# Rules for Certification of Racing Sailing Yachts

Effective from 1 July 2025

# Part B

## Hull and Stability

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هيئة الإمـــــارات للتصـــنـيـف
EMIRATES CLASSIFICATION SOCIETY

# GENERAL TERMS AND CONDITIONS
# OF EMIRATES CLASSIFICATION SOCIETY – L.L.C – O.P.C (TASNEEF)
# EFFECTIVE AS OF 1 APRIL 2025

## DEFINITIONS

| | |
|---|---|
| **Administration** | means the government of the state whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case. |
| **Client** | means the interested party and any other party who requires the Services. |
| **Certificate of Classification** | means a certificate of classification, issued by a Society and the certificate confirms that the vessel's structure, machinery, and equipment meet the society's specific technical rules and regulations. |
| **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. |
| **Register of Ships** | means a register book, also known as a Register of Ships, is a comprehensive record of vessels that are classified by a society. |
| **Rules** | means the documents below issued by the Society:<br>a. Rules for the classification of Ships or other special units.<br>b. Complementary rules containing the requirements for certification of products, plants, systems and other or containing the requirements for the assignment of additional class notations.<br>c. Rules for the application of statutory rules, containing the rules to perform the duties delegated by administrations.<br>d. Guides to carry out particular activities connected with Services.<br>e. Any other technical document, as for example rule variations or interpretations. |

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**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** means Emirates Classification Society LLC OPC and/or its affiliated entities providing the Services.

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

**UAE** means United Arab Emirates.

**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.

1.2 The Society (a) sets forth and develops Rules; (b) publishes the Register of Ships[1]; and (c) issues certificates, statements and reports based on its survey activities.

1.3 The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.

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

**ARTICLE 2**

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

2.2 The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification. The Rules for Classification of Ships are published on the Society's website: www.tasneefmaritime.ae

2.3 The Society exercises due care and skill:

(a) in the selection of its Surveyors; and

(b) in the performance of its Services, taking into account the level of its technical knowledge at the time the

Services are performed.

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

**ARTICLE 3**

3.1 The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflect the discretionary opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).

3.2 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.

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

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

3.5 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.

3.6 The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties including, without limitation, Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

3.7 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 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.

3.8 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.

3.9 In consideration of the above, and within the limits of liability under Article 5 below, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered, where these are attributable to the Interested Party.

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

**ARTICLE 4**

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

4.2 In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees and costs, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of non-payment of the invoice within the contractually agreed terms, the Society reserves the right to request, in addition to the full payment of the principal amount due and without the need for further formal notice, also:

(a) Late payment interest at a rate of 5% per annum, calculated from the due date of the invoice until full payment is received, in accordance with the applicable laws in the United Arab Emirates or the country from where the invoice is issued. Any applicable VAT, taxes, or statutory levies shall be borne by the Client as per the laws of the respective jurisdiction;

(b) full reimbursement of any costs incurred for debt recovery, including, but not limited to, legal fees, administrative expenses, and the costs of any extrajudicial actions; and

(c) any additional amount due as compensation for damages suffered as a result of the delay or non-compliance, where documented.

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.

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

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

4.6 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 Article 2), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

5.2 Therefore, subject to what provided for in Article 5.3 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.

5.3 Notwithstanding the provisions in Article 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).

5.4 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 AED 300,000 (Three Hundred Thousand Dirhams). Payment of compensation under this Article 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 Article 5.

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

**ARTICLE 6**

6.1 Any dispute, controversy, or claim arising out of or relating to these Rules, the Services of the Society, or the interpretation, breach, or termination thereof, shall first be referred to the parties' senior management for amicable resolution within thirty (30) days of written notice by either party.

6.2 If the dispute is not resolved amicably under Article 6.1, it shall be exclusively governed by and construed in accordance with the laws of the Emirate of Abu Dhabi and the applicable federal laws of the United Arab Emirates. The courts of Abu Dhabi shall have exclusive jurisdiction to settle any such dispute.

**ARTICLE 7**

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

7.2 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.

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

7.4 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.

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

**ARTICLE 8**

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

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

(a) to immediately suspend payment or performance of the Services which are the object of the contract until such;

(b) time as the Trading Sanctions are in force;

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

(d) to terminate the contract, without prejudice of the Society's rights pursuant to Article 4.

**ARTICLE 9**

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

**ARTICLE 10**

When the Society provides its Services to a consumer - i.e. a natural person who does not act within the scope of his business or professional activity - the following provisions do not apply Article 3 (as far as the Society is solely entitled to the authentic interpretation of the Rules); Article 4, (as far as the payment of the fees is also due for Services not concluded due to causes not attributable to the Interested Party); Article 5 (as far as the exclusion of liability is concerned), and Article 6 (as far as the jurisdiction of a Board of Arbitrators based in Abu Dhabi is concerned).

**ARTICLE 11**

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

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

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

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

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# RULES FOR CERTIFICATION OF RACING SAILING YACHTS

## Part B
## **Hull and Stability**

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# Chapter 1

## GENERAL

# SECTION 1 GENERAL REQUIREMENTS

## 1 Rule application

### 1.1

**1.1.1** Part B consists of the following Chapters:

- Ch 1 General
- Ch 2 Composite
- Ch 3 Stability

For racing yachts made of steel or alluminium RINA Rules for the Classification of Yachts (RES 31), Pt B, Ch 2 or Ch 3 as applicable, are to be used together with the General Subdivision criteria set in Ch 1 of the present Rules.

Racing yachts of unusual form, speed or proportions or of types or material other than those considered in Pt B will be given special consideration by RINA, also on the basis of equivalence criterion.

## 2 Equivalents

### 2.1

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

## 3 Direct calculations for monohull and twin hull yacht

### 3.1 Direct calculations for monohull racing yachts

#### 3.1.1 General

Generally the verification of the scantling is to be carried out using one of the following standard or a mix of them:

- Direct calculations using Loads and safety factors reported in these Rules;
- formulas reported in the Rules for the Classification of Yachts (RES 31);
- EN/ISO 12215;

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

#### 3.1.2 Loads

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

The condition in d) is to be checked in yacht for which, in the opinion of the Society, significant racking effects are anticipated.

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

The vertical and transverse accelerations and the impact pressure $p_2$ are to be calculated as stipulated in Sec 5 or may be declared by the Shipyard and agreed with the Society.

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

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

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

a) **Load condition in still water**

The following loads are to be considered:

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

b) **Combined load condition 1**

The following loads are to be considered:

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

c) **Combined load condition 2**

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

d) **Combined load condition 3**

The following loads are to be considered:

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

### 3.1.3 Structural model

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

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

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

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

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

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

### 3.1.4 Boundary conditions

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

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

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

b) **Combined load condition 3**

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

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

### 3.1.5 Checking criteria

For structures made of composite materials the allowable stresses are defined in Ch 2.

## 3.2 Direct calculations for twin hull racing yachts

### 3.2.1 General

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

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

### 3.2.2 Loads

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

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

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

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

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

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

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

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

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

**a) Load condition in still water**

The following loads are to be considered:

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

**b) Combined load condition 1**

The following loads are to be considered:

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

**c) Combined load condition 2**

The following loads are to be considered:

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

**d) Combined load condition 3**

The following loads are to be considered:

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

### 3.2.3 Structural model

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

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

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

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

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

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

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

#### 3.2.4 Boundary conditions

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

a) **Load condition in still water**

   The vertical resultant of the loads, in general other than zero, is to be balanced by introducing two vertical forces at the fore and aft ends of the model, both distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical resultant of the loads. Where a plane model is adopted, the vertical resultant is to be balanced by a single force, distributed as specified above and acting on the plane of the model itself.

b) **Combined load condition 1**

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

c) **Combined load condition 2 and 3**

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

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

#### 3.2.5 Checking criteria

For structures made of composite materials, the allowable stresses are defined in Ch 2.

## 4 Definition and symbols

### 4.1 General

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

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

### 4.2 Symbols

#### 4.2.1

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

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

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

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

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

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

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

B : Maximum outside breadth, in metres.

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

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

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

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

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

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

s : Spacing of ordinary stiffeners, in metres.

S : Web frame spacing, in metres.

LH : hull lenght defined in EN ISO/ 8666.

## 4.3 Definitions

### 4.3.1 Rule frame spacing

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

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

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

### 4.3.2 Superstructure

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

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

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

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

### 4.3.3 Bulkhead deck

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

### 4.3.4 Watertight bulkhead

Watertight bulkheads are bulkheads extended watertight till the deck.

### 4.3.5 Weather deck

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

#### 4.3.6 Deckhouse

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

#### 4.3.7 Weathertight

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

#### 4.3.8 Watertight

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

#### 4.3.9 Cofferdam

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

## 5 Subdivision, integrity of hull and superstructure

### 5.1 Drawings

#### 5.1.1

The following drawing to be sent for examination:

- Mid-ship section
- Transversal and longitudinal sections
- Transversal and longitudinal bulkheads
- Decks
- Lamination
- Position and details of doors, hatches, glazing, ventilation openings, scuppers, ob. discharges and air pipes

### 5.2 Number of watertight bulkheads and decks

**5.2.1** All racing yachts are to have at least the machinery enclosed in watertight bulkheads/decks.

**5.2.2** All racing yachts have to be provided with a watertight collision bulkhead within 15% of LH from the bow and abaft the forward end of LWL. As an alternative a permanently installed closed-cell foam buoyancy effectively filling the forward 30% LH of the hull.

**5.2.3** In watertight bulkhead required in [5.2.2] an access hatch is to be provided. The hatch is to have permanently attached means of watertight closure operable without keys or other tools.

#### 5.2.4 Openings in watertight bulkheads and decks

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

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

In general, when the pipe passing through the bulkhead is non-metallic, the above device is to be a 3mm steel sleeve fitted in a way to restore the structural integrity of the bulkhead, having a length of 10 D, where D is the external diameter of the pipe; the length of the above pipe is not required to be more than 400 mm.

#### 5.2.5 Watertight bulkheads and doors

Doors in watertight bulkheads are to be approved watertight doors.

#### 5.2.6 Cable transit

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

#### 5.2.7 Watertight bolted connections

As a general rule, watertight bolted connection are required to be spaced not more than 5d where d in the bolt diameter. In case of bolted connection not fitted in tanks (e.g door frames, cover of void spaces or cofferdams, or plates on bulkheads) the space may be increased up to 10d.

### 5.3 Sea connections and overboard discharge

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

The above valve may be made of non metallic material provided that the sea discharge is positioned at a point corresponding to an angle more than 10° or more than the angle corresponding to the intersection of the deck with the side, whichever is the less

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

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

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

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

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

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

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

Reference is to be made to Ch 2, Sec 1, [6.4].

Engine exhaust outlets which penetrate the hull below the freeboard deck are to be provided with means to prevent back flooding into the hull through a damaged exhaust system or the exhaust piping is looped up above the waterline on the outboard side of the system to a minimum height of 300 mm and is of equivalent construction to the hull.

### 5.4 Stern and side doors below the weather deck

#### 5.4.1 Side/shell doors

Side/shell doors located below the deck, if any, are to be watertight.

#### 5.4.2 Other fittings

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

### 5.5 Hatch on the weather deck

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

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

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

- be closed at sea;
- be fitted in a protected location close to the center line;
- have at least two drains in the aft part leading overboard;
- be fitted with gaskets;
- be provided with open/close indication in a suitable location.

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

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

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

**5.5.5** Hatches, which are required to be watertight are to be hydraulically tested.

## 5.6 Scantling of glazing

### 5.6.1 General

The scantling of glazing and relevant fixing arrangement are to be done in accordance with the Rules for the Classification of Yachts (RES 31) or EN/ ISO 11336-1 or EN/ ISO 12216.

## 5.7 Skylights

**5.7.1** The relevant locking devices are to be the same as required for flush hatches.

For the scantling of the glazing see [5.6] or EN/ ISO12216.

**5.7.2** A minimum of one portable cover for each size of glazed opening is to be provided which can be assessed rapidly and efficiently secured in the event of breakage of the skylight.

**5.7.3** Skylights which are designated for escape purposes are to be openable from either side and in the direction of escape they are to be openable without a key.

All handles on the inside are to be non-removable. An escape skylight is to be readily identified and easy and safe to use, having due regard to its position.

## 5.8 Outer doors

### 5.8.1 Doors in the superstructure's side

Doors of exposed bulkheads of superstructures are to be of adequate dimensions and construction such as to guarantee their weathertight integrity and to be hinged in the forward edge.

The use of FRP for doors on the weather deck other than machinery spaces may be accepted, providing the doors are sufficiently strong.

Where the doors are to be used as a means of escape, the securing arrangements are to be operable from both sides.

Where the doors are to be used as a means of escape, and are electrically operated they have to be also manually operable from both sides of the door in case of failure of the electrical system.

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

The height of the sills of doors above the exposed deck that give access to compartments below the deck is to be not less than 75mm.Reverse sill may be accepted provided that the following conditions are to the satisfaction of the Society.

Doors on the weather deck which give direct access to machinery spaces are to be outward opening.

Companionway have to be built using deck head.

The application of the requirements of other rules equivalent to those of this section may be evaluated by the Society.

## 5.9 Ventilation ducts

### 5.9.1 General

Accommodation spaces are to be protected from gas or vapour fumes from machinery, exhaust and fuel systems. The yacht is to be adequately ventilated throughout all spaces. The accommodation is to be protected from the entry of gas and/or vapour fumes from machinery, exhaust and fuel systems.

Ventilation ducts are to be of efficient construction and, generally, when serving any spaces below the deck or an enclosed superstructure are to have a suitable coming height.

Ventilation ducts are to be kept as far inboard as practicable and the height above the deck of the ventilation ducts openings is to be sufficient to prevent the ingress of water when the yacht heels.

Machinery spaces are to be adequately ventilated so as to ensure that, when machinery therein is operating at full power in all weather conditions, an adequate supply of air is maintained to the spaces for safety and for the operation of the machinery, according to the Manufacturer's instructions.

The design and positioning of ventilation duct openings are to be considered with care, above all in zones of high stress or in exposed zones. The deck plating in way of the coamings is to be adequately stiffened.

The scantlings of ventilation ducts exposed to the weather are to be equivalent to those of the adjacent deck or bulkhead.

Te position of the air intake may be accepted below the weather deck, provided that the following requirements are satisfied:

a) the minimum down flooding angle meets the minimum of the stability criteria

b) means are provided to the satisfaction of the Society in order to guarantee the hull integrity.

c) a bilge level alarm associated with additional automatic bilge pumps is to be provided inside the compartments

where such ducts are fitted

d) the openings are fitted, as far as practicable, close to the weather deck and in any case are as small as possible.

Ventilation ducts which, for any reason, can be subjected to liquid pressure are to be made watertight and have scantlings suitable for withstanding the foreseen pressure.

### 5.9.2 Closing appliances

All ventilation ducts openings are to be provided with efficient weathertight closing appliances.

As a general rule, closing appliances are to be permanently attached to the ventilation ducts coaming.

Ventilation ducts are to be fitted with a suitable means of preventing ingress of water and spray when open and have a suitable drainage arrangements leading overboard.

## 5.10 Air pipes

### 5.10.1 General

Air pipes serving fuel and other tanks is to be of efficient construction, be fitted with a coming of sufficient height to prevent inadvertent flooding and provided with permanently attached means of weathertight closure. Means of closure may be omitted if it can be shown that the open and of an air pipe is afforded adequate protection by other structures which will prevent the ingress of water.

Air pipes fitted on the side of the yacht may be accepted provided that the pipe is raised to a point close to the deck.

## 5.11 Bulwarks and guardrails or guardline

### 5.11.1 General

Suitable protection from falling overboard are to be provided. EN/ ISO 15085 may be applied or another suitable national or international standard such as Lifeline in Offshore Special Regulation.

### 5.11.2 Handholds

Suitable handholds to be provided in all accessible spaces below the deck.

## 5.12 Means to reboard

### 5.12.1 General

Suitable ans to reboard and recover one person from the water are to be provided. EN/ ISO 15085 may be applied.

## 5.13 Freeing ports

**5.13.1**

Any bulwarks or guardrails are to be provided with freeing port openings having dimensions for each side not less than the value given from formula:

A = 0,035 l

Where:

A ($m^2$) = freeing port area for each side;

l (m) = length of bulwark on one side, but need not exceed 0,7 $L_{ll}$

The value given from the above formula is to be corrected for the height of the bulwarks according to the following criteria.

If the bulwark height exceeds 1,2 m, the freeing port area is to be increased by 0,004 $m^2$ per metre of bulwark length for each 0,1 m difference in height. Where the bulwark height is less than 0,9 m, the freeing port area is to be decreased by the same ratio.

On a flush deck ship with a deckhouse amidships having a breadth at least 80% of the beam of the ship and the passageways along the side of the ship not exceeding 1.5 m in width, two wells are formed. Each shall be given the required freeing port area based upon the length of each well.

Where the solid bulwark height does not exceed 150 mm, specific freeing ports, as defined above, are not required.

**5.13.2** In individual cases, when the Society considers that the above requirements cannot be met, alternative arrangements to achieve adequate safety standards may be considered and approved.

In general to accepts smaller area than that require by the formula what follows may be considered:

- The stability verification with the well flooded may allow a reduction of 50% of the required area
- The real area of the well in respect of the length of the well multiplied by the breath of the well allow a reduction
- The distance from the freeboard deck if more than a superstructure height allows a reduction of 50% of the required area, for decks located less than hs above the freeboard deck a reduction factor equal to 0,5*(hs/hv), where hv is the actual height of the deck above the freeboard deck.

**5.13.3** For superstructure deck higher than the first tier, the value given in the formula above may be multiplied by 0,5 and unsymmetric arrangement may be accepted based on an increase of at least 50% of the total area required.

**5.13.4** AS an alternative to the scantling proposed above the EN/ ISO 11812 may be accepted .

**5.13.5** In any case, the freeing ports arrangement must take into account the sloping deck, by avoiding, as far as possible, the positioning of freeing ports with a major area in the bow zone.

**5.13.6 Recesses**

Any recess in the weather deck is to be of weathertight construction and is to be self draining under all normal conditions of heel and trim of the yacht.

The means of drainage provided is to be capable of efficient operation when the yacht is heeled to an angle of 10° in the case of a motor yacht, and 30° in the case of a sailing yacht.

The drainage arrangements is to have the capability of draining the recess (when fully charged with water) within 3 minutes (see Note 1) when the yacht is upright and at the load line draught. Means are to be provided to prevent the backflow of sea water into the recess.

When it is not practical to provide drainage which meets the above requirements, alternative safety measures may be considered by the Society.

Where the above requirements for quick drainage cannot be met, the effect on intact and damage stability is to be considered taking into account the mass of water and its free surface effect.

## 5.14 Tanks

**5.14.1** "Tanks" means the structural tanks that are part of the hull and intended to contain liquids (water, fuel oil or lube oil). In order to contain fuel oil with a flashpoint 55° C, the use of non structural tanks is required.

Non structural fuel tanks are to be in accordance with Pt B, Ch 1, Sec 4 of the Rules for the Classification of Yachts (RES 31).

## 5.15 Cofferdam arrangement

**5.15.1** Cofferdams are to be provided between compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and those intended for fresh water (drinking water, ...).

**5.15.2** Cofferdams separating fuel oil tanks from lubricating oil tanks and the latter from those intended for the carriage of fresh water may not be required when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness required by 2 mm in the case of tanks carrying fresh water, and by 1 mm in all other cases
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to the required pressure head.

## 5.16 Inflatable gasket

**5.16.1** Inflatable gasket may be accepted only for doors located in superstructure not contributing to buoyancy.

## 5.17 Mast and Rigging

**5.17.1**
Unless a specific notation is required the scantlings of masts and rigging are left to the experience of the builder. Surveyor, however, have to verify that the attachments of shrouds and stays to the hull are such as to withstand at least twice the load expected on such rigging. The mast step is to be of strong construction, and is to be extended so as not to be connected to the transverse and longitudinal framing of the bottom of the hull. The wedging on deck is to be provided with watertight means. When the mast rests on deck, the underlying structure is to be strengthened in way such as to avoid giving way.

# SECTION 2 HULL OUTFITTING

## 1 Rudders and steering gear

### 1.1 Rudder

**1.1.1** For rudders reference is to be made to Sec 6.

### 1.2 Steering gear and associated apparatus

**1.2.1 General**

The steering gear and associated apparatus to be in accordance with the Manufacturer's specifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable.

## 2 Propeller shaft brackets

### 2.1 General

**2.1.1** The propeller braket is to be in accordance with the Manufacturer's specifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable.

## 3 Sailing yacht appendages and component fastenings

### 3.1 Keel and keel connection

**3.1.1** The keel and keel arrangement is to be in accordance with the Manufacturer's spcifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable

## 4 Stabiliser arrangements

### 4.1 General

**4.1.1** The stabilizer arrangement is to be in accordance with the Manufacturer's specifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable.

## 5 Thruster tunnels

### 5.1 General

**5.1.1** The thickness of the tunnel is to be in accordance with the Manufacturer's specifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable.

## 6 Water-jet drive ducts

### 6.1 General

**6.1.1** Water Jet drive ducts is to be in accordance with the Manufacturer's specifications or a suitable international standard or the requirements of the Rules for the Classification of Yachts (RES 31) as far as it is practicable.

# 7 FOILS

## 7.1 General

**7.1.1** The scantling of foiling is to be done by the Manufacturer and subject to the Society verification. The Manufacturer has to define the static and dynamic loads that the foil is supposed to be subject. The safety coefficients will be agreed with the Society at the earlies stage of design.

# SECTION 3 EQUIPMENT

## 1 General

### 1.1

**1.1.1** If anchoring equipment are forseen their scantling is to be in accordance with Pt B, Ch 1, Sec 3 of the Rules for the Classificiation of Yachts (RES 31) or another suitable national or international standard such as World Sail off shore special regulation.

## 2 Means for Towing

### 2.1

**2.1.1** Means are to be provided to tow the racing yacht also capsized.

# SECTION 4 NON-STRUCTURAL FUEL TANKS

## 1 General

### 1.1

**1.1.1** Tanks for liquid fuel are to be designed and constructed so as to withstand, without leakage, the dynamic stresses to which they will be subjected. They are to be fitted with internal diaphragms, where necessary, in order to reduce the movement of liquid.

Tanks are to be arranged so as to be accessible at least for external inspection and check of piping.

Where their dimensions permit, tanks are to include openings allowing at least the visual inspection of the interior.

Such tanks are to be separated from accommodation spaces by integral gastight bulkheads. Tanks are to be arranged in adequately ventilated spaces equipped with a mechanical air ejector.

Upon completion of construction and fitting of all the pipe connections, tanks are to be subjected to a hydraulic pressure test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

At the discretion of the Society, leak testing may be accepted as an alternative, provided that it is possible, using liquid solutions of proven effectiveness in the detection of air leaks, to carry out a visual inspection of all parts of the tanks with particular reference to pipe connections.

## 2 Metallic tanks

### 2.1 General

**2.1.1** Tanks intended to contain diesel oil are to be made of stainless steel, nickel copper, steel or aluminium alloys.

Steel tanks are to be suitably protected internally and externally so as to withstand the corrosive action of the salt in the atmosphere and the fuel they are intended to contain.

The upper part of tanks is generally not to have welded edges facing upwards or be shaped so as to accumulate water or humidity.

To this end, zinc plating may be used, except for tanks intended to contain diesel oil, for which internal zinc plating is not permitted.

Tanks are to be effectively earthed.

### 2.2 Scantlings

**2.2.1** The thickness of metallic tank plating is to be not less than the value t, in mm, given by the following formula:

$$t = 4 \cdot s \cdot (h_s \cdot K)^{0,5}$$

where:

s : stiffener spacing, in m;

$h_S$ : static internal design head, in m, to be assumed as the greater of the following values:

- vertical distance from the pdr (see below) to a point located 2 m above the tank top
- two-thirds of the vertical distance from the pdr to the top of overflow

K : $\frac{235}{R_S}$

where $R_S$ is the minimum yield stress, in N/mm², of the tank material. Where light alloys are employed, the value of RS to be assumed is that corresponding to the alloy in the annealed condition;

pdr : point of reference, intended as the lower edge of the plate, or, for stiffeners, the centre of the area supported by the stiffener.

In any case the thickness of the tank is to be not less than 2 mm for steel and not less than 3 mm for light alloy.

The section modulus of stiffeners is to be not less than the value Z, in cm³, given by the formula:

$Z = 4 \cdot s \cdot S^2 \cdot h_S \cdot K$

where:

S : stiffener span, in m.

# 3 Non-metallic tanks

## 3.1 General

**3.1.1** Fuel tanks may be made of non-metallic materials.

The materials adopted are to withstand the corrosive action of the fuel to be carried.

The acceptance of non-metallic tanks will be subject to tests on materials (such as after immersion in the fuel to be carried).

## 3.2 Scantlings

**3.2.1** The scantlings of non-metallic tanks will be specially considered by the Society on the basis of the characteristics of the material proposed and the results of strength tests performed on a sample.

