions:

- the ships are to have a gross tonnage not exceeding 200
- the spaces intended for accommodation are, in general, to be arranged above the weather deck and on no more than two decks
- no cabins are to be available for passengers; for the crew cabins are only to be available if adjacent to the navigation bridge
- no vehicles or goods are carried on board
- the arrangement of stores within the accommodation block is limited to those having a deck area not exceeding 4 m^2. Paints or other flammable liquids are not stored
- ships are engaged on voyages in restricted areas having a duration not exceeding one hour from a place of refuge.

Possible different conditions may be accepted at Tasneef's discretion in individual cases.

For ships operating in the Venetian Lagoon, Tasneef will establish the extent of the application of the requirements of this Section, in relation to the constructional characteristics of the ships.

3 Requirements applicable to cargo ships (including fishing vessels)

3.1 General and application

3.1.1 Except for special cases to be individually considered by Tasneef, cargo ships (including fishing vessels) having gross tonnage and/or Rule length within the limits specified below may be constructed of reinforced plastics, aluminium alloy or wood, provided that they do not carry crude oil, petroleum products, liquefied gases, dangerous chemicals and other flammable liquid products.

3.1.2 Cargo ships dealt with in this item [3] are to comply, as appropriate, with the requirements given in Part C, Chapter 4 of the Tasneef Rules.

3.2 Ships constructed of reinforced plastics

3.2.1 Field of application The provisions of this item [3.2] apply to ships having Rule length not exceeding 50 metres and to ships with reinforced plastic hull.

3.2.2 Detection and alarm

For all ships with **AUT** notation, irrespective of their length, machinery spaces are to be protected by a fixed fire detection and fire alarm system complying with the requirements of Pt C, Ch 4 and Pt F, Ch 3, Sec 2 of the Tasneef Rules.

3.3 Ships constructed of aluminium alloys

3.3.1 Field of application

The provisions of this item [3.3] apply to ships of less than 100 gross tonnage constructed of aluminium alloys.

3.3.2 Detection and alarm

For ships with **AUT** notation, machinery spaces are to be protected by a fixed fire detection and fire alarm system complying with the requirements of Pt C, Ch 4 and Pt F, Ch 3, Sec 2 of the Tasneef Rules.

3.4 Wooden ships

3.4.1 Field of application

The provisions of this item [3.4] apply to wooden ships of less than 200 gross tonnage.

3.4.2 Detection and alarm

For ships with **AUT** notation, machinery spaces are to be protected by a fixed fire detection and fire alarmm system complying with the requirements of Pt C, Ch 4 and Pt F, Ch 3, Sec 2 of the Tasneef Rules.