TÜRK LOYDU

Chapter 9 – Rules for Construction and Classification of Yachts

2016

This edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red color.

Unless otherwise specified, these rules apply to yachts for which the date of contract for construction is on or after 1st of August 2016. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Conditions" of applicable latest edition are to be applied (see, Classification and Surveys).

If there is difference between the rules in English and Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version. Once downloaded, this document will become UNCONTROLLED. Please check www.turkloydu.org for the amended and valid version.

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AMENDMENTS

Revised Sections	RCS No.	EIF Date*
Section 03	05/2018	01.01.2019
Section 07	05/2018	01.01.2019
Section 07	04/2017	01.01.2018
Section 05	03/2017	01.07.2017
Section 06	03/2017	01.07.2017
Section 01	01/2017	01.01.2017

* Entry into Force (EIF) Date is provided for general guidance only, EIF dates given in Rule Change Summary (RCS) are considered valid. In addition to the above stated changes, editorial corrections may have been made.

SECTION 1

CLASSIFICATION and SURVEYS

Page

A. Classification

1. General Instructions

1.1 Definitions

1.1.1 *Yacht* means a vessel which is propelled mechanically or by sail or by a combination of both and engaged in a private use (such as pleasure and sport) of a lenght 14 m and over. For yachts having length of less than 14 m, parts and scope of these rules to be applied shall be decided by **TL** in each case.

1.1.2 *Class Society* means Türk Loydu (**TL**).

1.1.3 *Administration* means the Government of the State whose flag the yacht is entitled to fly.

1.1.4 *Rules* means requirements published by class society essential for classification.

1.1.5 *Surveyor* means technical staff authorized for performing tasks in relation to classification and survey duties.

1.1.6 C*lassification* means services verifying compliance with the rules throughout thr yacht's life.

1.1.7 *Certification* means services confirming compliance with the requirements of related rules and regulations.

1.1.8 Date of "*contract for construction*" of a yacht the date on which the contract to build the yacht is signed between the prospective owner and the shipbuilder. This date is to be declared to **TL** by the party applying for the assignment of class to a newbuilding.

The date of "*contract for construction*" of a series of yachts, including specified optional yachts for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

Yachts built under a single contract for construction are considered a "series of yachts" if they are built to the same approved plans for classification purposes.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than one year after the contract to build the series was signed.

If a *contract for construction* is later amended to include additional yachts or additional options, the date of "*contract for construction*" for such yachts is the date on which the amendment to the contract is signed between the prospective owner and the shipbuilder.
The amendment to the contract is to be considered as a "new contract" to which the above applies.

If a *contract for construction* is amended to change the yacht type, the date of "*contract for construction*" of this modified yacht, or yachts, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

1.2 Field of Application of Rules

The rules contained in the scope of this publication, is only applicable to yatchs for private use defined in 1.1.1 above. These rules are not applicable to commercial yachts.

1.3 Scope of Classification/Evaluation

1.3.1 Plan Approval

Plan approval is approval of appropriate and sufficient calculation and plans submitted to **TL** for approval.

1.3.2 Hull Construction Certificate

When confirmed that the hull is constructed under the supervision of **TL** surveyors and according to **TL** approved calculations and plans, Hull Construction Certificate is to be issued related only to the hull construction.

For issuance of this certificate, the list of plans required to be submitted to **TL** are as follows. **TL** reserve the right to demand additional plans.

- General Arrangement Plan

- Lines Plan
- Longitudinal Section Plan
- Midship Section and Typical Sections Plan
- Transverse Bulkheads
- Shell Expansion Plan (for steel and aluminium alloy hulls)
- Lamination Plan (for Composite Hull)
- Deck Construction Plan
- Superstructure Construction Plan
- Main Engine (s), Auxiliary Engines, Generators and Steering Gear Seatings Plan
- Hull-Deck Bonding Details (for Composite Hull)
- Welding Plan (for steel and aluminium alloy hulls)
- Non-destructive Examination Plan (for steel and aluminium alloy hulls)
- Ballast Keel – Hull Attachment Plan (for sailing yachts)
- Built-in Fuel and Water Tanks Construction Plans
- Tank Arrangement and Capacity Plan
- Door, Window and Openings Plan
- Guard Rails, Bulwarks and Freeing Ports Plan
- Construction and Hull Attachment Plan of Bow Thruster Tunnels
- Crane Supports Plan
- Hull Structure Plan in way of Chain Plates
- Supporting Structure Plan for Anti-Heeling Device
- Steering Arrangement Plan
- Propeller Shaft System Plan
- Inclining Experiment Procedure
- Stability Booklet

1.3.3 Scope of Classification

Classification covers verifying the yacht's hull and machinery (including electric installations) are in conformity with these rules

On application by the yacht's owner, e.g. rigging may be classed separately.

All construction phases are to be carried out under the supervision of Türk Loydu surveyors.

Assignment of class, issuance of the class certificate, assignment of the corresponding character of classification and notation thereto are conditional upon proof being furnished of compliance with the **TL** Construction rules in force on the date of placing the order.

TL reserve the right to add special remarks and informations regarding operation of the yacht which is of relevance for the yatch's class, in the class certificates.

TL reserve the right to extend the scope of classification regarding all kind of equipment of yacht directly effecting human life and safety of environment.

1.4 Classification Process

1.4.1 General

The classification process consists of :

1.4.1.1 The development of rules, guidelines and other documents relevant to design and construction of yachts.

1.4.1.2 The review of plans and documents and performing surveys, checks and test during and after construction to verify compliance with such rules, guidelines and other documents.

1.4.1.3 The assignment of class when compliance with the **TL** rules, guidelines and other documents has been verified.

1.4.1.4 The issuance of class certificate.

1.4.1.5 The performance of annual, intermediate, class renewal and occasional surveys to verify that the yacht meets the conditions for maintenance of class.

1.4.1.6 If type approval is requested for series produced yachts, for each separate production a protocol containing the subjects starting from application phase to issuance of type approval certificate is to be arranged between **TL** and yacht owner and/or producer.

1.4.2 Rules and Regulations

1.4.2.1 The latest edition of **TL** Rules for Construction and Classification of Yachts, **TL** Material Rules, **TL** Welding Rules and other special rules of **TL** applicable on the date of contract between shipyard and shipowners are to be taken as a basis for the classification of new yachts.

1.4.2.2 The rules, guidelines and other documents are, in general, developed by **TL** staff and accepted by the related rule development committees.

In rule development, international rules and regulations, theoretical researchs and service experiences are utilized.

1.4.2.3 Respective flag state rules and regulations will not be affected by Classification and Survey rules. Various requirements stipulated by international conventions are taken into account in **TL** Rules.

1.4.3 Certificates and Reports

1.4.3.1 If the applicable requirements have been met, class is to be assigned. The assignment of class is documented by the issuance of a class certificate. Class certificates are issued only for the use of **TL**, its clients and other authorized entities.

1.4.3.2 Certificates, reports and other document issued by **TL** are in no way intended to replace the duties and responsibilities of flag state, designers, shipbuilders, manufacturers, suppliers, owners, operators, etc.

The activities of such parties falling outside the scope of the classification, such as design, manufacturing, choice of machinery and equipment, form and performance of the ship, life-saving appliances, number and qualification of crew remain responsibility of these parties.

1.4.3.3 **TL** will release information from reports and certificates to the Port State to assist in rectification of deficiencies during port state controls. Such information includes recommendations, survey due dates, and certificate expiration dates.

1.4.3.4 The class is to be retained on the condition that the requirements applicable for retention of class are complied with. Retention of class is confirmed by annual endorsements and renewal of the class certificate at five year intervals.

1.4.4 Responsibilities

1.4.4.1 Surveyor's intervention

For the purpose of verifying compliance with the rules, the client is to provide the Society's surveyors with the free access to ships and/or to their premises.

Free access is also to be given to auditors accompanying the **TL** surveyors within the scope of audits as required in pursuance of TL's internal quality system.

The clients are to take the necessary measures for the surveyor's inspections and testing to be carried out safely. The surveyor is to be constantly accompanied during surveys by personnel of the client.

1.4.4.2 Operation and maintenance of yachts

The classification of a yacht is based on the principle that the ship is operated in a proper manner by competent crew.

It is to be assumed that the yacht is not to be loaded more than the draught of the ship corresponding to the freeboard assigned, that the yacht is to be properly loaded taking into account its stability and strength and that the cargoes are to be properly stowed and secured

Documents issued by **TL** in relation to its activities reflect the condition of the yacht found at the time and within the scope of the survey. It is the interested party's responsibility to ensure proper maintenance of the yacht and to inform **TL** of any events or circumstances affecting the class.

1.4.4.3 Port state inspections

In case of a yacht's detention by port state control the operators are obliged to call in a **TL** surveyor without delay. This requirement has to be met in any case, where the deficiencies are related to statutory certificates issued by **TL** on behalf of a flag state.

1.4.4.4 Disclosure of information

TL will not disclose any information received or reports made in connection with classification to any other party than those entitled or to those having been given the right to receive information by legislation, court decision or written permission from the owner.

Information recorded in **TL**'s Register of Ships which encompasses the status of classification and statutory surveys and certificates issued by **TL**, overdue conditions, class suspensions and withdrawals are to be published and/or released to any interested party.

1.4.5 Appeals

The client may request in writing that a decision made by **TL** is to be taken up for reconsideration. **TL** will subsequently consider the matter and announce its decision according to its procedures.

2. Assignment of Class

2.1 General

2.1.1 Request for classification of a new yacht or an existing yacht is to be submitted to **TL** in writing by the client.

2.1.2 Class is assigned to a yacht after approval of necessary plans and completion of surveys during construction or class entry surveys.

2.2 Assignment of Class to a New Yacht

2.2.1 Application for Classification

The written application for classification is to be submitted to **TL** by the shipyard or the yacht owner using the **TL**'s "new building classification request form". The party who is responsible to observe the **TL** rules according to contract of construction will have to make the application..

Where the applicant considers particulars already having been approved by **TL** (for previous new buildings) to be used fort he classification, this will have to be specifically stated in the application. Amendments to construction rules having been introduced meanwhile shall be taken into account.

2.2.2 Examination of Construction Particulars

Construction details are to be submitted to **TL** for examination in triplicate in due time prior to commencement of construction, as detailed in the Construction Rules. The particulars to be submitted have to contain all details required for examination in accordance with **TL**'s Yacht Rules. **TL** reserve the right to request additional information and particulars to be submitted.

Construction details and plans to be submitted for components subject to approval will be examined by **TL**, two copies will be kept in **TL** and the rest of copies returned.

The result of examinations is to be stated both on plans and approval letter.

Any deviation from approved plans require to be approved by **TL** prior to being realized.

The list of plans required to be submitted to **TL** are as follows. **TL** reserve the right to demand additional plans.

- General Arrangement Plan
- Lines Plan
- Longitudinal Section Plan
- Midship Section and Typical Sections Plan
- Transverse Bulkheads
- Shell Expansion Plan (for steel and aluminium alloy hulls)
- Lamination Plan (for Composite Hull)
- Deck Construction Plan
- Superstructure Construction Plan
- Main Engine (s), Auxiliary Engines, Generators and Steering Gear Seatings Plan
- Hull-Deck Bonding Details (for Composite Hull)
- Welding Plan (for steel and aluminium alloy hulls)
- Non-destructive Examination Plan (for steel and aluminium alloy hulls)
- Ballast Keel – Hull Attachment Plan (for sailing yachts)
- Built-in Fuel and Water Tanks Construction Plans
- Detached Fuel and Water Tanks Plans
- Tank Arrangement and Capacity Plan
- Door, Window and Openings Plan
- Guard Rails, Bulwarks and Freeing Ports Plan
- Construction and Hull Attachment Plan of Bow Thruster Tunnels
- Crane Supports Plan
- Hull Structure Plan in way of Chain Plates
- Supporting Structure Plan for Anti-Heeling Device
- Steering Arrangement Plan
- Propeller Shaft System Plan
- Propeller Plan (for Ø > 1m)
- Exhaust System
- Fuel System
- Cooling Water System
- Bilge System
- Sewage System
- Structural Fire Protection Plan
- Engine Room Ventilation Plan
- Sea Water Fire Extinguishing System
- Engine Room Fixed Fire Extinguishing System
- Portable Fire Extinguishers Plan
- Means of Escape
- Fire Control Plan
- Electrical Single Line Diagrams
- Electrical Power/Balance Calculation

- Main and Emergency Distribution Boards
- Main and Emergency Lighting Plan
- Inclining Experiment Procedure
- Stability Booklet

2.2.3 Surveys During Construction

When a yacht is constructed under the supervision of **TL**, the Society carries out surveys, attends tests and trials stated in its rules.

TL verifies that the work is carried out in compliance with the applicable rules and standards.

The survey at the clients sites may consist of a combination of visual inspections, tests, measurements and review of records.

Welding of hull structures, machinery installations and equipment is to be carried out by approved welders, with approved welding consumables.

Where specified by the rules, tests are to be carried out in the presence of **TL** surveyor.

A test programme for dock and sea trials is to be submitted to **TL** by the client.

Tests in addition to those stated in **TL** rules may be requested by **TL** in order to verify compliance with the rules.

2.2.4 Use of Materials, Machinery and Equipment

Materials, machinery and equipment to be installed on new buildings are to, in general, be new.

All materials, machinery and equipment covered by the class and used or fitted on board yachts are to be certified according to **TL** rules.

Second hand materials, machinery and equipment may be used on new buildings subject to the specific agreement of **TL** and the owner.

New installation of materials which contain asbestos is not permitted for all new and existing yachts.

2.2.5 Defects and deficiencies

TL may reject items found as defective or need supplementary survey and tests.

All repairs need to be preliminary agreed with **TL**. When the defect tolerances are specified in **TL** rules or by the manufacturer, they are to be taken into consideration during repair works.

2.2.6 Class Certificate

When **TL** satisfied that all requirements corresponding to the class in question have been met, an interim class certificate or the class certificate is to be issued. Interim class certificate is valid to a date not exceeding 12 months from assignment of class.

Class may be assigned with recommendation.

The interim certificate is to be replaced by a full term class certificate when **TL** has confirmed that applicable requirements have been met.

The class certificate is valid to a date not exceeding 5 years from the date of class assignment provided condition for class retention are complied with.

TL reserves the right to introduce special remarks in the class certificate stating assumptions for the assignment of the class and restrictions regarding the use of the yacht.

2.3 Assignment of Class to a Yacht in Service

2.3.1 General

When an Owner applies to **TL** for a yacht in service for classification, she will be admitted to **TL**’s class upon verification of documentation and satisfactory surveys.

2.3.2 Documents

For a yacht built in accordance with rules of an IACS member society, the following documentation is to be submitted to **TL** which is to be taken as a basis for forthcoming surveys.

Main plans

- General arrangement plan
- Stability booklet
- Damage stability booklet, where required

Steel Plans

- Midship section
- Longitudinal section and decks
- Shell expansion
- Bulkheads

Machinery plans

- Shafting arrangement
- Propellers
- Rudder blade and rudder stock
- Steering gear
- Bilge piping diagram
- Ballast piping diagram
- Wiring diagram
- Fire safety plan

If the documentation stated in 2.3.2 is not available, these documents are to be prepared and submitted to **TL** for approval.

For yachts not constructed according to an IACS member Society's rules, the documents stated in 2.3.2 are to be submitted to **TL** for approval.

2.3.3 Class Enrty Surveys

Prior to assignment of class to an existing yacht, that yacht is to undergo the surveys based on the age and type of the yacht.

2.3.3.1 Hull Surveys

The extent of these surveys is to be as follows:

For yachts ≤ 5 years, the survey is to be carried out in the scope of an annual survey.

For yachts > 5 years, the survey is to be carried out in the scope of class renewal survey.

2.3.3.2 Machinery Surveys

Examination and tests of the main and all auxiliary machinery necessary for operation of the yacht. Examination of the remote controls of emergency fire pumps, bilge pumps, fuel pumps, luboil pumps and mechanical suction fans under working conditions.

Examination of pressure vessels.

Examination of Oil Firing Equipment**.**

Examination of electric installations.

Examination of starting equipment.

A short sea trial may be required, if the yacht has been laid up for a long period.

2.3.4 Class Certificate

When **TL** satisfied that all requirements corresponding to the class in question have been met, an interim class certificate or the class certificate is to be issued. Interim class certificate is valid to a date not exceeding 12 months from transfer of class.

Class may be assigned with recommendation.

The interim certificate is to be replaced by a full term class certificate when **TL** has confirmed that applicable requirements have been met.

The class certificate is valid to a date not exceeding 5 years from date of class assignment or, if **TL** accepts the periodical surveys credited by the previous class society, until the expiry date of the class certificate of the previous class society.

2.4 Register

2.4.1 General

The Classification data of each yacht classed will be included in the **TL** data file. An extract of these yacht data will be entered in the Register published by **TL.**

During the period of Class **TL** will update these details on the basis of relevant reports submitted by the Surveyors.

The class entry date is entered in the Register book. For yachts built under the supervision of **TL**, the due date for the periodical surveys is to be calculated from this date. For yachts built under the supervision of an other class society, the due date for the periodical surveys will depend upon the existing periodical survey schedule defined by the previous class society.

3. Maintenance of Class

3.1 General Requirements

The hull and machinery have the same period of class. The class is to be valid on condition that the hull and the machinery are subjected to all surveys stipulated and that any repairs required are carried out to the satisfaction of **TL**.

Retention of class is conditional upon the yacht is being adequately manned, and the hull, machinery and equipment is being operated such as to comply with the design and with the applicable rules.

Classed yachts are to be subjected to surveys for the retention of class. These surveys include, intermediate survey, class renewal survey, bottom survey (survey performed on shore or under water), propeller shaft survey, boiler survey and other surveys required for retention of additional class notations.

These surveys are to be carried out at the intervals laid down in the following. In addition to the above periodical surveys, yachts are to be subjected to occasional surveys, where required.

The surveys are to be performed according to the relevant requirements in order to verify that the hull, machinery and equipment comply with the applicable rules and will remain in satisfactory condition.

If the hull and/or machinery are not subjected to the prescribed surveys on their due dates, the class will be suspended.

If special equipment classed is not subjected to the prescribed surveys on their due dates, the class of the special equipment only will be suspended.

TL Head Office or one of the Society's representations are to be immediately informed about any average or deficiencies and damages to hull and machinery or other equipment classed, where these may be of relevance to the yacht's class, including information on casualties. A survey will have to be arranged for a date no later than that of yacht's arrival at the next port.

If the survey reveals that yacht's class has been affected, it will be maintained only on condition that the repairs or modifications demanded by **TL** will be carried out within the period specified by the Surveyor.

3.2 Definitions

3.2.1 Anniversary date

Anniversary date means the day of the month of each year in the period of class which corresponds to the expiry date of the period of class.

3.2.2 Ballast tank

A ballast tank is a tank which is used primarily for sea water ballast.

3.2.3 Close-up survey

A close-up survey is a survey where the details of structural components are within the close visual inspection range of the surveyor, i.e. normally within reach of hand.

3.2.4 Coating condition

Coating condition is defined as follows:

Good: condition with only minor spot rusting.

Fair: condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for poor condition.

Poor: condition with general breakdown of coating over 20% or more or hard scale at 10% or more, of areas under consideration.

3.2.5 Corrosion prevention system

A corrosion prevention system is normally considered a full hard protective coating.

Hard protective coating is usually to be epoxy coating or equivalent. Other coating systems, which are neither soft nor semi-hard coatings, may be considered acceptable as alternatives, provided that they are applied and maintained in compliance with the manufacturer’s recommendations.

3.2.6 Critical areas

Critical areas are locations which have been identified from calculations to require monitoring or from service history of the subject ship or from similar ships, to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

3.2.7 Exceptional circumstances

Exceptional circumstances means unavailability of repair facilities, unavailability of essential materials, equipment or spare parts, or delays incurred by action taken to avoid severe weather conditions.

3.2.8 Overall survey

An overall survey is a survey intended to report on the overall condition of the hull structure and determine the extent of additional close-up surveys.

3.2.9 Overdue surveys

Each periodical survey is assigned a limit date specified by the relevant requirements of the rules by which it is to be completed.

A survey becomes overdue when it has not been completed by its limit date.

3.2.10 Period of class

Period of class means the period starting either from the date of the initial classification or from the credited date of the last class renewal survey, and expiring at the limit date assigned for the next class renewal survey.

3.2.11 Recommendations

Any defect and/or deficiency affecting the class and to be dealt with within a specific period of time is indicated as a recommendation. Recommendation is pending until it is cleared. Where it is not cleared by its limit date, the recommendation is overdue.

3.2.12 Representative tanks or spaces

Representative tanks or spaces are those which are expected to reflect the condition of other tanks or spaces of similar type and with similar corrosion prevention systems. When selecting representative tanks or spaces, account is to be taken of the service and repair history on board and identifiable critical structural areas and/or suspect areas.

3.2.13 Substantial corrosion

Substantial corrosion is an extent of corrosion such that assessment of the corrosion pattern indicates wastage in excess of 75% of allowable margin, but within acceptable limits.

3.2.14 Suspect areas

Suspect areas are locations showing substantial corrosion and/or considered by the surveyor to be prone to rapid wastage.

3.2.15 Time window

Time window means the fixed period during which annual and intermediate surveys are to be carried out.

3.2.16 Transverse section

A transverse section includes all longitudinal members contributing to longitudinal strength, such as plating, longitudinals and girders, longitudinal bulkheads. For transversely framed yachts, a transverse section includes adjacent frames and their end connections in way of transverse sections.

3.3 Survey Procedure

3.3.1 General

The objective of a survey is to be to ascertain that the yacht are in compliance with the rules and suitable for continued safe operation.

A survey may consist of an overall examination of the yacht, checking selected items, attending required tests and trials.

When a survey results in the identification of significant corrosion, structural defects or damages which, in the opinion of the surveyor, affect the yacht's class, remedial measures are to be taken before the yacht continues in service.

3.3.2 Postponement of Survey and Extension of Certificate

TL reserves the right to extent the class certificate by postponing the survey, taking into account particular circumstances.

When a survey becomes overdue during a voyage, the following procedure is to be applied.

In the case intermediate surveys, no postponement is granted. Such surveys are to be performed within their prescribed time window.

In the case of a class renewal survey, **TL** may grant an extension of class to allow for completion of the class renewal survey, provided that there is documented agreement to such an extension prior to the expiry date of the class certificate. Such an extension is to be granted only until arrival at the first port of call which the yacht can be surveyed after the expiry date of the class certificate.

TL, may extend the scope of survey stated in Section 3, whenever and so far as considered necessary.

The extent of any survey also depends on the condition of the ship. If the surveyor has any doubt as to the condition of the ship, or be advised of any deficiency or damage which may affect class, then further examination and testing may be conducted

3.3.3 Preparations for Surveys

The yacht owner is to provide the necessary facilities for the safe execution of the surveys.

Tanks and other spaces are to be safe for access. These spaces are gas freed and adequately ventilated. Before entering a tank or an enclosed space, it will be confirmed that the atmosphere on tank is freed from harmful gases and oxygen range is adequate.

In preparation for survey and thickness measurements and to allow for a through examination, all spaces are to be cleaned. Spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. to reveal corrosion, deformation, fracture, damage or other structural deterioration and sufficiently illuminated.

Where soft coatings have been applied, safe access is to be provided to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft coating is to be removed.

A communication system is to be provided between the survey party in the space under examination and the responsible officer on deck or wheelhouse.

Explosimeter, oxygen-meter, breathing apparatus, life lines, riding belts with rope and hook and whistles are to be made available during the survey.

Adequate protective clothings is to be made available during surveys.

When examination of associated structure is required, the following applies:

Ceilings in compartments and floors in the engine room are to be removed to the necessary extent for examination of the structure below.

Cement or other protective sheating is to be removed when there is any doubt as to the condition of the plating underneath.

In the case of solid ballast spaces, the solid ballast is to be partially removed for examination of the condition of the structure in way. Should doubt arise, the surveyor may require more extensive removal of the solid ballast.

Insulation of refrigerated goods compartments is to be removed over the necessary extent for examination by the surveyor of the condition of the structure, unless constructional arrangements make such inspection possible without removing the insulation.

3.3.4 Access to Structures

For overall survey, means are to be provided to enable the surveyor to examine the hull structure in a safe way.

During close-up surveys, one or more of the following means of access is to be provided:

- Permanent stagings and passages through structures,
- Temporary stagings and passages through structures,
- Lifts and movable platforms
- Boats and rafts
- Other equivalent means.

3.3.5 Damages and Repairs

Any damages and wastages over allowable limits on frames and their end attachments and/or adjacent side plating, bottom structure and bottom plating, watertigh and oiltight bulkheads, affecting the yatch's class are to be permanently repaired immediately after the survey.

Where adequate repair facilities are not available, consideration may be given to allowing the yacht to proceed directly to a repair facility. This may require temporary repairs for the intended voyage.

Damages or excessive wastage at the areas noted above and not immediately affecting the yacht's structural or watertight/weathertight integrity may be temporarily repaired for a period to be defined.

Where parts are damaged or worn to such an extent that they no longer comply with the requirements of **TL**, they are to be repaired or replaced.

Maintenance work, repairs and conversions of classed yachts and special equipment have to be carried out under the supervision of **TL** to ensure maintenance or reassignment of class.

The areas affected by the repair and conversion are to be treated in the same way as newbuildings, irrespective of whether the hull, the machinery including the electrical installation and other equipment classed are concerned.

If following major conversions a new character of class and/or new notations are assigned so that new certificates have to be issued, commencement of a new period of class may be agreed upon.

3.4 Class Certificate

3.4.1 Issue of Class Certificate

For all classed yacht, a class certificate, bearing the class notation and an expiry date, is to be issued.

This certificate is also provided with annexes giving information necessary for the management of the certificate and for performing the class surveys.

The class certificate and its annexes are to be made available to **TL** surveyors upon request.

3.4.2 Validity of Class Certificate

During the class period, a class certificate is valid when it is not expired.

The class is maintained during a certain period or at a given date, when during the said period or at such date the condition for suspension or withdrawal of class are not met.

At the request of the owner, a statement confirming the maintenance of class may be issued by **TL** based on the information in its records.

3.4.3 Endorsement and Renewal of the Class Certificate

3.4.3.1 Endorsement of the Class Certificate

The class certificate is to be endorsed with the relevant entries in the appropriate annexes upon satisfactory completion of intermediate and class renewal surveys.

Each endorsement consists of sections for the description of:

- The surveys held,

- The imposed, deleted and postponed recommendations,

- The unchanged existing recommendation.

3.4.3.2 Renewal of the Class Certificate

A new class certificate will replace the existing class certificate when class renewal survey has been satisfactory completed and **TL** is satisfied that the requirements for retention of class have been met.

The new class certificate is to be valid to a date not exceeding 5 years from:

- The expiry date of the existing certificate when the class renewal survey has been completed within 12 months before the expiry date of the existing class certificate, or

- The expiry date of the existing certificate when the class renewal survey has been completed after the expiry date of the existing class certificate, or

- The completion date of the class renewal survey when the class renewal survey has been completed more than 12 months before the expiry date of the existing certificate, or

- The completion date of the class renewal survey when the class renewal survey has been commenced more than 12 months before the expiry date of the existing certificate.

In cases where postponement of a class renewal survey has been granted, the new class certificate is to be valid to a date nor exceeding 5 years from the expiry date of the existing certificate before the postponement was granted.

In cases where the class renewal surveys carried out concurrently with a conversion, the validity of the new certificate is to be 5 years from the date of completion of the conversion, if so decided by **TL**.

3.5 Suspension and Withdrawal of Class

3.5.1 General

Class may be withdrawn at any time if **TL** finds it justified.

TL may suspend or withdraw a yacht's class where the condition for retention of class has been violated.

The decision to suspend or withdraw a yacht's class is made by **TL.** However, in cases of automatic suspension, no individual evaluation is made.

Suspension or withdrawal of class may take effect immediately or after a specified period of time.

If the violation only affects requirements related to additional class notations, the suspension or withdrawal may be limited to these class notations only.

When the class is suspended or withdrawn, **TL** will notify the client and flag state in writing, make an entry to this effect in its register and make the information publicly available.

In the case of class suspension, a time limit will be given for when the class will be withdrawn.

3.5.2 Suspension of Class

The class may either be suspended automatically or following the decision of **TL**. In both cases, the yacht is to be considered as not retaining its class beginning from the date of suspension until the date when class is reinstated.

The class will automatically be suspended with immediate effect if the class renewal surveys for hull, machinery and equipment related to main class are not completed before the expiry date of the class certificate or extension given for completion of surveys.

If the intermediate survey for main class are not completed within defişned time window, the class is automatically suspended with immediate effect.

TL may decide to suspend a ship's class if the ship is deemed to be unable to continue safe operation.

If any outstanding debt owed to **TL** is not paid within a notified date, **TL** may suspend the ship's class with immediate effect.

In addition to the conditions laid down above, a yacht's class may be suspended with immediate effect in cases where:

- Repair of deficiencies has not been carried out or otherwise dealt with in an appropriate manner, or

- Repair of deficiencies has not been surveyed and accepted by the surveyor,

3.5.3 Reinstatement Following Class Suspension

If the overdue surveys leading to class suspension as given in paragraph 3.5.2 are carried out within the specified time, the class is to be reinstated provided the following is met:

- The results of the survey are such that all observed deficiencies are satisfactory rectified. **TL** may, after consideration, accept that minor deficiencies are pending to be carried out.

- No overdue periodical surveys or overdue conditions of class at that time.

TL reserves the right to reject an application for reinstatement of class.

When the class is reinstated, **TL** will confirm this in writing to the client and to the flag administration.

If the class has been suspended due to outstanding debt, the class will automatically be reinstated when all outstanding debt has been paid, provided that there is no other reason for suspension

3.5.4 Withdrawal of class

The class is to be withdrawn at the clients request.

If the overdue surveys specified in paragraphs 3.5.2 are not carried out within the specified time after the class suspension, **TL** will withdrawn the yacht's class.

When a yacht proceeds to sea without having rectified a condition of class which was required to be dealt with before leaving port, the class will be withdrawn with immediate effect.

If any outstanding debt owed to **TL** is not paid within a notified date, **TL** may withdraw the yacht's class with one month's written notice.

TL, also, will withdraw the class, when the yacht is reported as a constructive total lost, when the yacht is lost and when the yacht is reported scrapped.

When the withdrawal of class of a ship comes into effect, **TL** will forward the client and the flag administration written notice, delete the yacht from its register and make the information publicly available.

3.5.5 Re-assignment of Class Following Class Withdrawal

If the circumstances leading to withdrawal of class no longer exist, a yacht may be re-assigned class upon written request. The extent of survey is to be decided by **TL**.

TL reserves the right to reject an application for re-assignment of class.

A new class certificate is to be issued when the survey has been satisfactory completed and **TL** is satisfied that the requirements for retention of class have been met.

When the yacht is re-assigned class, **TL** will confirm this in writing to the client and to the flag administration and make the information publicly available.

3.6 Change of Yacht Ownership

In the case of change of ownership, the yacht retains its current class provided that **TL** is informed of the change in advance to carry out any survey deemed appropriate and the new owner signs the request involving acceptance of **TL**'s general condition and rules

4. Character of Classification

4.1 General

Classification notations are assigned in order to determine applicable rule requirements for assignment and retention of class. Within the scope of classification, the characteristics of hull, machinery and equipment are reflected in the classification notations.

Classification notations cover mandatory and optional class notations.

4.2 Mandatory Class Notations

4.2.1 General

All yachts classed by **TL** are to be given a class notation consisting of a construction symbol, character of class, service area restriction notation (if any), yacht type notation, survey scheme notation and damage stability notation.

4.2.2 Construction Symbols

The construction symbols are to be given as follows:

+ The construction symbol + is to be given to yachts constructed under the supervision of **TL** and with the certification of materials, machinery and equipment required to be certified according to **TL** rules.

(+) The construction symbol (+) is to be given to yachts constructed under the supervision of **TL** and without certification of materials, machinery and equipment required to be certified according to **TL** rules.

[+] The construction symbol [+] is to be given to yachts constructed under the supervision of and in accordance with the rules of another recognized classification society and later assigned class with **TL.**

For such yachts the class notations which **TL** considers to have the equivalent intent is to be assigned.

The yachts which have been constructed under no classification will have any of the notations mentioned above.

4.2.3 Character of Class

4.2.3.1 Hull

The character of class **1 A 5** is to be given to yachts with its hull found to be in compliance with the requirements of **TL** construction rules.

4.2.3.2 Machinery

The character of class **M** is to be given to yachts with its machinery and equipment found to be in compliance with the requirements of **TL** construction rules.

4.2.4 Service Area Notations

4.2.4.1 Unrestricted Service Area

UN (unrestricted navigation) service area notation is to be given to yachts navigating any season of a year and any area.

4.2.4.2 Restricted Service Area

For yachts less than 24 m. in length, **LN-B** (limited Navigation-Design Category B) service area notation is to be given to yachts with specified design category B and **LN-C** (Limited Navigation-Design Category C) to yachts with specified design category C, according to Recreational Craft Directive 94/25/EC and 2003/44/EC

4.2.5 Damage Stability

4.2.5.1 General Notation

Yachts which proof of subdivision and damage stability is required are to be given **YFS** notation. For details see Section 12.

4.2.6 Yacht Types

4.2.6.2 Motor Yacht

Yachts propelled by internal combustion engines are to be given **Motor Yacht** notation.

4.2.6.1 Sailing Yacht

Yachts both propelled by internal combustion engines and sails and furthermore having the following sail area (A_S) according to ISO 8666 are to be given **Sailing Yacht** notation.

$$A_s \geq 0{,}07\ (D_{Max})^{2/3}$$

D_{Max} , is the maximum displacement in metric tons.

4.3 Optional Class Notations

Class notations to be given to yachts upon application by the yacht owners are as follows:

4.3.1 Ice Strengthening

Ships complying with the requirements of TL rules, Chapter 1, Hull, Section 14 relating to strengthening for navigation in ice are to be given **ICE-B4, ICE-B3, ICE-B2, ICE-B1** or **ICE-B** class notations.

Index 4 represents the highest notation. Notations ICE-B4 to ICE-B1 corresponding to ice classes IA Super to IC of the Finnish/ Swedish Ice Class Rules as amended.

Ships complying with the requirements of **TL** rules relating to navigation in polar ice-covered waters are to be given PC1, PC2, PC3, PC4, PC5, PC6 or PC7 notations. Index 1 represents the highest notation. Notations PC1 to PC7 are based on the IACS Unified Requirements for Polar Ships.

4.3.2 Fuel Cell Systems

Yachts with fuel cell systems the nominal power of which is equal or exceeds 10% of the total nominal power of the machinery installation (excluding the emergency supply power) and complying with **TL** Rules, Chapter 26 - Guidelines for the Use of Fuel Cell Systems on Board of Ships are to be given **FC-xxx** notation.
"xxx" means the percentage of the fuel cell system related to the nominal power of the machinery installation.

Yachts with fuel cell systems the nominal power of which is below 10% of the nominal power of the machinery installation are to be given **with FC** notation.

4.3.3 Novel Designs

Yachts, machinery installations or essential parts constructed in accordance with a design, for which sufficient experience is not available are to be given **EXP** notation. **TL** will decide at what intervals the required periodical surveys will have to be carried out.

Where experience over a prolonged period of time had proved the efficiency of the design, the notation EXP may be cancelled.

4.3.4 Equipment

When using equipment number calculated according to formulea given in Section 2, C.7 and **TL** certified anchors and chain cables chosen from Table 2.3, **EN** notation is to be given.

4.3.5 Optional Notations Specific for Yachts

4.3.5.1 Yachts having machinery installation fitted with equipment for unattended machinery spaces, so that it does not require to be operated and/or maintained for periods of at least 24 hours are to be given **YAUT** notation.

4.3.5.2 Yachts provided with a system for remote control of the main propulsion plant from the bridge are to be given **YR** notation.

4.3.5.3 Yachts provided with permanent means of total buoyancy or constructional characteristics such as to allow the vessel to float are to be given **YSS** notation.

4.3.5.4 Sailing yachts having masts and rigging constructed according to the related **TL** rules and classed as special equipment are to be given **YDA** notation (see also Section 11).

5. Certification of Materials, Machinery and Equipment

5.1 General

For the classification of new constructions specified materials, machinery and equipment used in yachts to be classed by **TL** are to be certified according to **TL** rules.

Certification includes both plan approval (if required) and survey during production and/or of the final product.

Scope of certification required for classification is given in item 5.3.5 and details can be found in related parts of **TL** rules and international standards.

5.2 Requirements to be Met by the Manufacturer

Manufacturers of materials, machinery and equipment are to be considered for approval according to criteria established by **TL**.

Quality control of materials, machinery and equipment to be certified is to be traceable and documented.

5.3 Certification Procedure

5.3.1 General

Certification of materials, machinery and equipment is to be documented by **TL** product certificate, **TL** type approval certificate, works certificate and test report.

TL product certificate signed by **TL** surveyor is a certificate stating conformity with rule requirements that tests are carried out on the certified product itself, that tests are made on samples taken from the certified product itself and that tests are performed in presence of the surveyor or in accordance with special agreements.

TL type approval certificate is to be issued when compliance with the design requirements is confirmed. Type approval procedure is normally used for approval of standard designs and/or mass produced components. Type approval procedure may consist of plan approval, initial survey and type testing.

Works certificate signed by the manufacturer is a certificate stating conformity with rule requirements that tests are carried out on the certified product itself, that tests are made on samples taken from the certified product itself and that tests are witnessed and signed by manufacturer’s quality control department.

Test report signed by the manufacturer is a document stating conformity with the rule requirements and that tests are carried out on samples from the current production.

Where work certificate or test report is required, the surveyor may, at any time, require the tests to be carried out in his presence.

Certified products are to be properly marked for identification and traceability.

5.3.2 Plan Approval

Plan approval of materials, machinery and equipment is to be carried out to verify their compliance with **TL** rules and/or internationally accepted standards.

Upon approval of drawings and/or documents, a letter or design verification report is to be issued by **TL**.

5.3.3 Surveys

Survey is to be performed on the basis of approved design documentation for the actual application and as required in the applicable **TL** rules. Compliance with the approved design documentation and applicable requirements is to be documented by certificates issued by **TL**.

5.3.4 Suspension and withdrawal of certificates

Product certificates, type approval certificates or approval of manufacturer certificate may be suspended or withdrawn if **TL** finds it justified.

Suspension or withdrawal of a certificate may take effect immediately or after a specified period of time. When a certificate is suspended or withdrawn **TL** is to notify the client in writing and make the information publicly available.

In the case of suspension, a time limit is to be given for when the certificate will be withdrawn.

5.3.5 Tests and Certification of Materials and Equipment to be Used in Yatch Construction

Tests required to be performed and certificates to be provided for materials and equipment to be used in new built yachts are as follows:

TL Product Certificate of Hull Construction Steels **(1)**

TL Product Certificate of Hull Construction Aluminium Alloys **(1)**

TL Type Approval Certificate of Welding Consumables **(1)**

TL Type Approval Certificate of Marine Plywoods **(1)**

TL Type Approval Certificate or **TL** Product Certificate of Resins to be used in Hull Construction **(1)**

TL Product Certificate or **TL** Type Approval Certificate of Reinforcement Materials to be used in Hull Construction **(1)**

TL Type Approval Certificate of Sandwich Laminate Core Materials to be Used in Hull Construction **(1)**

TL Type Approval Certificate of Structural Glues to be Usede in Hull Construction **(1)**

TL Type Approval Certificate of Sealing Materials to be Used in Pipe and Cable Penetrations Located in

Watertight Bulkheads and Main Deck **(1)**

TL Type Approval Certificate or **TL** Product Certificate of Watertight Doors Located in Watertight Bulkheads **(1)**

EC Type Approval Certificate or **EC** Product Certificate Proving that Side Doors and Stern Doors are satisfied the Provision of ISO 12216 “Requirements for Equipment to be Mounted in Area 1” (for yachts not longer than 24 m. in length)

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1) *Applicable for yachts for* ***+1A5*** *hull class notation*

TL Type Approval Certificate or **TL** Product Certificate of Side Doors and Stern Doors **(1)** (for yachts longer than 24 m. in length)

EC Type Approval Certificate or **EC** Product Certificate Proving that Side Scuttles and Hatchways are satisfied the Provision of ISO 12216 (for yachts not longer than 24 m. in length)

TL Type Approval Certificate or **TL** Product Certificate of Side Scuttles and Hatchways **(1)** (for yachts longer than 24 m. in length)

Work Certificate of Toughened Glass or Laminated Glass

Work Certificate of Steering Gear

TL Test Certificate of Rudder Stock Material ı**(2)**

Work Certificate of Anchors (for yachts not having EN notation)

TL Test Certificate of Anchors (for yachts having EN notation) **(2)**

Work Certificate of Chain Cables (for yachts not having EN notation)

TL Test Certificate of Chain Cables (for yachts having EN notation) **(2)**

Work Certificate of Windlasses

Work Certificate of Boat Winches

EC Wheel Mark Conformity Certificate of Life Rafts

TL Product Certificate of Main Propulsion Machinery and Power Transmission Equipment **(2)**

TL Product Certificate of Gensets **(2)** (for P ≥ 50 kW/kVA)

Work Certificate of Gensets (for P < 50 kW/kVA)

TL Test Certificate of Propeller Material **(2)**

Work Certificate of Shaft Bearings

TL Product Certificate of Propellers **(2)** (for propellers having diameter > 1 m.)

Propellers Chemical Analysis Report and Examination by **TL** (for propellers having diameter up to 1 m.)

TK Type Approval Certificate or **EC** Type Approval Certificate of Fire Pumps

TK Type Approval Certificate or **EC** Type Approval Certificate of Bilge Pumps

TK Type Approval Certificate of Fire Detectors

TK Type Approval Certificate or Work Certificate of Portable Fire Extinguishers

TL Product Certificate or **EC** π Mark Conformity Certificate of Pressure Vessels (CO_2 bottles, etc.)

TK Type Approval Certificate or **EC** Type Approval Certificate of Fire Hoses.

TK Type Approval Certificate or **EC** Type Approval Certificate of Exhaust Hoses

TL Product Certificate or **TL** Type Approval Certificate of Electric Cables.

TL Product Certificate or **TL** Type Approval Certificate of Main Electrical Distribution Board **(2)** (for P ≥ 100kW)

Work certificate of Main Electrical Distribution Board (for P < 100kW)

TK : Class Society Recognized by **TL** (IACS member Class Society)

2) *Applicable for yachts for* ***+M*** *machinery class notation.*

B. Surveys

1. General

1.1 **TL** may agree to testing and analysis procedures as a supplement to or equivalent substitute for conventional survey and inspection such as by uncovering/opening up of components.

1.2 **TL** reserve the right to extend the scope of survey and/or inspection for given reasons, e.g. in the light of special experience gained during operation.

1.3 **TL**, reserve the right to demand surveys to be held between the due dates of regular surveys, if this is considered necessary. These surveys may substitute for envisaged periodical surveys.

1.4 If a ship has to be surveyed in a port where, or near which, there is no Agent or Surveyor to **TL**, **TL** head office is to be informed, if no possible the locally responsible Consul, a component Office or Authority, or the Average Commissioner ot the insurance Company concerned is to be requested to cause the yacht to be surveyed by an expert. The commission of the Expert is to be confirmed by the Consul, the Office or Authority, or the Average Commissioner. The Master shall request the Expert to forward to **TL** forthwith a report on the condition of the yacht and on the repairs as well as on the decision arrived at. A copy of the report is to be retained on board yacht. The decision of the expert is subject to the approval of **TL**, who will decide on whether the yacht has to be surveyed again.

1.5 In principle, the acting Surveyors will be chosen by **TL**. However, the operator of a ship and/or an installation classed is free to have any findings of surveys or decisions which he deems to be doubtful checked by other **TL** Surveyors upon his request.

1.6 The records of each survey, as well as special requirements upon which the maintenance of class has been made conditional, will be stated in the relevant survey report. By his Signature in the report the surveyor only certifies what he saw by himself and checked at the moment the survey was held.

The reports prepared by the Surveyor will be checked at **TL** Head Office. If there are no objections, the results will be recorded.

1.7 Where defects are repaired provisionally only, or where the Surveyor does not consider immediate repairs or replacements necessary, the yacht's class may be confirmed for a limited period. This subject will be declared to the owner in writing.

1.8 **TL** will also undertake on request other surveys and checks stipulated by additional regulations and requirements of the flag state. Such surveys are subject to agreements made in each individual case and/or to the regulations of the country concerned .

All activities as outlined above and, where appliacable, issuance of relevant certificates are likewise subject to the general conditions of A.

If for some reason a yacht's class has expired or has been withdrawn by **TL**, all statutory certlficates issued by **TL** will automatically become void. If subsequently the class is renewed or reassigned, validity of these certi ficates will within the scope of its original period of validity be revived, provided that all surveys meanwhile having fallen due have been carried out.

2. Surveys, Definitions, Period of Surveys

2.1 Periodical Surveys

2.1.1 Intermediate Survey

a) Intermediate surveys are to be carried out for the yacht's hull, machinery including the electrical installation and for special equipment (if available)

b) Intermediate surveys are to be carried out at half the period of class after the classification or renewal of the class of the yacht.

For instance, intermediate survey of a yacht having class notation (1A5) falls due 2,5 years after the commencement of class period.

Time interval granted by **TL** for carrying out these surveys is ±6 months.

2.1.2 Class Renewal Surveys

a) Class renewal surveys are to be carried out for the yacht's hull, machinery, including the electrical installation and for any special equipment classed,

b) A class renewal may be carried out in several parts. The whole survey period must not exceed 12 months and the class renewal survey must have been completed by the end of the class period.

c) The new period of class will commence;

- at the end of the month in which the previous class expires, provided that the class renewal survey has been completed within the 6 months preceeding that date,

- at the end of the month in which the surveys tor class renewal were completed, if this is the case more than 6 months before expiry of the previous class .

d) If a bottom survey is intended to be credited to a class renewal, all checkings of hull and machinery prescribed for the respective class renewal and requiring bottom survey will have to be carried out.

A bottom survey for class renewal may be carried out up to 12 months before completion of the class renewal.

2.1.3 Bottom Survey

Bottom survey, serve the purpose of checking of the bottom structure and related components of yacht externally.

This examination can be carried out either on shore or as an in-water survey when yacht is at sea. But, there is to be minimum of two bottom survey during each five-year class renewal survey period and bottom survey carried out in conjuction with class renewal survey should be realised when the yacht on shore. In principle, bottom surveys are to be carried out as a part of intermediate and class renewal surveys. However, in all cases the intervals between any two such surveys is not to exceed 36 months. In exceptional circumstances, **TL** reserve the right to assess the extension of this period.

2.1.4 Propeller Shaft Survey

2.1.4.1 Definition

Propeller shaft surveys serve the examination of propeller shaft, propeller boss, propeller and other propelling systems. This survey is to be carried out as a part of class renewal survey at intervals of 5 years.

2.2 Occasional Surveys

2.2.1 Damage and Repair Surveys

Damage and repair surveys fall due if checks of the yacht's hull, machinery or electrical installations and/or some special equipment classed have revealed that they no longer comply with **TL**' s Construction Rules. These surveys are also to be carried out if damage may be assumed in consequence of an average or some other event.

2.2.2 Conversion Surveys

In the case of conversions of a yacht's hull or rnachinery surveys are to be conducted in accordance with the relevant approved particulars, as in the case ot newbuildings.

3. Scope of Periodical Surveys

3.1 Intermediate Surveys

The requirements contained in this item apply to intermerdiate surveys of all kinds of yachts. During intermediate surveys, in addition to bottom survey, hull, machinery including electric installations are to be generally examined visually and, where applicable, by tests to confirm that the yacht is satisfactorily maintained and in good condition.

As stated in item 2.2.2, any conversion in the yacht's hull, machinery and electrical installation affecting the class is to be carried out under the supervision of **TL**.

The scope of detailed surveys and examinations are as follows:

Overall examination of whole hull structure

The scope of examination should be as folows:

- In addition to the bottom hull survey, side shell, deck, superstructure platings should be examined.

- Connection attachment of frames, floors, bulkheads, structural elements, engine seatings, shaft and rudder bosses and structural tank boundaries should be examined.

- Connection between deck and deck houses or superstructures and also hull-deck connection should be examined.

- End attachments of hull structural elements, guard rail stays, windlass, shaft brackets, fenders, bollards, mast ladders, riggings, chainplates, etc. should be examined.

- For GRP (Glass Reinforced Plastic) yachts, condition of gelcoat is to be examined, especially any crack, bubbles and other kind of defect are to be investigated.

- Yachts constructed using sandwich structures, it is to be carefully checked that skins are not detached from the core material. This check will be carried out by hammering the shell and evaluating the differences in the sound heart or by non-destructive examination recognized by **TL**. Connection between hull and deck, especially when they constructed from different materials, should be carefully examined.

Side shell doors and stern doors together with closing appliances

Accessible parts of steering system

Plating of freeboard deck, exposed decks and superstructure deck

All openings located on the superstructure together with closing appliances and safety systems

All openings on the freeboard deck and exposed decks together with their coamings, closing appliances and safety systems

All side scuttles and their deadlights together with closing appliances

Bulwarks, guard rails, freeing ports, pasarellas with its railings, accommodation ladders

Scuppers, sewage discharges, valves located on all discharges and their control mechanisms

Ventilation outlets together with closing appliances and flame screens, overflow and air escape pipes

All automatic air escape heads installed on exposed decks

Life raft foundations, bollards, chocks, chain pipe and similar deck equipment, masts and related riggings, lightning rods

Anchors, anchor chains, mooring ropes, windlass and mooring winches (if available)

Watertight bulkheads, watertight doors together with their remote controls, watertight bulkhead penetration

Main and emergency steering appliances including their related equipment and control systems

Fire divisions, fire doors, fire dampers located in ventilation ducts

Closing appliances of skylights and all other openings

- Confirmation that emergency escape routes from accommodation and service spaces are satisfactory
- Control of engine room and other spaces
- Where fitted, the helicopter deck and its supporting structure, safety net and arrangements for the prevention of sliding
- Availability of approved stability documentation on board yacht
- Visual inspection of all machinery spaces including engine room with special regard to fire and explosion hazards
- Checking that emergency escape routes from machinery spaces are not blocked
- Inspecting of all hydraulic, pneumatic, steam and other machinery systems and confirming that they are properly maintained
- Testing of means of communication between navigating bridge and control room and other control stations
- Confirming that rudder angle indicator located on the bridge is in good working order
- Inspection of bilge system, bilge wells, level alarms (where fitted) in accessible places
- Operational test of bilge pumps
- Visual inspection of expansion joints in sea water system
- External inspection pressure vessels with their appliances and safety devices
- External inspection and operational test of fore and aft thruster assembly (where provided).

General examination, visually and in operation, as feasible, of the electric installations for power and lighting. These examination is to include the following systems:

- Main and emergency generators
- Electric motors
- Main and sub distribution switchboards, main switchgears
- Cables and circuit protective devices
- All indicators of electrical systems
- Emergency source of power
- Checking that fire control plan are properly posted
- Examination and operational testing of manual and automatic fire doors
- Checking that the remote controls for stopping fans in machinery spaces are in working order
- Operational test of quick closing fuel valves
- Operational test of fire dampers
- Operational test, at random, of fire and/or smoke detectors
- Confirmation and operational tests of fire main system that main and emergency fire pumps operated seperately, have separate sea water suctions and located in separate places.
- Corfirming that fire hoses and nozzles are situated at their respective locations and in good working condition
- Examination of fixed fire-fighting system and their accessories as a whole, examination of CO_2 receivers (or other gas), control system, piping, instruction and marking

- Confirming for evidence of proper maintenance and servicing and checking date of last system test

- Checking of the alarm of fixed fire-fighting system

- Confirming that portable fire extinguishers are in their stowed position according to approved plan, their external surface are clean and dry

- Confirming that release control device of portable fire extinguisher is in working order

- Confirming that the supplies in the receivers of portable fire extinguishers are satisfactory and that they are properly maintained

- In sailing yachts, visual examination of masts and riggings, chain plates, all connecting bolts where practicable

- In sailing yachts, visual examination of the attachment of the ballast keel

- Examination the record of monitoring of the mast and rigging in accordance with a planned maintenance schedule where requested by the surveyor.

3.2 Bottom Survey

When bottom survey is carried out in dry condition, yacht is to be placed on blocks of sufficient

In general, keel, bottom and side shell plating and whole bottom structure, rudder system, propeller shaft system, sea chests, all sea water inlets, valves are to be examined.

In metalic yachts, the outer shell is to be visually examined for excessive corrosion, deterioration, deformation or bukling.

In GRP (Glass Reinforced Plastic) yachts, condition of gelcoat is to be examined for presence of cracking, blistering or other damage

In wooden yachts, particularly condition of caulking and rivets is to be examined.

The parts which necessitate immediate repairs are to be recorded.

Sea chests, their gratings, strainers, sea water connections, overboard discharge outlets are to be examined.

Propellers, propeller shafts, shaft brackets, visible parts of stern tubes are to be examined, the clearances of the shaft bearings are to be measured and recorded.

Visible parts of steering system are to be visually examined.

3.3 Class Renewal Surveys

In addition to the requirements for the intermediate surveys stated in (3.1), the following surveys and examinations are to be carried out in the scope of class renewal surveys:

- The presence of “osmosis” phenomena in the laminates of the underwater body and/or of cracks in the gelcoat is to be verified.
  To this end, the yacht is to be made available for the bottom survey in dry condition before the application of any paint, so as to allow a careful visual inspection.

- Examination of fresh water, ballast and fuel tanks internally, if possible,

- Hose tests of openings closed watertight,

- Examination of anchors, anchor chain cables and mooring ropes,

- Examination and operational tests of bilge and ballast pipings and associated pumps,

- External examination of sea valves and taking into account the findings obtained and the surveyor’s opinion, opening up of the valves and examination internally,

- External examination of propeller shaft and where required by the findings obtained and at the surveyor’s discretion, examination of drawn shaft,

- Open-up inspection of the main units of engine assembly when deemed necessary by the surveyor,

- Partly or wholly open-up inspection of main propulsion machinery where it is verified that this machinery is in satisfactory condition as a result of general examination and investigation of the maintenance records by the surveyor,

- Testing of the main units of machinery and electric installation while the yachts is floating condition.

3.4 Propeller Shaft Survey

The scope of propeller shaft survey consists the followings:

Examination by dismantling the propeller

- Inspection of shaft bearings following the drawing of propeller shaft completely (inner and outer bearings depending on the shaft type)

- Examination of aft end and conical parts of cylindrical portion of propeller shaft, welding of flanges -if flanged connection is used- by means of a suitable crack detection method.

- Examination of shaft bearing surfaces, liners, shaft joining parts, threaded end of shaft and nut.

- Examination of oil sealing gland covers, if provided.

- Measuring and recording of bearing clearances.

4. Corrosion and Wear Tolerances, Thickness Measurements

4.1 Weared or damaged parts which no longer comply with **TL**’s requirements are to be repaired or renewed.

4.2 The elements which thickness reduction is more than 10% comparing with the original thickness are to be renewed.

4.3 The anchors which weight reduction is more than 10% of rule weight are to be renewed.

The anchor chain cables which diameter reduction is more than 5% are to be replaced.

4.4 The scope of thickness measurements to be performed on older steel yachts is left to the surveyor’s discretion. Dicision for the scope of thickness measurements will depend on the construction and maintenance of the yacht.

SECTION 2

HULL CONSTRUCTION - GENERAL REQUIREMENTS

A. General Requirements

1. Application of Rules

These Rules apply to hulls of normal type yachts intended for unrestricted service which are to be classed by **TL**.

Section 2 applies in general to all yachts, irrespective of the material used for the construction of the hull.

Section 3 contains requirements relevant to the scantlings of hull structures of wooden yachts.

Section 4 contains requirements relevant to the scantlings of hull structures of yachts constructed of glass reinforced plastics and composite materials.

Section 5 and 6 contains requirements relevant to the scantlings of hull structures of steel and aluminium alloy yachts, respectively.

Yachts with hulls constructed of materials other than those above, and yachts of unusual form, speed or proportions or of types other than those considered in this section will be given special consideration by **TL**, also on the basis of equivalence criterion

2. Equivalents

In examining constructional plans, **TL** 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 on the basis of direct calculations of the structural strength.

3. Direct Calculations

3.1 General

Direct calculations are to be carried out, on the basis of the most modern technology, whenever requested by **TL** and, in general, in cases of unusual yachts or structures which have special characteristics.

3.2 Loads and Loading Conditions

In direct calculations both static and dynamic loads are to be taken into account.

Static loads are derived from the load conditions foreseen by the designer or the standard conditions foreseen by the rule scantling formulas.

Dynamic loads may be derived from recognised formulas, scale model test or values measured on similar full scale vessels.

3.3 Allowable Stresses

Allowable stresses for direct calculations are established on a case-by-case basis by **TL** on the basis of the load conditions considered, the model adopted and the hull material.

4. Definitions and Symbols

4.1 General

Definitions and symbols given in 4.2 and 4.3 apply to all Sections contained in this rule.

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.

4.2 Symbols

L_H = Hull length is the distance measured parallel to the static load waterline, from the foreside of the stem to the after side of the stern or transom, excluding projections removable parts that can be detached in a non-destructive manner and without affecting the structural integrity of the craft (pulpits at either ends of the craft, platforms, rubbing strakes and fenders, etc) [m].

L = Scantling length on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest [m].

L_{BP} = Length between perpendiculars is the distance measured on the full load waterline from fore perpendicular to aft perpendicular [m].

L_C = Load Line length means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel or the length from the fore side of the stem to the axis of the rudder stock on that waterline, whichever is the greater [m].
In yachts designed with a rake of keel the waterline on which this is measured is to be parallel to the designed waterline.

BK = Fore perpendicular, is the perpendicular at the intersection of the full load waterline (hull untrimmed) with the fore side of the stem.

KK = Aft perpendicular, is the perpendicular at the intersection of the full load waterline (hull untrimmed) 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 rudder, the position of aft perpendicular and the relevant L_{BP} will be specially considered.

B = Maximum outside breadth [m].

H = Depth measured vertically on the transverse section at 0,5 L, from moulded base line to the top of the deck beam at side on the weather deck [m].

H_1 = Depth measured vertically on the transverse section at 0,5 L, from the lower side of 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 [m].

T = Draft measured at 0,5 L between the full load waterline and the lower side of the keel. In the case of hulls with a drop or ballast keel, mthe 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 = Draft measured to the lower side theoretically extended, if necessary, to 0,5 L, of the fixed ballast keel, where fitted, or the drop keel [m].

Δ = Displacement of the yacht at draft T [t].

V = Maximum design speed of the yacht at displacement Δ [kn].

s = Spacing of ordinary stiffeners [m].

S = Web frame spacing [m].

See Figure 2.1.

4.3 Definitions

4.3.1 Rule Frame Spacing

The Rule frame spacing, sR [m], is obtained as follows:

$$s_R = 0{,}350 + 0{,}005\ L$$

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.

4.3.3 Freeboard Deck

Reference is made to the definition in ILLC, Annex 1.
The freeboard deck is normally the uppermost complete deck exposed to 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 freeboard 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 freeboard deck.

4.3.4 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.

4.3.5 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.

4.3.6 Weathertight

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

4.3.7 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.

5. Subdivision, Integrity of Hull and Superstructure

5.1 All yachts are to have at least the following transverse watertight bulkheads:

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

5.2 Openings in watertight Bulkheads and Decks

Note: *Type and positions of the watertight doors and manholes etc. on the bulkheads are subject for approval..*

5.2.1 Openings in watertight Bulkheads and Decks

5.2.1.1 As a general rule, no access openings are to be fitted in the collision bulkhead. Special consideration will be given in case of yachts with particular design only if the access is positioned as far above the design waterline as possible and its closing appliances are watertight.

An emergency escape of maximum size 500x500 mm may be accepted.

The closures have to be watertight. Closing devices operated from one side only will be subject to special consideration. A draining pipe of the fore peak may only pass through the collision bulkhead if a closing device is positionned directly over the collision bulkhead.

5.2.1.2 The number of openings in watertight subdivisions is to be limited to the minimum compatible with the proper working of the yacht. Access openings, Pipes, air-conditioning lines and electrical cable may be carried through watertight subdivisions provided that water tightness, structural integrity and fire proofness of the bulkhead are ensured by devices suitable in the opinion of **TL**.

When the pipe passing through the bulkhead is non-metallic, the above device is, as a minimum, to be a pipe of the same material as the bulkhead, fitted in a way to restore the structural integrity of the bullhead, 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.

Air vents belonging to deep tank sor tunnels or passing twin decks, are to stand maximum pressure and have to be watertight.

5.2.1.3 Watertight arrangements including gaskets, electrical wires etc are to be of fire-proof material.

5.2.1.4 Openings below the freeboard are allowed only if their number is the minimum as far as possible and every opening is fitted with appropriate closing device. The approval of subject openings is up to the surveyors satisfaction.

5.2.1.5 Lead or other heat sensible material are not to be used in systems where the water integrity may be damaged in case of a fire.

5.2.1.6 Valves, not involved in the pipe systems are not allowed on watertight bulkheads and decks.

5.2.2 Doors on Watertight Bulkheads

5.2.2.1 There may be a door placed on watertight bulkheads other than the collision bulkhead. These doors are to be of sliding type under the maximum draught level. **TL** may grant exemptions in special cases. **TL** may approve hinged doors over the maximum draft level.

5.2.2.2 Doors, stated in 5.2.2.1 are to be of watertight type, appropriate produced, mounted, have at lest the same strength as the bulkhead without any openings, and be able to be closed watertight. This doors are to be appropriate mounted into the door frame in order to esablish watertightness.

5.2.2.3 The doors with their frames are to be tested according their watertightness according **TL** before mounting on the yacht. Type approved doors may be accepted by **TL** as an alternative. After mounting on the yacht, the doors are to be tested on watertightness via soap test and operational tests.

5.2.2.4 Door indicators, show wheather the doors are open or shut, are to be placed in the wheelhouse.

5.3 Collision Bulkheads

5.3.1 Collision bulkhead is to be watertight and extend up to the freeboard deck. This bulkhead is to be located at a distance from the forward perpendicular of not less than 0,05 L , and not more than 0,10 L. In any case it is not necessary that the collision bulkhead is positioned at a distance more than 2 m from the forward perpendicular.

5.3.2 Where any part of the yacht below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distance stipulated in 5.3.1 are to be measured from a point either:

- at the mid-length of such extension, or
- at a distance 1,5 per cent of the length L of the yacht forward of the forward perpendicular, or
- at a distance 3 metres forward of the forward perpendicular;

whichever gives the smallest measurement.

5.3.3 Where long forward superstructures are fitted, the collision bulkhead is to be extended weathertight to the first tier superstructure deck.

5.3.4 The bulkhead may have steps or recesses provided that they are within the limits in 5.3.1 or 5.3.2.

For yachts of 500 gross tonnage or less, the following conditions (see Fig.2.2) must be complied with, when a stepped collision bulkhead is fitted:

a) The upper part of the bulkhead may be fitted at a distance less than 5%L from the forward perpendicular (but in any case not more than 300 mm ahead of the forward perpendicular)

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

c) The vertical lower part of the step is fitted at a distance behind the fore perpendicular of not more than 5%L

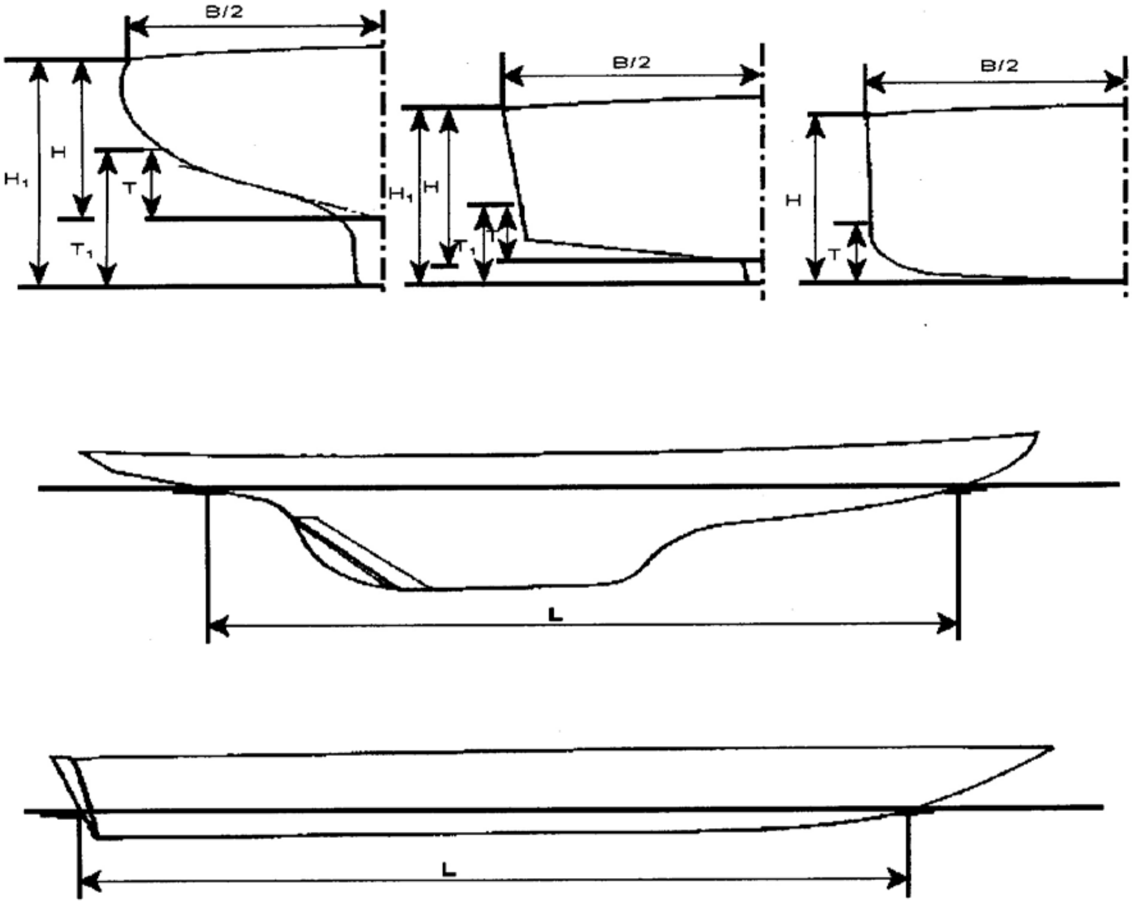


Figure 2.1 Dimensions of Hull

d) No point of the collision bulkhead profile in the longitudinal plane of symmetry can have a distance of less than 500 mm from the stem post; such distance is to be measured perpendicularly to the stem post profile

e) The space of the recess below the horizontal plane defined by the horizontal part of the step fitted at 500 mm above the maximum waterline is to be filled with closed cell high density foam

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

g) For yachts having a Length L less than 24 m according to ISO 8666, the required maximum distance stated in a) may be increased provided that the following criteria are satisfied:

1) The horizontal step forming the lower part of the vertical collision bulkhead is to be fitted at a height above the maximum waterline of not less than 700 mm;

2) The requirements given in d) and e);

3) Additional bilge arrangements are to be provided, in order to increase the capacity of bilge pumping in the fore spaces bounded by the collision bulkhead.

Such means should be considered case by case by **TL**;

4) Considering the flooding of the forward compartment, it must be checked that at the end of the flooding, and taking into consideration the loss of stability due to the free surface, compliance with the stability criteria of Sec 12 is assured and, in addition, no point of the maximum waterline level (considering the effective trim and heel angle after flooding) is above the door sills.

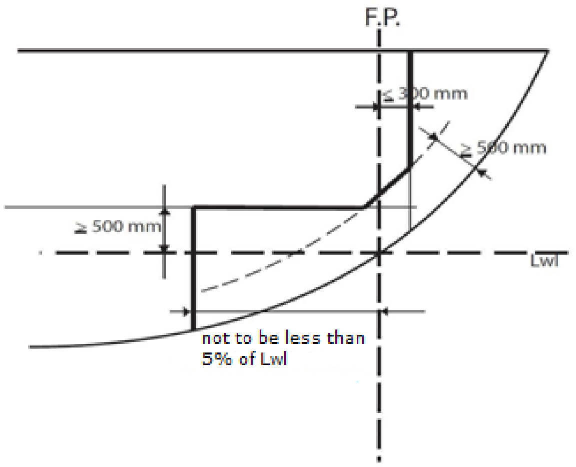


Figure 2.2 Stepped Collision Bulkhead

5.3.5 **TL** may, on a case-by-case basis, accept a distance from the collision bulkhead to the forward perpendicular greater than the maximum specified in 5.3.1 and 5.3.2, provided that, in the event of flooding of the space forward of the collision bulkhead, the waterline is not below the bulkhead deck and that, taking into account the loss of stability due to the free surface, compliance with the stability criteria will be guaranteed.

5.4 Sea Connections and Overboard Discharges

5.4.1 Overboard discharges are to be kept to a minimum and located, as far as practicable, above the full load waterline.
In any case a metallic valve is to be fitted on the side of the hull under the conditions of Sec. 7, Tab. 7.25 and Tab. 7.26, Note 2.

The sea connection for the engine cooling system is to 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.

5.4.2 All pipes leading to the sea and located under the full load waterline are to be of adequate thickness, in general metallic, sea corrosion-resistant 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.

5.4.3 Pipes for the discharge of exhaust from the engines leading to the shell without a valve are to be made as follows:

5.4.3.1 from below the maximum waterline up to 300 mm above the maximum waterline or to a waterline corresponding to a heeling angle of 7°, whichever is the greater, the piping is to be made of corrosion resistant material, galvanically compatible and resistant to exhaust products. The wall thickness pipe is to be not less than 5 mm if made of steel. If a composite material pipe is fitted the material is to have strength equivalent to that of side laminate or bottom laminate according to the location of the sea connection. The material is to be suitable to withstand the temperatures reached by the exhaust and in addition reference is to be made to the requirements of Sec. 4;

5.4.3.2 300 mm or more above the maximum waterline, flexible hoses compyling with the requirements of ISO Standard 13363 may be accepted;

5.4.3.3 such hoses are to be secured by means of at least two stainless steel hose clamps at each end. The clamps are to be at least 12 mm wide and are not to be dependent on spring tension to remain fastened. The joint location is to be readily accessible and visible at all times. Joints fitted lower than 300 mm above the maximum waterline may be accepted provided that they remain above the maximum waterline and additional bilge suctions and an alarm are fitted in the area where the joints are located, or a watertight compartment is provided in the area where the joint is fitted. Where a metallic valve is fitted on the side in way of the sea connection, the exhaust pipe material is to be resistant to the exhaust temperature and non-metallic material may be accepted for the entire length. The non-metallic materials are to meet the requirements in Sec. 7, Tab. 7.25 and 7.26..

5.5 Stern and Side Doors Below the Weather Deck

5.5.1 Side and Shell Doors Leading to a Non-watertight Space

Stern and side doors fitted on yachts not more than 24 m are to meet the requirements of ISO Standard 12216 as for appliances to be fitted on area I.

5.5.2 Side and Shell Doors Leading to Internal Compartment

Stern and side doors fitted on yachts more than 24 m, the doord leading to the internal compartments are to be in compliance with the following requirements:

5.5.2.1 All stern and side openings are to be provided with adequate means of closure.
The means of closure is to be watertight or weathertight depending on the distance of the lower edge of the closure from the maximum waterline.

If such distance is equal to or more than 500 mm, a weathertight means of closure may be accepted.

If the above distance is less than 500 mm a watertight means of closure is to be provided.

When the distance from the maximum waterline to the lower edge of the means of closure is less than 500 mm, but no essential equipment is installed in the compartment, and all the doors leading to internal compartments where essential equipment is installed are to be provided with watertight means of closure, a weathertight means of closure may be fitted.

When a watertight means of closure is requested, the requirements of Serction 2, Appendix are to be complied with.

5.5.2.2 Electrical equipment installed in the space where the access is provided by means of the side or stern doors is to have a degree of protection of at least IP 54.

The degree of protection of such equipment may be considered according to the height of installation from the platform and according to the means of protection in order to avoid water spray directly reaching the electrical equipment.

5.5.2.3 In any case at the completion of the installation all watertight and weatertight doors are to be checked by a "hose test". The hose test is to be carried out at a minimum pressure in the hose of not less than $2{,}0\ 10^5$ Pa, and the nozzle is to be applied at a 0 maximum distance of 1,5 m. The nozzle diameter is to be not less than 12 mm.

Spraying shall continue for at least 5 min. After this duration, the ingress of water shall not exceed 0,02 l.