In general, for tanks made of composite material, the thickness t, in mm, of the plating and the module of stiffeners Z, in $cm^3$, are to be not less, respectively, than the values:

$t = 6 \cdot s \cdot (h_S \cdot k_{of})^{0,5}$

$Z = 15 \cdot s \cdot S^2 \cdot h_S \cdot K_0$

where:

$k_{of}$ , $k_0$ : as defined in Ch 4;

s, S, $h_S$ : as defined in [2.2].

In any case, the thickness is to be not less than 8 mm with reinforcement not less than 30% in weight fraction.

The surface of the tanks is to be internally coated with resin capable of withstanding hydrocarbons and externally coated with self-extinguishing resin.

The self-extinguishing characteristic is to be ascertained by a test carried out according to ASTM D635 on specimens having all their surface impregnated with the self-extinguishing resin used. During such test the flame speed is not to exceed 6 cm/min.

# 4 Tests on tanks

## 4.1 General

**4.1.1** Prior to their installation on board, tanks are to be subjected to a hydraulic pressure test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

On the base of additional verifications proposed by the Shipyard (such as NDT) a leak testing with an air pressure as per [4.1.2]. may be accepted by the Society as an alternative.

### 4.1.2 Leak testing

Leak testing is to be carried out by applying an air pressure of 0,15 bar.

Prior to inspection of the tightness of welding, in the case of metallic tanks and pipe connections, it is recommended that the air pressure is raised to 0,2 bar and kept at this level for about 1 hour. The level may then be lowered to the test pressure before carrying out the welding tightness check of the tank and connections by means of a liquid solution of proven effectiveness in the detection of air leaks.

The test may be supplemented by arranging a pressure gauge and checking that the reading does not vary over time.

Leak testing is to be performed before any primer and/or coating is applied. In the case of tanks made of composite material, the test is to be carried out before the surface is externally coated with self-extinguishing resin.

### 4.1.3 Test on tanks

In the case of tanks made of composite material, the test is to be carried out before the surface is externally coated with self-extinguishing resin.

# 5 Alternatives

## 5.1 General

**5.1.1** As an alternative the tanks may be certified in accordance with EN/ISO 13591.

# SECTION 5 LOADS

## 1 General

### 1.1

**1.1.1** The static and dynamic design loads defined in this Section are to be adopted unless other value are agreed with the Designer/Shipyard.

For yachts of speed exceeding 10 $L^{0,5}$ knots or yachts of unusual shape, additional information may be required in the form of basin test results on prototypes.

Alternative methods for the determination of acceleration and loads may be taken into consideration by the Society also on the basis of model tests or experimental values measured on similar yachts, or generally accepted theories.

In such case a report is to be submitted giving details of the methods used and/or tests performed.

Pressures on panels and stiffeners may be considered as uniform and equal to the value assumed in the point of reference pdr as defined in [2.3].

## 2 Definitions and symbols

### 2.1 General

**2.1.1** The definitions of the following symbols are valid for all of Pt B. The meanings of those symbols which have specific validity are specified in the relevant Chapters or Sections.

### 2.2 Definitions

#### 2.2.1 Chine

In hulls without a clearly visible chine, this is the point of the hull in which the tangent to the hull has an angle of 50° on the horizontal axis.

#### 2.2.2 Bottom

The bottom is that part of the hull between the keel and the chines.

#### 2.2.3 Side Shell

The side shell is that part of the hull between the chine and the highest continuous deck.

### 2.3 Symbols

#### 2.3.1

$\beta_x$ : Deadrise of the transverse section under consideration.

In hulls without a clearly visible deadrise, this is the angle formed by the horizontal axis and the straight line joining keel and chine.

$Pp_{AV}$ : Forward perpendicular: perpendicular at the intersection of the full load waterline plane (with the yacht stationary in still water) and the fore side of the stem.

$Pp_{AD}$ : Aft perpendicular: perpendicular at the intersection of the full load waterline plane (with the yacht stationary in still water) and the aft side of the sternpost or transom.

pdc : Design deck, intended as the first deck above the full load waterline, extending for at least 0,6 L and constituting an effective support for side structures.

pdr : Point of reference, intended as the lower edge of the plating panel or the centre of the area supported by the stiffener, depending on the case under consideration.

$\Delta$ : Displacement, in t, of the yacht at full load draught T. Where unknown, to be assumed equal to $0,42 \cdot L \cdot B \cdot T$.

$C_B$ : Block coefficient, given by the relationship:

$$C_B = \frac{\Delta}{1,025L \cdot B \cdot T}$$

$C_S$ : Support contour of the yacht, in m, defined as the transverse distance, measured along the hull, from the chines to 0,5 L. For twin hull yachts, $C_S$ is twice the distance measured along the single hull.

g : Acceleration of gravity = 9,81 m/s$^2$.

LCG : Longitudinal centre of gravity of the yacht; where unknown, to be taken as located in the section at 0,6 L from the $Pp_{AV}$.

$a_{CG}$ : Maximum design value of vertical acceleration at LCG, in g, provided by the Designer based on an assessment of the service conditions (speed, significant wave height) envisaged in the design.

V : Maximum service speed, in knots.

## 3 Design acceleration

### 3.1 Vertical acceleration at LCG

#### 3.1.1 General

The design vertical acceleration at LCG, $a_{CG}$ (expressed in g), is defined by the Designer and corresponds to the average of the 1% highest accelerations in the most severe sea conditions expected. Generally, it is to be not less than:

$$a_{CG} = S \cdot \frac{V}{L^{0,5}}$$

where S is given by:

$$S = 0,65C_F$$

where:

$$C_F = 0,2 + [0,6 / (V / L^{0,5})] \geq 0,32$$

Values of S reduced to as low as 80% of the foregoing value may be accepted, at the discretion of the Society, if justified on the basis of the results of model tests or prototype tests.

The sea area to which the aforementioned value refers is defined with reference to the significant wave height $H_S$ which is exceeded for an average of not more than 10% of the year:

- Open-sea service: $H_s \geq 4,0$ m;

If the design acceleration cannot be defined by the Designer, the $a_{CG}$ value corresponding to the value of S calculated with the above-mentioned formula is to be assumed.

#### 3.1.2 Longitudinal distribution of vertical acceleration

The longitudinal distribution of vertical acceleration along the hull is given by:

$$a_v = k_v \cdot a_{CG}$$

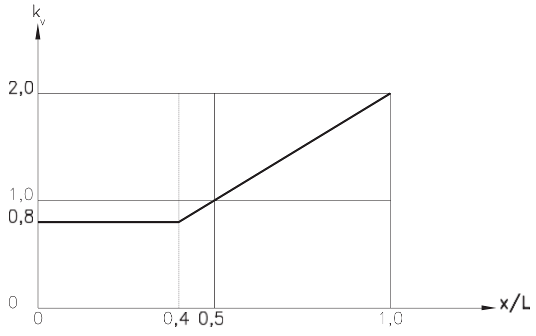
where:

$K_V$ : Longitudinal distribution factor, defined in Fig 1, equal to 2.x/L or 0,8, whichever is the greater, where x is the distance, in m, from the calculation point to the aft perpendicular;

$a_{CG}$ : Design acceleration at LCG (see [3.1]).

Variation of $a_V$ in the trasverse direction may generally be disregarded.

**Figure 1**



### 3.2 Transverse acceleration

**3.2.1** Transverse acceleration, to be used in direct calculations for yachts with many tiers of superstructure for which significant racking effects are anticipated, is defined on the basis of model tests and full-scale measurements.

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

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

where:

$H_{sl}$ : permissible significant wave height, in m, at speed V

r : distance of the calculation point from:

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

## 4 Overall loads

### 4.1 General

**4.1.1** Overall loads may be calculated in accordance with Pt B, Ch 1, Sec 4 of the Rules for the Classification of Yachts (RES 31) or may be agreed with the Designer/Shipyard.

## 5 Local loads

### 5.1 General

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

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

External pressure generally determines the scantlings of side and bottom structures, whereas internal loads generally determine the scantlings of deck structures.

Where internal loads are caused by concentrated masses of significant magnitude (e.g. tanks, machinery), the capacity of the side and bottom structures to withstand such loads is to be verified according to criteria stipulated by the Society. In such cases, the inertial effects due to acceleration of the yacht are to be taken into account.

Such verification is to disregard the simultaneous presence of any external wave loads acting in the opposite direction to internal loads.

### 5.2 Load points

**5.2.1** Pressure on panels and strength members may be considered uniform and equal to the pressure at the following load points:

- for panels:
  lower edge of the plate, for pressure due to hydrostatic head and wave load;
- for strength members:
  centre of the area supported by the element.

Where the pressure diagram shows cusps or discontinuities along the span of a strength member, a uniform value is to be taken on the basis of the weighted mean value of pressure calculated along the length of the member.

### 5.3 Design pressure for the bottom

#### 5.3.1 General

The design pressure p, in kN/m², for the scantlings of structures on the bottom of the hull, plating and stiffeners is to be assumed as equal to the greater of the values $p_1$ and $p_2$ defined as follows:

$$p_1 = 0,24L^{0,5} \cdot \left(1 - \frac{h_0}{2T}\right) + 10 \cdot (h_0 + a \cdot L)$$

$$p_2 = 15 \cdot (1 + a_V) \cdot \frac{\Delta}{L \cdot C_S} \cdot g \cdot F_L \cdot F_1 \cdot F_a$$

$h_0$ : vertical distance, in m, from the pdr to the full load waterline;

a : coefficient function of the longitudinal position of pdr, equal to:

- 0,036 aft of 0,5 L
- 0,04/($C_B$ - 0,024) in way of $Pp_{AV}$
- values for intermediate positions obtained by linear interpolation;

$F_L$ : coefficient given in Fig 3 as a function of the longitudinal position of the pdr;

$F_1$ : coefficient function of the shape and inclination of the hull to be taken > 0,4 given by:

$$\left( F_1 = \frac{50 - \beta_X}{50 - \beta_{LCG}} \right) \geq 0,4$$

where $b_{LCG}$ is the deadrise angle, in degrees, of the section in way of the $L_{CG}$;

$F_a$ : coefficient given by:

$$F_a = 0,30 - 0,15 \cdot \log\left(\frac{1,43 \cdot A_1 \cdot T}{\Delta}\right)$$

where $A_1$ is the surface, in m$^2$, of the plating panel considered or the surface of the area supported by the stiffener;

$a_V$ : maximum design value of vertical acceleration, in g, at the transverse section considered.

The pressure $p_1$ is, in any case, not to be assumed as < 10 D.

## 5.4 Design pressure for the side shell

### 5.4.1 General

The pressure p, in kN/m$^2$, for the scantlings of side structures, plating and associated stiffeners is to be taken as equal to the value $p_1$, defined as follows:

$$p_1 = 66,25 \cdot (a + 0,024) \cdot (0,15L - h_0)$$

The pressure $p_1$ in any case, not to be assumed as < 10 $h_1$, where $h_1$ is as defined in [5.4.2].

For the zones located forward of 0,3 L from the $Pp_{AV}$, the value p is to be not less than the value $p_2$ defined as follows:

$$p_2 = C_1 \{ k_V \cdot [0,6 + \text{sen}\gamma \cdot \cos(90 - \alpha)] + C_2 \cdot L^{0,5} \cdot \text{sen}(90 - \alpha) \}^2$$

where:

a, $h_0$ : as defined in [5.3.1]

$C_1$ : coefficient given by Fig 4 as a function of the load surface A, in m$^2$, bearing on the element considered; for plating, A = 2,5s is to be taken

$C_2$ : coefficient given by Fig 5 as a function of $C_B$ and the longitudinal position of the element considered

$k_V$ : 0,625 . $L^{1/2}$ + 0,25V

$\alpha$ : angle formed at the point considered by the side and the horizontal axis (see Fig 6)

$\gamma$ : angle formed by the tangent at the waterline, corresponding to the draught T, taken at the point of intersection of the transverse section of the element considered, with the above waterline and the longitudinal straight line crossing the above intersection (see Fig 7).

The value $p_2$ may, in any case, be assumed as not greater than 0,5p, where p is the design pressure for the bottom as defined in [5.3.1], calculated at the section considered.

## 5.5 Design heads for decks

**5.5.1** The design heads, hd in m, for the various decks are shown in Tab 1.

Sheltered areas are intended to mean decks intended for accommodation.

The design heads shown in Tab 1 assume a uniformly distributed load with mass density of 0,7 t/m$^3$ and a consequent load per square metre of deck, in kN/m$^2$, equal to 6,9 $h_d$.

Where distributed loads with mass density greater or lower than the above are envisaged, the value $h_d$ will be modified accordingly.

In the case of decks subject to concentrated loads, the scantlings of deck structures (plating and stiffeners) will also need to be checked with the aforementioned loads. Different values may be agreed with the Designer/Shipyard.

**Table 1**

| Deck | EXPOSED WEATHER AREA | | SHELTERED AREA (also partially by deckhouses) |
|---|---|---|---|
| | FWD 0,075 L from FWD PP | AFT 0,075 L from FWD PP | |
| | $h_d$ | $h_d$ | $h_d$ |
| Deck below pdc | - | - | 0,9 |
| pdc | 1,5 | 1,0 | 0,9 |
| Decks over pdc | 1,2 | 0,9 | 0,7 |

## 5.6 Design heads for watertight bulkheads

### 5.6.1 Subdivision bulkheads

The scantlings of subdivision bulkheads, plating and associated stiffeners are to be verified assuming a head $h_B$ equal to the vertical distance, in m, from the pdr to the highest point of the bulkhead.

### 5.6.2 Tank bulkheads

The scantlings of tank bulkheads, plating and associated stiffeners are to be verified assuming as $h_T$, in m, the greater of the following values:

- vertical distance from the pdr to a point located at a height h, in m, above the highest point of the tank given by:

  $$h_T = [1 + 0,05(L - 50)]$$

  where the value of L is to be taken no less than 50 m and no greater than 80 m
- 2/3 of the vertical distance from the pdr to the top of the overflow pipe.

**Figure 2**

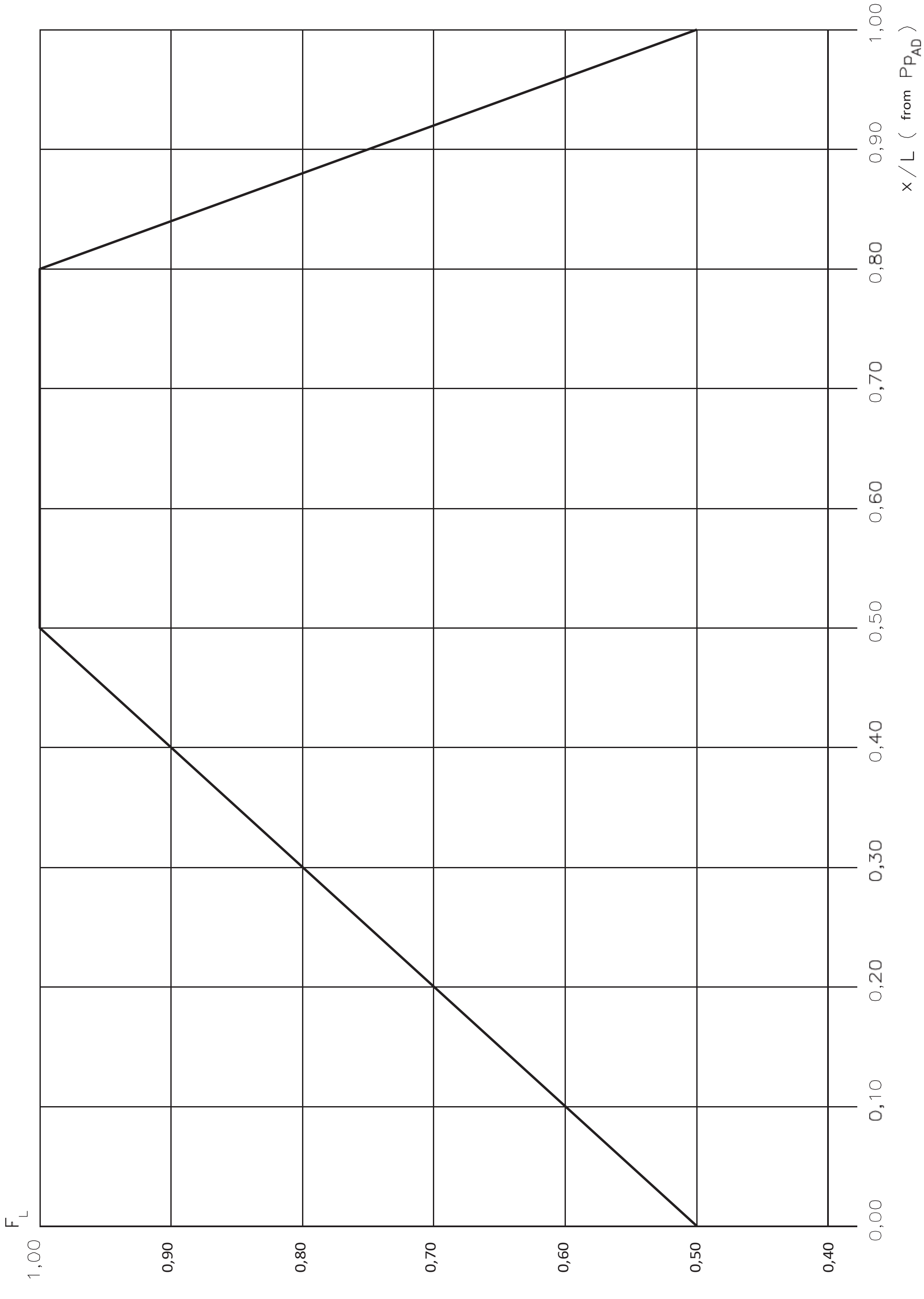

x / L ( from $P_{PAD}$ )
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
1,00
$F_L$
1,00
0,90
0,80
0,70
0,60
0,50
0,40

**Figure 3**

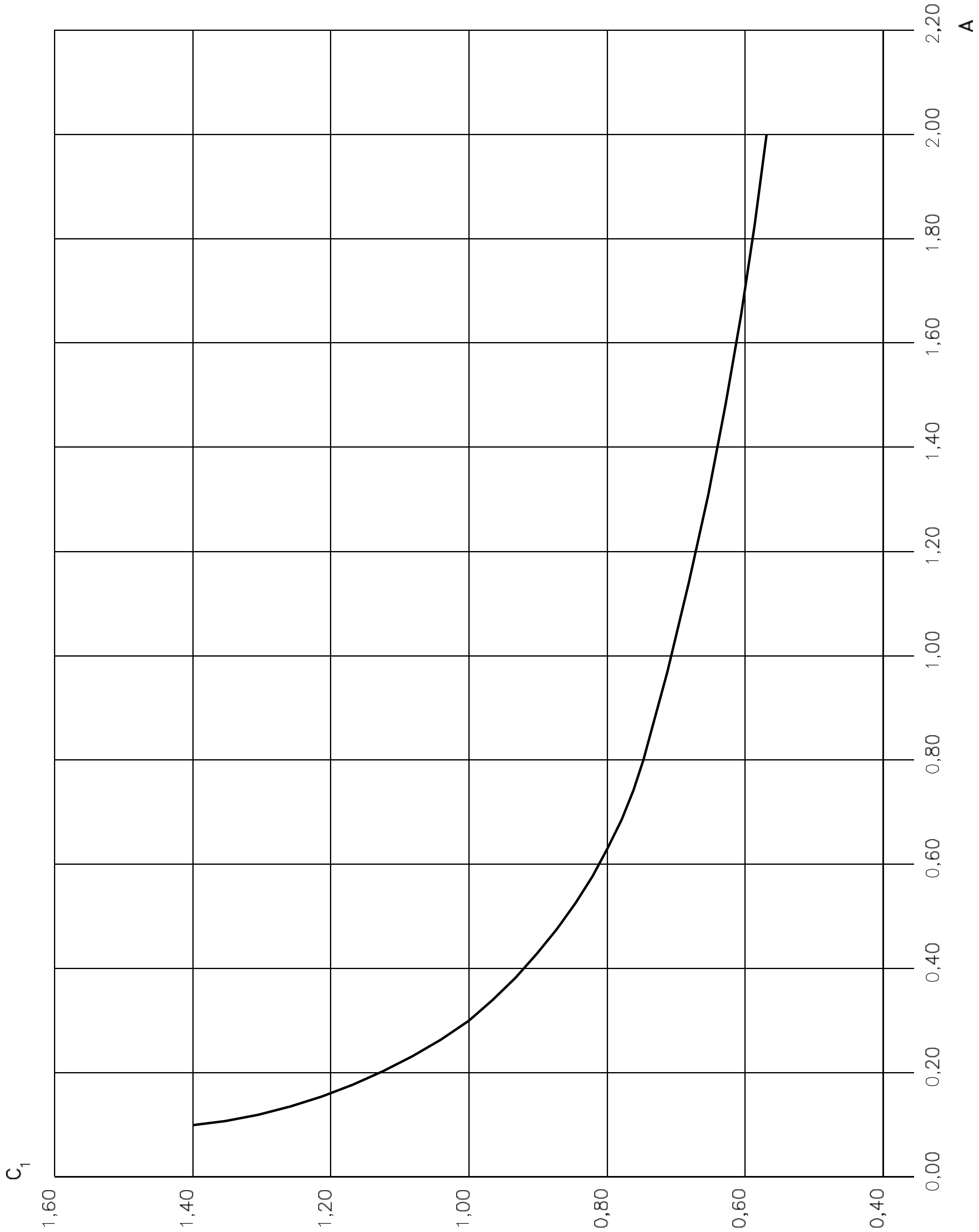
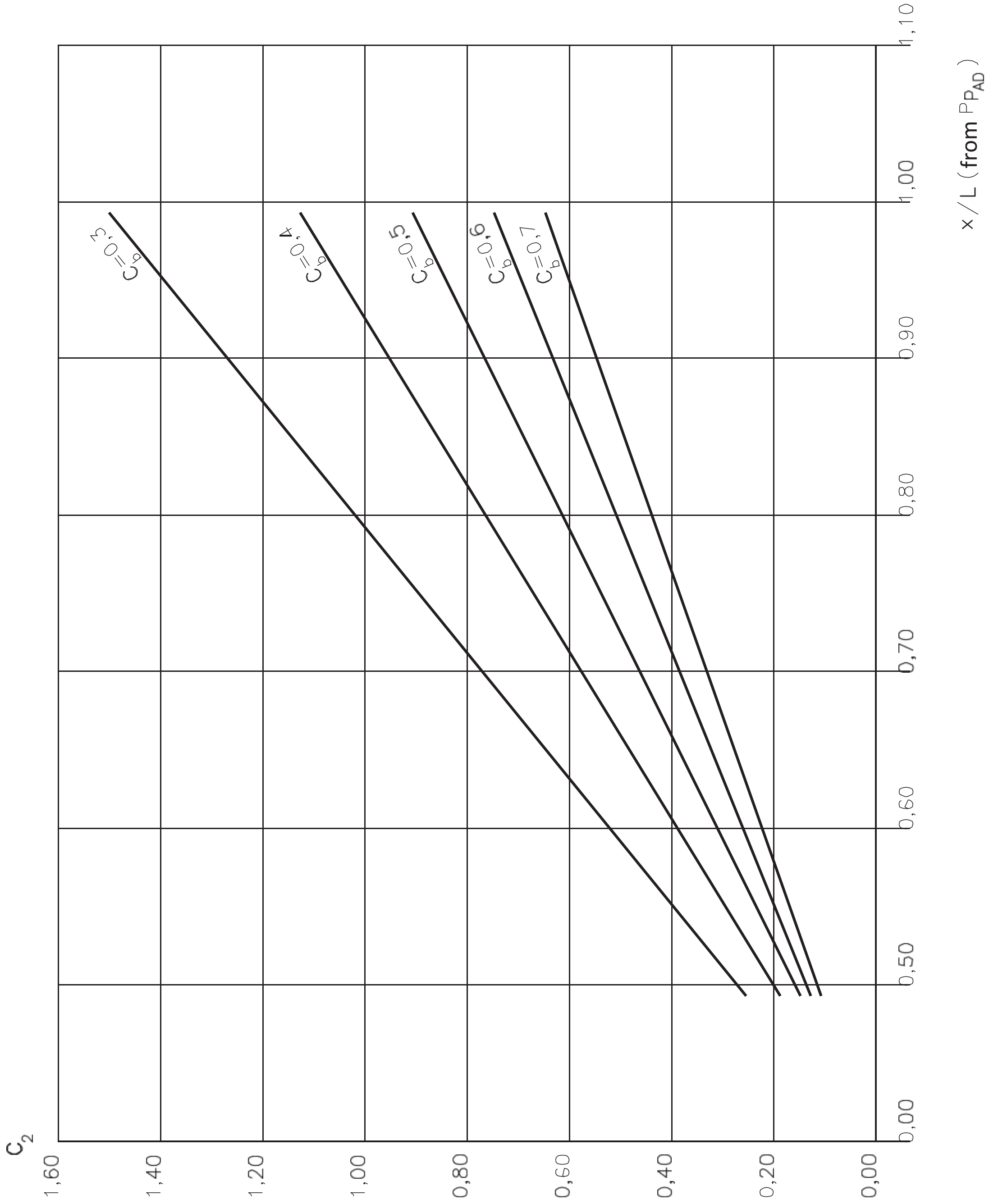

A
2,20
2,00
1,80
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
$C_1$
1,60
1,40
1,20
1,00
0,80
0,60
0,40

**Figure 4**



$C_2$
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
0,50
0,60
0,70
0,80
0,90
1,00
1,10
x / L ( from $P_{P_{AD}}$ )
$C_b$=0,3
$C_b$=0,4
$C_b$=0,5
$C_b$=0,6
$C_b$=0,7

**Figure 5**

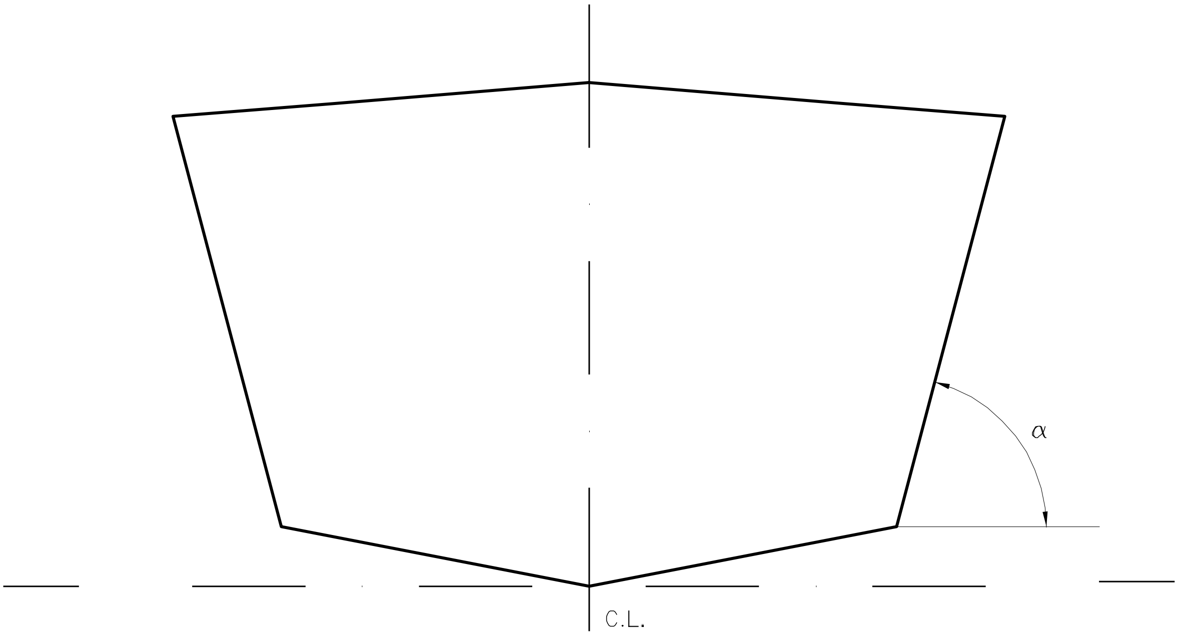
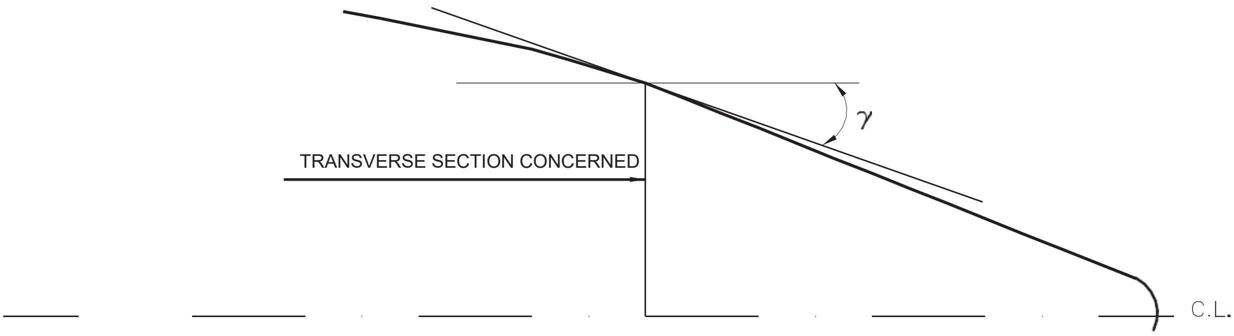



**Figure 6**



# SECTION 6 RUDDERS

## 1 General

### 1.1 Application

#### 1.1.1 General

The scantling of the rudder is to be in accordance with the Rules for the Classification of Yachts (RES 31) Pt B, Ch 1, Sec 6 using nt=0,2 or as an alternative in accordance with EN/ ISO 12215.

# Chapter 2

COMPOSITE

# SECTION 1 GENERAL REQUIREMENTS

## 1 Field of application

### 1.1

**1.1.1** Chapter 4 of Section B applies to monohull yachts with hulls made of composite materials and a length L not exceeding 60 m, with sail power with or without auxiliary engines.

Multi-hulls or hulls with a greater length will be considered on a case-by-case basis.

In the examination of constructional plans, the Society may take into consideration material distribution and structural scantlings other than those that would be obtained by applying these regulations, provided that structures with longitudinal, transverse and local strength not less than that of the corresponding Rule structure are obtained or provided that such material distribution and structural scantlings prove adequate, in the opinion of the Society, on the basis of direct test calculations of the structural strength.

## 2 Definitions and symbols

### 2.1 Premise

**2.1.1** The definitions and symbols in this Article are valid for all the Sections of this Chapter.

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

### 2.2 Symbols

**2.2.1**

$\gamma_r$ : density of the resin; standard value 1,2 g/cm$^3$;

$\gamma_v$ : density of the fibres; standard value for glass fibres 2,56 g/cm$^3$;

p : mass per area of the reinforcement of a single layer, in g/m$^2$;

q : total mass per area of a single layer of the laminate, in g/m$^2$;

$g_c$ : p/q = content of reinforcement in the layer; for laminates in glass fibre the most frequent maximum values of gc are the following, taking into account that reinforcements are to be "wet" by the resin matrix and compacted therein: 0,34 for reinforcements in mat or cut filaments, 0,5 for reinforcements in woven roving or cloth;

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

Q : total mass per area of the laminate, in gm$^2$, excluding the surface coating of resin;

$G_c$ : P/Q = content of reinforcement in the laminate; for laminates with glass fibre reinforcements the value of $G_C$ is to be not less than 0,30;

$t_i$ : thickness of a single layer of the laminate, in mm. In the case of glass reinforcements such thickness is given by:

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

p being expressed in kg/m$^2$;

$t_F$ : $St_i$ = total thickness of the laminate.

### 2.3 Definitions

**2.3.1**

**Reinforced plastic**:a composite material consisting mainly of two components, a matrix of thermosetting resin and of fibre reinforcements, produced as a laminate through moulding;

**Reinforcements**:reinforcements are made up of an inert resistant material matrix of thermosetting resin and of fibre reinforcements, encapsulated in the matrix (resin) to increase its resistance and rigidity. The reinforcements usually consist of glass fibres or other materials, such as aramid or carbon type fibres;

**Single-skin laminate**:reinforced plastic material with, in general, the shape of a flat or curved plate, or moulded.

**Sandwich laminate** :material composed of two single-skin laminates, structurally connected by the interposition of a core of light material.

## 3 Plans, calculations and other information to be submitted

### 3.1

**3.1.1** Plans with the scantlings, the layout and the major structures of the hull are to be submitted to the Society for examination sufficiently in advance of commencement of the laminating of the hull. See Ch 1, Sec 1, [5].

The plans are to indicate the scantlings and the minimum mechanical properties of the laminates as well as the percentage in mass of the reinforcement in the laminate.

The above-mentioned plans are also to contain the associated lamination details, the percentage in mass of the reinforcement, the type of resin, the core material characteristics, the sandwich construction process and the type of structural adhesive used (if any). In the case of reinforcements other than glass, the minimum mechanical properties of the laminate are to be indicated.

A list of all materials used in the construction including the commercial name and the relevant characteristics of each component such as gel coat, resin, fibre reinforcement, core material, fire retardant additives or resins, adhesive, core bonding materials, details of the process of sandwich construction and details of the materials used for granting reserve of buoyancy (and method of installation) is to be sent with the initial submission of the plans and a copy of this list is to be provided to the attending Surveyor.

The list above is for guidance purposes only; in particular, the same plan may be relative to one or more of the subjects indicated.

Furthermore, for documentation purposes, copies of the following plans are to be submitted:

- general arrangement;
- capacity plan;
- lines plan;

### 3.2

**3.2.1** If a Builder for the construction of a new yacht of a standard design wants to use drawings already approved for a yacht similar in design and construction and classed with the same class notation and the same navigation, the drawings may not be sent for approval, but the Request of Survey for the yacht shall be submitted enclosed to a list of the drawings the Builder wants to refer to and copy of the approved drawings are to be sent to the Society.

It's the Builder responsibility to submit for approval any modification to the approved plans prior to the commencement of any work.

Plan approval of standard design yachts is only valid so long as no applicable Rule changes take place. When the Rules are amended, the plans are to be submitted for new approval.

## 4 Direct calculations

### 4.1

**4.1.1** As an alternative to those based on the formulae in this Chapter, scantlings may be obtained by direct calculations carried out in accordance with the provisions of Ch 1, Sec 1.

Chapter 1 provides schematisations, boundary conditions and loads to be used for direct calculations.

The scantlings of the various structures are to be such as to guarantee that stress levels do not exceed the allowable values stipulated in Tab 1. The values in column 1 are to be used for the load condition in still water, while those in column 2 apply to dynamic loads.

**Table 1**

| Member | Allowable stresses | |
|---|---|---|
| | 1 | 2 |
| Keel, bottom plating | 0,4 s | 0, 8 s |
| Side plating | 0,4 s | 0,8 s |
| Deck plating | 0,4 s | 0,8 s |
| Bottom longitudinals | 0,6 $s_t$ | 0,9 $s_t$ |
| Side longitudinals | 0,5 $s_t$ | 0,9 $s_t$ |
| Deck longitudinals | 0,5 $s_t$ | 0, 9 $s_t$ |
| Floors and girders | 0,4 $s_t$ | 0,8 $s_t$ |
| Frames and reinforced side stringers | 0,4 $s_t$ | 0,8 $s_t$ |
| Reinforced beams and deck girders | 0,4 $s_t$ | 0,8 $s_t$ |

**Note 1:**
$\sigma$(N/mm$^2$): the ultimate bending strength for single-skin laminates; the lesser of the ultimate tensile strength and the ultimate compressive strength for sandwich type laminates. In this case the shear stress in the core is to be no greater than 0,5 $R_t$ where $R_t$ is the ultimate shear strength of the core material;
$\sigma_t$(N/mm$^2$): the ultimate tensile strength of the laminate.

# 5 General rules for design

## 5.1

**5.1.1** The hull scantlings required in this Chapter are in general to be maintained throughout the length of the hull.

For yachts with length L greater than 30 m, reduced scantlings may be adopted for the fore and aft zones.

In such case the variations between the scantlings adopted for the central part of the hull and those adopted for the ends are to be gradual.

In the design, care is to be taken in order to avoid structural discontinuities in particular in way of the ends of superstructures and of the openings on the deck or side of the yacht.

Such spacing is to be suitably reduced in the areas forward of amidships subject to the forces caused by slamming.

# 6 Construction

## 6.1 Principles of building

### 6.1.1 Definitions

The stiffeners with the lowest spacing are defined in this Chapter as ordinary stiffeners.

Depending on the direction of ordinary stiffeners, a structure is made of one of the following systems:

- longitudinal framing,
- transverse framing.

Ordinary stiffeners are supported by structural members, defined as primary stiffeners, such as:

- keelsons or floors,
- stringers or web frames,
- reinforced beams or deck stringers.

### 6.1.2 General provisions

The purpose of this item [6.1.2] is to give some recommended structural details. However, they do not constitute a requirement; different details may be proposed by builders and agreed upon by the Society, provided that builders give justifications, to be defined in each special case.

Arrangements are to be made to ensure the continuity of longitudinal strength:

- in areas with change of stiffener framing,
- in areas with large change of strength,
- at connections of ordinary and primary stiffeners.

Arrangements are to be made to ensure the continuity of transverse strength in way of connections between hulls of catamarans and axial structure.

Structure discontinuities and rigid points are to be avoided; when the strength of a structural element is reduced by the presence of an attachment or an opening, proper compensation is to be provided.

Openings are to be avoided in highly stressed areas, in particular at ends of primary stiffeners, and for webs of primary stiffeners in way of pillars.

If necessary, the shape of openings is to be designed to reduce stress concentration.

In any case, the corners of openings are to be rounded.

Connections of the various parts of a hull, as well as attachment of reinforcing parts or hull accessories, can be made by moulding on the spot, by bonding separately moulded, or by mechanical connections.

Bulkheads and other important reinforcing elements are to be connected to the adjacent structure by corner joints (see Fig 1) on both sides, or equivalent joints.

The mass per $m^2$ of the corner joints is to be at least 50% of the mass of the lighter of the two elements to be fitted, and at least 900 $g/m^2$ of mat or its equivalent.

The width of the layers of the corner joints is to be worked out according to the principle given in Fig 1.

The connection of the various parts of the hull, as well as connection of reinforcing members to the hull, can be made by adhesives, subject to special examination by the Society.

#### 6.1.3 Plates

The edges of the reinforcements of one layer are not to be juxtaposed but to overlap by at least 50 mm; these overlaps are to be offset between various successive layers.

Prefabricated laminates are fitted by overlapping the layers, preferably with chamfering of edges to be connected.

The thickness at the joint is to be at least 15% higher than the usual thickness.

Changes of thickness for a single-skin laminate are to be made as gradually as possible and over a width which is, in general, not to be less than thirty times the difference in thickness, as shown in Fig 2.

The connection between a single-skin laminate and a sandwich laminate is to be carried out as gradually as possible over a width which is, in general, not to be less than three times the thickness of the sandwich core, as shown in Fig 3.

a) **Deck-side shell connection**

This connection is to be designed both for the bending stress shown in Fig 4, caused by vertical loads on deck and horizontal loads of sea water, and for the shear stress caused by the longitudinal bending.

In general, the connection is to avoid possible loosening due to local bending, and ensure longitudinal continuity. Its thickness is to be sufficient to keep shear stresses acceptable.

Fig 5 to Fig 8 give examples of deck-side shell connections.

b) **Bulkhead-hull connection**

In some cases, this connection is needed to distribute the local load due to the bulkhead over a sufficient length of hull. Fig 9 and Fig 10 give possible solutions. The scantlings of bonding angles are determined according to the loads acting upon the connections.

The builder is to pay special attention to connections between bulkheads of integrated tanks and structural members.

c) **Passages through hull**

Passages of metal elements through the hull, especially at the level of the rudder stock, shaft brackets, shaft line, etc., are to be strongly built, in particular when subjected to alternating loads.

Passages through the hull are to be reinforced by means of a plate and counterplate connected to each other.

d) **Passages through watertight bulkheads**

The continuous omega or rectangle stiffeners at a passage through a watertight bulkhead are to be watertight in way of the bulkhead.

e) **Openings in deck**

The corners of deck openings are to be rounded in order to reduce local stress concentrations as much as possible, and the thickness of the deck is to be increased to maintain the stress at a level similar to the mean stress on the deck.

The reinforcement is to be made from a material identical to that of the deck.

### 6.1.4 Stiffeners

Primary stiffeners are to ensure structural continuity.

Abrupt changes in web height, flange breadth and cross-sectional area of web and flange are to be avoided.

In general, at the intersection of two stiffeners of unequal sizes (longitudinals with web frames, floors, beams or frames with stringers, girders or keelsons), the smallest stiffeners (longitudinals or frames) are to be continuous, and the connection between the elements is to be made by corner joints according to the principles defined in [6.1.2].

Fig 11 to Fig 13 give various examples of stiffeners.

Connections between stiffeners are to ensure good structural continuity. In particular, the connection between deck beam and frame is to be ensured by means of a flanged bracket. However, some types of connections without bracket may be accepted, provided that loads are light enough. In this case, stiffeners are to be considered as supported at their ends.

### 6.1.5 Pillars

Connections between metal pillars subject to tensile loads and the laminate structure are to be designed to avoid tearing between laminate and pillars.

Connections between metal pillars subject to compressive loads and the laminate structure are to be carried out by mean of intermediate metal plates. The welding of the pillar to the metal plate is to be carried out before fitting of the plate on board the yacht.

Fig 13 gives the principle for connection between the structure and pillars subject to compressive loads.

### 6.1.6 Engine seating

The engine seating is to be fitted on special girders suitably positioned between floors, which locally ensure sufficient strength in relation to pressure and weight loads.

Fig 15 gives an example of possible seating.

**Figure 1**

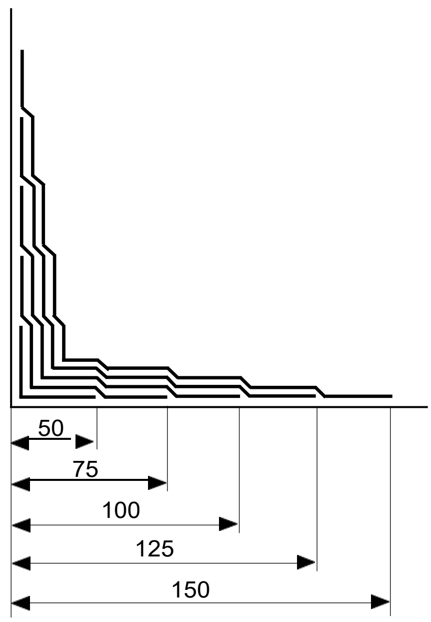



**Figure 2**

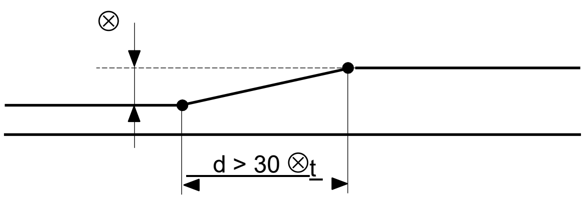


**Figure 3**

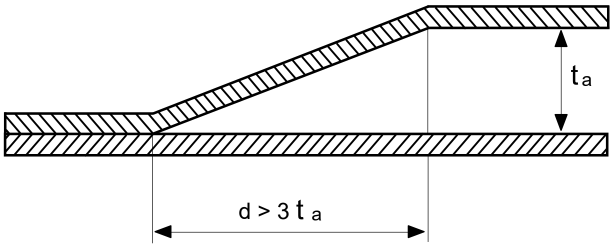



**Figure 4**

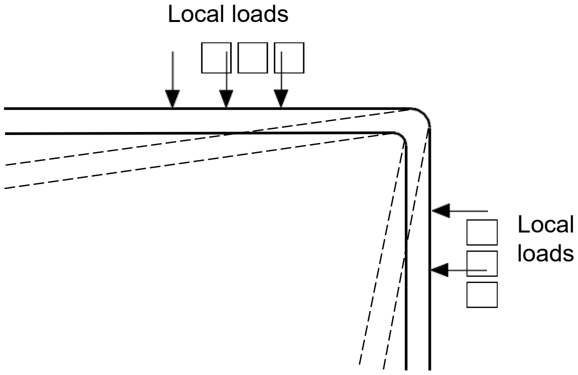



**Figure 5**

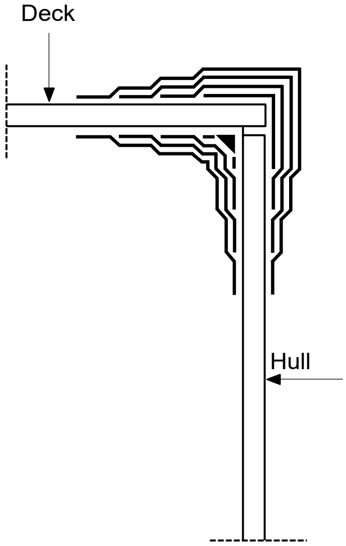


**Figure 6**

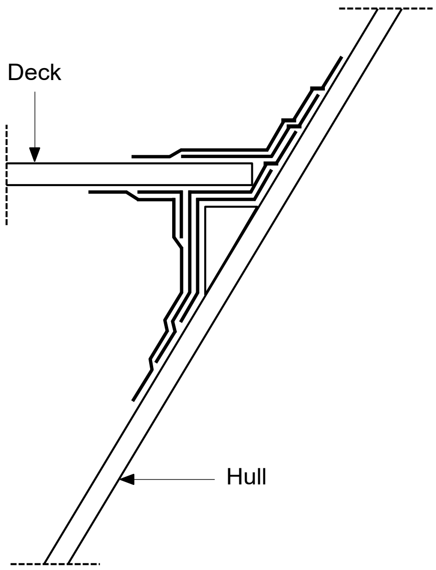



**Figure 7**

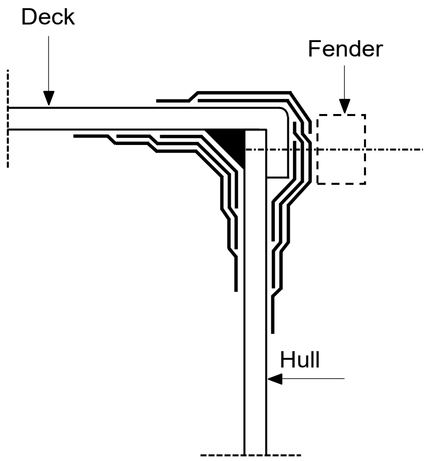



**Figure 8**

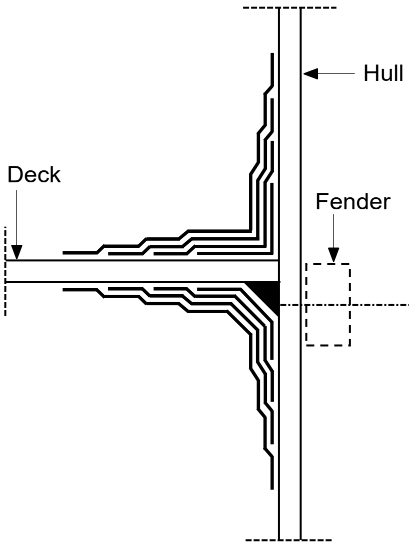


**Figure 9**

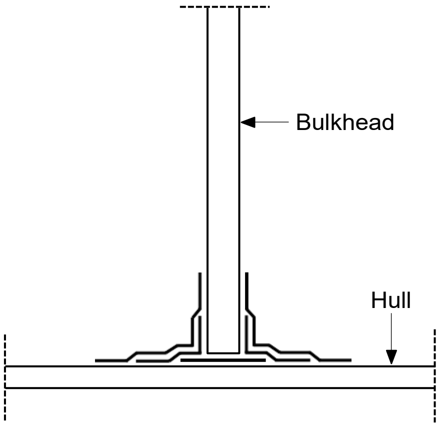



**Figure 10**

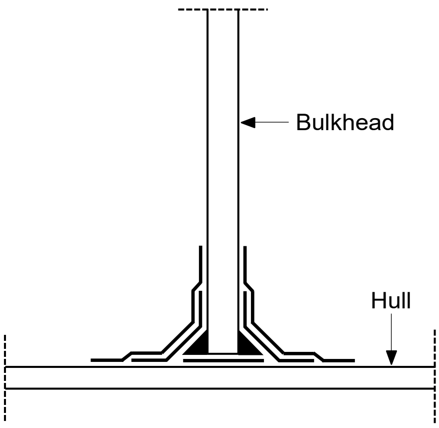



**Figure 11**

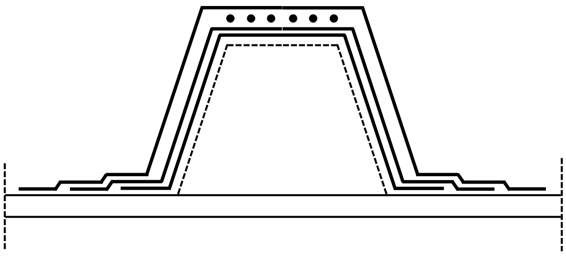


**Figure 12**

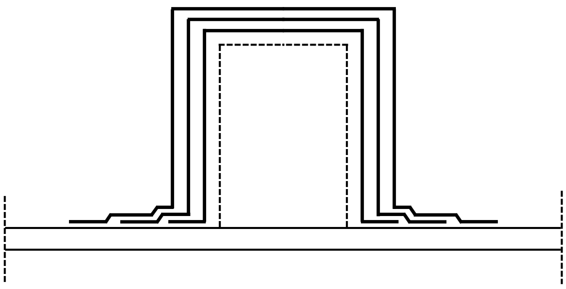


**Figure 13**

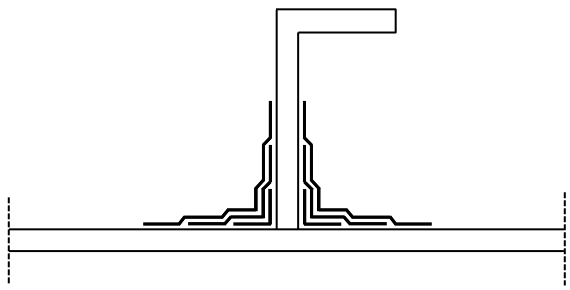


**Figure 14**

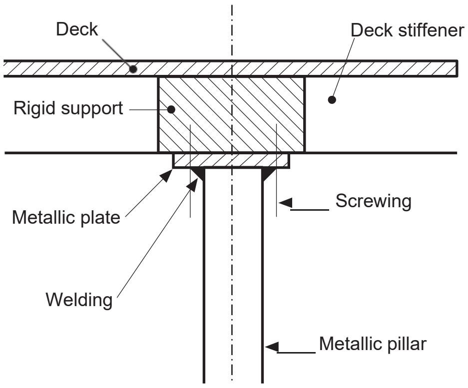
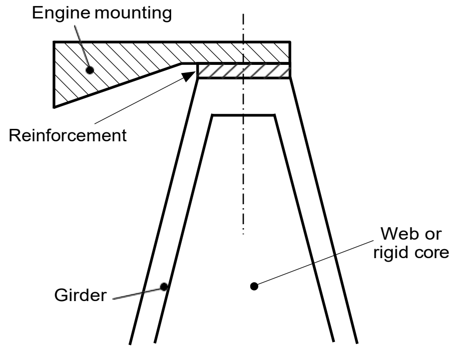



**Figure 15**




## 6.2 Engine exhaust

**6.2.1** Engine exhaust discharge arrangements made of laminates are to be of the water injection type with a normal service temperature of approximately 70° C and a maximum temperature not exceeding 120° C.