5.5.2.4 Stern and side doors are to be fitted with proper gaskets, and adequate securing devices.

5.5.2.5 The lower part of each of these openings is, in general, to be above the deepest sea going condition.

5.5.2.6 Doors are preferably to open outwards.

5.5.3 Other Fittings

Recesses for wells, gangways, winches, platforms, etc fitted above 500 mm height from the full load waterline are to be weathertight; the ones fitted at or below the above height 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.

5.6 Hatches on the Weather Deck

5.6.1 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 in general weathertight. In general, hatches are to be hinged on the forward side. Coamings above the weather deck and deck above are to be not less than the following value:

	Deck Position 1	Deck position 2
Hatch coaming height	100 mm.	75 mm.

Where;

Deck position 1: any position on the exposed weather deck or superstructure deck above forward of 0,25 L_C.

Deck position 2: any position on the exposed superstructure deck aft of 0,25 L_C.

Greater coamings may be required where closing appliances are not permanently attached.

5.6.2 Where the hatches may be required to be used as a means of escape, the securing arrangements are to be operable from both sides.

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

- Be closed at sea;
- Be fitted in a protected location;
- Have at least two drains in the aft part leading overboard;
- Be fitted with gaskets;
- Have at least 4 clips of size 600 x 600 mm;
- Have non-oval hinges which can be considered as clips.

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

For yachts having length L_H not more than 24 m underISO 8666, the requirements of ISO Standard 12216 are to be applied.

5.7 Sidescuttles and Windows

5.7.1 General

For yachts not more than 24 m under ISO 8666, the requirements of ISO 12216 are to be applied.

For yachts more than 24 m the following requirements apply to sidescuttles and rectangular windows providing light and air, located in positions which are exposed to the action of the sea or inclement weather below and above the weather deck.

Sidescuttles and rectangular windows may be of “nonopening”, “opening” or “non-readily openable” type.

5.7.2 Zones for the determination of scantling

For the purpose of determining the scantlings of sidescuttles and rectangular windows, the yacht may be subdivided into zones which are defined as follows:

• **Zone A:**

Zone between the full load waterline and a line drawn parallel to the sheer profile and having its lowest point not less than 500 mm or 2,5% B, whichever is greater, above the full load waterline;

• **Zone B:**

Zone above Zone A bounded at the top by the deck from which the freeboard is calculated;

• **Zone C:**

Zone corresponding to the 1st tier of superstructures and above.

5.7.3 Scantling and Arrangement of Sidescuttles and Rectangular Windows

Sidescuttles and rectangular windows may be classified as follows, depending on their constructional characteristics:

- (medium series) non-opening or non-readily openable type, with deadlight: Type B;

- (light series) non-opening or opening type, without deadlight: Type C.

The following requirements apply:

- in Zone A neither side-scuttles nor rectangular windows are permitted;

- in Zone B in general only type B sidescuttles and rectangular windows are permitted; for yachts having gross tonnage not greater than 250, in Zone B an openable portlight type with deadlight may be fitted, provided that in the compartments a bilge level alarm is fitted connected to the automatic bilge pump. Alternatively, an automatic alarm for open position may be accepted.

For yachts having gross tonnage greater than 250, openable portlights with deadlight may be accepted if an automatic alarm for open position is provided.

In addition, a bilge level alarm connected to the automatic bilge pumps is to be provided.

For yachts having gross tonnage of not more than 300 GT, in Zones B and C, portlights with deadlight complying with ISO 12216 may also be accepted providing they undergo a hydraulic test at a pressure not less than 3 times the rule pressure of the side plate calculated at the position where the side scuttle is fitted, and in addition provided that they have undergone a mechanical test with the deadlight closed and without the glass pane to a pressure of not less than 0,85 KPa. In zone C, the above deadlight may be omitted. When the portlights are not provided with a deadlight, the above pressure test is to be carried out at a pressure of not less than 4 times the rule pressure of the side plate.

- in Zone C, even where protecting openings giving direct access to spaces below deck, type C sidescuttles and rectangular windows are permitted.

For the thickness of toughened glass panes of sidescuttles and rectangular windows, having surfaces not exceeding 0,16m^2, and fitted below the weather deck, see Tab 2.1.

Table 2.1

Clear light diameter [mm]	**Thickness of toughened glass [mm]**	
	Sidescuttle Type B (medium series)	**Sidescuttle Type C (light series)**
200	8	6
250	8	6
300	10	6
350	12	8
400	12	8
450	15	8

For oval sidescuttles, reference is to be made to the equivalent surface area.

Different thickness may also be accepted on the basis of a hydraulic pressure test, performed on a mock-up representative of the arrangement, the result of which confirms that the proposed thickness is able to ensure watertight integrity at a pressure not less than 4 times the design pressure of the hull in that zone.

Sidescuttles and rectangular windows with surfaces exceeding 0,16 m^2 may be accepted in Zone B. Their acceptance will be considered by **TL** case by case in relation to their number, type and location.

The relevant drawings with dimensions of clear opening, thickness of glass and position in respect of the deepest waterline are to be sent for approval.

The thickness of the glass for such sidescuttles/rectangular windows fitted below the weather deck is given by the following formula:

$$t = 0{,}015 \cdot b\sqrt{\beta \cdot p}$$

where;

p = Design pressure computed at the lower edge of the windows but not less than 20 kN/m^2 [kN/m^2],

b = Shorter side of the window [mm],

β = 0,54 A – 0,078 A^2 – 0,17

β = 0,75 for $A > 3$

a = Long side of the window [mm],

A = Ratio a/b

Different thickness may also be accepted on the basis of a hydraulic pressure test, performed on a mock-up representative of the arrangement, the result of which confirms that the proposed thickness is able to ensure watertight integrity at a pressure not less than 4 times the design pressure of the hull in that zone.

In any case, the thickness cannot be assumed less than 15 mm.

Where sidescuttles and rectangular windows with surface exceeding 0,16 m2 are fitted in zone B, the construction details are to be submitted to **TL**; in addition, tests on mock-ups representative of the arrangement as well as direct calculations for the zone of the side concerned may also be required in order to demonstrate the local structural adequacy.

Deadlights of the fixed type are to be arranged where monolithic toughened glass panes are fitted.

Deadlights of the non-fixed type may be arranged when laminated glass panes are fitted; however, they may be omitted, at the discretion of **TL** where the glass pane is of the laminated (shatterproof) type with a polycarbonate core of thickness greater than 3mm.

All windows and portlights are to be hose tested after installation according to **TL** Rules.

5.7.4 Windows Above Weather Deck

The required thicknesses of toughened glass panes in Standard rectangular windows are given in Table 2.2 as a function of the standard sizes of clear light.

The thickness of toughened glass panes in rectangular windows of other sizes is given by the following formula:

$$t = 0{,}005 \cdot b\sqrt{\beta \cdot p}$$

Here;

Table 2.2

Nominal sizes (clear light) of rectangular window [mm]	Thickness of toughened glass [mm]	Total minimum number of closing appliances of opening type rectangular window
300×500	6	4
355×500	6	4
400×560	6	4
450×630	6	4
500×710	6	6
560×800	7	6
900×630	8	6
1000×710	8	8
1100×800	9	8

p = Design pressure to be assumed 15 kN/m^2 for frontal Windows and 10 kN/m^2 for lateral windows [kN/m^2],

b = Shorter side of the windowı [mm],

β = 0,54 A – 0,078 A^2 – 0,17

β = 0,75 for $A > 3$

a = Long side of the window [mm],

A = Ratio a/b

Different thickness may also be accepted on the basis of a hydraulic pressure test, performed on a mock-up representative of the arrangement, the result of which confirms that the proposed thickness is able to ensure watertight integrity at a pressure not less than 4 times the design pressure.

A mock-up can be deemed representative of a set of glass panes of the same type if they have the same thickness and the dimensions "a" and "b" of each glass pane differ from those of the mock-up by not more than +/- 10%.

The thickness of toughened glass panes of windows of other shapes will be the subject of special consideration by **TL** in relation to their shape.

TL reserves the right to impose limitations on the size of rectangular windows and require the use of glass panes of increased thickness in way of front bulkheads which are particularly exposed to heavy seas.

5.7.5 Materials Other Than Toughened Glass

Materials other than toughened glass may be used for sidescuttles and windows above and below the weather deck.

The thickness of the sheets may be obtained by multiplying the Rule thickness for toughened glass by 1,3 in the case of polycarbonate sheets and 1,5 in the case of acrylic sheets.

5.7.6 Thickness of laminated glass

The thickness of laminated glass is to be such that:

$$t_\ell^2 = t^2{}_{K1} + t^2{}_{K2} + ... + t^2{}_{Kn}$$

where;

t_ℓ = Equivalent thickness of the single sheet glass pane,

t_K = Thickness of the single sheet in the laminate,

n = Number of sheets in the laminate.

5.8 Skylights

For yachts not more than 24 m under ISO 8666, the requirements of ISO 12216 are to be applied. For yachts more than 24 m, skylights fitted on the weather deck may be considered as fitted in zone B and therefore their thickness is to be in accordance with item 5.7.4 or 5.7.5. The design pressure to be assumed is 15 kN/m2 if fitted in deck position 1 and 10 kN/m2 if fitted in deck position 2.

The locking devices are to be the same required for flush hatches.

5.9 Outer Doors

5.9.1 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.

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

The height of the sills of doors above the exposed deck that give access to compartments below the deck is to be not less than the following value:

	Deck position 1	**Deck position 2**
Outer doors	100 mm.	75 mm.
Companionways	100 mm.	75 mm.

Doors on the weather deck to 1st tier accommodation or other spaces protecting access below may have four clips.

5.9.2 Sliding Glass Doors

Arrangements with sliding glass doors or glass walls are generally permissible only for the after end bulkhead of superstructures.

The glass used is to be of the toughened type or equivalent. The thickness may be determined using the formula in 5.7.4 assuming for P the value corresponding to 10 kN/m2.

The sills of these doors are to be in accordance with the requirements set out in 5.9.1.

5.10 Drawings

A plan showing the position portlights, windows, skylights, external doors and glass walls is to be submitted; their dimensions and sills are to be clearly indicated.

5.11 Ventilation

5.11.1 General

Accommodation spaces are to be protected from gas or vapour fumes from machinery, exhaust and fuel systems. Yachts are to be adequately ventilated throughout all spaces.

The 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 in the spaces for the safety and the operation of the machinery, according to the Manufacturer's specification.

Ventilating openings are to be designed and positioned with care, above all in exposed zones or those subject to high stress. The deck plating in way of the coamings is to be adequately stiffened.

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

Ventilators are to be adequately stayed.

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

For yachts having gross tonnage not greater than 350, the 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 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

5.11.2 Closing Appliances

All ventilator openings, having a duct section of 0,20 m^2 or more, are to be provided with efficient weathertight closing appliances unless:

- the height of the coaming is greater than 4,5 m above the deck if fitted in Position 1;
- the height of the coaming is greater than 2,3 m above the deck if fitted in Position 2.

As a general rule, closing appliances are to be permanently attached to the ventilator coamings.

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

5.12 Air Pipes

5.12.1 General

Air and sounding pipes are to comply with Machinery Rules for yachts.

5.12.2 Height of air pipes

The height of air pipes from the upper surface of decks exposed to the weather are to comply with Machinery Rules for yachts.

5.13 Bulwarks, Guardrails

5.13.1 Strength, Location and Height

Bulwarks, guardrails or guardline are to be arranged on exposed decks. Where this is not practicable, and for an area not normally accessed under operational conditions, they may be omitted and handrails are to be provided. Handrails are to meet the requirements of ISO 15085.

For yachts not more than 24 m under ISO 8666, the requirements of ISO 15085 are to be applied.

For yachts more than 24 m the requirements of ISO 15085 are to be applied for the strength of the guardline and guardrails structure.

The height of bulwarks or rails, or a combination of both, is to be not less than 600 mm. Lesser heights may be considered with regard to location and hazards involved.

The maximum clearance below the lowest course of the guardline is to be 230 mm. The other courses of guardline are to be not more than 380 mm.

The stanchions are to be spaced at not more than 2,2 m.

5.14 Freeing Ports

5.14.1 General

Bulwarks are to be provided with freeing port openings having dimensions given in the following:

- Yachts having L_H more than 24 m. under ISO 8666:

Freeing port area A for each side [m^2] :

$$A = 0{,}07 \cdot \ell$$

Where:

ℓ = Length of bulwark on one side, but need not exceed 0,7 L_H

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 in height, the freeing port area is to be decreased by the same ratio.

- Yachts having L_H equal to or less than 24 m. under ISO 8666:

The requirements of ISO 11812 are to be complied with.

For yachts having gross tonnage less than 300 GT, the area of freeing ports openings calculated according to the above formula can be reduced up to 50%, providing the following conditions are complied with:

- the well in which the above port freeing openingsare fitted is to be considered flooded
- the stability standards of Chapter 6 must be satisfied, keeping in mind the water embarked in the well and the free surface of the water
- after well flooding, the unit must not assume a trim that can jeopardize the safety conditions
- the degree of flooding of the well will be assessed case by case in relation to the conformation and height of the bulwark, taking into account the trim that the unit assumes
- in every case this calculation criterion can be applied to a unit that has a height of the exposed deck over the full load water level of not less than two meters.

For yachts of no more than 200 GT, the above conditions do not need to be checked.

5.14.2 Freeing Port Arrangement

Where they exceed 230 mm in depth, freeing port openings are to be protected by rails or bars spaced not more than 230 mm apart.

The lower edges of the freeing ports shall be as near the deck as practicable. The area of freeing ports is to be located for two-thirds in the half of the well nearer the lowest point of the sheer curve.

5.14.3 Cockpits and Cockpits Drainage

For yachts not more than 24 m under ISO 8666, recesses and their means for discharge outboard are to be in compliance with ISO 11812.

For yachts more than 24 m, the total area A of the means of discharge outboard is to be not less than the value given by the formula:

$A = 0{,}003\ V \quad [m^2]$

where V is the value of the well, in m^3.

B. Hull Attachments

1. Rudders and Steering Gears

1.1 General

These requirements apply to ordinary profiled rudders without any special arrangement for increasing the rudder force, such as fins or flaps, steering propellers, etc.

Unconventional rudders of unusual type or shape and those with speeds exceeding 45 knots will be the subject of special consideration by **TL**.

In such cases, the scantlings of the rudder and the rudder stock will be determined by means of direct calculations to be agreed with **TL** as regards the loads and schematisation.

In general, the loads will be determined either by model tests, or by measurements taken on similar yachts, or using recognised theories.

The stresses in N/mm^2 are not to be greater than the following:

- torsional stress = 70/e
- Von Mises equivalent stress = 120/e
  e, as defined in 1.2.1.

The "steering gear" of a yacht means all apparatus and devices necessary for the operation of the rudder, or equivalent means of manoeuvre, constituted by:

- Main steering gear, designed to ensure control of the yacht at the maximum navigational speed;
- Auxiliary steering gear, enabling control of the yacht in the event of an emergency due to mechanical breakdown of the components of the main steering gear.

1.2 Rudder Stock

1.2.1 Rudder Subject to Torque Only

The diameter D_T [mm] of rudder stocks, assumed in solid bar and subject to torque only, is given by the following formula

$$D_T = 12\left(A \cdot R \cdot V^2 \cdot e\right)^{1/3}$$

where;

A = Total rudder area bounded by the rudder's external contour including the mainpiece [m^2]

R = Horizontal distance [m] from the centroid of area to the centerline of pintles, to be taken not less than 0,12 b, where b is the width of the rudder [m], if the latter has a rectangular contour. For rudders with non-rectangular contours b=A/h is to be taken, where h is the rudder height [m], in way of centreline of pintles mentioned above.

V = Maximum design speed of the yacht at full load draught [kn]. In case of sailing yachts (with or without auxiliary engine), the following Formula is to be used for the calculation of V :

$V = 2{,}3\ L^{0{,}5}$

Where L, is the length as defined in A.4.2.

e = 235/R_S, the minimum yield stres R_S is to be taken not greater than 0,7 · R_M, where R_M is the minimum ultimate tensile strength of the rudder stock material.

However, the diameter D_T is no to be taken less than $20 \cdot e^{1/3}$.

For rudder stocks made of material which is more corrosion resistant than mild steels, a lower value for diameter D_T than that obtained as above may be accepted by **TL** on a caseby-case basis. In no case is such value to be reduced by more than 10%.

The diameter of rudder stocks made of composite materials may be derived using the above formulae, taking as the value R_S for the calculation of e, the value of shear tensile strength of the composite material.

The acceptance of rudder stocks made of composite material is, in any event, subject to an inspection of the fabrication procedure and, where appropriate, to omparative working tests.

1.2.2 Rudder Stocks Subject to Torque and Bending

The diameter D_{TF} of rudder stocks subject to torque and bending, as in the case of rudders with two bearings (with solepiece) and of space rudders (see types II A, II B and III in Figure 2.4) is not to be less than the value ontained from the formula:

$$D_{TF} = K \cdot D_T$$

where;

D_T = Diameter of the rudder stock, as defined and calculated in 1.2.1 [mm],

K = 1,08+0,06 (H/R), for type II A and II B rudders,

= 1,08+0,24 (H/R), for type III rudders,

H = Vertical distance from the centroid of the area A to the lower end of the rudder stock bearing in way of piece [m],

The diameter of the rudder, required in way of the mainpiece bearing, is to be extended at the upper part to at least 10% of the height of the bearing or to a height equivalent to 2 D_{TF}, whichever is the greater; beyond this limit, the rudder stock diameter may be gradually tapered so as to reach the value of D_T in way of the coupling between rudder stock and tiller.

At the lower part, the diameter D_{TF} is to be extended as far as the coupling between the rudder stock and the mainpiece; in the absence of such coupling, the diameter may be gradually tapered below the upper edge of the rudder blade.

1.2.3 Tubular Rudder Stocks

Where a tubular rudder stock is adopted, its inner iameter d_1 and outer diameter d_2, in mm, are to comply with the following formula:

$$\left[\frac{d_2^4 - d_1^4}{d_2}\right]^{1/3} \geq D$$

Where D = D_T for rudders dealt with 1.2.1 and D = D_{TF} for rudders dealt with 1.2.2.

1.3 Coupling Between Rudder Stock and Mainpiece

1.3.1 Horizontal Couplings

Horizontal flange couplings between the rudder stock and the mainpiece when not integral are to have:

- Flanges of dimensions such that the coupling bolts are distributed on a circumference having a diameter not less than 2D or in a similar manner, where D is as defined in 1.2.3;

- Flanges of thickness not less than the diameter d of the bolts;

- Bolts of diameter d, in mm, not less than 0,65 $D/n^{0,5}$, where n is the number of bolts, which in no case is to be less than 4;

- Bolts whose axes are at a distance not less than 1,2 d from the external edge of the flanges;

- Bolt nuts provided with means of locking.

1.3.2 Cone Couplings

Cone couplings of the shape shown in Fig 2.3 are to have the following dimensions:

a) Cone coupling with hydraulic arrangements for assembling and disassembling the coupling

Taper:

$1/20 \leq (d_1 - d_0) / t_s \leq 1/12$

$t_s \geq 1{,}5 \cdot d_1$

$d_G \geq 0{,}65 \cdot d_1$

$t_N \geq 0{,}60 \cdot d_G$

$d_N \geq 1{,}2 \cdot d_0$ and in any case

$d_N \geq 1{,}5 \cdot d_G$

Between the nut and rudder gudgeon a washer is to be fitted having a thickness not less than 0,13 d_G and an outer diameter not less than 1,3 d_0 and 1,6 d_G, whichever is the greater.

b) Cone coupling without hydraulic arrangements for assembling and disassembling the coupling

Taper:

$1/12 \leq (d_1 - d_0) / t_s \leq 1/8$

$t_s \geq 1{,}5 \cdot d_1$

$d_G \geq 0{,}65 \cdot d_1$

$t_N \geq 0{,}60 \cdot d_G$

$d_N \geq 1{,}2 \cdot d_0$ and in any case

$d_N \geq 1{,}5 \cdot d_G$

The dimensions of the locking nut, in both (a) and (b) above, are given purely for guidance, the determination of adequate scantlings being the responsibility of the designer.

In cone couplings of type (b) above, a key is to be fitted having a cross section 0,25 D_T x 0,10 D_T.

In cone couplings of type (a) above, the key may be omitted. In this case the designer is to submit to **TL** shrinkage calculations and supply all data necessary for the relevant check.

1.4 Rudder Mainpiece and Blade

1.4.1 Mainpiece Types

The rudder mainpiece is formed by the stock, extended into the blade when the coupling does not exist, or otherwise, by a solid or tubular bar, a double T or a box structure, as in the case of rudders with double plating.

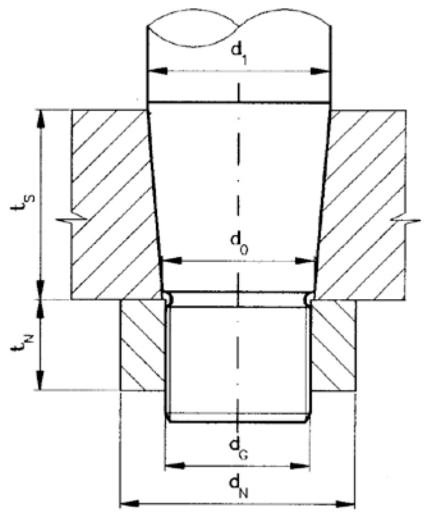


Figure 2.3

The arms or the webs supporting the blade are to be structurally connected to the mainpiece.

1.4.2 Plate Rudders

The following requirements apply to rudders made of hull plates of ordinary steel; plates of other metallic material, e.g. aluminium alloy or stainless steel, are permitted; their scantlings will be stipulated on the basis of their characteristics in accordance with a criterion of equivalence.

Single-plate rudders are to have:

- Mainpiece with section equal, or equivalent, to that of the stock in way of the upper edge of the blade, gradually tapered in the lower half to not less than 50%;

- Plate with thickness t = 5 + 0,11 (D_T - 20) mm, to be linearly increased with the arm spacing s, when s is greater than 750 mm;

- Horizontal arms with solid rectangular section, or equivalent each having, at the root, section modulus, in cm^3,

  W = 7 + 0,8 (D_T - 20);
  for D_T < 60 mm, W = 7 cm^3 is to be taken.

Double-plate rudders are to have:

- Mainpiece of section equal, or equivalent, to the section specified for single-plate rudders;

- Thickness t, in mm, of the plating, including that of upper or lower closing, and vertical and horizontal webs, given by the following formula:

$$t = D_T^{0,45} \cdot \left(0,7 + s/10^3\right)$$

where;

s = Spacing of the horizontal webs, to be taken for the calculation as not greater than 1000 [mm].

D_T = Rudder stock diameter as defined in 1.2.1 [mm].

• Welded connections complying with the requirements of Section 5 for steel rudders, and Section 6 for aluminium alloy rudders;

- Internal surfaces protected by painting; the filling of the rudder with light material of expanded type is permitted;

- Drainage hole.

1.4.3 Rudders with Blade Made of Glass Reinforced Plastics

Such rudders are to have, in particular:

- Stock and mainpiece, in solid or tubular bar, made of hull steel or light alloy, and mainpiece arms, of the same material, structurally connected to the mainpiece;

- Blade made of a single plate or composed of two preformed plates, made of glass reinforced plastics, complying with the requirements of Section 4 and filled with light material;

- Mass per unit surface, m, in kg/m^2, of the glass reinforcement of the material, m = 0,6Vb, where V and b are as defined in 1.2.1. The thickness of the plate is, in any case, to be not less than 5 mm.

1.4.4 Cast Rudders

For rudders and their stocks obtained by casting, the type of material and the relevant mechanical characteristics are to be submitted to **TL**.

Castings with sharp edges and sharp section changes are to be avoided, in particular when stock and plating are cast in one piece.

1.5 Rudder Bearings, Pintles and Stuffing Boxes

1.5.1 Rudder Bearings

Rudder "bearings" means:

- The bearing supporting the radial load fitted at the rudder trunk, that at the solepiece and that in way of the stock/ tiller coupling;

- A bearing, or equivalent device, carrying the vertical load, in order to support the weight of the rudder;

- Rudder stop devices, designed to prevent the rudder from lifting as necessary.

The rudder trunk bearing height h, in mm, is to be between 1,5 D and 2 D, where D is the local stock diameter as defined in 1.2.3.

Lower values of h, but in no case less than 1,2 D, may be accepted except in the case of spade rudders, for which h ≥1,5 D is required.

If the rudder stock is lined in way of the trunk bearing (for instance with stainless steel brush), the lining is to be shrunk on.

Any proposed welding overlay may be accepted subject to the use of a welding process recognised as suitable by **TL**.

1.5.2 Pintles

The minimum diameter D_A, in mm, of the pintles, outside of any lining or welding, is given by the following formula:

$D_A = c + 0,6\ D$

where:

c : 1,0 for rudders dealt with in 1.2.1
5,0 in other cases;

D : Rudder stock diameter as defined in 1.2.3.

The height of the pintle bearing surface is to be approximately 1,2 D_A, but in no case less than D_A.

The tapering of any truncated cone-shaped part of the pintle, in way of the connection to the hull, is to be 1:6 with respect to the diameter.

For any lining or welding, the requirements of 1.5.1 apply.

1.5.3 Sealing Devices

In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted to prevent water from entering the hull.

1.6 Steering Gear and Associated Apparatus

1.6.1 Premise

These requirements apply to the most commonly used types of steering gear, which are dealt with below; any different types will be specially considered by **TL** in each case.

1.6.2 Types of Steering Gear

Remote controlled steering gear of one of the following types:

- tiller; hydraulic actuator of the tiller and associated piping; valves and hydraulic pump controlled by rudder wheel;

- the above apparatus, with the addition of an electric pump feeding the actuator through distributor and gyropilot follow-up link

1.6.3 Steering Gear of Remote Controlled Type with Rope or Chain

The rudder tiller, or quadrant, is to have:

- Hub of height h ≥ D_T [mm] and thickness t=0,4 D_T [mm]

- Section modulus W [cm^3] in way of the connection to the hub:

$$W \geq 0{,}15 \frac{D_T^3}{1000} \cdot \frac{\ell_y - b}{\ell_y}$$

where;

D_T = Rule diameter of the rudder stock subject to torque only [mm],

ℓ_y = Length of the tiler, measured from the rudder stock to the point of connection of rope or chain to the stock [mm].

b = 0,5 D_T + t [mm]

The tiler-stock coupling is to be of the type with square section or with cylindrical section and key and the tiller hub is to be bolted, in particular:

- the hub bolts are to have diameter d_b [mm], not less than the value given by the formula:

$$d_b = \frac{0{,}4 \cdot D_T}{(2n)^{0,5}}$$

Where n, is the number of bolts on each side of the hub, in any case the diameter d_b is to be not less than 12 mm.

- the coupling key is to have rounded edges, length [mm] equal to the hub thickness, thickness equal to 0,17D_T [mm] and section area equal to 0,25D_T^2 [mm^2].

The chain or rope is to run as straight as practicable and the driving pulleys is to have a pitch diameter not less than 16 times the diameter of the chain or rope and in no case less than 45 mm. Such pulleys and the connection of any tackles are to be securely fastened to the hull.

The rudder wheel and the windlass is to be securely fastened to a column, or equivalent support provided for the purpose and it is to be possible, in general, to

rotate the rudder up to the maximum side angle with not more than 5 turns of the rudder wheel.

1.6.4 Steering Gear with Hydraulic or Electro-hydraulic Type Remote Control

The parts of such steering gear are to comply with applicable requirements of the Rules.

2. Propeller Shaft Brackets

2.1 Double Arm Brackets

Double arm propeller shaft brackets consist of two arms forming an angle as near as practicable to 90°, and converging into a propeller shaft bossing.
Arms having elliptical or trapezoidal section with round fairing are to have an area A [mm^2], at the root not less than that given by the following relationship

$$A = 87{,}5 \cdot 10^{-3} d_p^2 \left(\frac{1600 + R_{ma}}{R_{ma}} \right)$$

where;

d_p = Rule diameter of the propeller shaft made of steel with ultimate tensile strength R_m = 400 N/mm^2 measured inside the liner, if any, [mm],

R_{ma} = Minimum ultimate tensile strength of the material of the brackets [N/mm^2],

The maximum thickness in way of the above section is to be not less than 0,4 d_p.

The boss length will approximately be 4 d_P, but in no case may a length less than 3 d_P be accepted. The boss thickness is to be minimum 0,25 d_P. In any case when the diameter of the shaft propeller is calculated according to Sec. 7,C.2.2.3, boss thickness is to be not less than 0,35 d_P.

When the brackets are connected by means of palms, the latter are to have thickness not less than 0,2 d_p and are to be connected to the hull by means of bolts with nuts and lock nuts on the internal hull structures, which are to be suitably stiffened to the satisfaction of **TL**.

The thickness of the plating in the vicinity of the connection is to be increased by 50%. In the case of metal hulls and brackets of the same material, the connection between bracket and hull is to be carried out by means of welding.

The brackets are to be continuous through the plating and to be connected internally to suitable transverse or longitudinal structures.

2.2 Single Arm Brackets

2.2.1 Yachts Having Length of 24 m. and More

Single arm shaft brackets are to have a section modulus at ship plating level of not less than:

$$W = \frac{30}{R_{ma}} \cdot 10^{-3} \cdot \ell \cdot d_{so}^2 \cdot \left(n \cdot d_{so}\right)^{0,5} \qquad \left[cm^3\right]$$

where;

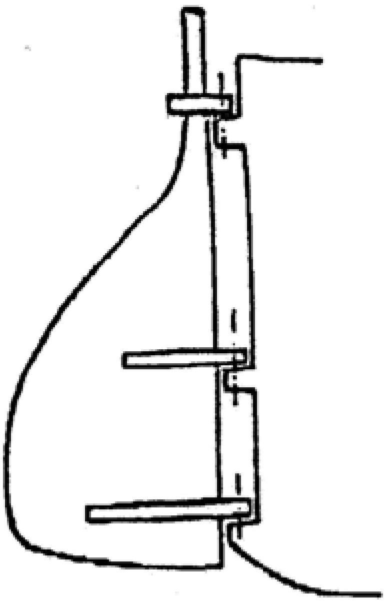
ℓ = Length of the arm measured from the shell plating to the centreline of the shaft boss [m],

n = Shaft revolution per minute,

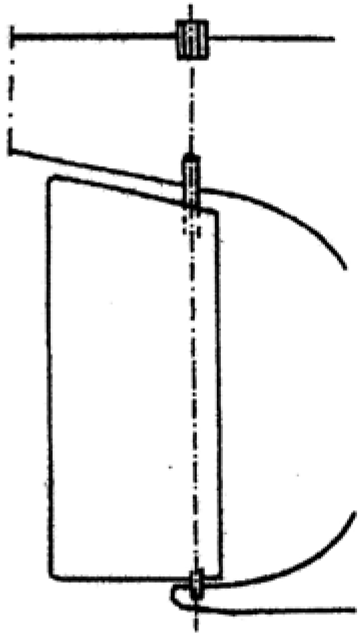
d_{so} = Rule diameter of the propeller shaft for carbon steel material [mm],

R_{ma} = Minimum tensile strength of arms with appropriate metallurgical temper [N/mm^2],

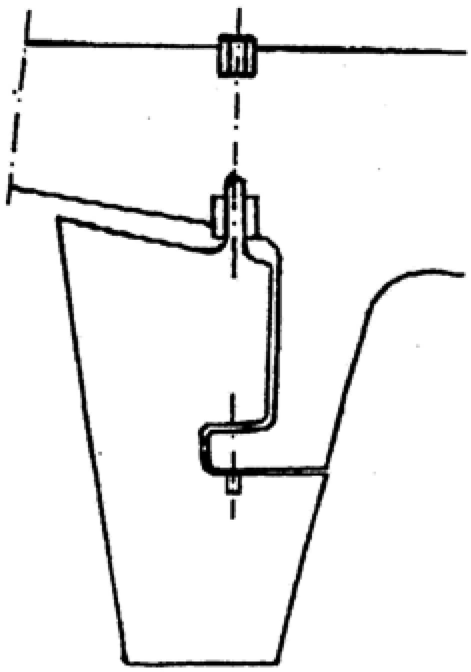
Boss thickness is to be calculated as for the double arm brackets.



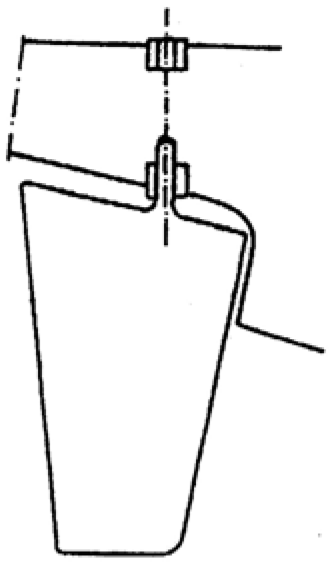
Type I



Type II A



Type II B



Type III

Figure 2.4

2.2.2 Yachts Having Length of Less than 24 m

Single arm shaft brackets are to have a section modulus at ship plating level of not less than:

$$W = \frac{\ell_o \cdot d^2}{112 \cdot R_m} \left[cm^3\right]$$

d = Actual shaft diameter (mm)

ℓo = Length of shaft boss (mm)

R_m = tensile strength (MPa).

The section modulus at shaft boss is to be not less than 0,6 W.

3. Sailing Yacht Appendages and Component Fastenings

3.1 Keel Connection

The typical ratio of the weight of external ballast to light displacement is generally 0,4 . 0,5.

The ballast may be internal or external to the hull.

In the first case, the ballast is to be permanently secured, by clips or equivalent means, to the resistant structures of the hull (floors, frames, etc.) but in no case to the plating, on which it is never to bear, so as not to shift even during rolling or pitching.

In the second case, the connection to the hull is to be effected by means of bolts long enough to incorporate the height of the ballast, either wholly or in part; such bolts are to pass through the hull, with a head (or nut and lock nut) at one end and a nut and lock nut at the other, towards the inside of the hull.

The surface of the ballast keel head is to be flush with the surface of the hull, the bolt holes are to be fashioned with equipment designed to achieve an almost complete absence of play between bolt and hole, and the locking of the nuts is to be uniform.

The diameter d, [mm], at the bottom of the thread of each keel bolt is given by the following formula:

$$d = \sqrt{\frac{2 \cdot W_k \cdot h_k \cdot b_{max}}{R_{eH} \cdot \Sigma(b_i^{\,2})}} \quad [mm]$$

where;

d_{min} = 12 mm for R_{eH} = 235 N/mm^2

d = Keel bolt root diameter

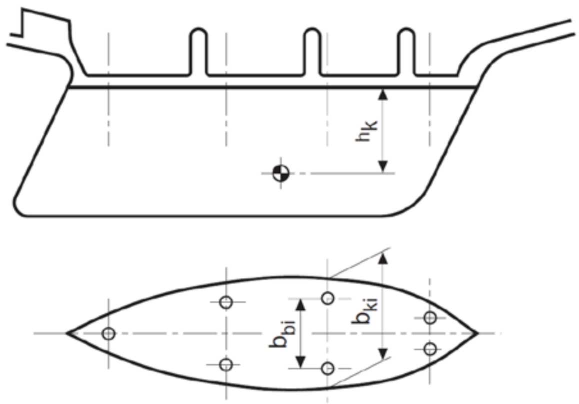
W_k = Total weight of the ballast keel [N],

h_K = The distance from the centroid of the ballast to the plane attachment of the ballast to the hull [mm]. See figure below.

b_{max} = Maximum scantling breadth b

b_i = Distance between two keel bolts. See figure below.

$$b_i = 0{,}5\, b_{bi} + 0{,}4\, b_{ki}$$



Note: *If the ballast keel bolts can not be placed on the same transverse section of the centerline of the keel, they should be placed stagered from the centerline as far as possible. If the keel bolts are placed on the centerline; b_{bi} should be taken zero, b_{ki} will be the breadth of keel where the bolt is placed.*

R_{eH} = Yielding strength of keel bolt material [N/mm^2]

There should be appropriate washer placed under each head bolt (as a refference for yachts under 24 m; the diameter should be not less than 4 times of the keel diameter (d) and the thickness is to be at least 0,25 times of the keel diameter (d)). The stab should be long enough for a checknut or other means of closing.

Keel bolt should be produced from approved, corrosive resistant material. Nuts, washers and other fitting may be produced from the same or similar material as the bolts. Doublers or brackets may be used in order transfer the loads to the girders, floors or both together. The balast keel weight should be uniformly distributed to the keel bolts, which will be established by the distance between the keel bolts. In alluminum bots, the bolts, nuts, washer have to be appropriately insulated. Stud bolts have to be connected via bolts placed in backing plates or via “j” bolts or other efficient methods to the keel; taking possible loads into account.

3.2 Grounding

It is to be verified that the arrangement is strong enough to withstand the grounding loads. It is assumed that the conventional grounding loads are the following:

a) Longitudinal grounding loads acting in the aft direction and parallel to the longitudinal hull axis. The load is to be applied to the bottom edge of the keel.

$L_{GL} = 3{,}1\ \Delta$ (if $L_{wL} > 20$ m)
$L_{GL} = 1{,}60\ \Delta$ (if $L_{wL} < 10$ m)

b) Vertical grounding load VGL, in tons, acting upward on the bottom of the keel.

$V_{GL} = 1{,}60\ \Delta$

It is to be verified that shear stress and primary stress due to the load as indicated in a and b are not more than the value given from the following formula:

shear stress < 0,70 η_B

primary stress < 0,70 η_R

where:
Δ : is the maximum displacement of the vessel, in tonnes;

η_R : is the minimum shear yield stress of the bolts material [N/mm].

Where direct calculations are carried out to determine the diameter of bolts, the degree of locking is to be taken into account and a safety factor ≥ 3,5 in relation to the ultimate tensile strength and ≥ 2 in relation to the yield stress of the bolt material is to be applied.

3.2 Chain Plates

3.2.1 General

The loads created by yacht’s rigging (stays, aft stays, shrouds) are to be indicated by the designer or shipyard.

This loads are:

F_a : Design loads designated by the designer for various service conditions and sail types taking into account all wind directions and sail reducements.

F_b : If load F_a is not indicated, ultimate tensile loads of stays and shrouds are to be considered.

Not: *Shrouds made of aramide or carbon material, design load F_a recommended.*

3.2.2 Loads on Chainplate

As a general rule, F_S load to be taken into account when determining the scantling of chain plate is:

$F_S = P_D \cdot C_i$ [N]

where:

F_D : Design load (F_a or F_b) [N]

C_i : safety factors for F_a and F_b :

- 3, if F_a used for F_D
- 1,2, if F_b used for F_D

When more than one shroud or stay are connected to the same chainplate, the global load to be applied is the sum of larger F_S of stronger shroud plus 0,8 F_S of the other shrouds.

3.2.3 Loads on local hull supporting structures

Design load acting on the local hull structure supporting chainplate is to be taken as 1,45 F_S stated in 3.2.2.

3.2.4 Criteria to be checked on metallic chainplates

$$\sigma_{tensile} = F_S / A_t \quad [MPa]$$

where;

F_s : Load stated in 3.2.2 [N]

A_t : Sectional area of chainplate part subject to tensile [mm^2]

$\sigma_{torsion}$ = F_S / (D*t) [MPa]

F_S : Load stated in 3.2.2 [N]

D : Diameter of chainplate part subject to torsion [mm]

t : Thickness of chainplate part subject to torsion [mm]

τ_{shear} = Fs / As [MPa]

F_S : Load stated in 3.2.2 [N]

As : Sectional area of chainplate part subject to shear [mm^2]

3.2.5 Chainplate fastenings

Many arrangements may be adopted according to the design philosophy.
Basically, the following arrangement could be adopted:

a) Single strap design:

In this case the chainplates may be fitted internally or externally and by means of bolts. In the case of internal fittings, the bolts are to have large heads; on account of their appearance, washers are not normally fitted on the outside of the hull;

In case chainplate is connected to the hull by bolts, the followings are to be observed:

- Either, a backing plate with the thickness of 0,25 times bolt diameter

- Or, a washer with thickness of at least 0,25 times bolt diameter and with diameter of at least 4 times the bolt diameter.

b) Bracket connection

In this case the chainplate is connected to a plywood bracket by means an angle or flat bar chainplate.

The chainplate is to be bolted to the bracket. Where possible, the chainplates are to be bolted directly to the bulkhead. Where the chainplate and bolts penetrate, the hull or deck is to be made watertight with a flexible sealant.

Chainplates are to be generally of mild steel, stainless steel, monel or aluminium. Bolts are to be galvanically compatible with the other materials and are to be sea corrosion-resistant.

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3.3 Component Fastenings

Components can be satisfactorily fastened with bolts, screws or rivets. These fasteners are to be of a corrosion resistant metal. Bolts, washers, backing plates and fittings are to be of a compatible material. Where chemically incompatible, adequately insulation is to be provided. If the components are to be fitted to a hull structure in sandwich construction with low density core materials, the local hull area is to be replaced with structurally effective inserts in way of bolted connections and fittings. The inserts are to be sea adequately bonded to the laminate skins.

Alternatively, the local area can be replaced with monolithic laminate of the same thickness as the sandwich laminate.

4. Stabilizer Arrangements

4.1 General

The scantlings, arrangement and efficiency of stabilizer arrangements do not fall within the scope of Classification; nevertheless, the bedplates of the various components, the supporting structures and the watertight integrity are to be examined.

4.2 Stabilizer Arrangements

4.2.1 The stabilizer fin machinery is to be supported by adequately reinforced structures. Drawings are to be submitted for approval showing the position, the supporting structures and the loads transmitted.

4.2.2 The shell plating in way of stabilizer fins is to be adequately reinforced. In the case of fixed type stabiliser fins, the passage to the hull and the components necessary for the operation of the system, supported by adequately reinforced structures, are to be arranged in a watertight box with an inspection opening fitted with a watertight cover.

The aim of the watertight box is to guarantee the floatability and safely operation of the yacht caused by any impact acting on the stabilizer fin. In addition to the requirements given in 4.2.3, the followings are to be taken into account when determining the position and the scope of the watertight box:

- Material of the stabilizer fin

- Designated breaking mode of stabilizer fin shaft

- Damage stability requirements of yacht

- Floatability of the yacht after the impact acting to the stabilizer fin

- Function of the space containing the stabilizer fin.

4.2.3 The watertight walls constitude the fore and aft watertight partitions for recractable type stabilizer fins are to be located at least 1/3.C (where C is length of the fin) from the fore and aft end of the stabilizer fin. See, Figure 2.5. Main watertight subdivision bulkheads, where appropriate, can be accepted as watertight partitions.

4.2.4 Where it is not practicable to construct watertight compartments for stabilizer fins, breakaway fins can be used.

For the evaluation of acceptability of the breakaway stabilizer fins the following have to be observed:

- To prove by the designer that the stabilizer fin are breakable (designed for breaking in case of any impact).

- Calculations prooving that the stabilizer fins do not cause any damage affecting the hull structure in the vicinity and thus structural and watertight integrity of the hull is not to be effected.

- The drawings showing the smaller watertight compartment or secondary protection of penetration gasket in the area of stabilizer fin.

- Shell expansion plan containing insert plate below the operational area covering all operational angles.

In metal structures, watertight box is to be at least of the same thickness as the adjacent shell plating. However, this thickness is not to be less than 12 mm. The box is to be well stiffened.

For GRP vessels, the scantling of the watertight boxes and their stiffeners will be considered case by case. Laminate thickness of watertight box in which stabilizer fin retracted are to be specially considered. In general, the thickness is not to be less than obtained for bottom plating. Where it is not practical to provide a watertight box, the arrangement will be specially considered by **TL**.

The insert plate is to be provided to the shell plating in the area of stabilizer fin or the laminate is to be increased. The thickness of insert plate or the thickness of increased laminate is to be at least 150% of the bottom plating in the vicinity and is to extend on the area of 1,25 times of the length of fin root, additionally to cover all the operational angles. Besides, insert plate for retractible stabilizer fins is to extend at least 25% of fin root length from the boundary of opening of plating.

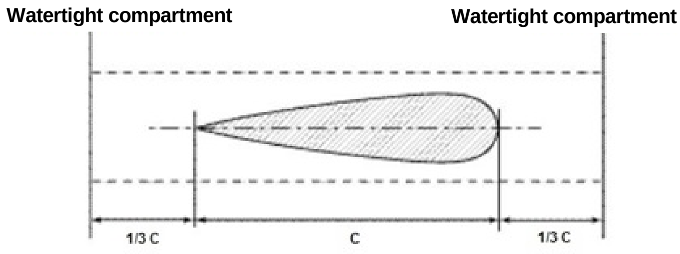

Figure 2.5 Positioning of stabilizer fin

4.3 Stabilizing Tanks

The tank structures are to comply with the requirements for tank bulkheads, taking into account the maximum head that may arise in service.

Where sloshing is foreseeable the scantlings will be the subject of special consideration.

5. Thruster Tunnels

5.1 Tunnel Wall Thickness

The thickness of the tunnel is to be in accordance with the Manufacturer's specifications; in general, the thickness is to be not less than:

- For steel tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 2 mm), and in any case not less than 7 mm.

- For light alloy tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 1 mm), and in any case not less than 8 mm.

- For composite tunnels: the Rule thickness of the adjacent plating increased by 25%; in any case the thickness is to be not less than 8 mm. If tunnel diameter is not more than 300 mm, a thickness not less than the Rule thickness of the adjacent plating can be accepted.

5.2 Tunnel Arrangement Details

5.2.1 The system for connecting the tunnel to the hull depends on the material used for the construction.

5.2.2 The thickness of the plating is to be locally increased by 50% in way of the tunnel attachment.

5.2.3 The tunnel is to be connected to the plating by means of full penetration welding.

5.2.4 For tunnels in composite material, the weight of the connecting laminate stiffener is to be equal to the weight of the bottom plating stiffener. The stiffener is to be arranged on both sides of the plating laminate.

Prior to the connecting lamination, the surfaces of the tunnel and the plating concerned are to be suitably cleaned and prepared and the edges of the cuts are to be sealed with resin.

6. Water Jet Drive Ducts

The thickness of the duct is to be in accordance with the Manufacturer's specifications and, in general, is to be not less than that of the adjacent plating.

The duct is to be adequately supported, stiffened and fully integrated with the hull structure.

The water-jet drive supporting structures are to be able to withstand the loads induced by the propulsion system in the following conditions:

- Maximum thrust ahead

- Maximum thrust at the maximum lateral inclination

- Maximum reverse thrust (astern speed).

The foregoing loads are to be provided by the water-jet drive Manufacturer.

All hull openings are to be adequately reinforced and to have well rounded corners.

The thickness of the plating in the vicinity of the duct entrance is to be locally increased as stated in 5.2.2.

7. Crane Support Arrangements

Crane foundations are to be designed considering the worst combinations of the following loadings:

- Maximum load capacity;

- The weight of the crane itself.

Insert plates are to be provided in the deck in way of the crane foundation; in order to avoid concentration of forces. These insert plates are to have suitable dimensions, be suitably prepared and have round corners. The thickness of these inserts shall be in accordance with the Designer's calculations.

A drawing of this arrangement with all the forces acting and the detail of the connection to the deck is to be sent for approval.

C. Equipment

1. General

The anchoring equipment required in 7 is intended for temporary mooring of a yacht within or near a harbour, or in a sheltered area.

The equipment is therefore not designed to hold a yacht off fully exposed coasts in rough weather or to stop a yacht which is moving or drifting. In such conditions the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated.

The anchoring equipment required in 7 is deemed suitable to hold a yacht in good holding ground where the conditions are such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors will be significantly reduced.

It is assumed that under normal circumstances a yacht will use one anchor only. The minimum amount of equipment required is stipulated in Table 2.3 in relation to the EN value.

Equipment given is applicable for the vessels for which additional class notation **EN** is requested. If this is not the case, the equipment shown three lines above in relation to the EN value calculated can be used.

2. Anchors

2.1 The mass per anchor given in Table 2.3 applies to normal type anchors. When use is made of “High Holding Power” anchors, the mass of the anchors may be equal to 75% of that shown in Table 2.3.

The actual mass of each anchor may vary by + or – 7% with respect to that shown in Table 2.3, provided that the total mass of the two anchors is at least equal to the sum of the masses given in Table 2.3.

2.2 Upon requested by the owner, for vessels having the notation **K 20**, one anchor may be used with **TL** consent.

3. Anchor Chain Cables

Chain cables are to have proportions in accordance with recognised unified standards and to be of the steel grade given in Tab 2.3.

Grade 1 chain cables are generally not to be used in association with "high holding power" anchors

4. Wire and Synthetic Ropes for Anchors

Where EN<30, the chain cables required in columns 7 and 8 of Table 2.3 may be replaced by wire ropes of breaking load not less than that of the corresponding chains.

In this case, a shorter legth of chain cable is to be fitted between the wire rope and the anchor, of a length equal to 2 m. or the distance from the anchor in the stowed position to the winch, whichever is the lesser.

Where EN≤130, the chain cables required in Table 2.3 may be replaced by synthetic ropes, provided that the following conditions are met.

Fibre ropes, except polypropylene ropes, may be made of polyamide or other equivalent synthetic fibre.

The length of synthetic fibre rope L_{sfr}, is not to be less than the following values :

$L_{sfr} = L_{ch}$ where, EN < 60

$L_{sfr} = L_{ch}$ (EN+170)/200 where, 60 < EN ≤ 130

Where; L_{ch}, is the length of chain cable given in Table 2.3.

Effective breaking load of synthetic fibre ropes is not to be less than P_s (kN) = 1,5 BL.

Where BL(kN), is the breaking load of chain cable.

In this case, a shorter legth of chain cable is to be fitted between the synthetic rope and the anchor, of a length equal to 2 m. or the distance from the anchor in the stowed position to the winch, whichever is the lesser.

5. Mooring Ropes

Mooring lines may be of wire, natural or synthetic fibre, or a mixture of wire and fibre.

Where steel wires are used, they are to be of the flexible type.

Steel wires to be used with mooring winches, where the wire is wound on the winch drum, may be constructed with an independent metal core instead of a fibre core.

In colums 9 and 11 in Table 2.3, the diameters [mm] of Manila three-stranded superior quality ropes are given for information purposes.

Where synthetic fibre ropes are adopted, their size will be determined taking into account the type of material used and the manufacturing characteristics of the rope, as well as the different properties of such ropes in comparison with natural fibre ropes.

The equivalence between synthetic fibre ropes and natural fibre ropes may be assessed by the following formula:

$$CR_S = 7{,}4 \cdot \frac{\delta \cdot CR_M}{CR_M^{1/9}}$$

Here;

δ = Elongation to breaking of the synthetic fibre rope, to be assumed not less than 30%,

CR_S = Breaking load of the synthetic fibre rope [kN]

CR_M = Breaking load of the natural fibre rope [kN]

Where synthetic fibre ropes are used, rope diameters under 20 mm are not permitted, even though a smaller diameter could be adopted in relation to the required breaking load.

6. Windlass

6.1 General

In yachts fitted with anchor which mass is more than 50 kg, power driven, suitable for the size of chain cable and having characteristics stated below, one windlass is to be provided.

The windlass is to be fitted in a suitable position in order to ensure an easy lead of the chain cables to and through the hawse pipes. The deck in way of the windlass is to be suitably reinforced.

A suitable stopping device is to be fitted in order to prevent the anchor from shifting due to movement of the yacht.

6.2 Working Test on Windlasss

6.2.1 The working test of the windlass is to be carried out on board in the presence of the **TL** Surveyor.

6.2.2 The test is to demonstrate that the windlass works adequately and has sufficient power to simultaneously weigh the two bower when both are suspended to 55 m of chain cable, in not more than 6 min.

Table 2.3

EN	1st anchor [kg]	2nd anchor [kg]	Chain cable diameter			Chain cable length		Towing ropes			Mooring ropes			
			Studless [mm]	With stud		On 1st anchor [m]	On 2nd anchor [m]	Manila rope dia. [mm]	Breaking load [kN]	Rope length (m)	Number of ropes	Rope dia. [mm]	Breaking load [kN]	Rope length [m]
				Grade 1 steel [mm]	Grade 2 steel [mm]									
15	14	10	6	-	-	50	50	18	20	90	2	15	13,7	50
20	20	14	6	-	-	50	50	18	20	90	2	15	14,7	50
25	27	19	8	-	-	50	50	20	25	110	2	16	16,7	55
30	32	22	8	-	-	50	50	23	31	110	2	17	17,7	55
35	41	29	8	-	-	60	60	26	39	110	2	17	18,6	60
40	50	35	10	-	-	70	60	28	46	135	2	18	20,6	60
50	68	48	10	-	-	80	65	32	60	135	2	19	23,5	65
60	92	64	10	-	-	90	65	35	71	180	2	20	25,5	65
70	116	81	11	-	-	100	70	38	80	180	2	22	28,4	70
80	137	96	12,5	-	-	110	70	39	88	180	2	22	30,4	70
90	155	110	12,5	-	-	110	80	39	88	180	2	24	33,3	80
100	170	120	14,5	14	12,5	110	80	42	99	180	2	24	35,3	80
110	183	128	14,5	14	12,5	110	80	43	104	180	2	25	37,3	90
120	196	138	16	16	12,5	110	80	44	108	180	3	25	38,2	90
130	208	145	17,5	16	14	110	110	45	112	180	3	26	39,2	90
140	220	154	17,5	16	14	110	110	45	114	180	3	26	40,2	100
150	230	160	19	17,5	16	110	110	45	116	180	3	26	41,2	100
160	240	170	20,5	19	16	110	110	46	118	180	3	27	42,2	100
170	250	180	20,5	19	16	120	110	46	120	180	3	27	43,1	110
180	260	190	22	20,5	17,5	120	110	46	122	180	3	27	44,1	110
190	270	200	24	22	19	120	110	47	124	180	3	28	45,1	110
200	290	210	24	22	19	120	110	47	126	180	3	28	46,1	120
210	300	220	-	24	19	130	120	50	128	180	4	28	46,1	130
220	310	230	-	24	22	140	130	51	130	180	4	28	46,1	130
230	320	240	-	24	22	150	140	52	134	180	4	30	47	130

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EN	1st anchor [kg]	2nd anchor [kg]	Chain cable diameter			Chain cable length		Towing ropes			Mooring ropes			
			Studless [mm]	With stud		On 1st anchor [m]	On 2nd anchor [m]	Manila rope dia. [mm]	Breaking load [kN]	Rope length (m)	Number of ropes	Rope dia. [mm]	Breaking load [kN]	Rope length [m]
				Grade 1 steel [mm]	Grade 2 steel [mm]									
260	360	270	-	28	24	180	140	53	142	180	4	30	47	140
270	375	280	-	28	26	180	140	54	144	180	4	30	48	150
280	390	295	-	30	26	180	140	54	146	180	4	30	48	150
290	405	310	-	30	26	180	150	54	148	180	4	30	48	150
300	420	320	-	30	28	180	160	55	150	180	4	30	49	150
310	440	330	-	32	28	180	170	55	152	180	4	32	49	160
320	460	340	-	34	30	190	170	55	152	180	4	32	49	170
330	480	350	-	34	30	200	170	55	154	180	4	32	50	170
340	490	360	-	34	30	210	170	56	156	180	4	32	50	170
350	500	370	-	36	32	220	170	56	156	180	4	32	50	170
360	510	380	-	36	32	230	170	56	158	180	4	32	52	180
370	520	390	-	36	34	230	180	57	158	180	4	32	52	190
380	530	400	-	38	34	230	190	57	160	180	4	32	53	190
390	540	410	-	40	34	230	190	58	160	180	4	32	53	190
400	555	420	-	42	36	230	200	59	160	180	4	32	53	190

6.2.3 Where two windlasses operating separately on each chain cable are adopted, the weighing test is to be carried out for both, weighing an anchor suspended to 82,5m of chain cable and verifying that the time required for the weighing (excluding the housing of the anchors in the hawse pipe) does not exceed 9 min. Where the depth of water in the trial area is inadequate, or the anchor cable is less than 82,5 m, suitable equivalent simulating conditions will be considered as an alternative.

7. Equipment Number and Equipment

All yachts are to be provided with anchors, chain cables and ropes based on their Equipment Number EN, as shown in Table 2.3 and calculated in the following:.

$$EN = (0{,}5 \cdot L \cdot B \cdot H)^{2/3} + 2 \cdot B \cdot h + 0{,}1 \cdot A$$

where;

h = $a + \sum h_n$

a = Distance from the summer load waterline amidships to the weather deck [m]

h_n = Height (from weather deck) at the centreline of each tier n of superstructures or deckhouses having a breadth gtreater than B/4 [m],

A = Area in profile view of the parts of the hull, superstructure and deckhouses above the summer load waterline which are within the length L of the yacht and also have a breadth greater than B/4 [m^2].

All yachts are to be equipped with two bower anchors (shown in columns 2 and 3 of Table 2.3). Where EN< 80, however, the anchor required in column 3 may be replaced by a kedge anchor (an anchor with fixed palms) of equal mass fitted with a chain cable (pendant) of size as in column 4 and length of approximately 9 m.

Column 7 and 8 indicate the lengths of chain to be connected to the first and second anchors, respectively.

Where EN<80, the chain required in column 8 for the second anchor or the kedge anchor may be replaced by a wire rope of length equal to that shown in the column and breaking load not less than that of the corresponding chain.

8. Chain Locker

8.1 The chain locker is to be of capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes and self-stowing of the cables.

The minimum required stowage capacity without mud box for the two anchor chains is as follows:

$$S = 1{,}1 \cdot d^2 \cdot \frac{\ell}{100000} \quad [m^3]$$

d = Chain diameter according to Table 2.3 [mm]

ℓ = Total length of stud link chain cable according to Table 2.3.

The total stowage capacity is to be distributed on two chain lockers of equal size for the port and starboard chain cables. The shape of the base areas shall as far as possible be quadratic with a maximum edge length of 33.d. As an alternative, circular base areas may be selected, the diameter of which shall not exceed 30-35 d.

If size of yacht permits, the following free depth is to be provided above the stowage of each chain locker, in addition:

h = 750 [mm] for L = 24 m.

h = 1500 [mm] for L ≥ 48 m.

For intermediate lengths L linear interpolation is to be applied for the depth h.

For the lowest tier of superstructure h is to be measured at centreline from the upper deck or from a notional deckline where there is local discontinuity in the upper deck.

When determining h, sheer and trim will not be taken into consideration.

When the calculated EN value corresponds between two values in Table 2.3, linear interpolation may be used.

8.2 The chain locker boundaries and their access openings are to be watertight as necessary to prevent flooding of adjacent spaces, where essential installation or equipment are arranged, in order to not affect the proper operation of the yacht after accidental flooding of the chain locker.

8.3 Adequate drainage facilities of the chain locker are to be provided.

8.4 Where the chain locker boundaries are also tank boundaries, see D. for scantlings.

9. Sailing Yachts

For sailing yachts (with or without auxiliary engine), the value of EN is to be calculated using the Formula given in 7. Where drop or ballast keel is fitted, H is to be replaced by H_1 (see A.4.2).

D. Fuel Tanks

1. General

The requirements of this subsection apply to yachts more than 24 m. For yachts not more than 24m under ISO 8666, the requirements of ISO 10088 are to be applied.

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

Tanks are to be arranged on special supports on the hull and securely fastened to them so as to withstand the stresses induced by movement of the yacht.

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

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

In tanks intended to contain fuel with a flashpoint below 55°C determined using the closed cup test (petrol, kerosene and similar), the above openings are to be arranged on the top of the tank.

Such tanks are to be separated from accommodation spaces by integral gastight bulkheads.

Tanks are to be arranged in adequately ventilated spaces equipped with a mechanical air ejector.

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

At the discretion of **TL**, 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

Tanks intended to contain diesel oil or gas-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.

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

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

Tanks are to be effectively earthed.

2.2 Scantlings

The thickness of metallic tank plating is to be not less than the value t given by the following formula [mm]:

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

where;

s = Stiffener spacing [m],

h_s = Static internal design head to be assumed as the greater of the following values [m]:

a) Vertical distance from **rn** (see below) to a point located 2 m above the tank top.

b) Two-thirds of the vertical distance from **rn** to the top of overflow

c) 2,8 [m].

K = $\frac{235}{R_S}$ where R_s is the minimum yield stress of the tank material [N/mm^2]. Where light alloys are employed, the value of R_s to be assumed is that corresponding to the alloy in the annealed condition.

rn = 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 3 mm for light alloy.

The section modulus of stiffeners is to be not less than the value W [cm^3] given by the formula:

$$W = 4 \cdot s \cdot S^2 \cdot h_s \cdot K$$

where;

S = Stiffener span [m].

3. Non-Metallic Tanks

3.1 General

Fuel tanks may be made of non-metallic materials.

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 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.

3.2 Scantlings

The scantlings of non-metallic tanks will be specially consideredby **TL** 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 [mm], of the plating and the module of stiffeners W [cm^3], are to be not less, respectively, than the values

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

$$W = 15 \cdot s \cdot S^2 \cdot h_s \cdot K_o$$

where;

k_{of}, k_o = as defined in Section 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.

3.3 Tank Tests

3.3.1 General

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.

At the discretion of **TL**, leak testing may be accepted as an alternative in accordance with the conditions stipulated in 3.3.2.

3.3.2 Leak Testing

Leak testing is to be carried out by applying an air pressure of 0,015 MPa. 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 0,02 MPa 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.

E. Loads

1. General

The static and dynamic design loads defined in this Section are to be adopted in the formulae for scantlings of hull and deck structures stipulated in Section 4,5 and 6.

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 **TL** 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 “m” as defined in 2.

2. Definitions and Symbols

The definitions of the following symbols are valid for all of the Sections. They are not repeated in the various Sections, whereas the meanings of those symbols which have specific validity are specified in the relevant Sections:

Displacement vessel : A vessel that is supported by the bouyancy of the water it displaces. In general, for the purpose of these sections, displacement vessel is a craft having $V/L^{0,5} \leq 4$.

Semi-planing vessel : A craft that is supported partially by the bouyancy of the water it displaces and partially by the dynamic pressure generated by the bottom surface running over the water.

Planing vessel : A craft in which the dynamic lift generated by the bottom surface running over the water supports the total weight of the vessel.

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.

Bottom : The bottom is that part of the hull between the keel and the chine.

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

β_x = Deadrise of the transverse section under consideration. In hulls without a clearly visible deadrise, this is the angle formed by the horizontal axis and the straight line joining keel and chine [°],

BK = 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.

KK = 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.

dg = 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.

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

Δ = Displacement of the yacht at full load draught T [t]. Where unknown, to be assumed equal to 0,42 · L · B · T,

C_B = Block coefficient given by the relationship:

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

C_s = Support contour of the yacht 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 [m],

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 0,6L from the BK,

a_{CG} = Maximum design value of vertical acceleration at LCG [g]. It is to be provided by the designer based on an assessment of the service conditions (speed, significant wave height) envisaged in the design.

V = Maximum service speed [kn].

3. Design Accelerations

3.1 Vertical Acceleration at LCG

3.1.1 General

The design vertical acceleration at LCG [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:

$$a_{CG} = S \cdot \frac{V}{\sqrt{L}}$$

$$S = 0{,}65 \cdot C_F$$

$$C_F = 0{,}2 + 0{,}6/\left(\frac{V}{\sqrt{L}}\right) \geq 0{,}32$$

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

The sea area to which the above mentioned 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 Figure 2.6, equal to $2 \cdot \frac{x}{L}$ or 0,8 whichever is the greater, where x is the distance [m] from the calculation point to the aft perpendicular,

a_{CG} = Design acceleration at LCG.

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

3.2 Transverse Acceleration

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 [g] at the calculation point of the yacht may be obtained from:

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

where;

H_{et} = Permissible significant wave height at speed V [m],

r = Distance of the calculation point from:

= 0,5 H for monohull yachts,

= Waterline at draught T for twin hull yachts.

4. Overall Loads

4.1 General

Overall loads are to be used for the check of longitudinal strength of the yacht, as required, in relation to the material of the hull, in Sections 4,5 and 6.

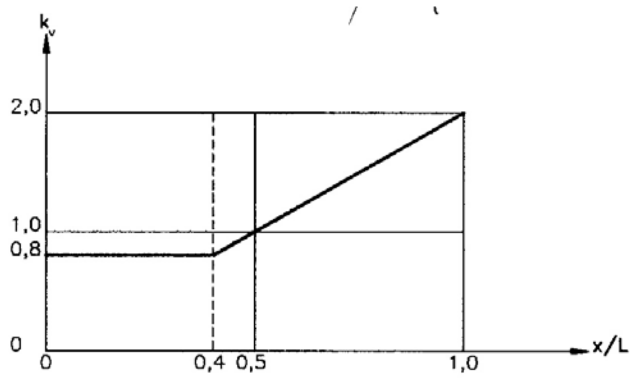


Figure 2.6

4.2 Longitudinal Bending Moment and Shear Force

4.2.1 General

The values of the longitudinal bending moment and shear force are given, as a first approximation, by the formulae in 4.2.2. For large yachts, the results of experimental tank tests may be taken into account.

If the actual distribution of weights along the yacht is known, a more accurate calculation may be performed in accordance with the procedure given in 4.2.3.**TL** reserves the right to require calculations to be carried out according to 4.2.3 whenever deemed necessary.

4.2.2 Bending Moment and Shear Force

The total bending moments M_{bH}, in hogging conditions, and M_{bS}, in sagging conditions [kN·m], are the greater of those given by the formulae in a) and b) below.

For yachts of L > 100 m, only the formula in b) is generally to be applied; the formula in a) is to be applied when deemed necessary by **TL** on the basis of the motion characteristics of the yacht.

The total force T_b [kN], is given by the formula in c) below.

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

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

Where a_{CG}, is the vertical acceleration at the LCG.

The same value of M_b is taken for a yacht in sagging conditions or in hogging conditions.

b) Bending moment due to stil water loads and wave induced loads.

$M_{bH} = M_{SWH} + 0,95 \cdot S \cdot C \cdot L^2 \cdot B \cdot C_B$

$M_{bS} = M_{SWS} + 0,55 \cdot S \cdot C \cdot L^2 \cdot B \cdot (C_B+0,7)$

where;

M_{bH} = Still water hogging bending moment [kN.m], where not supplied, the following may be assumed for the checks:

$M_{bH} = 85 \cdot C \cdot L^2 \cdot B \cdot (C_B+0,7) \cdot 10^{-3}$

M_{bS} = Still water sagging bending moment [kN.m], where not supplied, the following may be assumed for the checks:

$M_{bS} = 63 \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7) \cdot 10^{-3}$

S = parameter defined in 3.1.1,

= 0,21 for displacement yachts,

C = 6 + 0,02 L

For the purpose of this calculation, C_B may not be taken less than 0,6.

c) Total shear force

$$T_S = \frac{3,1 \cdot M_b}{L}$$

Where M_b is the greater of M_{bH} and M_{bS} calculated according to a) or b) above, as applicable.

4.2.3 Bending Moment and Shear Force Taking into Account the Actual Distribution of Weights

a) The distribution of quasi-static bending moment and shear force, due to still water loads and wave induced loads, is to be determined from the difference in weight and buoyancy distributions in sagging and hogging for each loading condition envisaged.

b) For calculation purposes, the following values are to be taken for the design wave:

- wave length [m]

  $\lambda = L$

- wave height [m]

  $$h = \frac{L}{15 + \frac{L}{20}}$$

- wave form: sinusoidal.

c) In addition, the increase in bending moment and shear force, due to impact loads in the forebody area, for the sagging condition only, is to be determined as specified below. For the purpose of this calculation, the hull is considered longitudinally subdivided into a number of intervals, generally to be taken equal to 20. For smaller yachts, this number may be reduced to 10 if justified on the basis of the weight distribution, the hull forms and the value of the design acceleration a_{CG}.

For twin hull yachts, the following procedure is to be applied to one of the hulls, i.e. the longitudinal distribution of weight forces g_i and the corresponding breadth B_i are to be defined for one hull.

The total impact [kN], is:

$F_{SL} = \Sigma \, q_{SLi} \, . \, \Delta \, x_i$

Where q_{SLi} is the additional load, per length unit, per x/L $\geq$ 0,6 (see Figure 2.7) computed with the following formula [kN/m].

$$q_{SLi} = P_0 \cdot B_i \cdot \sin\left[2\pi\left(\frac{x_i}{L} - 0{,}6\right)\right]$$

Where;

Δx_i = Length of interval [m],

x_i = Distance from the aft perpendicular [m],

B_i = Yacht breadth at the uppermost deck in way of the coordinate x_i, for twin hull yachts B_i is the maximum breadth of one hull considered at the transverse section considered [m],

x_i, B_i = To be measured at the centre of interval ί,

P_0 = Maximum hydrodynamic pressure calculated by the following formula [kN/m²]:

$$\left(P_0 = \frac{a_{v1} \cdot G \cdot \left(r_0 + x_W^2\right)}{f_{SL} \cdot \left[r_0^2 + 0{,}5 \cdot L \cdot \left(x_{SL} - z_W\right) - x_{SL} \cdot x_W\right]}\right)$$

a_{v1} = Design vertical acceleration in way of the forward perpendicular,

G = Weight force calculated from the following formula [kN]:

$G = \Sigma g_i \,.\, \Delta x_i$

g_i = Weight per unit length of interval ί, for twin hull yachts g_i is defined for one hull [kN/m], .

x_w = Distance of LCG from the midship perpendicular, calculated by the following formula [m]:

$$x_w = \frac{\Sigma\left(g_i \cdot \Delta x_i \cdot x_i\right)}{\Sigma\left(x_i \cdot \Delta x_i\right)} - 0{,}5 \cdot L$$

r_0 = Radius of gyration of weight distribution calculated as follows [m]:

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

Normally ; $0{,}2 \,.\, L < r_0 < 0{,}25 \,.\, L$ (guidance value)

X_{SL} = Distance from the centre of surface F_{SL} to the midship perpendicular, calculated from the following formula [m]:

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

$$f_{SL} = \Sigma\left(\Delta x_i \cdot B_i\right) \cdot \sin\left[2\pi \cdot \left(\frac{x_i}{L} - 0{,}6\right)\right] \quad \left[m^2\right]$$

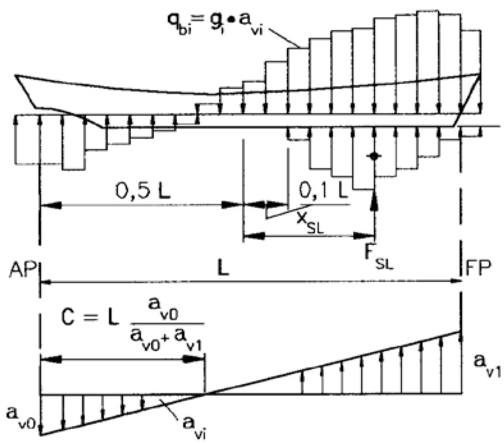


Figure 2.7

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

- for x/L < 0,6

$q_{si} = q_{bi} = g_i \,.\, a_{vi}$

Where;

a_{vi} = Total dimensionless vertical acceleration at the interval considered calculated by the following formula:

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

a_h = Acceleration due to heaving motion,

a_P = Acceleration due to pitching motion.

a_h and a_p are relative to g.

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

$$a_P = \frac{F_{SL}}{G} \cdot \left[\frac{x_{SL} \cdot x_W}{r_0^2 - x_W^2} \right] \quad \left[m^{-1} \right]$$

- for $x/L \geq 0{,}6$

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

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

4.3 Design Total Vertical Bending Moment

4.3.1 The design total vertical bending moment M_T [kN.m] is to be taken equal to the greater of the values indicated in 4.2.2 a) and b), for planing or semi-planing yachts. For displacement yachts, the value of M_T is to be taken equal to the greater of those given in 4.2.2 b).

4.4 Transverse Loads for Twin Hull Yachts

4.4.1 General

For catamarans, the hull connecting structures are to be checked for the load conditions specified in 4.4.2 and 4.4.3 below. These load conditions are to be considered as acting separately.

The design moments and forces given in the following paragraphs are to be used unless other values are verified by model tests, full-scale measurements or any other information provided by the designer.

For yachts of length L > 65 m or speed V > 45 knots, or for yachts with structural arrangements that do not permit a realistic assessment of stress conditions based on simple models, the transverse loads are to be evaluated by means of direct calculations.

4.4.2 Transverse Bending Moment and Shear Force

The transverse bending moment M_{bt} [kN . m] and shear force T_{bt} [kN], are given by:

$$T_{bt} = \frac{\Delta \cdot a_{CG} \cdot g}{4}$$

Where;

b = Transverse distance between the centres of the two hulls [m],

a_{CG} = Vertical acceleration at LCG (see 3.1)

4.4.3 Transverse Torsional Connecting Moment

The catamaran transverse torsional connecting moment is given by [kN . m] :

$$M_{tt} = 0{,}125 \cdot \Delta \cdot L \cdot a_{CG} \cdot g$$

Where a_{CG} is the vertical acceleration at LCG which need not be taken greater than 1 g.for this calculation.