**6.2.2** The resins used for the lamination are to be type approved and to have adequate resistance to heat and to chemical agents as well as a high deflection temperature.

As a general rule, the exhaust ducts are to be internally coated with two layers of mat of 600 g/m$^2$ laminated with vinylester resin; a flame-retardant or self-extinguishing polyester resin having a thickness not less than 1,5 mm with a low deflection at high temperature may be accepted. Details of these resins are to be enclosed with the list required in [3.1.1] and general characteristics are to be reported on the relevant drawings.

**6.2.3** Additives or pigments which may impair the mechanical properties of the resin are not to be used.

## 6.3 Tanks for liquids

**6.3.1** Structural tanks are to be intended to contain fuel oil or lube oil. Integral tanks may be of single-skin laminates and sandwich construction.

For single-skin laminates and sandwich construction tanks the following requirements are to be applied:

- the final ply of the laminate is to be covered with fibreglass chopped strand mat of heavy weight (at least 600 gr/m$^2$). Alternatively, the internal thickness of the tanks is to be not less than 10 mm;
- the internal surface of the tanks is to have a heavy resin coat, which may incorporate a light fibre tissue, as a barrier to prevent any undue absorption by the laminate. This may be carried out with the use of special resin (isophaltic type) resistant to hydrocarbons. Alternatively, a suitable thickness of gel coat is to be applied;
- stiffeners are not to penetrate the tank boundaries so that, in the event of a fracture of the laminate or frame, the oil will not travel some distance along the continuous glass fibres due to a capillary action. Accordingly, the tank is to be isolated by means of diaphragms made of laminates to form the final internal barrier layer against oil absorption;
- the outer surfaces of the tanks are to be coated with a fire-retardant paint or resin.

  In addition for sandwich construction tanks the following requirements are to be applied:
- the cores are to be end grain balsa or closed cell polyvinylchloride foam;
- each balsa block is to be individually set with the space around it filled with resin.

**6.3.2** Mechanical tests are to be carried out on samples of the laminate "as is" and after immersion in the fuel oil at ambient temperature for a week. After the immersion the mechanical properties of the laminate are to be not less than 80% of the value of the sample "as is". For scantling calculations the mechanical characteristics obtained by the mechanical tests are to be assumed.

**6.3.3** Where the tank is formed by plywood bulkhead, its surface is to completely protected against the ingress of liquid by means of a layer of laminate of at least 4 mm in thickness.

**6.3.4** Tanks, complete with all pipe connections, are to be subjected to a hydraulic pressure test with a head above the tank top equal to h, as defined in Ch 1, Sec 5, or to the overflow pipe, whichever is the greater.

On the base of additional verifications proposed by the Shipyard (such as NDT) a leak testing with an air pressure as per Ch 1, Sec 4, [4.1.2] may be accepted by the Society as an alternative.

## 7 Plating attached to griders

### 7.1 Primary supporting members

#### 7.1.1

The section modulus and the moment of inertia of primary supporting members are to be calculated in association with an effective area $\mathbf{A_S}$, in cm$^2$, of attached load bearing plating obtained from the following:

$$A_S = 10c \cdot b_F \cdot t_S$$

where:

$$\mathbf{S}_L / \mathbf{b}_F < 8 : \mathbf{c} = 0,25 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right) - 0,016 \cdot \left(\frac{\mathbf{S}_L}{\mathbf{b}_F}\right)^2$$

for $\mathbf{S}_L / \mathbf{b}_F \geq 8 : \mathbf{c} = 1$

where:

**Girders**: primary supporting members of ordinary stiffeners such as deck girders, beams and web frames, side stringers, vertical and horizontal girders of bulkheads, floors, centre and side bottom girders, and similar.

**Ordinary stiffeners**: supporting members of shell plating, decks, double bottom or tank top plating, bulkheads, and similar.

$\mathbf{S}_L$ : overall length of the girder, in m

$b_F$ : actual width of the load bearing plating, i.e. one-half of the sum of the spaces between parallel stiffeners adjacent to that considered, in m

$\mathbf{t}_s$ : mean thickness, in mm, of the attached plating

$\mathbf{A}_s$ : area of the attached plating, in cm$^2$

$\mathbf{t}a$ : web thickness, in mm, in built sections

da : web depth in built sections, measured between the inside of the face plate and the inside of the attached plating, in mm

### 7.2 Ordinary stiffeners

**7.2.1** Unless otherwise stated in specific requirements, the section modulus and the moment of inertia of the ordinary stiffeners are to be calcolated in association with an effective load bearing plating having width equal to the spacing of the stiffeners and thickness equal to the mean thickness of the attached plating.

### 7.3 Special cases

**7.3.1** In way of fore and aft regions and, in general, where the web of the section is at an angle $\alpha$ less than 90° to the attached plating, the section modulus shall be calculated taking account of the inclination of the attached plating.

Where the above angle $\alpha$ is less than 75°, the section modulus of the stiffener may be approximately calculated by multiplying the section modulus of the web fitted at right angles to the attached plating by cos (90 - $\alpha$).

# SECTION 2 MATERIALS

## 1 General

### 1.1

**1.1.1** In addition to those in this Section, provisions regarding the characteristics and test and quality control procedures for the manufacture of composite materials are also specified in Pt D, Ch 6.

**1.1.2** The basic laminate considered in this Chapter is composed of an unsaturated resin, in general polyester, and of glass fibre reinforcements in the form of mat alternated with woven roving. The construction may consist of a single-skin laminate, a sandwich laminate, or a combination of both.

The reinforcement contained in the laminate is not less than 30% by weight; it is laid-up by hand, by mechanical pre-impregnation, or by spraying.

Laminates having a different composition or special systems of lay-up will be considered by the Society on a case-by-case basis upon submission of technical documentation illustrating details of the procedure.

All of the materials making up the laminates are to have properties suitable for marine use in the opinion of the Manufacturer. The products used in the production of the laminates, whether single-skin or sandwich (resins, reinforcements, stiffeners, cores, etc.), are to be type approved by the Society; any structural parts in plywood are to be made with material type approved by the Society. At the discretion of the latter, material type approved by other recognised Societies may be accepted.

## 2 Definitions and terminology

### 2.1

**2.1.1**

**Mat** : Reinforcements made up of regularly distributed filaments on the flat with no particular orientation and held together by a bond so as to form a mat that can be rolled up. The filaments may be cut to a predetermined length or continuous.

**Roving**: Made up of parallel filaments.

**Woven Roving**:Made from the weaving of roving. Due to their construction they have continuous filaments. Woven rovings of different types exist and can be differentiated by: the type of roving used in warp and weft, the name of the distribution per unit of length, respectively in warp and weft.

**Mat-woven roving**:Combined reinforcement made up of a layer of mat with cut filaments superimposed on a layer of woven roving by stitching or bonding.

**Hybrid** : Reinforcement having fibres of two or more different types; a typical example is that of glass fibre with aramid type fibre.

**Unidirectional**:Reinforcement made up of fibres that follow only one direction without interweaving.

**Biaxial** : Reinforcement made up of fibres that follow two directions (0°-90°), without interweaving.

**Quadriaxial**:Reinforcement made up of parallel fibres in the direction of filling and warp (0°, 90°) and in two oblique directions (+ 45°).

## 3 Materials of laminates

### 3.1 Resins

**3.1.1** Resins used are to be type approved by the Society for marine use.

Resins may be for laminating, i.e. form the matrix of laminates, or for surface coating (gel coat); the latter are to be compatible with the former, having mainly the purpose of protecting the laminate from external agents.

Polyester-orthophthalic type gel coat resins are not permitted. In the case of a hull constructed with a sandwich laminate on a male mould, the water resistance of the external surface will be the subject of special consideration.

Resins are to have the capacity for "wetting" the fibres of the laminate and for bonding them in such a way that the laminate has suitable mechanical properties and, in the case of glass fibre, not less than those indicated in [3.6].

The resins used are in general of the polyester, polyestervinylester or epoxide type; in any case, the resin is to have an ultimate elongation of not less than 3,0% if on the surface and 2,5% if in the laminate.

Compliant resins used in different structural applications are, as a general rule, always to be adopted in conjunction with over bonding lamination. The acceptance of structural fillets of compliant resins alone, without over bonding lamination, will be subject to special consideration after analysis of test results submitted by the Manufacturer demonstrating equivalent strength to over bonding laminates.

Resins are to be used within the limits and following the instructions supplied by the Manufacturer.

#### 3.1.2 Resins additives

Resin additives (catalysts, accelerators, fillers, wax additives and colour pigments) are to be compatible with the resins and suitable for their curing process. Catalysts which initiate the curing process of the resin and the accelerators which govern the gelling and setting times are to be such that the resin sets completely in the environmental conditions in which manufacture is carried out. The Manufacturer's recommendations for the level of catalyst and accelerator to be mixed into the resins are to be followed.

The inert fillers are not to significantly alter the properties of the resin, with particular regard to the viscosity, and are to be carefully distributed in the resin itself in such a way that the laminates have the minimum mechanical properties stated in these requirements.

Such fillers are not to exceed 13% (including 3% of any thixotropic filler) by weight of the resins.

The colour pigments are not to affect the polymerisation process of the resin, are to be added to the resin as a coloured paste and are not to exceed the maximum amount (in general 5%) recommended by the Manufacturer. The thixotropic fillers of the resins for surface coating are not to exceed 3% by weight of the resin itself.

Details of the resins additives are to be enclosed in the list required in Sec 1, [3.1.1].

#### 3.1.3 Flame-retardant additives

Where the laminate is required to have fire-retarding or flame-retardant characteristics, details of the proposed arrangements are to be submitted for examination.

Where additives are adopted for this purpose, they are to be used in accordance with the Manufacturer's instructions.

The results of tests performed by independent laboratories verifying the required characteristics are to be submitted.

Where fire-retarding or flame-retardant characteristics are required by the flag Administration, such properties are to be approved by the relevant Administration, or by the Society when authorised by the former.

Details of flame-retardant additives are to be enclosed in the list required in Sec 1, [3.1.1].

### 3.2 Reinforcements

#### 3.2.1 General

All fibre reinforcements are to be type approved by the Society. The reinforcements used and their characteristics are to be enclosed with the list required in Sec 1, [3.1.1].

The reinforcements taken into consideration in these requirements are mainly of fibres of three types: glass fibre, aramid type fibre and carbon type fibre.

The use of hybrid reinforcements obtained by coupling the above-mentioned fibres is also foreseen.

Structures can be obtained using reinforcements of one or more of the above-mentioned materials.

In the latter case the laminates may be made in alternate layers, i.e. made up of layers of one material or using hybrid reinforcements.

In any event, the manufacturing process is to be approved in advance by the Society, and to this end a technical report is to be sent illustrating the processes to be followed and the materials (resins, reinforcements, etc.) used.

Reinforcements made of materials other than the preceding may be taken into consideration on a case-by-case basis by the Society, which will stipulate the conditions for their acceptance.

The materials are to be free from imperfections, discoloration, foreign bodies, moisture and other defects and stored and handled in accordance with the Manufacturer's recommendations.

#### 3.2.2 Glass fibre

The glass generally used for the manufacture of reinforcements is that called type "E", having an alkali content of not more than 1%, expressed in $Na_2O$.

Reinforcements manufactured in "S" type glass may also be used.

Such reinforcements are to be used for the lamination in hull resin matrices, with the procedure foreseen by the Manufacturer, such that the laminates have the same mechanical properties required in the structural calculations and for "E" type glass, these not being less than those indicated in item [4].

Reinforcements in glass fibre are generally foreseen in the form of: continuous filament or chopped strand mat, roving, unidirectional woven roving and in combined products i.e. made up of both mat and roving.

#### 3.2.3 Aramid type fibres

Reinforcements in aramid type fibres are generally used in the form of roving or cloth of different weights (g/m$^2$).

Such reinforcements can be used in the manufacture of hulls either alone or alternated with layers of mat or roving of "E" type glass.

Hybrid reinforcements, in which the aramid type fibres are laid at the same time, in the same layer as "E" type glass fibres or carbon type fibres, may also be used.

#### 3.2.4 Carbon-graphite fibres

Carbon-graphite type fibres means those which are at present called "carbon" type, used in the form of products suitable to be incorporated as reinforcements by themselves or together with other materials like glass fibres or aramid type fibres, in resin matrices for the construction of structural laminates.

### 3.3 Core materials for sandwich laminates

**3.3.1** Core materials are to be type approved by the Society; these materials are to be used in accordance with the Manufacturer's instructions and the method used in the sandwich construction is to be forwarded for information purposes enclosed with the list required in Sec 1, [3.1.1]..

The materials considered in these requirements are rigid expanded foam plastics and balsa wood.

Particular care is to be given to the handling of these materials, which is to be in accordance with the Mnufacturer's recommendations.

The use of other materials will be taken into consideration on a case-by-case basis by the Society, which will decide the conditions for acceptance on the basis of a criterion of equivalence.

Polystyrene can only be used as buoyancy material.

**3.3.2** "Rigid expanded foam plastics" means expanded polyurethane (PUR) and polyvinyl chloride (PVC).

These materials, just like other materials used for cores, are to be of the closed-cell type, to be resistant to environmental agents (salt water, fuel oils, lube oils) and to have a low absorption of water.

Furthermore, they are to maintain a good level of resistance up to the temperature of 60°C and, if worked in non-rigid sheets made up of small blocks, the open weave backing and the adhesive are to be compatible and soluble in the resin of the laminate.

**3.3.3** Balsa wood is to be chemically treated against attacks by parasites and mould and oven dried immediately after cutting.

Its humidity is to be no greater than 12%; if worked in nonrigid sheets made up of small blocks, the open weave backing and the adhesive are to be compatible and soluble in the resin of the laminate.

The balsa wood is to be laid-up with its grain at right-angles to the fibres in the surface laminates.

**3.3.4** The ultimate tensile strength of the core materials is to be not less than the values indicated in Tab 1. Such characteristic is to be ascertained by tests; in any case, core materials for laminates having an ultimate tensile strength < 0,4 N/mm$^2$ are not acceptable.

**3.3.5** For the construction of sandwich structures with dry vacuum bagging techniques, core bonding paste is to be used; the characteristics are to be enclosed in the list as per Sec 1, [3.1.1]. The construction procedures of such sandwich structures will be subject to special consideration.

**Table 1**

| Material | Density (kg/m$^3$) | Minimum shear strength (N/mm$^2$) |
|---|---|---|
| Balsa end-grain | 104 | 1,6 |
| | 144 | 2,5 |

| Material | Density (kg/m$^3$) | Minimum shear strength (N/mm$^2$) |
|---|---|---|
| PVC, cross-linked | 80 | 0,9 |
| | 100 | 1,4 |
| PVC, linear | 80-96 | 1,2 |
| Polyurethane | 90 | 0,5 |

### 3.4 Adhesive and sealant material

**3.4.1** These materials are to be accepted by the Society before use. Details are to be submitted enclosed with the list required in Sec 1, [3.1.1].

### 3.5 Plywood

**3.5.1** Plywood for structural applications is to be marine plywood type approved by the Society.

Where it is used for the core of reinforcements or sandwich structures, the surfaces are to be suitably treated to enable the absorption of the resin and the adhesion of the laminate.

### 3.6 Timber

**3.6.1** The use of timber is subject to special consideration by the Society. In general, the Designer will be required to indicate on the drawings submitted the assumed characteristics such as strength and density.

### 3.7 Repair compounds

**3.7.1** Materials used for repairs are to be accepted by the Society before use.

For acceptance purposes, the Manufacturer is to submit full product details and user instructions, listing the types of repair for which the system is to be used.

Depending on the proposed uses, the Society may require some tests.

### 3.8 Type approval of materials

**3.8.1** Recognition by the Society of the suitability for use (type approval) of materials for hull construction may be requested by the Manufacturer. The type approval of resins, fibre products of single-skin laminates and core materials of sandwich laminates is carried out according to the requirements set out in the relevant RINA Rules for the Classification of Ships. Tab 2 lists the typical mechanical properties of fibres commonly used for reinforcements.

## 4 Mechanical properties of laminates

### 4.1 General

**4.1.1** The minimum mechanical properties, in N/mm$^2$, of laminates made with reinforcements of "E" type glass fibre may be obtained from the formulae given in Table 3 as a function of GC of the laminate as defined in Section 1.

These values are based on the most frequently used laminates made up of reinforcements of mat and roving type.

In the above-mentioned table, the values indicated are those corresponding to $G_C$ = 30, the minimum value allowed of the content of glass reinforcement.

The minimum mechanical properties of the glass laminates found in testing, as a function of $G_C$, are to be no less than the values obtained from the formulae in the above-mentioned table.

Laminates with reinforcements of fibres other than glass, described in [3.2], are to have mechanical properties that are in general greater than or at least equal to those given in Tab 3, the reinforcement content being equal. The Society reserves the right to take into consideration possible laminates having certain properties lower than those given in Tab 3, and will establish the procedures and criteria for approval on a case-by-case basis.

The scantlings indicated in this Chapter are based on the values of the mechanical properties of a laminate made with reinforcements in "E" type glass, with a reinforcement content equal to 0,30.

Whenever the mechanical properties of the reinforcement are greater than those mentioned above, the scantlings may be modified in accordance with the provisions of [4.2.1] below.

The mechanical properties and the percentage of reinforcement are to be ascertained, for each yacht built, from tests on samples taken preferably from the hull or, alternatively, having the same composition and prepared during the lamination of the hull (for the tests to be carried out, see Pt D, Ch 6, Sec 3).

**Table 2**

| | Specific gravity | Tensile modulus of elasticity N/mm$^2$ | Shear modulus of elasticity N/mm$^2$ | Poisson's ratio |
|---|---|---|---|---|
| E Glass | 2,56 | 69000 | 28000 | 0,22 |
| S Glass | 2,49 | 69000 | **(1)** | 0,20 |
| R Glass | 2,58 | **(1)** | **(1)** | **(1)** |
| Aramid | 1,45 | 124000 | 2800 | 0,34 |
| LM Carbon | 1,8 | 230000 | **(1)** | **(1)** |
| IM Carbon | 1,8 | 270000 | **(1)** | **(1)** |
| HM Carbon | 1,8 | 300000 | **(1)** | **(1)** |
| VHM Carbon | 2,15 | 725000 | **(1)** | **(1)** |
| **(1)** Values supplied by the Manufacturer and agreed upon with the Society prior to use | | | | |

**Table 3**

| 1 | | 2 |
|---|---|---|
| $R_m$ = ultimate tensile strength | $= 1278\ G_c^2 - 510\ G_c + 123$ | 85 |
| E = tensile modulus of elasticity | $= (37\ G_c - 4{,}75)\ .\ 10^3$ | 6350 |
| $R_{mc}$ = ultimate compressive strength | $= 150\ G_c + 72$ | 117 |
| $E_c$ = compressive modulus of elasticity | $= (40\ G_c - 6)\ .\ 10^3$ | 6000 |
| $R_{mf}$ = ultimate flexural strength | $= (502\ G_c^2 + 107)$ | 152 |
| $E_t$ = flexural modulus of elasticity | $= (33{,}4\ G_c^2 + 2{,}2)\ .\ 10^3$ | 5200 |
| $R_{mt}$ = ultimate shear strength | $= 80\ G_c + 38$ | 62 |
| G = shear modulus of elasticity | $= (1{,}7\ G_c + 2{,}24)\ .\ 10^3$ | 2750 |
| $R_{mti}$ = ultimate interlaminar shear strength | $= 22{,}5 - 17{,}5\ G_c$ | 17 |

The values of the mechanical properties are to be no less than those used for the scantling of the structures.

Where certain values are in fact found to be lower than those used for the scantlings, but no lower than 85% of the latter, the Society reserves the right to accept the laminate subject to any conditions for acceptance it may stipulate.

### 4.1.2 Mechanical properties of carbon fibre laminates

For carbon fibre laminates the following mechanical properties indicated in Tab 4 are to be assumed.

**Table 4**

| **Mechanical Properties** | **N/mm$^2$** |
|---|---|
| E = tensile module of elasticity (0° or 90° direction) | $75000\ G_C - 6730$ |
| Rm = ultimate tensile strength (0° or 90° direction) | $740\ G_C - 65$ |
| Rmc = ultimate compressive strength (0° or 90° direction) | $460\ G_C - 40$ |
| $R_{mf}$ = ultimate flexural strength | $Rmf = \frac{2,5Rm}{\left(1 + \frac{Rm}{Rmc}\right)}$ |
| Rmtc = ultimate interlaminar shear strength | 35 Mpa |

The above properties are reserved for hand laminated, woven roving and cross-plied 0/90 reinforcement high-strength carbon fibre.

For unidirectional reinforcement the following mechanical properties are to be considered.

**Table 5**

| Mechanical Properties | Parallel to the fibres | Perpendicular to the fibres |
|---|---|---|
| E = tensile module of elasticity | $151500\,G_C - 15750$ | $8025\,G_C^2 - 3150\,G_C + 3300$ |
| Rm = ultimate tensile strength | $1500\,G_C - 150$ | $38\,G_C^2 - 15\,G_C + 15$ |
| Rmc = ultimate compressive strength | $820\,G_C - 82$ | $1126\,G_C^2 - 45\,G_C + 45$ |
| $R_{mf}$ = ultimate flexural strength | $\dfrac{2,5Rm}{\left(1+\dfrac{Rm}{Rmc}\right)}$ | $\dfrac{2,5Rm}{\left(1+\dfrac{Rm}{Rmc}\right)}$ |
| Rmti = ultimate interlaminar shear strength | $230\,G_C^2 - 180\,G_C + 60$ | $230\,G_C^2 - 180\,G_C + 60$ |

The glass content GC are to be assumed according to the following.

**Table 6**

| Type of ply reinforcement | Open mould | | Vacuum bag |
|---|---|---|---|
| | Simple Surface | Complex surface | |
| Chopped strand mat sprayed up | 0,22 | 0,17 | 0,28 |
| Chopped strand mat hand lay-up | 0,22 | 0,17 | 0,28 |
| Woven roving | 0,40 | 0,28 | 0,50 |
| Roving-mat combination | [0,46 - 0,18 x Q ] - 0,08 | [0,35 - 0,11 x Q ] - 0,08 | [0,56 - 0,22 x Q ] - 0,08 |
| Multidirectional fabric | 0,41 | 0,30 | 0,50 |
| Unidirectional fabric | 0,46 | 0,32 | 0,57 |

$$\frac{\text{Total mass of mat}}{\text{Total mass of glass in laminate (Mat + Woven Roving)}}$$

The total thickness, in mm, of the laminate may be calculated with the following formula:

$$t = \frac{Q}{2,160}\left(\left(\frac{1,8}{Gc}\right) - 0,6\right)$$

where Q is in kg/m$^2$.

In order to determine the total content GC of the laminate of n ply, the following formula may be applied:

$$G_C = \frac{q1 + q2 + q3 + \dots qn}{\dfrac{q1}{gc1} + \dfrac{q2}{gc2} + \dfrac{q3}{gc3} + \dots \dfrac{qn}{gcn}}$$

where:

q : is the mass in kg/m$^2$ of the single ply;

$G_c$ : is the glass content of the single ply.

## 4.2 Coefficients relative to the mechanical properties of laminates

**4.2.1** The values of the coefficients $K_o$ and $K_{of}$ relative to the mechanical properties of the laminates that appear in the formulae of the structural scantlings of the hull in this Chapter are given by:

$K_o = 85 / R_m$

$$K_{of} = \left(\frac{152}{R_{mf}}\right)^{0,5}$$

where $R_m$ and $R_{mf}$ are the values, in N/mm², of the ultimate tensile and flexural strengths of the laminate. Such values may be calculated with the formulae in Tab 3 for glass fibre reinforcements or obtained from mechanical tests on samples of the laminate for other types of laminate.

Therefore, in the case of laminates with glass fibre having $G_C = 30$ (minimum allowed), it is to be assumed that:

$K_o = 1$

$K_{of} = 1$

The values $K_o$ and $K_{of}$ are to be taken as not less than 0,5 and 0,7, respectively, except in specific cases considered by the Society on the basis of the results of tests carried out.

# SECTION 3 CONSTRUCTION AND QUALITY CONTROL

## 1 Shipyards or workshops

### 1.1 General

**1.1.1** All constructions are to be built using materials and working processes approved or accepted by the Society.

The builder is to obtain approval or acceptance for the materials he uses; furthermore, it is the builder's responsibility to ensure that all the materials are used in accordance with the Manufacturer's instructions and recommendations.

Shipyards or workshops for hull construction are to be suitably equipped to provide the necessary working environment according to these requirements, which are to be complied with for the recognition of the shipyard or workshop as suitable for the construction of hulls in reinforced plastic. This suitability is to be ascertained by a RINA Surveyor, the responsibility for the fulfilment of the requirements specified below as well as all other measures for the proper carrying out of construction being left to the shipyard or workshop.

When it emerges from the tests carried out that the shipyard or workshop complies with the following provisions, uses type approved materials, and has a system of production and quality control that satisfies the RINA Rules for the Classification of Ships, so as to ensure a consistent level of quality, the shipyard or workshop may obtain from the Society a special recognition of suitability for the construction of reinforced plastic hulls.

The risks of contamination of the materials are to be reduced as far as possible; separate zones are to be provided for storage and for manufacturing processes. Alternative arrangements of the same standard may be adopted.

Compliance with the requirements of this Section does not exempt those in charge of the shipyard or workshop from the obligation of fulfilling all the hygiene requirements for work stipulated by the relevant authorities.

### 1.2 Moulding shops

**1.2.1** Where hand lay-up or spray lay-up processes are used for the manufacture of laminates, a temperature of between 16° and 32°C is to be maintained in the moulding shop during the lay-up and polymerisation periods. Small variations in temperature may be allowed, at the discretion of the RINA Surveyor, always with due consideration being given to the resin Manufacturer's recommendations. Where moulding processes other than those mentioned above are used, the temperatures of the moulding shop are to be established accordingly.

The relative humidity of the moulding shop is to be kept as low as possible, preferably below 70%, and in any case lower than the limit recommended by the resin Manufacturer. Significant changes in humidity, such as would lead to condensation on moulds and materials, are to be avoided.

Instruments to measure the humidity and temperature are to be placed in sufficient number and in suitable positions. If necessary, due to environmental conditions, an instrument capable of providing a continuous readout and record of the measured values may be required.

Ventilation systems are not to cause an excessive evaporation of the resin monomer and draughts are to be avoided.

The work areas are to be suitably illuminated. Precautions are to be taken to avoid effects on the polymerisation of the resin due to direct sunlight or artificial light.

### 1.3 Storage areas for materials

**1.3.1** Resins are to be stored in dry, well-ventilated conditions at the temperature recommended by the resin Manufacturer. If the resins are stored in tanks, it is to be possible to stir them at a frequency for a length of time indicated by the resin Manufacturer. When the resins are stored outside the moulding shop, they are to be brought into the shop in due time to reach the working temperature required before being used.

Catalysts and accelerators are to be stored separately in clean, dry and well-ventilated conditions in accordance with the Manufacturer's recommendations.

Fillers and additives are to be stored in closed containers that are impervious to dust and humidity.

Reinforcements, e.g. glass fibre, are to be stored in dust-free and dry conditions, in accordance with the Manufacturer's recommendations. When they are stored outside the cutting area, the reinforcements are to be brought into the latter in due time so as to reach the temperature of the moulding shop before being used.

Pre-impregnated reinforcements are to be stored in an area set aside for the purpose. The quality control documentation is to keep a record of the storage and depletion of the stock of such reinforcements.

Materials for the cores of sandwich type structures are to be stored in dry areas and protected against damage; they are to be stored in their protective covering until they are used.

### 1.4 Identification and handling of materials

**1.4.1** In the phases of reception and handling the materials are not to suffer contamination or degradation and are to bear adequate identification marks at all times, including those relative to RINA type approval. Storage is to be so arranged that the materials are used, whenever possible, in chronological order of receipt. Materials are not to be used after the Manufacturer's date of expiry, except when the latter has given the hull builder prior written consent.

## 2 Hull construction processes

### 2.1 General

**2.1.1** The general requirements for the construction of hand lay-up or spray lay-up laminates are set out below; processes of other types (e.g. by resin transfer, vacuum or pressurised moulding with mat and continuous filaments) are to be individually recognised as suitable by the Society.

### 2.2 Moulds

**2.2.1** Moulds for production of laminates are to be constructed with a suitable material which does not affect the resin polymerisation and are to be adequately stiffened in order to maintain their shape and precision in form. They are also not to prevent the finished laminate from being released, thus avoiding cracks and deformations.

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

Moulds are to be thoroughly cleaned, dried and brought to the moulding shop temperature before being treated with the mould release agents, which are not to have an inhibiting effect on the gel coat resin.

### 2.3 Laminating

**2.3.1** The gel coat is to be applied by brush, roller or spraying device so as to form a uniform layer with a thickness of between 0,4 and 0,6 mm. Furthermore, it is not to be left exposed for longer than is recommended by the Manufacturer before the application of the first layer of reinforcement.

A lightweight reinforcement, generally not exceeding a mass per area of 300 g/m$^2$, is to be applied to the gel coat itself by means of rolling so as to obtain a content of reinforcement not exceeding approximately 0,3.

In the case of hand lay-up processing, the laminates are to be obtained with the layers of reinforcement laid in the sequence indicated in the approved drawings and each layer is to be thoroughly "wet" in the resin matrix and compacted to give the required weight content.

The amount of resin laid "wet on wet" is to be limited to avoid excessive heat generation.

Laminating is to be carried out in such a sequence that the interval between the application of layers is within the limits recommended by the resin Manufacturer.

Similarly, the time between the forming and bonding of structural members is to be kept within these limits; where this is not practicable, the surface of the laminate is to be treated with abrasive agents in order to obtain an adequate bond.

When laminating is interrupted so that the exposed resin gels, the first layer of reinforcement subsequently laid is to be of mat type.

Reinforcements are to be arranged so as to maintain continuity of strength throughout the laminate. Joints between the sections of reinforcement are to be overlapped and staggered throughout the thickness of the laminate.

In the case of simultaneous spray lay-up of resin and cut fibres, the following requirements are also to be complied with:

- before the use of the simultaneous lay-up system, the Manufacturer is to satisfy himself of the efficiency of the equipment and the competence of the operator;
- the use of this technique is limited to those parts of the structure to which sufficiently good access may be obtained so as to ensure satisfactory laminating;
- before use, the spray lay-up equipment is to be calibrated in such a way as to provide the required fibre content by weight; the spray gun is also to be calibrated, according to the Manufacturer's instruction manual, such as to obtain the required catalyst content, the general spray conditions and the appropriate length of cut fibres. Such length is

generally to be not less than 35 mm for structural laminates, unless the mechanical properties are confirmed by tests; in any event, the length of glass fibres is to be not less than 25 mm;

- the calibration of the lay-up system is to be checked periodically during the operation;
- the uniformity of lamination and fibre content is to be systematically checked during production.

The manufacturing process for sandwich type laminates is taken into consideration by the Society in relation to the materials, processes and equipment proposed by the Manufacturer, with particular regard to the core material and to its lay-up as well as to details of connections between prefabricated parts of the sandwich laminates themselves. The core materials are to be compatible with the resins of the surface laminates and suitable to obtain strong adhesion to the latter (Manufacturer's instructions to be followed).

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

Where rigid core materials are used, then dry vacuum bagging techniques are to be adopted. Particular care is to be given to the core bonding materials and to the holes provided to ensure efficient removal of air under the core. Bonding paste is to be visible at these holes after vacuum bagging.

### 2.4 Hardening and release of laminates

**2.4.1** On completion of the laminating, the laminate is to be left in the mould for a period of time to allow the resin to harden before being removed. This period may vary, depending on the type of resin and the complexity of the laminate, but is to be at least 24 hours, unless a different period is recommended by the resin Manufacturer.

The hull, deck and large assemblies are to be adequately braced and supported for removal from the moulds as well as during the fitting-out period of the yacht.

After the release and before the application of any special post-hardening treatment, which is to be examined by the Society, the structures are to be stabilised in the moulding environment for the period of time recommended by the resin Manufacturer. In the absence of recommendations, the period is to be at least 24 hours.

### 2.5 Defects in the laminates

**2.5.1** The manufacturing processes of laminates are to be such as to avoid defects, such as in particular: surface cracks, surface or internal blistering due to the presence of air bubbles, cracks in the resin for surface coating, internal areas with non-impregnated fibres, surface corrugation, and surface areas without resin or with glass fibre reinforcements exposed to the external environment.

Any defects are to be eliminated by means of appropriate repair methods to the satisfaction of the RINA Surveyor.

Dimensions and tolerances are to conform to the approved construction documentation.

**2.5.2** The responsibility for maintaining the required tolerances rests with the builder.

Monitoring and random checking by the Surveyor does not absolve the builder from this responsibility.

### 2.6 Checks and tests

**2.6.1** Checks and tests are to be arranged during the lamination process by the hull builder, in accordance with the relevant quality system, and by the RINA Surveyor.

The hull builder is to maintain a constant check on the laminate.

Any defects found are to be eliminated immediately.

In general the following checks and tests are to be carried out:

a) check of the mould before the application of the release agent and of the gel coat;
b) check of the thickness of the gel coat and the uniformity of its application;
c) check of the resin and the amount of catalyst, accelerator, hardener and various additives;
d) check of the uniformity of the impregnation of reinforcements, their lay-up and superimposition;
e) check and recording of the percentage of the reinforcement in the laminate;
f) checks of any post-hardening treatments;
g) general check of the laminate before release from the mould;
h) check and recording of the laminate hardness before release from the mould;
i) check of the thickness of the laminate which, in general, is not to differ by more than 15% from the thickness indicated in approved structural plans;
j) mechanical tests on laminates taken from the hull or prepared during the lamination of the hull.

The thicknesses of the laminates are, in general, to be measured at not less than ten points, evenly distributed across the surface.

The above-mentioned checks and tests are to be carried out, as a rule, in the presence of a RINA Surveyor; where the shipyard has a system of production organisation and quality control certified by the Society, the checks may be carried out directly by the shipyard without the presence of a RINA Surveyor.

**2.6.2** Where ultrasonic thickness gauges are used, relevant tools are to be calibrated against an identical laminate (of measured thickness).

**2.6.3** As a general rule, a method of validating the complete laminate thickness is to be agreed between the builder and the Surveyor.

# SECTION 4 LONGITUDINAL STRENGTH

## 1 General

### 1.1

**1.1.1** The structural scantlings prescribed in Chapter 4 are also intended as appropriate for the purposes of the longitudinal hull strength of a yacht having length L not exceeding 40 m for monohull yachts or 35 m for catamarans and openings on the strength deck of limited size.

For yachts of greater length and/or openings of size greater than the breadth B of the hull and extending for a considerable part of the length of the yacht, a test of the longitudinal strength is required.

### 1.2

**1.2.1** To this end, longitudinal strength calculations are to be carried out considering the load and ballast conditions for both departure and arrival.

As a guide, the criteria used by the Society for tests of longitudinal hull beam strength are shown below.

## 2 Bending stresses

### 2.1

**2.1.1** In addition to satisfying the minimum requirements stipulated in the individual Chapters of these Rules, the scantlings of members contributing to the longitudinal strength of monohull yachts and catamarans are to achieve a section modulus of the midship section at the bottom and the deck such as to guarantee stresses not exceeding the allowable values.

Therefore:

$$\sigma_f \le f\sigma_l$$

$$\sigma_p \le f\sigma_l$$

where:

$$\sigma_f = \frac{M_T}{1000\,W_f} N/mm$$

$$\sigma_p = \frac{M_T}{1000\,W_p} N/mm^2$$

$W_f$, $W_p$ : section modulus, in m3, at the bottom and the deck, respectively, of the transverse section

$M_T$ : design total vertical bending moment defined in Ch 1, Sec 5

f : 0,33 for planing yachts

f : 0,25 for displacement yachts

$\sigma_l$ : the lesser of the values of ultimate tensile and ultimate compressive strength, in N/mm$^2$, of the bottom and deck laminate.

### 2.2

**2.2.1** In order to limit the flexibility of the hull structure, the moment of inertia J of the midship section, in m$^4$, is generally to be not less than the value given by the following formulae:

$J = 200 \cdot M_T \cdot 10^{-6}$ for planing yachts

$J = 230 \cdot M_T \cdot 10^{-6}$ displacement yachts.

## 2.3 Calculation of strength modulus

**2.3.1** Reference is to be made to Tab 1 for plating and Tab 2 for longitudinals for calculation of the midship section modulus.

**Table 1**

| | Deck | Side shell | Bottom |
|---|---|---|---|
| Mean thickness, in mm | $t_p$ | $t_m$ | $t_f$ |
| Young's modulus, in N/mm$^2$ | $E_p$ | $E_m$ | $E_f$ |

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

For each transverse section within the midship region, the section modulus, in m$^3$, is given by:

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

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

where:

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

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

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

$t_p$, $t_m$, $t_f$, $E_p$, $E_m$, $E_f$: values defined in Tab 1

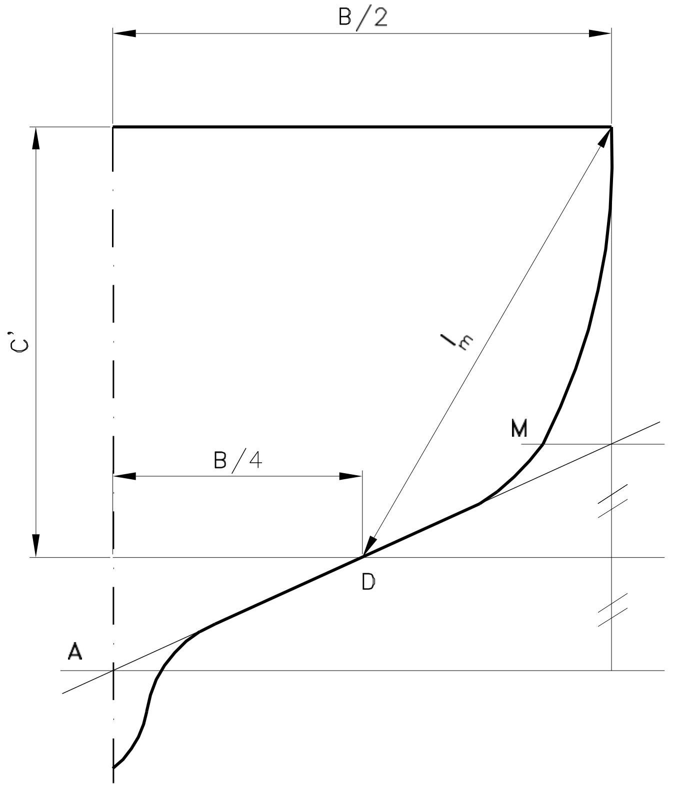
$t_{ps}$, $t_{ms}$, $t_{fs}$, $E_{ps}$, $E_{ms}$, $E_{fs}$, $l_{ps}$, $l_{ms}$, $l_{fs}$, $t_{pa}$, $t_{ma}$, $t_{fa}$, $E_{pa}$, $E_{ma}$, $E_{fa}$, $H_{pa}$, $H_{ma}$, $H_{fa}$, $n_p$, $n_m$, $n_f$: values defined in Tab 2

$l_m$, C' : length, in m, defined in Fig 1.

**Table 2**

| | | Deck | Side shell | Bottom |
|---|---|---|---|---|
| Flange | Mean thickness, in mm | $t_{ps}$ | $t_{ma}$ | $t_{fs}$ |
| | Young's modulus, in N/mm$^2$ | $E_{ps}$ | $E_{ma}$ | $E_{fs}$ |
| | Breadth in mm | $l_{ps}$ | $l_{ms}$ | $l_{fs}$ |
| Web | Equivalent thickness in Section I, in mm | $t_{pa}$ | $t_{ma}$ | $t_{fa}$ |
| | Young's modulus, in N/mm$^2$ | $E_{pa}$ | $E_{ma}$ | $E_{fa}$ |
| | Height in mm | $H_{pa}$ | $H_{ma}$ | $H_{fa}$ |
| | Number of longitudinals | $n_p$ | $n_m$ | $n_f$ |

**Figure 1**




## 3 Shear stresses

### 3.1

**3.1.1** The shear stresses in every position along the length L are not to exceed the allowable values; in particular.

$$\frac{T_t}{A_t} \cdot 10^{-3} \leq f \cdot \tau$$

where:

$T_t$ : total shear stress in kN defined in Ch 1, 5.4

f : defined in 2

$\tau$ : shear stress of the laminate, in N/mm²

$A_t$ : actual shear area of the transverse section, in m², to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings.

# SECTION 5 EXTERNAL PLATING

## 1 General

### 1.1

**1.1.1** Bottom and side plating are to be made using both single-skin laminate or sandwich structure.

When the two solutions are adopted for the hull, a suitable taper is to be made between the two types.

Bottom plating is the plating up to the chine or to the upper turn of the bilge.

When the side thickness differs from the bottom thickness by more than 3 mm, a transition zone is to be foreseen.

## 2 Definitions and symbols

### 2.1

**2.1.1**

S : larger dimension of the plating panel, in m

s : spacing of the longitudinal or transverse ordinary stiffener, in m

p : scantling pressure, in kN/m$^2$, given in Ch 1, Sec 5

$K_{of}$, $K_o$ : factors defined in Sec 2.

## 3 Keel

### 3.1

**3.1.1** The keel is to extend the whole length of the yacht and have a breadth $b_{CH}$, in mm, not less than the value obtained by the following formula:

$$b_{CH} = 30L$$

The thickness of the keel is to be not less than the value $t_{CH}$, in mm, obtained by the following formula:

$$t_{CH} = 1,4t$$

t being the greater of the values $t_1$ and $t_2$, in mm, calculated as specified in 5 assuming the spacing s of the corresponding stiffeners.

When calculating s, dead rise edge > 12° is considered as a stiffener.

The thickness $t_{CH}$ is to be gradually tapered transversely to the thickness of the bottom and, in the case of hulls having a U-shaped keel, the thickness of the keel is to extend transversely, as indicated in Sec 1, Fig 2 b), tapering with the bottom plating.

In yachts with sail and ballast keel, the thickness of the keel for the whole length of the ballast keel is to be increased by 30%; this increase is to extend longitudinally to fore and aft of the ballast for a suitable length.

When the hull is laminated in halves, the keel joint is to be carried out as shown in Sec 1, Fig 5 or in a similar way.

## 4 Rudder horn

### 4.1

**4.1.1** When the rudder is of the semi-spade type, such as Type I B shown in Ch 1, Sec 2, Fig 2, the relevant rudder horn is to have dimensions and thickness such that the moment of inertia J, in cm, and the section modulus Z, in cm$^3$, of the generic horizontal section of the same skeg, with respect to its longitudinal axis, are not less than the values given by the following formulae:

$$J = \frac{A \cdot h^2 \cdot V^2}{36} 10^{-3}$$

$$Z = \frac{A \cdot h \cdot V^2}{55}$$

where:

A : the rudder area, in $m^2$, acting on the horn;

h : the vertical distance, in mm, from the skeg section to the lower edge of the pintle (rudder heel);

V : maximum design speed of the yacht, in knots.

## 5 Bottom plating

### 5.1

**5.1.1** The thickness of bottom plating is to be not less than the greater of the values $t_1$ and $t_2$, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_a \cdot s \cdot k \cdot p^{0,5}$$

$$t_2 = 16 \cdot s \cdot k_{of} \cdot D^{0,5}$$

where:

$k_1$ : 0,26, when assuming $p=p_1$

: 0,15, when assuming $p=p_2$.

$k_a$ : coefficient as a function of the ratio S/s given in Tab 1.

The thickness of the plating of the bilge is, in any event, to be taken as not less than the greater of the thicknesses of the bottom and side.

The minimum bottom shell thickness is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

If the plating has a pronounced curve, as for example in the case of the hulls of sailing yachts, the thickness calculated with the formulae above may be reduced multiplying by (1 - f/s), f being the distance, in m, between the connecting beam and the two extremities of the plating concerned and the surface of the plating itself. This reduction is not to be assumed less than 0,70.

In sailing yachts with or without auxiliary engines in way of the ballast keel, when the width of the latter is greater than that of the keel, the thickness of the bottom is to be increased to the value taken for the keel.

**Table 1**

| S/s | $K_a$ |
|---|---|
| 1 | 17,5 |
| 1,2 | 19,6 |
| 1,4 | 20,9 |
| 1,6 | 21,6 |
| 1,8 | 22,1 |
| 2,0 | 22,3 |
| >2 | 22,4 |

## 6 Side plating and sheerstrake plating

### 6.1

**6.1.1** A sheerstrake plate of height h, in mm, not less than 0,025 L and thickness $t_c$, in mm, not less than the value in the following formula is to be fitted:

$$t_c = 1,30t$$

where t is the greater of the thicknesses $t_1$ and $t_2$, calculated as stated in [6.2] below.

### 6.2 Side plating

**6.2.1** The thickness of side plating is to be not less than the greater of the values $t_1$ and $t_2$, in mm, calculated with the following formulae:

$$t_1 = k_1 \cdot k_a \cdot s \cdot k \cdot p^{0,5}$$

$$t_2 = 12 \cdot s \cdot k_{of} D^{0,5}$$

where $k_1$ and $k_a$ are as defined in [5.1].

## 7 Openings in the shell plating

### 7.1

**7.1.1** Sea intakes and other openings are to be well rounded at the corners and located, as far as possible, outside the bilge strakes and the keel. Arrangements are to be such as to ensure continuity of strength in way of openings.

The edges of openings are to be suitably sealed in order to prevent the absorption of water.

### 7.2

**7.2.1** Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects.

### 7.3

**7.3.1** The internal walls of sea intakes are to have external plating thickness increased by 2 mm, but not less than 6 mm.

## 8 Local stiffeners

### 8.1

**8.1.1** The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the propulsion engine bedplates, stem (the thickness is not required to be greater than that of the keel in this case), propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

### 8.2

**8.2.1** Where the aft end is shaped such that the bottom plating aft has a large flat area, the Society may require the local plating to be increased and/or reinforced with the fitting of additional stiffeners.

### 8.3

**8.3.1** The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements as indicated in [3.1.1].

### 8.4

**8.4.1** The thickness of the transom is to be not less than that of the side plating for the portion above the waterline, or less than that of the bottom for the portion below the waterline.

Where water-jets or propulsion systems are fitted directly to the transom, the scantlings of the latter will be the subject of special consideration.

In such case a sandwich structure with marine plywood core of adequate thickness is recommended.

## 9 Cross-deck bottom plating

### 9.1

**9.1.1** The thickness is to be taken, the stiffener spacing s being equal, no less than that of the side plating.

Where the gap between the bottom and the waterline is so small that local wave impact phenomena are anticipated, an increase in thickness and/or additional internal stiffeners may be required.

# SECTION 6 SINGLE BOTTOM

## 1 General

### 1.1

**1.1.1** This Section stipulates the criteria for the structural scantlings of a single bottom, which may be of either longitudinal or transverse type.

### 1.2 Longitudinal structure

**1.2.1** A centre girder is to be fitted. In the case of a keel with a dead rise > 12°, the centre girder may be omitted but in such case the fitting of a longitudinal stringer is required.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

**1.2.2** The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

**1.2.3** Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

### 1.3 Transverse structure

**1.3.1** The transverse framing consists of ordinary stiffeners arranged transversely (floors) and placed at each frame supported by girders, which in turn are supported by transverse bulkheads or reinforced floors.

**1.3.2** A centre girder is to be fitted. In the case of a keel with a dead rise > 12°, the centre girder may be omitted but in such case the fitting of a longitudinal stringer is required.

Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

**1.3.3** The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

**1.3.4** Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

**1.3.5** Floors are to be fitted in way of reinforced frames at the sides and reinforced deck beams.

Any intermediate floors are to be adequately connected to the ends.

## 2 Definitions and symbols

### 2.1

**2.1.1**

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m$^2$, given in Ch 1, Sec 5;

$K_o$ : coefficient defined in Sec 2.