5. Local Loads

5.1 General

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 **TL**.

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.

$$M_{bt} = \frac{\Delta \cdot b \cdot a_{CG} \cdot g}{5}$$

5.2 Load Points

Pressure on panels and strength members is to 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.

5.3 Design Pressure for the Bottom

5.3.1 Planing and Semi-planing Yachts

The design pressure p [kN/m^2], 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:

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

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

Where;

h_0 = Vertical distance from m to the full load waterline[m],

a = Coefficient function of the longitudinal position of m:

- 0,036 for aft of 0,5 L
- 0,04 / (C_B - 0,024) in way of BK
- values for intermediate position ontained by linear interpolation.

F_L = Coefficient given in Figure 2.8 as a function of the longitudinal position of m,

F_1 = Coefficient function of the shape and inclination of the hull given by:

$$F_1 = \frac{50 - \beta_x}{50 - \beta_{LGC}}$$

β_{LGC} = Deadrise angle of the section in way of LCG [°],

F_a = Coefficient given by:

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

Where A_1 is the surface of the plating panel considered or the surface of the area supported by the stiffener [m^2].

a_v = Maximum design value of vertical acceleration at the transverse section considered [g].

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

5.3.2 Displacement Yachts

For the purpose of the evaluation of the design pressure for the bottom, sailing yachts with or without auxiliary engine are also included as displacement yachts.

The pressure p [kN/m^2], for the scantlings of hull structures, plating and stiffeners located below the full load waterline is to be taken as equal to the value p_1, defined as follows:

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

Where h_0 and a are as defined in 5.3.1

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

5.4 Design Pressure for the Side Shell

5.4.1 Planing or Semi-planing Yachts

The pressure p [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:

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

The pressure p_1 is, 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 BK, the value p [kN/m^2], is to be not less than the value p_2 defined as follows:

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

Where;

a and h_0 = as defined in 5.3.1

C_1 = Coefficient given by Figure 2.9 as a function of the load surface A [m^2] bearing on the element considered, for plating, A=2,5 · s is to be taken,

C_2 = Coefficient given by Figure 2.10 as a function of C_B and longitudinal position of the element considered,

k_v = $0,625 \cdot L^{0,5} + 0,25$ V

α = Angle formed at the point considered by the side and horizontal axis [°] (see Figure 2.11),

γ = Angle formed by the tangent at the waterline, corresponding to the draught T, taken at the point of intersection of the transverse section of the element considered, with the above waterline and the longitudinal straight line crossing the above intersection [°] (Figure 2.12).

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

5.4.2 Displacement Yachts

For the purpose of the evaluation of the design pressure for the side shell, sailing yachts with or without auxiliary engine are also included as displacement yachts.

The design pressure p [kN/m^2], for the scantlings of side structures located above the full load waterline is to be taken as equal to the value p_1 defined as follows:

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

Where;

h_0, a = As defined in 5.3.1,

h_1 = Distance from m to the straight line of the beam of the highest continuous deck [m].

The pressure p_1 is, in any case, not to be assumed as < 10 · h_1.

5.5 Design Heads for Decks

The design heads for the various decks are shown in Table 2.4.

Sheltered areas are intended to mean decks intended for accommodation.

The design heads shown in Table 2.4 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_0 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.

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 rn to the highest point of the bulkhead.

5.6.2 Tank Bulkheads

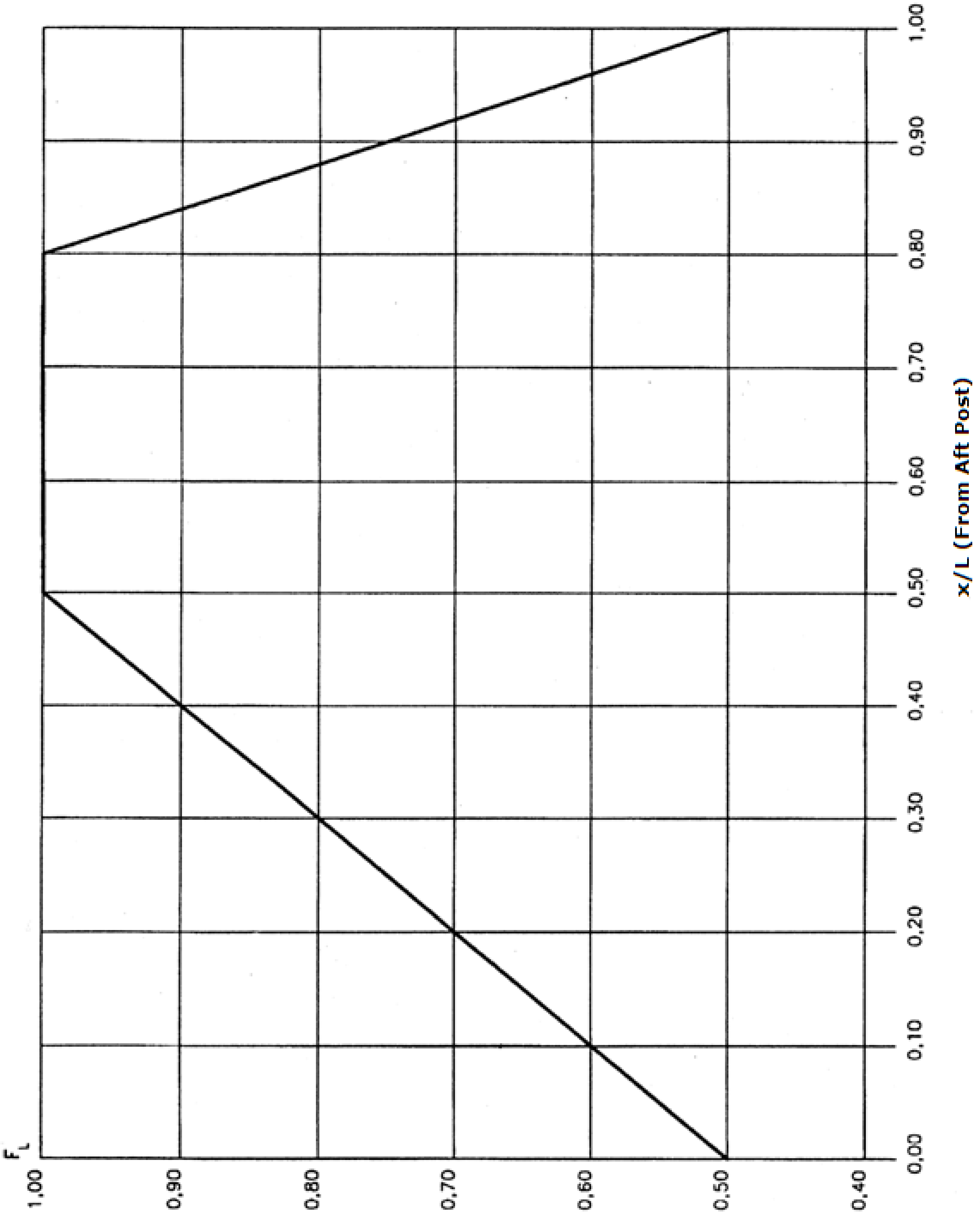
The scantlings of tank bulkheads, plating and associated stiffeners are to be verified assuming as h_T [m] the greater of the following values:

- Vertical distance from rn to a point located at a height h 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.

- h_2 = 2/3 of the vertical distance from rn to the top of the overflow pipe.



x/L (From Aft Post)
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 2.8

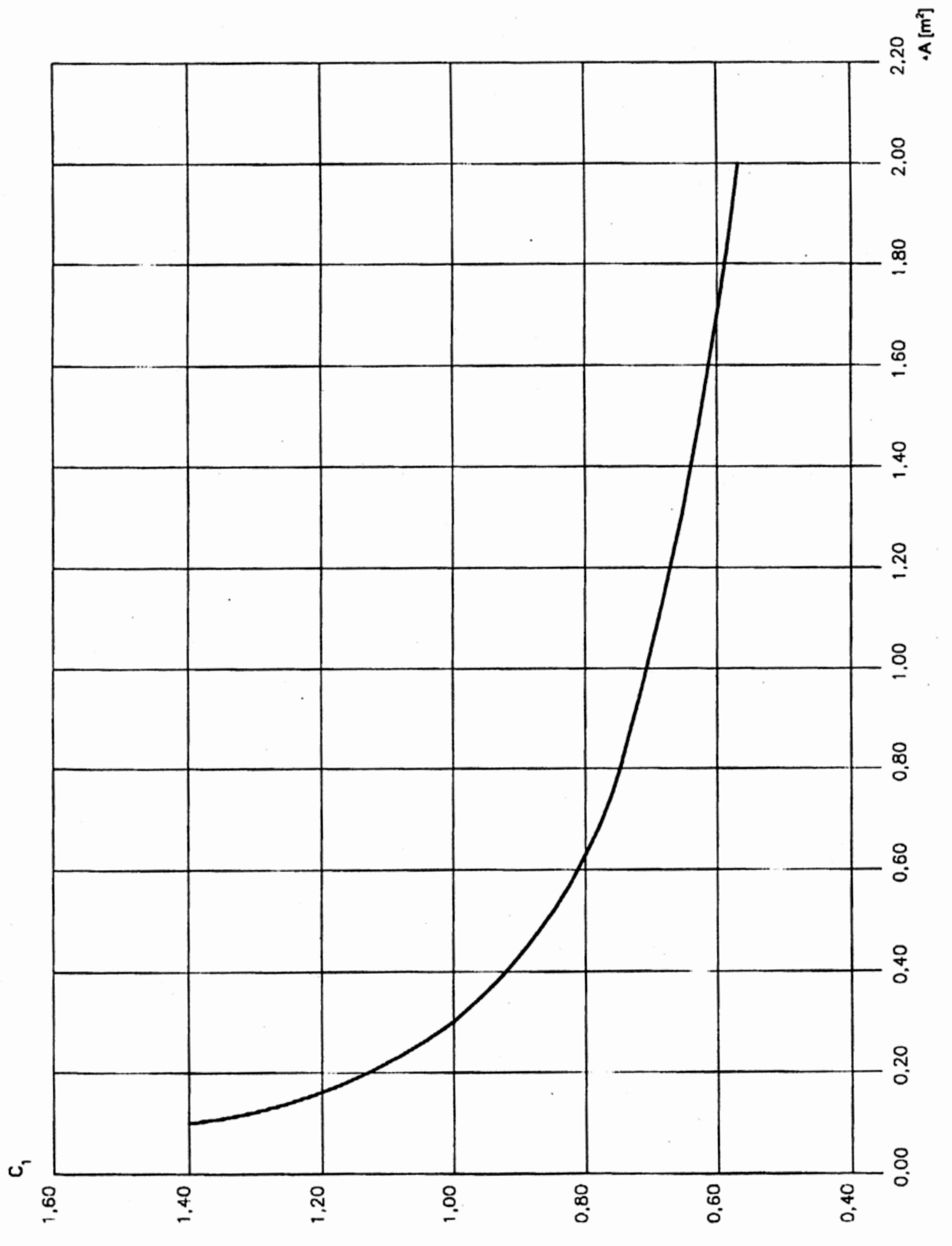

A [m²]
2,20
2,00
1,80
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
C1
1,60
1,40
1,20
1,00
0,80
0,60
0,40

Figure 2.9

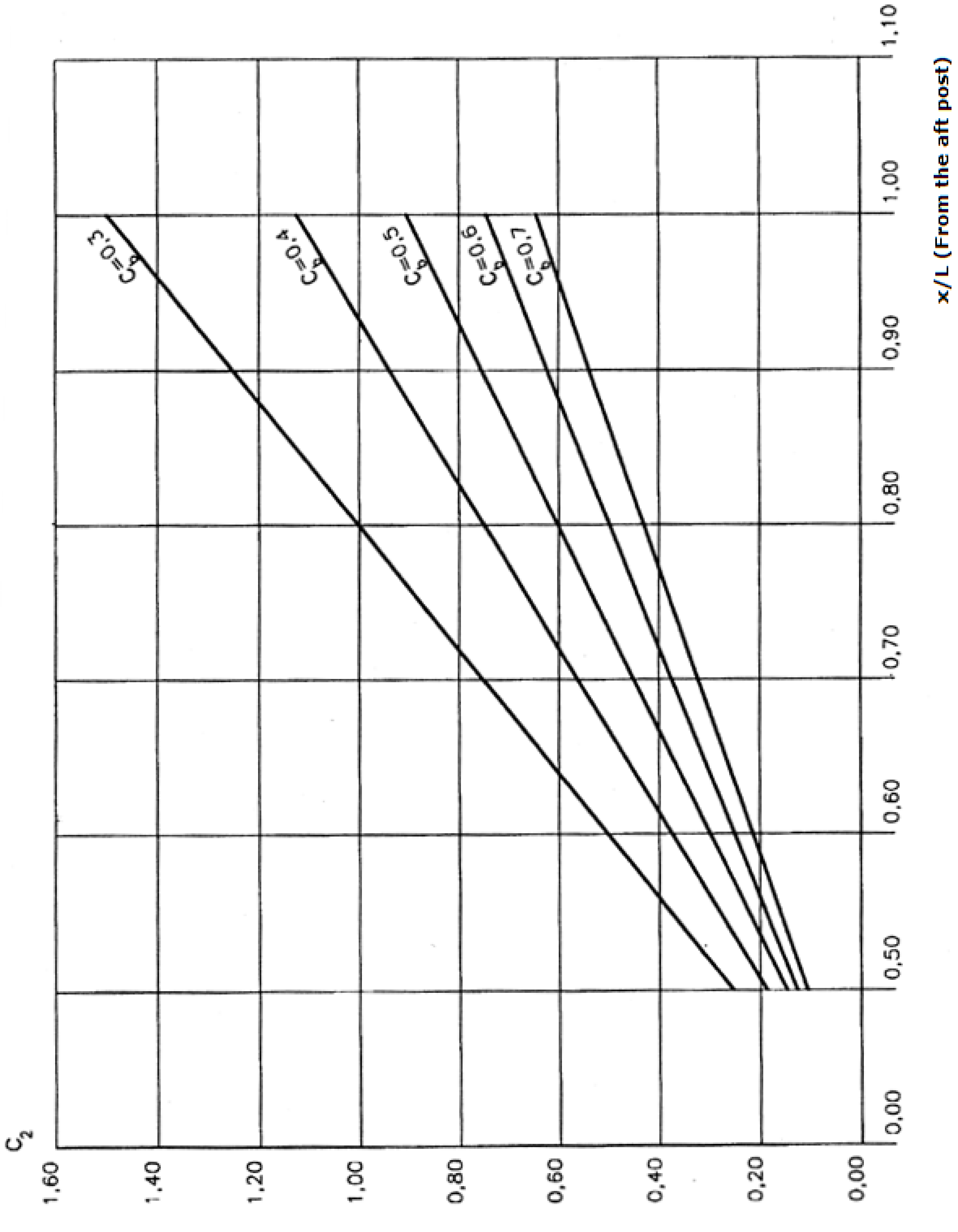
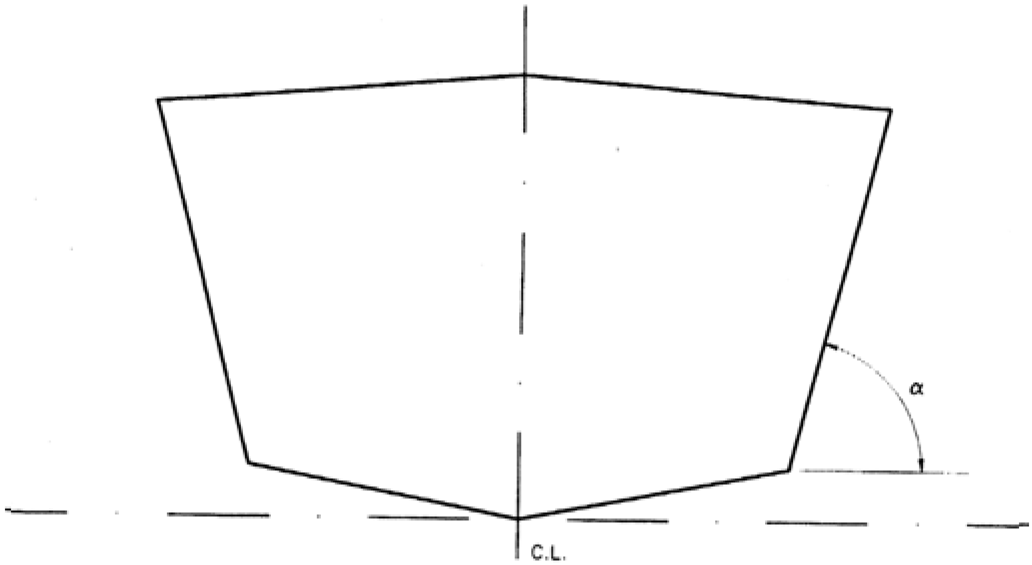
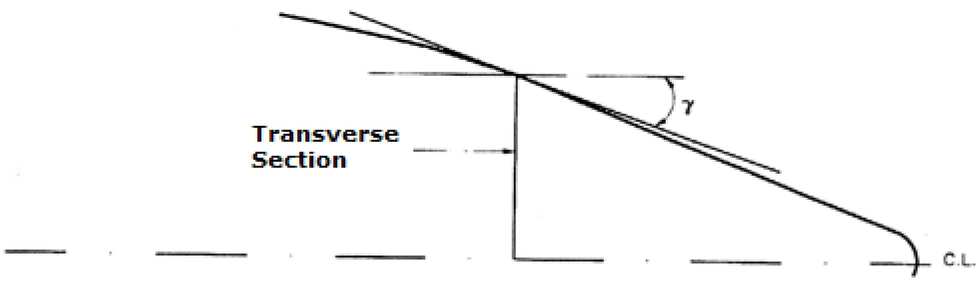

C2
x/L (From the aft post)
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
0,00
0,50
0,60
0,70
0,80
0,90
1,00
1,10

Figure 2.10

Table 2.4

Deck	Exposed weather deck		Sheltered areas(also partially by deck-houses)
	Forward 0,075 L from fore perpendicular	Aft 0,075 L from fore perpendicular	
	h_d	h_d	h_d
Deck below m	-	-	0,9
m	1,5	1,0	0,9
Deck above m	1,2	0,9	0,7





SECTION 2 - APPENDIX

SIDE SHELL DOORS and STERN DOORS

1. General

1.1 Application

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

1.2 Arrangement

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

1.2.2 Where the sill of any side door is below the uppermost load line, the arrangement is considered by **TL**.

1.2.3 Doors are preferably to open outwards.

1.3 Definitions

1.3.1 Securing Device

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

1.3.2 Supporting Device

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

1.3.3 Locking Device

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

2. Design Loads

2.1 Side and Stern Doors

2.1.1 Design Forces

The design external forces F_d and the design internal forces F_i to be considered for the scantlings of primary supporting members and securing and supporting devices of side doors and stern doors are to be obtained, in kN, from the formulae in Tab 2.4.

3. Scantlings of Side Doors and Stern Doors

3.1 General

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

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

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

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

3.2 Plating and ordinary stiffeners

3.2.1 Plating

The thickness of the door plating is to be not less than that obtained according to the requirements for side plating, using the door stiffener spacing.

3.2.2 Ordinary stiffeners

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

Table 2.4 Design Forces

Structural Elements	**External Forces F_d [kN]**	**Internal Forces F_i [kN]**
Securing and supporting devices of doors opening inwards	$A \cdot P_d + F_p$	$F_0 + 10 \cdot W$
Securing and supporting devices of doors opening outwards	$A \cdot P_d$	$F_0 + 10 \cdot W + F_p$
Primary supporting members **(1)**	$A \cdot P_d$	$F_0 + 10 \cdot W$

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

A : Area [m^2] to be determined on the basis of the load area taking account of the direction of the pressure

W : Mass of the door [t]

F_P : Total packing force [kN]; the packing line pressure is normally to be taken not less than 5 kN /m

F_0 : the greater of F_C and 5A [kN]

F_C : Accidental force [kN], due to loose cargoes etc., to be uniformly distributed over the area A.

The aforementioned value is to be assumed considering the failure of the lashing of the objects to be carried in the space behind the doors: in such case F_C is to be assumed not less than the weight in KN of the heaviest object to be carried in the space behind the doors. However, the value of F_C may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.

P_d : Design pressure for the side shell, not to be taken less than 25 kN/m^2

3.3 Primary Supporting Members

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

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

3.3.3 Scantlings of primary supporting members are generally to be verified through direct calculations on the basis of the design loads in Table 2.4 and the strength criteria given in 5. In general, isolated beam models may be used to calculate the loads and stresses in primary supporting members, which are to be considered as having simply supported end connections.

4. Securing and Supporting of Doors

4.1 General

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

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

4.2 Scantlings

4. 2.1 Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the allowable stresses defined in 5.

4.2.2 When the securing and supporting devices are equally spaced, the distribution of the forces acting on each device may be obtained by dividing the total design force given in 2.1.1 by the number of the supporting devices.

For arrangements of the securing and supporting devices different from the above, a direct calculation may be necessary to assess the distribution of the forces acting on the devices.

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

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

5. Strength Criteria

5.1 Primary Supporting Members and Securing and Supporting Devices

5.1.1 Fiber Reinforced Plastic Structures

The allowable normal and shear stress are to be in conformity with the requirements stated in Section 4.

5.1.2 Steel Structures

It is to be checked that the normal stress σ, the shear stress τ and the equivalent stress σ_V, induced in the primary supporting members and in the securing and supporting devices of doors by the design forces defined in 2.1.1, are in compliance with the following formulae:

$$\sigma \leq \sigma_{müs}$$

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

Where;

$\sigma_{müs}$ = Allowable normal stress [N/mm²],

$\sigma_{müs}$ = 120 / k

$\tau_{müs}$ = Allowable shear stress [N/mm²],

$\tau_{müs}$ = 80 / k

$\sigma_{vmüs}$ = Allowable equivalent stress [N/mm²],

$\sigma_{vmüs}$ = 150 / k

k = Material factor defined in Section 5.

5.1.3 Pins

Pins in securing and supporting devices are to be checked for shear stress τ and normal stress σ due to bending moment using the above criteria.

Where;

τ = 103 F / (2n A) [N/mm²],

σ = 5,1 . 103 F . ℓ / nd³ [N/mm²],

F = Design force defined in 2.1.1 [kN],

n = Number of fixed bearings supporting the pin,

A = Cross-sectional area of the pin [mm²],

ℓ = Distance between two consecutive fixed bearings [mm],

d = Diameter of the pin [mm].

If the radial clearance between pin and bearing and the axial clearance between two consecutive bearings of the pins are small and ℓ is nearly equal to d, the normal stress due to bending moment can be disregarded.

5.1.4 Bearings

For steel to steel bearings in securing and supporting devices, nominal bearing pressure is to be checked.

σ_B, is to be in compliance with the following formula [N/mm²]:

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

where;

$$\sigma_B = 10 \ .\ F / A_B$$

F = Design force defined in 2.1.1 [kN]

A_B = Projected bearing area [cm^2]

$R_{eH,B}$ = Yield stress of the bearing material [N/mm^2].

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

5.1.5 Bolts

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

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

$$\sigma_T \leq \sigma_{TMÜS}$$

Where;

$\sigma_{Tmüs}$ = Allowable tension in way of threads of bolts [N/mm^2]

$\sigma_{Tmüs}$ = 125 / k

k = Material factor defined in Section 4.

6. Securing and Locking Arrangement

6.1 Systems for Operation

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

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

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

6.1.2 Doors with a clear opening area equal to or greater than 10 m^2 are to be provided with closing devices operable from a remote control position above the freeboard deck.

This remote control is provided for the:

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

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

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

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

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

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

7. Operating and Maintenance Manuals

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

- special safety precautions
- service conditions
- maintenance

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

SECTION 3

HULL CONSTRUCTION – WOODEN HULLS

Page

A. Materials

1. Suitable Timber Species

The species of timber suitable for construction are listed in Table 3.1 together with the following details:

- Commercial and scientific denomination;
- Natural durability and ease of impregnation;
- Average physical-mechanical characteristics at 12% moisture content.

The durability classes are relative to the solid timber's resistance to moulds.

The suitability for use in the various hull structures is given in Table 3. 2.

The same species are suitable for the fabrication of marine plywood and lamellar structures in accordance with the provisions of item 2.

The use of timber species other than those stated in Table 3.1 and 3.2 may be accepted provided that the characteristics of the species proposed correspond with those of one of the species listed. The use of such types of timbers is subject to special consideration of **TL**, depending on the constructional member.

2. Timber Quality

2.1 Planking

The timber is to be well-seasoned, free from sapwood and any noxious organisms (moulds, insects, larvae, bacteria, etc.) which might impair its durability and structural efficiency.

The moisture content at the time of use is to be not greater than 20%.

Knots may be tolerated when they are intergrown, provided that their diameter is less than 1/5 of the dimension parallel to such diameter, measured on the section of the knot.

The grain is to be straight (the maximum admissible inclination in relation to the longitudinal axis of the piece is equal to a ratio of 1:10).

2.2 Marine Plywood and Lamellar Structures

The suitable timber species and criterias for the use of alternative species are listed in Table 3.1.

For marine plywood, the elevated temperatures reached during drying and pressing rule out the possibility of survival of insects and larvae in the finished panels.

Moreover, this factor contributes in enabling the marine plywood to have a lower moisture content than that of solid timber of the same species in the same ambient conditions, rendering it less prone to attacks of mould.

Therefore, assuming the same species of timber, the durability of marine plywood is greater than that of solid timber.

In any case, the thickness of the individual layers constituting the plywood or the lamellar structure is to be reduced in direct proportion to the durability of the species used; the maximum recommended thicknesses are listed in Table 3.1.

The minimum number of plywood layers used in the construction is 3 for thicknesses not greater than 6 mm and 5 for greater thicknesses.

The marine plywood adopted for hull construction and structural parts in general is to be type tested by **TL** in accordance with the relevant regulations.

3. Checking and Certification of Timber Quality

The quality of timber, plywood and lamellar structures is to be certified as complying with the provisions of item 2.1 and 2.2 by the builder to the **TL** surveyor, who, in event of doubts or objections, will verify the circumstances by performing appropriate checks.

Such certification is to refer to the checks carried out during building survey in the yard, relative to the following characteristics:

Table 3.1 **Basic Physical/ Mechanical Characteristics of Timbers for Hull Construction**

Commercial name	Origin (1)	Botanical name (2)	Mass density [kg/m³]	Natural durability (3)	Ease of impreg-nation (3)	Mechanical characteristics (4)			
						R_f [N/mm²]	E_f [N/mm²]	R_c [N/mm²]	R_t [N/mm²]
White Mulberry	Turkey	Morus alba	650	C/D	2	-	-	41	-
Doussıe'	Africa	Afzelia spp	800	A	4	114	16000	62	14,0
Iroko	Africa	Chlorophora excelsa	650	A/B	4	85	10000	52	12,0
Larch	Europe	Larix decidua	550	C/D	3/4	89	12800	52	9,4
Elm	Europe	Ulmus spp	650	D	2/3	89	10200	43	11,0
Elm	Turkey	Ulmus carpihifolia	680	C/D	2	89	11000	56	8,5
Black pine	Turkey	Pinus nigra	560	C/D	1	110	11300	48	6,7
Chesnut	Europe	Castanea spp	600	B	4	59	8500	37	7,4
Chesnut	Turkey	Castanea sativa	630	B	4	77	9000	50	8,5
Khaya	Africa	Khaya spp	520	C	4	74	9600	44	10,0
Red pine	Turkey	Pinus brutia	570	C/D	1	82	8732	45	7,3
Fir	America	Pseudotsuga men. l	500	C/D	3/4	85	13400	50	7,8
Fir (Toros)	Turkey	Abios cilicica	680	C/D	3	84	10600	47	6,6
Makoré	Africa	Tieghemella spp	660	A	4	86	9300	50	11,0
White Oak	America	Quercus spp	730	B/C	4	120	15000	65	12,6
Oak	Europe	Quercus robur	710	B	4	125	15600	68	13,0
Oak	Turkey	Quercus petrea	700	B/C	4	119	11300	61	-
Mahogany	America	Swietenia spp	550	B	4	79	10300	46	8,5
Okoumé	Africa	Aucoumea Klein.	440	D	3	51	7800	27	6,7
Sapeli	Africa	Entandrophragma cylindricum	650	C	3	105	12500	56	15,7
Cedar Red	America	Thuja plicata	380	B/C	3	51	7600	31	6,8
Cedar	Turkey	Cedrus libani	520	B	3	77	-	45	-
Sipo	Africa	Entandrophragma utile	640	B/C	3/4	100	12000	53	15,0
Teak	Asia	Tectona grandis	680	A	4	100	10600	58	13,0

Abbreviations:

Natural durability

A = very durable

B = durable (maximum permissible thickness for the fabrication of marine plywood 5 mm)

C = not very durable (maximum permissible thickness for the fabrication of marine plywood 2,5 mm)

D = not durable (maximum permissible thickness for the fabrication of marine plywood 2 mm)

Ease of treatment for impregnation

1 = permeable 2 = not very resistant 3 = resistant 4 = very resistant

Notes :

(1) *Area of natural growth*

(2) *Unified botanical name (spp = different species)*

(3) *Level of natural durability and ease of treatment for impregnation according to Standard EN 350/**2***

(4) *Mechanical characteristics with 12% moisture content, source: Wood Handbook: wood as an engineering material - 1987, USDA*

- *Ultimate flexural strength R_f (strength concentrated amidships)*
- *Bending modulus of elasticity E_f (strength concentrated amidships)*
- *Ultimate compression strength R_c (parallel to the grain)*
- *Ultimate shear strength R_t (parallel to the grain).*

Table 3.2 **Guide for Selection of Hull Construction Timbers**

Species of timber / **Structural items**	**Pine**	**Doussie**	**Iroko**	**Elm (Europe)**	**Elm (Turkey)**	**Chestnut**	**Fir (America)**	**Fir (Turkey)**	**Larch**	**Makoré**	**Mahogany**	**Oak (America)**	**Oak (Turkey)**	**Sapeli**	**Cedar (America)**	**Cedar (Turkey)**	**Teak**
Keel, hog, stern-post, dead-woods		I	II	II	II	III				II	II	II	II	III			I
Stern		I		II	II					II	II	II		III			I
Bilge stringer	III	I				II	III	III	II			II		III		III	I
Beam shelves, clamps, water-ways	III	I	II			II	III	III	II			II	II	III			I
Floors		I			II	II				II	II	II	II				I
Frames, web frames	III **(2)**	I				III			II **(2)**	II		II **(1)**	II **(1)**	III			I
Bent frames	III					III						II **(1)**	II **(1)**				
Planking below waterline		I	II			II	III		II		II	II	II	III			I
Planking above waterline		I	II			II	III	III	III		II	II		III			I
Deck planking		I	II				II								III	III	I
Beams, bottom girders	III **(2)**	I					II		II	II **(2)**	II **(2)**	II **(1)**	II **(1)**			II **(2)**	I
Vertical brackets					II	III			II			II **(1)**	II				
Horizontal brackets					II	III			II			I	I				
Gunwale margin planks			II								II	II	II				

Suitability of timber for use:
I = very suitable
II = fairly suitable
III = scarcely suitable

Note

(1) *The timber concerned may be employed either in the natural or in the laminated form.*

(2) *The timber may be employed only in laminated form.*

a) for solid timber: mass density and moisture content;

b) for plywood and lamellar structures: glueing test. Such checks are not required for quality assurance material certified by **TL.**

4. Mechanical Characteristics and Structural Scantlings

The structural scantlings indicated in this section apply to timber with the following density δ [kg/m^3] and a moisture content not exceeding 20%:

- Bent frames: δ = 720
- Non-bent frames keel and stem: δ = 640
- Shell and deck planking, shelves and clamps, stringers and beams: δ = 560.

The scantlings given in this Section are to be modified as a function of the density of the timber employed and its moisture content, in accordance with the relationship:

$$S_1 = S / K$$

$$K = \frac{\delta_e}{\delta} + (U - U_e) \cdot 0{,}02$$

Where;

S_1 = Corrected section (or linear dimension),

S = Rule section (or linear dimension) obtained in accordance with this section,

δ_e = Density of the timber species (or plywood) used,

δ = Standard density of the timber species of reference,

U = Standard moisture content percentage (20% for solid timber, 15% for plywood or lamellar structures),

U_e = Maximum expected moisture content balance for the part considered, in service conditions.

Reductions in scantlings exceeding those obtained using the formulae above may be accepted on the basis of the mechanical base characteristics of the timber, plywood or lamellar structures actually employed.

B. Fastening, Working and Protection of Timber

1. Fastening

Glues for timber fastenings are to be of resorcinol or phenolic type, i.e. durable and water-resistant in particular.

Urea formaldehyde glues may only be used in well-ventilated parts of the hull not subject to humidity.

Glues are to be used according to the manufacturer's instructions on timber with moisture content not exceeding 15-18% or, for urea-type glues, 12,5-15%.

The parts to be glued are to be carefully prepared and cleaned and, in particular, all traces of grease are to be removed.

Where rivets, screws and bolts are made of normal steel, they are to be highly galvanized.

Through bolts are to be clinched on washers, or tightened by a nut, also on washers. Nuts and washers are to be of the same material as that of the bolts.

Where connecting bolts go through shell planking or keel, they are to have heads packed with cotton or other suitable material.

Where screw fastenings are used for planking, the threading is to penetrate the support frame for a distance equal to the planking thickness.

The use of suitable glues in place of mechanical connections will be the subject of special consideration by **TL**.

In general, such replacement of fastening methods will be accepted subject to the satisfactory outcome of tests, on representative samples of the joints, conducted with procedures stipulated on the basis of the type of glue, the type of connection and any previous documented applications.

In any event, **TL** reserves the right to require a minimum number of mechanical connections.

2. Timber Working

Timber working is to be appropriate to the species and hardness of the timber, as well as to the type of hull construction, e.g. grown or web frames, lamellar structures, board or plywood planking.

Lamellar structure is generally employed for bent structural parts, with lamellas as continuous as possible or with scarf joints and normally glued before bending.

For bent parts, suitable thicknesses are to be chosen such as to avoid excessive stresses during bending.

The lamellas are generally to be made using the same species of timber.

The lamellas are to be arranged with their fibres parallel to the length of the element to be constructed.

3. Protection

Inaccessible surfaces of internal hull structures are to be treated with a suitable wood preservative according to the Manufacturer's instructions and compatible with the glues, varnishes and paints employed. The timber of the internal bottom of the hull is to be smeared with oil or varnish; any synthetic resins used as coating are to be applied to dry timber with the utmost care.

All cut edges of plywood are to be sealed with glue, paint or other suitable products such as to prevent the penetration of moisture along the end-grain.

C. Building Methods for Planking

1. Shell Planking

1.1 Simple Skin

Planks are to be arranged such that strake butts are at least 1,2 meters apart from those of adjacent strakes and at least three continuous strakes separate two butts arranged on the same frame.

The butts of garboards are to be arranged clear of those in the keel, and the butts of the sheer strake are to be arranged clear of those of the waterway.

Butts may be strapped or scarfed, and wooden straps are to have thickness equal to that of the planking, width so as to overlap adjacent strakes by at least 12 mm and length as necessary for the connection while leaving a space for water drainage between the strap edge and the frame.

Scarfs are to have length not less than 5 times the planking thickness, to be centered on the frames and to be connected by means of glueing and pivoting.

1.2 Double Diagonal Skin

This consists of an inner skin of thickness not exceeding 0,4 of the total thickness and an outer skin arranged longitudinally.

1.3 Double Longitudinal Skin

This consists of an inner and outer skin, arranged such that the seams of the outer skin fall on the middle of the planks of the inner skin.

The inner skin is to have thickness not exceeding 0,4 of the total thickness and to be connected to the frames by means of screws or nails and to the outer skin by means of screws or through bolts. The outer skin is, in turn, to be connected to the frames by means of through bolts. When frames other than laminated frames are employed, the use of screws is permitted. A suitable elastic compound layer is to be arranged between the two skins.

1.4 Laminated Planking in Several Cold-Glued layers

The construction of cold moulded laminated planking is to be effected in places at a constant temperature. It is therefore of the utmost importance that the manufacturer should be equipped with adequate facilities for this type of construction.

The planks forming the laminate are to be of width and thickness adequate for the shape of the hull; the width is generally not to exceed 125 mm.

The number of layers is to be such as to obtain the required thickness.

1.5 Plywood Planking

Plywood planking consists of panels as large as practicable in relation to the shape of the hull. The butts are to be suitably staggered from each other and from machinery foundations.

The connection of seams is to be achieved by means of glue and bolts; the connection of butts is to be effected by means of scarfs or straps. Scarfs are to have length not less than 8 times the thickness and, where effected in place, to be backed by straps, at least 10 times as wide as the thickness, glued and fastened.

The strap connection is to be effected using straps of the same plywood.

1.6 Double skin with inner plywood and outer longitudinal strakes

This consists of two layers: one internal of plywood, arranged as described in 1.5, the other external, formed by planks in longitudinal strakes arranged as described in 1.3. The plywood thickness is to be not less than 0,4 of the total thickness.

1.7 Fastening and Caulking

Butt-straps on shell planking (see Figure 3.1) are to be connected by means of through bolts of the scantlings given in Table 3.3 for the connection of planking to frames, and are to be proportionate in number to the width a of panels, as follows:

- $a < 100$ mm.
  3 bolts at each end of plank

- $100 \leq a < 200$ mm.
  4 bolts at each end of plank

- $200 \leq a < 250$ mm.
  5 bolts at each end of plank

The number and scantlings of bolts to be used for connection of planking to frames are given in Table 3.3.

The following types of connection are to be adopted:

- Type I framing: all through fastenings;

- Type II framing with grown or laminated frames: bolts in way of bilge stringers or side longitudinals, wood screws for other connections;

- Type II framing with metal frames: all connections formed by through bolts with nuts;

- Type III framing: connections as above depending on whether bent, grown, laminated or steel frames are concerned.

All fastenings for strengthened frames in way of masts are to be through fastenings.

When plywood planking is adopted, it is to be connected to frames by means of nails or screws spaced 75 mm apart and with diameters as given in Table 3.4.

Planks of shell planking, if not glued, are to have caulked seams and butts.

1.8 Sheating of Planking

When use is made of reinforced plastic or synthetic resin sheathing, the hull is to be prepared by carefully levelling every joint and filling every bolt hole with suitable compounds after adequate sinking of the bolts. The protective sheathing is to cover keel, false keel and deadwood as far as practicable, prior to the fitting of external ballast in the keel, where envisaged.

When sheathing is applied, the moisture content of the timber is to be as low as possible

2. Deck Planking

2.1 Planking

The butts of planks of two contiguous strakes are to be spaced at least 1,20 m apart; two plank butts on the same beam are to be separated by at least three

strakes of continuous planking.
Butts are to be set onto a beam and may be simple or scarfed.

2.2 Plywood

Plywood panels are to be as long as possible. The butts are to be arranged clear of those of adjacent panels and are to be strapped or otherwise set onto a strong beam.
Longitudinal joints are to be set onto longitudinal structures of sufficient width for the connection. All joints are to be sealed watertight.

2.3 Plywood Sheathed with Laid Deck

The butts of plywood panels are to be in accordance with the specifications given in 2.2, while the distribution of plank butts is to comply with the provisions of 2.1.

2.4 Longitudinal Planking

When longitudinal planking is adopted, each plank is to be fastened to beams by means of a wood screw or lateral nail. In addition, each plank may be connected to that adjacent by means of a glued, sunk-in strip.

Plywood planking is to be glued and riveted to beams, or otherwise fastened by means of screws with pitch not less than 75 mm and diameter in accordance with that shown in Table 3.3.

2.5 Caulking

Wood planking is to be caulked or made watertight by the application of a suitable elastic compound.
Wooden dowels used to cover bolt holes are to be glued.

.

Table 3.3 Connection of Shell and Deck Planking, Scantlings of Fastenings

Thickness of planking [mm]	Shell Planking				Deck Planking		Number of fastening per plank				
	Grown, laminated or steel frames			Bent frames	Wood screws diam. [mm]	Bolts with nuts diam. [mm]	Width of a plank "a" [mm]				
	Diameter			Diam.							
	Bolts with nuts [mm]	Wood screw [mm]	Copper nail [mm]	Copper nail [mm]			a < 100	100 ≤ a < 150	150 ≤ a < 180	180 ≤ a < 205	205 ≤ a < 225
18	4,5	5,0	4,5	2,5	4,5	4,5	2	2	3	3	3
20	4,5	5,0	5,0	3,0	5,0	4,5	2	2	3	3	3
22	6,0	5,0	6,5	3,5	5,0	6,0	2	2	3	3	3
24	6,0	5,0	6,5	3,5	5,5	6,0	2	2	3	3	3
26	7,0	5,5	6,5	3,5	5,5	6,0	1	2	2	3	3
28	7,0	5,5	6,5	4,5	5,5	6,0	1	2	2	3	3
30	7,0	5,5	6,5	4,5	5,5	6,0	1	2	2	3	3
32	8,0	6,5	7,5	5,0	6,5	8,0	1	2	2	3	3
34	8,0	6,5	7,5	5,5	6,5	8,0	1	2	2	3	3
36	8,0	7,0	7,5	5,5	6,5	8,0	1	2	2	2	3
38	8,0	7,0	7,5	5,5	7,0	8,0	1	2	2	2	3
40	9,0	8,0	9,5	6,0	7,0	8,0	1	2	2	2	3
42	9,0	8,0	9,5	6,0	7,0	9,0	1	2	2	2	3
44	10,0	8,0	9,5	-	8,0	9,0	1	2	2	2	3
46	12,0	8,5	11,0	-	8,0	10,0	1	2	2	2	3
48	12,0	8,5	11,0	-	8,0	10,0	1	2	2	2	3
50	14,0	10,0	12,5	-	8,5	12,0	1	2	2	2	3
52	14,0	10,0	12,5	-	8,5	12,0	1	2	2	2	3

Table 3.4 Connections of Shell and Deck Planking in Plywood

Thickness of plywood	Overlap of seams		Width of butt-straps		Diameter of fastenings	
	Shell and deck planking, on keel, stringers, shelves or carlings				Wood screw	Copper nail
[mm]	[mm]		[mm]		[mm]	[mm]
6	25	Single fastening	150	Single fastening	4,5	3,5
8	28		175		5,0	3,5
10	32		200		5,0	4,5
12	35		225		5,5	4,5
14	35		250		5,5	5,0
16	45		280		5,5	5,0
18	45	Double fastening	350	Double fastening	6,5	5,0
20	50		350		6,5	5,5
22	50		350		6,5	6,0
24	60		380		7,0	6,5
26	60		380		7,0	6,5

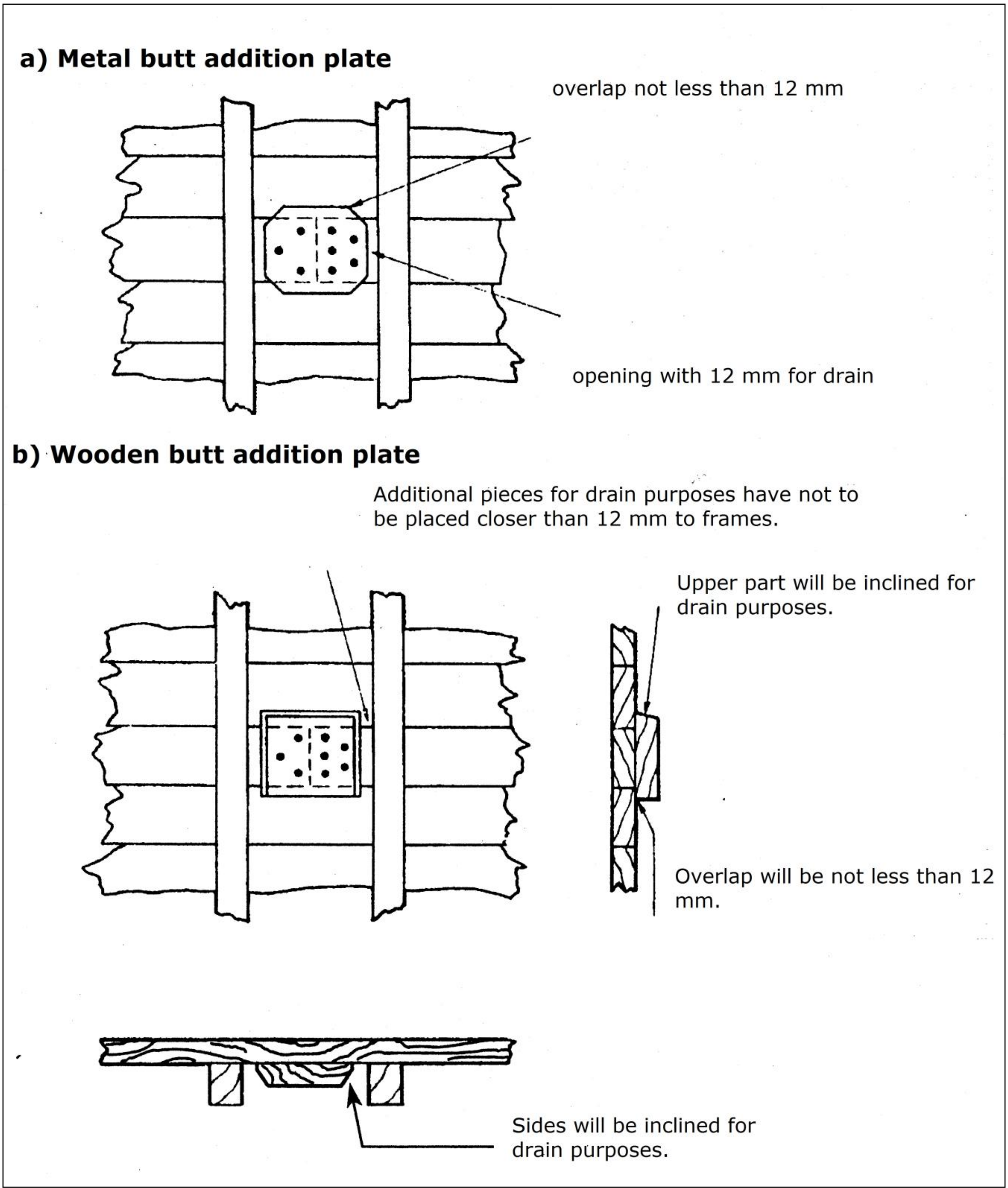
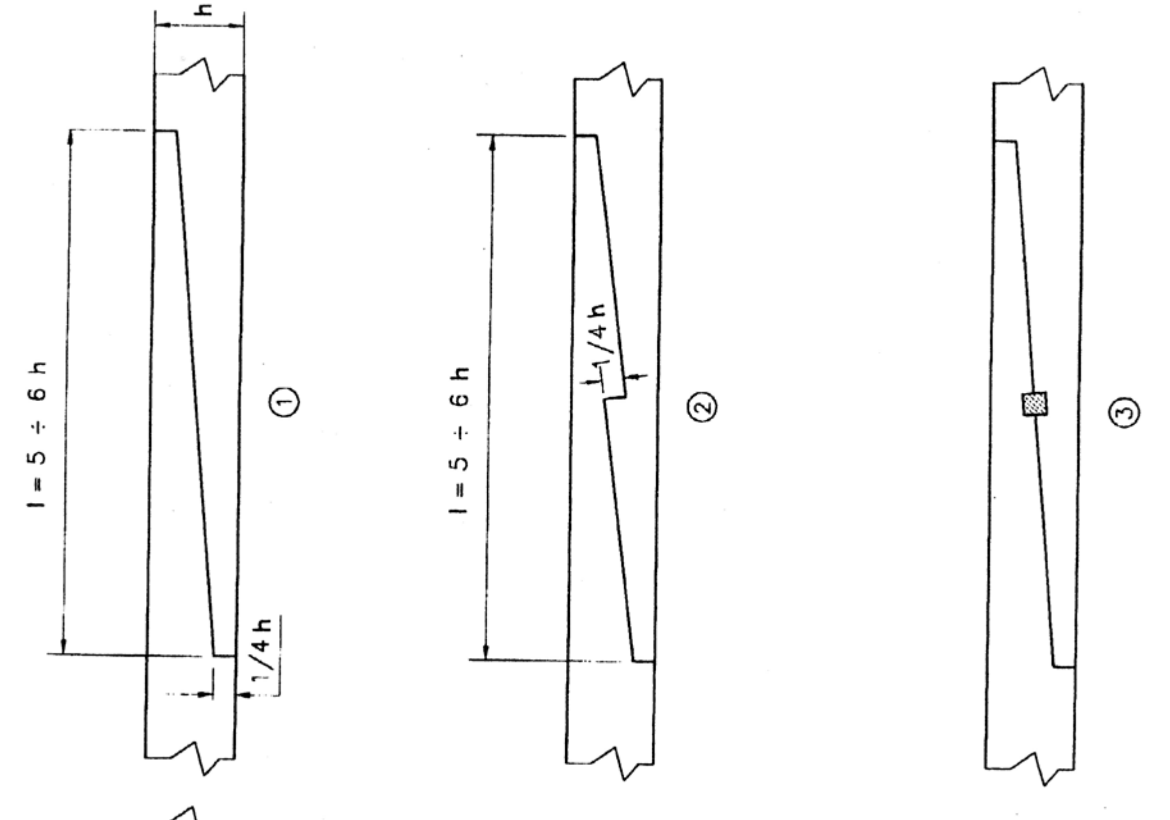


Figure 3.1 Butt-straps on shell planking



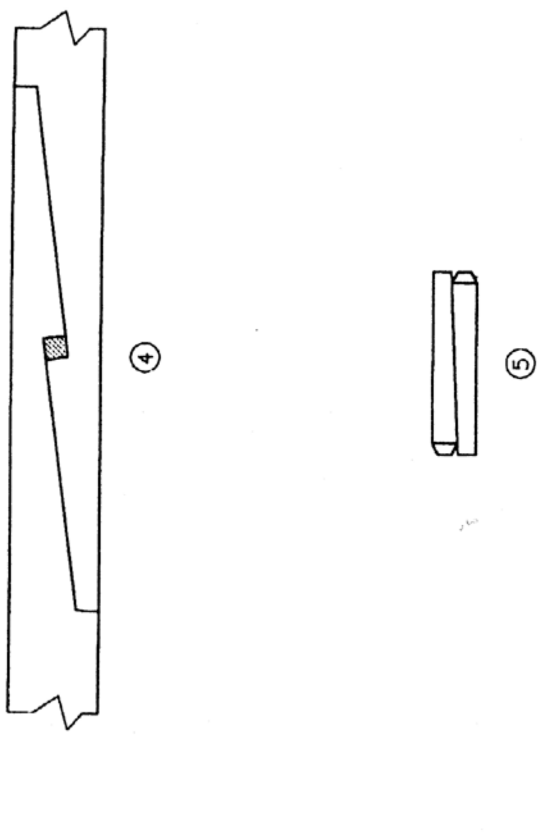


Figure 3.2 Usual Types of Scarf Joints

1. Plane scarf
2. Hooked scarf
3. Tabled scarf
4. Tabled hooked scarf
5. Double wedges

D. Structural Scantlings of Sailing Yachts with or without Auxiliary Engine

1. General

The rules in this section apply to hulls of ***length L ≤ 52 m*** with round bottom of shape similar to that shown in Figure 3.3 and 3.4, and fitted with fixed ballast or drop keel.

2. Keel

The scantlings of wooden keels are given in Table 3.5.

The keel thickness is to be maintained throughout the length, while the width may be gradually tapered at the ends so as to be faired to the stem and the sternpost.

The breadth of the rabbet on the keel for the first plating strake is to be at least twice the thickness and not less than 25 mm.

The wooden keel is to be made of a minimum number of pieces; scarf joints may be permitted with scarf 6 times as long as the thickness and tip 1/4 to 1/7 of the thickness of the hooked or tabled type, if bolted, or of the plain type, if glued. It is recommended that scarfs should not be arranged near mast steps or ends of engine foundation girders.

Where the keel is cut for the passage of a drop keel, the width is to be increased.

Where the mast is stepped on the keel, it is to be arranged aft of the forward end of the ballast keel.

Where this is not practicable, effective longitudinal stiffeners are to be arranged extending well forward and aft of the mast step and effectively connected to the keel.

Bolted scarfs are to be made watertight by means of softwood stopwaters.

3. Stem and Sternpost

The stempost is to be adequately scarfed to the keel and increased in width at the heel as necessary so as to fit the keel fairing.

Stempost scantlings are given in Table 3.5.

The sternframe is shown in Figure 3.5 and sternpost scantlings are given in Table 3.5.

The lower portion of the sternpost is to be tenoned or otherwise attached to the keel. The connection is completed by a stern deadwood and a large bracket fastening together false keel, keel and post by means of through bolts. The counter stern is to be effectively connected to the sternpost; where practicable, such connection is to be effected by scarfs with through bolts.

The cross-sectional area of the counter stern at the connection with the sternpost is to be not less than that of the latter; such area may be reduced at the upper end by 25%.

4. Frames

4.1 Types of Frames

4.1.1 Bent Frames

Bent frames consist of steam warped listels. Their width and thickness are to be uniform over the whole length; the frames are to be in one piece from keel to gunwale and, where practicable, from gunwale to gunwale, running continuous above the keel.

4.1.2 Grown Frames

Grown frames consist of naturally curved timbers connected by means of scarfs, or butted and strapped. Their width is to be uniform, while their depth is to be gradually tapered from heel to head.

The length of scarfs is to be not less than 6 times the width, and they are to be glued.

Grown frames may built up by utilizing twinning method comprising connection of the elements side to side by bolts provided that the sizes on lower and upper ends are adequate.

1. Ballast keel
2. Wood keel
3. False keel
4. Stempost heel
5. Upper portion of stempost.
6. Sternpost
7. Deadwood
8. Stern counter

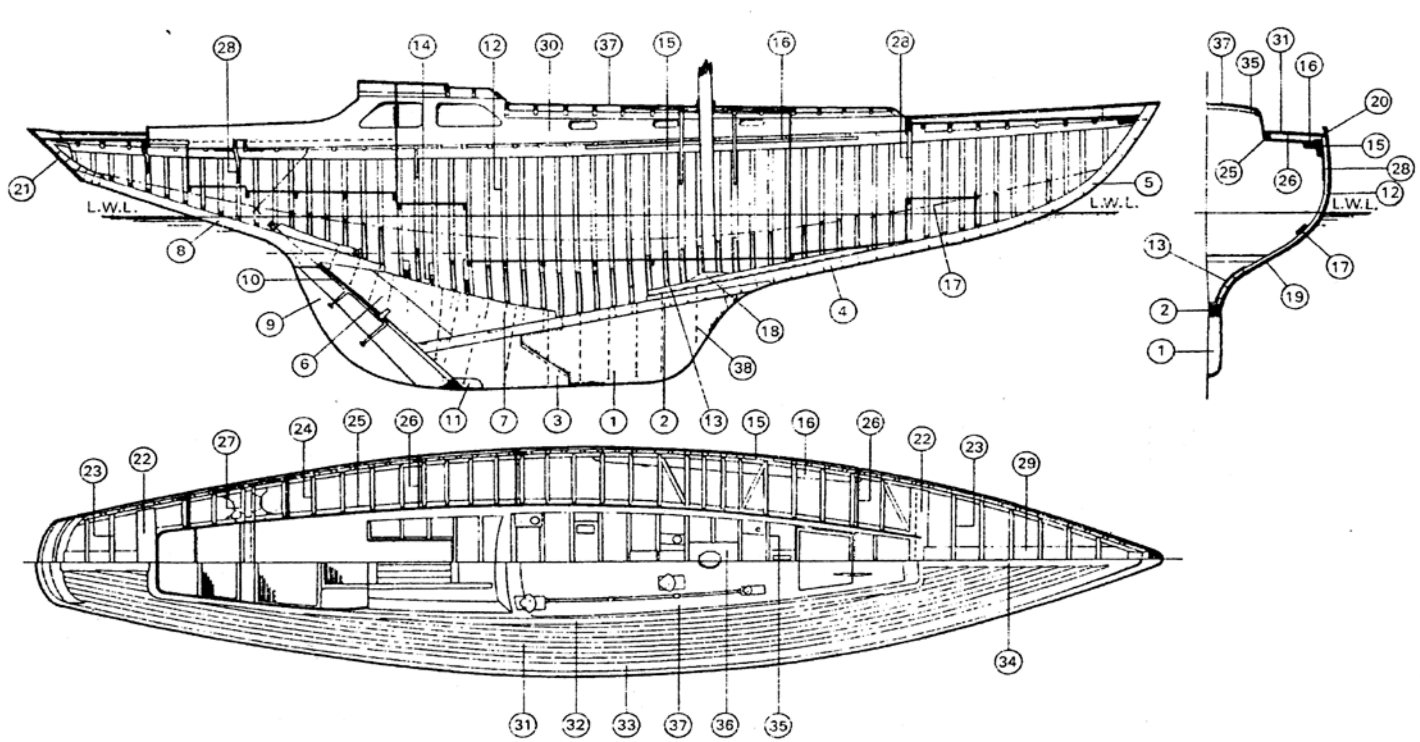


Figure 3.3 Sailing Yachts – Construction profile

9. Rudder
10. Rudder stock
11. Heel piece
12. Frames
13. Forged floor
14. Wooden floor
15. Beam shelve
16. Beam clamp
17. Bilge stringer
18. Mast step
19. Coachroof shelve
20. Seam
21. Transom
22. Strong beam
23. Ordinary beam
24. Half beam
25. Carling
26. Connecting rod
27. Horizontal bracket
28. Forged bracket
29. Deck wedging
30. Coachroof coaming
31. Deck
32. Margin planking
33. Waterway board
34. King plank
35. Coachroof beam
36. Mast wedging
37. Coachroof deck
38. Keel bolts

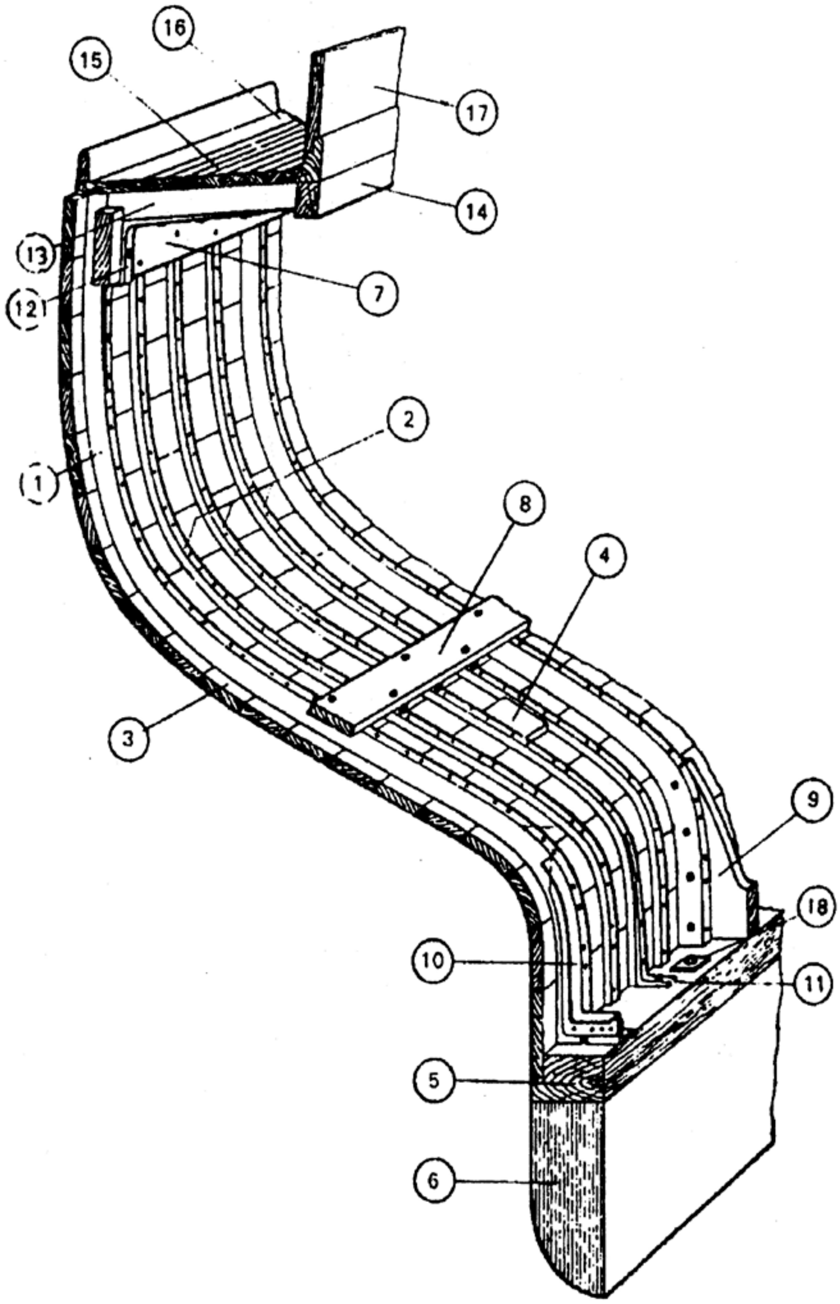


Figure 3.4 Sailing Yachts – Midship Section

1. Grown frame
2. Bent frame
3. Shell planking
4. Butt strap
5. Wood keel
6. Ballast keel
7. Beam shelve
8. Bilge stringer
9. Wooden floor
10. Steel angle floor
11. Forged floor
12. Forged bracket
13. Half beam
14. Carling
15. Deck planking
16. Waterway board
17. Coachroof coaming
18. Keel bolt

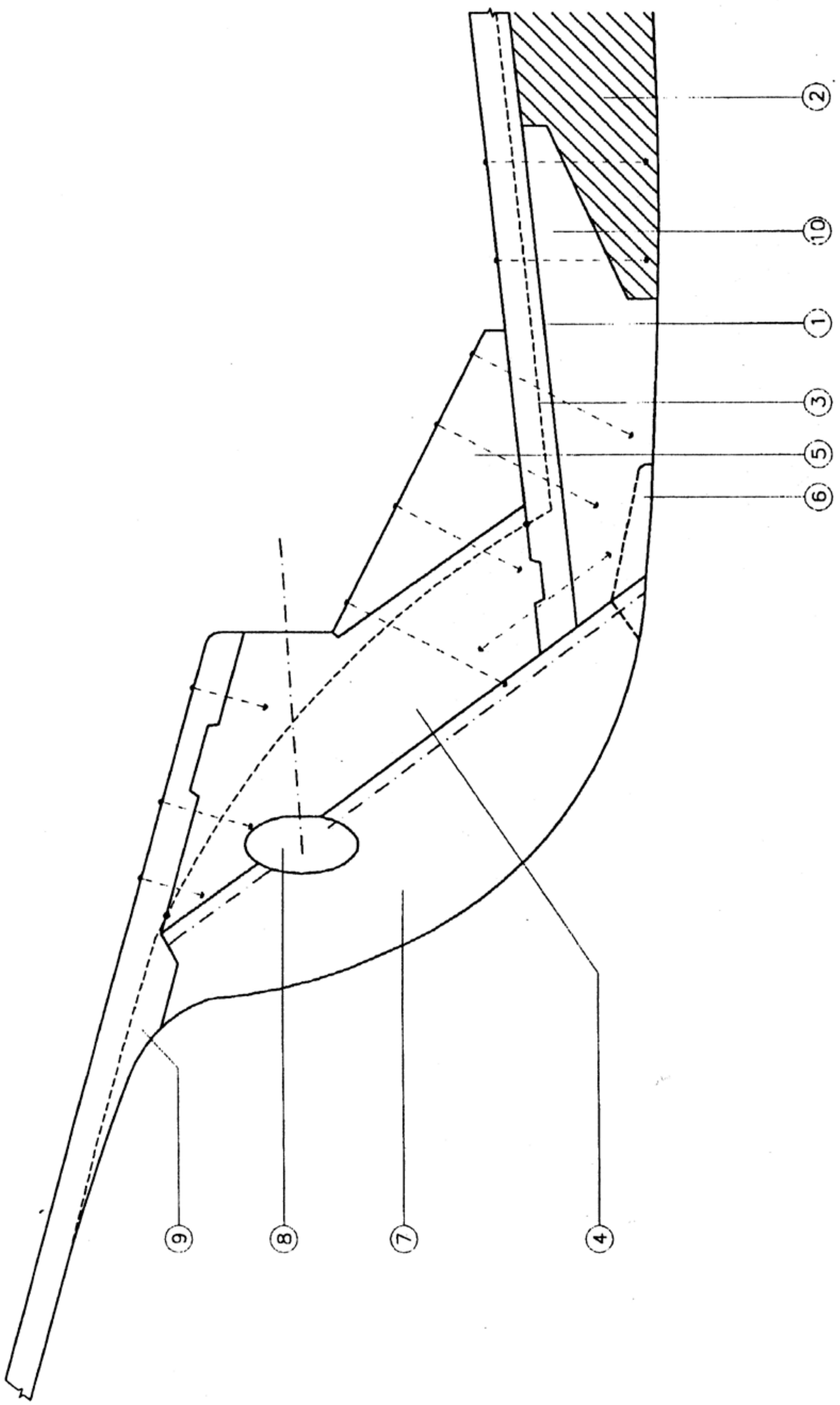


Figure 3.5 Sailing Yachts – Stern Frame

1. Wood keel
2. External ballast
3. Rabbet
4. Sternpost
5. Knee
6. Heel piece
7. Rudder
8. Propeller aperture
9. Stern counter
10. Hog

Table 3.5 Keel, Stempost, Sternpost

Length L [m]	Keel		Stempost				Sternpost	
			at heel		at head			
	Width [mm]	Depth [mm]	Width [mm]	Depth [mm]	Width [mm]	Depth [mm]	Width [mm]	Depth [mm]
14	285	140	155	155	125	125	125	125
16	320	160	170	170	140	140	140	140
18	355	175	190	190	150	150	150	150
20	385	195	205	205	165	165	165	165
22	410	210	220	220	175	175	175	175
24	435	230	240	240	190	190	190	190
26	455	245	255	255	200	200	200	200
28	470	260	270	270	215	215	215	215
30	480	280	290	290	230	230	230	230
32	489	297	310	310	245	245	245	245
34	495	314	330	330	260	260	260	260
36	503	332	350	350	275	275	275	275
38	507	349	370	370	290	290	290	290
40	510	367	390	390	305	305	305	305
42	515	384	410	410	320	320	320	320
44	517	402	430	430	335	335	335	335
46	520	419	450	450	350	350	350	350
48	523	437	470	470	365	365	365	365
50	525	454	490	490	380	380	380	380
52	527	472	510	510	395	395	395	395

.4.1.3 Laminated frames

Laminated frames consist of glued wooden layers. The glueing may take place before forming where the latter is slight; otherwise it is to be carried out in place or be prefabricated by means of suitable strong moulds.

4.1.4 Steel frames

Steel frames consist of angles properly curved and bevelled such that the flange to planking is closely fayed to the same planking.

4.2 Framing Systems and Scantlings

The admissible framing systems and the frame scantlings are indicated in Table 3.6.

The following framing systems are to be used:

Type I : all equal frames, of the bent type

Type II : all equal frames, of grown, laminated or steel angle type

Type III: frames of scantlings as required for type II, but alternated with one, two or three bent frames. These types are hereafter referred to, respectively, as Type III_1, Type III_2, Type III_3 .

When a frame spacing other than that specified in the Table is adopted, the section modulus of the frame is to be modified proportionally. For wooden rectangular sections, a being the width and b the height of the rule section for the spacing s, a_1 and b_2 the actual values for the assumed spacing s_1, it follows that:

$$a_1 \cdot b_1^2 = a \cdot b^2 \cdot \frac{s_1}{s}$$

The width of frames is to be not less than that necessary for the fastening; their depth is in any case to be assumed as not less than 2/3 of the width, except where increased width is required for local strengthening in way of masts.

The Table scantlings, duly modified where necessary for the specific gravity of the timber and for the frame spacing, are to be maintained for 0,6 of the hull length amidships; outside such zone, the following reductions may be applied:

- For bent or laminated frames: 10% in width,

- For grown frames: 20% in width throughout the length of the frame, and 20% in depth of the head,

- For metal frames: 10% in thickness.

Frames may have a reduction in strength of 25% where cold laminated planking is adopted in place, in accordance with the provisions of 8.

Frames are to be properly shaped so as to fit the planking perfectly.

Where no floors are arranged, the frames are to be wedged into and fastened at the heels of the centreline structural member of the hull.
When internal ballast supported by the frames is arranged, the latter are to be increased in scantlings.

Frames adjacent to masts are to be strengthened on each side as follows, or equivalent arrangements are to be provided.

- Type I framing: Three grown frames are to be fitted, with scantlings as required for Type II framing, but with constant depth equal to that indicated in Table 3.6 for the heel. Such frames are to be arranged instead of alternate bent frames. Otherwise, six consecutive bent frames with a cross-section increased by 60% in respect of that shown in the above-mentioned Table may be fitted.

- Type II framing:Three grown frames are to be fitted, with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned Table and constant depth. Such frames are to be alternated with ordinary grown frames. If alternate frames are adopted, they are to be stiffened by reverse frames of scantlings as prescribed for the reverse frames of plate floors.

- Type III framing: Three grown frames with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned Table, and constant depth, are to be arranged at Rule spacing, with one or two intermediate bent frames. If steel frames are adopted, three are to be stiffened by reverse frames with scantlings as required for the frames of plate floors, and arranged with one or two intermediate bent frames.

Where, in way of the mast, a sufficiently strong bulkhead is provided, such increased frames may be reduced in number to two.

In yachts with transom, vertical stiffeners are to be arranged in line with bottom stiffeners, having cross-sectional area of at least 120% of frames, beam and equal depth with frames and 50% increased thickness.

5. Floors

5.1 General

Floors may be made of wood or steel or aluminium alloy.

- Wooden floors, as a rule, may only be employed in association with grown frames and are to be flanked by them.

- Forged floors are employed in association with either bent, grown or laminated frames, and are arranged on the internal profile of the frames.

- Angle floors may be employed with either bent, grown or laminated frames, and may be arranged as shown in Figure 3.6. When they are arranged with a flange inside, an angle lug is to be fitted in way of the throat, for the connection to the wooden keel (see the above mentioned Figure).

- Plate floors may be employed in association with either grown or angle frames (see the above-mentioned Figure). The internal edge is to be provided with a reverse angle or a flange; in the latter case, the thickness is to be increased by 10%.

- Laminated floors may be employed with laminated frames and may be arranged as shown in Figure 3.6. In this case:

  The bolts used are to be located vertical to the lamination,

  Thickness of floor is to be equal to the frames used. Depth should be obtained by inertia calculated for wooden floors depending on the related hull dimensions (see Table 3.7 (b)).

  Note: These are scantlings of floors located onto the frames, the depth of frame is not deducted from the depth of floor.

5.2 Arrangement of Floors

Where Type I framing with bent frames is adopted (see Table 3.6), floors are to be fitted inside 0,6 L amidships as follows:

- on every second frame if the hull depth does not exceed 2,75 metres and on every frame in hulls of greater depth;

- on every second frame inside 0,6 L amidships, and outside such area over an extent corresponding to the length on the waterline;

- on every third frame elsewhere.

Where Type III framing is adopted, a floor is to be fitted in way of every grown, laminated or angle frame. Where one or two intermediate bent frames are arranged, and the depth D exceeds 2,40 metres, floors are to be fitted on bent frames located inside 0,6 L amidships.

Where three intermediate bent frames are arranged, a floor is to be fitted on the central frame.

5.3 Scantlings and fastenings

The scantlings of floors are given in Table 3.7

The length of arms of wooden, forged or angle floors is measured from the corner, following the external profile. The depth of plate floors is to be measured vertically.

.

At the hull ends, the length of arms need not exceed one third of the frame span.

Wooden floors are to be made of suitably grained or laminated timber, and their height at the ends is to be not less than half the height of the throat.

Where the ballast keel bolts cross wooden floors, the width of the latter at the throat is to be locally increased, if necessary, so as to be not less than three and a half times the diameter of the bolt.

Lugs for the connection of angle or plate floors to the wooden keel, if penetrated by the ballast keel bolts, are to have a flange width at least three times the diameter of the bolt and thickness equal to that of the plate floor plus 2,5 mm.

At the end of the hull, when frames are continuous through the centre structure, floors need not be fitted; whenever practicable, however, the frames are to be attached to the centre structure by means of three through-bolts.

Floors are to be connected to frames by at least three bolts for arms with length l < 250 mm and greater length by the number of bolts determined according to the following formula;

$$n = \frac{0{,}096 \cdot \ell}{d}$$

where;

ℓ = arm length of floor

d = diameter of bolt used

n = number of bolt (as a minimum 3)

Yachts with stern counter, 4 bolts with adequate intervals may be used.