## 3 Longitudinal type structure

### 3.1 Bottom longitudinals

**3.1.1** The section modulus of longitudinal stringers is to be not less than the value Z, in cm$^2$, calculated with the following formula:

$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p_o$

where:

$k_1$ : 1,5 assuming $p=p_1$

: 1 assuming $p=p_2$

S : conventional span of the longitudinal stiffener, in m, equal to the distance between floors.

## 3.2 Floors

**3.2.1** The section modulus of the floors at the centreline of the span S is to be not less than the value $Z_M$, in $cm^3$, calculated with the following formula.

$Z_M = k_1 \cdot b \cdot S \cdot K_2 \cdot p_o$

where:

$k_1$ : 2,4 assuming $p = p_1$

1,2 assuming $p = p_2$

b : half the distance, in m, between the two floors adjacent to that concerned

S : conventional floor span equal to the distance, in m, between the two supporting members (sides, girders, keel with a dead rise edge > 12°).

In the case of a U-shaped keel or one with a dead rise edge ≤ 12° but > 8° the span S is still to be calculated considering the distance between girders or sides; the modulus $Z_M$ may, however, be reduced by 40%.

If a side girder is fitted on each side with a height equal to the local height of the floor, the modulus may be reduced by a further 10%.

## 3.3 Girders

### 3.3.1 Centre girder

When the girder forms a support for the floor, the section modulus is to be not less than the value $Z_{PC}$, in $cm^3$, calculated with the following formula:

$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p_o$

where:

$k_1$ : defined in [3.2]

$b'_{PC}$ : half the distance, in m, between the two side girders if supporting or equal to B/2 in the absence of supporting side girders

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value $Z_{PC}$, in $cm^3$, calculated with the following formula:

$Z_{PC} = k_1 \cdot b'_{PC} \cdot S_2 \cdot K \cdot p_o$

where:

$k_1$ : defined in [3.1]

$b'_{PC}$ : half the distance, in m, between the two side girders if present, or equal to B/2 in the absence of side girders

S : distance between the floors.

### 3.3.2 Side girders

When the side girder forms a support for the floor, the section modulus is to be not less than the value $Z_{PL}$, in $cm^3$, calculated with the following formula:

$Z_{PL} = k_1 \cdot b'_{PL} \cdot S_2 \cdot K \cdot p_o$

where:

$k_1$ : defined in [3.2]

$b'_{PL}$ : half the distance, in m, between the two adjacent girders or between the side and the girder concerned

S : conventional girder span equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value $Z_{PL}$, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b'_{PL} \cdot S^2 \cdot K \cdot p_o$$

where:

$k_1$ : defined in [3.1]

$b'_{PL}$ : half the distance, in m, between the two adjacent girders or between the side and the adjacent girder

S : distance between the floors, in m.

# 4 Transverse type structures

## 4.1 Ordinary floors

**4.1.1** The section modulus for ordinary floors is to be not less than the value Z, in cm³, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K \cdot p_o$$

where:

$k_1$ : defined in [3.1]

S : conventional span in m, of the floor equal to the distance between the members which support it (girders, sides).

## 4.2 Centre girder

**4.2.1** The section modulus of the centre girder is to be not less than the value $Z_{PC}$, in cm³, calculated with the following formula:

$$Z_{PC} = k_1 \cdot b_{PC} \cdot S^2 \cdot K \cdot p_o$$

where:

$k_1$ : defined in [3.2]

$b_{PC}$ : half the distance, in m, between the two side girders if supporting, or equal to B/2 in the absence of supporting side girders

S : conventional span of the centre girder, equal to the distance, in m, between the two supporting members (transverse bulkheads, floors).

## 4.3 Side girders

**4.3.1** The section modulus is to be not less than the value $Z_{PL}$, in cm³, calculated with the following formula:

$$Z_{PL} = k_1 \cdot b_{PL} \cdot S^2 \cdot K \cdot p_o$$

where:

$k_1$ : defined in [3.2]

$b_{PL}$ : half the distance, in m, between the two adjacent girders or between the side and the girder adjacent to that concerned

S : conventional girder span equal to the distance, in m, between the two members which support it (transverse bulkheads, floors).

# 5 Constructional details

## 5.1

**5.1.1** The centre girder and side girders are to be connected to the stiffeners of the transom by means of suitable fittings.

# SECTION 8 SIDE STRUCTURES

## 1 General

### 1.1

**1.1.1** Where tanks intended for liquids are arranged above the double bottom, the section modulus of longitudinals is to be no less than that required for tank stiffeners as stated in Sec 10.

The longitudinal type structure consists of ordinary stiffeners placed longitudinally supported by reinforced frames, generally spaced not more than 2 m apart, or by transverse bulkheads.

The transverse type structure is made up of ordinary reinforcements placed vertically (frames), which may be supported by reinforced stringers, by decks, by flats or by the bottom structures.

Reinforced frames are to be provided in way of the mast and the ballast keel, in sailing yachts, in the machinery space and in general in way of large openings on the weather deck.

## 2 Definitions and symbols

### 2.1

**2.1.1**

s : spacing of longitudinal or transverse ordinary stiffeners, in m;

p : scantling pressure, in kN/m$^2$, defined in Ch 1, Sec 5 ;

$K_o$ : factor defined in Sec 2.

## 3 Ordinary stiffeners

### 3.1

**3.1.1** The section modulus of the frames is to be not less than the value Z, in cm$^3$, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

$k_1$ : 1,75 assuming $p=p_1$

: 1,1 assuming $p=p_2$

S : conventional frame span, in m, equal to the distance between the supporting members.

The ordinary frames are to be well connected to the elements which support them, in general made up of a beam and a floor.

### 3.2 Longitudinals

**3.2.1** The section modulus of the side longitudinals is to be not less than the value Z, in cm$^3$, calculated with the following formula:

$$Z = k_1 \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

$k_1$ : 1,9 assuming $p=p_1$

: 1 assuming $p=p_2$

S : conventional span of the longitudinal, in m, equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads.

# 4 Reinforced beams

## 4.1 Reinforced frames

**4.1.1** The section modulus of the reinforced frames is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K_{CR} \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

$k_1$ : 1 assuming $p=p_1$

: 0,7 assuming $p=p_2$

$K_{CR}$ : 2,5 for reinforced frames which support longitudinal ordinary stiffeners, or reinforced stringers;

: 1,1 for reinforced frames which do not support ordinary stiffeners;

s : spacing, in m, between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned;

S : conventional span, in m, equal to the distance between the members which support the reinforced frame.

## 4.2 Reinforced stringers

**4.2.1** The section modulus of the reinforced stringers is to be not less than the value calculated with the following formula:

$$Z = k_1 \cdot K'_{CR} \cdot s \cdot S^2 \cdot K_o \cdot p$$

where:

$k_1$ : defined in [4.1]

$K_{CR}$ : 2,5 for reinforced stringers which support ordinary vertical stiffeners (frames);

: 1,1 for reinforced stringers which do not support ordinary vertical stiffeners;

s : spacing, in m, between the reinforced stringers or 0,5 D in the absence of other reinforced stringers or decks;

S : conventional span, in m, equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames.

# SECTION 9 DECKS

## 1 General

### 1.1

**1.1.1** This Section lays down the criteria for the scantlings of decks, plating and reinforcing or supporting structures.

The reinforcing and supporting structures of decks consist of ordinary reinforcements, beams or longitudinal stringers, laid transversely or longitudinally, supported by lines of shoring made up of systems of girders and/or reinforced beams, which in turn are supported by pillars or by transverse or longitudinal bulkheads.

Reinforced beams together with reinforced frames are to be placed in way of the masts in sailing yachts.

In sailing yachts with the mast resting on the deck or on the deckhouse, a pillar or bulkhead is to be arranged in way of the mast base.

## 2 Definitions and symbols

### 2.1

**2.1.1**

pdc : calculation deck, meaning the first deck above the full load waterline, extending for at least 0,6 L and constituting an efficient support for the structural elements of the side; in theory, it is to extend for the whole length of the yacht;

s : spacing of transverse or longitudinal ordinary stiffeners, in m;

$h_B$, $h_T$ : scantling height, in m, the value of which is given in Ch 1, Sec 5;

$K_o$, $K_{of}$ : factor defined in Sec 2;

$L_1$ : scantling length, in m, to be assumed not less than 15 m.

## 3 Deck plating

### 3.1 Weather deck

**3.1.1** The thickness of the weather deck plating, considering that said deck is also a strength deck, is to be not less than the value t, in mm, calculated with the following formula:

$$t = 0,15 \cdot k_a \cdot s \cdot k_{of} \cdot L_1^{0,5}$$

On yachts of L > 30 m a stringer plate is to be fitted with width b, in m, not less than 0,025 L and thickness t, in mm, not less than the value given by the formula

$$t = 0,2 \cdot k_a \cdot s \cdot k_{of} \cdot L_1^{0,5}$$

where ka is defined in Sec 5, [5.1] and $L_1$ is the length of the scantling, to be assumed not less than 15 m.

### 3.2 Lower decks

**3.2.1** The thickness of decks below the weather deck intended for accommodation spaces is to be not less than the value calculated with the formula:

$$t = 0,13 \cdot k_a \cdot s \cdot k_o \cdot L_1^{0,5}$$

where $k_a$ is defined in Sec 5, [5.1].

Where the deck is a tank top, the thickness of the deck is, in any event, to be not less than the value calculated with the formulae given in Sec 10 for tank bulkhead plating.

# 4 Stiffening and support structures for decks

## 4.1 Ordinary stiffeners

**4.1.1** The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value Z, in $cm^3$, calculated with the following equation:

$$Z = 14 \cdot s \cdot S^2 \cdot h \cdot k \cdot C_1$$

where:

$C_1$ : 1 for weather deck longitudinals

: 0,63 for lower deck longitudinals

: 0,56 for beams.

## 4.2 Reinforced beams

**4.2.1** The section modulus for girders and for ordinary reinforced beams is to be not less than the value Z, in $cm^3$, calculated with the following equation:

$$Z = 15 \cdot b \cdot S^2 \cdot h \cdot k_o$$

where:

b : average width of the strip of deck resting on the beam, in m. In the calculation of b, any openings are to be considered as non-existent

S : conventional span of the reinforced beam, in m, equal to the distance between the two supporting members (pillars, other reinforced beams, bulkheads).

## 4.3 Pillars

**4.3.1** Pillars are, in general, to be made of steel or aluminium alloy tubes, and connected at both ends to plates supported by efficient brackets which allow connection to the hull structure by means of bolts. Details are to be sent for approval.

The section area of pillars is to be not less than the value A, in cm2, given by the formula:

$$A = \frac{Q \cdot C}{12,5 - 0,045\lambda}$$

where:

Q : load resting on the pillar, in kN, calculated with the following formula:

$$Q = 6,87 \cdot A \cdot h$$

where:

A : area of the part of the deck resting on the pillar, in $m^2$.

h : scantling height, defined in [2.1.1].

$\lambda$ : the ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

C : 1 for steel pillars

: 1,6 for aluminium alloy pillars.

**4.3.2** Pillars are to be fitted on main structural members. Wherever possible, deck pillars are to be fitted in the same vertical line as pillars above and below, and effective arrangements are to be made to distribute the load at the heads and heels of all pillars.

**4.3.3** The attachment of pillars to sandwich structures is, in general, to be through an area of single-skin laminate. Where this is not practicable and the attachment of the pillar has to be by through bolting through a sandwich structure then a wood or other suitable solid insert is to be fitted in the core in way.

# SECTION 10 BULKHEADS

## 1 General

### 1.1

**1.1.1** The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Ch 1.

The scantlings indicated in this Section refer to bulkheads made of reinforced plastic both in single-skin and in sandwich type laminates.

Whenever bulkheads, other than tank bulkheads, are made of wood, it is to be type approved marine plywood and the scantlings are to be not less than those indicated in Ch 5.

Pipes or cables running through watertight bulkheads are to be fitted with suitable watertight glands.

## 2 Symbols

### 2.1

**2.1.1**

s : spacing between the stiffeners, in m

S : conventional span, equal to the distance, in m, between the members that support the stiffener concerned

$h_s$, $h_B$ : as defined in Ch 1, Sec 5

$k_o$, $k_{of}$ : as defined in Sec 2.

## 3 Plating

### 3.1

**3.1.1** The watertight bulkhead plating is to have a thickness not less than the value $t_S$, in mm, calculated with the following formula:

$$t_S = k_1 \cdot s \cdot k_{of} \cdot h^{0,5}$$

The coefficient $k_1$ and the scantling height h have the values indicated in Tab 1.

**Table 1**

| Bulkhead | $k_1$ | h (m) |
|---|---|---|
| Collision bulkhead | 5,8 | $h_B$ |
| Watertight bulkhead | 5,0 | $h_B$ |
| Deep tank bulkhead | 5,3 | $h_T$ |

## 4 Stiffeners

### 4.1 Ordinary stiffeners

**4.1.1** The section modulus of ordinary stiffeners is to be not less than the value Z, in $cm^3$, calculated with the following formula:

$$Z = 13,5 \cdot s \cdot S^2 \cdot h \cdot c \cdot k_o$$

The values of the coefficient c and of the scantling height h are those indicated in Tab 2.

## 4.2 Reinforced beams

**4.2.1** The horizontal webs of bulkheads with ordinary vertical stiffeners and reinforced stiffeners in the bulkheads with horizontal ordinary stiffeners are to have a section modulus not less than the value Z, in $cm^3$, calculated with the following formula:

$$Z = C_1 \cdot b \cdot S^2 \cdot h \cdot k$$

where:

$C_1$ : 10,7 for subdivision bulkheads

: 18 for tank bulkheads

b : width, in m, of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener

h : scantling height indicated in Tab 2.

**Table 2**

| Bulkhead | h (m) | c |
|---|---|---|
| Collision bulkhead | $h_B$ | 0,78 |
| Watertight bulkhead | $h_B$ | 0,63 |
| Deep tank bulkhead | $h_T$ | 1 |

# 5 Tanks for liquids

## 5.1

**5.1.1** See Sec 1.

# SECTION 11 SUPERSTRUCTURES

## 1 General

### 1.1

**1.1.1** First tier superstructures or deckhouses are intended as those situated on the uppermost exposed continuous deck of the yacht, second tier superstructures or deckhouses are those above, and so on.

Where the distance from the hypothetical freeboard deck to the full load waterline exceeds the freeboard that can hypothetically be assigned to the yacht, the reference deck for the determination of the superstructure tier may be the deck below the one specified above, see Ch 1, Sec 1, [4.3.2].

When there is no access from inside superstructures and deckhouses to 'tweendecks below, reduced scantlings with respect to those stipulated in this Section may be accepted at the discretion of the Society.

## 2 Boundary bulkhead plating

### 2.1

**2.1.1** The thickness of the boundary bulkheads is to be not less than the value t, in mm, calculated with the following formula:

$$t = 3,7 \cdot s \cdot K_{of} \cdot h^{0,5}$$

s : spacing between the stiffeners, in m

h : conventional scantling height, in m, the value of which is to be taken not less than that indicated in Tab 1

$K_{of}$ : factor defined in Sec 2.

**Table 1**

| Type of bulkhead | h (m) |
|---|---|
| 1st tier front | 1,5 |
| 2nd tier front | 1,0 |
| Other bulkheads wherever situated | 1,0 |

In any event, the thickness t is to be not less than the values shown in Table 2 of Sec 1 of this Chapter.

## 3 Stiffeners

### 3.1

**3.1.1** The stiffeners of the boundary bulkheads are to have a section modulus not less than the value Z, in $cm^3$, calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K_o$$

where:

h : conventional scantling height, in m, defined in [2.1]

$K_o$ : factor defined in Sec 2

s : spacing of the stiffeners, in m

S : span of the stiffeners, equal to the distance, in m, between the members supporting the stiffener concerned.

# 4 Superstructure decks

## 4.1 Plating

**4.1.1** The superstructure deck plating is to be not less than the value t, in mm, calculated with the following formula:

$$t = 3,7 \cdot s \cdot K_{of} \cdot h^{0,5}$$

where:

s : spacing of the stiffeners, in m

$K_{of}$ : factor defined in Sec 2

h : conventional scantling height, in m, defined in [2.1].

## 4.2 Stiffeners

**4.2.1** The section modulus Z, in $cm^3$, of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated with the following formula:

$$Z = 5,5 \cdot s \cdot S^2 \cdot h \cdot K_o$$

where:

S : conventional span of the stiffener, equal to the distance, in m, between the supporting members

s, h, $K_o$ : as defined in [3.1]

Reinforced beams (beams, stringers) and ordinary pillars are to have scantlings as stated in Sec 9.

# SECTION 12 SCANTLINGS OF STRUCTURES WITH SANDWICH CONSTRUCTION

## 1 Premise

### 1.1

**1.1.1** The sandwich type laminate taken into consideration in this Section is made up of two thin laminates in reinforced plastic bonded to a core material with a low density and low values for the mechanical properties.

The core material is, in general, made up of balsa wood, plastic foam of different densities or other materials (honeycomb) which deform easily under pressure or traction but which offer good resistance to shear stresses.

The thicknesses of the two skins are negligible compared to the thicknesses of the core.

The thickness of the core is to be not less than 6 times the minimum thickness of the skins.

The thicknesses of the two skins are to be approximately equal; the thickness of the external skin is to be no greater than 1,33 times the net thickness of the internal skin.

The moduli of elasticity of the core material are negligible compared to those of the skin material.

Normal forces and flexing moments act only on the external faces, while shear forces are supported by the core .

The scantlings indicated in the following Articles of this Section are considered valid assuming the above-mentioned hypotheses.

The scantlings of sandwich structures obtained differently and/or with core materials or with skins not corresponding to the above-mentioned properties will be considered case-by-case on the principle of equivalence, on submission of full technical documentation of the materials used and any tests carried out.

## 2 General

### 2.1 Laminating

**2.1.1** Where the core material is deposited above a prefabricated skin, as far as practicable the former is to be applied after the polymerisation of the skin laminate has passed the exothermic stage.

**2.1.2** Where the core is applied on a pre-laminated surface, even adhesion is to be ensured.

**2.1.3** When resins other than epoxide resins are used, the layer of reinforcement in contact with the core material is to be of mat.

**2.1.4** Prior to proceeding with glueing of the core, the latter is to be suitably cleaned and treated in accordance with the Manufacturer's instructions.

**2.1.5** Where the edges of a sandwich panel are to be connected to a single-skin laminate, the taper of the panel is not to exceed 30°.

In zones where high density or plywood insert plates are arranged, the taper is not to exceed 45°.

### 2.2 Vacuum bagging

**2.2.1** Where the vacuum bagging system is used, details of the procedure are to be submitted for examination.

The number, scantlings and distribution of venting holes in the panels are to be in accordance with the Manufacturer's instructions.

The degree of vacuum in the bagging system both at the beginning of the process and during the polymerisation phase is not to exceed the level recommended by the Manufacturer, so as to avoid phenomena of core evaporation and/or excessive monomer loss.

### 2.3 Constructional details

**2.3.1** In general the two skins, external and internal, are to be identical in lamination and in resistance and elasticity properties.

In way of the keel, in particular in sailing yachts with a ballast keel, in the zone where there are hull appendages, such as propeller shaft struts and rudder horns, in way of the connection to the upper deck and in general where connections with bolts are foreseen, as a rule, single-skin laminate is to be used.

The use of a sandwich laminate in these zones will be carefully considered by the Society bearing in mind the properties of the core and the precautions taken to avoid infiltration of water in the holes drilled for the passage of studs and bolts.

The use of sandwich laminates is also ill-advised in way of structural tanks for liquids where fuel oils are concerned.

Such use may be accepted by increasing the thickness of the skin in contact with the liquid, as indicated in Sec 10.

## 3 Symbols

### 3.1

**3.1.1**

S : conventional span of the strip of sandwich laminate equal to the minimum distance, in m, between the structural members supporting the sandwich (bulkheads, reinforced frames);

p : scantling pressure, in kN/m$^2$, as defined in Ch 1, Sec 5;

h : scantling height, in m, given in Ch 1, Sec 5;

$R_{to}$ : ultimate tensile strength, in N/mm$^2$, of the external skin;

$R_{ti}$ : ultimate tensile strength, in N/mm$^2$, of the internal skin;

$R_{co}$ : ultimate compressive strength, in N/mm$^2$, of the external skin;

$R_{ci}$ : ultimate compressive strength, in N/mm$^2$, of the internal skin;

t : ultimate shear strength, in N/mm$^2$, of the core material of the sandwich;

h : net height, in mm, of the core of the sandwich.

## 4 Minimum thickness of the skins

### 4.1

**4.1.1** The thickness of the skin laminate is to be sufficient to obtain the section modulus prescribed in the following Articles; furthermore, it is to have a value, in mm, not less than that given by the following formulae:

a) Bottom

$$t_o = 0,50 \cdot (2,2 + 0,25L)$$

$$t_i = 0,40 \cdot (2,2 + 0,25L)$$

b) Side and weather deck

$$t_o = 0,45 \cdot (2,2 + 0,25L)$$

$$t_i = 0,35 \cdot (2,2 + 0,25L)$$

where:

$t_o$ : thickness of the external laminate of the sandwich

$t_i$ : thickness of the internal laminate of the sandwich.

Thicknesses less than the minimums calculated with the above formulae, though not less than those in Tab 2, may be accepted provided they are sufficient in terms of buckling strength.

In the case of a sandwich structure with a core in balsa wood or polyurethane foam and other similar products, the critical stress $s_{CR}$, in N/mm$^2$, given by the following formula, is to be not less than 1,1 $s_C$:

$$\sigma_{CR} = 0,4 \cdot \frac{(E_F \cdot E_A \cdot G_A)^{1/3}}{1 - \nu^2}$$

where:

$E_F$ : compressive modulus of elasticity of the laminate of the skin considered, in, in N/mm$^2$;

$E_A$ : compressive modulus of elasticity of the core material of the skin considered, in N/mm²;

$G_A$ : shear modulus of elasticity of the core material, in N/mm²;

$\sigma_C$ : actual compressive strength on the skin considered, in N/mm²

$\nu$ : Poisson coefficient of the laminate of the skin considered.

## 5 Bottom

### 5.1

**5.1.1** The section moduli $Z_{So}$ and $Z_{Si}$, in cm³, corresponding to the external and internal skins, respectively, of a strip of sandwich of the bottom 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$Z_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

where:

$k_1$ : 1,6 assuming $p=p_1$

: 0,4 assuming $p=p_2$

The moment of inertia of a strip of sandwich 1 cm wide is to be not less than the value $I_S$, in cm⁴, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where:

R : the greater of the ultimate compressive strengths of the two skins, in N/mm²;

$E_S$ : the mean of the four values of the compressive and tensile moduli of elasticity of the two skins, in N/mm²;

Z : $Z_{So}$ or $Z_{Si}$, in cm³, whichever is the greater.

The net height of the core $h_a$, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{k_1 \cdot p \cdot S}{\tau}$$

where:

$k_1$ : 0,5 assuming $p=p_1$

: 0,2 assuming $p=p_2$

## 6 Side

### 6.1

**6.1.1** The section moduli $Z_{So}$ and $Z_{Si}$, in cm³, corresponding to the external and internal skins, respectively, of a strip of sandwich of the side 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$Z_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

where:

$k_1$ : 1,6 assuming $p=p_1$

: 0,4 assuming $p=p_2$

The moment of inertia of a strip of sandwich of the side 1 cm wide is to be not less than the value $I_S$, in cm⁴, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where R and $E_S$ are as defined in [5]:

The net height of the core $h_a$, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{k_1 \cdot p \cdot S}{\tau}$$

where:

$k_1$ : 0,5 assuming $p=p_1$

: 0,2 assuming $p=p_2$

## 7 Decks

### 7.1

**7.1.1** The section moduli $Z_{So}$ and $Z_{Si}$, in cm³, corresponding to the external and internal skins, respectively, of a strip of sandwich of the deck 1 cm wide are to be not less than the values given by the following formulae:

$$Z_{So} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{co}}$$

However, the modulus $Z_{So}$ may be assumed not greater than that required for the side in [6.1], having the same conventional span S as defined in [3.1.1].

$$Z_{Si} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{ti}}$$

The moment of inertia of a strip of sandwich 1 cm wide is to be not less than the value $I_S$, in cm⁴, given by the following formula:

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where R and $E_S$ are as defined in [5].

The net height of the core $h_a$, in mm, is to be not less than the value given by the following formula:

$$h_a = \frac{7 \cdot h \cdot S}{\tau}$$

## 8 Watertight bulkheads and boundary bulkheads of the superstructure

### 8.1

**8.1.1** The scantlings shown in this Article apply both to subdivision bulkheads and to tank bulkheads.

They may also be applied to boundary bulkheads of the superstructure assuming for h the relevant value indicated in Ch 4, Sec 11.

The section modulus $Z_S$, in cm³, and the moment of inertia $I_S$, in cm⁴, of a strip of sandwich 1 cm wide are to be not less than the values given by the following formulae:

$$Z_S = 15 \cdot h \cdot S^2 \cdot \frac{1}{R}$$

$$I_S = 40 \cdot S \cdot Z \cdot \frac{R}{E_S}$$

where:

R : the greater of the ultimate compressive strengths of the two skins, in N/mm²;

$E_S$ : the mean of the values of the compressive moduli of elasticity of the two skins, in N/mm²;

The net height of the core $h_a$, in mm, is to be not less than the value given by the formula:

$$h_a = \frac{7 \cdot h \cdot S}{\tau}$$

# SECTION 13 STRUCTURAL ADHESIVES

## 1 General

### 1.1

**1.1.1** Structural adhesives are to be used according to the Manufacturer's specifications. The details of the structural adhesives are to be enclosed in the list required in Ch 1, Sec 1, [3.1.1].

The above-mentioned information is to include the material data sheet containing all the details of the structural adhesive.

The process for the application of the adhesive is to be submitted and is to include:

- The maximum bond line thickness;
- Surface preparation and cleanliness of the surface to be bonded;
- Handling, mixing, application and curing requirements of the structural adhesive;
- Non-destructive test methods and acceptability criteria for any defects found;
- Remedial work in order to rectify excessive unevenness of the faying surface or local undulations;
- Details relevant to the level of training required for the personnel involved in the application of structural adhesives.

Details listed in the material data sheet are to be specified in the construction plan submitted for approval.

**1.1.2** For hull for which structural adhesives are used, a special class notation will be assigned as indicated in Part A.

### 1.2

**1.2.1** The structural adhesives are to have the following properties:

a) The adhesive is to be compatible with the lamination resin;

b) It is recommended that the elastic modulus of the adhesive is should be compatible with the elastic modulus of the GRP skin: this means that the ratio between the two elastic moduli shall be such as to avoid stress concentration in the skin substrate when a longitudinal shear force is applied to the joint;

c) The mechanical properties of the adhesive are to be rapidly achieved. That means no use of screws or bolts is necessary to hold the substrate together while the adhesive cures;

d) A greater safety factor (ratio of failure strain to actual strain) than the one of the adjacent structure is to result;

e) The minimum shear strength obtained from a lap-shear test is to be not less than 7 $N/mm^2$. All failures of test samples are to be either cohesive or fibre tear.

## 2 Design criteria for bonded connection

### 2.1

**2.1.1** In general the shear stress at the inner surface of the plating is to be calculated by direct calculations according to the requirements of Ch 1, Sec 5. In general, the calculation of the flange connection between the internal reinforcement and the plating is to be carried out as indicated in this paragraph.

A typical stiffener/plating connection is shown in the following Fig 1:

The linear load due to the bending moment calculated at the inner surface plating can be obtained from the following formula:

$$Q_p = \frac{P \times (E \times A)_p \times Y_p}{(E \times I)_{sp}}$$

where:

$Q_p$ : is the linear load in N/mm applied to the inner surface of the plating and due to the bending moment ;

P= 500 x p x s x S: is the total load in N applied to the panel of dimension (Sxs) and due to the design pressure as calculated according to items Ch 1, Sec 5, [5.3] and Ch 1, Sec 5, [5.4];

ExA=$E_p$ x b x $t_p$ ;

where:

$E_p$: is the inplane elastic modulus of the plating in N/mm$^2$;

b: is the width of the plate associated with the stiffener, in mm;

$t_p$ : is the thickness of the associated plate, in mm ;

$Y_p$: is the distance from the centroid of the associated plate to the neutral axis, in mm;

$(ExI)_{sp}$ :is the flexural rigidity of the composite element (stiffener and plating) combined around the neutral axis, in N/mm$^2$;

The shear stress for the jointing adhesive for plating can be calculated with the following formula:

$$\tau_p = \frac{Q_p}{b} (N/mm^2)$$

It is to be verified that $t_p$ is not greater than 20% of the nominal bond shear strength as indicated by the Manufacturer's adhesive. For guidance, Tab 1 indicates some data regarding the nominal shear strength and the allowable design stress for certain structural adhesives.

**Figure 1 :**

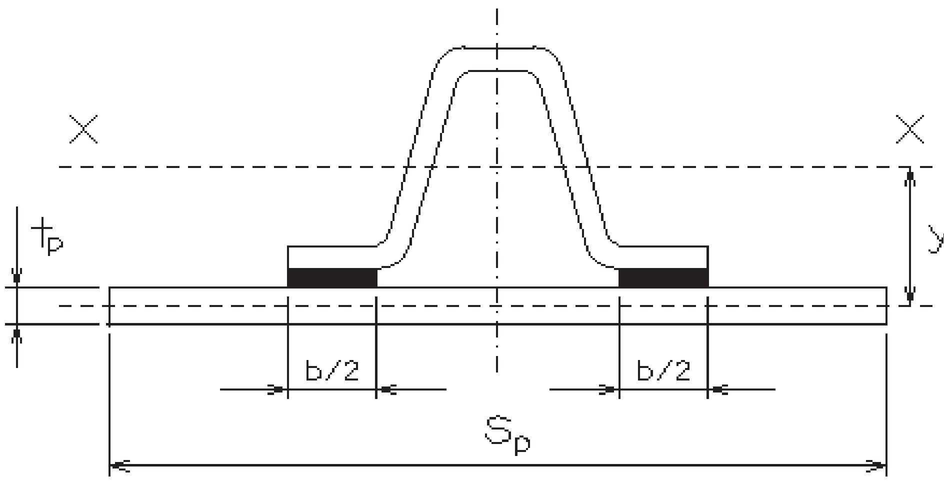



**Table 1**

| Adhesive | Nominal bond shear strength [N/mm$^2$] | Allowable design stress [N/mm$^2$] |
|---|---|---|
| Cold-cured epoxy | 28 | 5,2 |
| Polyester or vinylester resin or paste | 14 | 3,5 |
| Epoxy type paste | 41 | 8,5 |

# Chapter 3

## STABILITY

# SECTION 1 STABILITY

## 1 General

### 1.1

**1.1.1** Each yacht is to be provided with a stability booklet, approved by the Society, which contains sufficient information to enable the Master to operate the yacht in compliance with the applicable requirements contained in this Section Where any alterations are made to a yacht so as to materially affect the stability information supplied to the Master, amended stability information is to be provided. If necessary the yacht is to be re-inclined. Stability data and associated plans are to be drawn up in the working language of the yacht and any other language the Administration the flag of which the yacht is entitled to fly may require. The format of the trim and stability booklet and the information included are specified in App 2.

**1.1.2** This Section outlines the minimum requirements for intact stability for both motor and sailing yachts. This Section deals with the standards for intact stability.

**1.1.3** An intact stability standard proposed for assessment of a yacht type not covered by the standards defined in this Section is to be submitted to the Society for approval at the earliest opportunity.

**1.1.4** If curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) are used to ensure compliance with the relevant intact stability criteria those limiting curves are to extend over the full range of operational trims, unless the Society agrees that trim effects are not significant. When curves or tables of minimum operational metacentric height (GM) or maxi-mum centre of gravity (VCG) versus draught covering the operational trims are not available, the Master is to verify that the operating condition does not deviate from a studied loading condition, or verify by calculation that the stability criteria are satisfied for this loading condition taking into account trim effects.

**1.1.5** If used, permanent ballast is to be located in accordance with a plan approved by the Society and in a manner that prevents shifting of position. Permanent ballast is not to be removed from the yacht or relocated within the yacht without the approval of the Society. Permanent ballast particulars are to be noted in the yacht's stability booklet. Attention is to be paid to local or global hull strength requirements arising from the fitting of additional ballast.

**1.1.6** As an alternative to this Section EN/ISO 12217 Category A for sailing yacht may be applied.

**1.1.7** In addition to the requirements set in [2] or in EN/ISO 12217 the yacht should be capable of self-righting from an inverted position with or without reasonable intervention from the crew and independent of the condition of the rig. Either with, or without, reasonable intervention from the crew, a boat shall be capable of self-righting from an inverted position. Self righting shall be achievable whether or not the rig is intact. Boats with moveable/variable ballast shall comply with this requirement in flat water using manual power only and shall demonstrate that any equipment to be used in re-righting the boat is ready for use at all times and will function and is operable by the crew with the boat inverted. Re-righting the boat shall not require flooding any part of the boat.

## 2 Intact Stability Standards

### 2.1 Stability

#### 2.1.1 Standard criteria

The curves of static stability for seagoing conditions are to meet the following criteria:

a) the area under the righting lever curve (GZ curve) is not to be less than 0,055 metre-radians up to 30º angle of heel and not less than 0,09 metre-radians up to 40º angle of heel, or the angle of downflooding, if this angle is less;
b) the area under the GZ curve between the angles of heel of 30º and 40º or between 30º and the angle of downflooding if this is less than 40º, is not to be less than 0.03 metre-radians;
c) the righting lever (GZ) is to be at least 0,20 metres at an angle of heel equal to or greater than 30º;
d) the maximum GZ is to occur at an angle of heel preferably exceeding 30º but not less than 25º;

e) after correction for free surface effects, the initial metacentric height (GM) is not to be less than 0,15 metres;

f) in the event that the yacht's intact stability standard fails to comply with the criteria defined in a) to e), the Society may be consulted for the purpose of specifying alternative but equivalent criteria;

g) crowding of persons;

The angle of heel on account of crowding of persons to one side is not to exceed 10° and in any event the freeboard deck is not to be immersed.

Note 1: $\theta_f$ is an angle of heel at which openings in the hull, super structures or deckhouses which cannot be closed weathertight sub merge. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

### 2.1.2 Alternative criteria

The curves of statical stability for seagoing conditions are to meet the following criteria:

a) the area under the righting lever curve (GZ curve) is not to be less than 0,075 metre-radians up to an angle of 20º when the maximum righting lever (GZ) occurs at 20º and not less than 0,055 metre-radians up to an angle of 30º when the maximum righting lever (GZ) occurs at 30º or above. When the maximum GZ occurs at angles between 20º and 30º the corresponding area under the GZ curve $A_{req}$ is to be taken as follows:

$A_{req}$={0,055 + 0,002(30 - $\theta_{max}$) metre radians;

where $\theta_{max}$ is the angle of heel in degrees at which the GZ curve reaches its maximum.

b) the area under the GZ curve between the angles of heel of 30º and 40º, or between 30º and the angle of downflooding if this is less than 40º, is not to be less than 0,03 metre-radians;

c) the righting lever (GZ) is to be at least 0,20 metres at an angle of heel where it reaches its maximum;

d) the maximum GZ is to occur at an angle of heel not less than 20º;

e) after correction for free surface effects, the initial metacentric height (GM) is not to be less than 0,15 metres;

f) if the maximum righting lever (GZ) occurs at an angle of less than 20º, approval of the stability is to be considered by the Society as a special case.

**2.1.3** For the purpose of assessing whether the stability criteria are met, GZ curves are to be produced for the loading conditions applicable to the operation of the yacht.

## 2.2 Additional criteria

### 2.2.1 Monohull

a) Curves of static stability (GZ curves) are to be produced or at least the Loaded Departure with 100% consumables and the Loaded Arrival with 10% consumables.

b) The GZ curves required by a) should have a positive range of not less than 90º. For yachts of more than 45 m, a range of less than 90º may be considered but may be subject to agreed operational criteria.

c) In addition to the requirements of b), the angle of steady heel is to be greater than 15 degrees (see Fig 1). The angle of steady heel is obtained from the intersection of a 'derived wind heeling lever' curve with the GZ curve required by a).

In the figure:

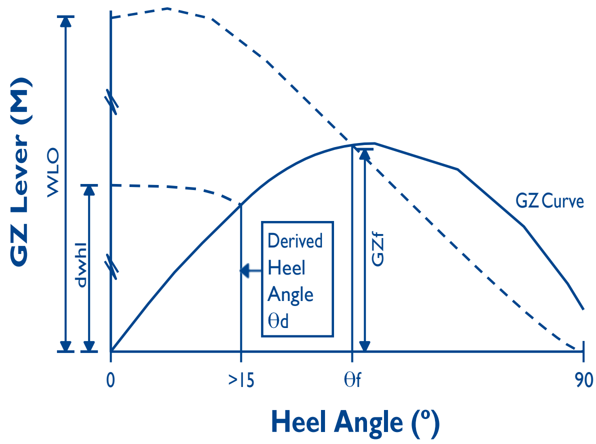
'dwhl' = the 'derived wind heeling lever' at any angle $\theta$

$$dwhl = 0,5 \times WLO \times Cos^{1,3}\theta$$

where:

$$WLO = \frac{GZ_f}{Cos^{1,3}\theta_f}$$

**Figure 1**




Noting that:

WLO is the magnitude of the actual wind heeling lever at 0º which would cause the yacht to heel to the 'downflooding angle' $\theta_f$ or 60º, whichever is the lesser.

GZf is the lever of the yacht's GZ at the downflooding angle ($\theta_f$) or 60º, whichever is the lesser.

$\theta_d$ is the angle at which the 'derived wind heeling' curve intersects the GZ curve. (If $\theta_d$ is less than 15º the yacht will be considered as having insufficient stability).

$\theta_f$ the 'downflooding angle' is the angle of heel causing immersion of the lower edge of openings having an aggregate area, in square metres, greater than:

$$\frac{\Delta}{1500}$$

where $\Delta$ = yacht's displacement in tonnes.

All regularly used openings for access and ventilation are to be considered when determining the downflooding angle. No opening, regardless of size, which may lead to progressive flooding is to be immersed at an angle of heel of less than 40º. Air pipes to tanks can, however, be disregarded.

If, as a result of immersion of openings in a superstructure, a yacht cannot meet the required standard, those superstructure openings may be ignored and the openings in the weather deck used instead to determine $\theta_f$. In such cases the GZ curve is to be derived without the benefit of the buoyancy of the superstructure.

d) It might be noted that provided the yacht complies with the requirements of [2.3] as applicable and is sailed with an angle of heel which is no greater than the 'derived angle of heel', it should be capable of withstanding a wind gust equal to 1,4 times the actual wind velocity (i.e. twice the actual wind pressure) without immersing the 'downflooding openings' or heeling to an angle greater than 60º.

### 2.2.2 Multi-hull

a) Curves of static stability in both roll and pitch are to be prepared for at least the Loaded Arrival with 10% consumables. The VCG is to be obtained by one of the three methods listed below:

1) inclining of complete yacht in air on load cells, the VCG being calculated from the moments generated by the measured forces, or

2) separate determination of weights of hull and rig (comprising masts and all running and standing rigging), and subsequent calculation assuming that the hull VCG is 75% of the hull depth above the bottom of the canoe body, and that the VCG of the rig is at half the length of the mast (or a weighted mean of the lengths of more than one mast), or

3) detailed calculation of the weight and CG position of all components of the yacht, plus a 15% margin of the resulting VCG height above the underside of canoe body.

b) If naval architecture software is used to obtain a curve of pitch restoring moments, then the trim angle is to be found for a series of longitudinal centre of gravity (LCG) positions forward of that necessary for the design waterline. The curve can then be derived as follows:

GZ in pitch = CG' x cos (trim angle)

$$\text{trim angle} = \tan^{-1}\left(\frac{T_{FP} - T_{AP}}{L_{BP}}\right)$$

where:

CG' = shift of LCG forward of that required for design trim, measured parallel to base line

$T_{FP}$ = draught at forward perpendicular

$T_{AP}$ = draught at aft perpendicular

$L_{BP}$ = length between perpendiculars

Approximations to maximum roll or pitch moments are not acceptable.

c) Data is to be provided to the user showing the maximum advised mean apparent wind speed appropriate to each combination of sails, such wind speeds being calculated as the lesser of the following:

$$v_w = 1,5\sqrt{\frac{LM_R}{A'_S h\cos\phi_R + A_D b}}$$

or

$$v_w = 1,5\sqrt{\frac{LM_P}{A'_S h\cos\phi_P + A_D b}}$$

where:

$v_W$ = maximum advised apparent wind speed (knots)

$LM_R$ = maximum restoring moment in roll (N-m)

$LM_p$ = limiting restoring moment in pitch (N-m), defined as the pitch restoring moment at the least angle of the following:

1) angle of maximum pitch restoring moment, or
2) angle at which foredeck is immersed
3) 10º from design trim

$A'_S$ = area of sails set including mast and boom (square metres)

h = height of combined centre of effort of sails and spars above the waterline

$f_R$ = heel angle at maximum roll righting moment (in conjunction with LMR)

$f_P$ = limiting pitch angle used when calculating LMP (in conjunction with LMP)

$A_D$ = plan area of the hulls and deck (square metres)

b = distance from centroid of AD to the centreline of the leeward hull

This data are to be accompanied by the note:

In following winds, the tabulated safe wind speed for each sail combination should be reduced by the boat speed.

d) If the maximum safe wind speed under full fore-and-aft sail is less than 27 knots, it is to be demonstrated by calculation using annex D of EN/ISO 12217-2 (2002) that, when inverted and/or fully flooded, the volume of buoyancy, expressed in cubic metres (m3), in the hull, fittings and equipment is greater than:

1.2 x (fully loaded mass in tonnes)

thus ensuring that it is sufficient to support the mass of the fully loaded yacht by a margin. Allowance for trapped bubbles of air (apart from dedicated air tanks and watertight compartments) is not to be included.

e) The maximum safe wind speed with no sails set calculated in accordance with c) above is to exceed 36 knots.

f) Trimarans used for unrestricted operations are to have sidehulls each having a total buoyant volume of at least 150% of the displacement volume in the fully loaded condition.

g) The stability information booklet is to include information and guidance on:

1) the stability hazards to which these yachts are vulnerable, including the risk of capsizing in roll and/or pitch;
2) the importance of complying with the maximum advised apparent wind speed information supplied;
3) the need to reduce the tabulated safe wind speeds by the yacht speed in following winds;
4) the choice of sails to be set with respect to the prevailing wind strength, relative wind direction, and sea state;

5) the precautions to be taken when altering course from a following to a beam wind.

h) In yachts required to demonstrate the ability to float after inversion (according to c) above), an emergency escape hatch is to be fitted to each main inhabited watertight compartment such that it is above both upright and inverted waterlines.

## 2.3 Element of Stability

**2.3.1** Unless otherwise specified, the lightship weight, vertical centre of gravity (KG) and longitudinal centre of gravity (LCG) of a yacht are to be determined from the results of an inclining experiment.

**2.3.2** An inclining experiment is to be conducted in accordance with a detailed standard which is approved by the Society, and in the presence of a RINA Surveyor.

**2.3.3** The inclining experiment and the lightweight check are to be conducted in accordance with the provisions of App 1.

**2.3.4** The report of the inclining experiment and the lightship particulars derived are to be approved by the Society prior to their use in stability calculations.

**2.3.5** For sister yachts, in order to verify the stability documentation the following procedure is to be applied:

a) the shipyard declares that a yacht is dealt with as a prototype.

An inclining experiment is to be carried out on this first yacht (prototype) and, on the basis of the results, a full stability booklet is to be prepared, taking into account the Rule stability requirements.

The above documents are to be examined and approved.

b) In the case of a declared sister yacht (same hull, machinery, subdivision, general arrangement and furniture, as far as reasonable), a lightweight survey is to be carried out instead of an inclining test, provided that:

1) the yacht is built by the same shipyard;
2) the same drawings are used;
3) 3) when the sister yacht is built, the light yacht displacement difference in comparison to the prototype is not greater than $\pm$ 2% and LCG difference is not greater than 1%;
4) a sister yacht statement is communicated to the Society, thus formalising the request to waive the inclining experiment for the sister yacht.

Should a yacht be declared a sister yacht of a prototype, the following documentation is to be sent for approval:

a) lightship weight report (duly signed by the attending RINA Surveyor and by the shipyard representative);

b) stability booklet as photocopy of the prototype, only updated for the general description (yacht’s name, port of registry, flag, etc).

**2.3.6** Should a yacht be declared a sister yacht of a prototype, the following documentation is to be sent for approval:

a) lightship weight report (duly signed by the attending RINA Surveyor and by the shipyard representative);

b) stability booklet as photocopy of the prototype with the following updating: general description (yacht's name, port of registry, flag, etc) and loading condition considering the new lightship data.

## 2.4 Stability Documents

**2.4.1** A yacht is to be provided with a stability information booklet for the Master, which is to be approved by the Society.

**2.4.2** The stability information booklet is to be contain the information specified in App 2.

**2.4.3** A yacht with previously approved stability information which undergoes a major refit or alterations is to be subjected to a complete reassessment of stability and provided with newly approved stability information.

A major refit or major alteration is one which results in a change in the lightship weight of 2% and above, and/or a change in the longitudinal centre of gravity of 1% and above (measured from the aft perpendicular), and/or an increase in the calculated vertical centre of gravity of 0,25% and above (measured from the keel).

**2.4.4** Sailing yachts are to have, readily available, a copy of the Curves of Maximum Steady Heel Angle to Prevent Downflooding in Squalls, or in the case of a multi-hull, the values of maximum advised mean apparent windspeed, for the reference of the watchkeeper. This is to be a direct copy taken from that contained in the approved stability booklet.

**2.4.5** The overall sail area and spar weights and dimensions are to be as documented in the yacht's stability information booklet. Any rigging modifications that increase the overall sail area, or the weight/dimensions of the rig aloft, are to be accompanied by an approved update of the stability information booklet.

# APPENDIX 1 INCLINING TEST AND LIGHTWEIGHT CHECK

## 1 General

### 1.1 General conditions of the yacht

**1.1.1** Prior to the test, the Society's Surveyor is to be satisfied of the following:

a) the weather conditions are to be favourable;

b) the yacht is to be moored in a quiet, sheltered area free from extraneous forces, such as to allow unrestricted heeling. The yacht is to be positioned in order to minimise the effects of possible wind, stream and tide;

c) the ship is to be upright however, with inclining weights in the initial position, up to 0,5° of list is acceptable.

The actual trim and deflection of keel, if practical, are to be considered in the hydrostatic data. In order to avoid excessive errors caused by significant changes in the water plane area during heeling, hydrostatic data for the actual trim and the maximum anticipated heeling angles are to be checked beforehand and the trim is to be taken not more than 1% of the length between perpendiculars.

Otherwise, hydrostatic data and sounding tables are to be available for the actual trim.

d) cranes, derrick, lifeboats and liferafts capable of inducing oscillations are to be secured;

e) pipes and any other system containing liquids are to be filled;

f) the bilge and the decks are to be thoroughly dried;

g) preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim.

The shape of the tank is to be such that the free surface effect can be accurately determined and remains almost constant during the test. All cross connections are to be closed;

h) the weights necessary for the inclination are to be already on board, located in the correct place;

i) all work on board is to be suspended and crew or personnel not directly involved in the inclining test are to leave the yacht;

j) the yacht is to be as complete as possible at the time of the test. The number of weights to be removed, added or shifted is to be limited to a minimum. Temporary material, tool boxes, staging, sand, debris, etc on board are to be reduced to an absolute minimum.

## 2 Inclining weights

### 2.1

**2.1.1** The total weight used is preferably to be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side. the Society may, however, accept a smaller inclination angle for large yachts provided that the requirement on pendulum deflection or U-tube difference in height specified in [3] is complied with. Test weights are to be compact and of such a configuration that the VCG (vertical centre of gravity) of the weights can be accurately determined. Each weight is to be marked with an identification number and its weight. Recertification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, is to be available during the inclining test to shift weights on the deck in an expeditious and safe manner. Water ballast and people are generally not acceptable as inclining weight.

**2.1.2** Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Society is required. The following conditions are to be met:

a) inclining tanks are to be wall-sided and free of large stringers or other internal members that create air pockets;

b) tanks are to be directly opposite to maintain the yacht's trim;

c) specific gravity of ballast water is to be measured and recorded;

d) pipelines to inclining tanks are to be full. If the yacht's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used;

e) blanks are to be inserted in transverse manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control is to be maintained during the test;

f) all inclining tanks are to be manually sounded before and after each shift;

g) vertical, longitudinal and transverse centres are to be calculated for each movement;

h) accurate sounding/ullage tables are to be provided. The yacht's initial heel angle is to be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard) are to be used when establishing the initial heel angle;

i) verification of the quantity shifted may be achieved by a flowmeter or similar device;

j) the time to conduct the inclining is to be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of wind shifts over long periods of time.

## 3 Pendulums

### 3.1

**3.1.1** The use of three pendulums is recommended but a minimum of two are to be used to allow identification of bad readings at any one pendulum station. However, for yachts of a length equal to or less than 30 m, only one pendulum may be accepted. They are each to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, to each side of upright, of at least 10 cm. To ensure that recordings from individual instruments are kept separate, it is suggested that the pendulums should be physically located as far apart as practical.

The use of an inclinometer or U-tube is to be considered in each separate case. It is recommended that inclinometers or other measuring devices should only be used in conjunction with at least one pendulum.

## 4 Means of communication

### 4.1

**4.1.1** Efficient two-way communications are to be provided between central control and the weight handlers and between central control and each pendulum station. One person at a central control station is to have complete control over all personnel involved in the test.