In cases where the different bolt diameter is chosen by the designer, different number of bolts may be accepted provided that equivalent connection ensured to those stated in the rules.

For diameter of bolts, see Table 3.12 (a).

5.4 Laminated floors to be used together with laminated frames

Thickness of the laminated floors in the centerline of the yacht, is to be equal to those frames on which is connected. The height of laminated floors is to be determined according to the moment of inertia of element having the depth of 75% of wooden floor obtained from Table 3.7. (b). The height may be slightly reduced towards to the ends.

In case of single frame continuously passing through the centreline, the height of floor may be taken as half of the value determined above, as from the height of frame.

Table 3.6 (a) Frames

Depth H_1 [m] (1)	Typee I Bent frames only			Type II Grown frames, or laminated frames, or steel frames only							
	Frame spacing [mm]	Width [mm]	Depth [mm]	Frame spacing [mm]	Grown frames			Laminated frames		Steel frames	
					Width [mm]	Depth At heel [mm]	Depth At head [mm]	Width [mm]	Depth [mm]	Section modulus [cm^3]	Scantlings[mm] (2)
1,60	145	19	15	185	18	23	18	20	20	0,7	30x30x3
1,80	155	24	19	200	24	30	24	24	24	0,7	30x30x3
2,00	165	30	23	220	30	37	28	28	28	0,8	30x30x4
2,20	175	35	27	237	36	44	33	31	31	1	35x35x4
2,40	185	41	30	255	43	50	37	35	37	1,2	35x35x4
2,60	195	46	34	270	48	57	42	38	40	1,7	45x30x4
2,80	205	51	37	288	55	65	47	42	46	2,3	45x45x5
3,00	215	57	40	305	61	74	53	47	52	3,1	50x50x5
3,20	225	62	43	322	68	83	58	50	59	4,4	60x30x6
3,40	235	67	46	340	75	91	68	54	66	6	65x50x7
3,60	245	72	49	355	81	100	80	59	74	7,9	75x50x6
3,80	255	77	52	375	87	112	92	63	84	10,2	80x60x7
4,00	265	82	55	390	94	124	100	67	94	12,5	90x60x7
4,20	-	-	-	408	100	135	117	73	102	14,5	90x60x8
4,40	-	-	-	425	106	150	-	77	110	16,5	-
4,60	-	-	-	442	112	165	-	81	118	18,8	-
4,80	-	-	-	459	118	180	-	86	128	21,3	-
5,00	-	-	-	476	125	195	-	90	138	24	-
5,20	-	-	-	493	131	205	-	96	146	26,9	-
5,40	-	-	-	510	137	220	-	100	157	30,1	-
5,60	-	-	-	527	144	235	-	104	168	33,6	-
5,80	-	-	-	544	150	250	-	108	178	37,5	-
6,00	-	-	-	561	156	265	-	112	188	41,9	-
6,20	-	-	-	578	162	280	-	116	198	46,7	-

Table 3.6 (b) Frames

Depth H_1 [m] (1)	Type III Main frames (grown or laminated or steel frames) alternated with bent frames				
	Spacing between main frames and intermediate frames			Bent frames	
	1 bent frame [mm]	2 bent frames [mm]	3 bent frames [mm]	Length [mm]	Depth [mm]
1,60	330	440	520	20	18
1,80	365	470	545	25	20
2,00	390	500	570	29	22
2,20	410	520	590	33	24
2,40	446	540	620	37	28
2,60	460	570	640	39	29
2,80	490	590	670	41	31
3,00	515	620	695	43	33
3,20	560	650	730	45	35
3,40	590	690	770	48	39
3,60	620	725	800	50	43
3,80	650	765	840	53	47
4,00	680	800	870	56	51
4,20	-	-	-	-	-

(1) *For hulls fitted with external ballast in the keel, 0,75 H_1 may be assumed in place of H_1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 H is taken in lieu of H_1*

(2) *The scantlings of angles are given for guidance purposes..*

Type I framing system is only applicable where H_1 does not exceed 3,0 m.

Type II framing system is only applicable where H_1 does not exceed 3,60 m.

The frame spacing is intended as that measured amidships across the width of the frames.

Table 3.7 (a) Floors

Depth H_1 [m] (1)	Floors on bent frames					Plate floors on grown or steel floors	
	Length of arms	Forged floors		Steel angle floors (2)		0,6 L amidships	Outside 0,6 L amidships
		At throat	At the ends	Section modulus	Scantlings		
	[mm]	[mm]	[mm]	[cm^3]	[mm]	[mm]	[mm]
1,60	220	25x6	15x6	0,3	25x25x5	120x3	100x3
1,80	250	25x6	15x6	0,3	25x25x5	150x3	110x3
2,00	280	25x8	16x6	0,3	25x25x5	170x3	130x3
2,20	310	25x10	18x6	0,6	30x30x5	200x3	145x3
2,40	350	25x12	19x6	1,0	30x30x5	230x4	170x4
2,60	375	26x13	20x6	1,0	35x35x5	270x4	180x4
2,80	405	27x14	22x6	1,2	35x35x5	280x4	190x4
3,00	430	29x15	24x6	1,4	40x40x4	300x5	200x4
3,20	465	31x16	25x6	1,4	40x40x4	320x5	220x4
3,40	495	33x17	27x6	1,5	40x40x4	330x5	230x4
3,60	530	35x17	28x6	1,5	40x40x4	340x6	240x4
3,80	-	-	-	-	-	345x6	245x4
4,00	-	-	-	-	-	350x6	250x4
4,20	-	-	-	-	-	360x6	260x5
4,40	-	-	-	-	-	365x7	260x5
4,60	-	-	-	-	-	370x7	270x5
4,80	-	-	-	-	-	380x7	280x5
5,00	-	-	-	-	-	390x8	280x6
5,20	-	-	-	-	-	390x8	280x6
5,40	-	-	-	-	-	400x8	280x6
5,60	-	-	-	-	-	405x9	290x6
5,80	-	-	-	-	-	410x9	290x7
6,00	-	-	-	-	-	420x9	290x7
6,20	-	-	-	-	-	425x9	290x7

6. Beam Shelves, Beam Clamps in way of Masts, Bilge Stringers

6.1 Beam Shelves

The cross-sectional area of beam shelves through 0,6 L amidships is to be not less than that indicated in Table 3.8. Outside such zone, the cross-section may be gradually decreased to reach, at the end, a value equal to 75% of that shown. The cross-section to be considered is to be inclusive of the dappings for fixing of beams.

Where beam shelves are made of two or more pieces, the connection is to be effected by means of glued scarfs adequately arranged so as to be staggered in respect of the sheer strake, waterway and bracket joints. Scarfs are generally arranged vertically.

When the weather deck is not continuous owing to the presence of raised decks, the shelf is to extend to the hull end or, alternatively, stiffeners are to be fitted to prevent excessive discontinuity due to the interruption of the deck. The scantlings of frames may be required to be increased.

Where angle frames are employed, reverse lugs are to be fitted in order to allow connection to the beam shelf.

When Type III framing is adopted, the shelf is to rest on the bent frames with interposition of suitable chocks.

The shelves are to be connected to each frame by a through bolt for heights ≤ 180 mm and by two through bolts for greater heights. If metal frames are adopted, bolting of the shelf is to be effected on a reverse lug. For bolt scantlings, see Table 3.12 (b),

6.2 Beam clamps in way of masts

In way of masts, a beam clamp is to be arranged, of length approximately equal to the hull breadth in the same position.

Such clamp, with cross-section equal to approximately 75% of that required for shelves, may be arranged so that its wider side is faying to the beams and leaning against the shelf or, alternatively, it may be arranged below the shelf.

6.3 Bilge Stringers

In hulls with Type I or Type III framing, a bilge stringer is to be arranged, having cross-section for 0,6 L amidships not less than that given in Table 3.8. Outside such zone, the cross-section may be decreased to reach, at the ends, a value equal to 75% of that required.

The greater dimension of the stringer is to be arranged against the frames.

When the stringer is built of two or more pieces, these are to be connected by means of glued scarfs parallel to the planking. Such scarfs are to be properly staggered in the port and starboard stringers and arranged clear of the joints of other longitudinal elements.

Where angle frames are adopted, these are to be connected to the stringer by means of a reverse lug.

When Type III framing is adopted, chocks are to be fitted for the connection between stringer and intermediate bent frames.

In lieu of a bilge stringer, two side stringers having cross section equal to 60% of that required for the bilge stringer may be fitted.

6.4 End breasthooks

The beam shelves and the stringers are to be connected to each other at the hull ends, and with the centre line structure, by means of suitable breasthooks or brackets.

In hulls with exceptionally raked ends, such breasthooks are to be arranged with adequate design.

7. Beams

7.1 Scantlings of beams

The scantlings of beams are given in Tab 3.9. Where the spacing adopted is other than that shown in the Table, the scantlings, following correction as necessary for the weight of the timber employed, are to be modified in accordance with the following relationship:

Table 3.7 (b) Floors

Depth H_1 [m] (1)	Floors on grown or laminated frames							
	Length of arms		Forged floors		Wooden floors		Steel angle floors (2)	
	0,6 L amidships[mm]	Outside 0,6L amidships [mm]	At throat [mm]	At the ends [mm]	Width [mm]	Depth [mm]	Section modulus [cm^3]	Scantlings [mm]
1,60	350	230	19x9	19x9	20	40	0,34	20x20x4
1,80	380	250	25x10	20x10	23	55	0,36	20x20x4
2,00	410	280	31x12	27x10	26	68	0,71	25x25x5
2,20	450	320	38x14	33x10	31	80	1,00	30x30x5
2,40	480	350	44x16	40x10	36	95	1,20	35x35x4
2,60	510	380	48x18	43x10	42	108	1,20	35x35x4
2,80	550	400	52x20	47x10	47	120	1,90	40x40x5
3,00	580	430	56x22	50x12	51	135	2,40	45x45x5
3,20	610	460	60x24	52x13	56	148	3,60	50x50x6
3,40	650	500	64x26	54x14	60	160	5,70	55x55x8
3,60	680	530	69x28	56x16	64	170	6,90	60x60x8
3,80	720	560	73x30	58x17	70	180	6,90	60x60x8
4,00	750	590	77x31	61x18	75	190	9,00	65x65x9
4,20	780	620	80x31	63x20	80	200	10,50	70x70x9
4,40	820	650	-	-	84	212	11,80	75x55x9
4,60	850	680	-	-	89	224	13,80	90x75x6
4,80	880	710	-	-	94	236	15,40	90x60x8
5,00	920	740	-	-	98	249	18,00	90x90x9
5,20	950	770	-	-	102	261	19,90	100x100x8
5,40	980	800	-	-	107	273	21,60	90x90x11
5,60	1010	830	-	-	112	285	24,70	100x100x10
5,80	1040	860	-	-	117	298	25,90	100x75x11
6,00	1070	890	-	-	121	310	27,60	100x80x8
6,20	1100	920	-	-	126	322	31,10	130x65x8

(1) *For hulls fitted with external ballast in the keel, 0,75 H_1 may be assumed in place of H_1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 H is taken in lieu of H_1.*

(2) *The scantlings of angles are given for guidance purposes.*

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$$a_1 \cdot b_1^2 = a \cdot b^2 \cdot \frac{s_1}{s}$$

where a and b are the width and height of the rule cross section, a_1 and b_1 are the width and height of the modified section, s is the rule spacing, and s_1 the assumed spacing.

Laminated beams may be reduced in width by 15%.

Strong beams are to be fitted in way of openings which cause more than two beams to be cut and in way of masts, when deemed necessary by **TL.**

7.2 End attachments of beams and beam knees

Beams are to be dovetailed on the shelf. When plywood deck planking is employed, in place of the dovetail a simple dapping may be adopted, having depth not less than 1/4 of the beam depth; in this case, the beam is to be fastened to the shelf by means of a screw or pin.

End connections of half beams are to be dovetailed on the longitudinal member. This longitudinal member is to have the same depth as beam and the width of 150% of width of the beam.

Vertical knees are to be fitted, to the extent required in Table 3.10, to strong beams and to suitably distributed ordinary beams. Each arm of the knees is to be connected to the shelf and the frame by means of 4 bolts, which need not to go through the planking, with a diameter as shown in Table 3.12 (b).

Bulkheads of adequate scantlings, connected to the beam and frame, can be considered as substitutes for knees.

At the ends of the hull, the length of knee arms may be not more than one third of the span of the beam or frame.

In Table 3.10, the scantlings of forged plate knees are given.

The depth at the throat is to be not less than 1,6 h for naturally curved wooden knees and not less than 1,4 h for laminated wooden knees, h being the depth at heel of a grown frame.

7.3 Local strengthening

The beams and decks are to be locally strengthened at the attachments of halliards, bollards and cleats, at skylight ends, and in way of foundations of winches.

In way of mast wedgings, four strong beams are to be fitted, with scantlings as prescribed in Table 3.9, but constant section equal to that indicated for amidships. The beams are to be arranged, as far as practicable, in proximity of the web frames dealt with in 4.2.

All openings on deck are to be properly framed so as to constitute an effective support for half beams.

7.4 Lower deck and associated

In hulls with depth, measured from the upper side of the wooden keel to the weather deck beam at side, ≥ 3 meters, a lower deck or cabin deck is to be arranged and fitted with beams having scantlings not less than 60% of those of the weather deck.

When the depth, measured as specified above, exceeds 4,3 meters, vertical knees are to be arranged no smaller in scantlings than prescribed in Table 3.10 as a function of the beam span, and in number equal to half of those required for the weather deck.

8. Planking

8.1 Shell Planking

The basic thickness of shell planking is given in Table 3.11. Such thickness is to be modified as follows. If the frame spacing is other than that indicated in Table 3.6, the thickness is to be increased where there is greater spacing, or may be reduced where there is smaller spacing, by:

- 6 mm for every 100 mm of difference if Type I framing is adopted;

- 4 mm for every 100 mm of difference if Type II or III framing is adopted.

Table 3.8 Beam Shelves and Bilge Stringers

Length L [m]	Cross-sectional area of beam shelves [cm^2]	Cross-sectional area of bilge stringers [cm^2]
14	90	55
16	110	68
18	130	77
20	150	105
22	170	120
24	190	140
26	220	160
28	250	175
30	280	190
32	295	205
34	320	220
36	340	240
38	370	255
40	396	270
42	420	285
44	450	300
46	470	315
48	490	340
50	520	360

Table 3.9 Beams

Length of beam [m]	Spacing of beams [mm]	Ordinary beams for 0,6 L amidships			Ordinary beams outside 0,6 L amidships, half beams			Strong beams		
		Width [mm]	Depth		Width [mm]	Depth		Width [mm]	Depth	
			At mid beam [mm]	At beam ends [mm]		At mid beam [mm]	At beam ends [mm]		At mid beam [mm]]	At beam ends [mm]
1,50	220	23	37	25	20	27	22	34	42	34
2,00	270	31	50	34	26	36	29	43	55	43
2,50	310	36	61	42	33	41	37	53	68	53
3,00	350	45	72	50	39	54	43	61	81	61
3,50	390	51	80	57	47	61	48	72	91	72
4,00	430	57	90	63	48	67	53	78	101	78
4,50	480	62	99	69	52	74	57	85	111	85
5,00	520	68	106	75	57	80	62	93	120	93
5,50	560	72	114	80	59	87	65	98	128	98
6,00	600	78	121	86	62	95	69	107	136	107
6,50	640	83	129	92	64	103	71	116	144	116
7,00	680	86	132	96	67	113	74	128	156	128
7,50	720	95	146	105	69	125	76	140	168	140
8,00	760	101	155	111	73	133	79	149	179	149
8,50	800	107	164	117	77	141	81	157	189	157
9,00	840	113	173	123	81	148	83	165	200	165
9,50	880	119	182	130	84	156	85	173	210	173
10,00	910	125	191	137	88	164	88	182	220	182
10,50	950	131	200	144	91	173	90	190	231	190
11,00	990	137	209	150	95	181	91	198	242	198
11,50	1030	143	218	158	99	189	93	206	253	206
12,00	1060	149	227	164	103	197	95	214	263	214
12,50	1100	155	236	171	106	204	97	222	273	222
13,00	1140	161	245	178	108	213	98	230	284	230
13,50	1180	167	254	184	112	221	99	239	294	239
14,00	1220	173	263	191	116	229	101	247	305	247

Table 3.10 Vertical Knees of Beams

Length of beams [m]	Number of knees on each side (1)	Length of arms		Forged knees		Steel angle knees		Plate knees (steel) thickness [mm]
		For 0,6L amidships [mm]	Outside 0,6L amidships [mm]	At throat [mm]	At the ends [mm]	Scantlings (2) [mm]	Section modulus [cm^3]	
1,50	3	280	220	20x7	17x4	25x25x3	0,25	3
2,00	4	320	250	23x10	20x5	25x25x4	0,40	3
2,50	4	360	290	27x13	24x6	30x30x4	0,80	3
3,00	5	400	320	34x17	30x7	40x40x5	1,70	4
3,50	6	440	350	41x20	37x7	50x50x5	3,00	4
4,00	7	490	390	48x23	42x8	55x55x5	4,30	4
4,50	8	530	420	53x26	46x9	60x60x6	5,90	5
5,00	9	570	450	57x28	49x10	75x50x6	7,50	5
5,50	10	610	490	62x30	52x11	75x50x7	9,30	5
6,00	10	650	520	67x32	54x12	90x60x7	11,50	6
6,50	11	700	560	72x34	55x14	90x60x8	14,00	6
7,00	12	740	590	78x35	57x16	100x65x7	16,00	6
7,50	12	780	620	81x37	58x17	100x65x8	19,00	7
8,00	13	820	650	-	-	100x75x9	21,50	7
8,50	14	860	680	-	-	90x90x13	25,10	7
9,00	14	900	710	-	-	90x90x16	30,10	7
9,50	15	940	740	-	-	120x80x10	34,10	8
10,00	16	980	770	-	-	120x80x12	40,40	8
10,50	17	1030	800	-	-	120x80x14	46,40	8
11,00	17	1070	830	-	-	150x100x10	54,10	9
11,50	18	1110	870	-	-	140x140x13	63,30	9
12,00	19	1150	900	-	-	150x100x14	74,10	9
12,50	20	1190	930	-	-	150x150x16	88,70	10
13,00	20	1240	960	-	-	150x150x18	99,30	10
13,50	21	1280	990	-	-	160x160x19	118,00	10
14,00	21	1320	1030	-	-	250x90x10	140,00	11

(1) *The number of knees is given on the basis of the maximum breadth B of the hull, using the column for the length of beam.*
(2)*The scantlings of angles are only given as indications.*

After correction for spacing as indicated above, and for the weight of the timber, where necessary, the planking thickness may be reduced: by 10% if arranged in diagonal or longitudinal double skin; by 10% if laminated and cold moulded in loco, when the frames are reduced in scantlings by 25% in respect of the value given in Table 3.6; the thickness may be decreased by 25% where the frames have not been reduced in respect of the requirements of the Table 3.6.

When plywood is employed, the thickness may be reduced in relation to the type of framing adopted; the maximum reduction permitted is 25%.

Sheathing of the hull is not required; where envisaged, e.g. in copper or reinforced plastics, it will be specially considered by **TL** (see F, 1.8).

8.2 Deck Planking

Deck planking may be:

- Constituted by planks parallel to the gunwale limited by a stringer board at side and by a king plank at the centerline;
- Plywood;
- Plywood with associated planks as above.

The thickness of the deck is given in Table 3.11 and is subject to the following modifications:

- If the beam spacing is other than that indicated in Table 3.9, the thickness is to be modified by 3 mm for every 100 mm of variation in spacing;

- If plywood is employed, the thickness may be reduced by 30%;

- If plywood is adopted in association with planking, the specific mass of the plywood/planking assembly is to be not less than 430 kg/m3, and the combined thickness may be reduced by 30%. In addition, the plywood thickness is to be not less than 30% of the combined thickness, or less than 6,5 mm; when the planking thickness is less than 19 mm, the seams are to be made watertight by the application of a suitable elastic compound approved by **TL**.

A further reduction of 1,5 mm may be applied to the deck thickness when the deck is sheathed with nylon, reinforced plastics or other approved coverings.

The canvas is to be closely fitted to the deck, and the seams are to be sewn. Securing by means of overlap and tacks is permitted only if the seams are fitted with a metal strap.

The fixed fittings on deck, in particular winches, windlasses, bollards and fairleads, are to be well secured on suitable basements and isolated by means of coatings of appropriate materials. Before applying such insulating materials to the basements, the timber is to be protected by suitable preservative solutions or paints.

Guardrail stanchions are to be fastened by at least two pins, one of which is to be a through pin.

8.3 Superstructures, skylights

When coachroofs are adopted, the opening on deck is to be well framed and the coaming on the weather deck is to be not less in thickness than that required in Table 3.11.

The coachroof deck is to have sheathing as prescribed in Table 3.11, though such sheathing may be reduced in thickness in accordance with the specifications in 8.2 for the weather deck. If the beam spacing is other than that indicated in Table 3.9, the thickness is to be modified by 3 mm for every 100 mm of difference in spacing.

When deckhouses are adopted, they are to have a coaming fastened to the beams and carlings by means of through bolts.

The structure of deckhouses is to be similar to that required for coachroofs. Depending on their size, deckhouses are to be adequately stiffened to the satisfaction of **TL.**

Deck openings for skylights are to be well framed and provided with shutters of adequate thickness.

8.4 Masts and rigging

Each yacht is to be provided with masts, rigging and sails sufficient in number and in good condition. The scantlings of masts and rigging are left to the experience of builders and ship owners.

Care will be taken by the **TL** surveyor, however, in verifying that the attachments of shrouds and stays to the hull are such as to withstand at least twice the load expected on such rigging.

The mast step is to be of strong construction, and is to be extended so as not to be connected to the transverse and longitudinal framing of the bottom of the hull. The wedging on deck is to be provided with watertight means.

When the mast rests on deck, the underlying structure is to be strengthened in way such as to avoid giving way. If the mast rests on a coachroof, the hull is to be strengthened in way by means of a bulkhead or a stiffened frame.

For shrouds and stays in wire and not in rod, the breaking loads of wires in galvanized steel, in spiral shape, 1x19 wires (col. 1), and in stainless steel 1x19 wires, in spiral shape (col. 2) are included below for information purposes.

Diameter [mm]	Metallic cross-section area [mm^2]	Breaking load [kN]	
		Column 1	Column 2
3	5,37	7,75	7,36
4	9,55	13,73	13,73
5	14,2	21,09	20,60
6	21,5	30,90	29,43
7	29,2	41,69	40,22
8	38,2	54,94	52,97
10	59,7	85,35	83,39
12	86,0	122,63	122,63

Table 3.11 Planking – Basic Thickness

Length [m]	Shell and deck planking [mm]	Deck planking in deckhouses and coachroofs [mm]	Coamings of coachroofs [mm]
14	29	20	26
16	32	22	28
18	35	23	30
20	39	24	32
22	43,5	25	34
24	45,5	26	36
26	47,5	27	36
28	50	28	36
30	52	29	36
32	53	30	37
34	55	31	39
36	58	32	40
38	61	33	41
40	63	34	42
42	66	35	44
44	69	36	45
46	72	37	46
48	75	38	47
50	78	40	49

Table 3.12 (a) Floor Fastenings

Depth of yacht H [m]	Diameter of bolts			
	At throat		In the arms	
	Grown or laminated or steel frames [mm]	Bent frames [mm]	Grown or laminated or steel frames [mm]	Bent frames [mm]
1,8	8	7	7	7
2,0	9	8	8	7
2,2	10	8	8	7
2,4	12	8	8	8
2,6	12	9	9	8
2,8	14	10	10	8
3,0	14	12	12	8
3,2	16	12	12	9
3,4	18	14	14	9
3,6	20	14	14	9
3,8	20	-	14	-
4,0	20	-	16	-
4,2	22	-	16	-
4,4	20	-	18	-
4,6	22	-	20	-
4,8	24	-	21	-
5,0	26	-	23	-
5,2	27	-	25	-
5,4	30	-	27	-
5,6	32	-	29	-
5,8	34	-	31	-
6,0	37	-	33	-
6,2	40	-	36	-

Table 3.12 (b) Fastenings of Longitudinal Structures and Beam Knees

Length of yacht L [m]	Diameter of bolts		
	Centreline structures of yacht [mm]	Scarfs and breasthook arms [mm]	Beam shelves and beam knees [mm]
14	14	11	8
16	16	11	8
18	18	12	10
20	18	14	11
22	20	14	11
24	20	14	11
26	20	14	11
28	22	16	12
30	22	18	14
32	23	18	15
34	24	19	16
36	24	19	16
38	25	19	16
40	25	19	16
42	26	19	16
44	26	19	16
46	27	19	16
48	27	19	16
50	27	20	17

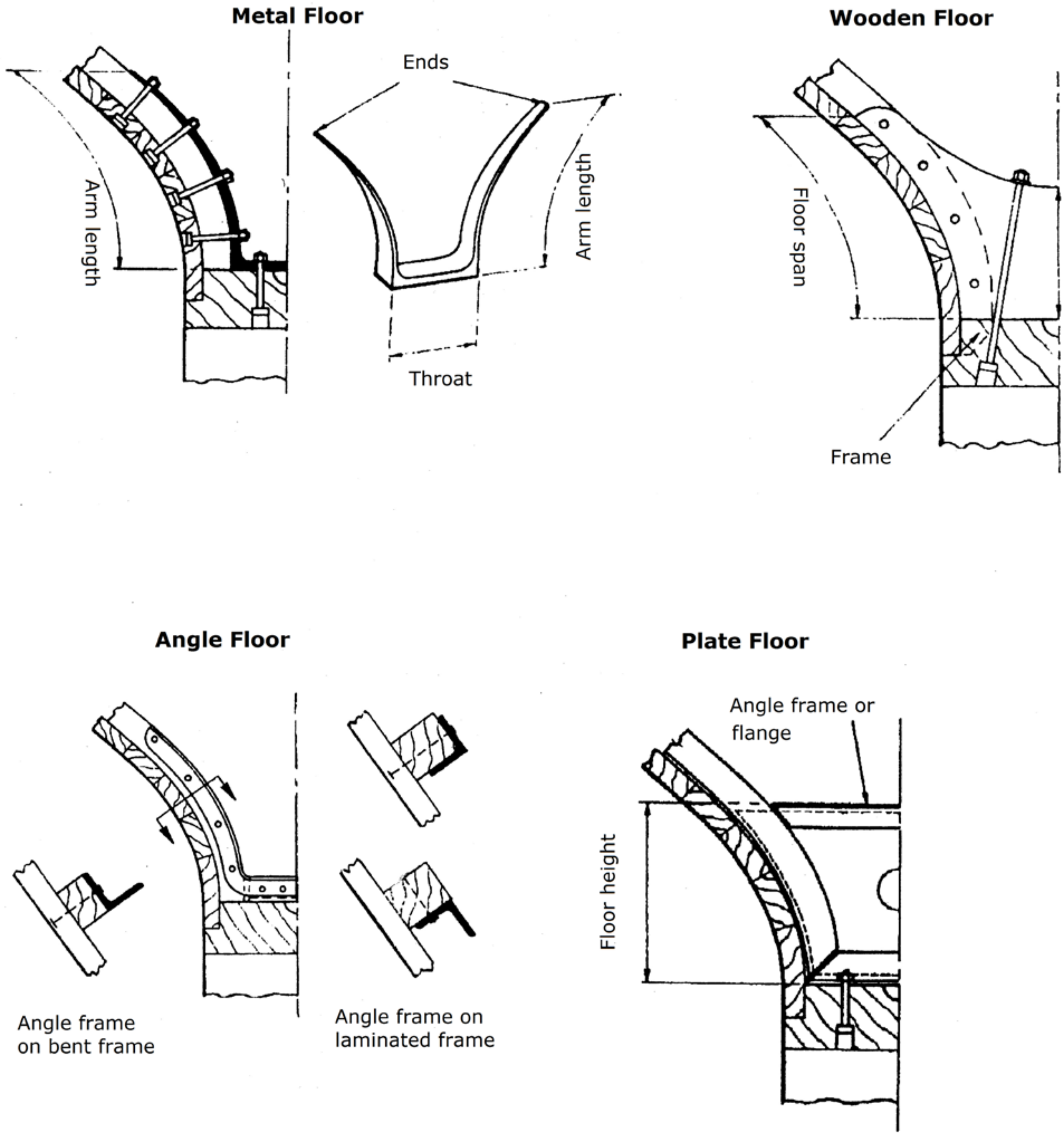


Figure 3.6 Sailing Yachts – Typical Floors

E. Structural Scantlings of Motor Yachts

1. General

The scantlings in this Section apply to yachts of length L ≤ 35 metres with a chine hull of the type shown in Figure 3.7 and Figure 3.8 and speed not exceeding 40 knots.

For yacht which differ substantially from the above as regards dimensions and/or speed, or yachts with round keels, the scantlings are determined by equivalence criteria

2. Keel- Stempost

The minimum breadth of the keel and the aggregate cross-sectional area of keel and hog frame are given in Table 3.13. Such scantlings are to be maintained up to the stem end, while they may be reduced by 30% at the stern end.

Where they are made from a number of pieces, the keel and hog frame are to be scarfed.

The scarfs are to be 6 times the thickness and of hooked or tabled type, if bolted, or of plain type, if glued; the length may be reduced to not less than 4 times the thickness where the scarf is bolted and glued.

The keel scarfs are to be spaced not less than 1,5 metres apart from those of the hog frame.

Stempost scantlings are given in Table 3.13 and a typical stern frame is shown in Figure 3.9.

3. Transom

In chine hulls, the sternpost is replaced by a transom. The transom structure consists of a frame having profile parts with a cross-section not less than 120% of bottom frames, side frames or beams; moreover, the structure's vertical stiffeners, arranged in way of keel and bottom girders, are to have a cross-section with a height equal to that of the side frames and width increased by 50%.

The stiffeners above are generally to be spaced not more than 600 mm apart.

The thickness of transom planking is to be equal to that given in Table 3.14 (col. 2), with any modifications required in accordance with those specified for shell planking.

4. Floors and Frames

4.1 General

The ordinary framing of the hull is divided into three parts:

- Bottom frames, comprising those between the keel and the chine stringers;
- Side frames, comprising those between the chine stringers and the waterways;
- Beams.

The bottom frames, generally made of two pieces, one port and one starboard of the keel, are butted in way of the centerline and connected by means of a double plywood floor.

The side frames are in one piece connected to the bottom frames by means of double plywood brackets.

The beams are connected to the side frames by means of double plywood brackets.

4.2 Bottom and side frames

Frame scantlings are given in Table 3.15, where three different types of frames are considered:

When a frame and strong frame spacing other than that specified in the Table 3.15 is adopted, the section modulus of the frame is to be modified according to Section 3, D.4.2.

Type I : Solid or laminated frames, of constant scantlings throughout the length of the hull;

Type II : Solid or laminated frames, alternated with one or two bent frames. Only the former are connected by means of floors and brackets; the scantlings are as prescribed for Type I frames;

Type III : Solid or laminated frames, associated with bent longitudinals; this type of framing is to be associated with double-skin cross planking or cold moulded laminated multi-layer planking or, alternatively, with plywood planking.

4.3 Floors

The floors connecting bottom frames (see 4.1) are to have thickness equal to half that required for the latter, extend at the yacht's centreline to a height not less than twice that prescribed for the heel of such frames and overlap the frames by a distance not less than 2,5 times their depth so as to constitute an effective connection by means of glue and clenched bolts. The space between the two floors above the frames is to be fitted with a chock; alternatively, the frames may be shaped so as to have, at the centerline, a depth above the keel equal to that required for the heel of the frames. For floors, see Figure 3.8

4.4 Frame and beam brackets

The connection of bottom frames to side frames and of the latter to beams is to be achieved by means of double brackets similar to those described for floors, but overlapping both frames and beams by a distance not less than twice their respective depths (see Figure 3.11 and Figure 3.12).

The thickness of each of the double brackets is to be taken not less than half thickness of the frame used. For diameter and numbers of bracket connecting bolts, see D,7.2.

Table 3.13 Keel and Stempost

Length L [m]	Keel		Stempost		
	Minimum breadth [mm]	Cross-section of keel or keel and hog (1) [cm^2]	Width at heel and at head [mm]	Cross-section at heel [cm^2]	Cross-section at head [cm^2]
1	2	3	4	5	6
14	140	189	140	189	132
16	160	228	160	228	160
18	175	270	175	270	189
20	195	312	195	312	218
22	210	360	210	360	252
24	230	413	230	413	289
26	245	462	245	462	324
28	260	516	260	516	361
30	280	570	280	570	399

(1) *Where there is no hog frame, a reduction in keel area of 10% in respect of that prescribed may be permitted. A keel cross-section reduced such as to be not less than 0,85 of that given in col. 3 may be accepted provided that the difference is compensated by an increased cross-section of girders.*

Table 3.14 Shell and Deck Planking

Length L [m]	Shell planking: Transverse framing system [mm]	Shell planking: Longitudinal framing system [mm]	Weather deck planking [mm]	Deck of superstructures (quarterdeck, deckhouses, coachroofs, trunks) [mm]
1	2	3	4	5
14	21,5	17,5	21,5	17,5
16	25,0	21,0	25,0	19,0
18	27,0	24,0	27,0	21,0
20	29,0	25,0	29,0	21,0
22	31,0	27,0	31,0	21,0
24	32,0	28,5	32,0	21,0
26	34,0	30,0	34,0	21,0
28	36,0	32,0	36,0	21,0
30	37,5	33,5	37,5	21,0

Table 3.15 (a) Frames

Depth H [m]	Type I framing system (either grown, or laminated frames only)											Type II framing system (either grown or laminated frames with bent frames in between)				
	Spacing of web [mm]	Between keel and chine					Between chine and deck					Spacing between main frames depending on the application			Bent frames	
		Grown frames			Laminated frames		Grown frames			Laminated frames		1 bent frame [mm]	2 bent frames [mm]	3 bent frames [mm]	Width [mm]	Depth [mm]
		Width [mm]	Depth At heel [mm]	Depth At head [mm]	Width [mm]	Depth [mm]	Width [mm]	Depth At heel [mm]	Depth At head [mm]	Width [mm]	Depth [mm]					
1,9	237	24	60	54	24	47	24	50	44	24	43	410	520	590	26	17
2,1	255	26	72	65	26	56	26	60	55	26	51	446	540	620	30	19
2,3	270	28	82	75	28	61	28	70	63	28	56	460	570	640	31	20
2,5	288	30	96	88	30	71	30	81	74	30	65	490	590	670	33	22
2,7	305	32	112	102	32	82	32	93	84	32	75	515	620	695	34	23
2,9	322	35	127	116	35	93	35	103	90	35	85	560	650	730	36	25
3,1	340	39	140	127	39	104	39	117	108	39	94	590	690	770	38	27
3,3	355	44	148	135	44	113	44	122	110	44	103	620	725	800	40	30
3,5	375	50	162	148	50	125	50	131	115	50	114	-	-	-	-	-
3,7	390	55	178	162	55	135	55	143	123	55	125	-	-	-	-	-
3,9	408	60	200	182	60	157	60	156	130	60	143	-	-	-	-	-

Table 3.15 (b) Frames

Depth H [m]	Type III framing system (grown or laminated frames or bentwood longitudinals)															
	Spacing of web [mm]	Between keel and chine					Between chine and deck					Bent wood longitudinals				
		Grown frames			Laminated frames		Grown frames			Laminated frames		Spacing [mm]	Between keel and chine		Between chine and deck	
		Width [mm]	Depth At heel [mm]	Depth At head [mm]	Width [mm]	Depth [mm]	Width [mm]	Depth At heel [mm]	Depth At head [mm]	Width [mm]	Depth [mm]		Width [mm]	Depth [mm]	Width [mm]	Depth [mm]
1,9	470	25	69	58	25	46	25	48	44	25	43	210	33	20	33	17
2,1	510	27	83	70	27	55	27	58	54	27	50	225	37	23	37	19
2,3	540	29	97	82	29	62	29	68	65	29	56	240	39	25	39	20
2,5	570	31	113	96	31	70	31	79	74	31	65	255	41	27	41	22
2,7	610	34	130	110	34	82	34	91	82	34	74	270	43	28	43	23
2,9	640	37	148	126	37	92	37	104	94	37	84	285	45	30	45	25
3,1	680	41	160	136	41	103	41	112	106	41	93	300	48	33	48	27
3,3	710	46	176	150	46	112	46	122	110	46	103	315	50	36	50	30
3,5	750	52	192	163	52	124	52	135	115	52	113	330	53	39	53	33
3,7	780	58	208	176	58	135	58	146	122	58	123	345	55	42	55	36
3,9	820	62	232	197	62	156	62	160	129	62	142	360	58	45	58	39

5. Side girders and bottom longitudinals

On bottom frames, at least two continuous girders are to be fitted at each side, with a cross section not less than 30 cm^2 for $L \leq 14$ m, not less than 90 cm^2 for , $L \geq 20$ m and intermediate values for between 14 and 20 m.

For hulls with L>14 m, such girders, continuous over bottom frames, are to be connected to the bottom planking by means of chocks between frames, set on a bent longitudinal continuous through the floors and connected to the planking. The chocks and the bent longitudinal may be omitted, but in such case the bottom planking thickness given in Table 3.14 is to be augmented such as to achieve a cross section throughout the bottom increased by at least half that of the longitudinals.

A similar longitudinal but with a cross section reduced to 0,65 of those described above and not fastened to the planking is to be fitted on side frames of hulls with L > 14 m.

Such longitudinal may be omitted where Type III framing is adopted.

6. Beams

The arrangement of beams is generally to be carried out as follows:

- For hulls with Type I framing: beams on every frame;

- For hulls with Type II or III framing: beams in way of solid or laminated frames, with bracket connection and intermediate beams, without brackets, let into the shelf.

Beams are to have width equal to that of the frames to which they are connected and section modulus [cm^3], not less than:

$$W_1 = K_1 \cdot a \cdot s$$

At the ends of large openings, beams are to be fitted having a section modulus [cm^3], not less than:

$$W_2 = K_2 \cdot a \cdot s$$

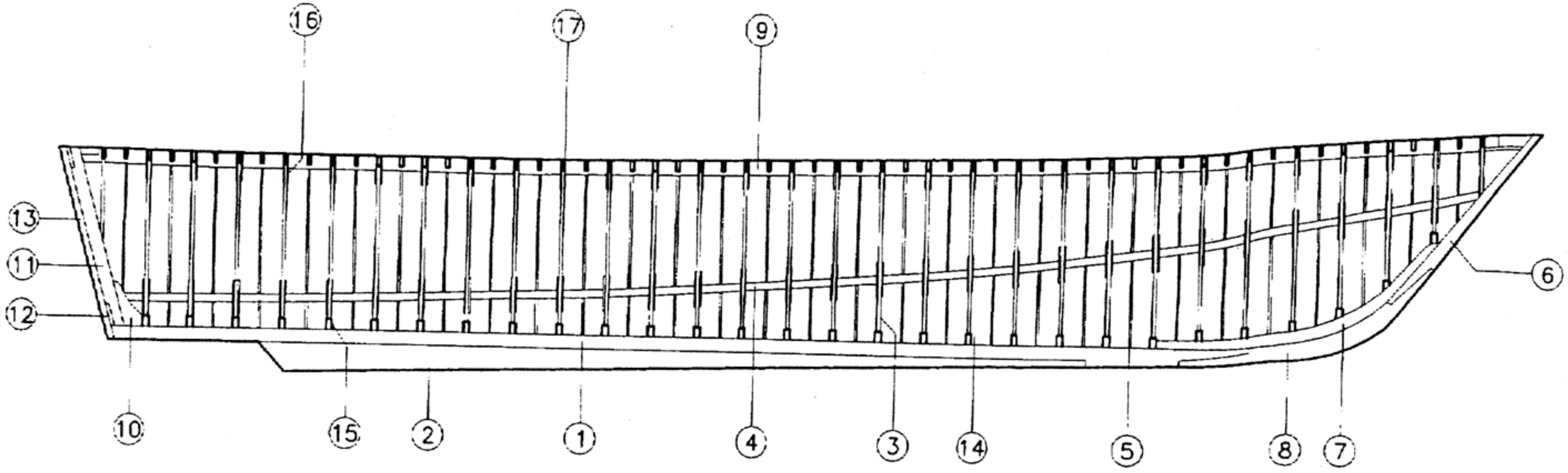


Figure 3.7 Motoryachts– Construction profile

1. Keel	**10.** Knee
2. Hog	**11.** Transom stiffener
3. Grown frame	**12.** Transom frame
4. Chine stringer	**13.** Transom planking
5. Bent frame	**14.** Chine knees
6. Stempost	**15.** Floors
7. Apron	**16.** Beam knees
8. Stem	**17.** Beams
9. Beam shelf	

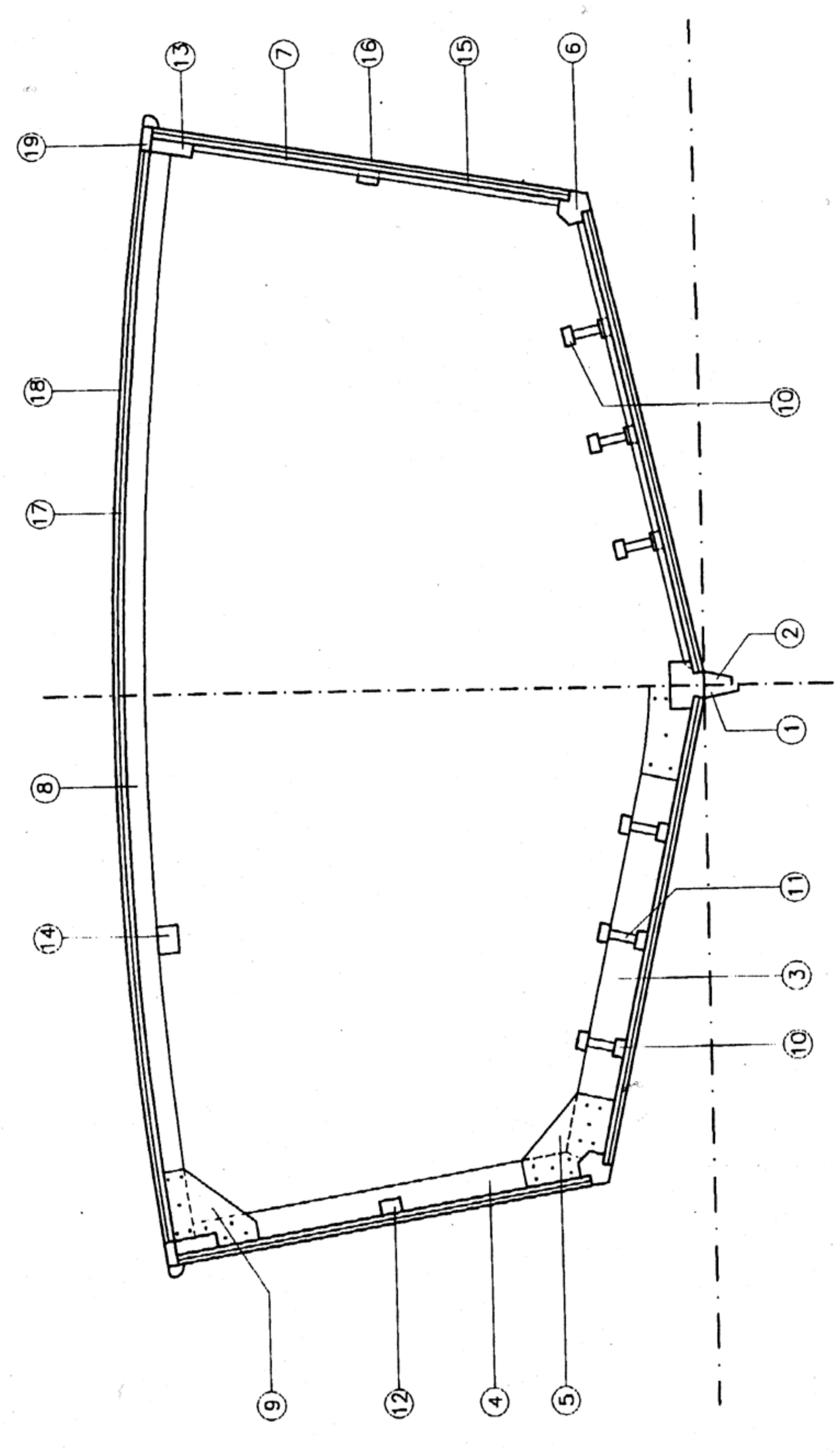


Figure 3.8 Motoryachts – Midship Section

1. Keel
2. Hog
3. Bottom frame
4. Side frame
5. Double knee
6. Chine
7. Bent frame
8. Beam
9. Double knee
10. Bottom dtringer
11. Deadwood
12. Side stringer
13. Beam shelf
14. Carling
15. Bottom and side planking-inner skin
16. Bottom and side planking-outer skin
17. Deck planking-inner skin
18. Deck planking-outer skin
19. Waterway

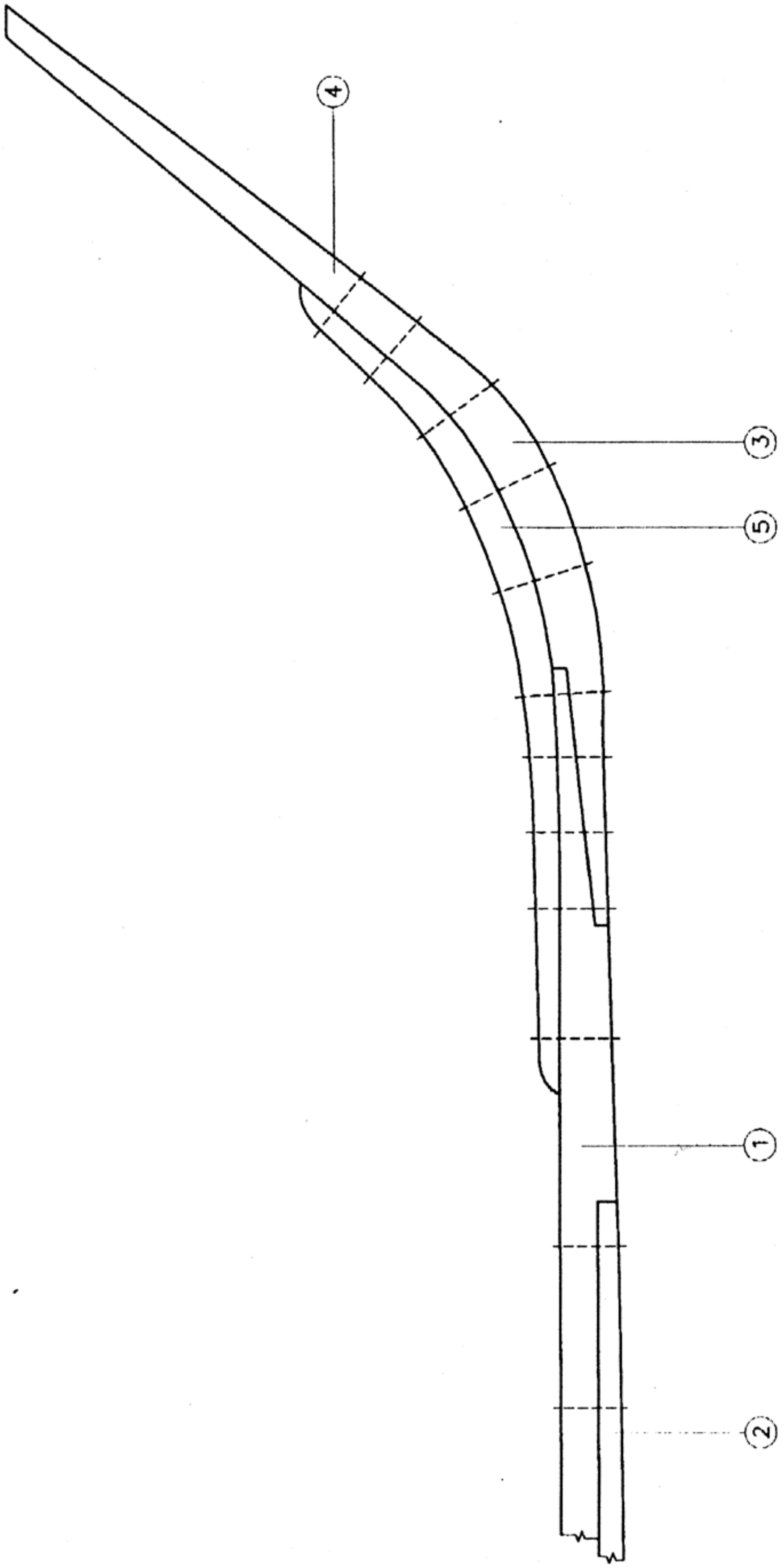


Figure 3.9 Motoryachts – Stem

1. Keel
2. Hog
3. Stem
5. Stempost
6. Apron

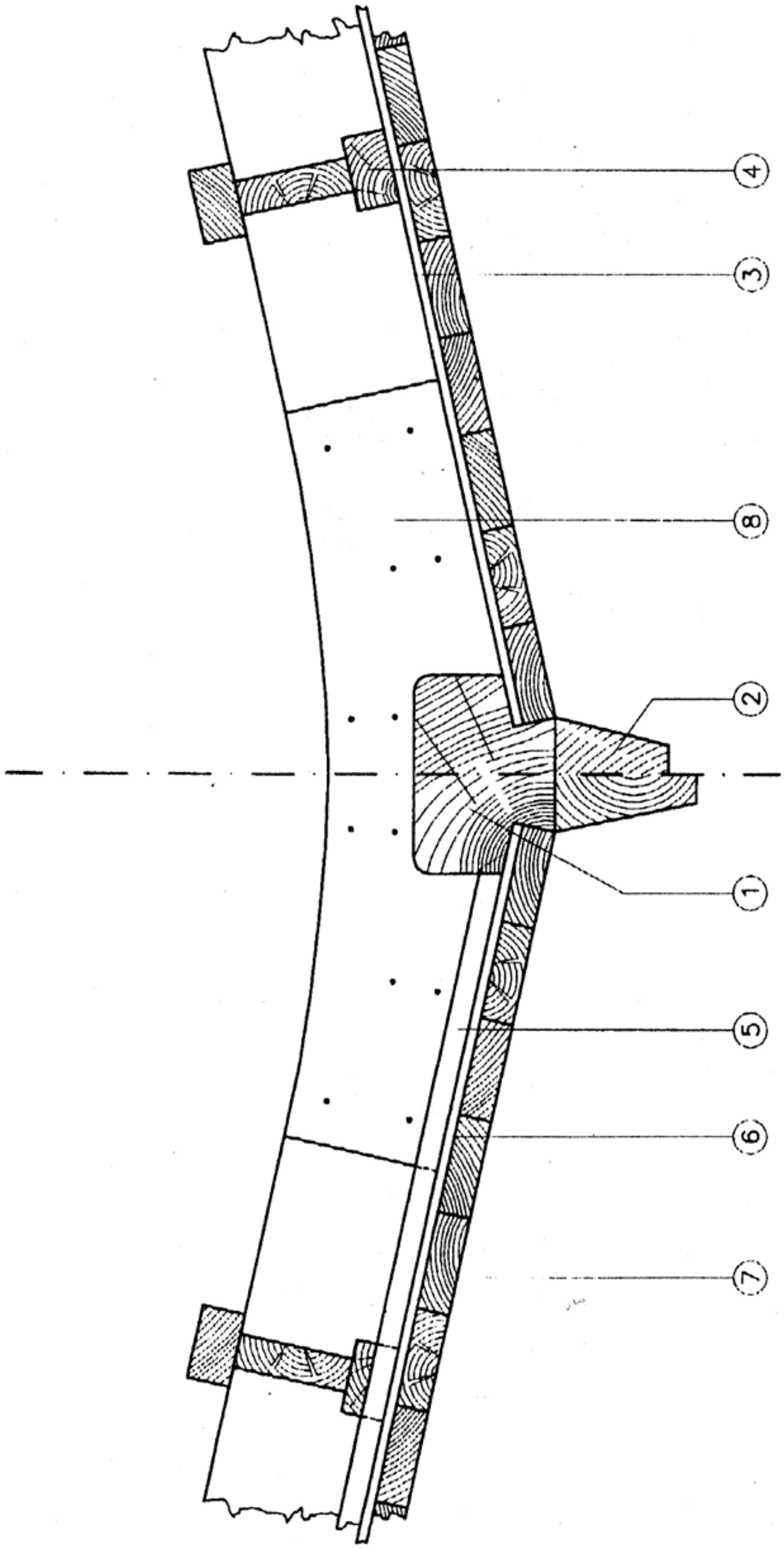


Figure 3.10 Motoryachts – Detail of floor

1. Keel
2. Hog
3. Bottom frame
4. Bottom stringer
5. Bent frame
6. Planking-inner skin
7. Planking-outer skin
8. Double floor

where:

W_1 and W_2 = section modulus of beams without planking contribution [cm^3]

a = width of beams [cm]

s = beam spacing [cm]

K_1, K_2 = coefficients given by Tab 3.16 as a function of the beam span.

Where laminated beams are arranged, the section moduli W_1 and W_2 may be reduced to 0,85 of those indicated above.

Table 3.16

Beam span [m]	Coefficient for calculation of beam section modulus			
	K_1		K_2	
	At the centreline	At the ends	At the centreline	At the ends
1,2	9,4	4,26	17,1	8,7
2,0	14,3	6,43	23,0	11,4
2,5	18,0	8,5	31,0	15,1
3,0	22,2	10,7	38,6	17,7
3,5	24,7	12,5	43,6	22,2
4,0	28,3	13,9	48,7	23,6
4,5	30,6	14,9	52,5	25,2
5,0	32,4	16,3	56,8	27,7
5,5	35,1	17,1	60,0	28,7
6,0	36,9	18,1	63,5	31,8
6,5	38,7	19,5	70,0	35,0
7,0	39,6	20,5	73,5	40,2
7,5	40,5	23,0	81,0	45,4

7. Beam shelves and chine stringers

The cross-sectional area of beam shelves and chine stringers is to be not less than that given by Table 3.17 below as a function of L and to have the ratio $b/a < 3$, where b is the depth and a the thickness of the bar.

The cross-section of shelves and stringers is to be considered as inclusive of the dapping for beam and frame ends.

8. Shell Planking

8.1 Thickness of shell planking

The basic thickness of shell planking is given in Table 3.14

If the frame spacing is other than that shown in Table 3.15, the planking thickness is to be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced:

- By 10% if a diagonal or longitudinal double-skin planking is adopted;

- By 15% if composite planking constituted by inner plywood skin and one or two outer longitudinal diagonal strakes is adopted;

- By 25% if laminated planking (i.e. at least three cold moulded layers) or plywood is adopted.

Moreover, the plywood thickness is to be not less than 30% of the total thickness or less than 6 mm.

Yachts with speed > 25 knots are to have bottom frames (floors and longitudinals) stiffened in respect of the scantlings in this Section and planking thickness increased as follows (for deadrise ≤ 25°) in respect of the values in Table 3.14:

- speed from 26 to 30 knots: 5%
- speed from 31 to 35 knots: 10%
- speed from 36 to 40 knots: 15%.

When the deadrise is between 25° and 30° and outer longitudinal strakes are fitted on the bottom planking, the above increase in thickness may be reduced but is generally to be no less than half of the percentage values above.

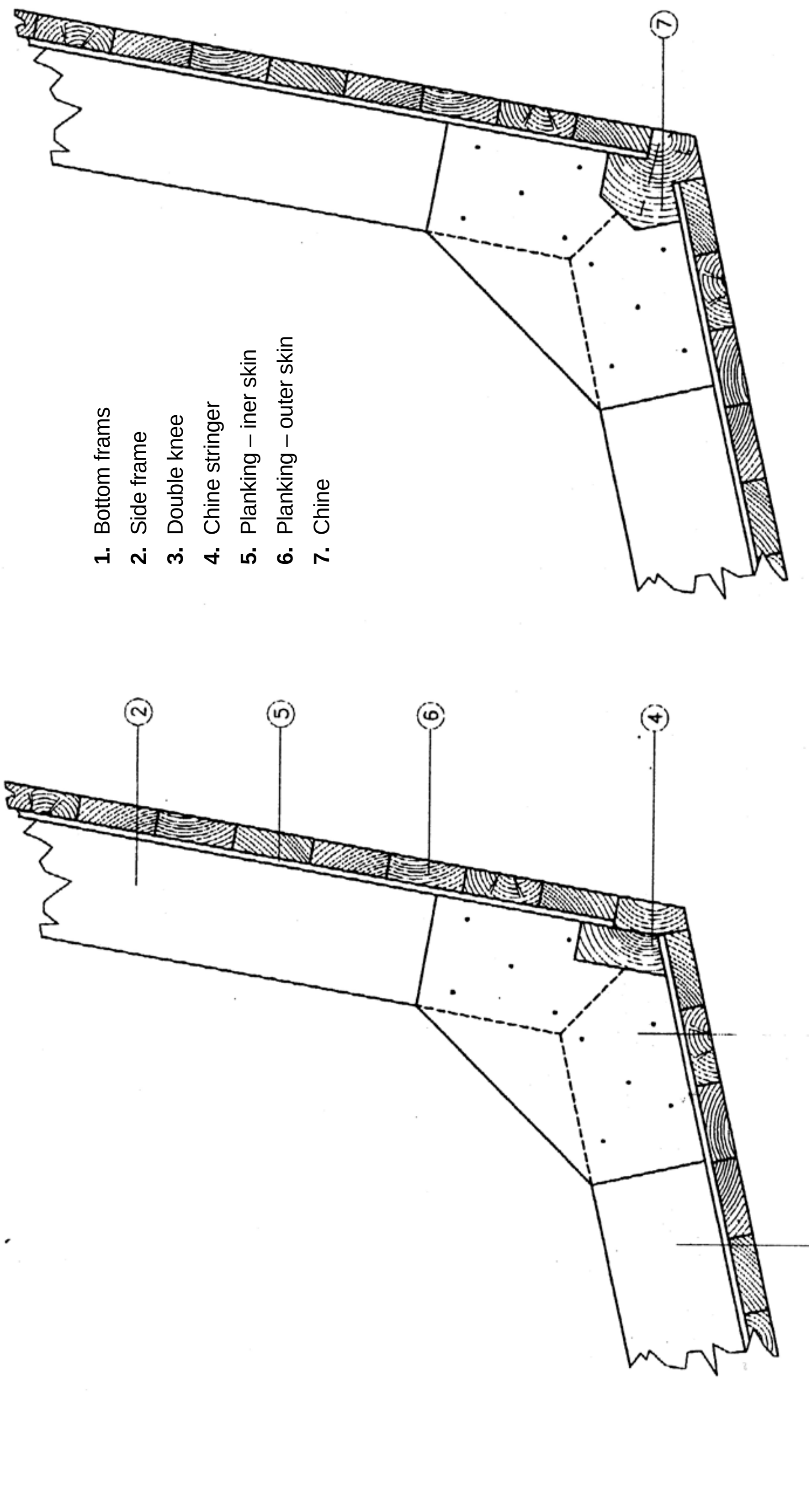


Figure 3.11 Motoryachs – Details of Chine

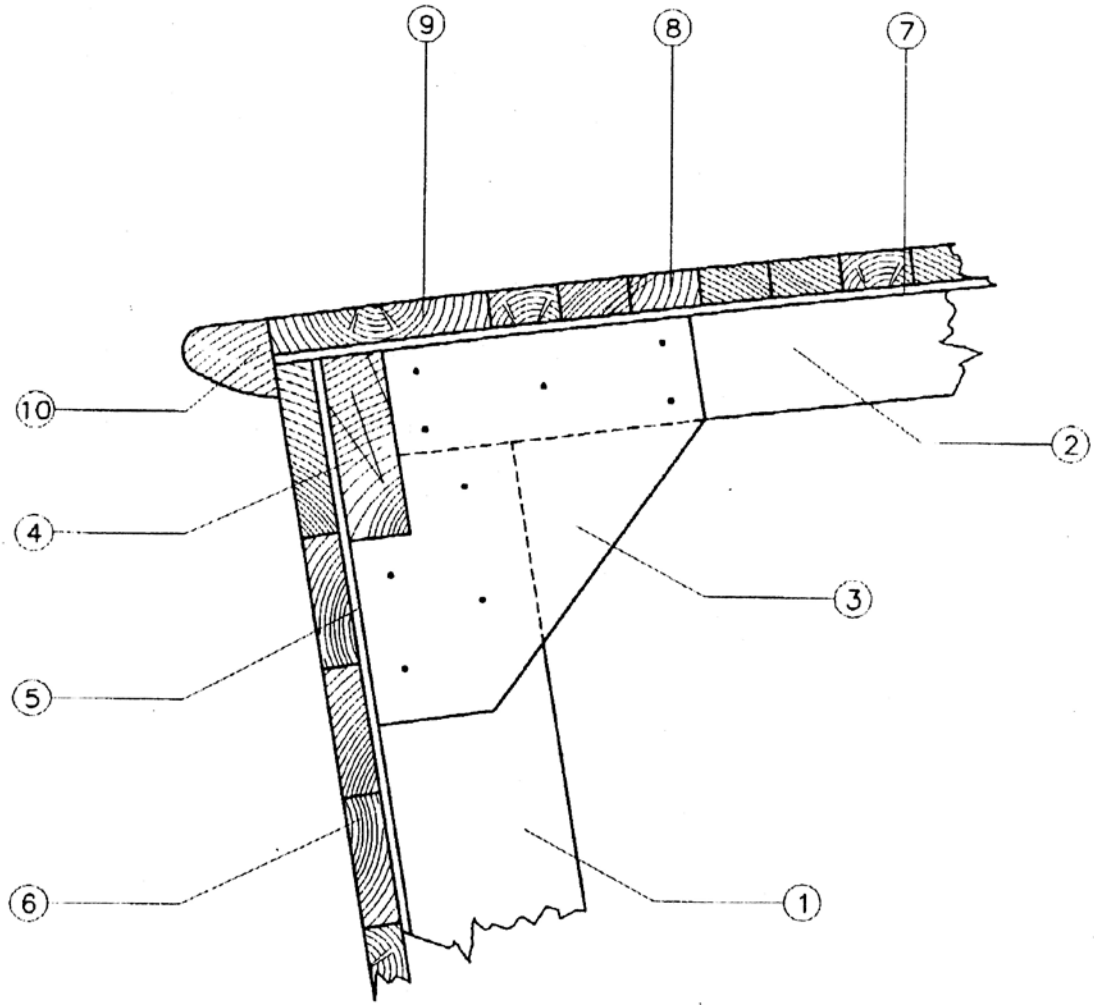


Figure 3.12 Motoryachts – Detail of Gunwale Connection

1. Side frame
2. Beam
3. Double knee
4. Beam shelf
5. Side planking-inner skin
6. Side planking-outer skin
7. Deck planking – inner skin
8. Deck planking-outer skin
9. Waterway
10. Rubbing piece

Table 3.17

Hull length L [m]	**Cross-sectional area of beam shelves [cm²]**	**Cross-sectional area of chine stringers [cm²]**
14	45	52
16	55	64
18	65	72
20	75	84
22	85	96
24	95	112
26	110	128
28	125	140
30	140	152
32	155	164
35	177	182

9. Deck planking

9.1 Weather deck

Deck planking may be constituted by planks flanked by a stringer board at side and by a king plank at the centerline. Such planking may be solely plywood or plywood with associated planking arranged as described above.

The thickness of deck planking is given in Table 3.14. If the beam spacing is other than that prescribed in Table 3.15, the planking thickness is to be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced as follows :

- by 30% if plywood or plywood associated with planking is employed.

Moreover, the plywood thickness is to be not less than 30% of the total thickness or less than 6 mm.

9.2 Superstructure decks

The thickness of planking of superstructure decks is given in Table 3.14. Such thickness is subject to the reductions and increases for weather deck planking as provided for in 9.1.

9.3 Lower deck

In hulls with depth, measured between the upper keel side and the weather deck beam, greater than or equal to 3,10 metres, a lower or cabin deck is to be arranged, with beams having a section modulus not less than 60% of that prescribed in item 6 for weather deck beams and effectively fastened to the sides by means of a shelf with a cross-sectional area not less than 2/3 of that required in Table 3.17.

When the depth, as measured above, exceeds 4,30 meters, the fastening of beams to side is to be completed by means of plywood brackets arranged at least at every second beam and having scantlings as prescribed in 4.4.

The scantlings of the deck planking are to be not less than those required in 9.2.

F. Watertight bulkheads, lining, machinery space

1. Wooden Watertight Bulkheads

Wooden watertight bulkheads are to be made of plywood with stiffener reinforcements.

1.1 Thickness of Bulkhead

Thickness of the bulkhead plating is to be not less than :

$$t = C \cdot a \cdot (h_1 \cdot k)^{1/2} \ \ [mm]$$

where ;

a = spacing of stiffeners [m],

h_1 = distance measured from bulkhead bottom edge to bulkhead deck [m],

k = 12 ; as standard value for teak, oak, sipo-mahogany,

= 16 ; as standard value for less firm wood, e.g. khaya-mahagoni, sound pine,

C = 4,0 ; in case of collision bulkhead,

= 2,9 ; for other bulkheads.

As regards the number of watertight bulkheads, attention is drawn to the provisions of Section 2.

The plywood, normally arranged in vertical panels, is to be scarfed or strapped in way of vertical stiffeners.
Connection to the hull is to be effected by means of a grown or laminated frame and made watertight by packing where necessary.

Glues for timber fastenings are to be of resorcinic or phenolic type, durable and water-resistant in particular.

1.2 Bulkhead Stiffeners

The section modulus of the stiffeners is not to be less than :

$$W = k \cdot C \cdot a \cdot (h_2 + 0,5) \cdot \ell^2 \quad [cm^3]$$

where ;

h_2 = distance measured from the centre of the stiffener up to the bulkhead deck [m],

ℓ = length of stiffener [m].

2. Steel Bulkheads

Steel watertight bulkheads are to be of thickness as shown in Table 3.18 as a function of the spacing of stiffeners and the height of the bulkhead.

The scantlings are given on the assumption that the lowest strake is horizontal and subsequent strakes vertical. When all strakes are horizontal, the thickness of the third and higher strakes may be decreased by a maximum of 0,5 mm per strake so as to reach a reduction of 25%, in respect of the Table thickness, for the highest strake.

If the spacing is other than that shown in the Table, the thickness is to be modified by 0,5 mm for every 100 mm of difference in spacing.

The spacing of vertical stiffeners is not to exceed 600 mm for the collision bulkhead.

The scantlings of vertical stiffeners, without end connections, are to be not less than:

$$W = (4,2 + 4H) \cdot s \cdot S^2 \quad , \quad [cm^3]$$

where:

W = section modulus of vertical stiffener with associated strip of plating one spacing wide [cm^3]

H = distance from midpoint of stiffener to top of bulkhead [m]

s = spacing of vertical stiffeners [m]

S = aggregate span of vertical stiffeners [m].

The connection of the bulkhead to planking is to be effected on grown or laminated frames, and provided with watertight packing where necessary.

Bulkheads are to be caulked or made watertight by means of suitable gaskets. On completion, any watertight bulkheads and doors are to be tested using a strong jet of water.

3. Internal Lining of Hull and Drainage

Where ceilings or internal linings are arranged, they are to be fitted so as to be, as far as practicable, easily removable for maintenance and painting of the underlying structures. Linings are to allow sufficient ventilation of air spaces between them and planking.

Limber holes are to be provided in the bottom structures such as to allow the drainage of bilge liquids into suction wells.

4. Machinery Space

The scantlings of floors, web frames and foundation girders are to be adequate for the weight, power and type of machinery; their suitability and that of associated connections is to be satisfactory with particular regard to engine running and navigation tests when required by these rule.

Table 3.18 Watertight Steel Bulkheads

Height of bulkhead [m]	Spacing of vertical stiffeners [mm]	Thickness of lower strake [mm]	Thickness of other strakes [mm]
1,60	310	3,0	2,5
1,80	325	3,0	3,0
2,00	340	3,5	3,0
2,20	360	4,0	3,5
2,40	375	4,0	3,5
2,60	390	5,0	4,5
2,80	410	5,0	4,5
3,00	425	5,5	5,0
3,20	440	5,5	5,0
3,40	460	5,5	5,0
3,60	475	6,0	5,5
3,80	490	6,0	5,5
4,00	510	6,0	5,5
4,20	525	6,0	5,5
4,40	540	6,5	6,0
4,60	560	6,5	6,0
4,80	575	6,5	6,0
5,00	590	6,5	6,0

SECTION 4

HULL CONSTRUCTION – FIBER REINFORCED PLASTIC HULLS

Page

A. General Requirements

1. Field of Application

Requirements in this Section applies to monohull yachts with a hull made of composite materials and a length L not exceeding 60 m, with motor or sail power with or without an auxiliary engine.

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

In the examination of constructional plans, **TL** 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 **TL**, on the basis of direct test calculations of the structural strength.

2. Definitions and Symbols

2.1 General

The definitions and symbols in this item are valid for all the sections.

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

γ_r = density of the resin standart value = 1,2 [gr/cm^3],

γ_v = density of the fibres, standard value for glass fibres = 2,56 [gr/cm^3],

p = mass per area of the reinforcement of a single layer [gr/m^2],

q = total mass per area of a single layer of the laminate [gr/m^2],

$g_c = p/q$ = Content of reinforcement in the layer; for in glass fibre the most frequent maximum values of g_c 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 [gr/m^2],

Q = total mass per area of the laminate excluding the surface coating of resin [gr/m^2],

$G_c = P/Q$ = 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 the case of glass reinforcements such thickness is given by [mm];

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

p being expressed in [kg/m^2] .

t_F = Σ t_i = total thickness of the laminate[mm].

2.3 Definitions

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 fibrereinforcements, 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

List of plans to be submitted to **TL** for approval is given in Section 1, A.2.2.2.

The above-mentioned plans are also to contain the relative lamination details, the percentage, in mass, of the reinforcement, the type of resin, core materials 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, is to be sent with the initial submission of the plans.

4. Direct Calculations

As an alternative to those based on the formulae in this Section, scantlings may be obtained by direct calculations carried out in accordance with the provisions of Section 2. Section 2 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 Table 4.1. 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.

5. General Rules for Design

5.1 General

The hull scantlings required in this Section are in general to be maintained throughout the length of the hull. For yachts with length L greater than 25 m, reduced scantlings may be adopted for the fore and aft zones.

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

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

For high speed hulls, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

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

Table 4.1

Member	Allowable stresses	
	1	2
Bottom plating	0,4 σ	0,8 σ
Side plating	0,4 σ	0,8 σ
Deck plating	0,4 σ	0,8 σ
Bottom longitudinals	0,6 σ_t	0,9 σ_t
Side longitudinals	0,5 σ_t	0,9 σ_t
Deck longitudinals	0,5 σ_t	0,9 σ_t
Floors and girders	0,4 σ_t	0,8 σ_t
Frames and reinforced side stringers	0,4 σ_t	0,8 σ_t
Reinforced beams and deck girders	0,4 σ_t	0,8 σ_t

Note:

σ[N/mm^2]: the ultimate bending strength for single-skin laminates; the lesser of the ultimate tensile strength and the ultimate compressive strength for sandwich type laminates. In this case the shear stress in the core is to be no greater than 0,5 R_t, where R_t is the ultimate shear strength of the core material;

σ_t[N/mm^2]: the ultimate tensile strength of the laminate

For yachts L> 15 m, the thicknesses of the laminates of the various members calculated using the formulae in this section are to be not less than the values in Table 4.2 [mm].

Table 4.2

Members	**Single-skin laminate**	**Sandwich laminate (1)**
Keel, bottom plating	5,5	4,5 / 3,5
Side plating	5	4 / 3
Inner bottom plating	5	4,5 / 3,5
Strength deck plating	4	3 / 2
Lower deck plating	3	2 / 2
Subdivision bulkhead plating	2,5	2 / 2
Tank bulkhead plating	4,5	4 / 3
Side superstructures	2,5	2 / 2
Front superstructures	3	2,5 / 2,5
Girders-floors	-	2 / 2
Any Stiffeners	-	2 **(2)**

(1) *The first value refers to the external skin, the second refers to the internal skin*

(2) *Intended to refer to the thickness of the layers encapsulating the core*

The minimum values shown are required for laminates consisting of polyester resins and glass fibre reinforcements.

For laminates made using reinforcements of fibres other than glass (carbon and/or aramid, glass and aramid), lower minimum thicknesses than those given in Table 4. 2 may be accepted on the basis of the principle of equivalence. In such case, however, the thickness adopted is to be adequate in terms of buckling strength.

5.3 Section Moduli and Geometric Properties of the Stiffening Elements

5.3.1 The section moduli of the stiffening elements (stiffener, floor, frame, etc.) are to be calculated directly from the profile dimensions and the effective width of plating.

5.3.2 The effective width of the connected laminate plate is measured from centre to centre of the unsupported panels adjoining the stiffener. It shall not exceed 300 mm.

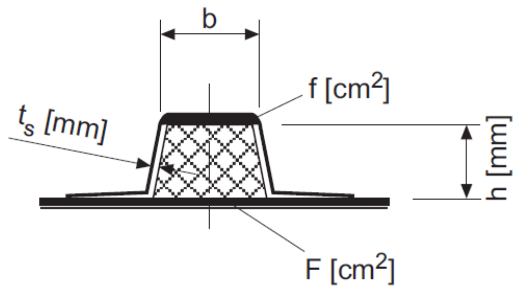
5.3.3 The section modulus of stiffener and connected laminate plate is calculated from the following formula :

$$W = \frac{f \cdot h}{10} + \frac{t_s \cdot h^2}{3000} \cdot \left(1 + \frac{100 \cdot (F - f)}{100 \cdot F + t_s \cdot h}\right) \quad [cm^3]$$

ts = thickness of an individual webı [mm]

5.3.4 Where the glass content of laminate by weight is Ψ = 0,30, the minimum thickness of the web may not be less than:

$t_{smin} = 0{,}025 \cdot h + 1{,}10$ [mm]



5.3.5 Where the glass content by weight Ψ of the stiffener's web laminate differs from 0,30, the thick-ness determined from 5.3.4 is to be divided by the value K_S.

$Ks = 1{,}30 \cdot \Psi + 0{,}61$

5.3.6 Should the tensile properties of the materials in the stiffener differ from those of the laminate plate, the effective tensile modulus of the stiffener in conjunction with the laminate plate is to be determined by correction of the cross-sectional area and/or the width of the various laminate layers in the stiffener in the ratio of the tensile modulus of each of the materials in the stiffener to that of the laminate plate.

5.3.7 Calculation of the laminate thicknesses to determine the section modulus of a top-hat type profile and connected plate

5.3.7.1 Thickness of the individual layer can be determined from the following formula:

$$t = 0.001 \cdot W \cdot \left(\frac{1}{\rho F} + \frac{1-\psi}{\psi} \cdot \frac{1}{\rho H} \right) \quad [mm]$$

W = weight per unit area of the reinforcing fibre [g/m^2]

ρ_F = fibre density (for glass reinforcement material = 2,6 [g/cm^3])

ρ_H = resin density (1,2 [g/cm^3] for PES)

Ψ **=** glass content of laminate by weight

6. Details of Construction

6.1 Principles of Building

6.1.1 Definitions

The stiffeners with the lowest spacing are defined in this Section 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 is to give some recommended structural details. However, they do not constitute a requirement; different details may be proposed by builders

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

- in areas with change of stiffener framing,

- in areas with large change of strength,

- at connections of ordinary and primary stiffeners.

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

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

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

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

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

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

Bulkheads and other important reinforcing elements are to be connected to the adjacent structure by corner joints (see Figure 4.1) 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 Figure 4.1.

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 **TL.**

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 Figure 4.2.

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 Figure 4.3.

a) Deck-Side Shell Connection

This connection is to be designed both for the bending stress shown in Figure 4.4, caused by vertical loads on deck and horizontal loads of seawater, and for the shear stres 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.

Figure 4.5 to Figure 4.8 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.

Figure 4.9 and Figure 4.10 give possible solutions. The scantlings of bonding angles are determined according to the loads acting upon the connections.

c) Passages Through Hull

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

Figure 4.11 to Figure 4.13 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 ship.

Figure 4.14 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.

Figure 4.15 gives an example of possible seating.

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/m2 laminated with vinylester resin; a flame-retardant or self-extinguishing polyester resin, having a thickness of not less than 1,5 mm, with a low deflection at high temperature may be accepted.

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

6.3 Tanks for Liquids

6.3.1 Structural tanks are to be intended to contain fuel oil or lube oil. No integral tanks are to contain gasoline. Integral tanks may be of single-skin laminates and sandwich construction.

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

- the final ply of the laminate is to be covered with fibreglass chopped strand mat of heavy weight (at least 600 gr/m2). 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 gelcoat 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 Section 2,E., or to the overflow pipe, whichever is the greater.

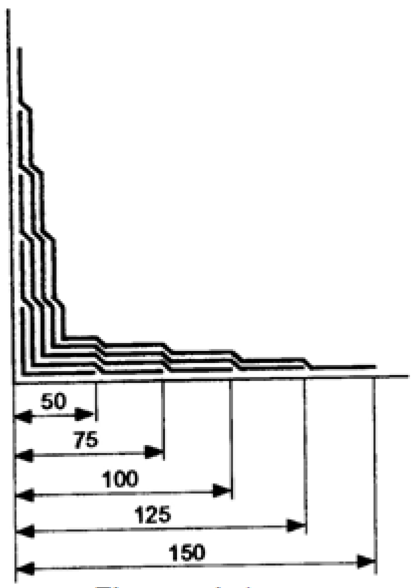


Figure 4.1

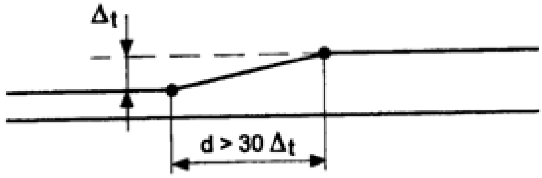


Figure 4.2

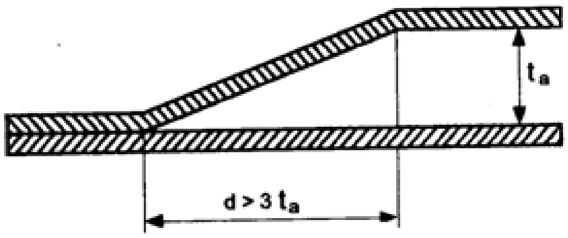


Figure 4.3

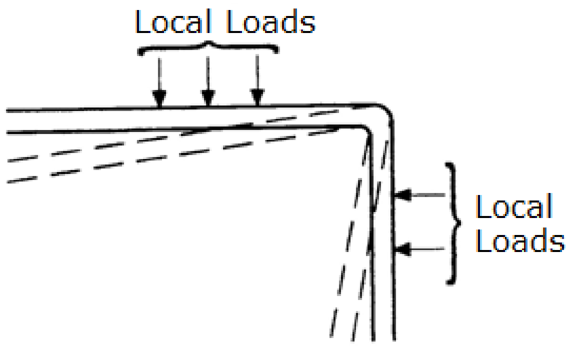


Figure 4.4

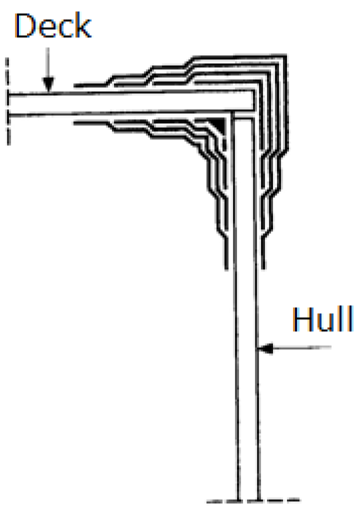


Figure 4.5

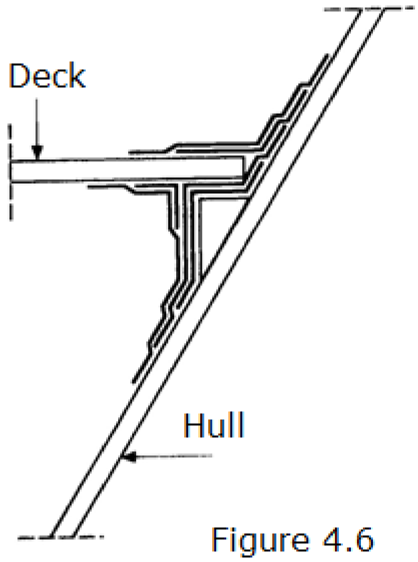


Figure 4.6

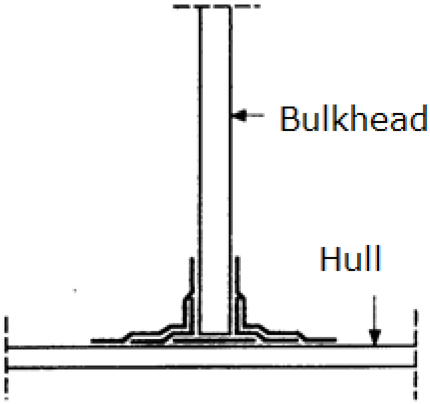
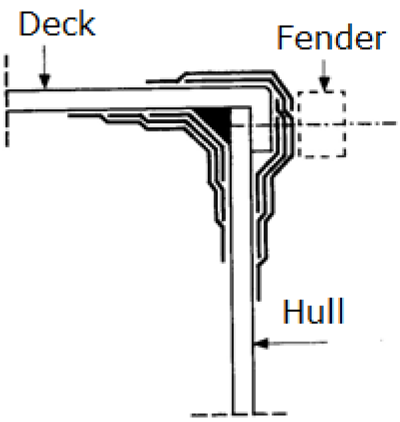


Figure 4.9



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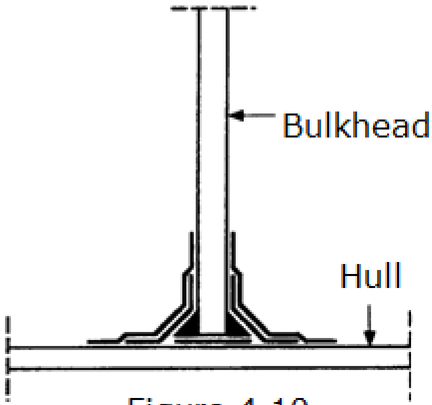

Figure 4.10

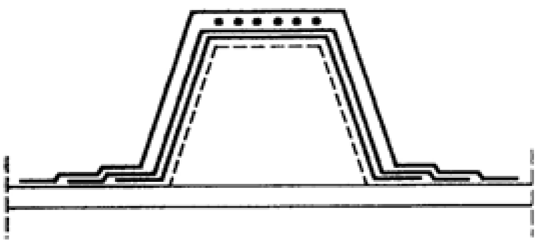
Figure 4.11

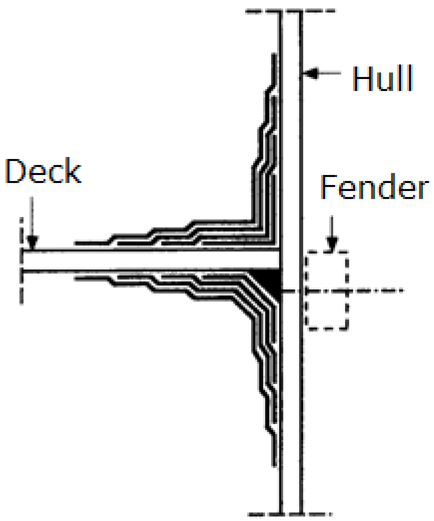

Figure 4.8

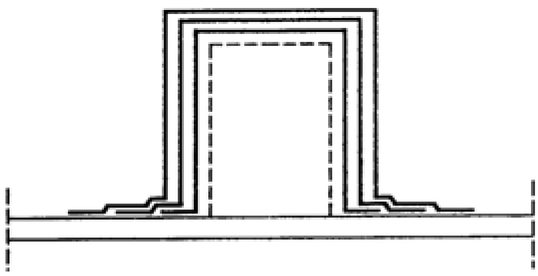
Figure 4.12

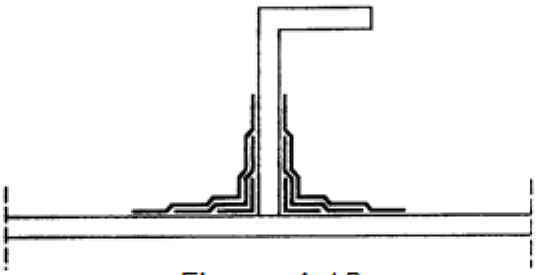

Figure 4.13

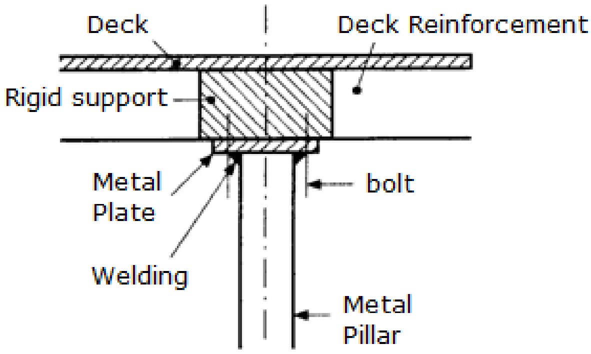

Figure 4.14

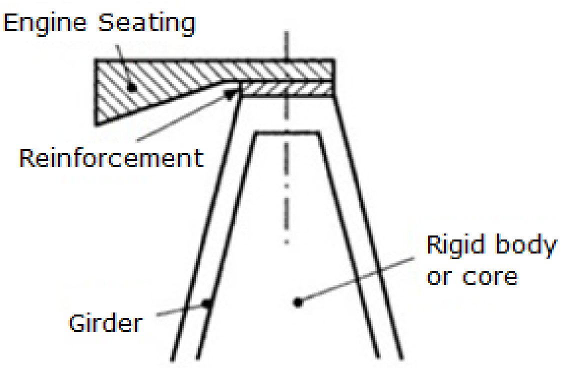

Figure 4.15

At the discretion of **TL**, leak testing with an air pressure of 0,015 MPa may be accepted as an alternative, provided that it is possible, using liquid solutions of proven effectiveness in the detection of air leaks, to carry out a visual inspection of all parts of the tanks with particular reference to pipe connections.

B. Materials

1. General

The basic laminate considered in this Section is composed of an unsaturated resin, in general polyester, and of glass fibre reinforcements in the form of mat alternated with woven roving.

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

Laminates having a different composition or special systems of lay-up will be considered 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. **TL** reserve the right to carry out special controls based upon the information given to itself.

2. Definitions

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 pre-determined 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 paralel fibres in the direction of weft and warp (0°, 90°) and in two oblique directions (+ 45°).

3. Materials of laminates

3.1 Resins

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 3.5.

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.

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

3.1.1 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 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.
- 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.
- 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.

3.1.2 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.

3.2 Reinforcements

3.2.1 General

The reinforcements taken into consideration in these Section 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.

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n any event, the manufacturing process is to be approved in advance by **TL**, 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 **TL** which will stipulate the conditions for their acceptance.

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 3.5.

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 fibre

Reinforcements in aramid type fibres are generally used in the form of roving or cloth of different weights (g/m2).

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 The materials considered in these requirements are rigid expanded foam plastics and balsa wood. The use of other materials will be taken into consideration on a case-by-case basis by **TL**, 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 (PU) and polyvinyl chloride (PVC).

These materials, just as 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, be compatible with the resins of the laminates. .

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

Table 4.3. 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.

3.4 Adhesive and sealant material

These materials are to be accepted by **TL** before use.

Table 4.3

Material	**Density [kg/m^3]**	**Minimum tensile strength [N/mm^2]**
Balsa	104	1,6
	144	2,5
Polyvinyl chloride (PVC) Cross-linked	80	0,9
	100	1,4
PVC, linear	80-96	1,2
Polyurethane	90	0,5

3.6 Plywood

Plywoods using for structural application is to be approved marine plywood by **TL**.

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

The use of timber is subject to special consideration by **TL.**

3.7 Repair compounds

Materials used for repairs are to be accepted by **TL** before use. Depending on the proposed uses, **TL** may require some tests.

3.8 Type approval of materials

Recognition by **TL** 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 **TL** requirements..

Table 4.4 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 of laminates made with reinforcements of "E" type glass fibre may be obtained from the formulae given in Table 4.5 as a function of G_C of the laminate as defined in A.2.2.

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 of the above-mentioned Table.

Laminates with reinforcements of fibres other than glass, described in 3.2, are to have mechanical properties that are in general greater than or at least equal to those given in Table 4.5. **TL** reserves the right to take into consideration possible laminates having certain properties lower than those given in Table 4.5, and will establish the procedures and criteria for approval on a case-by-case basis.

The scantlings indicated in this Section 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.

Table 4.4

	Specific gravity	Tensile modulus of elasticity [N/mm²]	Shear modulus of elasticity [N/mm²]	Poisson's ratio
E Glass	2,56	69 000	28 000	0,22
S Glass	2,49	69 000	**(1)**	0,20
R Glass	2,58	**(1)**	**(1)**	**(1)**
Aramid	1,45	124 000	2800	0,34
LM Carbon	1,80	230 000	**(1)**	**(1)**
IM Carbon	1,80	270 000	**(1)**	**(1)**
HM Carbon	1,80	300 000	**(1)**	**(1)**
VHM Carbon	2,15	725 000	**(1)**	**(1)**

(1) *Values supplied by the Manufacturer and agreed upon with TL prior to use.*

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. below.

The mechanical properties are to be ascertained from tests on samples taken preferably from the hull or, alternatively, having the same composition and prepared during the lamination of the hull.

Tests are to be carried out at the time of the construction of the first vessel to be classed by **TL** and on completion of the ascertainments of the suitability of the shipyard as given in C.

The tests are to be repeated periodically at the request of **TL** and in the case of the use of special manufacturing processes for the laminates differnt from those used previously.

Mechanical tests are also to be required when reduction coefficients used for scantlings are lower than those obtained by calculating the values of the mechanical properties with the formulas in Table 4.5.

4.1.2 Mechanical Properties of Carbon Fibre Laminates

For carbon fibre laminates the following mechanical properties indicated in Table 4.6 may be assumed.

The properties in Table 4.6 are reserved for hand laminated, woven roving and crossplied 0/90° reinforcement high strengh carbon fibre.

For unidirectional reinforcement the mechanical properties in Table 4.7 are to be considered

The glass content G_C may be assured according to the Table 4.8.

$$Q = \frac{\text{Total mass of mat}}{\text{Total mass of glass in laminate (mat + wowen roving)}}$$

The total thickness [mm] of the laminate may be calculated by the following formula:

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

Where Q is the mass per square meter [kg/m²].

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

$$G_c = \frac{q_1 + q_2 + q_3 + \ldots\ldots + q_n}{\frac{q_1}{g_{c1}} + \frac{q_2}{g_{c2}} + \frac{q_3}{g_{c3}} + \ldots\ldots + \frac{q_n}{g_{cn}}}$$

where;

q = The mass of the single ply [kg/m²]

g_c = Glass content of the single ply.

4.2 Coefficient Relative to the Mechanical Properties of Laminates

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 section 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 [N/mm^2], of the ultimate tensile and flexural strengths of the laminate. Such values may be calculated with the formulae in Table 4.5 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 **TL** on the basis of the results of tests carried out.

For laminates of sandwich type structures the coefficient is given by the formula:

$$k'_{of} = \left(\frac{85}{R_m}\right)^{0,5}$$

Where R_m is the ultimate tensile strength of the surface laminate [N/mm^2].

C. Construction and Quality Control

1. Shipyards or Workshops

1.1 General

Shipyards or workshops for hull construction are to be suitably equipped to provide the required working environment according to these requirements, which are to be complied with for the recognition of the shipyard or workshop as suitable for the construction of hulls in reinforced plastic. This suitability is to be ascertained by a **TL** Surveyor.

However, 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 **TL** Rules, so as to ensure a consistent level of quality, the shipyard or workshop may obtain from **TL** 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. 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

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 **TL** 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

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.

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

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 **TL** 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

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 **TL**.

2.2 Moulds

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.

Table 4.5

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

Table 4.6

Mechanical properties	[N/mm²]
E = Tensile module of elasticity (0° or 90° direction)	$75000 \cdot G_c – 6730$
R_m = Ultimate tensile strength (0° or 90° direction)	$740 \cdot G_c – 65$
R_{mc} = Ultimate compressive strength (0° or 90° direction)	$460 \cdot G_c – 40$
R_{mf} = Ultimate flexural strength	$R_{mf} = \dfrac{2{,}5\,R_m}{\left(1+\dfrac{R_m}{R_{mc}}\right)}$
R_{mti} = Ultimate interlaminar shear strength	35 MPa

Table 4.7

Mechanical properties	Parallel to the fibres	Perpendicular to the fibres
E = Tensile module of elasticity	$151500 \cdot G_c – 15750$	$8025 \cdot G_c^2 – 3150 \cdot G_c + 3300$
R_m = Ultimate tensile strength	$1500 \cdot G_c – 150$	$38 \cdot G_c^2 – 15 \cdot G_c + 15$
R_{mc} = Ultimate compressive strength	$820 \cdot G_c – 82$	$1126 \cdot G_c^2 – 45 \cdot G_c + 45$
R_{mf} = Ultimate flexural strength	$\dfrac{2{,}5\,R_m}{\left(1+\dfrac{R_m}{R_{mc}}\right)}$	$\dfrac{2{,}5\,R_m}{\left(1+\dfrac{R_m}{R_{mc}}\right)}$
R_{mti} = Ultimate interlaminar shear strength	$230 \cdot G_c^2 – 180 \cdot G_c + 60$	$230 \cdot G_c^2 – 180 \cdot G_c + 60$

Table 4.8

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 rowing	0,40	0,28	0,50
Roving-mat combination	(0,46 – 0,18 · Q) – 0,08	(0,35 – 0,11 · Q) – 0,08	(0,56 – 0,22 · Q) – 0,08
Multidirectional fabric	0,41	0,30	0,50
Unidirectional fabric	0,46	0,32	0,57

2.3 Laminating

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 **TL** 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. 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

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 **TL**, 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 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 TL 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.

2.6 Checks and Tests

2.6.1 Checks and tests are to be arranged during the lamination process by the hull builder by the presence of **TL** 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:

1- check of the mould before the application of the release agent and of the gel coat;

2- check of the thickness of the gel coat and the uniformity of its application;

3- check of the resin and the amount of catalyst, accelerator, hardener and various additives;

4- check of the uniformity of the impregnation of reinforcements, their lay-up and superimposition;

5- check and recording of the percentage of the reinforcement in the laminate;

6- check carried out during placing the core material to sandwich structure;

7- check carried out before placing the stiffeners

8- checks of any post-hardening treatments;

9- general check of the laminate before release from the mould;

10- check and recording of the laminate hardness before release from the mould;

11- 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;

12- mechanical tests on laminates taken from the hull or prepared during the lamination of the hull;

13- check of hull when released from the mould;

14- check during connection of hull and deck;

15- check before loading to sliding vehicle, if any.

The scope of lamination survey for certain lamination processses in closed mould (such as infusion lamination) is to be decided together with **TL** surveyor. But, in every case, special examinations are required for the following stages:

a) Before the application of lamination, during releasing the additive and gel-coat,

b) When dry reinforcement (layers and cores) are located on the mould,

c) Before application of lamination, during vacuum application for initial control and in conjunction with the following:

- Connection of vacuum bag
- Application of vacuum
- Vacuum/ leakage control

d) verifying and recording the followings during resin infusion:

- Waiting time
- Infusion time
- Vacuum level during infusion

e) Examining the result of lamination after removing the vacuum bag,

f) Before placing the stiffeners,

g) After releasing the hull from mould for final inspection,

h) When starting connection of hull and deck,

i) Before loading to sliding vehicle, if any.

Where the satisfactory records and internal control document has been submitted by the shipyard based on its internal quality control, the checks may be carried out directly by the shipyard without the presence of **TL** Surveyor

In addition, during checking of first vessel, for the purpose of verifying that the shipyard has equipped with adequate equipment, it carries out an examination to assure the quality of material used, production method and laminate quality.

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

As a rule, the above mentioned checks are to be carried out in the presence of **TL** surveyor. Where the shipyard has a system of production organisation and quality control certificate by **TL**, the checks may be carried out directly by the shipyard without the presence of **TL** surveyor.

2.6.2 Where ultrasonic thickness gauges are used, the relevant tools are to be calibrated against an identical laminate.

D. Longitudinal Hull Strength

1. General

The structural scantlings prescribed in this section are also intended as appropriate for the purposes of the longitudinal hull strength of a yacht having length L not exceeding 40 m 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 check of the longitudinal strength is required.

The means of such a check is to be stipulated by **TL** case by case in relation to the quality of the laminates and the lay out of the vessel.

2. Bending Stresses

2.1 General

In addition to satisfying the minimum requirements stipulated in the individual sections of these Rules, the scantlings of members contributing to the longitudinal strength of yachts 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:

$$\sigma_d \leq f \cdot \sigma_u$$

$$\sigma_g \leq f \cdot \sigma_u$$

where;

$$\sigma_d = \frac{M_T}{1000 \cdot W_d} \quad [\text{N/mm}^2]$$

$$\sigma_g = \frac{M_T}{1000 \cdot Wg} \quad [\text{N/mm}^2]$$

W_d, W_g = Section modulus at the bottom and the deck, respectively, of the transverse section [m^3].

M_T = Design total vertical bending moment defined in Section 2, E.

f = 0,33 for planing yachts.

= 0,25 for displacement yachts.

σ_u = the lesser of the values of ultimate tensile and ultimate compressive strength of the bottom and deck laminate [N/mm^2].

2.2 Moment of Inertia of the Midship Section

In order to limit the flexibility of the hull structure, the moment of inertia of the midship section [m^4], is to be not less than the value given by the following formulae:

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

$I = 230 \cdot M_T \cdot 10^{-6}$ for displacement yachts

2.3 Midship Section Modulus

Reference is to be made to Table 4.8 for plating and Table 4.9 for longitudinals for calculation of the midship section modulus.

Table 4.8

	Deck	Side shell	Bottom
Mean thickness [mm]	t_g	t_b	t_d
Young's modulus [N/mm^2]	E_g	E_b	E_d

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 is given by:

$$W_g = \frac{1}{E_g}\left[C \cdot P + \frac{C}{6} \cdot A\left(1 + \frac{F-P}{F+0{,}5 \cdot A}\right)\right] \cdot 10^{-3} \quad \left[m^3\right]$$

$$W_d = \frac{1}{E_d}\left[C \cdot P + \frac{C}{6} \cdot A\left(1 + \frac{F-P}{F+0{,}5 \cdot A}\right)\right] \cdot 10^{-3} \quad \left[m^3\right]$$

where;

$P = t_g \cdot B \cdot E_g + n_g \cdot (I_{gf} \cdot t_{gf} \cdot E_{gf} + t_{gg} \cdot H_{gg} \cdot E_{gg})$

$A = 2\,[t_b \cdot I_m \cdot E_b + n_b \cdot (t_{bf} \cdot I_{bf} \cdot E_{bf} + t_{bg} \cdot H_{bg} \cdot E_{bg})]$

$$F = t_d \cdot \frac{B}{2} \cdot E_d + n_d \cdot \left(I_{df} \cdot t_{df} \cdot E_{df} + t_{dg} \cdot H_{dg} \cdot E_{dg}\right)$$

t_g, t_b, t_d, E_g, E_b, E_d values defined in Table 4.8,

t_{gf}, t_{bf}, t_{df}, E_{gf}, E_{bf}, E_{df}, I_{gf}, I_{bf}, I_{df}, t_{gg}, t_{bg}, t_{dg}, E_{gg}, E_{bg}, E_{dg}, H_{gg}, H_{bg}, H_{dg}, n_g, n_b, n_d values defined in Table 4.9.

I_m, C values defined in Figure 4.16.

3. Shear Stresses

The shear stresses in every position along the length L are not to exceed the following allowable value:

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

Where;

T_t = Total shear stress defined in Section 2 [kN],

f = defined in 2,

τ = Shear stress of the laminate [N/mm^2],

A_t = actual shear area of the transverse section, to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings [m^2]

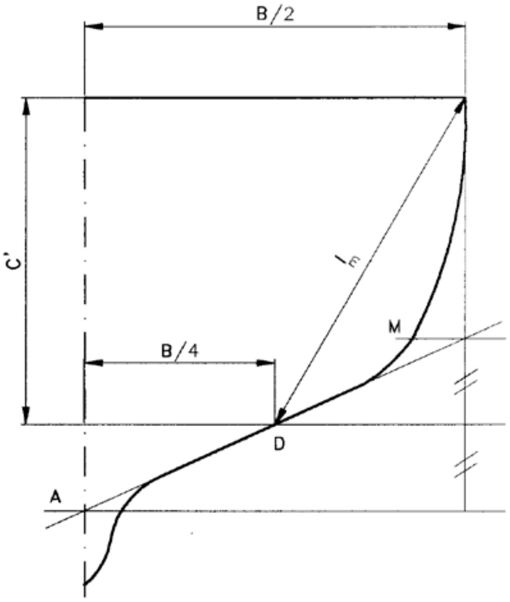

Figure 4.16

Table 4.9

		Deck	**Side shell**	**Bottom**
Flange	Mean thickness [mm]	t_{gf}	t_{bf}	t_{df}
	Young's modulus[N/mm^2]	E_{gf}	E_{bf}	E_{df}
	Breadth [mm]	I_{gf}	I_{bf}	I_{df}
Web	Equivalent thickness in Section I [mm]	t_{gg}	t_{bg}	t_{dg}
	Young's modulus [N/mm^2]	E_{gg}	E_{bg}	E_{dg}
	Height [mm]	H_{gg}	H_{bg}	H_{dg}
	Number of longitudinals	n_g	n_b	n_d

E. External Plating

1. General

Bottom and side plating may be made using both single-skin laminate and sandwich structure.

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

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

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

2. Definitions and Symbols

S = Larger dimension of the plating panel [m],

s = Spacing of the ordinary longitudinal or transverse stiffener [m],

p = Scantling pressure given in Section 2, E [kN/m^2],

k_{of}, k_o = Factors defined in B,4.2.

3. Keel

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

$$b_{CH} = 30 \cdot L$$

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

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

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

Appraising "s" dead rise angle ≥ 12° is considered as a stiffener

The thickness t_{CH} is to be gradually tapered transversally, 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, transversally, as indicated in Figure 4.2, 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 Figure 4.5 or in a similar way.

4. Rudder Horn

When the rudder is of the semi-spade type, such as TypeI I B shown in Section 2, Figure 2.1, the relevant rudder horn is to have dimensions and thickness such that the moment of inertia I [cm^4], and the section modulus W [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:

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

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

Where;

A = The rudder area acting on the horn [m^2],

h = the vertical distance [mm], from the skeg section to the lower edge of the pintle (rudder heel);

V = Maximum design speed of the yacht [knots].

5. Bottom Plating

The thickness of bottom plating is to be not less than the greater of the values t_1 and t_2 [mm] calculated by the following formulae:

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

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

Where;

k_1 = 0,26 (when assuming $p = p_1$)

= 0,15 (when assuming $p = p_2$)

k_a = Coefficient as a function of the ratio S/s given in Table 4.10.

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 150mm above the statical load waterline, whichever is the greater.

Table 4.10

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

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

In sailing yachts with or without auxiliary engine 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.

6. Sheerstrake Plating and Side Plating

6.1 Sheerstrake

A sheerstrake plate of height [mm] not less than 0,025 L and thickness tc [mm] not less than the value in the following formula is to be fitted:

$$t_c = 1{,}3 \cdot t$$

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

6.2 Side Plating

The thickness of side plating is to be not less than the greater of the values t_1 and t_2 [mm], calculated by the following formulae:

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

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

where k_1 ve k_a are as defined in 5.

7. Openings in the Shell Plating

7.1 Sea Intakes and Other Openings

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.

7.1.2 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.

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

8.3 The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements.

8.4 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 (for twin hull vessels)

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.

F. Single Bottom Structures

1. General

1.1 Scope

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 transversally (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

s = Spacing of ordinary longitudinal or transverse stiffeners [m],

p = Scantling pressure given in Section 2, E [kN/m^2],

k_o = Coefficient defined in B.4.2.

3. Longitudinal Type Structure

3.1 Bottom Longitudinals

The section modulus of bottom longitudinals is to be not less than the value W [cm^3] calculated by the following formula:

$$W = k_1 \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = 1,5 (assuming $p = p_1$)

= 1,0 (assuming $p = p_2$)

S = Span of the longitudinal stiffener equal to the distance between floors m].

3.2 Floors

The section modulus of the floors at the centreline of the span S, is to be not less than the value W_D [cm^3] calculated by the following formula:

$$W_D = k_1 \cdot b \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = 2,4 (assuming $p = p_1$),

= 1,2 (assuming $p = p_2$),

b = Half the distance between the two floors adjacent to that concerned [m],

S = Floor span equal to the distance between the two supporting members (sides, girders) [m].

In the case of a U-shaped keel or one with a dead rise ≤ 12^o but >8^o the span S is to calculated with regard to the distances between girders or sides. In this case, the modulus WD may 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 W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.2,

b_{MIO} = half the distance between the two side girders if supporting or equal to B/2 in the absence of supporting side girders [m],

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

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b'_{MIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.1,

b'_{MIO} = half the distance between the two side girders if present or equal to B/2 in the absence [m],

S = Distance between floors [m].

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 W_{YIO} [cm^3], calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.2,

b_{YIO} = Half the distance between the two adjacent girders or between the side and the girder concerned [m],

S = Conventional girder span equal to the distance between the two supporting members (transverse bulkheads, floors) [m].

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value W_{YIO} [cm^3], calculated by the following formula:

$$W_{YIO} = k_1 \cdot b'_{YIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.1,

b'_{YIO} = half the distance between the two adjacent girders or between the side and the adjacent girder [m],

S = Distance between the floors [m].

4. Transverse Type Structures

4.1 Ordinary Floors

The section modulus for ordinary floors is to be not less than the value W_D [cm^3], calculated by the following formula:

$$W_D = k_1 \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where:

k_1 = Defined in 3.1,

S = Span of the floor equal to the distance between the members which support it (girders, sides) [m].

4.2 Centre Girder

The section modulus of the centre girder is to be not less than the value W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.2,

b_{MIO} = Half of the distance between two supporting side girders, if any sider girders are fitted. If there are no side girders fitted, B/2 [m].

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

4.3 Side Girders

The section modulus is to be not less than the value W_{YIO} [cm^3] calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 3.2,

b_{YIO} = Half the distance between two adjacent girders or between the side and the girder adjacent to that concerned [m],

S = Girder span equal to the distance between the two members which support it (transverse bulkheads, floors) [m].

G. Double Bottom Structures

1. General

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

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.2 The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead of the machinery space, or as near thereto as practicable, is requested for yachts of L > 50 m.

1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.
The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of **TL**.

1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

The edges of the holes are to be suitably sealed in order to prevent the absorption of liquid into the laminate.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2. Minimum Height

The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value h_{db} obtained from the following formula:

$$h_{db} = 28 \cdot B + 32\,(T + 10)\ \text{[mm]},$$

The height of the double bottom is in any event to be not less than 700 mm.

For yachts less than 50 m in length, **TL** may accept reduced height.

3. Inner Bottom Plating

The thickness of the iner bottom plating is to be not less than the value calculated by the following formula:

$t_1 = 1{,}3\,(0{,}04\ L + 5\ s + 1) \cdot k_{of}$ for single-skin laminate

$t_1 = (0{,}04\ L + 5\ s + 1) \cdot k_{of}$ for sandwich laminate

Where;

S = Spacing of the ordinary stiffeners [mm],

k_{of} = Coefficient for the properties of the material defined in B.4.2.

For yachts of length L < 50 m the thickness is to be maintained throughout the length of the hull.

For yachts of length L > 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquid cargoes, the thickness of the top is also to comply with the provisions of J.

4. Centre Girder

A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness of the core of a sandwich type centre girder is to be not less than the following value:

$$t_c = (0{,}125\ L + 3{,}5) \cdot k_{of}$$

k_{of} is defined in B.4.2.

Where a single-skin laminate is used for the centre girder, the thickness is to be not less than twice that defined above.

5. Side Girders

5.1 Arrangement

Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

Watertight girders are to have thickness not less than that required in J. for tank bulkheads

5.2 Side Girders in Way of Engine Seatings

Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height no less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6. Floors

6.1 Thickness of Floors

The thickness of the core of sandwich type floors is to be not less than the following value:

$$t_d = (0{,}125\ L + 1{,}5)\ k_{of}$$

k_{of} is defined in B.4.2.

Where a single-skin laminate is used for floors, the thickness is to be not less than twice that calculated above.

Watertight floors are also to have thickness not less than that required in J. for tank bulkheads.

6.2 Arrangement

When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be arranged in longitudinally framed double bottoms in the following locations.

- under buklheads and pillars
- outside the machinery space at an interval no greater than 2 m
- in the machinery space under the bedplates of main engines
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7. Bottom and Inner Bottom Longitudinals

The section modulus of bottom stiffeners is to be no less than that required for single bottom longitudinals stipulated in F.

The section modulus of inner bottom stiffeners is to be no less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquid cargoes 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 J.

H. Side Structures

1. General

This item lays down the criteria for the scantlings of the reinforcement structures of the side hull which may be of longitudinal or transverse type.

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

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

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

2. Definitions and Symbols

s = Spacing of ordinary longitudinal or transverse stiffeners [m],

p = Scantling pressure defined in Section 2, E [kN/m²],

k_o = Factor defined in B 4.2.

3. Ordinary Stiffeners

3.1 Frames

The section modulus of the frames is to be not less than the value W_p [cm³] calculated by the following formula:

$$W_p = k_1 \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = 1,75 (assuming $p = p_1$)

= 1,10 (assuming $p = p_2$)

S = Frame span equal to the distance between the supporting members [m].

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 Side Longitudinals

The section modulus of the side longitudinals is to be not less than the value W_P [cm³] calculated by the following formula:

$$W_P = k_1 \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = 1,9 (assuming $p = p_1$)

= 1,0 (assuming $p = p_2$)

S = Span of the longitudinal equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkhead [m].

4. Reinforced Beams

4.1 Reinforced Frames

The section modulus of the reinforced frames W_{DP} [cm^3] is to be not less than the value calculated by the following formula:

$$W_{DP} = k_1 \cdot K_{DP} \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = 1,0 (assuming $p = p_1$)

= 0,7 (assuming $p = p_2$)

K_{DP} = 2,5 for reinforced frames which support ordinary longitudinal stiffeners, or reinforced stringers,

= 1,1 for reinforced frames which do not support ordinary longitudinal stiffeners,

s = Spacing between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned [m],

S = Span equal to the distance between the members which support the reinforced frame [m].

4.2 Reinforced Stringers

The section modulus of the reinforced stringers W_{DS} [cm^3] is to be not less than the value calculated by the following formula:

$$W_{DS} = k_1 \cdot K_{DS} \cdot s \cdot S^2 \cdot k_o \cdot p$$

Where;

k_1 = Defined in 4.1,

K_{DS} = 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 between the reinforced stringers or 0,5 H in the absence of other reinforced stringer or decks [m],

S = Span equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames [m].

I. Decks

1. General

This item 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 transversally 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 mast 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

hg = 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 ordinary transverse or longitudinal stiffeners [m],

h = Scantling height given in Section 2, E. [m],

k_o, k_{of} = Factor defined in B.4.2.

3. Deck Plating

3.1 Weather Deck

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 [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 [mm], not less than 25 L and thickness t [mm], not less than the value given by the formula:

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

Where;

k_a = Factor defined in E.5.

L_1 = Scantling length [m] to be assumed not less than 15 m.

3.2 Lower Decks

The thickness t [mm] of decks below the weather deck intended for accommodation spaces is to be not less than the value calculated by the formula:

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

k_a = Factor defined in E.5.

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

4. Stiffening and Support Structures for Decks

4.1 Ordinary Stiffeners

The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value W_{NT} [cm^3] calculated with the following equation:

$$W_{NT} = 14 \cdot s \cdot S^2 \cdot h \cdot k_{of} \cdot C_1$$

Where;

C_1 = 1,0 for weather deck longitudinals,

= 0,63 for lower deck longitudinals,

= 0,56 for beams.

4.2 Reinforced Beams

The section modulus for girders and for ordinary reinforced beams W_{DT} [cm^3] is to be not less than the value calculated by the following equation:

$$W_{DT} = 15 \cdot b \cdot S^2 \cdot h \cdot k_o$$

Where;

b = Average width of the strip of deck resting on the beam [m]. In the calculation of b any openings are to be considered as non-existent.

S = Span of the reinforced beam equal to the distance between the two supporting members (pillars, other reinforced beams, bulkheads) [m].

4.3 Pillars

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.

The section area of pillars is to be not less than the value A_p [cm^2], given by the formula:

$$A_p = \frac{Q \cdot C}{12,5 - 0,045\,\lambda}$$

Where;

C = 1,0 for steel pillars,

= 1,6 for aluminium alloy pillars,

Q = Load resting on the pillar calculated by the following formula [kN]:

$$Q = 6,87 \cdot A \cdot h$$

Where;

A = Area of the part of the deck resting on the pillar [m^2],

h = Scantling height defined in 2,

λ = The ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

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.

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 must be by means of bolting through a sandwich structure then a wood, or other suitable solid insert is to be fitted in the core in way.

J. Bulkheads

1. General

The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Section 2,A.

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 Section 3.

2. Symbols

s = Spacing between stiffeners [m],

S = Span equal to the distance between the members that support the stiffener concerned [m],

h_T, h_B = As defined in Section2, E.

k_o, k_{of} = As defined in B.4.2.

3. Bulkhead Plating

The watertight bulkhead plating is to have a thickness not less than the value t_p in mm, calculated with the following formula:

$$t_p = k_1 \cdot s \cdot k_{of} \cdot h^{0,5}$$

The coefficinet k_1 and the scantling height h have the values indicated in Table 4.11

Table 4.11

Bulkheads	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

The section modulus of ordinary stiffeners is to be not less than the value W [cm^3], calculated by the following formula:

$$W = 13{,}5 \cdot s \cdot S^2 \cdot h \cdot c \cdot k_o$$

The values of the coefficient c and of the scantling height h are those indicated in Table 4.6.

4.2 Reinforced Beams

The horizontal webs of bulkheads with ordinary vertical stiffeners and reinforced stiffeners in the bulkheads with ordinary horizontal stiffeners are to have a section modulus not less than the value W [cm^3], calculated by the following formula:

$$W = C_1 \cdot b \cdot S^2 \cdot h \cdot k_o$$

Where;

C_1 = 10,7 for subdivision bulkheads,

= 18,0 for tank bulkheads,

b = Width of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener [m],

h = Scantling height indicated in Table 4.12.

5. Tanks for Liquids

See section 2, D.

Table 4.12

Stiffeners	h [m]	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Deep tank bulkhead	h_T	1,00

K. Superstructures

1. General

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.

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 **TL**.

2. Boundary Bulkhead Plating

The thickness of the boundary bulkheads is to be not less than the value t [mm], calculated by the following formulae:

$$t = 3{,}7 \cdot s \cdot k_{of} \cdot h^{0{,}5}$$

Where;

s = Spacing between the stiffeners [mm]

h = Scantling height given in Table 4.13 [m],

k_{of} = Factor defined in B.4.2.

3. Stiffeners

The stiffeners of the boundary bulkheads are to have a section modulus not less than the value W [cm^3], calculated by the following formula:

$$W = 5{,}5 \cdot s \cdot S^2 \cdot h \cdot k_o$$

Where;

h = Scantling height given in Table 4.13 [m],

k_o = Factor defined in B.4.2,

s = Spacing of the stiffeners [m],

S = Span of the stiffeners equal to the distance between the members supporting the stiffener concerned [m].

Table 4.13

Type of bulkhead	h [m]
1st tier front	1,5
2nd tier front	1,0
Other bulkheads where ever situated	1,0

4. Superstructure Decks

The superstructure deck plating is to be not less than the value t [mm], calculated by the following formula:

$$t = 3,7 \cdot s \cdot k_{of} \cdot h^{0,5}$$

Where;

s = Spacing of the stiffeners [m],

k_{of} = Factor defined in B.4.2,

h = Scantling height given in Section 2, E [m].

5. Deck Stiffeners

The section modulus W [cm^3], of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated by the following formula:

$$W = 5,5 \cdot s \cdot S^2 \cdot h \cdot k_o$$

Where;

S = Span of the stiffeners equal to the distance between the supporting members [m],

s, h = As defined in 4.

Reinforced beams and girders and ordinary pillars are to have scantlings as stated in I.

L. Scantlings of Structures with Sandwich Construction

1. Premise

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 moduli of elasticity of the core material are negligible compared to those of the skin material.

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 based on the principle of equivalence, on submission of full technical documentation of the materials used and on 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

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,

2.3 Constructional Details

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 the 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 **TL** 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 J.

3. Symbols

S = Span of the strip of sandwich laminate equal to the minimum distance between the structural members supporting the sandwich (bulkhead, reinforced frames) [m],

p = Scantling pressure as defined in Section 2, E. [kN/m^2],

h = Scantling height given in Section 2, E. [m],

R_{to} = Ultimate tensile strength of the external skin [N/mm^2],

R_{ti} = Ultimate tensile strength of the internal skin [N/mm^2],

R_{co} = Ultimate compressive strength of the external skin [N/mm^2],

R_{ci} = Ultimate compressive strength of the internal skin [N/mm^2],

τ = Ultimate shear strength of the core material of the sandwich [N/mm^2],

h_a = Net height of the core of the sandwich [mm].

4. Minimum Thickness of the Skins

The thickness of the skin laminate is to be sufficient to obtain the section modulus prescribed in the following items; furthermore, it is to have a value not less than that given by the following formulae [mm]:

a) Bottom

$t_o = 0,50 \cdot (2,2 + 0,25\ L)$

$t_i = 0,40 \cdot (2,2 + 0,25\ L)$

b) Side and weather deck

$t_o = 0,45 \cdot (2,2 + 0,25\ L)$

$t_i = 0,35 \cdot (2,2 + 0,25\ L)$

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 may be accepted provided they are sufficient in terms of buckling strength.

In the case of a sandwich structure with a core in balsa wood or polyurethane foam and other similar products, the critical stress σ_{CR} [N/mm^2], given by the following formula, is to be not less than 1,1 σ_C:

$$\sigma_{CR} = 0,4 \cdot \left(\frac{E_F \cdot E_A \cdot G_A}{1 - v^2} \right)^{1/3}$$

E_F = Compressive modulus of elasticity of the laminate of the skin considered [N/mm^2],

E_A = Compressive modulus of elasticity of the core material of the skin considered [N/mm^2],

G_A = Shear modulus of elasticity of the core material [N/mm^2],

σ_C = Actual compressive strength of the skin considered [N/mm^2],

ν = Poisson coefficient of the laminate of the skin considered.

5. Bottom

The section moduli W_{So} and W_{Si} [cm^3], 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:

$$W_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$W_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

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 [cm^4], given by the following formula:

$$Is = 40 \cdot S \cdot W \cdot \frac{R}{E_S}$$

Where;

R = The greater of the ultimate compressive strengths of the two skins [N/mm^2],

E_S = The mean of the four values of the compressive and shear moduli of elasticity of the two skins [N/mm^2],

W = W_{So} or W_{Si} whichever is the greater [cm^3].

The net height of the core h_a [mm], is to be not less than the value given by the formulae:

$$h_a = \frac{k_1 \cdot p \cdot S}{\tau}$$

Where;

k_1 = 0,5 (assuming $p = p_1$)

= 0,2 (assuming $p = p_2$)

6. Side

The section moduli W_{So} and W_{Si} [cm^3] 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:

$$W_{So} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{co}}$$

$$W_{Si} = k_1 \cdot p \cdot S^2 \cdot \frac{1}{R_{ti}}$$

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 [cm^4], given by the following formula:

$$\text{Is} = 40 \cdot S \cdot W \cdot \frac{R}{E_S}$$

Where; R, E_S ve W are as defined in 5.

The net height of the core h_a [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

The section moduli W_{So} and W_{Si} [cm^3], corresponding to the external and internal skins, respectively, of a strip of sandwich of the deck 1 cm wide are to be not less than the values given by the following formulae:

$$W_{So} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{co}}$$

However, the modulus W_{So} may be assumed not greater than that required for the side in 6.1, having the same S.

$$W_{Si} = 15 \cdot h \cdot S^2 \cdot \frac{1}{R_{ti}}$$

The moment of inertia of a strip of sandwich 1 cm wide is to be not less than the value I_S [cm^4], given by the following formula:

$$\text{Is} = 40 \cdot S \cdot W \cdot \frac{R}{E_S}$$

W, R, E_S are as defined in 5.

The net height of the core ha, 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

The scantlings shown in this item 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 K.

The section modulus W_S [cm^3], and the moment of inertia I_S [cm^4], of a strip of sandwich 1 cm wide are to be not less than the values given by the following formulae:

$$W_S = 15 \cdot h \cdot S \cdot \frac{1}{R}$$

$$I_S = 40 \cdot S \cdot W \cdot \frac{R}{E_S}$$

Where;

R = The greater of the ultimate compressive shear strength of the two skins [N/mm^2],

E_S = The mean of the values of the compressive moduli of elasticity of the two skins [N/mm^2].

The net height of the core h_a [mm] is to be not less than the value given by the formulae:

$$h_a = \frac{7 \cdot h \cdot S}{\tau}$$

M. Structural Adhesives

1. General

Structural adhesives are to be used according to the Manufacturer's specifications. The details of the structural adhesives in the scope of the followings are to be submitted.

a) Material data containing all the details of the structural adhesive,

b) Construction plans,

c) The process of application containing the followings:

- surface preparation and cleanliness of the surface to be bonded,
- Handling, mixing and application,
- Remedial work in order to rectify excessive unevenness of the faying surface or local undulation,
- Details relevant to the level of training required for personel involved in the application of structural adhesives.

2. Properties of Adhesives

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 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 that of the adjacent structure is to achieved;

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;

f) the type approval of structural materials is issued by **TL** subject to the satisfactory outcome of the following test carried out on the base of a testing scheme agreed with **TL**:

- lap-shear static test to be performed according to ASTM D3165 standard using FRP substrates; the shear strength is to be achieved on:
  - 5 samples at room temperature of 23° C;
  - 5 samples at room temperature of 23° C after exposure to 5 cycles of laboratory aging according to ASTM D1183 standard;

Requirements to be complied with: the average of the results obtained after conditioning according to ASTM D1183 shall not be less than 85% of the average of the results without conditioning;

- Peel-static test to be performed according to ASTM D3807 standard using FRP substrates; the strength properties are to be achieved on:
  - 5 samples at room temperature of 23° C;
  - 5 samples at room temperature of 23° C after exposure to 5 cycles of laboratory ageing according to ASTM D1183 standard;

Requirements to be complied with the average of the results obtained after conditioning according to ASTM D1183 is to be not less than 85% of the average of the results without conditioning;

- lap-shear fatigue dynamic test to be performed according to ASTM D3163 standard using substrates that can be metallic; the shear strength is to be achieved on:
  - 5 samples at room temperature of 23 °C after exposure to 2 cycles of laboratory aging according to ASTM D1183 standard.
  -

Requirements to be complied with: the sample shall withstand without breaks the fatigue tests carried out at 30 Hz, generally applying a load of 50% of the static shear strength for 1,000,000 cycles.

3. Design Criteria for Bonded Connection

In general the shear stress at the inner surface of the plating is to be calculated by direct calculations.

The calculation of the flange connection between the internal reinforcement and the plating is to be carried out as indicated in this item.

A typical stiffener/ plating connection is shown in the Figure 4.17:

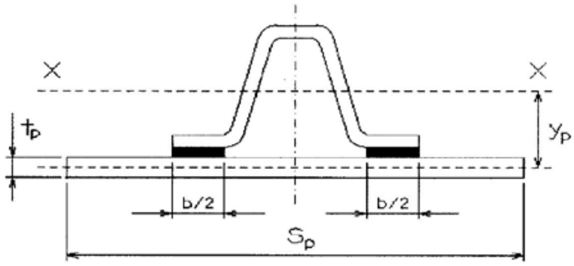

Figure 4.17

The linear load due to the bending moment calculated at the inner surface plating can be obtained from the following formulae:

$$Q = \frac{P \cdot (E \cdot A) \cdot p \cdot Y_p}{(E \cdot L) sp}$$

Where;

Q_p = Linear load applied to the inner surface of the plating and due to the bending moment [N/mm],

P = 500 · p · s · S , total load applied to the panel of dimension (Sxs) and due to the design pressure [N],

$(E \cdot A)_p = E_p \cdot b \cdot t_p$,

E_p = Inplane elastic modulus of the plating [N/mm^2],

b = Width of the plate associated with the stiffener [mm],

t_p = Thickness of the associated plate [mm],

Y_p = Distance from the centroid of the associated plate to the neutral axis [mm],

$(E \cdot \ell)_{sp}$ = Flexural rigidity of the composite element (stiffener and plating) combined around the neutral axis [N/mm^2].

The shear stress for the jointing adhesive for plating can be calculated by the following formula:

$$\tau_p = \frac{Q_p}{b} \qquad \left[N/mm^2\right]$$

It is to be verified that τ_p is not greater than 20% of the nominal bond shear strength as indicated by the Manufacturer's instruction. For guidance, Table 4.14 indicates some data regarding the nominal shear strength and the allowable design stress for certain structural adhesives.

Table 4.14

Adhesive	**Nominal bond shear strength [N/mm²]**	**Allowable design stress [N/mm²]**
Cold-cured epoxy	28	5,2
Polyester or vinylester resin or paste	14	3,5
Epoxy type paste	41	8,5

SECTION 5

HULL CONSTRUCTION – STEEL HULLS

Page

A. General Requirements

1. Field of Application

This section applies to monohull yachts with a hull made of steel and a length L not exceeding 120 m, with motor or sail power with or without an auxiliary engine.

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

In the examination of constructional plans, **TL** 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, on the basis of direct test calculations of the structural strength.

This section may also be used to check the structural scantlings of hulls made of metals with superior mechanical properties, other than steel, such as titanium and its alloys.

In general the following types are considered usable in the field of pleasure yachts:

- Titanium: TiCP2, TiCP3, TiCP4;
- Titanium alloys: Ti6AL4V grade 5, Ti5AL2.5Sn grade 6 and Ti3AL2.5V grade 9.

For the scantlings of the plating and stiffeners, a coefficient K depending on the minimum yield strength of the material used, is to be adopted.

The value of the minimum yield strength is, however, to be not more than 0,7 of the ultimate tensile strength of the material.

Higher values may be adopted, at the discretion of **TL**, on condition that additional buckling strength and fatigue calculations are carried out.

In any case use of these materials is subject to the examination of the technical documentation of the manufacture of the material and the welding processes and tests that will be adopted.

2. Definitions and Symbols

2.1 Premise

The definitions and symbols in this item are valid for all the Sections.

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

2.2 Definitions and Symbols

L = Scantling length [m], on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest;

B = Maximum breadth of the yacht [m] outside of the frames; in tests of the longitudinal strength of twin hull yachts, B is to be taken as equal to twice the breadth of the single hull, measured immediately below the cross-deck;

H = Depth of the yacht [m] measured vertically inthe transverse section at half the length L, from the base line up to the deck beam of the uppermost continuous deck;

T = Draft of the yacht [m] measured vertically in the transverse section at half the length L, from the base line to the full load waterline with the yacht at rest in calm water;

s = Spacing of the ordinary longitudinal or transverse stiffener [m];

Δ = Displacement [t] of the yacht measured from the outside frames at draught T;

K = Factor as a function of the mechanical properties of the steel used, as defined in B.

3. Plans, Calculations and Other Information to be Submitted for Approval

The list of plans to be submitted to **TL** in triplicate for approval is stated in Section 1, A.2.2.2, in general.

4. Direct Calculations

As an alternative to those based on the formulae in this section, scantlings may be obtained by direct calculations.

The scantlings are to be such as to guarantee that stress levels do not exceed the allowable values.

In the case of use of materials with superior mechanical properties, other than steel, such as those indicated in 1., the allowable stresses will be stipulated by **TL** on the basis of such properties and of any further fatigue tests and/ or buckling checks.

5. Buckling Strength Checks

5.1 Application

Where required, the critical buckling strength of steel plating and stiffeners subject to compressive stresses is to be calculated as specified below.

5.2 Elastic Buckling Stresses of Plates

5.2.1 Compressive Stress

The elastic buckling strength is give by the following formula:

$$\sigma_E = 0{,}9 \cdot m_c \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2 \quad \text{[N/mm}^2\text{]}$$

Where;

$m_c = \dfrac{8{,}4}{\psi + 1{,}1}$ For plating with stiffeners paralel to compressive stress

$m_c = c \cdot \left[1 + \left(\dfrac{a}{b}\right)^2\right]^2 \cdot \dfrac{2{,}1}{\Psi + 1{,}1}$ For plating with stiffeners perpendicular to compressive stress

E = Young's modulus, to be taken equal to $2{,}06.10^5$ [N/mm²] for steel structures,

t = Thickness of plating [mm],

a = Shorter side of the plate [m],

b = Longer side of the plate [m],

c = Coefficient equal to:

- 1,30 when the plating is stiffened by floors or deep girders
- 1,21 when the plating is stiffened by ordinary stiffeners with angle or T sections
- 1,10 when the plating is stiffened by ordinary stiffeners with bulb sections
- 1,05 when the plating is stiffened by flat bar ordinary stiffeners

Ψ = Ratio between the smallest and largest compressive stresses when the stres present a linear variation across the plate.

5.2.2 Shear Stress

The elastic buckling stres is given by the following formula:

$$\tau_E = 0{,}9 \cdot m_t \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2 \quad \text{[N/mm}^2\text{]}$$

Where;

$$m_t = 5{,}34 + 4 \cdot \left(\frac{a}{b}\right)^2$$

E, t, a and b, are as defined in 5.2.1.

5.3 Elastic Buckling Stresses of Stiffeners

5.3.1 Column Buckling Without Rotation of the Transverse Section

For the column buckling mode (perpendicular to the plane
of plating) the elastic buckling stress is given by the following formula:

$$\sigma_E = 0{,}001 \cdot E \frac{I_a}{A \cdot L^2} \quad \text{[N/mm}^2\text{]}$$

Where;

E = Young's modulus to be taken equal to 2,06.10^5 [N/mm^2] for steel structures.

I_a = Moment of inertia of the stiffener including plate flange [cm^4]

A = Cross-sectional area of the stiffener including plate flange [cm^2]

L = Span of the stiffener [m]

5.3.2 Torsional Buckling

For the torsional mode, the elastic buckling stress is given by the following formula:

$$\sigma_E = \frac{\pi^2 \cdot E \cdot I_W}{10^4 \, I_p \cdot \ell^2}\left(m^2 + \frac{C_K}{m^2}\right) + 0{,}385 \cdot E \cdot \frac{I_t}{I_p} \quad \text{[N/mm}^2\text{]}$$

Where;

E, I = defined in 5.3.1.

$$C_K = \frac{C \cdot I^4}{\pi^4 \cdot E \cdot I_W} \cdot 10^6$$

m = Number of half-waves given in Table 5.1.

Table 5.1

	0<C<1	4<C<36	36<C<144	(m-1) m<C<m (m+1)
m	1	2	3	m

I_t = St. Venant moment of inertia of profile without plate flange, equal to [cm^4] :

$$= \frac{h_w \cdot t_w^{\;3}}{3} \cdot 10^{-4} \quad \text{for flat bars}$$

$$= \frac{1}{3} \cdot \left[h_w \cdot t_w^3 + b_f \cdot t_f^3 \left(1 - 0{,}63 \frac{t_f}{b_f}\right)\right] \cdot 10^{-4}$$

for flanged profile

I_p = Polar moment of inertia of profile about connection of stiffener to plate, equal to [cm^4]:

$$= \frac{h_w^3 \cdot t_w}{3} \cdot 10^{-4} \quad \text{for flat bars}$$

$$= \left(\frac{h_w^3 \cdot t_w}{3} + h_w^2 \cdot b_f \cdot t_f \right) \cdot 10^{-4} \quad \text{for flanged profiles}$$

I_w = Sectional moment of inertia of profile about connection of stiffener to plate, equal to [cm^6]:

$$= \frac{h_w^3 \cdot t_w^3}{36} \cdot 10^{-6} \quad \text{for flat bars}$$

$$= \frac{t_f \cdot b_f^3 \cdot h_w^2}{12} \cdot 10^{-6} \quad \text{for T profiles}$$

$$= \frac{b_f^3 \cdot h_w^2}{12\left(b_f + h_w\right)^2} \cdot \left[t_f \cdot \left(b_f^2 + 2b_f \cdot h_w + 4h_w^2\right) + \left(3t_w \cdot b_f \cdot h_w\right)\right] \cdot 10^{-6} \quad \text{For flanged profiles}$$

h_w = Web height [mm],

t_w = Web thickness [mm],

b_f = Flange width [mm],

t_f = Flange thickness [mm], for bulb profiles, the mean thickness of the bulb may be used,

C = Spring stiffness factor exerted by supporting plate, equal to:

$$= \frac{k_p \cdot E \cdot t^3}{3s \cdot \left(1 + \frac{1{,}33 \cdot k_p \cdot h_w \cdot t^3}{1000 \cdot s \cdot t_w^3}\right)} \cdot 10^{-3}$$

t = Plating thickness [mm],

s = Spacing of stiffeners [m],

k_p = 1 – η_p , not to be taklen less than 0,

η_p = σ_p / σ_{Ep}

σ_p = calculated compressive stress in the stiffener,

σ_{Ep} = Elastic buckling stress of plating as calculated in 5.2.1.

5.3.3 Web Buckling

The elastic buckling stres is given by the following formula:

$$\sigma_E = 3{,}8 \cdot E \cdot \left(\frac{t_w}{h_w}\right)^2 \qquad [\text{N/mm}^2]$$

Where;

E = Defined in 5.3.1.

t_w, h_w = Defined in 5.3.2.

5.4 Critical Buckling Stress

5.4.1 Compressive Stress

The critical buckling stres in compression for plating and stiffeners is given by the following formula:

$$\sigma_C = \sigma_E \qquad \text{if} \qquad \sigma_E \le \frac{R_{eH}}{2}$$

$$\sigma_C = R_{eH}\left(1 - \frac{R_{eH}}{4 \cdot \sigma_E}\right) \qquad \text{if} \qquad \sigma_E \rangle \frac{R_{eH}}{2}$$

Where;

R_{eH} = Minimum yield stres of steel used [N/mm²],

σ_E = Elastic buckling stres calculated according to 5.2.1 and 5.3.2.

5.4.2 Shear Stress

The critical buckling shear stres for plating and stiffener is given by the following formula:

$$\tau_C = \tau_E \qquad \text{if} \qquad \tau_E \le \frac{\tau_F}{2}$$

$$\tau_C = \tau_F\left(1 - \frac{\tau_F}{4 \cdot \tau_E}\right) \qquad \text{if} \qquad \tau_E \rangle \frac{\tau_F}{2}$$

Where;

τ_F = 0,58 R_{eH}

R_{eH} = Minimum yield stres of steel used [N/mm²],

τ_E = Elastic buckling stres calculated according to 5.2.2.

6. General Rules for Design

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

For yachts with length L greater than 50 m, reduced scantlings may be adopted for the fore and aft zones.

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

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

For high speed hulls, as a rule, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

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

7. Minimum Thicknesses

The thicknesses of plating and stiffeners calculated using the formulae in this section are to be not less than the values shown in Table 5.2.

Lesser thicknesses may be accepted provided that, in the opinion of **TL,** their adequacy in terms of buckling strength and resistance to corrosion is demonstrated.

Where plating and stiffeners contribute to the longitudinal strength of the yacht, their scantlings are to be such as to fulfil the requirements for yacht longitudinal strength stipulated in D.

Table 5.2

Member	Minimum Thickness [mm]
Keel, bottom plating	$t_1 = 1{,}35 \cdot L^{1/3} \cdot K^{0,5}$
Side platingı	$t_2 = 1{,}15\ L^{1/3} \cdot K^{0,5}$
Open strength deck plating	$t_3 = 1{,}15\ L^{1/3} \cdot K^{0,5}$
Lower and enclosed deck plating	$t_4 = t_3 - 0{,}5$
1 st tier superstructure front bulkhead	$t_5 = t_4$
Superstructure bulkhead	$t_6 = t_5 - 1$
Watertight subdivision bulkhead	$t_7 = t_2 - 0{,}5$
Tank bulkhead	$t_8 = t_2$
Cantre girder	$t_9 = 1{,}75 \cdot L^{1/3} \cdot K^{0,5}$
Floors and side girder	$t_{10} = 1{,}30 \cdot L^{1/3} \cdot K^{0,5}$
Tubular pillars	$0{,}03\ d \cdot K^{0,5} \geq 3{,}0$ **(1)**
(1) *d = Diameter of the pillar [mm]*	

8. Corrosion Protection

All steel structures, with the exception of fuel tanks, are to be suitably protected against corrosion.

Such arrangements may consist of coating or cathodic protection.

The structures are to be clean and free from slag before the coating is applied.

When a primer is used after the preparation of the surfaces and prior to welding, as well as not impairing the latter the composition of the primer is to be compatible with the subsequent layers of the coating cycle.

The coating is to be applied with adequate thickness in accordance with the Manufacturer's specifications.

Paint or other products containing nitrocellulose or other highly flammable substances are not to be used in machinery or accommodation spaces.

B. Materials

1. General

For hull construction and for fittings the materials prescribed in this section are to be used.

The acceptance of materials not foreseen in this section (for example, the materials indicated in A) is to be decided case by case, in general at the time of the approval of the relevant plans.

The materials, in the condition of supply, are to satisfy the requirements laid down by the regulations or those specifically stipulated for individual cases and they are to be approved in conformity with the applicable requirements.

TL reserves the right to accept, on the conditions specifically agreed on, materials other than those foreseen in this section.

These rules presume that welding and other setting up processes, at low or high temperatures, are carried out in accordance with normal good practice and in observance of the applicable requirements of **TL**. These requirements may include executory conditions, such as the requirement that the welding is carried out with a determined pre-heating and/ or that this or other process at low or high temperature should be followed by appropriate thermal treatment.

Welding procedures are to be approved for the specific type of material used, within the limits and the conditions laid down in the applicable **TL** requirements.

2. Steels for Hull Structure

In general, material quality of steel plates, profiles and bars to be used in various hull structural members is indicated below;

- Ordinary hull structural steels with a minimum nominal upper yield point of 235 N/mm^2 of TL-A, TL-B, TL-D and TL-E grade,

- Higher strength hull structural steels with a minimum nominal upper yield point of 315 N/mm^2 of TL-A32, TL-D32 and TL-E32 grade, with a minimum nominal upper yield point of 355 N/mm^2 of TL-A36, TL-D36 and TL-E36 grade, with a minimum nominal upper yield point of 390 N/mm^2 of TL-A40, TL-D40 and TL-E40 grade.

Material selection for hull structural members, is to be effected in conformity with "Hull Construction Rules" and "Material Rules" depending on the classification by material thickness and stress concentration of structural member

In the case of vessels exposed to low temperature below 0°C for long periods, the type of steel is to be decided in relation to the thickness used, weather and sea.

3. Steels for Forgings, Castings and Pipes

3.1 General

For structural members for which approval of the plans is not required, except otherwise prescribed, weldable steels having an ultimate tensile strength of 400 - 650 N/mm^2 are to be used and other mechanical and chemical properties are to be in accordance with relevant **TL** rules. These steels are to be approved when required in accordance with relevant rules.

For structural members for which approval of the plans is required, the requisities of items 3.2 and 3.3 apply.

For the scope and methods of tests, **TL** "Material Rules" apply.

3.2 Steel Forgings

Forgings for structural members for which a check of the scantlings is required are to have the chemical and mechanical properties prescribed for the type of steel indicated in the relative approved plans.

3.3 Steel Castings

In general, for castings intended for stem, rudder parts, parts of steering gear and fittings for which the check of scantlings is required, except otherwise prescribed, C and C-Mn weldable steel with a minimum tensile strength equal to 400 - 520 N/mm^2 is to be used.

The possible use of castings welded to main platings contributing to hull strength members is subject to specisl approval, additional tests and requisities may be required at the discretion of **TL**, such as resilience requirements corrolated to those of the platings to which the castings are to be welded and non-destructive tests.

3.4 Pipes

Steel pipes as indicated in the approved plans of structural members for which pipes are used and conforming with the relevant **TL** rules may be utilized. These pipes are to have tensile strength equal to 410 - 530 N/mm^2. The use of steels other than those mentioned above is subject to special approval by **TL**, depending on the relevant chemical and mechanical properties. .

4. The Factor K for Scantlings of Structural Members Made of High Strength Steel

The value of the factor K which appears in the formulas for structural scantlings in this section is a function of the value of the minimum yield strength R_{eH} specified for the steel to be used, as shown in Table 5.3.

For steels having R_{eH} = 235 N/mm^2, K=1 is assumed.

In terms of the scantlings of the structural members of the hull, steels having R_{eH} ≥ 235 N/mm^2 are considered high strength.

Table 5.3 shows the values of the factor K to be taken as a function of the value R_{eH} of the various grades of high strength steel for hull structures having the value R_{eH} ≤ 390 N/mm^2 .

In cases where the use of steels with intermediate values is allowed, the value of factor K can bed determined by linear interpolation.

Acceptance of the use of steels or materials such as those indicated in item 1. having R_{eH} > 390 N/mm^2 is subject to special consideration by **TL**, which reserves the right to stipulate the relevant conditions.

Table 5.3

Grade of steel	R_{eH} N/mm^2	K
32	315	0,780
36	355	0,720
40	390	0,700

C. Welded Joints

1. General

1.1 Application

1.1.1 The requirements of this Section apply to the preparation, execution and inspection of welded connections in hull structures.

The general requirements relevant to fabrication by welding and qualification of welding procedures are given in **TL** Rules for Welding of Hull Structures.
The requirements relevant to the non-destructive examination of welded connections are given in the same rules.

1.1.2 Weld connections are to be executed according to the approved plans. Any detail not specifically represented in the plans is, in any event, to comply with the applicable requirements.

1.1.3 It is understood that welding of the various types of steel is to be carried out by means of welding procedures approved for the purpose, even though an explicit indication to this effect may not appear on the approved plans.

1.1.4 The quality standard adopted by the shipyard is to be submitted to **TL** and applies to all constructions unless otherwise specified.

1.2 Base Material

1.2.1 The requirements of this item apply to the welding of hull structural steels or aluminium.

1.2.2 The service temperature is intended to be the ambient temperature, unless otherwise stated.

1.3 Welding Consumables and Procedures

1.3.1 Approval of Welding Consumables and Procedures

Welding consumables and welding procedures adopted are to be approved by **TL.**

The requirements for the approval of welding consumables are given in **TL** Welding of Hull Structure Rules, Section 5, for the approval of welding procedures are given in Section 4.

1.3.2 Welding Consumables

For welding of hull structural steels, the minimum consumable grades to be adopted are specified in **TL** Welding of Hull Structure Rules, section 5, Table 5.3.

For welding of other materials, the consumables indicated in the welding procedures to be approved are considered by **TL** on a case by case basis.

1.4 Welders and Equipment

1.4.1 Welders

Manual and semi-automatic welding is to be performed by welders certified by **TL** in accordance with recognised standards

1.4.2 Automatic Welding Operators

Personnel manning automatic welding machines are to be competent and sufficiently trained.

1.4.3 Organisation

The internal organisation of the shipyard is to be such as to ensure compliance in full with the requirements in 1.4.1 and 1.4.2 and to provide assistance for and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

1.4.4 NDT operators

Non-destructive tests are to be carried out by qualified personnel, certified by **TL,** or by recognised bodies.

1.4.5 Technical Equipment

The welding equipment is to be appropriate to the adopted welding procedures, of adequate output power and such as to provide for stability of the arc in the different welding

In particular, the welding equipment for special welding procedures is to be provided with adequate and duly calibrated measuring instruments, enabling easy and accurate reading.

Manual electrodes, wires and fluxes are to be stocked in suitable locations so as to ensure their preservation in good condition.

1.5 Documentation to be Submitted

Documents to be submitted for approval, are to contain the necessary data relevant to the fabrication by welding of the structure.

2. Type of Connections and Preparation

2.1 General

The type of connection and the edge preparation are to be appropriate to the welding procedure adopted, the structural elements to be connected and the stresses to which they are subjected

2.2 Butt Welding

2.2.1 General

In general, butt connections of plating are to be full penetration, welded on both sides except where special procedures or specific techniques, considered equivalent by **TL**, are adopted.

Connections different from the above are to be examined by **TL** on a case by case basis; in such cases, the relevant detail and workmanship specifications are to be approved.

2.2.2 Welding of Plates with Different Thicknesses

If the welding is perpendicular to the principle stress where the gross plate thicknesses differ mor than 4 mm and the thinner plate has a gross thickness equal to or less than 10 mm, differences must be accommodated by bevelling the proud edge at a ratio of at least 1:3 or according to the notch category. When the difference in thickness is less than the above values, it may be accommodated in the weld transition between plates.