## 5 Documentation

### 5.1

**5.1.1** The person in charge of the inclining test is to have available a copy of the following plans at the time of the test:

a) hydrostatic curves or hydrostatic data;

b) general arrangement plan of decks, holds, inner bottoms;

c) capacity plan showing capacities and vertical and longitudinal centres of gravity of tanks. When water ballast is used as inclining weights, the transverse and vertical centres of gravity for the applicable tanks are to be available for each angle of inclination;

d) tank sounding tables;

e) draught mark locations;

f) docking drawing with keel profile and draught mark corrections, if available.

## 6 Calculation of the displacement

### 6.1

**6.1.1** The following operations are to be carried out for the calculation of the displacement:

a) draught mark readings are to be taken at aft, midship and forward, at starboard and port sides;

b) the mean draught (average of port and starboard reading) is to be calculated for each of the locations where draught readings are taken and plotted on the yacht's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot is to yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/ draughts are to be taken again;

c) the specific gravity of the sea water is to be determined. Samples are to be taken from a sufficient depth of the water to ensure a true representation of the sea water and not merely surface water, which could contain fresh water from run-off of rain. A hydrometer is to be placed in a water sample and the specific gravity read and recorded. For large yachts, it is recommended that samples of the sea water should be taken forward, midship and aft, and the readings averaged. For small yachts, one sample taken from midship is sufficient. The temperature of the water is to be taken and the measured specific gravity corrected for deviation from the standard, if necessary;

d) A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site. Correction is necessary if specific gravity is measured when the sample temperature differs from the temperature at the time of the inclining test. Where the value of the average calculated specific gravity is different from that reported in the hydrostatic curves, adequate corrections are to be made to the displacement curve;

e) all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the yacht's trim and the position of air pipes;

f) it is to be checked that the bilge is dry, and an evaluation of the liquids which cannot be pumped, remaining in the pipes, is to be carried out;

g) the entire yacht is to be surveyed in order to identify all items which need to be added, removed or relocated to bring the yacht to the lightship condition. Each item is to be clearly identified by weight and location of the centre of gravity;

h) the possible solid permanent ballast is to be clearly identified and listed in the report.

## 7 Inclining procedure

### 7.1

#### 7.1.1

The standard test generally employs eight distinct weight movements as shown in Fig 1 and Tab 1.

**Figure 1**

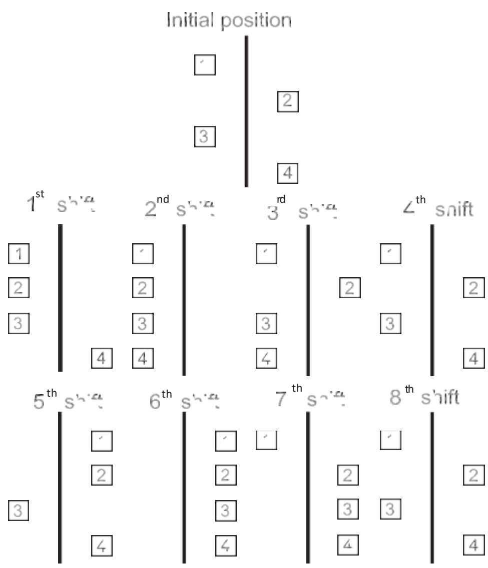


**Table 1 : Weight shift procedure**

| No. of Weights or Weight Groups | | | | |
|---|---|---|---|---|
| Weight shifts | Four | | Six | |
| | PS | SB | PS | SB |
| No. 0 | 2, 4 | 1, 3 | 2, 4, 6 | 1, 3, 5 |
| No. 1 | 4 | 1, 2, 3 | 4, 6 | 1, 2, 3, 5 |
| No. 2 | | 1, 2, 3, 4 | | 1, 2, 3, 4, 5, 6 |
| No. 3 | 1 | 2, 3, 4 | 6 | 1, 2, 3, 4, 5 |
| No. 4 | 1, 3 | 2, 4 | 2, 4, 6 | 1, 3, 5 |
| No. 5 | 1, 2, 3, | 4 | 1, 2, 3, 4, 6 | 5 |
| No. 6 | 1, 2, 3, 4 | | 1, 2, 3, 4, 5, 6 | |
| No. 7 | 2, 3, 4 | 1 | 1, 2, 4, 6 | 3, 5 |
| No. 8 | 2, 4 | 1, 3 | 2, 4, 6 | 1, 3, 5 |
| PS and SB denotes port and starboard sides of ship respectively.<br>The underlined numbers indicate the last weight groups shifted. | | | | |

The weights are to be transversally shifted, so as not to modify the ship’s trim and vertical position of the centre of gravity.

After each weight shifting, the new position of the transverse centre of gravity of the weights is to be accurately determined.

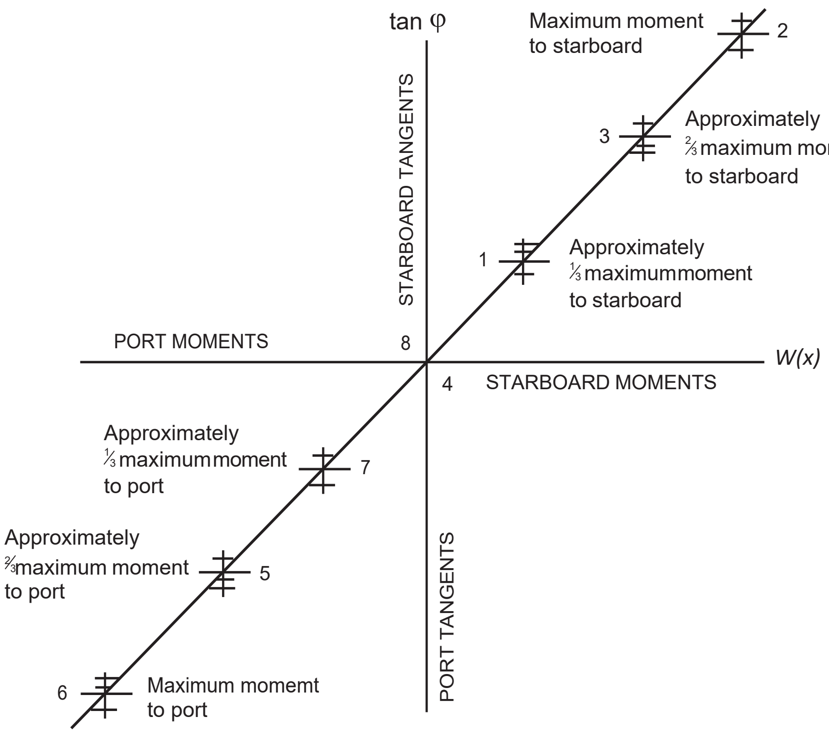
After each weight movement, the distance the weight was moved (centre to centre) is to be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph as shown in Fig 2.

The pendulum deflection is to be read when the ship has reached a final position after each weight shifting.

During the reading, no movements of personnel are allowed.

For yachts with a length equal to or less than 30 m, six distinct weight movements may be accepted

**Figure 2 : Graph of resultant tangents**



The plotting of all the readings for each of the pendulums during the inclining experiment aids in the discovery of bad readings. Since the ratio tangent/moment should be constant, the plotted line should be straight. Deviations from a straight line are an indication that there were other moments acting on the ship during the inclining. These other moments are to be identified, the cause corrected, and the weight movements repeated until a straight line is achieved. Fig 2 to Fig 5 illustrate examples of how to detect some of these other moments during the inclining, and a recommended solution for each case. For simplicity, only the average of the readings is shown on the inclining plots.

**Figure 3 : Excessive free liquids (re-check all tanks and voids and pump out as necessary; re-do all weight movements and re-check freeboard and draught readings**

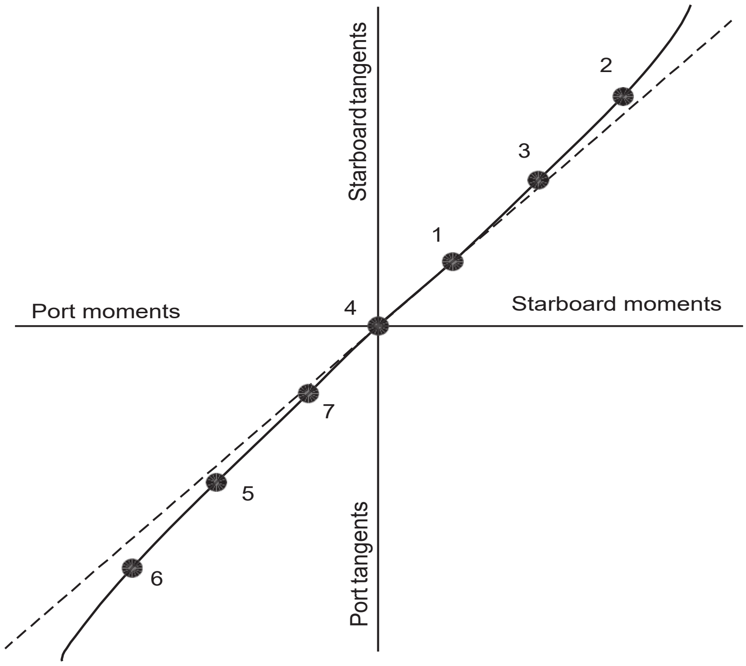



**Figure 4 : Yacht touching bottom or restrained by mooring lines (take water soundings and check lines: re-do weight movements 2 and 3)**

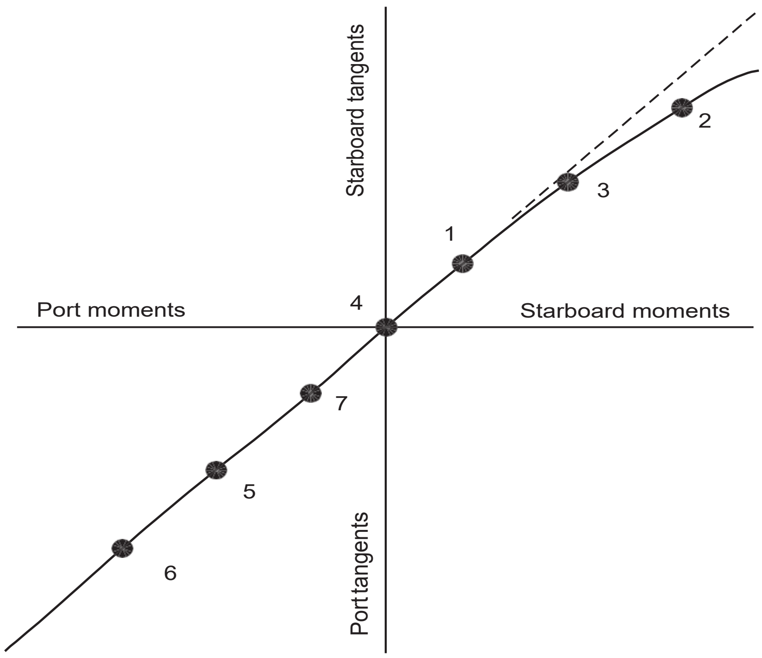


**Figure 5 : Steady wind from port side came up after initial zero point taken (plot acceptable)**

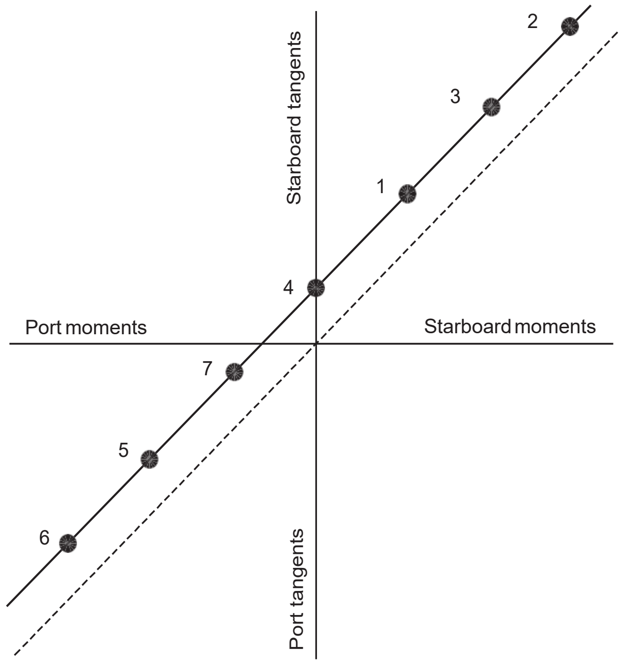
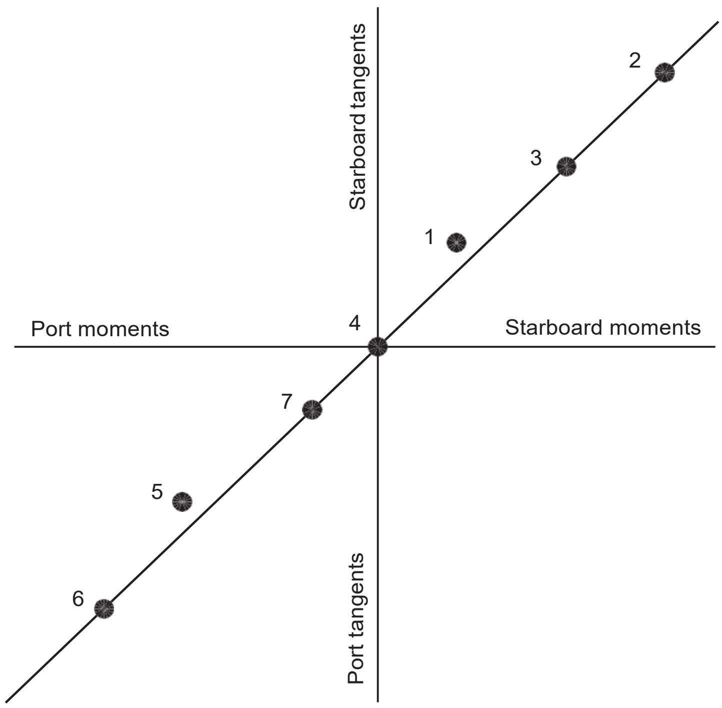



**Figure 6 : Gusty wind from port side (re-do weight movements 1 and 5)**




## 8 Lightweight check

### 8.1

**8.1.1** An inclining test for an individual yacht may be dispensed with by the Society on a case-by-case basis, provided that basic stability data are available from the inclining test of a sister yacht and a satisfactory lightweight check is performed in order to prove that the sister yacht corresponds to the prototype yacht. In general acceptable values for the acceptance of the lightweight check are those reported in Sec 1, [2.4.5] b) 3).

# APPENDIX 2 STABILITY INFORMATION BOOKLET

## 1 Information to be included

### 1.1 General

**1.1.1** A stability information booklet is a stability manual, to be approved by the Society, which is to contain sufficient information to enable the Master to operate the yacht in compliance with the applicable requirements contained in the Rules.

### 1.2 List of information

**1.2.1** The following information is to be included in the stability information booklet:

a) a general description of the yacht, including:
   - the yacht's name
   - the yacht type
   - the yard, the hull number and the year of delivery
   - the moulded dimensions
   - the design draft
   - the displacement corresponding to the above-mentioned draughts;

b) clear instructions on the use of the booklet;

c) general arrangement and capacity plans indicating the assigned use of compartments and spaces (stores, accommodation, etc.);

d) a sketch indicating the position of the draught marks referred to the yacht's perpendiculars;

e) hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the yacht, curves or tables corresponding to such range of trim. A clear reference relevant to the sea density, in $t/m^3$, is to be included as well as the draught measure (from keel or underkeel);

f) cross curves (or tables) of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered in the computation of these curves;

g) tank sounding tables or curves showing capacities, centre of gravity, and free surface data for each tank;

h) lightship data from the inclining test, including lightship displacement, centre of gravity co-ordinates, place and date of the inclining test, as well as the Society approval details specified in the inclining test report. It is recommended that a copy of the approved test report be enclosed with the stability information booklet. Where the above-mentioned information is derived from a sister yacht, the reference to this sister yacht is to be clearly indicated, and a copy of the approved inclining test report relevant to this sister yacht is to be included;

i) standard loading conditions and examples for developing other acceptable loading conditions using the information contained in the booklet;

j) intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surface effect, GZ values and curve when applicable, reporting a comparison between the actual and the required values), which are to be available for each of the above-mentioned operating conditions;

k) information on loading restrictions when applicable;

l) information about openings (location, tightness, means of closure), pipes or other progressive flooding sources;

m) information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable;

n) any other necessary guidance for the safe operation of the yacht;

o) a table of contents and index for each booklet.

## 2 Loading conditions

### 2.1

**2.1.1** The standard loading conditions to be included in the stability information booklet are:

a) yacht in the fully loaded departure condition, with full stores and fuel and the full number of guests;

b) lightship condition;

c) yacht in the fully loaded arrival condition, with only 10% stores and fuel remaining and the full number of guests.

Such loading cases are considered as a minimum requirement and additional loading cases may be included as deemed necessary or useful.

See also Ch 1, Sec 1, [5.14.4].

## 3 Stability curve calculation

### 3.1 General

**3.1.1** Hydrostatic and stability curves are normally prepared on a designed trim basis. However, where the operating trim or the form and arrangement of the yacht are such that change in trim has an appreciable effect on righting arms, such change in trim is to be taken into account.

The calculations are to take into account the volume to the upper surface of the deck sheathing.

### 3.2 Superstructures and deckhouses which may be taken into account

**3.2.1** Enclosed superstructures complying with the International Load Line Convention (ILLC) may be taken into account.

The second tier of similarly enclosed superstructures may also be taken into account. Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in the ILCC.

Where deckhouses comply with the above conditions, except that no additional exit is provided to a deck above, such deckhouses are not to be taken into account; however, any deck openings inside such deckhouses are to be considered as closed even where no means of closure are provided.

Deckhouses, the doors of which do not comply with the requirements in the ILCC, are not to be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of the ILCC. Deckhouses on decks above the freeboard deck are not to be taken into account, but openings within them may be regarded as closed.

Trunks may be taken into account. Hatchways may also be taken into account having regard to the effectiveness of their closures.

As guidance, windows (pane and frame) that are fitted in superstructure contributing to buoyancy as to be designed with strength in accordance to Ch 1, Sec 1, [5.6].

Superstructures and deckhouses not regarded as enclosed may, however, be taken into account in stability calculations up to the angle at which their openings are flooded (at this angle, the static stability curve is to show one or more steps, and in subsequent computations the flooded space is to be considered non-existent).

### 3.3 Angle of flooding

**3.3.1** In cases where the yacht would sink due to flooding through any openings, the stability curve is to be cut short at the corresponding angle of flooding and the yacht is to be considered to have entirely lost its stability.

Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes are not to be considered as open if they submerge at an angle of inclination more than 30°. If they submerge at an angle of 30° or less, these openings are to be assumed open if the Society considers this to be a source of significant progressive flooding; therefore, such openings are to be considered on a case-by-case basis.

## 4 Effects of free surfaces of liquids in tanks

### 4.1 General

**4.1.1** For all loading conditions, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks.

### 4.2 Consideration of free surface effects

**4.2.1** Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition.

Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. Free surface effects for small tanks may be ignored under the condition in [4.8].

### 4.3 Categories of tanks

**4.3.1** Tanks which are taken into consideration when determining the free surface correction may be one of two categories:

a) Tanks with fixed filling level (e.g. liquids, water ballast). The free surface correction is to be defined for the actual filling level to be used in each tank;

b) Tanks with variable filling level (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquids and water ballast during liquid transfer operations).

Except as permitted in [4.6], the free surface correction is to be the maximum value attainable among the filling limits envisaged for each tank, consistent with any operating instructions.

### 4.4 Consumable liquids

**4.4.1** In calculating the free surface effect in tanks containing consumable liquids, it is to be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account is to be that where the effect of free surface is the greatest.

### 4.5 Water ballast tanks

**4.5.1** Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surface effect is to be calculated to take account of the most onerous transitory stage relating to such operations.

### 4.6 GMo and GZ curve corrections

**4.6.1** The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately.

In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0 degrees angle of heel according to the categories indicated in [4.3].

The righting lever curve may be corrected by any of the following methods:

a) Correction based on the actual moment of fluid transfer for each angle of heel calculated; corrections may be calculated according to the categories indicated in [4.3];

b) Correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of heel calculated; corrections may be calculated according to the categories indicated in [4.3].

c) Correction based on the summation of $M_{fs}$ values for all tanks taken into consideration, as specified in [4.3].

Whichever method is selected for correcting the righting lever curve, only that method is to be presented in the yacht's stability information booklet. However, where an alternative method is described for use in manually calculated loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, are to be included.

### 4.7 Free surface moment

**4.7.1** The values for the free surface moment at any inclination in metre-tonnes for each tank may be derived from the formula:

$$M_{fs} = v b \rho k \delta^{0,5}$$

where:

v : Tank total capacity, in m$^3$

b : Tank maximum breadth, in m

$\rho$ : Mass density of liquid in the tank, in t/m$^3$

k : Dimensionless coefficient to be determined from Tab 5 according to the ratio b/h. The intermediate values are determined by interpolation.

$\delta$ : Tank block coefficient, equal to:

$$\delta = \frac{v}{blh}$$

l : Tank maximum length, in m

h : Tank maximum height, in m.

### 4.8 Small tanks

**4.8.1** Small tanks which satisfy the following condition using the values of k corresponding to an angle of inclination of 30° need not be included in the correction:

$$\frac{M_{fs}}{\Delta_{min}} < 0,01 m$$

where:

$\Delta_{min}$ : Minimum yacht displacement, in t, calculated at dmin

dmin : Minimum mean service draught, in m, with 10% stores and minimum water ballast, if required.

### 4.9 Remainder of liquid

**4.9.1** The usual remainder of liquids in the empty tanks need not to be taken into account in calculating the corrections, providing the total of such residual liquids does not constitute a significant free surface effect.

**Table 1 : Value of coefficient k for calculating free surface corrections**

$$k = \frac{\sin\theta}{12} \cdot \left(1 + \frac{(\tan\theta)^2}{2}\right) \cdot \frac{b}{h}, \quad \text{where} \quad \cot\theta \geq \frac{b}{h}$$

$$k = \frac{\cos\theta}{8} \cdot \left(1 + \frac{\tan\theta}{b/h}\right) - \frac{\cos\theta}{12 \cdot (b/h)^2} \cdot \left(1 + \frac{(\cot\theta)^2}{2}\right), \quad \text{where} \quad \cot\theta < \frac{b}{h}$$

| θ<br>b/h | 5° | 10° | 15° | 20° | 30° | 40° | 45° | 50° | 60° | 70° | 75° | 80° | 85° | θ<br>b/h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 0,11 | 0,12 | 0,12 | 0,12 | 0,11 | 0,10 | 0,09 | 0,09 | 0,09 | 0,05 | 0,04 | 0,03 | 0,02 | 20 |
| 10 | 0,07 | 0,11 | 0,12 | 0,12 | 0,11 | 0,10 | 0,10 | 0,09 | 0,07 | 0,05 | 0,04 | 0,03 | 0,02 | 10 |
| 5,0 | 0,04 | 0,07 | 0,10 | 0,11 | 0,11 | 0,11 | 0,10 | 0,10 | 0,08 | 0,07 | 0,06 | 0,05 | 0,04 | 5,0 |
| 3,0 | 0,02 | 0,04 | 0,07 | 0,09 | 0,11 | 0,11 | 0,11 | 0,10 | 0,09 | 0,08 | 0,07 | 0,06 | 0,05 | 3,0 |
| 2,0 | 0,01 | 0,03 | 0,04 | 0,06 | 0,09 | 0,11 | 0,11 | 0,11 | 0,10 | 0,09 | 0,09 | 0,08 | 0,07 | 2,0 |
| 1,5 | 0,01 | 0,02 | 0,03 | 0,05 | 0,07 | 0,10 | 0,11 | 0,11 | 0,11 | 0,11 | 0,10 | 0,10 | 0,09 | 1,5 |
| 1,0 | 0,01 | 0,01 | 0,02 | 0,03 | 0,05 | 0,07 | 0,09 | 0,10 | 0,12 | 0,13 | 0,13 | 0,13 | 0,13 | 1,0 |
| 0,75 | 0,01 | 0,01 | 0,01 | 0,02 | 0,02 | 0,04 | 0,04 | 0,05 | 0,09 | 0,16 | 0,18 | 0,21 | 0,16 | 0,75 |
| 0,5 | 0,00 | 0,01 | 0,01 | 0,02 | 0,02 | 0,04 | 0,04 | 0,05 | 0,09 | 0,16 | 0,18 | 0,21 | 0,23 | 0,5 |
| 0,3 | 0,00 | 0,00 | 0,01 | 0,01 | 0,01 | 0,02 | 0,03 | 0,03 | 0,05 | 0,11 | 0,19 | 0,27 | 0,34 | 0,3 |
| 0,2 | 0,00 | 0,00 | 0,00 | 0,01 | 0,01 | 0,01 | 0,02 | 0,02 | 0,04 | 0,07 | 0,13 | 0,27 | 0,45 | 0,2 |
| 0,1 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,01 | 0,01 | 0,01 | 0,02 | 0,04 | 0,06 | 0,14 | 0,53 | 0,1 |