2.2.3 Edge Preparation

Depending on the plate thickness, the welding method and the welding position, butt joints are to be of the square, V or X shape conforming to the relevant standards (e.g. ISO 2553, EN 29629, TS).

2.2.4 Welding on Permanent Backing

Where the welds are accessible from one side only, the welded joints are to be executed as lesser bevelled welds with an open root and attached permanent weld pool support (backing).

2.2.5 Sections, bulbs and flat bars

Butt joints of longitudinals of the shell plating and strength deck within 0,6 L amidships subject to high stresses are to be full penetration. Other solutions may be adopted if deemed acceptable by **TL**.

2.3 Fillet Welding

2.3.1 General

In general, ordinary fillet welding (without bevel) may be adopted for T connections of the various structural elements, where they are subjected to low stresses (in general not exceeding 30 N/mm^2).
Where this is not the case, partial or full T penetration welding is to be adopted.

2.3.2 Fillet Welding Types

Fillet welding may be of the following types:

- Continuous filet welding, where the weld is constituted by a continuous filet on each side of the abutting plate,
- Intermittent filet welding, which may be subdivided into:
- chain welding,
- scallop welding,
- staggered welding.

2.3.3 Continuous Fillet Welding

Continuous fillet welding is to be adopted:

- for watertight connections,
- for connections of brackets, lugs and scallops,
- at the ends of connections for a length of at least 75mm,
- where intermittent welding is not allowed.

Continuous fillet welding may also be adopted in lieu of intermittent welding wherever deemed suitable, and it is recommended where the spacing b, stated in 2.3.4, is low.

2.3.4 Intermittent Welding

The spacing b and the length ℓ, in mm, of an intermittent weld, shown in Figure 5.1 for chain welding, Figure 5.2 for scallop welding and Figure 5.3 for staggered welding are to be such that:

$$\frac{b}{\ell} \le \varphi$$

where the coefficient φ is defined in Table 5.4 for the different types of intermittent welding, depending on the type and location of the connection.

In general, staggered welding is not allowed for connections subjected to high alternate stresses.

In addition, the following limitations are to be complied with:

- chain welding (see Figure 5.1):

$\ell \ge 75$ mm

b- ℓ ≤ 150 mm

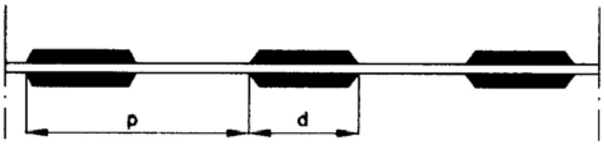

Figure 5.1 Intermittent Chain Welding

- Scallop welding (see Figure 5.2):

$\ell \ge 75$ mm.

b - ℓ ≤ 150 mm.

v ≤ 0,25 b , without being greater than 75 mm..

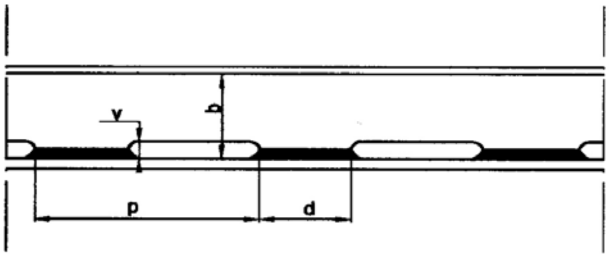

Figure 5.2 Intermittent Scallop Welding

- Staggered welding (see Figure 5.3):

$\ell \ge 75$ mm.

$$\frac{b}{2} - \ell \le 150\ mm.$$

$b \le 2\ \ell$ for connections subjected to high alternate stresses.

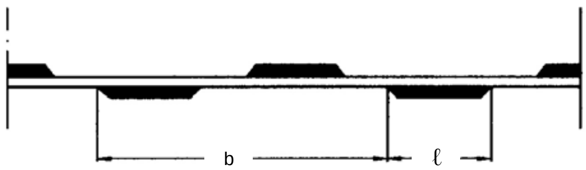

Figure 5.3 Intermittent Staggered Welding

2.3.5 Throat Thickness of Fillet Weld T Connections

The throat thickness a_u of intermittent filet welds is to be determined according to the selected pitch ratio (b / ℓ) by applying the formula:

$$a_u = 1{,}1 \cdot a \cdot b/\ell \quad [mm]$$

a = Required fillet weld throat thickness for a continuous weld according to **TL** Hull Construction Rules, Section 20, Table 20.3 or determined by calculation [mm],

b = Pitch [mm],

ℓ = Fillet weld length [mm].

2.3.6 Throat Thickness of Welds Between Cut-outs

The throat thickness of the welds between the cut-outs in primary supporting member webs for the passage of ordinary stiffeners is to be not less than the value obtained from the following formula:

$$a_c = a_u \cdot \frac{\varepsilon}{\lambda}$$

where;

a_u = Throat thickness defined in 2.3.5,

ε, λ = Dimensions to be taken as shown in Figure 5.4 for continuous welding, Figure 5.5 for intermittent scallop welding [mm].

2.3.7 Throat Thickness of Deep Penetration Fillet Welding

When fillet welding is carried out with automatic welding procedures, the throat thickness required in 2.3.5 may be reduced up to 15%, depending on the properties of the electrodes and consumables. However, this reduction may
not be greater than 1,5 mm.

The same reduction applies also for semi-automatic procedures where the welding is carried out in the downhand position.

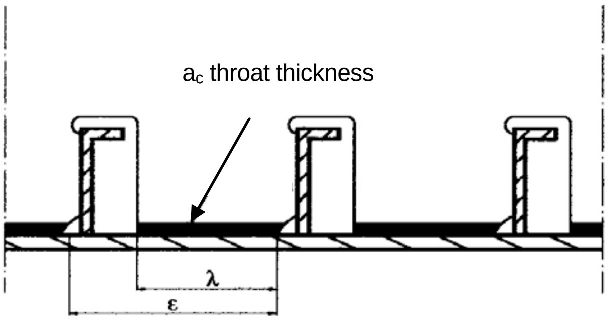

Figure 5.4 Continuous fillet welding between cut-outs

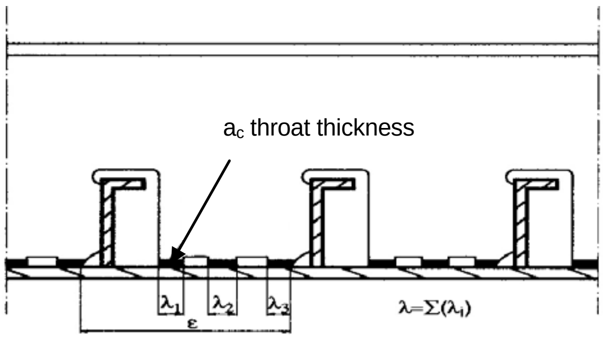

Figure 5.5 Intermittent scallop fillet welding between cut-outs

Table 5.4 Coefficient φ for the various connections

Hull area	Connection of	Connection to		φ (1) Chain	φ (1) Scallop	φ (1) Staggered
General, unless otherwise specified	Watertight plates	Boundaries		-	-	-
	Webs of ordinary stiffeners	Plating		3,5	3,0	4,6
		Face plate of fabricated stiffeners	At ends **(2)**	-	-	-
			Elsewhere	3,5	3,0	4,6
Bottom and double-bottom	Longitudinal ordinary stiffeners	Bottom and inner bottom plating		3,5	3,0	4,6
	Centre girder	Keel		1,8	1,8	-
		Inner bottom plating		2,2	2,2	-
	Side girders	Bottom and iner bottom plating		3,5	3,0	4,6
		Floors (interrupted girders)		2,2	-	-
	Floors	Bottom and inner bottom plating	In General	3,5	3,0	4,6
			At ends (20% of span) for longitudinally framed double bottom	1,8	-	-
		Inner bottom plating in way of brackets of primary supporting members		1,8	-	-
		Girders (interrupted floors)		2,2	-	-
	Partial side girders	Floors		1,8	-	-
	Web stiffeners	Floor and girder webs		3,5	3,0	4,6
Side	Ordinary stiffeners	Side and plating		3,5	3,0	4,6
Deck	Strength deck	Side plating		Partial penetration welding		
	Non-watertight decks	Side plating		2,2	-	-
	Ordinary stiffeners and intercoastal girders	Deck plating		3,5	3,0	4,6
	Hatch coamings	Deck plating	In general	-	-	-
			At corners of hatchways for 15% of the hatch length	-	-	-
	Web stiffeners	Coaming webs		3,5	3,0	4,6
Bulkheads	Watertight bulkhead structures	Boundaries		-	-	-
	Non-watertight bulkhead structures	Boundaries	Wash bulkheads	2,2	2,2	-
			Others	3,5	3,0	4,6
	Ordinary stiffeners	Bulkhead Plating	General	3,5	3,0	4,6
			At ends (25% of span) where no end brackets are fitted	-	-	-

Structures located forward of 0,75 L from the FP **(3)**	Bottom longitudinal ordinary stiffeners	Bottom plating		2,2	-	-
	Floors and girders	Bottom and inner bottom plating		1,8	-	-
	Side frames in panting area	Side plating		2,2	-	-
	Webs of side girders in single side skin structures	Side plating and face plate	$A < 65$ cm^2 **(4)**	1,8	1,8	-
			$A \geq 65$ cm^2 **(4)**	-	-	-
After peak **(3)**	Internal structures	Each other		-	-	-
	Ordinary side stiffeners	Side plating		-	-	-
	Floors	Bottom and inner bottom plating		-	-	-
Machinery space **(3)**	Centre girder	Keel and inner bottom plating	In way of main engine foundation	-	-	-
			In way of seating of auxiliary machinery and boilers	-	-	-
			Elsewhere	1,8	1,8	-
	Side girders	Bottom and inner bottom plating	In way of main engine foundation	-	-	-
			In way of seating of auxiliary machinery and boilers	-	-	-
			Elsewhere	2,2	2,2	-
	Floors (except in way of main engine foundations)	Bottom and inner bottom plating	In way of seating of auxiliary machinery and boilers	-	-	-
			Elsewhere	2,2	2,2	-
	Floors in way of main engine foundations	Bottom plating		-	-	-
		Foundation plates		-	-	-
	Floors	Centre girder	Single bottom	-	-	-
			Double bottom	1,8	1,8	-
Superstructures and deckhouses	External bulkheads	Deck	In general	-	-	-
			Engine and boiler casings at corners of openings (15% of opening length)	-	-	-
	Internal bulkheads	Deck		3,5	3,0	4,6
	Ordinary stiffeners	External and Internal bulkhead plating		3,5	3,0	4,6
Pillars	Elements composing the pillar section	Each other (fabricated pillars)		-	-	-
	Pillars	Deck	Pillars in compression	-	-	-
			Pillars in tension	Full penetration welding		
Ventilators	Coamings	Deck		-	-	-

Rudder	Webs in general	Each other		-	2,2	-
		Plating	In general	-	2,2	-
			Top and bottom plates of rudder plating	-	-	-
	Horizontal and vertical webs directly connected to solid parts	Each other		-	-	-
		Plating		-	-	-

(1) *In connections for which no φ value is given in the table above intermittent type is not permitted and continuous welding is to be adopted.*

(2) *Ends of ordinary stiffeners means the area extended 75 mm from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes.*

(3) *For connections not mentioned, the requirements for the central part apply.*

(4) *A is the face plate sectional area of the side girders [cm2].*

2.4 Corner and T Joints

2.4.1 T joints with complete union or the abutting plates shall be made as single or double-bevel welds with a minimum root face and adequate air gap and grooving of the root and capping from the opposite side. Full root penetration T welds with single or double-bevel is shown in Figure 5.6. The effective weld thickness is to be determined according to the thickness of the abutting plate.

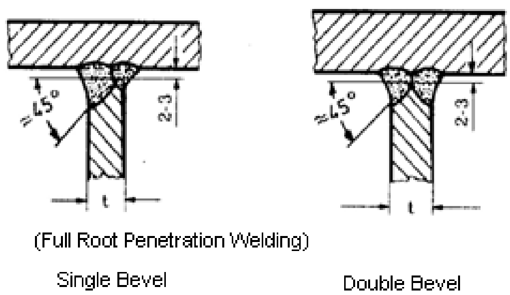

Figure 5.6
Single and double-bevel welds with full root penetration

2.4.2 T joints with a defined incomplete root penetration with gap "f" is to be made as single or double-bevel welds as shown in Figure 5.7, as described in 2.4.1 with a back-up weld but without grooving of the root. The effective weld thickness is to be determined as the thickness of the abutting plate t minus f, where f is to be assigned value of 0,2 t subject to a maximum of 3 mm. Missing weld cross section is compensated by additional fillet welds in both sides. As a practical dimension, a leg length of z=h/3 at the root of the weld may be prescribed. h is the depth of the weld as shown in Figure 5.7.

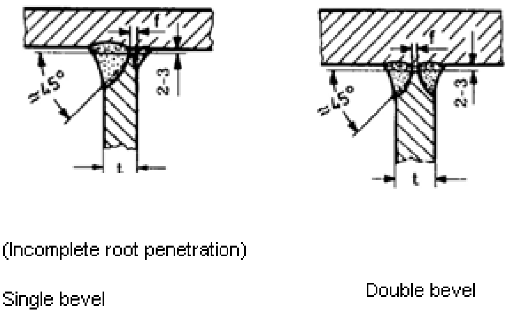

Figure 5.7
T weld with defined incomplete root penetration

2.4.3 Corner, T and double T joints with both an unwelded root face c and a defined incomplete root penetration f is to be made in accordance with Figure 5.8. The effective weld thickness is to be determined as the thickness of the abutting plate t minus (c+f), where f is to be assigned a value of 0,2 t subject to a maximum of 3 mm.

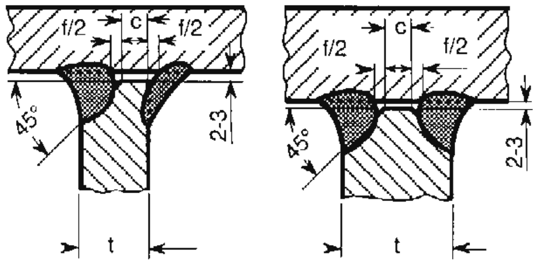

Figure 5.8
Single and double-bevel welds with unwelded root face and defined incomplete root penetration

2.4.4 T joints which are accessible from one side only may be in accordance with Figure 5.9 in a manner analogous to the butt joints referred to in 2.4.2 using a weld pool support, or as single side, single bevel welds.

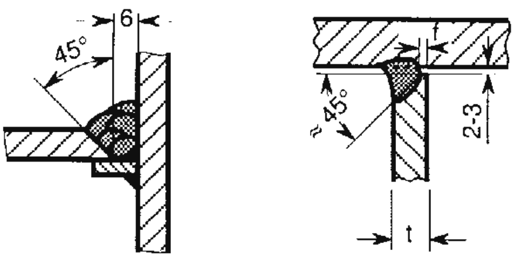

Figure 5.9
Single side welded T joints

2.5 Lapped Joints

2.5.1 Lapped joints running transversely to the main direction of load should be avoided wherever possible and may not be used for heavily loaded components. Lapped welds may be accepted for components subject to low loads provided that wherever possible, they are orientated parallel to the direction of the main stress.

2.5.2 The width of the lap shall be 1,5 t + 15 mm (t = thickness of the thinner plate). Except where another value is determined by calculation, the filet weld throat thickness "a" shall equal 0,4 times the thickness of the thinner plate. The fillet weld must be continuous on both sides and must meet at the ends.

2.6 Plug Welding

In the case of plug welding, the plugs should, wherever possible, take the form of elongated holes lying in the direction of the main stress. The width of the holes shall be equal to at least twice the thickness of the plate and shall not be less than 15 mm. The ends of the holes shall be semicircular. Plates or sections placed underneath should at least equal the perforated plate in thickness and should project on both sides to a distance of 1,5 × the plate thickness subject to a maximum of 20 mm. Wherever possible, only the necessary fillet welds shall be made, while the remaining void is packed with a suitable filler. Lug-joint welding is not permitted.

2.7 Slot Welding

Slot welding may be adopted subject to the special agreement of **TL**, in each case.

3. Specific Weld Connections

See **TL** Rules for Welding of Hull Structures, Section 12, G.

4. Workmanship

4.1 Forming of Plates

Hot or cold forming is to be performed according to the requirements of recognised standards depending on the material grade and rate of deformation.

4.2 Welding Procedures and Consumables

The welding procedures and consumables are to be used within the limits of their approval and in accordance with the conditions of use specified in the respective approval documents.

4.3 Welding Operations

4.3.1 Weather Protection

Adequate protection from the weather is to be provided to parts being welded; in any event, such parts are to be dry.

In welding procedures using bare, cored or coated wires with gas shielding, the welding is to be carried out in weather protected conditions, so as to ensure that the gas outflow from the nozzle is not disturbed by winds and draughts.

4.3.2 Butt Connection Edge Preparation

The edge preparation is to be of the required geometry and correctly performed. In particular, if edge preparation is carried out by flame, it is to be free from cracks or other detrimental notches.

4.3.3 Surface Condition

The surfaces to be welded are to be free from rust, moisture and other substances, such as mill scale, slag caused by oxygen cutting, grease or paint, which may produce defects in the welds.

Effective means of cleaning are to be adopted, such as flame or mechanical cleaning.

The presence of a shop primer may be accepted, provided it has been approved by **TL.**

4.3.4 Assembling and Gap

The setting appliances and system to be used for positioning are to ensure adequate tightening adjustment and an appropriate gap of the parts to be welded.

The gap between the edges is to comply with the required tolerances or it is to be in accordance with normal good practice.

4.3.5 Gap in Fillet Weld T Connections

In fillet weld T connections, a gap g, as shown in Figure 5.10, not greater than 2 mm may be accepted without increasing the throat thickness calculated according to 2.3.5.

In the case of a gap greater than 2 mm, the above throat thickness is to be increased accordingly.

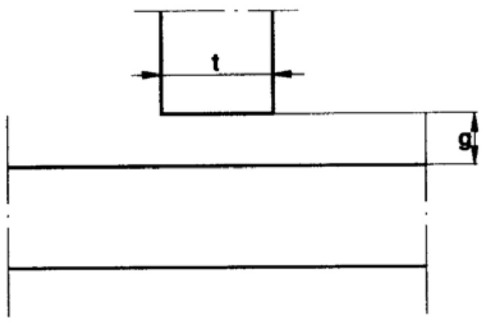

Figure 5.10 Gap in Fillet Weld T Connections

4.3.6 Plate Misalignment in Butt Connections

The misalignment m, measured as shown in Figure 5.11, between plates with the same gross thickness t is to be less than 0,15 t, without being greater than 3 mm, where t is the gross thickness of the thinner abutting plate.

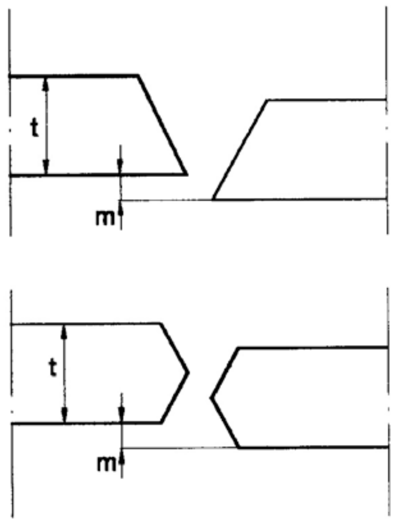

Figure 5.11 Plate Misalignment in Butt Connections

4.3.7 Misalignment in Cruciform Connections

The misalignment in cruciform connections, measured on the median lines as shown in Figure 5.12 is to be less than:

- t/2, in general, where t is the gross thickness of the thinner abutting plate.

TL may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

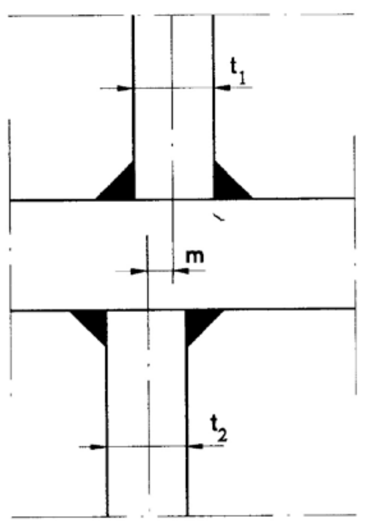

Figure 5.12 Misalignment in Cruciform Connections

4.3.8 Assembling of Aluminium Alloy Parts

When welding aluminium alloy parts, particular care is to
be taken so as to:

- reduce as far as possible restraint from welding shrinkage, by adopting assembling and tack welding procedures suitable for this purpose

- keep possible deformations within the allowable limits.

4.3.9 Preheating and interpass temperatures

Suitable preheating, to be maintained during welding, and
slow cooling may be required by **TL** on a case by case basis.

4.3.10 Welding Sequences

4.3.10.1 The welding sequence shall be chosen to allow shrinkage to take place as freely as possible and to minimize shrinkage stresses in the component. Butt joints in areas of plating shall invariably be fully welded, at least on one side, prior to the fastening of girders, stiffeners, etc. Where individual plates are later welded into position in areas of plating (as in the case of erection holes in the deck or shell plating), the longitudinal seams shall be left unwelded, or shall be opened up, to a distance of approx. 300 mm beyond the transverse joints. The transverse joints shall be welded first, followed by the longitudinal seams. The welding of patches may be performed in analogous manner, unless angular patches with rounded corners or round patches are used.

4.3.10.2 In special cases (e.g. when welding together particularly rigid components) and for similar, repetitive welding operations (e.g. for the welding of masts into ships), it is advisable to set down the assembly procedure or welding sequence in a welding sequence schedule.

4.3.11 Interpass Cleaning

In multi-pass welding, the slag of the previous run shall be completely removed before the next pass is laid down.

Pores, visible slag inclusions and other welding defects and cracks may not be welded over, but are to be machined out and repaired.

4.3.12 Stress Relieving

See **TL** Rules for Welding of Hull Structures, Section 9,E.

5. Modifications and Repairs During Construction

5.1 General

Deviations in the joint preparation and other specified requirements, in excess of the permitted tolerances and found during construction, are to be repaired as agreed with **TL.**

5.2 Gap and Weld Deformations

When the gap exceeds the required values, welding by building up or repairs are to be applied.

5.3 Defects

Defects and imperfections on the materials and welded connections found during construction are to be evaluated for possible acceptance on the basis of the applicable requirements.

Where the limits of acceptance are exceeded, the defective material and welds are to be repaired, if this is not possible discarded.

When any serious or systematic defect is detected either in the welded connections or in the base material, the Manufacturer is required to promptly inform the Surveyor and submit the repair proposal.

The Surveyor may require destructive or non-destructive examinations to be carried out for initial identification of the defects found and, in the event that repairs are undertaken, for verification of their satisfactory completion.

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6. Inspections and Checks

6.1 General

6.1.1 Materials, workmanship, structures and welded connections are to be subjected, at the beginning of the work, during construction and after completion, to inspections suitable to check compliance with the applicable requirements, approved plans and standards.

6.1.2 The Manufacturer is to make available to the Surveyor a list of the manual welders and welding operators and their respective qualifications.
The Manufacturer's internal organisation is responsible for ensuring that welders and operators are not employed under improper conditions or beyond the limits of their respective qualifications and that welding procedures are adopted within the approved limits and under the appropriate operating conditions.

6.2 Visual and non-destructive examinations

6.2.1 After completion of the welding operation and workshop inspection, the structure is to be presented to the Surveyor for visual examination at a suitable stage of fabrication.

As far as possible, the results of non-destructive examinations are to be submitted.

6.2.2 Non-destructive examinations are to be carried out with appropriate methods and techniques suitable for the individual applications, to be agreed with the Surveyor on a case by case basis.

6.2.3 Radiographic examinations are to be carried out on the welded connections of the hull in accordance with the **TL**'s requirements, the approved plans and the Surveyor's instructions.

6.2.4 **TL** may allow radiographic examinations to be partially replaced by ultrasonic examinations.

6.2.5 When the visual or non-destructive examinations reveal the presence of unacceptable defects, the relevant connection is to be repaired to sound metal for an extent and according to a procedure agreed with the Surveyor. The repaired zone is then to be submitted to non-destructive examination, using a method at least as effective as that adopted the first time and deemed suitable by the Surveyor to verify that the repair is satisfactory.
Additional examinations may be required by the Surveyor.

6.2.6 Ultrasonic and magnetic particle examinations may also be required by **TL** Surveyor in specific cases to verify the quality of the base material.

7. End Connections of Ordinary Stiffeners

7.1 Where ordinary stiffeners are continuous through primary supporting members, they are to be connected to the web plating so as to ensure proper transmission of loads, e.g. by means of one of the connection details shown in Figure 5.13 to Figure 5.16.

Connection details other than those shown in Figure 5.13 to Figure 5.16 may be considered by **TL.**

In all the above connections, the radius of all the scallops in the primary member around the stiffener is to be at least 20 mm.

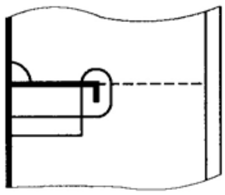

Figure 5.13 End connection of ordinary stiffener without collar plate

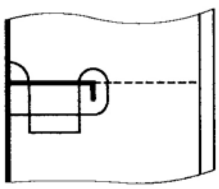

Figure 5.14 End connection of ordinary stiffener with collar plate

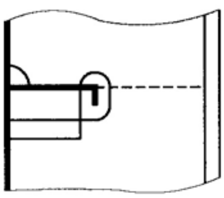

Figure 5.15 End connection of ordinary stiffener with one large collar plate

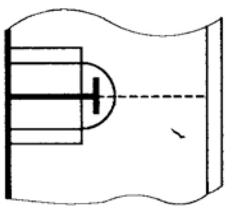

Figure 5.16 End connection of ordinary stiffener with two large collar plates

7.2 Where ordinary stiffeners are cut at primary supporting members, brackets are to be fitted to ensure the structural continuity.

The net thickness of brackets is to be not less than that of ordinary stiffeners. Brackets with net thickness [mm], less than 15 L_b, where L_b is the length [m] of the free edge of the end bracket, are to be flanged or stiffened by a welded face plate. The net sectional area [cm^2], of the flanged edge or face plate is to be at least equal to $10.L_b$.

7.3 Where necessary, it may require backing brackets to be fitted, as shown in Figure 5.17, in order to improve the fatigue strength of the connection.

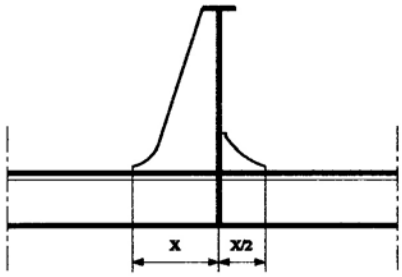

Figure 5.17 End connection of ordinary stiffener with backing bracket

8. End Connections of Primary Supporting Members

8.1 Bracketed end connections

8.1.1 Arm lengths of end brackets are to be equal, as far as practicable.

As a general rule, the height of end brackets is to be not less than that of the primary supporting member.

8.1.2 The thickness of the end bracket web is generally to be not less than that of the primary supporting member web.

8.1.3 The scantlings of end brackets are generally to be such that the net section modulus of the primary supporting member with end brackets is not less than that of the primary supporting member at mid-span.

8.1.4 The width [mm], of the face plate of end brackets is to be not less than 50 (L_b+1), where L_b is the length [m], of the free edge of the end bracket.

Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

8.1.5 Stiffening of end brackets is to be designed such that it provides adequate buckling web stability.

As guidance, the following prescriptions may be applied:

- where the length L_b is greater than 1,5 m, the web of the bracket is to be stiffened;
- the net sectional area [cm^2], of web stiffeners is to be not less than 16,5 ℓ_s, where ℓ_s is the span [m] of the stiffener;
- tripping flat bars are to be fitted to prevent lateral buckling of web stiffeners. Where the width of the symmetrical face plate is greater than 400 mm, additional backing brackets are to be fitted.

8.2 Bracketless end connections

8.2.1 As a general rule, in the case of bracketless crossing between primary supporting members (see Figure 5.18), the thickness of the common part of the web is to be not less than the value obtained, in mm, from the following formula:

$$t = 16 \frac{W}{A_o}$$

where;

W = The lesser of W_1 and $W_{2,3\ maks}$,

W_1 = Gross section modulus of member 1 [cm^3],

$W_{2,3\ maks}$ =The greater value of the gross section moduli of member 2 and 3 [cm^3],

A_o = Area of the common part of members 1, 2 and 3 [cm2].

In the absence of one of members 2 and 3 shown in Figure 5.18, the value of the relevant gross section modulus is to be taken equal to zero.

8.2.2 In no case may the thickness calculated according to 8.2.1 be less than the smallest web net thickness of the members forming the crossing.

8.2.3 In general, the continuity of the face plates is to be ensured.

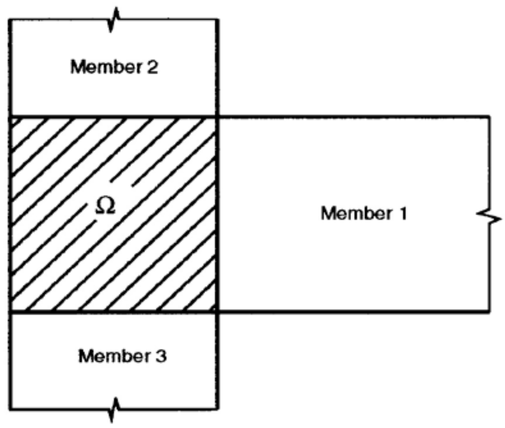

Figure 5.18 Bracketless end connections of primary supporting members

9. Cut-outs and Holes

9.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the depth of cut-outs is to be not greater than 50% of the depth of the primary supporting member.

9.2 Where openings such as lightening holes are cut in primary supporting members, they are to be equidistant from the face plate and corners of cut-outs and, in general, their height is to be not greater than 20% of the web height.

9.3 Openings may not be fitted in way of toes of end brackets.

9.4 Over half of the span of primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

At the ends of the span, the length of openings is to be not greater than 25% of the distance between adjacent openings.

9.5 The cut-out is to be reinforced to one of the solutions shown in Figure 5.19 to Figure 5. 21:

- continuous face plate : see Figure 5.19
- straight face plate : see Figure 5.20
- compensation of the opening : see Figure 5.21
- combination of the above solutions.

Other arrangements may be accepted provided they are supported by direct calculations.

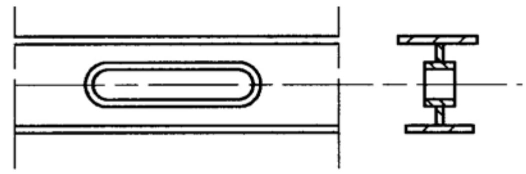

Figure 5.19 Stiffening of large openings in primary supporting members

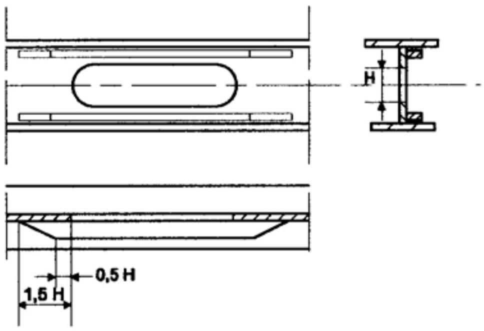

Figure 5.20 Stiffening of large openings in primary supporting members

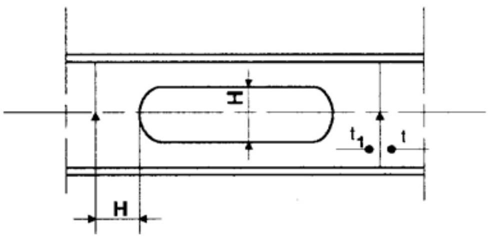

Figure 5.21 Stiffening of large openings in primary supporting members (insert plate)

10. Stiffening Arrangements

10.1 Webs of primary supporting members are generally to be stiffened where the height [mm], is greater than 100 t, where t is the web net thickness of the primary supporting member.

The web stiffeners of primary supporting members are to be spaced not more than 120 t apart.

10.2 As a general rule, tripping brackets (see Figure 5.22) welded to the face plate may be fitted every fourth spacing of ordinary stiffeners, without exceeding 4 m

- at the toe of end brackets
- at rounded face plates
- in way of cross ties
- in way of concentrated loads.

Where the width of the symmetrical face plate is greater than 400 mm, backing brackets are to be fitted in way of the tripping brackets.

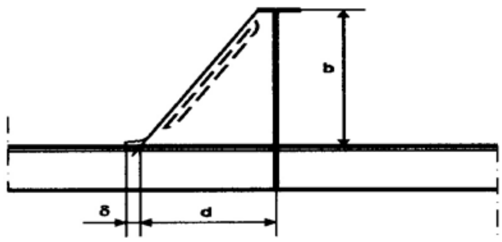

Figure 5.22 Primary supporting member: web sttiffener in way of ordinary stiffener

10.3 In general, the width of the primary supporting member face plate is to be not less than one tenth of the depth of the web, where tripping brackets are spaced as specified in 10.2.

10.4 The arm length of tripping brackets is to be not less than the greater of the following values:

d = 0,4 b

$$d = 0{,}85\, b \sqrt{\frac{S_t}{t}}$$

where;

b = height of tripping bracket shown in Figure 5.22 [mm],

S_t = Spacing of tripping brackets [m],

t = Thickness of tripping brackets [mm].

10.5 Tripping brackets with a net thickness less than 15 ℓ_b are to be flanged or stiffened by a welded face plate (ℓ_b = length of free edge of the bracket).

11. Riveted Connections

11.1 When riveted connections are employed, the mechanical properties of the rivets are to be indicated on the plans. **TL** may, at its discretion, require shear, tensile and compression tests to be carried out on representative specimens of riveted connections.

11.2 When rivets are used to connect materials of different types, precautions are to be taken against electrolytic corrosion.

D. Longitudinal Strength

1. General

1.1 The structural scantlings prescribed in this Section are also intended for the purposes of the longitudinal strength of a yacht of length having L not exceeding 50 m for monohull yachts or 40 m for catamarans and openings on the strength deck of limited size.

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

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

2. Bending Stresses

2.1 Allowable Stresses

In addition to satisfying the minimum requirements stipulated in the individual items of this Section, 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:

$$\sigma_d \le f \cdot \sigma_s \quad [N/mm^2]$$

$$\sigma_g \le f \cdot \sigma_s \quad [N/mm^2]$$

where;

$$\sigma_d = \frac{M_T}{1000\, W_d} \quad [N/mm^2]$$

$$\sigma_g = \frac{M_T}{1000\, W_g} \quad [N/mm^2]$$

W_d , W_g = section modulus at the bottom and the deck, respectively, of the transverse section [m^3],

M_T = design total vertical bending moment defined in Section 2, E,

f = 0,80 for planing yachts,

= 0,72 for displacement yachts,

σ_s = minimum yield stress of the material [N/mm^2]

2.2 Normal stresses

The compressive value of normal stresses is not to exceed the value of the critical stresses for plates and stiffeners calculated in A.

2.3 Moment of inertia of midship section

The moment of inertia of the midship section is to be not less than the value given by the following formula:

For planing yachts:

$$I = 5{,}32 \cdot M_T \cdot 10^{-6} \quad [m^4]$$

For displacement yachts:

$$I = 5{,}90 \cdot M_T \cdot 10^{-6} \quad [m^4]$$

3. Shear Stresses

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

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

T_t = Total shear defined in Section 2 [kN],

σ_s , f = Defined in 2,

A_t = Actual shear area of the transverse section to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings [m^2].

4. Calculation of the Section Modulus

In the calculation of the modulus and inertia of the midship section, all the continuous members, plating and longitudinal stiffeners are generally to be included, provided that they extend for at least 0,4 L amidships.

E. Plating

1. Definitions and Symbols

s = Spacing of ordinary longitudinal or transverse stiffener [m],

p = Scantling pressure given in Section 2, E [kN/m^2],

K = Factor defined in B, 4.

2. Keel

2.1 Plate Keel

The keel plating is to have a width b, throughout the length of the yacht, not less than the following value [mm]:

$$b = 4{,}5 \cdot L + 600$$

and a thickness not less than that of the adjacent bottom plating increased by 2 mm.

2.2 Solid Keel

The height and thickness of the keel, throughout the length of the yacht, are to be not less than the values h and t [mm], calculated by the following equations:

$$h = 1{,}5 \cdot L + 100$$

$$t = (0{,}35 \cdot L + 6) \cdot K^{0{,}5}$$

Lesser heights and thicknesses may be accepted provided that the effective area of the section is not less than that of the Rule section.

Lesser heights and thicknesses may also be acceptable if a centre girder is placed in connection with the solid keel.

The garboard strakes connected to the keel are each to have a width not less than 750 mm and a thickness not less than that of the bottom plating increased by 10%.

3. Bottom and Bilge

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

The thickness of the bottom plating and the bilge is to be not less than the greater of the values t_1 and t_2 [mm] calculated by the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0{,}5}$$

$$t_2 = 8 \cdot s \cdot (T \cdot K)^{0{,}5}$$

where ;

k_1 = 0,11 (assuıming $p=p_{1)}$,
= 0,07 (assuming $p=p_2$),

k_a = coefficient as a function of the ratio S/s given in Table 5.5 below, where S is the greater dimension of the plating [m].

Table 5.5

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

K_2 = Curvature correction factor given by $1 - h / \ell$ where h is the maximum curvature height (see Figure 5.23). This value is to be taken not less than 0,75.

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.

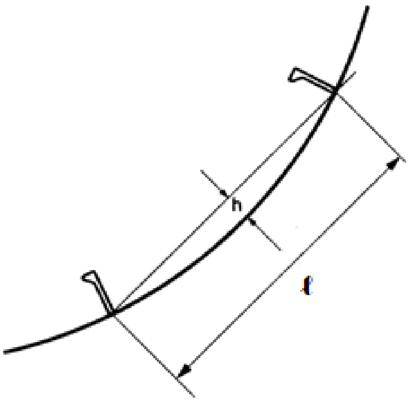

Figure 5.23

Sheet steel of plating connected to the stem or to the sternpost or in way of the propeller shaft struts is to have a thickness [mm] not less than the value t_e given by:

$$t_e = (0{,}05 \cdot L + 6) \cdot K^{0,5}$$

and, in any event, equal to the thickness of the bottom increased by 50%.

4. Side Plating

The thickness of side plating is to be not less than the greater of the values t_1 and t_2 [mm] calculated by the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 6{,}5 \cdot s \cdot (T \cdot K)^{0,5}$$

where;

k_1 , k_2 and k_a are defined in 3.

The thickness of the transom is to be no less than that required for the bottom, for the part below the waterline, and for the side, for the part above the waterline.

In the event of water-jet drive systems, the thickness of the transom will be the subject of special consideration.

5. Sheerstrake

In yachts having L > 50 m a sheerstrake plate of width [mm] not less than 0,025 L and thickness not less than the greater of the values of the plating of the side and the stringer plate is to be fitted.

In the case of sidescuttles or windows or other openings arranged on the sheerstrake plate, the thickness is to be increased sufficiently as necessary in order to compensate such openings.

In way of the ends of the bridge, the thickness of the sheerstrake is to be adequately increased.

6. Openings in the Shell Plating

6.1 Sea Intakes and Other Openings

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

An increase in the thickness of the local plating may be required where the openings are of unusual dimensions.

6.1.2 Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects. In any event, such openings are to be located well clear of welded connections.

6.1.3 The internal walls of sea intakes are to have external plating thickness increased by 1 mm, but not less than 6 mm.

7. Local Stiffeners

7.1 The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the stem, propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

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

7.3 The thickness of plating is to be locally increased in way of inner or outer permanent ballast arrangements.

The thickness is to be not less than 1,25 times that of the adjacent plating but no greater than that of the keel.

8. Cross-Deck Bottom Plating (for Twin Hull Vessels)

The thickness is to be taken, the stiffener spacing being equal, not 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.

F. Double Bottom Structures

1. General

1.1 This item stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.2 The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead in the machinery space is requested for yachts of L > 50 m.

On yachts of L > 61 m a double bottom is to be fitted, as far as practicable, outside the machinery space extending forward to the collision bulkhead and aft to the after peak bulkhead.

On yachts of L > 76 m the double bottom is to extend, as far as this is practicable, throughout the length of the yacht.

The double bottom is to extend transversally to the side so, as to protect the bottom in the bilge area, as far as possible.

1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.

The height of manholes is generally to be not greater than half of the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of **TL.**

1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2. Minimum Height

The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value obtained from the following formula:

$$h_{db} = 28 \cdot B + 32\,(T + 10) \qquad [mm],$$

The height of the double bottom is in any event to be not less than 700 mm. For yachts less than 50 m in length, **TL** may accept reduced height.

3. Inner Bottom Plating

The thickness of the inner bottom plating is to be not less than the value calculated by the following formula:

$$t_1 = (0{,}04\,L + 5s + 1) \cdot K^{0,5}$$

where;

s = Spacing of the ordinary stiffeners [m]

For yachts of length L < 50 m, the thickness is to be maintained throughout the length of the hull.

For yachts of length L > 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquid cargoes, the thickness of the top is also to comply with the provisions of J.

4. Centre Girder

A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness of the centre girder is to be not less than the following value:

$$t_c = (0{,}008\,h_{db} + 2) \cdot K^{0,5}$$

5. Side Girders

5.1 Arrangement

Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

5.2 Side Girders in Way of Engine Bedplates

Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height not less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted

6. Floors

6.1 Thickness of Floors

The thickness of the floors is to be not less than the following value:

$$t_d = (0{,}008\ h_{db} + 0{,}5) \cdot K^{0,5}$$

Watertight floors are also to have thickness not less than that required in J. for tank bulkheads.

6.2 Arrangement

When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be
arranged in longitudinally framed double bottoms in the following locations:

- under bulkheads and pillars
- outside the machinery space at an interval not greater than 2 m
- in the machinery space under the bedplates of main engines
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7. Bracket Floors

At each frame between solid floors, bracket floors consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating are to be arranged and attached to the centre girder and the magrin plate by means of flanged brackets with a width of flange not less than 1/10 of the double bottom depth.

The frame section modulus (bottom) is to be not less than:

$$W = k_1 \cdot s \cdot S^2 \cdot p \cdot K$$

where;

k_1 = 0,83 (assuming $p = p_1$)

= 0,36 (assuming $p = p_2$)

S = frame span equal to the distance between the mid-spans of the bracket connecting the frame/ reverse frame [m].

The reverse frame section modulus is to be not less than 85% of the frame section modulus.

Where tanks intended for liquid cargoes are arranged above the double bottom, the frame and reverse frame section moduli are to be no less than those required for tank stiffeners as stated in J.

8. Bottom and Inner Bottom Longitudinals

The section modulus of bottom stiffeners is to be not less than that required for single bottom longitudinals stipulated in G.

The section modulus of inner bottom stiffeners is to be not less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquid cargoes are arranged above the double bottom, the section modulus of longitudinals is to be not less than that required for tank stiffeners as stated in J.

9. Bilge Keel

9.1 Arrangement, Material and Scantlings

9.1.1 Arrangement

Where installed, bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The ends of the bilge keel are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

The arrangement shown in Figure 5.24 is recommended.

The arrangement shown in Figure 5.25 may also be accepted.

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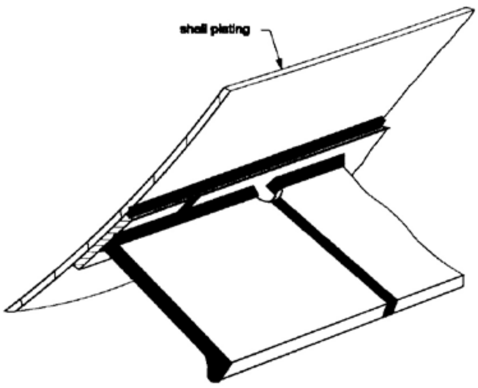

Figure 5.24 Bilge keel arrangement

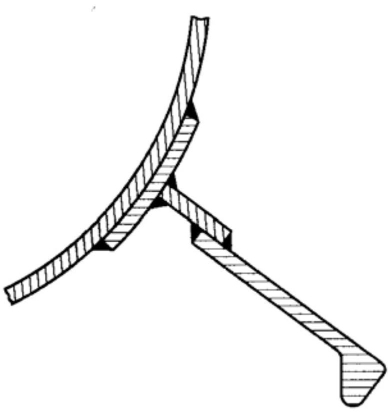

Figure 5.25 Bilge keel arrangement

9.1.2 Materials

The bilge keel and the intermediate flat are to be made of steel with the same yield stress and grade as that of the bilge strake.

9.1.3 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm.

9.2 Bilge keel connection

The intermediate flat, through which the bilge keel is connected to the shell, is to be welded as a shell doubler by continuous fillet welds.

The butt welds of the doubler and bilge keel are to be full penetration and shifted from the shell butts.

The butt welds of the bilge plating and those of the doublers are to be flush in way of crossing, respectively, with the doubler and with the bilge keel.

G. Single Bottom Structures

1. General

1.1 Scope

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

1.2 Longitudinal structure

1.2.1 The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The floors may be supported by girders, which in turn may be supported by transverse bulkheads, or by the sides of the hull.

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

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

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

1.3 Transverse structure

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

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

1.3.3 In way of the propeller shaft struts, the rudder horn and the ballast keel, additional floors are to be fitted with sufficiently increased scantlings.

1.3.4 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to be fitted as a continuation of the existing girders outside the engine room.

1.3.5 Floors of increased scantlings are to be fitted in way of reinforced frames at the sides and reinforced beams on the weather deck. Any intermediate floors are to be adequately connected to the ends.

2. Definitions and Symbols

s = spacing of ordinary longitudinal or transverse stiffeners [m],

p = scantling pressure given in Section 2, E [kN/m^2],

K = coefficient defined in B, 4.

3. Longitudinal Type Structure

3.1 Bottom Longitudinals

The section modulus of longitudinal stiffeners is to be not less than the value W [cm^3] calculated by the following formula:

$$W = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 0,83 (assuming $p = p_1$),

= 0,36 (assuming $p = p_2$),

S = Span of the longitudinal stiffener, equal to the distance between floors [m].

The bottom longitudinal stiffeners are preferably to be continual through the transverse members. Where they are to be interrupted in way of a transverse watertight bulkhead, brackets are to be provided at the ends.

3.2 Floors

The section modulus of the floors at the centreline of the span “S” is to be not less than the value W_D [cm^3] calculated by the following formula.

$$W_D = k_1 \cdot b \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b = Half the distance between the two floors adjacent to that concerned [m],

S = Floor span equal to the distance between the two supporting members (sides, girders, keel with a dead rise edge > 12°) [m].

In the case of a keel with a dead rise edge ≤ 12° but > 8°, the span S is always to be calculated considering the distance between girders or sides; the modulus W_D 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 W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b_{MIO}- = Half the distance [m], between the two side girders if supporting or equal to B/2 in the absence of supporting side girders

S = Girder span equal to the distance [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 W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b'_{MIO} \cdot S^2 \cdot K \cdot p$$

Where;

k_1 = Defined in 3.1,

b'_{MIO} = Half the distance between the two side girders if present or equal to B/2 in the absence of side girders [m],

S = Distance between the floors [m].

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 W_{YIO} [cm^3], calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1

b_{YIO} = Half the distance between the two adjacent girders or between the side and the girder concerned [m]

S = Conventional girder span equal to the distance between the two supporting members (transverse bulkheads, floors) [m].

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value W_{YIO} [cm^3], calculated by the following formula:

$$W_{YIO} = k_1 \cdot b'_{YIO} \; S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b'_{YIO} = Half the distance between the two adjacent girders or between the side and adjacent girder [m],

S = Distance between the floors [m].

4. Transverse Type Structures

4.1 Ordinary floors

The section modulus for ordinary floors is to be not less than the value W_D [cm^3], calculated by the following formula:

$$W_D = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1

S = Conventional span of the floor equal to the distance between the members which support it (girders, sides) [m].

4.2 Centre girder

The section modulus of the centre girder is to be not less than the value W_{MIO} [cm^3], calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 1,22 (assuming $p=p_1$),

= 0,75 (assuming $p=p_2$),

b_{MIO} = Half the distance [m], between the two side girders if supporting or equal to B/2 in the absence of supporting side girders

S = Span of the centre girder, equal to the distance between the two supporting members (transverse bulkheads, floors) [m]

4.3 Side Girders

The section modulus is to be not less than the value W_{YIO} [cm^3] calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 4.2,

b_{YIO} = Half the distance between the two adjacent girders or between the side and the girder adjacent to that concerned [m].

H. Side Structures

1. General

This item lays down the criteria for the scantlings of the reinforcement structures of the side, which may be of longitudinal or transverse type.

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

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

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

2. Definitions and Symbols

s = spacing of ordinary longitudinal or transverse stiffeners [m],

p = scantling pressure defined in Section 2, E [kN/m^2],

K = factor defined in B, 4.

3. Ordinary Stiffeners

3.1 Frames

The section modulus of the frames is to be not less than the value W_p [cm^3] calculated by the following formula:

$$W_p = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 0,67 (assuming $p = p_1$),

= 0,56 (assuming $p = p_2$),

S = Frame span equal to the distance between the supporting members [m] .

3.2 Longitudinal Frames

The section modulus of the longitudinal frames is to be not less than the value W_P [cm^3], calculated by the following formula:

$$W_P = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 0,83 (assuming $p = p_1$),

= 0,36 (assuming $p = p_2$e),

S = Span of the longitudinal equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads [m].

4. Reinforced Beams

4.1 Reinforced frames

The section modulus of the reinforced frames is to be not less than the value W_{DP} [cm^3], calculated by the following formula:

$$W_{DP} = k_1 \cdot K_{DP} \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 1,0 (assuming $p = p_1$),
= 0,7 (assuming $p = p_2$),

K_{DP} = 0,9 for reinforced frames which support ordinary longitudinal stiffeners, or reinforced stringers;
= 0,4 for reinforced frames which do not support ordinary stiffeners;

s = Spacing between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned [m];

S = Span equal to the distance between the members which support the reinforced frame [m].

4.2 Reinforced stringers

The section modulus of the reinforced frames is to be not less than the value W_{DS} [cm^3], calculated by the following formula:

$$W_{DS} = k_1 \cdot K_{DS} \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 4.1,

K_{DS} = 0,9 for reinforced stringers which support ordinary vertical stiffeners (frames),
= 0,4 for reinforced stringers which do not support ordinary vertical stiffeners,

s = Spacing between the reinforced stringers or 0,5 H in the absence of reinforced stringers or decks [m];

S = Span equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames [m].

5. Frame Connections

5.1 General

5.1.1 End connections of frames are to be bracketed.

5.1.2 Tweendeck frames are to be bracketed to the deck at the top and welded or bracketed at the bottom. In the case of bulb profiles, a bracket may be required to be fitted at the bottom.

5.1.3 Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

6. Scantling of Brackets of Frame Connections

6.1 General

As a general rule, for yachts of length greater than 50 m, the following scantlings may be adopted.

6.2 Upper brackets of frames

6.2.1 The arm length of upper brackets connecting frames to deck beams is to be not less than the value obtained from the following formula:

$$d = c \cdot \sqrt{\frac{W + 30}{t}}$$

where;

c = 48 for unflanged brackets,

= 44 for flanged brackets,

W = Section modulus of the stiffener [cm^3],

t = Bracket net thickness [mm].

6.2.2 For connections of perpendicular stiffeners located in the same plane, the required section modulus is to be taken equal to:

$W = W_2$ if $W_2 \leq W_1$

$W = W_1$ if $W_2 > W_1$

Where W_1 and W_2 , are the required section moduli of stiffeners as shown in Figure 5.26 and 5.27.

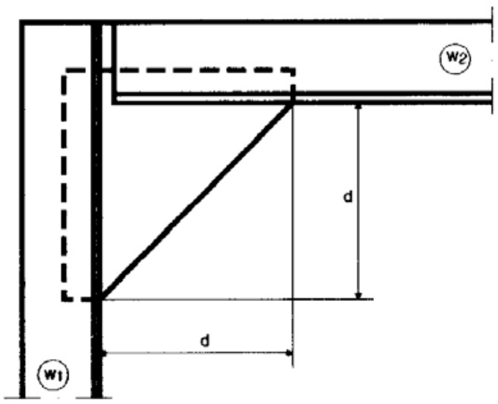

Figure 5.26 Connections of perpendicular stiffeners in the same plane

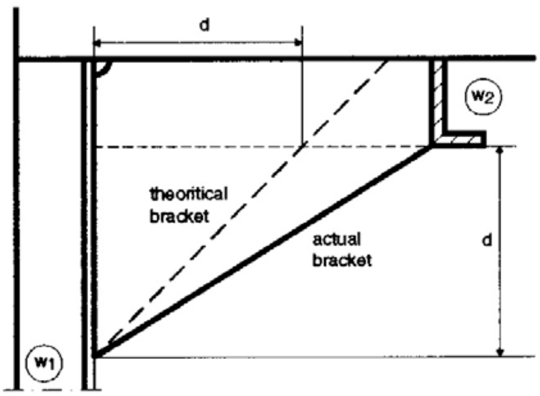

Figure 5.27 Connections of stiffeners located in perpendicular planes

6.2.3 For connections of frames to deck beams (see Figure 5.28), the required section modulus is to be taken equal to:

- for bracket "A" :

$W_A = W_1$ if $W_2 \leq W_1$

$W_A = W_2$ if $W_2 > W_1$

- for bracket "B" :

$W_B = W'_1$, but need not be greater than W_1.

Where W_1, W'_1 and W_2 are the required section moduli of stiffeners (see Figure 5.28).

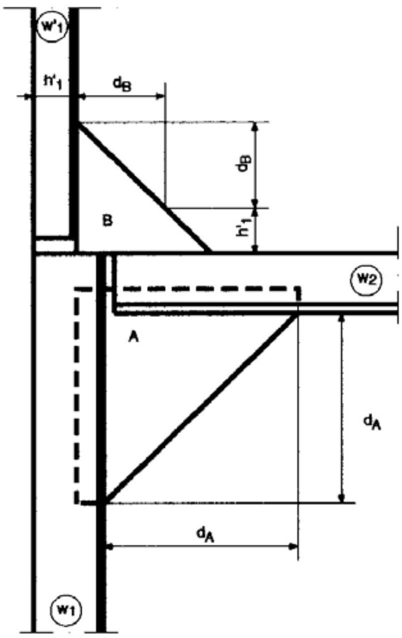

Figure 5.28 Connections of frames to deck beams

6.3 Lower brackets of frames

6.3.1 In general, frames are to be bracketed to the inner bottom or to the face plate of floors as shown in Figure 5.29.

6.3.2 The arm lengths d_1 and d_2 of lower brackets of frames are to be not less than the value obtained from the following formula:

$$d = c \cdot \sqrt{\frac{W + 30}{t}}$$

where;

c = 50 for unflanged brackets,

= 45 for flanged brackets,

W = required section modulus of the frame [cm^3],

t = bracket thickness [mm].

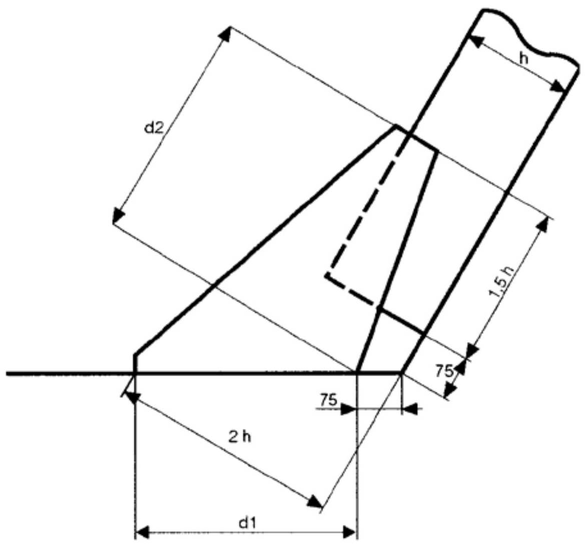

Figure 5.29 Lower Brackets of Frames

6.3.3 If the bracket thickness is less than 15 ℓ_b, where ℓ_b is the length of the bracket free edge, the free edge of the bracket is to be flanged or stiffened by a welded face plate.

The sectional area of the flange or the face plate is to be not less than 10 ℓ_b.

I. Decks

1. General

This item 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 transversally 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 mast 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

hg = 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 ordinary transverse or longitudinal stiffeners [m],

h_d = Scantling height the value of which is given in Section 2, E, Table 2.4 [m],

K = Factor defined in B, 4.

3. Deck Plating

3.1 Weather deck

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 [mm], calculated by the following formula :

$$t = 1{,}9 \cdot s \cdot (L \cdot K)^{0{,}5}$$

In yachts having L>50 m, a stringer plate is to be fitted with width [mm] not less than 25 L and thickness not less than the value given by the formula:

$$t = 2{,}4 \cdot s \cdot (L \cdot K)^{0{,}5}$$

The stringer plate of increased thickness may be waived if the thickness adopted for the deck is greater than Rule thickness.

3.2 Lower Decks

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 [mm], calculated by the following formula:

$$t = 1{,}15 \cdot s \cdot (L \cdot K)^{0{,}5}$$

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

4. Stiffening and Support Structures for Decks

4.1 Ordinary Stiffeners

The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value W_{NT} [cm^3], calculated by the following:

$$W_{NT} = 7{,}5 \cdot C_1 \cdot s \cdot S^2 \cdot K \cdot h_d$$

where;

C_1 = 1,44 for weather deck longitudinals,

= 0,63 for lower deck longitudinals,

= 0,56 for beams,

S = span equal to the distance between the two supprting members [m].

4.2 Reinforced Beams

The section modulus for girders and for ordinary reinforced beams is to be not less than the value W_{DT} [cm^3], calculated with the following equation:

$$W_{DT} = 4{,}75 \cdot b \cdot S^2 \cdot K \cdot h_d$$

where;

b = average width of the strip of deck resting on the beam [m]. In the calculation of b any openings are to be considered as non-existent

S = span of the reinforced beam [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 tubes.

The section area of pillars is to be not less than the value A_p [cm^2] given by the formula:

$$A_P = \frac{Q}{12{,}5 - 0{,}045 \cdot \lambda}$$

$$A = \frac{Q}{12{,}5 - 0{,}045 * \lambda}$$

where;

Q = Load resting on the pillar calculated by the following formula [kN]:

$$Q = 6{,}87 \cdot A \cdot h$$

where;

A = Area of the part of the deck resting on the pillar [m^2],

h = Scantling height defined in 2 [m],

λ = The ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

4.3.2 Pillar connections

Heads and heels of pillars are to be attached to the surrounding structure by means of brackets and insert plates so that the loads are well distributed.

Insert plates may be replaced by doubling plates, except in the case of pillars which may also work under tension, such as those in tanks. In general, the thickness of doubling plates is to be not less than 1,5 times the thickness of the pillar.

Pillars are to be attached at their heads and heels by continuous welding.

Pillars are to be connected to the inner bottom at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

J. Bulkheads

1. General

The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Section 2, A.

"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 independent metal tanks is required as stated in Section 2,D.

2. Symbols

s = Spacing between stiffeners [m],

S = Span equal to the distance between the members that support the stiffener concerned [m],

h_T, h_B = As defined in Section 2,E,

K = As defined in B, 4.

3. Bulkhead Plating

The watertight bulkhead plating is to have a thickness not less than the value t_p [mm] calculated by the following formula:

$$t_p = k_1 \cdot s \cdot (h \cdot K)^{0,5}$$

The coefficient k_1 and the scantling height h have the values indicated in Table 5.6.

Table 5.6

Bulkhead	k_1	h [m]
Collision bulkhead	4,35	h_B
Watertight bulkhead	3,8	h_B
Tank bulkhead	4,25	h_T

4. Stiffeners

4.1 Ordinary stiffeners

The section modulus of ordinary stiffeners is to be not less than the value W [cm^3] calculated by the following formulae:

$$W = 7,5 \cdot s \cdot S^2 \cdot h \cdot c \cdot K$$

The values of the coefficient c and of the scantling height h are those indicated in Table4 5.7.

4.2 Reinforced beams

The horizontal webs of bulkheads with ordinary vertical stiffeners and reinforced stiffeners in the bulkheads with ordinary horizontal stiffeners are to have a section modulus not less than the value W [cm^3], calculated by the following formula:

$$W = C_1 \cdot b \cdot S^2 \cdot h \cdot K$$

where;

C_1 = 6,0 for subdivision bulkheads,

= 10 for tank bulkheads,

b = Width of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener [m],

h = Scantling height indicated in Table 5.7.

Table 5.7

Stiffeners	h [m]	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Tank bulkhead	h_T	1,00

K. Superstructures

1. General

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.

When there is no access from inside superstructures and deckhouses to 'tweendecks" below, reduced scantlings with respect to those stipulated in this item may be accepted at the discretion of **TL.**

2. Boundary Bulkhead Plating

The thickness of the boundary bulkhead is to be not less than the value t [mm] calculated by the following formula:

$$t = 3 \cdot s \cdot (K \cdot h)^{0,5}$$

where;

s = Spacing between stiffeners [m],

h = Scantling height given in Table 5.8 [m],

K = Factor defined in B.4.

Table 5.8

Type of bulkhead	h [m]
1^{st} tier front	1,5
2^{nd} tier front	1,0
Other bulkhead whereever situated	1,0

In any event, the thickness t is to be not less than the values shown in Table 5.2.

3. Stiffeners

The stiffeners of the boundary bulkheads are to have a section modulus not less than the value W [cm^3], calculated by the following formula:

$$W = 3,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where;

h = Scantling height given in Table 5.8 [m],

K = Factor defined in B. 4,

s = Spacing of the stiffeners [m],

S = Span of the stiffeners, equal to the distance between the members supporting the stiffener concerned [m]

4. Superstructure Decks

4.1 Deck Plating

The superstructure deck plating is to be not less than the value t [mm], calculated by the following formula:

$$t = 4,3 \cdot s \cdot (K \cdot h)^{0,5}$$

where;

s = Spacing of the stiffeners [m],

K = Factor defined in B.4,

h = Scantling height defined in 2 [m].

4.2 Stiffeners

The section modulus W [cm^3], of both the longitudinal and
transverse ordinary deck stiffeners is to be not less than the value calculated by the following formula:

$$W = 5,5 \cdot s \cdot S^2 \cdot h \cdot K$$

where;

S = Span of the stiffener equal to the distance between the supporting members [m],

s, h = As defined in 2.

Reinforced beams and girders and ordinary pillars are to have scantlings as stated in I.

L. Ice Strengthening

For ice strengthening see **TL** Hull Construction Rules, Section 14.

SECTION 6

HULL CONSTRUCTION – ALUMINIUM ALLOY HULLS

Page

A. General Requirements

1. Field of Application

Section 6 applies to monohull yachts with a hull made of aluminium alloy and a length L not exceeding 90 m, with motor or sail power with or without an auxiliary engine.

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

In the examination of constructional plans, **TL** 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 on the basis of direct test calculations of the structural strength.

The formulae indicated in this Chapter are based on use of an aluminium alloy having yield strength, in the welded condition, $R_{p\,0,2}$ = 110 N/mm^2 (corresponding to a permanent elongation of 0,2%).

The scantlings of structures made with light alloys having different values of yield strength are obtained taking into account coefficient K as defined in B.

2. Definitions and Symbols

2.1 Premise

The definitions and symbols in this item are valid throughout this Section.

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

2.2 Definitions and symbols

L = Scantling length on the full load waterline, assumed to be equal to the length on the full load waterline with the yacht at rest [m];

B = Maximum breadth of the yacht, outside frames; in tests of the longitudinal strength of twin hull yachts, B is to be taken as equal to twice the breadth of the single hull, measured immediately below the cross-deck [m];

H = Depth of the yacht, measured vertically in the transverse section at half the length L, from the base line up to the deck beam of the uppermost continuous deck [m];

T = Draft of the yacht, in m, measured vertically in the transverse section at half the length L, from the base line to the full load waterline with the yacht at rest in calm water;

s = Spacing of the ordinary longitudinal or transverse stiffener [m];

Δ□ = Displacement of the yacht outside frames at draught T [t];

K = Factor as a function of the mechanical properties of the aluminium alloy used, as defined in B.

3. Plans, Calculations and Other Information to be Submitted for Approval

The list of plans to be submitted to **TL** in triplicate for approval is stated in Section 1, A.2.2.2, in general.

4. Direct Calculations

When deemed necessary by **TL**, direct calculations of the hull structural scantlings are to be carried out, on the basis of the most advanced calculation techinques.
When performing direct calculations the load specified, Section 2.E are generally to be applied. Where, in the opinion of **TL**, these requirements are deemed inappropriate, loads calculated according to other criteria are to be adopted.

5. General Rules for Design

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

For yachts with length L greater than 50 m, reduced scantlings may be adopted for the fore and aft zones. In such case the variations between the scantlings adopted for the central part of the hull and those adopted for the ends are to be gradual.

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

For yachts similar in performance to high speed craft, a longitudinal structure with reinforced floors, placed at a distance of not more than 2 m, is required for the bottom.

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

6. Minimum Thicknesses

In general, the thicknesses of plating, stiffeners and webs of reinforced beams are to be not less than the minimum values shown in Table 6.1.

Table 6.1

Member	Minimum thickness [mm]
Keel, bottom plating	$t_1 = 1,75 \cdot L^{1/3} \cdot K^{0,5}$
Side plating	$t_2 = 1,50 \cdot L^{1/3} \cdot K^{0,5}$
Open strength deck plating	$t_3 = 1,50 \cdot L^{1/3} \cdot K^{0,5}$
Lower and enclosed deck plating	$t_4 = t_3 - 0,5$
1st tier superstructure front bulkhead	$t_5 = t_4$
Superstructure bulkhead	$t_6 = t_5 – 1,5$
Watertight subdivision bulkhead	$t_7 = t_2 – 0,5$
Tank bulkhead	$t_8 = t_2$
Centre girder	$t_9 = 2,3 \cdot L^{1/3} \cdot K^{0,5}$
Floors and side girders	$t_{10} = 1,70 \cdot L^{1/3} \cdot K^{0,5}$
Tubular pillars	$t_{11} = 0,05 \cdot d$ **(1)**
(1) d= diameter of the pillar [mm]	

Lesser thicknesses may be accepted provided that, in the opinion of **TL**, their adequacy in terms of buckling strength and resistance to corrosion is demonstrated.

Where plating and stiffeners contribute to the longitudinal strength of the yacht, their scantlings are to be such as to fulfil the requirements for yacht longitudinal strength stipulated in D.

B. Materials

1. Wrought Aluminium Alloys

1.1 These Rules are applicable to the wrought aluminium alloys which are described below and which are intended for the fabrication of ships' hulls, superstructures and other ship structures as well as for pipelines.

1.2 These Rules are applicable to products made from wrought aluminium alloys having a product thickness of 3 to 50 mm inclusive. Requirements applicable to products having thicknesses outside this range are to be specially agreed with **TL**.

1.3 Alloys and material conditions which differ from the specified requirements given below, but which conform to national standards or the manufacturer's material specifications may be used provided that their properties and suitability for use, and also their weldability have been checked by **TL** and that **TL** has approved their use.

1.4 Alloy designations and material conditions which are indicated in these Rules comply with the designations of the Aluminium Association.

1.5 With regard to the definition of the material conditions EN 515 is applicable.

2. Requirements to be met by Manufacturers

Manufacturers wishing to supply products in accordance with these Rules shall be approved by **TL** for the alloys and product forms in question. This is conditional upon their fulfilling the manufacturing and quality control requirements and furnishing proof of this to **TL** prior to the commencement of supplies. **TL** reserves the right to carry out performance tests on products selected for this purpose

3. Manufacture and Material Condition

The starting material for rolled and pressed products is manufactured by continuous casting. Plates may be hot or cold rolled according to the characteristics (strength, dimensions, tolerances, etc.) required. Sections shall be extruded. Pipes and bars shall be extruded followed, where necessary, by drawing. For manufacturing methods of cast parts, manufacturer and foundry should come to an agreement. Pipes may also be fabricated from longitudinally welded strips.

All products shall be delivered in the material conditions specified for the alloy concerned.

4. Suitable Alloys

All alloys shall be suitable for use within seawater atmosphere or under exposure to seawater. The alloys mentioned in 4.1 and 4.2 may be used, if this precondition is satisfied and Aluminium alloys according to other standards and specifications may be used, if they are equivalent to those mentioned in 4.1 and 4.2 and if their suitability is confirmed by **TL**.

4.1 Alloys for use in load bearing structures

Table 6.2 specifies aluminium alloys which are suitable as welded, bonded or mechanically joint structural members exposed to marine environment.

Depending on the product type the wrought alloys may be supplied in the material conditions given in Table 6.2.

As regards chemical composition Table 6.4 applies, Table 6.5 as regards mechanical properties of plates and strips and Table 6.6 as regards mechanical properties of extruded sections, bars and pipes.

4.2 Wrought aluminium and wrought alloys for use in non-load bearing structures and for rivets

Aluminium and aluminium alloys which are suitable as welded, bonded or mechanically joint structural members in non-load bearing structures exposed to marine environment are given in Table 6.3.

The chemical composition of these materials shall be taken from EN 573-3 or equivalent standards.

The recommended product types for these alloys are also given in Table 6.3. They may be used in the material conditions specified in the relevant European or equivalent standards.

The alloys specified in Table 6.2 may also be used for non-load bearing structures applicable to all products and material conditions.

5. General Characteristics of Products

5.1 The products shall have a smooth surface compatible with the method of manufacture and shall be free of defects liable to impair further manufacturing processes or the proposed application of the products, e.g. cracks, laps, appreciable inclusions of extraneous substances and major mechanical damage.

5.2 Surface defects may be repaired only by grinding provided that this is accomplished with a gentle transition to the adjacent surface of the product and that the dimensions remain within the tolerance limits. Repair by welding is not permitted. For repair purposes only tools are to be used which are exclusively applied for aluminium processing.

6. Dimensional and geometrical tolerances

6.1 Unless otherwise agreed with **TL**, the following specified requirements are applicable in respect of permitted thickness tolerances.

- For plates and strips: Table 6.7,
- For open sections: Table 6.8,
- For closed sections: Table 6.9.

Other product shapes and other dimensional and geometrical tolerances are subject to the applicable standards.

Table 6.2 Wrought aluminium alloys:
Alloys, products and material conditions, recommended for use in load bearing structures

Designation of alloy	Sheets strips and plates	Extruded products			Drawn products		Forgings
		Bars	**Pipes**	**Sections**	**Bars**	**Pipes**	
TL-AW-5059 (AlMg5,5Mn0 8 ZnZr)	0/H111 H112 H116 H321	-	-	-	-	-	-
TL-AW-5083 (AlMg4,5Mn07) and TL-AW-5383 (AlMg4,5Mn0,9)	0/H111 H112 H116 H32	0/H111 H112	0/H111 H112	H112	0/H111	0/H111	H112
TL-AW-5086 (AlMg4)	0/H111 H112 H116 H32/H 321	0/H111 H112	0/H111 H112	H112	0/H111	0/H111	-
TL-AW-5454 (AlMg3Mn)	0/H111 H112 H32/H 321	0/H111 H112	0/H111 H112	H112	-	-	-
TL-AW-5754 (AlMg3)	0/H111 H112 H32	0/H111 H112	0/H111 H112	H112	0/H111	0/H111	H112
TL-AW-6005A (AlSiMg(A))	-	T6 **(1)**	T6 **(1)**	T6**(1)**	-	-	-
TL-AW-6061 (AlMg1SiCu)	-	T6 **(1)**	T6 **(1)**	T6 **(1)**	-	-	-
TL-AW-6082 (AlSiMgMn)	T6/T65 1	T6 **(1)**	T6 **(1)**	T5 T6 **(1)**	T6 **(1)**	T6 **(1)**	T6 **(1)**
TL-AW-6106 (AlMgSiMn)	-	-	-	T6 **(1)**	-	-	-

(1) *The properties may be achieved by quenching at the press.*

6.2 Compliance with tolerances and the requirements applicable to the general characteristics is the responsibility of the manufacturer. Examination of the products by the Surveyor does not release the manufacturer from this responsibility.

Where the performance of non-destructive tests is necessary, method and evaluation criteria shall be agreed with **TL**.

Table 6.3 Wrought aluminium and wrought aluminium alloys:
Alloys and products recommended for use in non-load bearing structures and for rivets

Designation of alloy	Sheets, strips and plates	Extruded products			Drawn products		Forgings	Electrical welded pipes	Drawn wire for rivets
		Bars	Pipes	Sections	Bars	Pipes			
EN AW-1050 A (Al99,5)	+	+	+	+	+	+	x	x	-
EN AW-1200 (Al99,0)	+	+	+	+	+	+	x	x	-
EN AW-3103 (AlMn1)	+	+	+	+	+	+	x	+	-
EN AW-5005 (AlMg1(B))	+	+	+	+	+	+	+	+	-
EN AW-5050 A (AlMg1,5(C))	+	x	x	x	x	x	x	+	-
EN AW-5251 (AlMg2)	+	+	+	+	+	+	x	+	-
EN AW-5052 (AlMg2,5)	+	+	+	+	+	+	x	x	-
EN AW-6060 (AlMgSi)	x	+	+	+	+	+	x	x	-
EN AW-6063 (AlMg0,7Si)	x	+	+	+	+	+	x	x	-
EN AW-5154 (AlMg3,5)	-	-	-	-	-	-	-	-	*
EN AW-5754 (AlMg3)	-	-	-	-	-	-	-	-	*

\+ *The recommended alloy is included in the relevant product standard.*
x *The recommended alloy is not included in the relevant product standard*
* *The recommended alloy, particularly in the material condition 0 and H32, is included in the relevant standard*
\- *The alloy is not recommended.*

7. Chemical Composition

7.1 The chemical composition of the alloys specified in these Rules shall correspond to the data given in Table 6.4.

For wrought aluminium and wrought alloys which are not specified therein the requirements of the standards or approved specifications shall be satisfied

7.2 The manufacturer shall determine the chemical composition on test specimens taken from each charge. Slight variations from the specified composition may be permitted by agreement of **TL** provided that the suitability of the product concerned for its intended purpose is not impaired thereby.

7.3 The analysis certificate produced by the manufacturer is normally accepted, with the Surveyor reserving the right to have occasional check analyses carried out.

Table 6.4 Chemical composition of selected wrought aluminium alloys

Alloy number	Chemical composition [%]									Other additions [%] (2)		Additional requirements
	Al	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	single	Total	
TL AW-5059	remainder	≤0,45	≤0,50	≤0,25	0,60-1,2	5,0-6,0	≤0,25	0,40-0,90	0,20	≤0,05	≤0,10	0,05 – 0,25 Zr
TL AW-5083	remainder	≤0,40	≤0,40	≤0,10	0,40-1,0	4,0-4,9	0,05-0,25	≤0,25	≤0,15	≤0,05	≤0,15	
TL AW-5086	remainder	≤0,40	≤0,50	≤0,10	0,20-0,70	3,5-4,5	0,05-0,25	≤0,25	≤0,15	≤0,05	≤0,15	
TL AW-5383	remainder	≤0,25	≤0,25	≤0,20	0,70-1,0	4,0-5,2	≤0,25	≤0,40	≤0,15	≤0,05	≤0,15	≤0,20 Zr
TL AW-5454	remainder	≤0,25	≤0,40	≤0,10	0,50-1,0	2,4-3,0	0,05-0,20	≤0,25	≤0,20	≤0,05	≤0,15	
TL AW-5754	remainder	≤0,40	≤0,40	≤0,10	≤0,50	2,6-3,6	≤0,30	≤0,20	≤0,15	≤0,05	≤0,15	0,10 ≤ Mn+Cr ≤ 0,6
TL AW-6005-A	remainder	0,50-0,90	≤0,35	≤0,30	≤0,50	0,4-0,70	≤0,30	≤0,20	≤0,10	≤0,05	≤0,15	0,12 ≤ Mn+Cr ≤ 0,5
TL AW-6061	remainder	0,40-0,80	≤0,70	0,15-0,40	≤0,15	0,80-1,2	0,04-0,35	≤0,25	≤0,16	≤0,05	≤0,15	
TL AW-6082	remainder	0,70-1,3	≤0,50	≤0,10	0,40-1,0	0,60-1,2	≤0,25	≤0,20	≤0,10	≤0,05	≤0,15	
TL AW-6106	remainder	0,30-0,60	≤0,35	≤0,25	0,05-0,20	0,4-0,80	≤0,20	≤0,10	–	≤0,05	≤0,10	

(1) Minor deviations of the prescribed composition may be accepted, *see* 7.2.

(2) *Other elements are seen as permissible additions. They need not to be specified, if their limit values are not exceeded.* .

Table 6.5 Material condition and mechanical properties of rolled products from wrought aluminium alloys (1) (Product thickness t=3 mm up to 50 mm.)

Alloy number	Material condition	Yield strength $R_{p0,2}$ [N/mm²] min.	Tensile strength R_m [N/mm²]	Thickness t [mm]	Elongation [%] min.	
					A_{50mm}	A_5
TL AW-5083	0/H111/H112	125	275-350	t≤12,5	16	-
				t>12,5	-	15
	H116	215	≥305	t≤12,5	12	-
				t>12,5	-	10
	H32/H321	215	305-380	t≤12,5	10	-
				t>12,5	-	9
TL AW-5086	0/H111/H112	100	240-310	t≤12,5	17	-
				t>12,5	-	16
	H116	195	≥275	t≤12,5	10	-
				t>12,5	-	9
	H32/H321	185	275-335	t≤12,5	10	-
				t>12,5	-	9
TL AW-5754	0/H111/H112	80	190-240	t≤12,5	18	-
				t>12,5	-	17
	H32	165	≥240	3≤t≤40	-	10
TL AW-5454	0/H111	85	≥215	3≤t≤40	-	10
	H32	180	≥250			
TL AW-5383	0/H111	145	≥290	3≤t≤40	-	17
	H116/H321	220	≥305	3≤t≤40	-	10
TL AW-5059	0/H111	160	≥330	3≤t≤50	-	24
	H116/321	270	≥370	3≤t≤20	-	10
		260	≥360	3≤t≤40	-	10

(1) *The mechanical properties are applicable to both longitudinal and transverse specimens.*

7.4 The material to be used for welded structural members should be made from ingots or billets with a hydrogen content of maximum 0,2 ml per 100 g aluminium, when measurement is carried out on the liquid metal during casting.

8. Mechanical properties

The required values of tensile strength, 0,2 % proof stress and elongation specified in Table 6.6 shall be fulfilled under tensile test.

9. Influence of Welding on Mechanical Characteristics

Welding heat input lowers locally the mechanical strength of aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111) or by heat treatment (series 6000).

Consequently, where necessary, a drop in mechanical characteristics of welded structures is to be considered in the heat-affected zone, with respect to the mechanical characteristics of the parent material.

The heat-affected zone may be taken to extend 25 mm on each side of the weld axis.

Aluminium alloys of series 5000 in 0 condition (annealed) or in H111 condition (annealed flattened) are not subject to a drop in mechanical strength in the welded areas.

Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas

10. Material factor K for Scantlings of Structural Members Made of Aluminium Alloy

The value of the material factor K to be introduced into formulae for checking scantlings of structural members, given in this Section and the various Appendices, is determined by the following equation:

$$K = \frac{110}{\eta \cdot R_{p0,2}}$$

where;

$R_{p0,2}$ = Minimum guaranteed yield stres of the parent material in delivery condition [N/mm^2]

η = Joint coefficient for the welded assembly corresponding to the aluminium alloy considered given in Table 6.10.

For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in annealed or welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

In the case of welding of two different aluminium alloys, the material factor K to be considered for the scantlings of welds is to be the greater material factor of the aluminium alloys of the assembly.

11. Riveted Connections for Aluminium Alloy Hulls

Use of rivets for connecting structures is limited, in principle, only to members which do not contribute to the overall strength of the hull

Whenever riveted connections are to be employed, mechanical and metallurgical properties of the rivets, is to be submitted.

Table 6.6 Material condition and mechanical properties of plates and strips made of wrought aluminium alloys (1)

Alloy number	Material condition	Yield strength $R_{p0,2}$ [N/mm^2] min.	Tensile strength R_m [N/mm^2]	Thickness t [mm]	Elongation [%] min.	
					A_{50min}	A_5
TL AW-5059	H112	200	≥330	3≤t≤50	-	10
TL AW-5083	0/H111	110	270-350	t≤12,5	10	-
	H112	125	>270	t>12,5	-	12
TL AW-5086	0/H111	95	240-320	t≤12,5	15	-
	H112			t>12,5	-	18
TL AW-5383	0/H111	145	≥290	3≤t≤50	-	17
	H112	190	≥310			13
TL AW-6005A	T5/T6	215	≥260	t≤12,5	8	-
				t>12,5	-	6
TL AW-6061	T5/T6	240	≥260	t≤12,5	10	-
				t>12,5	-	8
TL AW-6082	T5/T6	260	≥310	t≤12,5	10	-
				t>12,5	-	8

(1) *The mechanical properties are applicable to both longitudinal and transverse test specimens..*

Table 6.7 Permitted lower thickness tolerances for plates and strips

Nominal thickness [mm]	Thickness tolerance for product width [mm]		
	Up to 1500 mm	Over 1500 mm up to 2000 mmm	Over 2000 mm up to 3500 mm
Up to 4	0,10	0,15	0,15
Over 4 up to 8	0,20	0,20	0,25
Over 8 up to 12	0,25	0,25	0,25
Over 12 up to 20	0,35	0,40	0,50
Over 20 up to 50	0,45	0,50	0,65

Table 6.8 Permitted lower thickness tolerances for open sections

Nominal thickness [mm]	Thickness tolerances for sections which section shape is enclosed by a circle of [mm] diameter		
	Up to 250 mm	Over 250 mm Up to 400 mm	Over 400 mm
From 3 up to 6	0,25	0,35	0,40
Over 6	0,30	0,40	0,45

Table 6.9 Permitted lower thickness tolerances for closed sections

Nominal thickness [mm]	Thickness tolerance for sections which section shape is enclosed by a circle of [mm] diameter	
	Up to 250 mm	Over 250 mm up to 400 mm
From 3 up to 6	0,15	0,25
Over 6	0,20	0,30

C. Welded Joints

1. General

In general, Section 5, C. apply.

For aluminium alloy weldings, special processes for gas metal arc welding are to be applied under discretion of **TL** according “Welding Rules for Hull Structures”.

2. Welding Procedures for Aluminium Alloys

Welding procedures accepted for the construction of hulls are those semi-automatic with protection of argon gas or of argon-helium gas mix, with continuous fusible wire with manual welding process MIG (Metal-arc Inert Gas), and manual with argon gas protection, with a filler rod in the aforesaid alloy and torch having non fusible tungsten electrode, called TIG (Tungsten-arc Inert Gas). Welding procedures and filler materials other than the above is to be individually considered by **TL** during approval.

In particular, the following details are to be provided for the authorization to use welding procedures in production:

a) Category and grade of basic and filler materials,

b) Principal methods: type of joint (butt-welded, corner, etc.), preparation joints (thickness, caulking, right edges, etc.), welding position (flat, vertical, front, etc.) and other parameters (voltage, amperage, gas supply, etc.),

Table 6.10

Aluminium Alloys	η
- Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H 111), - Alloys hardened by work hardening (series 5000 other than condition 0 or H 111) and alloys hardened by heat treatment (6000 series)	1 $R'_{p0,2} / R_{p0,2}$
$R'_{p0,2}$: minimum guaranteed yield stress of metal in welded condition [N/mm²] i.e. ; - 0 or H 111 condition for series 5000 alloys, - For 6000 series, to be stated by the manufacturer.	

c) Welding conditions: cleaning methods of the edges to be welded, protection from atmospheric agents,

d) Special operating requirements for butt-welded joints, welding to start and end on heels outside joints, reverse chipping, provision for repair following any arc interruptions,

e) Type and extension of production checks.

3. Accessibility and Edge Preparation

For correct execution of welded joints, sufficient accessibility is necessary, depending on the welding process adopted and the welding position.

Edge cutting, to be carried out in general by machining, is to be regular and without burrs or cuts.

The structural parts to be welded as well as those adjacent, even if they have been previously pickled, are to be cleaned carefully before welding, using suitable mechanical means, such as stainless steel wire brushes, so as to eliminate oxides, grease or other foreign bodies which could give rise to welding defects.

Edge preparation, alignment of joints, spot-welding methods and root chipping are to be appropriate to the type of joint and welding position, and comply with **TL** requirements for the welding procedures adopted.

4. Tests

Tests of welded joints by **TL** surveyors are, in general, specified below. Irrespective of the extent of the aforesiad tests, the building shipyard is responsible for following that working methods, procedures and sequences comply with **TL** rules, approved plans and to the usual norms of good practice. To this end, the shipyard is to provide its own production control organization.

Inspections to be applied:

- Inspection of base materials for compliance with the requirements in B. and of structures with the approved plans.

- Inspection of the use and application conditions of welding procedures for compliance with those approved and verification that qualified welders are employed.

- Visual examination of edge preparations, root chipping and execution of welds in way of structural connections (e.g. crossing of butt-welded joints of panels or sheets of shell plating and strength deck, transverse joints of bent stringer plates, joints of inserts in way of openings, etc.) .

- Examination of radiographs of welded joints (radiographing is to be performed, if necessary, depending on the extent of the examinations), and inspection of performance of the ultrasonic or magnetic particle examinations which may be required.

- Inspection of any repairs, to be performed with procedures and inspection methods at the discretion of the **TL** Surveyor.

D. Design Loads and Hull Scantlings

1. Design Loads

1.1 Application

For design loads, the requirements in Section 2, E. apply.

2. Hull Scantlings

2.1 General

This item stipulates requirements for the scantlings of hull structures. The loads acting on such structures are to be calculated in accordance with Section 2,E.

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

For all other craft, **TL** may, at its discretion, accept scantlings for transverse structures of the hull based on direct calculations.

2.2 Overall strength

2.2.1 Longitudinal strength

In general, the scantlings resulting from local strength calculations in this Section are such as to ensure adequate longitudinal strength of the hull girder for the craft. Specific longitudinal strength calculations are to be carried according to the requirements of E.

2.2.2 Transverse strength of twin-hull craft

The equivalent Von Mises stresses obtained for load conditions in Section 2, E.4.4 are not to exceed 75/K N/mm^2.

In general, the bottom of the cross-deck is to be constituted by continuous plating for its entire longitudinal and transverse extension. Alternative solutions may, however, be examined by **TL** on the basis of considerations pertaining to the height of the cross-deck above the waterline and to the motion characteristics of the craft.

In the special case of twin hull craft, when the structure connecting both hulls is formed by a deck with single plating stiffened by n reinforced beams, the normal and shear stresses in the beams for the load condition in Section 2,E.4.4 can be calculated as indicated in 2.3.3.

For craft with L > 65 m or speed V > 45 knots, or for those craft whose structural arrangements do not permit a realistic assessment of stress conditions based on simple models, the transverse strength is to be checked by means of direct calculations carried out in accordance with the criteria specified in A.

2.2.3 Transverse strength in the special case of twin-hull craft when the structure connecting both hulls is formed by a deck with single plate stiffened by n reinforced beams

G, in Figure 6.1, is the centre of the stiffnesses r_i.. Its position is defined by::

$$a = \frac{\Sigma\, r_i \cdot x_i}{\Sigma\, r_i}$$

where;

a = The abscissa of the centre G with respect to an arbitrarily chose origin 0r_i [m],

r_i = $\dfrac{12 \cdot E_i \cdot I_i}{S_i^3} \cdot 10^6$ [N/m],

E_i = Young's modulus of the beam i [N/mm^2],

I_i = Bending inertia of the beam i [m^4],

S_i = span of the beam i between the inner faces of the hulls [m],

x_i = abscissa of the beam i with respect to the origin O [m].

If F_i [N] is the force taken over by the beam i, the deflection y_i [m] of the hull in way of the beam i is:

$$Y_i = \frac{F_i \cdot S_i^{\,3} \cdot 10^{-6}}{12 \cdot E_i \cdot I_i} = \frac{F_i}{r_i} = d_i \cdot \omega$$

d_i = x_i – a, abscissa of the beam i in relation to G [m],

ω = rotation angle of one hull in relation to the other around a transverse axis passing through G [rad].

Considering that the transverse torsional moment;

$$M_{tt} = \Sigma\, F_i \cdot d_i \cdot 10^{-3}$$

The formula for ω may be obtained as follows:

$$\omega = \frac{M_{tt}}{\Sigma_{ri} \cdot d_i^2} \cdot 10^3$$

As M_{tt}, r_i and d_i are known, and ω thus deduced, the force F_i [N], the bending moment M_i [Nm] and the corresponding normal and shear stresses can be evaluated in each beam:

$$F_i = \omega \,.\, r_i \,.\, d_i$$

$$M_i = F_i \,.\, S_i / 2$$

Beams calculated by the above method are assumed to be fixed in each hull as beams in way of bulkheads inside hulls.

2.3 Buckling strength of aluminium alloy structural members

2.3.1 Application

These requirements apply to aluminium alloy plates and stiffeners subjected to compressive loads, to calculate their buckling strength.

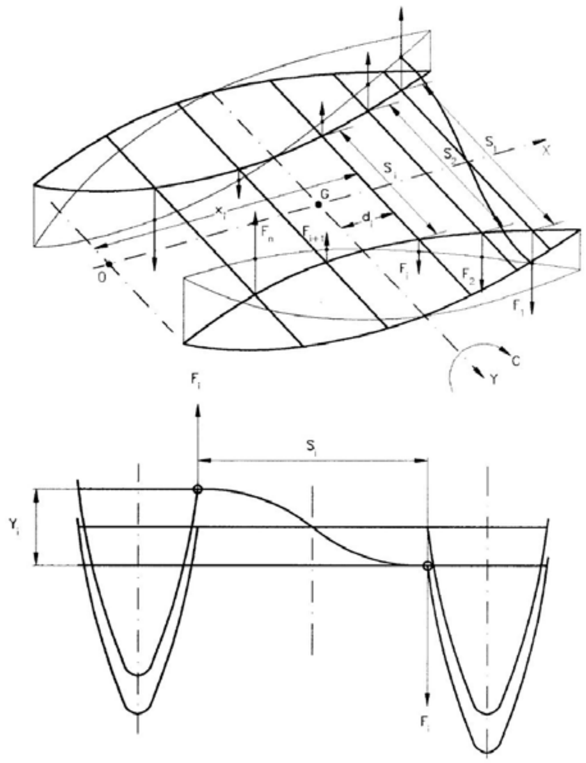

Figure 6.1

2.3.2 Elastic buckling stresses of plates

a) Compressive Stress

The elastic buckling stres is given by the following formula:

$$\sigma_E = 0{,}9 \cdot m_c \cdot \varepsilon \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2 \qquad [N/mm^2]$$

where;

m_c = coefficient equal to

= $(1 + \gamma^2)^2$ for uniform compression (Ψ) = 1,

= $1 + \frac{\gamma}{\gamma_1}(m_1 - 1)$ for compression-bending

Stress ($0 \le \Psi \le 1$), if ($\gamma < \gamma_1$)

= $\frac{2{,}1}{1{,}1 + \Psi} \cdot \left(1 + \gamma^2\right)^2$ for compression-bending

stress ($0 \le \Psi \le 1$), if ($\gamma \ge \gamma_1$)

$m_1 = \frac{2,1}{1,1+\Psi} \cdot \left(1+\gamma_1^2\right)^2$

t = plate thickness [mm],

E = $0,7 \, . \, 10^5$ [N/mm^2], Young's modulus,

a = shorter side of plate [m],

c = unloaded side of plate [m],

d = loaded side of plate [m],

Ψ = ratio between smallest and largest compressive stres in the case of linear variation acroos the panel ($0 \le \Psi \le 1$)

$\gamma = \frac{c}{d} \le 1$

$$\gamma_1 = \left[\frac{\left(4-\frac{1,1+\Psi}{0,7}\right)^{0,5}-1}{3}\right]^{0,5}$$

ε = coefficient equal to:

= 1 for edge d stiffened by a flat bar or bulb section, and $\gamma \ge 1$

= 1,1 for edge d stiffened by angle or T section, and $\gamma \ge 1$

= 1,1 for edge d stiffened by flat bar or bulb section and $\gamma < 1$

= 1,25 for edge d stiffened by angle or T section, and $\gamma < 1$.

b) Shear Stress

The elastic buckling stress is given by the following formula :

$$\tau_E = 0,9 \cdot m_t \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2 \quad \text{[N/mm}^2\text{]}$$

where;

$m_t = 5,34 + 4 \cdot \left(\frac{a}{b}\right)^2$

E, t and a are given in a).

b = longer side of plate [m].

2.3.3 Critical buckling stress

a) Compressive stress

The critical buckling stres is given by the following formula :

$$\sigma_c = \sigma_E \;, \quad \text{if} \quad \sigma_E \le \frac{R_{p0,2}}{2} \quad \text{[N/mm}^2\text{]}$$

$$\sigma_c = R_{p0,2} \cdot \left(1-\frac{R_{p0,2}}{4 \cdot \sigma_E}\right) \quad \text{if} \quad \sigma_E \rangle \frac{R_{p0,2}}{2} \quad \text{[N/mm}^2\text{]}$$

where;

$R_{p0,2}$ = minimum garanteed yield stres of aluminium alloy used in delivery condition [N/mm^2],

σ_E = 2.3.2 elastic buckling stres calculated according to a).

b) Shear stress

The critical buckling stres is given by the following formula :

$$\tau_c = \tau_E \;, \quad \text{if} \quad \tau_E \le \frac{\tau_F}{2} \quad \text{[N/mm}^2\text{]}$$

$$\tau_c = \tau_F \cdot \left(1-\frac{\tau_F}{4 \cdot \tau_E}\right), \text{ if} \quad \tau_E \rangle \frac{\tau_F}{2} \quad \text{[N/mm}^2\text{]}$$

where;

$\tau_F = \frac{R_{p0,2}}{\sqrt{3}}$

τ_E = elastic buckling stress calculated according to 2.3.2 b),

$R_{p0,2}$ = see a).

2.3.4 Axially loaded stiffeners

a) Elastic flexural buckling stress

The elastic flexural buckling stress is given by the following formula::

$$\sigma_E = 69{,}1 \cdot \left(\frac{r}{1000 \cdot c}\right)^2 \cdot m \cdot 10^4 \quad [N/mm^2]$$

where;

r = $10\left(\frac{I}{S + \varphi \cdot t \cdot 10^{-3}}\right)^{0,5}$, gyration radius [mm],

I = Moment of inertia of the stiffener calculated with a plate flange of width equal to ϕ [cm^4],

ϕ = Smaller of;

= 800 · a or 200 · c

S = Area of the cross-section of the stiffeners excluding attached plating [cm^2],

m = Coefficient depending on boundary conditions;

= 1, for a stiffener simply supported at both ends

= 2, for a stiffener simply supported at one end and fixed at the other end,

= 4, for a stiffener fixed at both ends.

b) Local elastic buckling stresses

The local elastic buckling stresses are given by the following formula:

- for flat bars:

$$\sigma_E = 55 \cdot \left(\frac{t_w}{h_w}\right)^2 \cdot 10^3 \quad [N/mm^2]$$

- built-up stiffeners with symmetrical flange :

$$\sigma_E = 27 \cdot \left(\frac{t_w}{h_w}\right)^2 \cdot 10^4 \quad \text{web}$$

$$\sigma_E = 11 \cdot \left(\frac{t_f}{b_f}\right)^2 \cdot 10^4 \quad \text{flange}$$

where;

h_w = Web height [mm],

t_w = Web thickness [mm],

b_f = Flange width [mm],

t_f = Flange thickness [mm].

c) Critical buckling stress

The critical buckling stres is given by the following formula:

$$\sigma_c = \sigma_E \quad , \text{ if } \quad \sigma_E \le \frac{\eta \cdot R_{p0,2}}{2} \quad [N/mm^2]$$

$$\sigma_c = \eta \cdot R_{p0,2} \cdot \left(1 - \frac{\eta \cdot R_{p0,2}}{4 \cdot \sigma_E}\right), \quad \text{if } \sigma_E \rangle \frac{\eta \cdot R_{p0,2}}{2} \quad [N/mm^2]$$

where;

$R_{p0,2}$ = see 2.3.3 a).

η = Joint coefficient for the welded assembly, see B.10.

σ_E = Either overall elastic buckling stress or local elastic buckling stress calculated according to a) and b) above, whichever is the lesser.

E. Longitudinal Strength

1. General

1.1 The structural scantlings prescribed in this Section are also intended for the purposes of the longitudinal strength of a yacht having length L not exceeding 45 m for monohull or 40 m for catamarans and openings on the strength deck of limited size.

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

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

2. Bending Stresses

2.1 Allowable stresses

In addition to satisfying the minimum requirements stipulated in the individual items of these Section, 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.

$\sigma_d \leq f \cdot \sigma_s$ [N/mm^2]

$\sigma_g \leq f \cdot \sigma_s$ [N/mm^2]

where;

$$\sigma_d = \frac{M_T}{1000 \cdot W_d} \quad [\text{N/mm}^2]$$

$$\sigma_g = \frac{M_T}{1000 \cdot W_g} \quad [\text{N/mm}^2]$$

W_d , W_g = Section modulus at the bottom and deck, respectively, of the transverse section [m^3],

M_T = Design total vertical bending moment defined in Section 2, E,

f = 0,80 for planing yachts,

= 0,72 for displacement yachts,

σ_s = Minimum yield stress of the material [N/mm^2].

2.2 Normal stresses

The compressive value of normal stresses is not to exceed the value of the critical stresses for plates and stiffeners calculated in D.

2.3 Moment of inertia of the midship section

The moment of inertia of the midship section is to be not less than the value given by the following formulae:

For planing yachts:

$$I = 16 \cdot M_T \cdot 10^{-6}$$

For displacement yachts:

$$I = 18 \cdot M_T \cdot 10^{-6}$$

3. Shear Stresses

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

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

T_t = Total shear stres defined in Section 2 [kN],

σ_s , f = Defined in 2,

A_t = Actual shear of the transverse section, to be calculated considering the net area of side plating and of any longitudinal bulkheads excluding openings [m^2].

4. Calculation of the Section Modulus

In the calculation of the modulus and inertia of the midship section, all the continuous members, plating and longitudinal stiffeners are generally to be included, provided that they extend for at least 0,4 L amidships.

F. Plating

1. Definitions and Symbols

s = Spacing of ordinary longitudinal or transverse stiffener [m],

p = Scantling pressure given in Section 2, E [kN/m^2],

K = Factor defined in B, 3.

2. Keel

2.1 Plate keel

The keel plating is to have a length b [mm] throughout the length of the yacht, not less than the value obtained by the following equation:

$$b = 4{,}5 \cdot L + 600$$

and a thickness not less than that of the adjacent bottom plating increased by 2 mm.

2.2 Solid keel

The height and thickness of the keel, throughout the length of the yacht, are to be not less than the values h [mm] and t [mm] calculated by the following equations:

$$h = 1{,}5 \cdot L + 100$$

$$t = 1{,}3 \cdot (0{,}35 \cdot L + 6) \cdot K^{0,5}$$

Lesser heights and thicknesses may be accepted provided that the effective area of the section is not less than that of the Rule section.

Lesser heights and thicknesses may also be acceptable if a centre girder is placed in connection with the solid keel.

The garboard strakes connected to the keel are each to have a width not less than 750 mm and a thickness not less than that of the bottom plating increased by 10%.

3. Bottom and Bilge Plating

Bottom plating is to extend to the chine or upper turn of the bilge, in any case the one extended as far as the waterline corresponding to draught T.

The thickness of the bottom plating and the bilge is to be not less than the greater of the values t_1 and t_2 [mm], calculated by the following formulae:

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 11 \cdot s \cdot (T \cdot K)^{0,5}$$

where;

k_1 = 0,15 (assuming $p=p_1$)

= 0,10 (assuming $p=p_2$)

k_a = Coefficient as a fuınction of the ratio S/s given in Table 6.11 below where S [m] is the greater dimension of the plating.

k_2 = Curvature correction factor given by 1-h/ ℓ to be taken not less than 0,75, where h is the distance measured perpendicularly from the chord ℓ to the highest point of the arc of plating between the two supports (see Figure 6.2).

Table 6.11

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

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

Sheet steel of plating connected to the stem or to the sternpost or in way of the propeller shaft struts is to have a thickness t_e [mm] not less than the value te given by:

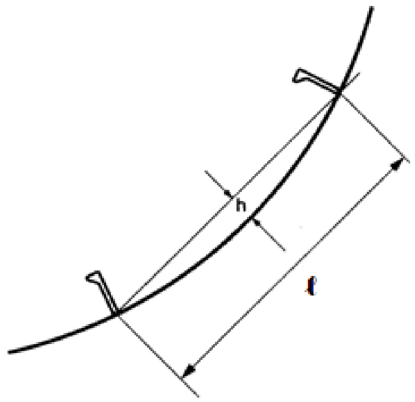

Figure 6.2

$$t_e = 1,3 \cdot (0,05 \cdot L + 6) \cdot K^{0,5}$$

and, in any event, equal to the thickness of the bottom increased by 50%.

4. Side Plating

The thickness of side plating is to be not less than the greater of the values t_1 and t_2 [mm], calculated by the following formulae;

$$t_1 = k_1 \cdot k_2 \cdot k_a \cdot s \cdot (p \cdot K)^{0,5}$$

$$t_2 = 10 \cdot s \cdot (T \cdot K)^{0,5}$$

where;

k_1 , k_2 ·and k_a are defined in 3.

5. Sheerstrake

In yachts having L> 50 m, a sheerstrake plate of height h, in mm, not less than 25 L and thickness not less than the greater of the values of the plating of the side and the stringer plate is to be fitted.

In the case of sidescuttles or windows or other openings arranged on the sheerstrake plate, the thickness is to be increased sufficiently as necessary in order to compensate such openings.

In way of the ends of the superstructure, the thickness of the sheerstrake is to be adequately increased.

6. Openings in the Shell Plating

6.1 Sea intakes and other openings

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

For areas having large openings, it may be necessary to increase the local plating thickness.

6.1.2 Openings in the curved zone of the bilge strakes may be accepted where the former are elliptical or fitted with equivalent arrangements to minimise the stress concentration effects. In any event, such openings are to be located well clear of welded connections.

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

7. Local Stiffeners

7.1 The thickness of plating determined with the foregoing formulae is to be increased locally, generally by at least 50%, in way of the stem, propeller shaft struts, rudder horn or trunk, stabilisers, anchor recesses, etc.

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

7.3 The thickness of plating is to be locally increased in way of inner or outer permanent ballast

arrangements.

The thickness is to be not less than 1,25 times that of the adjacent plating but no greater than that of the keel.

8. Cross Deck Bottom Plating (for Twin Hull Vessels)

The thickness is to be taken, the stiffener spacings being equal, not less than that of the side plating.

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

G. Double Bottom Structures

1. General

1.1 This Item stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.

The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.2 The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead in the machinery space, or as near thereto as practicable, is requested for yachts of L > 50 m.

On yachts of L > 61 m a double bottom is to be fitted outside the machinery space extending, as far as possible, forward to the collision bulkhead and aft to the after peak bulkhead.

On yachts of L > 76 m the double bottom is to extend, as far as possible, throughout the length of the yacht.

The double bottom is to extend transversally to the side so as to protect the bottom in the bilge area, as far as possible.

1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.

The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girder, or in floors and side girders below pillars, except in special cases at the discretion of **TL.**

1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2. Minimum Height

The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girder, is to be not less than the value obtained from the following formula:

$$h_{db} = 28 \cdot B + 32\,(T+10) \quad [\text{mm}]$$

The height of the double bottom is, in any event, to be not less than 700 mm. For yachts less than 50 m in length **TL** may accept reduced height.

3. Inner Bottom Plating

The thickness of the inner bottom plating is to be not less than the value calculated by the following formula:

$$t_1 = 1,4\ (0,04L + 5s + 1)\ k^{0,5}$$

where;

s = Spacing of the ordinary stiffeners [m]

For yachts of length L < 50 m, the thickness is to be maintained throughout the length of the hull.

For yachts of length L > 50 m, the thickness may be gradually reduced outside 0,4 L amidships so as to reach a value no less than 0,9 t_1 at the ends.

Where the inner bottom forms the top of a tank intended for liquid cargoes, the thickness of the top is also to comply with the provisions of K.

4. Centre Girder

A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.

The thickness of the centre girder is to be not less than the following value:

$$t_c = 1,4\ (0,008\ h_{db} + 2) \cdot K^{0,5}$$

5. Side Girders

5.1 Arrangement

Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.

A sufficient number of side girders are to be fitted so that the distance between them, or between one such girder and the centre girder or the side, does not exceed 3 m.

The side girders are to be extended as far forward and aft as practicable and are, as a rule, to terminate on a transverse bulkhead or on a floor or other transverse structure of adequate strength.

5.2 Side girders in way of engine bedplates

Where additional girders are foreseen in way of the bedplates of engines, they are to be integrated into the structures of the yacht and extended as far forward and aft as practicable.

Girders of height no less than that of the floors are to be fitted under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practicable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6. Floors

6.1 Thickness of Floors

The thickness of floors is to be not less than the following value:

$$t_d = (0,008\ h_{db} + 0,5) \cdot K^{0,5}$$

Watertight floors are also to have thickness not less than that required in K. for tank bulkheads.

6.2 Arrangement

When the height of a floor exceeds 900 mm, vertical stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be arranged in longitudinally framed double bottoms in the following locations.

- under buklheads and pillars
- outside the machinery space at an interval not greater than 2 m
- in the machinery space under the bedplates of main engines.
- in way of variations in height of the double bottom.

Solid floors are to be arranged in transversely framed double bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7. Bracket Floors

At each frame between solid floors, bracket floors consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating are to be arranged and attached to the centre girder and the magrin plate by means of flanged brackets with a width of flange not less than 1/10 of the double bottom depth.

The frame section modulus (bottom) is to be not less than:

$$W = k_1 \cdot s \cdot S^2 \cdot p \cdot$$

where;

k_1 = 1,6 assuming $p = p_1$,

= 0,68 assuming $p = p_2$.

S = Frame span equal to the distance between the mid-spans of the brackets connectinmg the frame/ reverse frame [m].

The reverse frame section modulus is to be not less than 85% of the frame section modulus.

Where tanks intended for liquid cargoes are arranged above the double bottom, the frame and reverse frame section moduli are to be no less than those required for tank stiffeners as stated in K.

8. Bottom and Inner Bottom Longitudinals

The section modulus of bottom stiffeners is to be not less than that required for single bottom longitudinals stipulated in H.

The section modulus of inner bottom stiffeners is to be not less than 85% of the section modulus of bottom longitudinals.

Where tanks intended for liquid cargoes are arranged above the double bottom, the section modulus of longitudinals is to be not less than that required for tank stiffeners as stated in K.

9. Bilge Keel

9.1 Arrangement, material and scantlings

9.1.1 Arrangement

Where installed, bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The ends of the bilge keel are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

The arrangement shown in Figure 6.3 is recommended.

The arrangement shown in Figure 6.4 may also be accepted.

9.1.2 Materials

The bilge keel and the intermediate flat are to be made of the same alloy as that of the bilge strake.

9.1.3 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm

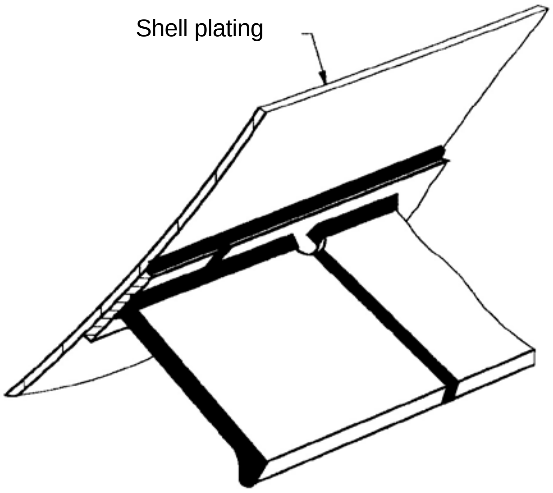

Figure 6.3 Bilge keel arrangement

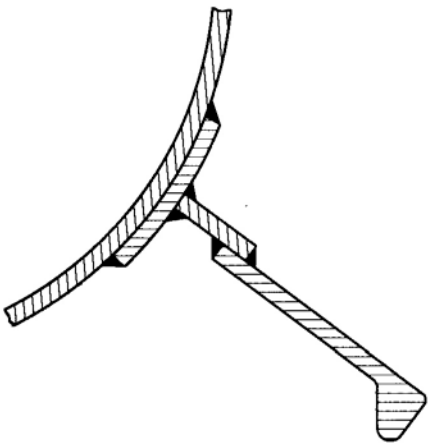

Figure 6.4 Bilge keel arrangement

9.2 Bilge keel connection

The intermediate flat, through which the bilge keel is connected to the shell, is to be welded as a shell doubler by continuous fillet welds.

The butt welds of the doubler and bilge keel are to be full penetration and shifted from the shell butts.

The butt welds of the bilge plating and those of the doublers are to be flush in way of crossing, respectively, with the doubler and with the bilge keel.

H. Single Bottom Structures

1. General

1.1 Scope

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

1.2 Longitudinal Structure

1.2.1 The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.

The floors may be supported by girders, which in turn may be supported by transverse bulkheads, or by the sides of the hull.

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

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

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

1.3 Transverse structure

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

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

1.3.3 In way of the propeller shaft struts, the rudder horn and the ballast keel, additional floors are to be fitted with sufficiently increased scantlings.

1.3.4 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to be fitted as a continuation of the existing girders outside the engine room.

1.3.5 Floors are to be fitted in way of reinforced frames at the sides and reinforced beams on the weather deck. Any intermediate floors are to be adequately connected to the ends.

2. Definitions and Symbols

s = Spacing of ordinary longitudinal or transverse stiffeners [m],

p = Scantling pressure given in Section 2, E [kN/m²],

K = Coefficient defined in B,10.

3. Longitudinal Type Structure

3.1 Bottom longitudinals

The section modulus of longitudinal stringers is to be not less than the value W [cm³], calculated by the following formula:

$$W = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 1,6 (assuming $p=p_1$)

= 0,7 (assuming $p=p_2$)

S = Span of the longitudinal stiffener equal to the distance between floors [m].

The bottom longitudinal stringers are preferably to be continual through the transverse members. Where they are to be interrupted in way of a transverse watertight bulkhead, brackets are to be provided at the ends.

3.2 Floors

The section modulus of the floors at the centreline of the span "S" is to be not less than the value W_D [cm³], calculated by the following formula.

$$W_D = k_1 \cdot b \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b = Half the disatance between the two floors adjacent to that concerned [m],

S = Floor span equal to the distance between the two supporting members (sides, girders, keel with a dead rise edge > 12°) [m].

In the case of a keel with a dead rise edge ≤12° but > 8° the span S is always to be calculated considering the distance between girders or sides; the modulus W_D 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 W_{MIO} [cm³] calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b_{MIO} = Half the distance between the two side girders if supporting or equal to B/2 in the absence of side girders [m],

S = Girder span equal to the distance between the two supporting members (transverse bulkheads, floors) b [m].

Whenever the centre girder does not form a support for the floors, the section modulus is to be not less than the value W_{MIO} [cm^3] calculated by the following formula:

$$W_{MIO} = k_1 \cdot b'_{MIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b'_{MIO} = Half the distance between the two side girders if present or equal to B/2 in the absence of side girders [m],

S = Distance between the floors [m].

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 W_{YIO} [cm^3] calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b_{YIO} = Half the distance between the two adjacent girders or between the side and the girder concerned [m],

S = Girder span equal to the distance between the two supporting members (transverse bulkheads, floors) [m].

Whenever the side girder does not form a support for the floors, the section modulus is to be not less than the value W_{YIO} [cm^3] calculated by the following formula:

$$W_{YIO} = k_1 \cdot b'_{YIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

b'_{YIO} = Half the distance between the two adjacent girders or between the side and the adjacent girder [m],

S = Distance between the floors [m].

4. Transverse Type Structures

4.1 Ordinary floors

The section modulus for ordinary floors is to be not less than the W_D [cm^3] calculated by the following formula:

$$W_D = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 3.1,

S = Span of the floor equal to the distance between the members which support it (girders, sides) [m].

4.2 Centre girder

The section modulus of the centre girder is to be not less than the value W_{MIO} [cm^3] calculated by the following formula:

$$W_{MIO} = k_1 \cdot b_{MIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 2,32 (assuming $p=p_1$)

= 1,43 (assuming $p=p_2$),

b_{MIO} = Half the distance between the two side girders if supporting or equal to B/2 in the absence of supporting side girders [m],

S = Span of the centre girder equal to the distance between the two supporting members (transverse bulkheades, floors) [m].

4.3 Side girders

The section modulus is to be not less than the value W_{YIO} [cm^3] calculated by the following formula:

$$W_{YIO} = k_1 \cdot b_{YIO} \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 4.2,

b_{YIO} = Half the distance between the two adjacent girders or between the side and the girder adjacent to that concerned [m],

S = Girder span equal to the distance between the two members which support it (transverse bulkheads, floors) [m].

I. Side Structures

1. General

This Item lays down the criteria for the scantlings of the reinforcement structures of the side, which may be of longitudinal or transverse type.

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

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

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

2. Definitions and Symbols

s = Spacing of ordinary longitudinal or transverse stiffeners [m],

p = Scantling pressure defined in Section 2, E [kN/m^2],

K = Factor defined in B, 10.

3. Ordinary Stiffeners

3.1 Transverse frames

The section modulus of the frames is to be not less than the value W_p [cm^3] calculated by the following formula:

$$W_p = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 1,27 (assuming $p = p_1$)

= 1,00 (assuming $p = p_2$)

S = Frame span equal to the distance between the supporting members [m].

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

3.2 Longitudinal stiffeners

The section modulus of the side longitudinals is to be not less than the value W_P [cm^3] calculated by the following formula:

$$W_P = k_1 \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = 1,60 (assuming $p = p_1$)

= 0,70 (assuming $p = p_2$)

S = Span of the longitudinal equal to the distance between the supporting members, in general made up of reinforced frames or transverse bulkheads [m].

4. Reinforced Beams

4.1 Reinforced frames

The section modulus of the reinforced frames W_{DP} [cm^3], is to be not less than the value calculated by the following formula:

$$W_{DP} = k_1 \cdot K_{DP} \cdot s \cdot S^2 \cdot K \cdot p$$

Where;

k_1 = 1,0 (assuming $p = p_1$)

= 0,7 (assuming $p = p_2$)

K_{DP} = 1,92 for reinforced frames which support ordinary longitudinal stiffeners, or reinforced stringers,

= 0,86 for reinforced frames which do not support ordinary stiffeners,

s = Spacing between the reinforced frames or half the distance between the reinforced frames and the transverse bulkhead adjacent to the frame concerned [m],

S = Span equal to the distance between the members which support the reinforced frame [m].

4.2 Reinforced Stringers

The section modulus of the reinforced stringers W_{DS} [cm^3] is to be not less than the value calculated by the following formula:

$$W_{DS} = k_1 \cdot K_{DS} \cdot s \cdot S^2 \cdot K \cdot p$$

where;

k_1 = Defined in 4.1,

K_{DS} = 1,92 for reinforced stringers which support ordinary vertical stiffeners (frames),

= 0,86 for reinforced stringers which do not support ordinary vertical stiffeners,

s = Spacing between the reinforced stringers or 0,5 H in the absence of other reinforced stringers or decks [m],

S = Span equal to the distance between the members which support the stringer, in general made up of transverse bulkheads or reinforced frames [m].

5. Frame Connections

5.1 General

5.1.1 End connections of frames are to be bracketed.

5.1.2 Tweendeck frames are to be bracketed to the deck at the top and welded or bracketed at the bottom to the deck.

In the case of bulb profiles, a bracket may be required to be fitted at the bottom.

5.1.3 Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

6. Scantling of Brackets of Frame Connections

6.1 General

As a general rule, for yachts of length greater than 50 m, the following scantlings may be adopted.

6.2 Upper brackets of frames

6.2.1 The arm length of upper brackets connecting frames to deck beams is to be not less than the value obtained from the following formula:

$$d = c \cdot \sqrt{\frac{W + 30}{t}}$$

where;

c = 48 for unflanged brackets,

= 44 for flanged brackets,

W = Section modulus of the stiffener [cm^3],

t = Bracket net thickness [mm].

6.2.2 For connections of perpendicular stiffeners located in the same plane, the required section modulus is to be taken equal to:

$W = W_2$, if $W_2 \leq W_1$

$W = W_1$, if $W_2 > W_1$

W_1 and W_2 are the required net section moduli of stiffeners, as shown in Figure 6.5 and 6.6.

6.2.3 For connections of frames to deck beams, the required section modulus is to be taken equal to (see Figure 6.7):

- for bracket “A” :

$W_A = W_1$, if $W_2 \leq W_1$

$W_A = W_2$, if $W_2 > W_1$

- for bracket “B” :

$W_B = W_1'$, but need not be greater than W_1.

Where W_1, W_1' and W_2 are required net section moduli of stiffeners (see Figure 6.7)

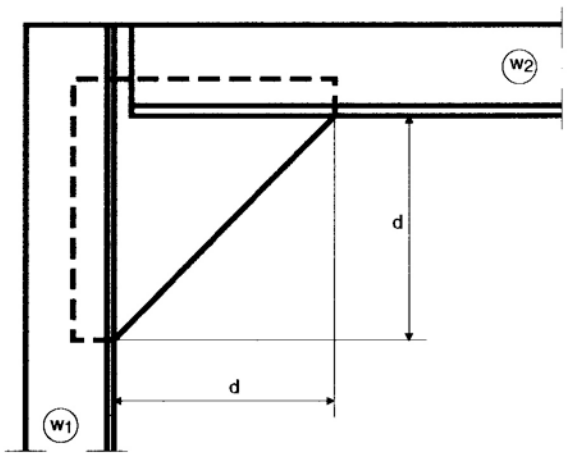

Figure 6.5 Connections of perpendicular stiffeners in the same plane

6.3 Lower brackets of frames

6.3.1 In general, frames are to be bracketed to the iner bottom or to the face plate of floors as shown in Figure 6.8.

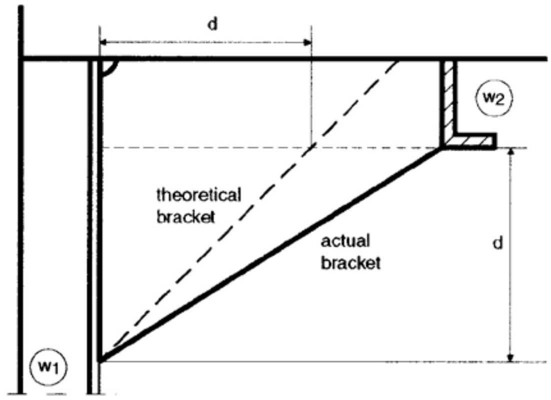

Figure 6.6 Connections of stiffeners located in perpendicular planes

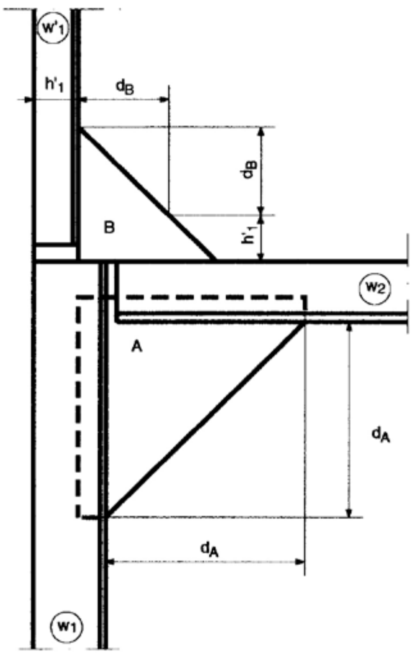

Figure 6.7 Connection of frames to deck beams

6.3.2 The arm lengths d_1 and d_2 of lower brackets of frames are to be not less than the value obtained from the following formula:

$$d = c \cdot \sqrt{\frac{W + 30}{t}}$$

where;

c = 50 for unflaged brackets,

= 45 for flanged brackets,

W = Required section modulus of the frame [cm^3],

t = Thickness of the bracket [mm].

6.3.3 If the bracket thickness is less than 15 ℓ_b , where ℓ_b is the length of the bracket free edge, the free edge of the bracket is to be flanged or stiffened by a welded face plate.

The sectional area of the flange or the face plate is to be not less than 10 ℓ_b.

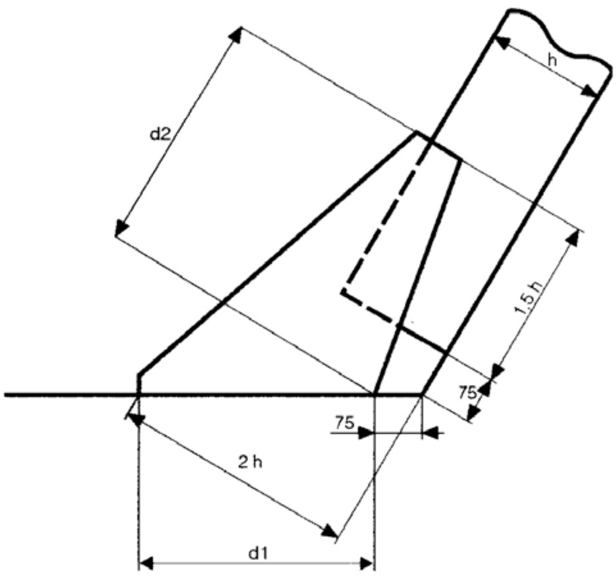

Figure 6.8 Lower brackets of main frames

J. Decks

1. General

This Item lays down the criteria and formulae for the scantlings of decks, plating and reinforcing of supporting structures.

The reinforcing and supporting structures of decks consist of ordinary reinforcements, beams or longitudinal stringers, laid transversally 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 mast 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

hg = 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 this deck is to extend for the whole length of the yacht.

s = Spacing of ordinary transverse or longitudinal stiffeners [m],

h = Scantling height, the value of which is given in Section 2, E [m].

K = Factor defined in B, 10.

3. Deck Plating

3.1 Weather deck

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 [mm], calculated by the following formula:

$$t = 2{,}5 \cdot s \cdot (L \cdot K)^{0,5}$$

In yachts having L > 50 m, a stringer plate is to be fitted with width [mm] not less than 25 L and thickness not less than the value given by the formula:

$$t = 3{,}1 \cdot s \cdot (L \cdot K)^{0,5}$$

The stringer plate of increased thickness may be waived if the thickness adopted for the deck is greater than Rule thickness.

3.2 Lower decks

The thickness of decks below the weather deck t [mm] intended for accommodation spaces is to be not less than the value calculated by the formula:

$$t = 1{,}5 \cdot s \cdot (L \cdot K)^{0{,}5}$$

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

4. Stiffening and Support Structures for Decks

4.1 Ordinary Stiffeners

The section modulus of the ordinary stiffeners of both longitudinal and transverse (beams) type is to be not less than the value W_{NT} [cm^3], calculated by the following equation:

$$W_{NT} = 14 \cdot C_1 \cdot s \cdot S^2 \cdot K \cdot h$$

where;

C_1 = 1,44 for weather deck longitudinals

= 0,63 for lower deck longitudinals

= 0,56 for beams

4.2 Reinforced Beams

The section modulus for girders and for ordinary reinforced beams is to be not less than the value W_{DT} [cm^3] calculated by the following equation:

$$W_{DT} = 9 \cdot b \cdot S^2 \cdot K \cdot h$$

where;

b = Average width of the strip of deck resting on the beam [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 tubes.

The section area of pillars is to be not less than the value A_p [cm^2] given by the formula:

$$A_p = \frac{1{,}6 \cdot Q}{12{,}5 - 0{,}045\,\lambda}$$

where;

Q = Load resting on the pillar, calculated by the following formula [kN]:

$$Q = 6{,}87 \cdot A \cdot h$$

where;

A = Area of the part of the deck resting on the pillar [m^2],

h = Scantling height, defined in 2 [m],

λ = The ratio between the pillar length and the minimum radius of gyration of the pillar cross-section.

4.3.2 Pillar Connections

Heads and heels of pillars are to be attached to the surrounding structure by means of brackets and insert plates so that the loads are well distributed.

Insert plates may be replaced by doubling plates, except in the case of pillars which may also work under tension, such as those in tanks.In general, the net thickness of doubling plates is to be not less than 1,5 times the net thickness of the pillar.

Pillars are to be attached at their heads and heels by continuous welding.

Pillars are to be connected to the inner bottom at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

K. Bulkheads

1. General

The number and position of watertight bulkheads are, in general, to be in accordance with the provisions of Section 2, A.

"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 independent metal tanks is required as stated in Section 2, D.

2. Symbols

s = Spacing between the stiffeners [m],

S = Span, equal to the distance between the members that support the stiffener concerned [m],

h_T, h_B = As defined in Section 2, E,

K = As defined in B, 10.

3. Bulkhead Plating

The watertight bulkhead plating is to have a thickness not less than the value t_p [mm] calculated by the following formulae:

$$t_p = k_1 \cdot s \cdot (h \cdot K)^{0,5}$$

The coefficient k_1 and the scantling height h have the values indicated in Table 6.12.

Table 6.12

Bulkhead	k_1	h [m]
Collision bulkhead	5,6	h_B
Watertight bulkhead	4,9	h_B
Tank bulkhead	5,5	h_T

4. Stiffeners

4.1 Ordinary Stiffeners

The section modulus of ordinary stiffeners is to be not less than the value W [cm^3] calculated by the following formula:

$$W = 14 \cdot s \cdot S^2 \cdot h \cdot c \cdot K$$

The values of the coefficient c and of the scantling height h are those indicated in Table 6.13..

Table 6.13

Stiffeners	h [m]	c
Collision bulkhead	h_B	0,78
Watertight bulkhead	h_B	0,63
Tank bulkhead	h_T	1,00

4.2 Reinforced Beams

The horizontal webs of bulkheads with ordinary vertical stiffeners and reinforced stiffeners in the bulkheads with ordinary horizontal stiffeners are to have a section modulus not less than the value W [cm^3], calculated by the following formula:

$$W = C_1 \cdot b \cdot S^2 \cdot h \cdot K * c$$

where;

C_1 = 11,4 for watertight bulkheads,

= 19,0 for deep tank bulkheads

b = Width of the zone of bulkhead resting on the horizontal web or on the reinforced stiffener [m],

h = Scantling height indicated in Table 6.13.

L. Superstructures

1. General

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.

When there is no access from inside superstructures and deckhouses to 'tweendecks" below, reduced scantlings with respect to those stipulated in this Item may be accepted at the discretion of **TL.**

2. Boundary Bulkhead Plating

The thickness of the boundary bulkheads is to be not less than the value t [mm], calculated by the following formula:

$$t = 3{,}9 \cdot s \cdot (K \cdot h)^{0{,}5}$$

where;

s = Spacing between the stiffeners [m],

h = Scantling height as indicated in Table 6.14 [m],

K = Factor defined in B, 3.

Table 6.14

Type of bulkhead	h [m]
1 st tier front	1,5
2 nd tier front	1,0
Other bulkhead wherever situated	1,0

3. Stiffeners

The stiffeners of the boundary bulkheads are to have a section modulus not less than the value W [cm^3] calculated by the following formula:

$$W = 6{,}5 \cdot s \cdot S^2 \cdot h \cdot K$$

where;

h = Scantling height defined in Table 6.14 [m],

K = Factor defined in B, 10,

s = Spacing of the stiffeners [m],

S = Span of the stiffeners, equal to the distance between the members supporting the stiffener concerned [m].

4. Superstructure Decks

4.1 Deck plating

The superstructure deck plating is to be not less than the value t [mm] calculated by the following formula:

$$t = 3{,}9 \cdot s \cdot (K \cdot h)^{0{,}5}$$

where;

s = Spacing of the stiffeners [m],

h = Scantling height defined in Table 6.14 [m].

4.2 Deck Stiffeners

The section modulus W [cm^3] of both the longitudinal and transverse ordinary deck stiffeners is to be not less than the value calculated with the following formula:

$$W = 6{,}5 \cdot s \cdot S^2 \cdot h \cdot K$$

where;

S = Span of the stiffener, equal to the distance between the supporting members [m],

s, h = As defined in 4.1.

Reinforced beams (beams, stringers) and ordinary pillars are to have scantlings as stated in J.

SECTION 7

MACHINERY and AUXILIARY SYSTEMS

A. General

1. Scope

This Section applies to main propulsion and essential auxiliary machinery systems and associated equipment, boilers and pressure vessels, piping systems, and steering and manoeuvring systems installed on board of classed yachts. Machinery and systems other than those stated in this Section are to be individually considered.

In the text of the various parts of this Section, the term "yacht" is intended to mean the pleasure vessel defined in Section 1,B. Item 1.1.1.

For ice strengthening see Chapter 4, Machinery Rules, Section 19.

2. Plans and Tests

2.1 For plans and tests, the requirements in Section 1 are to be complied with.

2.2 In yachts with L<15 m. the scope of plans and documents to be submitted may be reduced depending on the decision of **TL.**

3. Definitions

Basic concept and definitions applied in this section are described in following items:

- Rigid support
  In case of metal-to-metal contact where the engine mounts to the frame, rigidly.

- Flexible support
  A support that incorporates a sliding or flexible joint or stilt to accommodate early pressure and thus delays damage and distortion of the support. Friction or hydraulic devices may be used so that a support, when subjected to a load above its set load, yields mechanically rather than by distorting. This supports are also called as, resilient mount, shock absorber, vibration insulator, rubber insulator, damper etc.

- Means of escape
  Means of escape in case of fire means the provision of a safe route from the lowest part of the machinery room floor plates to a place of safety, enabling the person to escape from fire or smoke by his / her own unaided efforts**.**

- Engine room
  Engine room is a machinery space intended for the main engines and, in case of a ship with electric propulsion plants, the main generator.

- Machinery spaces
  Machinery spaces are all machinery spaces of Category A and all other spaces containing propelling machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

- Machinery spaces of Category A
  Machinery spaces of Category A are the spaces and trunks containing:

  - Internal combustion engines (ICE) used for main propulsion,
  - ICE used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW,
  - Any oil fired boiler or fuel oil unit,
  - Gas generators, incinerators, waste disposal units, etc., which use oil fired equipment.

- Main engine
  Main engine **is the engine being part of the propulsion plant.**

- Auxiliary machinery
  Auxiliary machinery is the machinery necessary for the operation of main engines, supply or consume of the ship with electric power and other kinds of energy, as well as functioning of the systems

- Equipment
  Equipment comprises all type of filters, heat exchangers, separators, purifiers, tanks and other arrangements ensuring normal operation of a machinery installation.

- Propulsion plant
  Propulsion plant is the total machinery and arrangements which generate, convert and transmit the power for ensuring the cruising of ship in safe at all specified rates of speed and comprising propellers, shafting, main gearing and main machinery, including electric propulsion units.

- Main active means of the ship's steering. It is a propulsion and steering unit being part of the propulsion plant.

- Auxiliary active means of the ship's steering. It is a propulsion and steering unit ensuring propulsion and steering of a ship at low speed or steering of a ship at zero speed when the ship is equipped with main means of propulsion and steering, and is used either in combination with the latter or when the main means of propulsion and steering are inoperative.

- Remote control
  Remote control is the changing of the speed and direction of rotation as well as starting and stopping the machinery from a remote position.

4. Design and Construction

4.1 General

The propulsion machinery, essential auxiliary machinery systems and associated equipment, boilers and other pressure vessels, piping systems and steering and manoeuvring systems are to be of a design and construction adequate for the service for which they are intended and are to be so installed and protected as to reduce to a minimum of any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

4.2 Ambient Conditions

The selection, layout and arrangements of all shipboard machinery, equipment and appliances shall ensure faultless continuous operation under the ambient conditions specified in Tables 7.1÷7.4.

Account is to be taken of the effects on the machinery installation of distortions of the ship's hull.

4.3 Vibration

Machinery, equipment and hull structures are normally subjected to vibration stresses. Design, construction and installation must in every case take account of these stresses.

The faultless long-term service of individual components shall not be endangered by vibration stresses.

4.4 Power of Machinery

Unless otherwise stated in each parts of this Section, power of machinery are to be determined as follows:

- for main propulsion machinery, the rated power/rotational speed declared by the Manufacturer according to a recognized Standard

- for auxiliary machinery, the power/rotational speed which is available in service

Table 7.1 Ambient conditions about inclinations

Installations, components	Angle of inclination [°] **(2)**			
	Athwartships		Fore-and-Aft	
	Static	Dynamic (rolling)	Static	Dynamic (pitching)
Main and auxiliary machinery	15	22,5	5 **(4)**	7,5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electrical and electronic appliances **(1)** and remote control systems	22,5 **(3)**	22,5 **(3)**	10	10

Notes :

(1) *Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur.*
(2) *Athwartships and fore-and-aft inclinations may occur simultaneously.*
(3) *In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to maximum of 30°.*
(4) *Where the length of the ship exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees where L = length of the ship, in metres.*

Table 7.2 Water temperature

Coolant	Temperature (°C)
Seawater	+ 32 **(1)**
Charge air coolant inlet to charge air cooler	+ 32 **(1)**

(1) ***TL*** *may approve lower water temperatures for ships operating only in special geographical areas.*

Table 7.3 Air temperatures at an atmospheric pressure of 100 kPa and at a relative humidity of 60%

Installations, components	Location, arrangement	Temperature range [°C]
Machinery and electrical installations **(1)**	in enclosed spaces	0 to +45 **(2)**
	on machinery components, boilers in spaces, subject to higher or lower temperatures	According to specific local conditions
	on the open deck	-25 to +45

(1) *Electronic appliances shall ensure satisfactory operation even at a constant air temperature of +55°C.*
(2) ***TL*** *may approve lower air temperatures for ships designed only for service in special geographical areas.*

Table 7.4 Other Ambient Conditions

Location	Conditions
In all spaces	Ability to withstand oil vapour and salt-laden air
	Trouble-Free operation within the temperature ranges stated in Table 1.3, and with a relative humidity up to 100% at a reference temperature of 45°C
	Tolerance to condensation is assumed
In specially protected control rooms	80% relative humidity at a reference temperature of 45°C
On the open deck	Ability to withstand temporary flooding with seawater and salt-laden spray

4.5 Astern Power

Sufficient power for going astern is to be provided to secure proper control of the yacht in all normal circumstances.

For main propulsion systems with reversing gears, controllable pitch propellers or electrical propeller drive, running astern is not to lead to an overload of propulsion machinery.

During the sea trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded.

4.6 Safety Devices

4.6.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

4.6.2 Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means are to be provided, where practicable, to protect against such pressure.

4.6.3 Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery are to be provided with automatic shut-off arrangements in case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

TL may permit provisions for overriding automatic shutoff devices.

See also the specific requirements given in the other parts of this Sections.

4.7 Fuels

4.7.1 Fuel oils employed for engines and boilers are, in general, to have a flash point (determined using the closed cup test) of not less than 60°C. However, for engines driving emergency generators, fuel oils having a flash point of less than 60°C but not less than 43°C are acceptable.

4.7.2 For yachts which special precautions are taken to **TL**'s approval, fuel oils having a flash point of less than 60˚C but not less than 43˚C may be used provided that, it is evident that the temperature of spaces where fuel oil is stored or employed will be at least 10˚C below the fuel oil flash point at all times.

4.7.3 Fuel oil having flash point of less than 43 °C may be employed on yachts provided that tanks for the storage of such fuel oil are to be located outside any machinery space and at a distance of not less than 760 mm inboard from the shell and bottom plating and from decks and bulkheads.

The spaces in which such fuel oil tanks are located are to be mechanically ventilated using exhaust fans providing not less than six air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixture. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings. The outlets for such exhaust are to discharge to a safe position.

A fixed vapour detection system is to be installed in each space through which fuel oil lines pass, with alarms provided at a continously manned control station.

Fort the arrangements of the piping installation **TL**’s special approval is requested.

4.7.4 For yachts not more than 24 metres according to ISO 8666, the use of petrol fuel also for propulsion engines may be accepted provided that the requirements of the relevant ISO Standards 10088 and 11105 are to be complied with concerning the ventilation of the spaces where fuels are stored or engines are installed and relevant to the protection of electrical devices against ignition of surrounding flammable gases.

4.8 Lighting

All machinery spaces must be adequately lit to ensure that control and monitoring instruments can be easily read.For lighting see Section 9.

4.9 Use of Asbestos

New installation of materials which contain asbestos is prohibited.

5. Arrangement and Installation

5.1 General

Provision is to be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

5.2 Floors

Floors in engine rooms are to be in general metallic, divided into easily removable panels.

5.3 Bolting Down

Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure a perfect fit.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain a perfect levelling and general alignment between the propulsion engines and their shafting.

5.4 Safety Devices on Moving Parts

Moving parts, flywheels, chain and belt drives, linkages and other components which could constitute an accident hazard for the operating personnel are to be fitted with guards to prevent contact.

5.5 Gauges

5.5.1 All gauges are to be grouped, as far as possible, near each manoeuvring position; in any event, they are to be clearly visible.

5.6 Ventilation in Machinery Spaces

5.6.1 Machinery spaces are to be sufficiently ventilated so as to ensure that machinery or boilers therein are operating at full power in all weather conditions.

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power. The requirements of the engine Manufacturer are to be followed.

5.6.2 The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

5.7 Hot Surfaces and Fire Protection

5.7.1 Surfaces having temperature exceeding 60°C with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

5.7.2 Surfaces of machinery with temperatures above 220°C, e.g. steam lines, thermal oil lines, exhaust gas lines, silencers, exhaust gas boıilers and turbochargers, are to be effectively insulated with non-combustible material. The insulation used is not to be oil absorbent and not permit the penetration of oil. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

5.7.3 Fire protection, detection and extinction are to comply with the requirements of Section 10.

5.8 Communications

5.8.1 At least one fixed means of voice communication is to be provided for communicating orders from the wheelhouse to the position in the machinery space or in the control room from which the speed and the direction of the thrust of the propellers are controlled.

5.8.2 Appropriate means of communication are to be provided from the wheel-house and the engine room to any other position from which the speed and direction of thrust of the propellers may be controlled.

5.8.3 Where the main propulsion system of the yacht is to be controlled from the wheel-house by a remote control system, the second means of communication may be the same bridge control system.

5.9 Machinery Remote Control, Alarms and Safety Systems

5.9.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, the requirements of Section 8 apply.

B. Construction and Tests of Engines

1. Diesel Engines

Where yachts more than 24 m in length are assigned + M class notation, main propulsion engines, engines driving electric generators including emergency generators and engines driving other auxiliaries essential for safety and navigation, when they develop a power of 110 kW and over; are to be designed, constructed, installed, tested and certified in accordance with the requirements of **TL** rules, Part B, Chapter 4, Machinery, Section 1 and Section 2 under the supervision of **TL**'s surveyors.

For propulsion and auxiliary diesel engines installed on yachts up to 24 m in length with (+) M class notation, the following certificates and alarms/indications (see Table 7.5 and Table 7.6) are required:

- Manufacturers' power declaration according to ISO Standard 8665;

- Exhaust emission according to EN ISO Standard 8178.

For propulsion and auxiliary diesel engines installed on yachts more than 24 m in length with (+) M class notation, the following certificates and alarms/indicates (see Table 7.5 and Table 7.6) are required:

- Manufacturers' power declaration according to ISO Standard 3046-1.

2. Gas Turbines

Where yachts more than 24 m in length are assigned + M class notation, main propulsion engines and engines driving other auxiliaries essential for safety and navigation, when they develop a power of 110 kW and over; are to be designed, constructed, installed, tested and certified in accordance with the requirements of **TL** rules, Part B, Chapter 4, Machinery, Section 1 and Section 4 under the supervision of **TL**'s surveyors.

3. Other Engines and Motors

In case of engines or motors other than those dealt in item 1 and 2, the maximum service power is to be checked according to criteria deemed adequate by **TL**, in relation to the concerned engine or motor type.

4. Gearing

Where yachts more than 24 m in length are assigned + M class notation, reduction and/or reverse gears intended for propulsion plants with a transmitted power of 220 kW and above; are to be designed, constructed, installed, tested and certified in accordance with the requirements of **TL** rules, Part B, Chapter 4, Machinery, Section 1 and Section 7 under the supervision of **TL**'s surveyors.

Alarms / indicators (alarms are to be visual and audible, indicators are to be fitted at a normally attended position)**:**

Table 7.5 Monitoring of main propulsion diesel engines

Symbols H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required R = remote	**Monitoring**		**Automatic control**				
			Main engine			**Auxiliary**	
Identification of system parameter	**Alarm**	**Indication**	**Slow-down**	**Shut-down**	**Control**	**Stand-by start**	**Stop**
Lubricating oil pressure	L						
Lubricating oil temperature		X					
Cylinder fresh cooling water temperature	H	X					
Exhaust gas temperature		X **(1)**					
Engine speed / direction of speed (when reversible)		X					
				H **(1)**			
Fault in the electronic governor system	X						

(1) *Indication is required for engines of 1000 kW and above*

Table 7.6 Monitoring of diesel engines used for auxiliary services

Symbols H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	**Monitoring**		**Automatic control**				
			Engine			**Auxiliary**	
Identification of system parameter	**Alarm**	**Indication**	**Slow-down**	**Shut-down**	**Control**	**Stand-by start**	**Stop**
Lubricating oil pressure	L						
Temperature of cooling water or cooling air		local					

For ice strengthening see, Chapter 4, Machinery, Section 19.

5. Pressure Vessels

Where yachts more than 24 m in length are assigned + M class notation, all kinds of pressure vessels to be used in yacht; are to be designed, constructed, tested and certified in accordance with the requirements of **TL** rules, Part B, Chapter 4, Machinery, Section 1 and Section 14 under the supervision of **TL**'s surveyors.

C. Shafting System

1. General

1.1 Application

1.1.1 This item applies to shafts, couplings, clutches and other shafting components transmitting power for main propulsion.

1.1.2 For yachts not more than 24 m in length, this item only applies to propeller shafts and intermediate shafts.

1.1.3 For ice strengthening see, Chapter 4, Machinery, Section 19.

2. Design and Construction

2.1 Materials

2.1.1 General

The use of other materials or steels having values of tensile strength exceeding the limits given in 2.1.2, 2.1.3 and 2.1.4 will be considered by **TL** in each case.

2.1.2 Shaft Materials

In general, shafts are to be of forged steel having tensile strength, R_m, between 400 and 930 N/mm^2.

2.1.3 Couplings, Flexible Couplings, Hydraulic couplings

Non-solid-forged couplings and stiff parts of elastic couplings subjected to torque are to be of forged or cast steel, or nodular cast iron.

Rotating parts of hydraulic couplings may be of grey cast iron, provided that the peripheral speed does not exceed 40m/s.

2.1.4 Coupling Bolts

Coupling bolts are to be of forged, rolled or drawn steel.

In general, the value of the tensile strength of the bolt material R_{mB} is to comply with the following requirements:

- $R_m \leq R_{mB} \leq 1,7\ R_m$
- $R_{mB} \leq 1100$ N/mm^2

2.1.5 Shaft Liners

Liners are to be of metallic corrosion-resistant material complying with the approved specification, if any; in the case of liners fabricated in welded lengths, the material is to be recognised as suitable for welding.

In general, they are to be manufactured from castings.

For small shafts, the use of liners manufactured from pipes instead of castings may be considered.

Where shafts are protected against contact with seawater not by metal liners but by other protective coatings, the coating procedure is to be approved by **TL.**

2.1.6 Sterntubes

The sterntubes thickness is considered by the **TL** on a case-by-case basis. In no case, however, may it be less than the thickness of the side plating adjacent to the sternframe. Where the materials adopted for the sterntube and the plating adjacent to the sternframe are different, the sterntube thickness is to be at least equivalent to that of the plating.

2.2 Scantling of Shafts

2.2.1 General

For the check of the scantling, the methods given in 2.2.2 and 2.2.3 apply for intermediate shafts and propeller shafts. As an alternative, the direct stress calculation method as per 2.2.5 may be applied.

2.2.2 Propeller, Intermediate and Thrust Shafts

The minimum diameter of intermediate and propeller shafts is not to be less than the value given by the following formula:

$$d_p = k \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160} \right]^{1/3}$$

where ;

d_p = Rule diameter of the intermediate or propeller shaft [mm]

k = 82, for unnotched intermediate shafts, fitted with solid flange couplings or with keyless shrunk-on couplings

= 90, for notched intermediate shafts (i.e. with keyway for non-solid flange couplings)

= 104, for propeller shafts constructed of corrosion-resistant steels or for propeller shafts fitted with continuous bronze liner or with effective oil lubrication system

= 109, for propeller shafts fitted with one continuous bronze liner, in contact with sea water

P = Maximum service power [kW]

n = Shaft rotational speed [r.p.m] corresponding to P power

Q = 0, in the case of solid shafts

= Ratio of the hole diameter to the outer shaft diameter in the concerned section, in the case of a hollow shaft; where $Q \le 0{,}3$, $Q = 0$ is to be taken.

= Hollow shafts whose longitudinal axis does not coincide with the longitudinal hole axis will be specially considered by **TL** in the individual cases.

R_m = Value of the minimum tensile strength of the shaft material [N/mm²].

Intermediate and propeller shafts having an actual minimum diameter less than above rule diameter may be accepted, provided they are based on documented satisfactory service experience and/or on technical documents submitted by the Manufacturer to **TL** and deemed suitable by the latter.

2.2.3 Corrosion-Resistant Propeller Shaft Materials

For corrosion-resistant material, such as Aquamet 17, Aquamet 22, Nickel copper alloy - monel K 500, stainless steel type 316 and Duplex steels, the following formula can be used to calculate the minimum diameter of the intermediate and propeller shaft:

$$d_p = k_m \cdot \left[\frac{P}{(n \cdot R_t)} \right]^{1/3}$$

where ;

d_p = Rule diameter of the intermediate and propeller shaft [mm],

k_m = Material factor (see, Table 7.7),

P = Maximum service power [kW],

n = Shaft rotational speed corresponding to P [rot/min.]

R_t = Yield strength in torsional shear [N/mm²].

Table 7.7 Values of factor k_m

Material	Material factor (k_m)	Maximum value R_t to be introduced in the formula [N/mm^2]
Aquamet 17, Aquamet 22	650	500
Stainless steel, type 316	530	160
Nickel copper alloy – monel K 500	560	460
Duplex steels	500	500

Shafts for which the scantling is determined according to the previous formula are to comply with the criteria listed in items a) to e), irrespective of the shaft material:

a) the span between two consecutive supports of the shaft is to be not more than the value given by the formula as indicated in 2.2.4;

b) the ratio between shaft diameter and propeller diameter is to be in general not more than 14:1 ;

c) the length of the cone shaft is to be verified in order to check that the sectional area of the key is not less than the value given in 2.5.5;

d) a visual inspection of the cone is required at every intermediate survey, and an inspection with a non-distructive system may be requested by the **TL** Surveyor.

e) lateral shaft vibrations analysis is to be carried out according to Section 8. If requested by **TL**, axial and torsional shaft vibration analisys is also to be submitted;

2.2.4 Shaft Bearing Spacing

The maximum shaft bearing space is to be not more than the value given by the following formula:

$$\ell = \left(0{,}7439 \cdot \frac{d_p}{n}\right)^{1/2} \cdot \left(\frac{E}{W_1}\right)^{1/4}$$

where ;

ℓ = Maximum unsupported length [m],

d_p = Shaft diameter [mm],

n = Shaft speed [rpm],

E = Modulus of elasticity of shaft material, in tension [Mpa],

W_1 = Shaft material specific weight [kg/dm^3].

The minimum required spacing for rigid bearings is to exceed 20 shaft diameters when possible to facilitate the alignment.

Assuming E = 196000 MPa and W_1 = 7,85 Kg/dm^3 (stainless steel), the value of ℓ can be obtained from Figuıre 7.1 as a function of d [mm]/n [rpm].

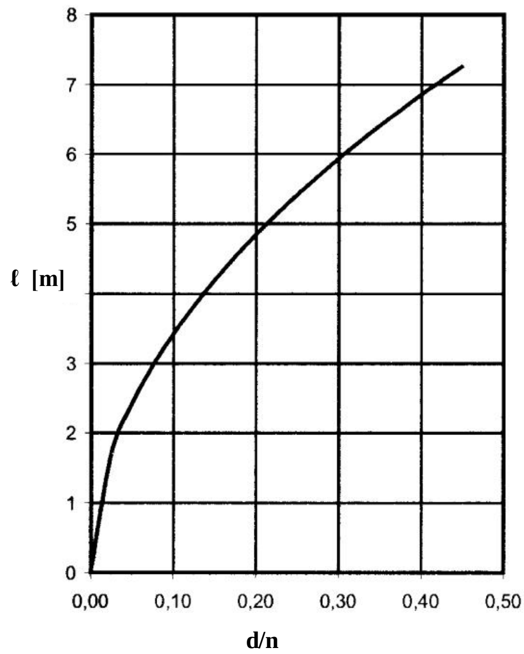

Figure 7.1 E = 196000 Mpa and W_1 = 7,85 kg/dm^3 (stainless steel), ℓ valuesi

2.2.5 Direct Stress Calculation Method

Shaft dimensions may be approved on the basis of documentation concerning fatigue considerations, or other methods accepted by **TL**.

2.3 Liners

2.3.1 General

Metal liners or other protective coatings approved by **TL** are required where propeller shafts are not made of corrosion-resistant material.

Metal liners are generally to be continuous; however, discontinuous liners, i.e. liners consisting of two or more separate lengths, may be accepted by **TL** on a case-by-case basis, provided that:

- they are fitted in way of all supports

- the shaft portion between liners, likely to come into contact with sea water, is protected by a coating of suitable material with characteristics, fitting method and thickness approved by **TL**.

2.3.2 Scantlings

The thickness of metal liners fitted on propeller shafts or on intermediate shafts inside sterntubes is to be not less than the value t [mm], given by the following formula:

$$t = \frac{d + 230}{32} [mm]$$

where ;

d = Actual diameter of the shaft [mm],

Between the sternbushes, the thickness may be reduced by 25%.

2.4 Stern Tube Bearings

2.4.1 Oil Lubricated Aft Bearings of Anti-friction Metal

a) The length of bearings lined with white metal or other anti-friction metal and with oil glands of a type approved by **TL** is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above, provided the nominal bearing pressure is not more than 0,8 N/mm2, as determined by static bearing reaction calculations taking into account shaft and propeller weight, as exerting solely on the aft bearing, divided by the projected area of the shaft. However, the minimum bearing length is to be not less than 1,5 times its actual inner diameter.

2.4.2 Oil Lubricated Aft Bearings of Synthetic Rubber, Reinforced Resin or Plastics Material

a) For bearings of synthetic rubber, reinforced resin or plastic material which are approved by **TL** for use as oil lubricated sternbush bearings, the length of the bearing is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above provided the nominal bearing pressure is not more than 0,6 N/mm^2, as determined according to 2.4.1 b). However, the minimum length of the bearing is to be not less than 1,5 times its actual inner diameter.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

2.4.3 Water Lubbricated Aft Bearings of Lignum Vitea or Antifriction Metal

Where the bearing comprises staves of wood (known as "lignum vitae") or is lined with antifriction metal, the length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.4 Water Lubbricated Aft Bearings of Synthetic Material

a) Where the bearing is constructed of synthetic materials which are approved by **TL** for use as water lubricated sternbush bearings, such as rubber or plastics, the length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

b) For a bearing design substantiated by experimental data, consideration may be given to a bearing length less than 4 times, but in no case less than 2 times, the rule diameter of the shaft in way of the bearing.

2.4.5 Grease Lubricated Aft Bearings

The length of grease lubricated bearings is generally to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.6 Oil or Grease Lubrication System

a) For oil lubricated bearings, provision for oil cooling is to be made.
A gravity tank is to be fitted to supply lubricating oil to the sterntube; the tank is to be located above the full load waterline.
Oil sealing glands are to be suitable for the various sea water temperatures which may be encountered in service.

b) Grease lubricated bearings will be specially considered by the **TL**.

2.4.7 Water Circulation System

Efficient water circulation is to be provided for water lubricated bearings.

The water grooves on the bearings are to be of ample section such as to ensure efficient water circulation and be scarcely affected by wear-down, particularly for bearings of the plastic type. The shut-off valve or cock controlling the water supply is to be fitted in way of the water inlet to the sterntube.

2.5 Couplings

2.5.1 Flange Couplings

a) Flange couplings of intermediate and thrust shafts and the flange of the forward coupling of the propeller shaft are to have a thickness not less than 0,2 times the rule diameter of the solid intermediate shaft and not less than the coupling bolt diameter calculated for a tensile strength equal to that of the corresponding shaft. The fillet radius at the base of solid forged flanges is to be not less than 0,08 times the actual shaft diameter.

The fillet may be formed of multi-radii in such a way that the stress concentration factor will not be greater than that for a circular fillet with radius 0,08 times the actual shaft diameter.

For non-solid forged flange couplings, the above filet radius is not to cause a stress in the fillet higher than that caused in the solid forged flange as above.

Fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

b) Where the propeller is connected to an integral propeller shaft flange, the thickness of the flange is to be not less than 0,25 times the rule diameter of the aft part of the propeller shaft. The fillet radius at the base of the flange is to be not less than 0,125 times the actual diameter.

The strength of coupling bolts of the propeller boss to the flange is to be equivalent to that of the aft part of the propeller shaft.

c) Non-solid forged flange couplings and associated keys are to be of a strength equivalent to that of the shaft.

They are to be carefully fitted and shrunk on to the shafts, and the connection is to be such as to reliably resist the vibratory torque and astern pull.

d) For couplings of intermediate and thrust shafts and for the forward coupling of the propeller shaft having all fitted coupling bolts, the coupling bolt diameter in way of the joining faces of flanges is not to be less than the value d_B, in mm, given by the following formula:

$$d_B = 0,65 \cdot \left[\frac{d^3 \cdot (R_m + 160)}{n_B \cdot D_C \cdot R_{mB}} \right]^{0,5} \quad [mm]$$

where ;

d = Rule diameter of solid intermediate shaft [mm],

n_B = Number of fitted coupling bolts,

D_C = Pitch circle diameter of coupling bolts [mm],

R_m = Value of the minimum tensile strength of intermediate shaft material taken for calculation of d [N/mm^2]

R_{mB} = Value of the minimum tensile strength of coupling bolt material [N/mm^2]. Where, in compliance with 2.1.1, the use of a steel having R_{mB} in excess of the limits specified in 2.1.4 is allowed for coupling bolts, the value of R_{mB} to be introduced in the formula is not to exceed the above limits.

e) Flange couplings with non-fitted coupling bolts may be accepted on the basis of the calculation of bolt tightening, bolt stress due to tightening, and assembly instructions.

To this end, the torque based on friction between the mating surfaces of flanges is not to be less than 2,8 times the transmitted torque, assuming a friction coefficient for steel on steel of 0,18. In addition, the bolt stress due to tightening in way of the minimum cross-section is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2 proof stress (R_p 0,2), of the bolt material.

Transmitted torque has the following meanings:

- For main propulsion systems powered by diesel engines fitted with slip type or high elasticity couplings, by turbines or by electric motors: the mean transmitted torque corresponding to the maximum continuous power P and the relevant speed of rotation n, as defined under 2.2.2.

- For main propulsion systems powered by diesel engines fitted with couplings other than those mentioned above: the mean torque above increased by 20% or by the torque due to torsional vibrations, whichever is the greater.

The value 2,8 above may be reduced to 2,5 in the following cases:

- Yachts having two or more main propulsion shafts,

- When the transmitted torque is obtained, for the whole functioning rotational speed range, as the sum of the nominal torque and the alternate torque due to the torsional vibrations.

2.5.2 Shrunk Couplings

Non-integral couplings which are shrunk on the shaft by means of the oil pressure injection method or by other means may be accepted on the basis of the calculation of shrinking and induced stresses, and assembly instructions.

To this end, the force due to friction between the mating surfaces is not to be less than 2,8 times the total force due to the transmitted torque and thrust.

The value 2,8 above may be reduced to 2,5 in the cases specified under item e) of 2.5.1.

The values of 0,14 and 0,18 will be taken for the friction coefficient in the case of shrinking under oil pressure and dry shrink fitting, respectively.

In addition, the equivalent stress due to shrinkage determined by means of the von Mises-Hencky criterion in the points of maximum stress of the coupling is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2% prof stress ($R_{p0,2}$), of the material of the part concerned.

The transmitted torque is that defined under item e) of 2.5.1.

2.5.3 Other Couplings

Types of couplings other than those mentioned in 2.5.1 and 2.5.2 above will be specially considered by **TL**.

2.5.4 Flexible Couplings

a) The scantlings of stiff parts of flexible couplings subjected to torque are to be in compliance with the requirements of 2.

b) For flexible components, the limits specified by the Manufacturer relevant to static and dynamic torque, speed of rotation and dissipated power are not to be exceeded.

c) Where all the engine power is transmitted through one flexible component only (ships with one propulsion engine and one shaft only), the flexible coupling is to be fitted with a torsional limit device or other suitable means to lock the coupling should the flexible component break.

2.5.5 Propeller Shaft Keys and Keyways

a) Keyways on the propeller shaft cone are to have well rounded corners, with the forward end faired and preferably spooned, so as to minimise notch effects and stress concentrations.

The fillet radius at the bottom of the keyway is to be not less than 1,25% of the actual propeller shaft diameter at the large end of the cone. The edges of the key are to be rounded.

The distance from the large end of the propeller shaft cone to the forward end of the key is to be not less than 20% of the actual propeller shaft diameter in way of the large end of the cone.

Holes for the key securing screws are only to be located within the first one half from its aft end.

b) The sectional area of the key subject to shear stress is to be not less than the value, given by the following formula:

$$A = 155 \cdot \frac{d^3}{\sigma_t \cdot d_{PM}} \left[mm^2\right]$$

where ;

d = Rule diameter calculated according to the formula in 2.2.2 (R_m is to be assumed equal to 400 N/mm^2),

d_{PM} = Diameter of the cone at the mid length of the key [mm],

σ_t = Minimum tensile strength of the key material [N/mm^2].

The effective area in crushing of key, shaft or boss is to be not less than:

$$A = 24 \cdot \frac{d^3}{\sigma_y \cdot d_{PM}} \left[mm^2\right]$$

where;

σ_y = Yield strength of the key, shaft boss material as appropriate [N/mm^2],

d, d_{PM} = Values given above.

2.5.6 Keys and Keyways of Inboard Shaft Connections

Round ended keys are to be used and the keyways are to be provided with a smooth fillet at the bottom. The radius of the fillet is to be at least 0,0125 of the diameter of the shaft at the coupling. The sharp edges at the top of the keyways are to be removed.

The effective area of the key in shear is to be not less than:

$$A = 126 \cdot \frac{d^3}{\sigma_t \cdot d_{PM}} \left[mm^2\right]$$

where ;

d, d_{PM}, σ_t is given in 2.5.5.

2.5.7 **TL** may accept different designs from which stated in 2.5.5 and 2.5.6 provided that they are based on direct calculation analysis taking in account a safety factor not less than of 4, or in alternative the relevant design may be based on recognised standard.

3. Arrangement and Installation

3.1 General

3.1.1 The installation is to be carried out according to the instructions of the component Manufacturer or approved documents, when required.

3.1.2 The joints between liner parts are not to be located in way of supports and sealing glands. Metal liners are to be shrunk on to the shafts by pre heating or forced on by hydraulic pressure with adequate interference; dowels, screws or other means of securing the liners to the shafts are not acceptable.

3.2 Protection of Propeller Shaft Against Corrosion

The propeller shaft surface is to be suitably protected in order to prevent any contact with sea water, unless the shaft is made of corrosion-resistant material.

3.3 Shaft Alignment

It has to be verified by alignment calculation that the requirements for shaft, gearbox and engine bearings are fulfilled in all relevant working conditions of the drive line. At this all essential static, dynamic and thermal effects have to be taken into account.

The calculation reports to be submitted shall include the complete scope of used input data and have to disclose the resulting shaft deflection, bending stress and bearing loads and must document the compliance of the specific maker requirements.

The final alignment on board has to be checked by suitable measurement methods in afloat condition in presence of the surveyor.

4. Material Tests, Workshop Inspection and Testing, Certification

4.1 Material Tests, Non-destructive Tests, Workshop Inspections and Testing

4.1.1 Material Tests

Shafting components are to be tested in accordance with Table 7.8. Magnetic particle or liquid penetrant tests are required for the parts listed in Table 7.8 and are to be effected in positions where experience shows defects are most likely to occur. Ultrasonic testing requires certificate.

D. Propellers

1. General

1.1 Application

1.1.1 Propulsion Propellers

The requirements of this Section apply to propellers exceeding 1,0 m. in diameter and intended for propulsion. They include fixed and controllable pitch propellers, including those ducted in fixed nozzles.

For ice strengthening, see Chapter 4, Machinery, Section 19.

1.2 Definitions

1.2.1 Solid Propeller

A solid propeller is a propeller (including hub and blades) cast in one piece.

1.2.2 Built-up Propeller

A built-up propeller is a propeller cast in more than one piece. In general, built-up propellers have the blades cast separately and fixed to the hub by a system of bolts and studs.

1.2.3 Controllable Pitch Propellers

Controllable pitch propellers are built-up propellers which include in the hub a mechanism to rotate the blades in order to have the possibility of controlling the propeller pitch in different service conditions.

1.2.4 Nozzle

A nozzle is a circular structural casing enclosing the propeller.

Table 7.8 Material tests and Non-destructive tests

Shafting components	Material tests (mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic
Coupling (separate from shafts)	All	İf diameter ≥ 100 mm.	İf diameter ≥ 100 mm.
Propeller shafts	All	İf diameter ≥ 250 mm.	İf diameter ≥ 250 mm.
Intermediate shafts	All	İf diameter ≥ 250 mm.	İf diameter ≥ 250 mm.
Thrust shafts	All	İf diameter ≥ 250 mm.	İf diameter ≥ 250 mm.
Cardan shafts	All	İf diameter ≥ 250 mm.	İf diameter ≥ 250 mm.
Flexible couplings (metallic parts only)	All	-	-
Coupling bolts or studs	All	-	-

1.2.5 Ducted Propeller

A ducted propeller is a propeller installed in a nozzle.

1.2.6 Rake

Rake is the horizontal distance between the line connecting the blade tip to the blade root and the vertical line crossing the propeller axis in the same point where the prolongation of the first line crosses it, taken in correspondence of the blade tip (see Figure 7.2). Aft rakes are considered positive, fore rakes are considered negative.

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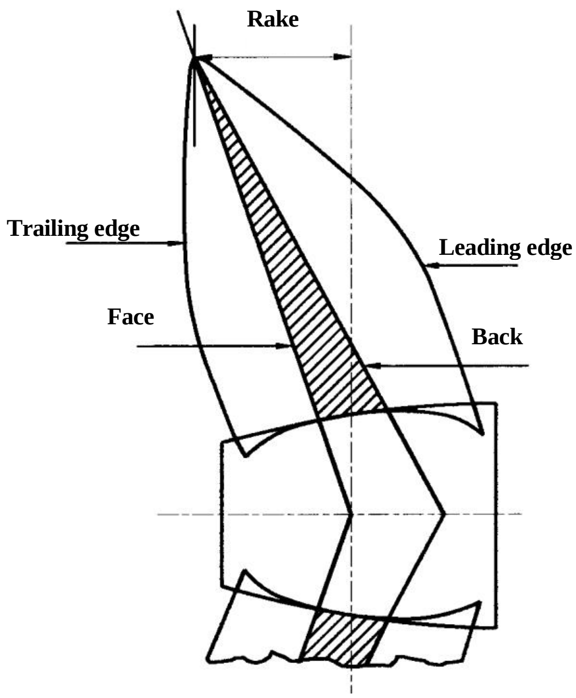


Figure 7.2 Rake

1.2.7 Rake Angle

Rake angle is the angle at any point between the tangent to the generating line of the blade at that point and a vertical line passing at the same point. If the blade generating line is straight, there is only one rake angle; if it is curved there are an infinite number of rake angles (see Figure 7.3).

1.2.8 Skew Angle

Skew angle is the angle between a ray starting at the centre of the propeller axis and tangent to the blade midchord line and a ray also starting at the centre of the propeller axis and passing at the blade tip (see Figure 7.4).

1.2.9 Skewed Propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

1.2.10 Highly skewed propellers and very highly skewed propellers

Highly skewed propellers are propellers having blades with skew angle between 25^o and 50^o. Very highly skewed propellers are propellers having blades with skew angle exceeding 50^o.

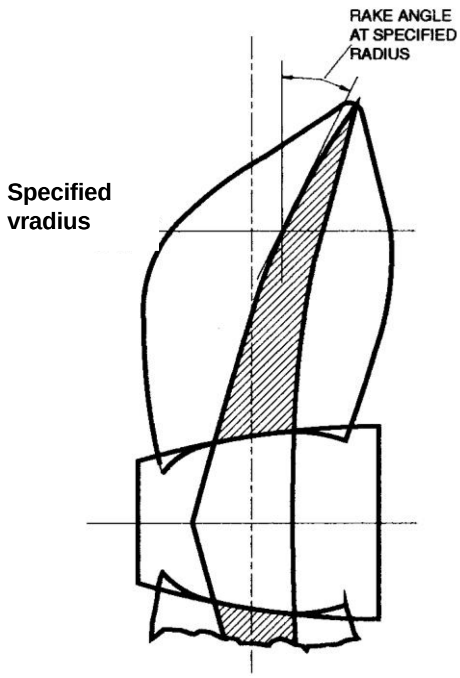


Figure 7.3 Rake angle

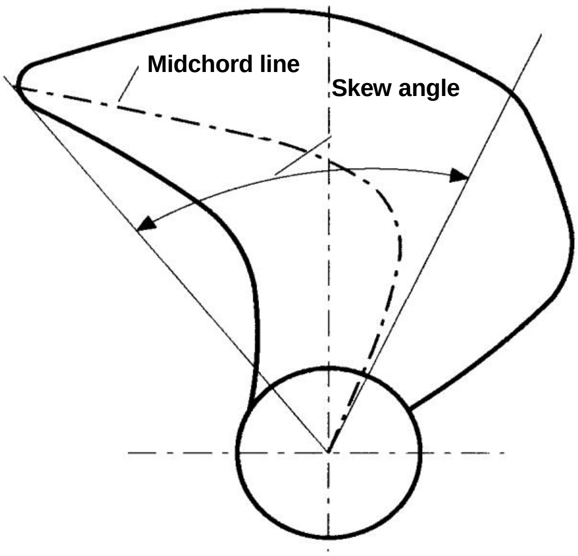


Figure 7.4 Skew angle

1.2.11 Leading edge

The leading edge of a propeller blade is the edge of the blade at side entering the water while the propeller rotates (see Figure 7.2).

1.2.12 Trailing edge

The trailing edge of a propeller blade is the edge of the blade opposite the leading edge (see Figure 7.2).

1.2.13 Blade developed area

Blade developed area is the area of the blade surface expanded in one plane.

1.2.14 Developed area ratio

Developed area ratio is the ratio of the total blade developed area to the area of the ring included between the propeller diameter and the hub diameter.

2. Design and Construction

2.1 Materials

2.1.1 Materials Used for Propeller Hubs and Blades

a) Table 7.9 indicates the minimum tensile strength R_m [N/mm^2], the density δ [kg/dm^3] and the material factor f of normally used materials.

b) Common bronze, special types of bronze and cast steel used for the construction of propeller hubs and blades are to have a minimum tensile strength of 400 N/mm^2.

c) Other materials are the subject of special consideration by **TL.**

Table 7.9 Materials for Propeller Blades and Hub

Material	R_m	δ	f
Common brass	400	8,3	7,6
Manganese brass (Cu1)	440	8,3	7,6
Nickel-manganese brass (Cu2)	440	8,3	7,9
Aluminium bronze (Cu3 and Cu4)	590	7,6	8,3
Steel	440	7,9	9,0

2.1.2 Materials for Studs

In general, steel (preferably nickel-steel) is to be used for manufacturing the studs connecting steel blades to the hub of built-up or controllable pitch propellers, and high tensile brass or stainless steel is to be used for studs connecting bronze blades.

2.2 Solid Propellers – Blade Thickness

a) The maximum thickness of the solid propeller blade at the section at 0,25 radius from the propeller axis is not to be less than that obtained from the following formula [mm]:

$$t_{0,25} = 2,8 \cdot \left[f \cdot \frac{1,5 \cdot 10^6 \cdot \rho \cdot M_T + 51 \cdot \delta \cdot \left(\frac{D}{100}\right)^3 \cdot B \cdot I \cdot N^2 \cdot h}{I \cdot z \cdot R_m} \right]^{0,5}$$

where;

f = Material factor as indicated in Table 7.9,

ρ = D/H,

H = Mean pitch of propeller [m]. When H is not known, the pitch $H_{0,7}$ at radius from the propeller axis may be used instead of H,

D = Propeller diameter [m],

M_T = Continuous transmitted torque [kNm], where not indicated, the value given by the following formula may be assumed for M_T :

$$M_T = 9,55 \cdot \left(\frac{P}{N}\right)$$

P = Power of propulsion machinery [kW],

N = Rotational speed of the propeller [rpm],

δ = Density of blade material given in Table 7.9 [kg/dm^3],

B = Expanded area ratio,

h = Rake [mm],

I = Developed width of blade section 0,25 R from propeller axis [mm],

z = Number of blades,

R_m = Minimum tensile strength of blade material [N/mm^2].

b) The maximum thickness of the solid propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the following Formula [mm]:

$$t_{0,6} = 1,66 \cdot \left[f \cdot \frac{1,5 \cdot 10^6 \cdot \rho_{0,6} \cdot M_T + 18,4 \delta \left(\frac{D}{100}\right)^3 B\, I_{0,6} \cdot N^2 h}{I_{0,6} \cdot z \cdot R_m} \right]^{0,5}$$

where;

$\rho_{0,6}$ = D / $H_{0,6}$

$H_{0,6}$ = Pitch at 0,6 R from propeller axis [m],

$I_{0,6}$ = Developed width of blade section at 0,6 R from propeller axis [mm].

c) The radius at the blade root is to be at least ¾ of the minimum thickness required in that position. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account. If the propeller hub extends over 0,25 radius, the thickness calculated by the formula in a) is to be compared with the thickness obtained by linear interpolation of the actual blade thickness up to 0,25 radius.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller Designer may be considered by **TL** on a case-by-case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller material R_m.

2.3 Built-up Propellers and Controllable Pitch Propellers

2.3.1 Blade Thickness

a) The maximum thickness of the blade at the section at 0,35 radius from the propeller axis is not to be less than that obtained from the following formula [mm]:

$$t_{0,35} = 2,36 \cdot \left[f \cdot \frac{1,5 \cdot 10^6 \cdot \rho_{0,7} \cdot M_T + 41 \delta \left(\frac{D}{100}\right)^3 B\, I_{0,35} \cdot N^2\, h}{I_{0,35} \cdot z \cdot R_m} \right]^{0,5}$$

where;

$\rho_{0,7}$ = D / $H_{0,7}$

$H_{0,7}$ = Pitch at 0,7 radius from the propeller axis [m]. The pitch to be used in the formula is the actual pitch of the propeller when the propeller develops the maximum thrust.

$I_{0,35}$ = Developed width of blade section at 0,35 R from propeller axis [mm].

b) The maximum thickness of the propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the formula in 2.2.1.b), using the value of $l_{0,35}$ in lieu of l.

c) The radius at the blade root is to be at least ¾ of the minimum thickness required in that position. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller Designer may be considered by **TL** on a case-by-case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller blade material Rm.

2.3.2 Flanges for Connection of Blades to Hubs

a) The diameter of the flange for connection to the propeller hub is not to be less than that obtained from the following formula:

$$D_F = D_C + 1,8 \cdot d_{PR} \text{ [mm]}$$

where ;

D_C = Stud pitch circle diameter [mm]

d_{PR} = Diameter of stud [mm]

b) The thickness of the flange is not to be less than 0,1 · D_F.

2.3.3 Studs

a) The diameter at the bottom of the thread of the studs is not to be less than that obtained from the following Formula [mm]:

$$d_{PR} = \left[\frac{4,6 \cdot 10^7 \rho_{0,7} \cdot M_T + 0,88 \cdot \delta \left(\frac{D^3}{10}\right) B \cdot I_{0,35} \cdot N^2\, h_1}{n_{PR} \cdot z \cdot D_C \cdot R_{m,PR}} \right]^{0,5} \quad 0,9$$

where;

h_1 = h + 1,125 · D_C

n_{PR} = Total number of studs in each blade,

$R_{m,PR}$ = Minimum tensile strength of the stud material [N/mm^2].

b) The studs are to be tightened in a controlled manner such that the tension on the studs is approximately 60- 70 % of their yield strength.

c) The shank of studs may be designed with a minimum diameter equal to 0,9 times the root diameter of the thread.

d) The studs are to be properly secured against unintentional loosening.

2.4 Skewed Propellers

2.4.1 Skewed Propellers

The thickness of skewed propeller blades may be obtained by the formulae in 2.2 and 2.3.1, as applicable, provided the skew angle is less than 25°.

2.4.2 Highly Skewed Propellers

a) For solid and controllable pitch propellers having skew angles between 25° and 50°, the blade thickness, in mm, is not to be less than that obtained from the following formulae:

- For solid propellers :

$t_{S0,25} = t_{0,25}\ (0{,}92 + 0{,}0032\varphi)$

- For built-up and controllable pitch propellers :
$t_{S0,35} = t_{0,35}\ (0{,}92 + 0{,}004\varphi)$

- For all propellers:

$t_{S0,6} = t_{0,6}\ (0{,}74 + 0{,}0129\ \varphi - 0{,}0001\ \varphi^2)$

$t_{S0,9} = t_{0,6}\ (0{,}35 + 0{,}0015\ \varphi)$

where;

$t_{S-0,25}$ = Maximum thickness of skewed propeller blade at the section at 0,25 R from the propeller axis [mm].

$t_{0,25}$ = Maximum thickness of normal shape propeller blade at the section at 0,25 R from the propeller axis, obtained by the formula in 2.2.1 [mm].

$t_{S-0,35}$ = Maximum thickness of skewed propeller blade at the section at 0,35 R from the propeller axis [mm].

$t_{0,35}$ = Maximum thickness of normal shape propeller blade at the section at 0,35 R from the propeller axis, obtained by the formula in 2.3.1 [mm].

$t_{S-0,6}$ = Maximum thickness of skewed propeller blade at the section at 0,6 R from the propeller axis [mm].

$t_{0,6}$ = Maximum thickness of normal shape propeller blade at the section at 0,6 R from the propeller axis, obtained by the formula in 2.2.1 [mm].

$t_{S-0,9}$ = Maximum thickness of skewed propeller blade at the section at 0,9 R from the propeller axis [mm].

φ = Skew angle.

b) As an alternative, highly skewed propellers may be accepted on the basis of a stress analysis, as stated in 2.4.3 for very highly skewed propellers.

2.4.3 Very Highly Skewed Propellers

For very highly skewed propellers, the blade thickness is to be obtained by a stress analysis according to a calculation criteria accepted by TL. The safety factor to be used in this direct analysis is not to be less than 9 with respect to the ultimate tensile strength of the propeller blade material, R_m.

2.5 Ducted Propellers

The minimum blade thickness of propellers with wide tip blades running in nozzles is not to be less than the values obtained by the applicable formula in 2.2 and 2.3.1, increased by 10%.

2.6 Features

2.6.1 Blades and Hubs

a) All parts of propellers are to be free of defects and are to be built and installed with clearances and tolerances in accordance with sound marine practice.

b) Particular care is to be taken with the surface finish of the blades.

2.6.2 Controllable Pitch Propellers Pitch Control System

a) Where the pitch control mechanism is operated hydraulically, two independent, power-driven pump sets are to be fitted. For propulsion plants up to 220 kW, one power-driven pump set is sufficient provided that, in addition, a hand-operated pump is fitted for controlling the blade pitch.

b) Pitch control systems are to be provided with an engine room indicator showing the actual setting of the blades. Further blade position indicators are to be mounted on the bridge and in the engine control room, if any.

c) Suitable devices are to be fitted to ensure that an alteration of the blade setting cannot overload the propulsion plant or cause it to stall.

d) Steps are to be taken to ensure that, in the event of failure of the control system, the setting of the blades

- does not change, or
- assumes a final position slowly enough to allow the emergency control system to be put into operation.

e) Controllable pitch propeller systems are to be equipped with means of emergency control enabling the controllable pitch propeller to operate should the remote control system fail. This requirement may be complied with by means of a device which locks the propeller blades in the "ahead" setting.

3. Arrangement and Installation

3.1 Fitting of Propeller on the Propeller Shaft

3.1.1 General

a) Screw propeller hubs are to be properly adjusted and fitted on the propeller shaft cone.

b) The forward end of the hole in the hub is to have the edge rounded to a radius of approximately 6 mm.

c) In order to prevent any entry of sea water under the liner and onto the end of the propeller shaft, the arrangement in Figure 7.5 is generally to be adopted for assembling the liner and propeller boss.

d) The external stuffing gland is to be provided with a sea water-resistant rubber ring preferably without joints. The clearance between the liner and the internal air space of the boss is to be as small as possible. The internal air space is to be filled with an appropriate protective material which is insoluble in sea water and non-corrodible or fitted with a rubber ring.

e) All free spaces between the propeller shaft cone, propeller boss, nut and propeller cap are to be filled with a material which is insoluble in sea water and non-corrodible.
Arrangements are to be made to allow any air present in these spaces to withdraw at the moment of filling. It is recommended that these spaces be tested under a pressure at least equal to that corresponding to the immersion of the propeller in order to check the tightness obtained after filling.

f) For propeller keys and key area, see C.

3.1.2 Shrinkage of Keyless Propellers

In the case of keyless shrinking of propellers, the following requirements apply:

a) The meaning of the symbols used in the subparagraphs below is as follows:

A = 100% theoretical contact area between propeller boss and shaft, as read from plans and disregarding oil grooves [mm^2]

d_{PM} = Diameter of propeller shaft at the mid-point of the taper in the axial direction [mm]

d_H = Mean outer diameter of propeller hub at the axial position corresponding to d_{PM} [mm]

K = d_H/d_{PM}

F = Tangential force at interface [N]

M_T = Torque transmitted assumed as indicated in 2.2.1 [Nm]

C = 1 for turbines, geared diesel engines, electrical drives and direct-drive reciprocating internal combustion engines with a hydraulic, electromagnetic or high elasticity coupling,

= 1,2 for diesel engines having couplings other than those specified above.

T = Temperature of hub and propeller shaft material assumed for calculation of pull-up length and push-up load [ºC],

V = Yacht speed at P power [knots]

S = Continuous thrust developed for free running Yacht [N]

s_F = Safety factor against friction slip at 35°C

θ = Half taper of propeller shaft (for instance: taper = 1/15, θ =1/30)

μ = Coefficient of friction between mating surfaces

p_{35} = Surface pressure between mating surfaces, [N/mm^2], at 35°C

p_T = Surface pressure [N/mm^2] between mating surfaces at temperature T

p_0 = Surface pressure between mating surfaces, [N/mm^2], at 0°C

p_{MAX} = Maximum permissible surface pressure [N/mm^2], at 0°C

d_{35} = Push-up length [mm], at 35°C

d_T = Push-up length [mm], at temperature T

d_{MAX} = Maximum permissible pull-up length [mm], at 0°C

W_T = Push-up load [N], at temperature T

σ_{ID} = Equivalent uni-axial stress in the boss according to the von Mises-Hencky criterion, [N/mm^2]

α_P = Coefficient of linear expansion of shaft material [mm/(mm°C)]

α_M = Coefficient of linear expansion of boss material, [mm/(mm°C)]

E_P = Value of the modulus of elasticity of shaft material, [N/ mm^2]

E_M = Value of the modulus of elasticity of boss material, [N/ mm^2]

$\square_P$ = Poisson's ratio for shaft material

$\square_M$ = Poisson's ratio for boss material

$R_{S,MIN}$ = Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\,0,2}$), of propeller boss material, [N/mm^2].

For other symbols, see 2.2.

b) The Manufacturer is to submit together with the required constructional plans specifications containing all elements necessary for verifying the shrinkage. Tests and checks deemed necessary for verifying the characteristics and integrity of the propeller material are also to be specified.

c) Moreover, the Manufacturer is to submit an instruction handbook, in which all operations and any precautions necessary for assembling and disassembling the propeller, as well as the values of all relevant parameters, are to be specified. A copy, endorsed by **TL**, is to be kept on board each yacht where the propeller is installed.

d) The formulae and other provisions below do not apply to propellers where a sleeve is introduced between shaft and boss or in the case of hollow propeller shafts. In such cases, a direct shrinkage calculation is to be submitted to **TL**.

e) The taper of the propeller shaft cone is not to exceed 1/15.

f) Prior to final pull-up, the contact area between the mating surfaces is to be checked and is not to be less than 70% of the theoretical contact area (100%). Non-contact bands extending circumferentially around the boss or over the full length of the boss are not acceptable

g) After final push-up, the propeller is to be secured by a nut on the propeller shaft. The nut is to be secured to the shaft.

h) The safety factor s_F against friction slip at 35°C is not to be less than 2,8, under the combined action of torque and propeller thrust, based on the power P [kW], assumed as indicated in 2.2.1 at the corresponding speed of rotation N of the propeller, plus pulsating torque due to torsionals.

i) For the oil injection method, the coefficient of friction μ is to be 0,13 in the case of bosses made of copper based alloy and steel. For other methods, the coefficient of friction will be considered in each case by **TL.**

j) The maximum equivalent uni-axial stress in the boss at 0°C, based on the von Mises-Hencky criterion, is not to exceed 70% of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the propeller material, based on the test piece value. For cast iron, the value of the above stress is not to exceed 30% of the nominal tensile strength.

k) For the formulae given below, the material properties indicated in the following items are to be assumed:

- Modulus of elasticity [N/mm²]:

  Cast and forged steel : E= 206000

  Cast iron : E= 98000

  Type Cu1 and Cu2 brass: E= 108000

  Type Cu3 and Cu4 brass: E= 118000

- Poisson's ratio:

  Cast and forged steel : $\nu = 0,29$

  Cast iron : $\nu = 0,26$

  All copper based alloys : $\nu = 0,33$

- Coefficient of linear expansion [mm/(mm °C)]

  Cast and forged steel and cast iron:

  $\alpha = 12,0 \cdot 10^{-6}$

  All copper based alloys: $\alpha = 17,5 \cdot 10^{-6}$

l) For shrinkage calculation the formulae in the following items, which are valid for the ahead condition, are to be applied. They will also provide a sufficient margin of safety in the astern condition.

- Minimum required surface pressure at 35 °C:

$$p_{35} = \frac{s_F \cdot S}{A \cdot B} \cdot \left[-s_F \cdot \theta + \left(\mu^2 + B \cdot \frac{F^2}{S^2} \right)^{0,5} \right]$$

where ;

$$B = \mu^2 - s_F^2 \theta^2$$

- minimum pull-up length at 35 °C :

$$d_{35} = \frac{p_{35} \cdot d_{PM}}{2 \cdot \theta} \cdot \left[\frac{1}{E_M} \cdot \left(\frac{K^2 + 1}{K^2 - 1} + \nu_M \right) + \frac{1 - \nu_p}{E_p} \right]$$

- minimum pull-up length at temperature T (T < 35 °C):

$$d_T = d_{35} + \frac{d_{PM}}{2\theta} \cdot (\alpha_M - \alpha_P) \cdot (35 - T)$$

- minimum surface pressure at temperature T:

$$p_T = p_{35} + \frac{d_T}{d_{35}}$$

- minimum push-up load at temperature T:

$$W_T = A \cdot p_T \cdot (\mu + \theta)$$

- maximum permissible surface pressure at 0ºC:

$$p_{maks} = \frac{0{,}7 \cdot R_{S,\,min} \cdot (K^2 - 1)}{(3K^4 + 1)^{0{,}5}}$$

- maximum permissible pull-up length at 0ºC:

$$d_{maks} = d_{35} \cdot \frac{p_{maks}}{p_{35}}$$

- Tangential force at interface:

$$F = \frac{200 C M_T}{d_{PM}}$$

- Continuous thrust developed for free running yacht; if the actual value is not given, the value, [N], calculated by one of the following formulae may be considered:

$$S = 1760 \cdot \frac{P}{V}$$

$$S = 57{,}3 \cdot 10^3 \cdot \frac{P}{H \cdot N}$$

3.1.3 Circulating Currents

Means are to be provided to prevent circulating electric currents from developing between the propeller and the hull. A description of the type of protection provided and its maintenance is to be kept on board

4. Testing and Certification

4.1 Material Tests

4.1.1 Where + M notation is requested the following material tests are to be carried out in the presence of a **TL** Surveyor.

4.1.2 Solid Propellers

Material used for the construction of solid propellers is to be tested in accordance with the requirements of **TL**'s Material Rules.

4.1.3 Built-up Propellers and Contollable Pitch Propellers

In addition to the requirement in 4.1.2, materials for studs and for all other parts of the mechanism transmitting torque are to be tested.

4.2 Inspection

4.2.1 Inspection of Finished Propeller

Finished propellers are to be inspected at the Manufacturer's plant by the **TL** Surveyor. At least the following checks are to be carried out:

- visual examination of the entire surface of the propeller blades
- conformity to approved plans of blade profile

- liquid penetrant examination of suspected and critical parts of the propeller blade, to the satisfaction of the Surveyor.

4.2.2 Controllable Pitch Propeller

The complete hydraulic system for the control of the controllable pitch propeller mechanism is to be hydrotested at a pressure equal to 1,5 times the design pressure. The proper operation of the safety valve is to be tested in the presence of the Surveyor.

4.2.3 Balancing

Finished propellers are to be statically balanced. For builtup and controllable pitch propellers, the required static balancing of the complete propeller may be replaced by an individual check of blade weight and gravity centre position.

4.3 Certification

4.3.1 Certification of Propellers

Propellers having the characteristics indicated in 1.1.1 are to be individually tested and certified. TL certificate is required for material tests of propellers and each relevant component when intended to be assigned with + M notation.

4.3.2 Mass Produced Propellers

Mass produced propellers may be accepted within the framework of the type approval program of **TL.**

E. Piping Systems

1. General

1.1 Application

1.1.1 General mrequirements applying to all piping systems are contained in:

- item 2 – design and construction,
- item 3 – welding of steel pipes,
- item 4 – bending of pipes,
- item 5 – arrangement and installation,
- item 12 – certification, inspection and testing.

1.1.2 Specific requirements for yacht piping systems are given in items 6 ÷ 11.

1.2 Definition

1.2.1 Piping and Piping Systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include turbines, internal combustion engines and reduction gears.

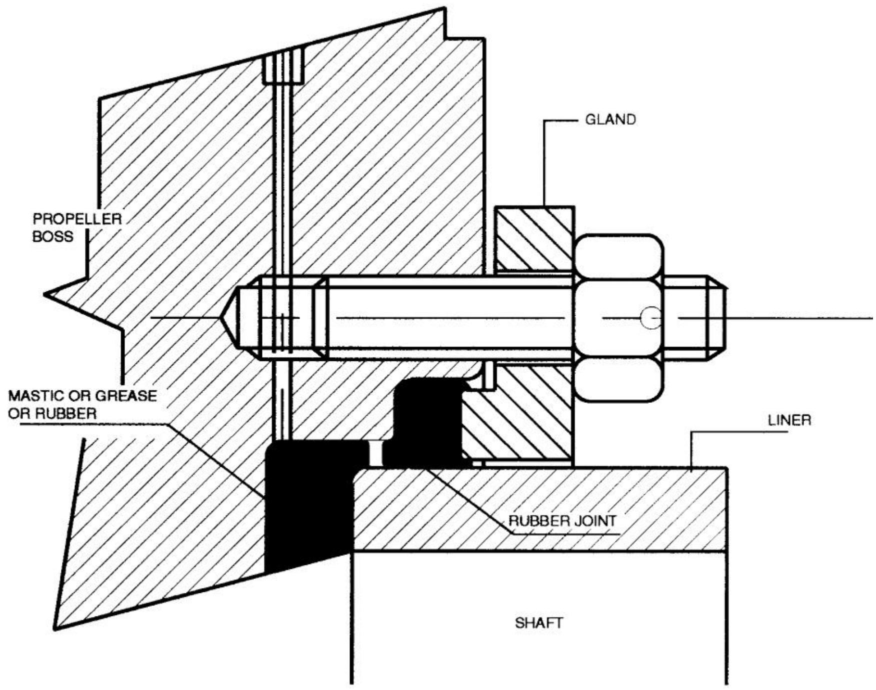


Figure 7.5 Example of sealing arrangement

1.2.2 Design Pressure

a) The design pressure of a piping system is the pressure considered by the Manufacturer to determine the scantling of the system components. It is not to be taken less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

b) The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

c) The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than the setting pressure of the safety valve for displacement pumps or the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps, whichever is the greater.

1.2.3 Design Temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

1.2.4 Flammable Oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils.

1.3 Symbols and Units

1.3.1 The following symbols and related units are commonly used in this Section. Additional symbols, related to some formulae indicated in this Section, are listed wherever it is necessary.

P = Design pressure [Mpa],

T = Design temperature [ºC],

t = Rule required minimum thickness [mm],

D = Pipe external diameter [mm].

1.4 Class of Piping Systems

1.4.1 Purpose of the Classes of Piping Systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.4.2 Definitions of the Classes of Piping Systems

Definitions of the classes of piping systems are given in Table 7.10.

2. General Requirements for Design and Construction

2.1 Materials

2.1.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended.

2.1.2 Use of Metallic Materials

a) Metallic materials are to be used in accordance with Table 7.11.

b) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of **TL** Material Rules.

c) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

d) Mechanical characteristics required for metallic materials are specified in **TL** Material Rules.

2.1.3 Use of Plastic Materials

The use of rigid plastic may be considered based on the conformity to the requirements of Section 7, Appendix.

The use of rigid plastic may be accepted for class II and class III piping for application other than bilge system, fuel oil, lubricating oil or other flammable liquid system in machinery space and other spaces where a fire risk exists, upon submission of the physical characteristics of the material.

A metallic automatic non-return valve is to be fitted where systems are connected to the sea. The sea valve is to be fitted in conformity to the requirements of Section 7, Appendix.

2.2 Thickness of Pressure Piping

2.2.1 Calculation of the Thickness of Pressure Pipes

a) The thickness of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Table 7.12 to Table 7.15.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}} \quad [mm]$$

where ;

$$t_0 = \frac{p \cdot D}{2Ke + p}$$

p, D = As defined in 1.3.1,

K = Permissible stres defined in 2.2.2,

e = Weld efficiency factor to be:

= 1, for seamless pipes and pipes fabricated according to an approved welding procedure,

= Specially considered by **TL** for other welded pipes, depending on the service and the manufacturing procedure.

b = Thickness reduction due to bending defined in 2.2.3 [mm],

c = Corrosion allowance defined in 2.2.4 [mm],

a = Negative manufacturing tolerance percentage,

= 10, for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to an approved weilding procedure,

= 12,5 for hot laminated seamless steel pipes.

Other cases is subjected to special consideration by **TL.**

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

2.2.2 Permissible Stress

a) The permissible stress K is given:

- in Table 7.16 for carbon and carbon-manganese steel pipes,

- in Table 7.17 for alloy steel pipes, and

- in Table 7.18 for copper and copper alloy pipes,

as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of the permissible stress (K) is not given in Table 7.16 or Table 7.17, it is to be taken equal to the lowest of the following values:

$$\frac{R_{m,20}}{2,7}, \quad \frac{R_e}{A}, \quad \frac{S_R}{A}, \quad S$$

where:

$R_{m,20}$ = Minimum tensile strength of the material at ambient temperature (20°C) [N/mm^2]

R_e = Minimum yield strength or 0,2% proof stres at the design temperature [N/mm^2]

S_R = Average stress to produce rupture in 100000 h at design temperature [N/mm^2]

S = Average stress to produce 1% creep in 100.000 h at design temperature [N/mm^2]

A = Safety factor to be taken equal to 1,6

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by **TL**.

2.2.3 Thickness Reduction Due to Bending

a) Unless otherwise justified, the thickness reduction due to bending is to be determined by the following formula:

$$b = \frac{D \cdot t_0}{2,5 \cdot \rho}$$

where ;

ρ = Bending radius measured on the centre-line of the pipe [mm],

D = As defined in 1.3.1,

t_0 = As defined 2.2.1.

b) When the bending radius is not given, the thickness reduction is to be taken equal to:

$$\frac{t_0}{10}$$

c) For straight pipes, the thickness reduction is to be taken equal to 0.

Table 7.10 Classes of Piping Systems

Media conveyed by the piping system	Class I	Class II	Class III
Fuel oil **(1)**	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Flammable hydraulic oil **(4)**	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Lubricating oil	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Air, gases, water, non-flammable hydraulic oil **(3)**	p > 4 or T > 300	other **(2)**	p ≤1,6 and T ≤ 200
Open-ended pipes (drains,overflows, vents, exhaust gas lines, boiler escape pipes)			Irrespective of T

(1) *Valves under static pressure on fuel oil tanks belong to class II.*

(2) *Pressure and temperature conditions other than those required for class I and class III.*

(3) *Valves and fittings fitted on the yacht side and collision bulkhead belong to class II.*

(4) *Steering gear piping belongs to class I irrespective of p and T*

Note 1*: p : Design pressure [MPa].*

Note 2: *T : Design temperature [°C].*

Table 7.11 Conditions of Use of Metallic Materials in Piping Systems

Material	Allowable classes	Maximum design temperature [ºC] (1)	Particular conditions of use
Carbon and carbon-manganese steels	I, II, III	400	Class I and II pipes are to be seamless drawn pipes **(2)**
Copper and aluminium brass	I, II, III	200	**(3)**
Copper-nickel	I, II, III	300	
Special high temperature resistant bronze	I, II, III	260	
Stainless steel	I, II, III	300	The use of austenitic stainless steel is not recommended where the medium is dirty or still sea water. In the systems which clean sea water is circulated, the use of stainless steel pipes of 316 L or better quality may result in satisfactory.
Spheroidal graphite cast iron	II, III	350	• Spheroidal cast iron of the ferritic type according to the material Rules of **TL** may be accepted for bilge and ballast. • The use of this material for pipes, valves and fittings for other services, in principle Classes II and III, will be subject to special consideration • Minimum elongation is not to be less than 12% on a gauge length of $5{,}65.S^{0,5}$, where S is the actual cross-sectional area of the test piece
Grey cast iron	II, III **(4)**	220	Grey cast iron is not to be used for the following systems: • piping systems subject to shocks, high stresses and vibrations • yacht side valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems
Aluminium and aluminium alloys	II, III	200	Auminium and aluminium alloys may be accepted in the engine spaces provided that they are suitably protected against the effect of heat for the following services: • flammable oil systems • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • bilge system • scuppers and overboard discharges. Outside the engine spaces proposal for the use of aluminium and aluminium alloy pipes my be accepted considering the fire risk of the compartment where suck pipes are fitted. In addition for the above services in engine spaces the minimum thickness of such pipes is to be not less than 4 mm. For scupper and overboard discharges the above insulation and the above required thickness may be omitted provided that they are fitted at their ends with closing means operated from a position above the main deck.

(1) *Maximum design temperature is not to exceed that assigned to the class of piping.*

(2) *Pipes fabricated by an approved welding procedure may also be used.*

(3) *Pipes made of copper and copper alloys are to be seamless.*

(4) *Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.*

Table 7.12 Minimum wall thickness for steel pipes

External diameter [mm]	Minimum nominal wall thickness [mm]		Minimum reinforced wall thickness [mm] (2)	Minimum extra reinforced wall thickness [mm] (3)
	Sea water pipes, bilge and ballast systems (1)	Other piping systems (1)		
10,2 – 12,0	-	1,6	-	-
13,5 – 19,3	-	1,8	-	-
20,0	-	2,0	-	-
21,3 – 25,0	3,2	2,0	-	-
26,9 – 33,7	3,2	2,0	-	-
38,0 – 44,5	3,6	2,0	6,3	7,6
48,3	3,6	2,3	6,3	7,6
51,0 – 63,5	4,0	2,3	6,3	7,6
70,0	4,0	2,6	6,3	7,6
76,1 – 82,5	4,5	2,6	6,3	7,6
88,9 – 108,0	4,5	2,9	7,1	7,8
114,3 – 127,0	4,5	3,2	8,0	8,8
133,0 – 139,7	4,5	3,6	8,0	9,5
152,4 – 168,3	4,5	4,0	8,8	11,0
177,8	5,0	4,5	8,8	12,7
193,7	5,4	4,5	8,8	12,7
219,1 and over	5,9	4,5	8,8	12,7

(1) *Attention is drawn to the special requirements regarding:*

- *bilge and ballast systems*
- *sounding, air and overflow pipes*
- *CO2 fire-extinguishing systems*

(2) *Reinforced wall thickness applies to pipes passing through tanks containing a fluid distinct from that conveyed by the pipe.*

(3) *Extra-reinforced wall thickness applies to pipes connected to the shell.*

Note 1*: A different thickness may be considered by* ***TL*** *on a case-by-case basis, provided that it complies with recognised standards.*

Note 2: *Where pipes and any integral pipe joints are protected against corrosion by means coating, lining, etc. at the discretion of* ***TL*** *thickness may be reduced by not more than 1 mm.*

Note 3: *The thickness of threaded pipes is to be measured at the bottom of the thread.*

Note 4: *The minimum thickness listed in this table is the nominal wall thickness and no allowance is required for negative tolerance or reduction in thickness due to bending.*

Table 7.13 Minimum wall thickness for copper and copper alloy pipes

External diameter [mm]	Minimum wall thickness [mm]	
	Copper	Copper alloy
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193 - 7 - 267	3,5	3,0
273 - 457,2	4,0	3,5
470	4,0	3,5
508	4,5	4,0

Note 1: *A different thickness may be considered by* ***TL*** *on a case-by-case basis, provided that it complies with recognised standards*

Table 7.15 Minimum wall thickness for stainless steel pipes

External diameter [mm]	Minimum wall thickness [mm]
8,0 - 10,0	0,8
12,0 - 20,0	1,0
25,0 - 44,5	1,2
50,0 - 76,1	1,5
88,9 - 108,0	2,0
133,0 - 159,0	2,5
193 - 7 - 267,0	3,0
273,0 - 457,2	3,5

Note 1: *A different thickness may be considered by* ***TL*** *on a case-by-case basis, provided that it complies with recognised standards*

2.2.4 Corrosion Allowance

The values of corrosion allowance are given for steel pipes in Table 7.19 and Table 7.21.

For stainless steel a corrosion allowance of 0,8 mm is to be used.

For the lubricating oil and hydraulic oil system, said value may be reduced to 0,3 mm.

2.3 Junction of Pipes

2.3.1 General

The following pipe connections may be used:

- Fully penetrating butt welds with/without provision to improve the quality of the root,
- Socket and slip-on sleeve welds with suitable fillet weld thickness and where appropriate in accordance with recognized standards,
- Steel flanges may be used in accordance with the permitted pressures and temperatures specified in the relevant standards,
- Mechanical joints (e.g. pipe unions, pipe couplings, press fittings) of approved type.

For the use of pipe connections see Table 7.20

2.3.2 Flange Connections

2.3.2.1 The dimensions of flanges and bolts are to comply with recognised standards.

2.3.2.2 Gaskets are to be suitable for the intended media under design pressure and temperature conditions and their dimensions and construction shall be in accordance with recognized standards.

2.3.2.3 Steel flanges may be used as shown in Tables 7.22 and 7.23 in accordance with the permitted pressures and temperatures specified in the relevant standards.

2.3.2.4 Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals.
Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

Table 7.14 Minimum wall thickness for Aluminium and Aluminium alloy pipes

External diameter [mm]	Minimum wall thickness [mm]
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
Above 273	5,5
Note 1: *A different thickness may be considered by **TL** on a case-by-case basis, provided that it complies with recognised standards.* ***Note 2:*** *For sea water pipes, the minimum thickness is not to be less than 5 mm.*	

a) Welding neck flanges according to standard up to 200 °C or 300 °C,

b) Loose flanges with welding collar; as for a),

c) Plain brazed flanges; only for pipe class III up to a nominal pressure of 16 bar and a temperature of 120 °C.

2.3.2.5 Flange connections for pipe classes I and II with temperatures over 300 °C are to be provided with necked-down bolts.

2.3.3 Welded Socket Connections

2.3.3.1 Welded socket connections may be accepted according to Table 7.21.

Following conditions are to be observed:

- The thicknesses of the sockets are to be at least equal to the thicknesses of the pipes,

- The clearance between the pipes and the sockets is to be as small as possible,

- The use of socket welded connections in systems of pipe class II may be accepted only under the condition that in the systems no excessive stress, erosion and corrosion are expected.

2.3.4 Screwed Socket Connections

2.3.4.1 Screwed socket connections with parallel and tapered threads shall comply with requirements of recognized national or international standards.

2.3.4.2 Screwed socket connections with parallel threads are permitted for pipes in class III with an outside diameter ≤ 60,3 mm. as well as for subordinate systems (e.g. sanitary and hot water heating systems). They are not permitted for systems for flammable media.

2.3.4.3 Screwed socket connections with tapered threads are permitted for the following:

a) Class I, outside diameter not more than 33,7 mm.

b) Class II and class III, outside diameter not more than 60,3 mm.

Screwed socket connections with tapered threads are not permitted for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

2.3.5 Brazed connections may be used after special approval by **TL**.

2.3.6 Mechanical Joints

2.3.6.1 Type approved mechanical joints may be used as shown in Tables 7.24 to 7.26.

2.3.6.2 Mechanical joints in bilge and seawater systems within machinery spaces or spaces of high fire risk must be flame resistant

2.3.6.3 Mechanical joints are not to be used in piping sections directly connected to sea openings or tanks containing flammable liquids

Table 7.16 Permissible stresses for carbon and carbon-manganese steel pipes

Minimum tensile strength [N/mm²]	Design temperature [ºC]												
	≤50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 7.17 Permissible stresses for alloy steel pipes

Type of steel	Minimum tensile strength [N/mm²]	Design temperature [ºC]									
		≤50	100	200	300	350	400	440	450	460	470
1 Cr 1/2 Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo, annealed	410	76	67	57	50	47	45	44	43	43	42
480 490 500 510 520 530 540 550 560 570	490	167	163	153	14	140	136	130	128	127	116
2 1/4Cr 1Mo, normalised and tempered above 750 ºC	490	167	163	153	144	140	136	130	122	114	105
1/2 Cr1/2Mo 1/4 V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Minimum tensile strength [N/mm²]	Design temperature [ºC]									
		480	490	500	510	520	530	540	550	560	570
1 Cr 1/2 Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo, annealed	410	42	42	41	41	41	40	40	40	37	32
480 490 500 510 520 530 540 550 560 570	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr 1Mo, normalised and tempered above 750 ºC	490	96	88	79	72	64	56	49	43	37	32
1/2 Cr1/2Mo 1/4 V	460	101	99	97	94	82	72	62	53	45	37

Table 7.18 Permissible stresses for copper and copper alloy pipes

Material (annealed)	Minimum tensile strength [N/mm^2]	Design temperature [°C]										
		≤50	75	100	125	150	175	200	225	250	275	300
Copper	215	41	41	40	40	34	27,5	18,5				
Aluminium brass	325	78	78	78	78	78	51	24,5				
Copper – Nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59	56	52	48	44
Copper – Nickel 70/30	365	81	79	77	75	73	71	69	67	65,5	64	62

Table 7.19 Corrosion allowance for steel pipes

Piping system	Corrosion allowance [mm]
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Fresh water	0,8
Sea water	3,0

Note 1: *For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.*

Note 2: *The corrosion allowance may be reduced where pipes and any integral pipe joints are protected against corrosion by means of coating, lining, etc.*

Note 3: *When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.*

Table 7.21 Corrosion allowance for non-ferrous metal pipes

Piping material (1)	Corrosion allowance (2) [mm]
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper - Nickel alloys with less than 10% of Ni	0,8
Copper - Nickel alloys with at least 10% of Ni	0,5
Aluminium and Aluminium alloys	0,5

(1) *The corrosion allowance for other materials will be speciallyconsidered by* ***TL.*** *Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded.*

(2) *In cases of media with high corrosive action, a higher corrosion allowance may be required by* ***TL.***

Table 7.20 Pipe connections

Type of connections	Pipe class	Nominal diameter
Welded butt-joints with special provisions for root side	I, II, III	All
Welded butt-joints without special provisions for root side	II, III	
Socket weld	III	≤ 60,3 mm.
	II	

2.3.6.4 The use of mechanical joints is not permitted in:

- Bilge lines inside ballast and fuel tanks,
- Seawater and ballast lines inside fuel tanks,
- Fuel and oil lines including air and overflow pipes inside machinery spaces and ballast tanks,
- Non water filled pressure water spraying systems

Mechanical joints inside tanks may be permitted only if the pipes contain the same medium as the tanks.

Unrestrained slip on joints may be used only where required for compensation of lateral pipe movement.

Table 7.22 Use of flange types

Pipe class	Toxic, corrosive and combustible media, liquefied gases (LPG)		Steam, thermal oils		Lubricating oil, fuel oil	Other media	
	PR [bar]	Type of flange	Temperature [°C]	Type of flange	Type of flange	Temperature [°C]	Type of flange
I	> 10 ≤ 10	A A, B **(1)**	> 400 ≤ 400	A A, B **(1)**	A, B	> 400 ≤ 400	A A, B
II	-	A, B, C	> 250 ≤ 250	A, B, C A, B, C, D, E	A, B, C, E **(2)**	> 250 ≤ 250	A, B, C A, B, C, D, E
III	-	-	-	A, B, C, D, E	A, B, C, E	-	A, B, C, D, E, F **(3)**

(1) *Type B only for* D_a *< 150 mm*

(2) *Type E only for t < 150°C and PR < 16 bar*

(3) *Type F only for water pipes and open-ended lines*

2.4 Flexible Hoses and Expansion Joints

2.4.1 General

a) The requirements given in this item 2.4 are in general applicable to yachts of more than 500 GT.

b) For yachts of not more than 500 GT and for use of flexible hoses for particular systems, the requirements given in Table 7.27 are applicable; for yachts having L_C < 24 m the requirements given in Table 7.28 are applicable.

c) Flexible hoses and expansion joints are to be of a type approved, designed in accordance with 2.4.2 and tested in accordance with E,12.2.1.

d) Flexible hoses and expansion joints are to be installed in accordance with the requirements stated in 5.7.3.

2.4.2 Design of Flexible Hoses and Expansion Joints

a) Flexible pipes and expansion joints are to be made of materials resistant to the marine environment and to the fluid they are to convey. Metallic materials are to comply with E,2.1.

b) Flexible pipes and expansion joints are to be designed so as to withstand:

- external contact with hydrocarbons
- internal pressure
- vibrations
- pressure impulses

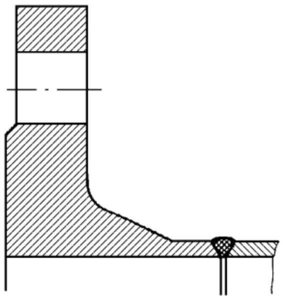
c) In machinery spaces and other locations where sources of ignition are present, flexible hoses intended for use in systems containing flammable liquids are to be approved fire-resisting materials. Type approved flexible hoses for which the fire endurance test in conformity with ISO 15540 and ISO 15541 was carried out may be accepted. Hoses complete with end attachments are to be type tested to verify fire resistance.

d) Flexible pipes intended to convey:

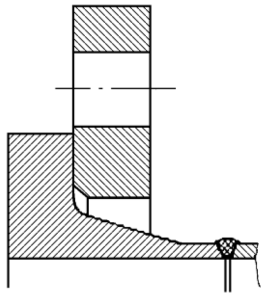
• gaseous fluid at a pressure higher than 1 MPa
• fuel oil or lubricating oil are to be fitted with a metallic braid.

Table 7.23 Types of flange connections

Type A

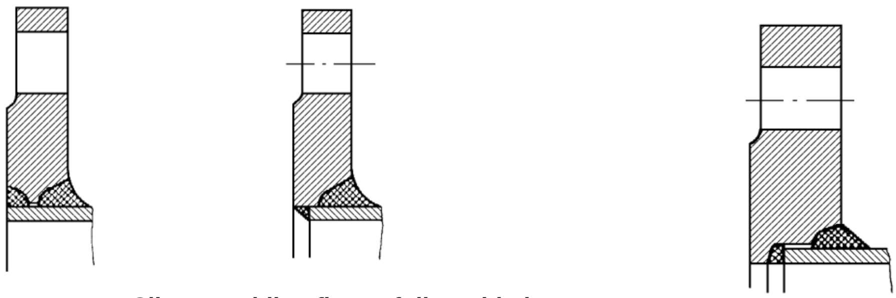


Welding neck flange



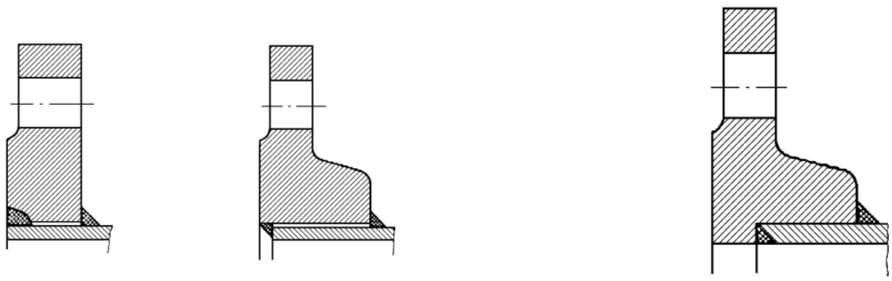
Loose flange with welding neck

Type B



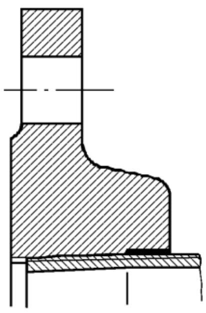
Slip-on welding flange fully welded

Type C



Slip-on welding flange

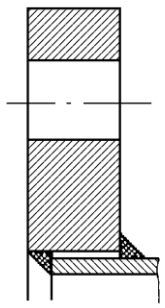
Type D



Socket screwed flange

- conical threads -

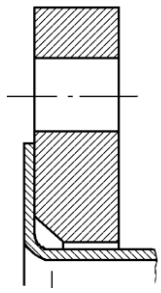
Type E



Plain flange

- welded on both sides -

Type F



Lap joint flange

- on flanged pipe -

Table 7.24 Example of mechanical joints

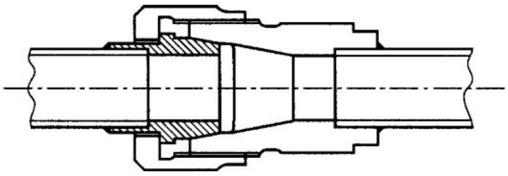
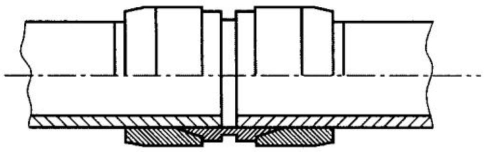
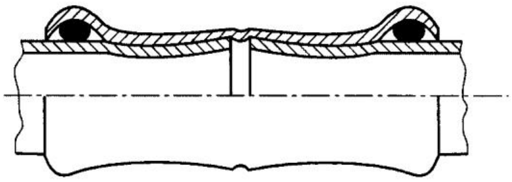
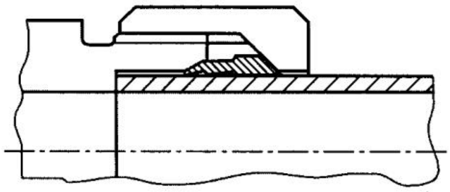
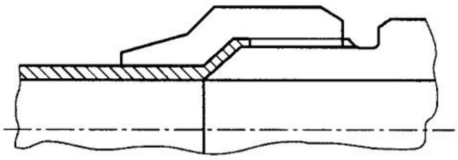
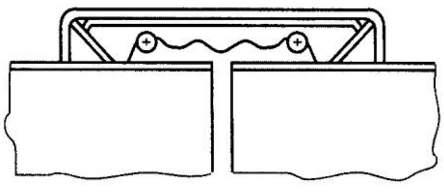
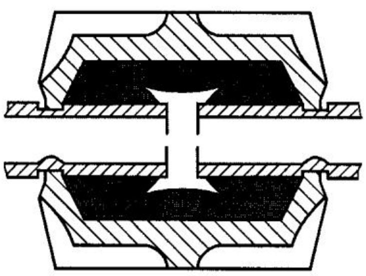
Pipe unions	
Welded and brazed type	
Compressed couplings	
Swage type	
Press type	
Bite type	
Flared type	
Slip-on joints	
Grip type	
Machine grooved type	

Table 7.24 Example of mechanical joints –continued-

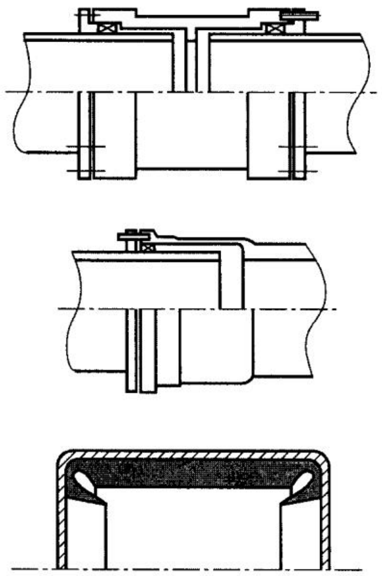
Slip type	

Table 7.25 Application of mechanical joints

Systems	Kind of connections		
	Pipe unions	**Compression couplings (6)**	**Slip-on joints**
Flammable joint (flash points < 60°C)			
Cargo oil lines	+	+	+ **(5)**
Crude oil washing lines	+	+	+ **(5)**
Vent lines	+	+	+ **(3)**
Flammable fluids (flash point > 60°C)			
Fuel oil lines	+	+	+ **(2) (3)**
Lubricating oil lines	+	+	+ **(2) (3)**
Hydraulic oil	+	+	+ **(2) (3)**
Thermal oil	+	+	+ **(2) (3)**
Sea water			
Bilge lines	+	+	+ **(1)**
Fire main and water spray	+	+	+ **(3)**
Foam system	+	+	+ **(3)**
Sprinkler system	+	+	+ **(3)**
Ballast system	+	+	+ **(1)**
Cooling water system	+	+	+ **(1)**
Non-essential systems	+	+	+
Fresh water			
Cooling water system	+	+	+ **(1)**
Condensate return	+	+	+ **(1)**
Non-essential systems	+	+	+

Table 7.25 Application of mechanical joints –continued-

Systems	Kind of connections		
	Pipe unions	**Compression couplings (6)**	**Slip-on joints**
Sanitary/drains/scuppers			
Deck drains (internal)	+	+	+ **(4)**
Sanitary drains	+	+	+
Scuppers and discharge (overboard)	+	+	-
Sounding/vent			
Water tanks/dry spaces	+	+	+
Oil tanks (flash point > 60°C)	+	+	+ **(2) (3)**
Miscellaneous			
Starting/control air **(1)**	+	+	-
Service air (non-essential)	+	+	+
Brine	+	+	+
CO_2 system **(1)**	+	+	-
Steam	+	+	-

Abbreviations :

+ Application is allowed

- Application is not allowed

Footnotes:

(1) *Inside machinery spaces of category A-only approved of fire resistant type provided that not to be in contradiction with Section 7,E.2.3.6.*

(2) *Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.*

(3) *Approved fire resistant types*

(4) *Above freeboard deck only*

(5) *In open decks- only approved fire resistant types*

(6) *If compression couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for Slip-on joints.*

Table 7.26 Application of mechanical joints depending upon the piping class

Types of joints	Piping systems classes		
	Class I	**Class II**	**Class III**
Pipe unions			
Welded and brazed type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Compression couplings			
Stage-type	+	+	+
Press type	-	-	+
Bite type Flared type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Slip-on joints			
Machine grooved type	+	+	+
Grip type	-	+	+
Slip type	-	+	+

Abbreviatios :

+ Application is allowed.

- Application is not allowed.

e) As a general rule, flexible hoses are to be fitted with crimped connections or equivalent. For water pipes subject to a pressure not exceeding 0,5 MPa, as well as for scavenge air and supercharge air lines of internal combustion engines, clips made of galvanised steel or corrosion-resistant material with thickness not less than 0,4 mm may be used.

f) Flexible pipes and expansion joints are to be so designed that their bursting pressure at the service temperature is not less than 4 times their maximum service pressure. Exemptions from this requirement may be granted for expansion joints of large diameter used on sea water lines.

g) The junctions of flexible hoses and expansion joints to their couplings are to withstand a pressure at least twice the bursting pressure defined in f).

2.4.3 Condition of Use of Flexible Hoses and Expansion Joints

a) The use of flexible hoses and expansion joints is to be limited as far as practicable.

b) Flexible hoses and expansion joints are to be as short as possible.

c) The use of non-metallic expansion joints on pipes connected to sea inlets and overboard discharges will be given special consideration by **TL.**

2.5 Valves and Accessories

2.5.1 General

a) Valves and accessories are normally to be built in accordance with a recognised standard.

Valves and fittings in piping systems are to be compatible with the pipes to which they are attached in respect of their strength and are to be suitable for effective operation at the maximum working pressure they will experience in service.

b) Shut-off valves are to be provided where necessary to isolate pumps, heat exchangers, pressure vessels, etc., from the rest of the piping system if the need arises, and in particular:

- to allow the isolation of duplicate components without interrupting the fluid circulation

- for survey or repair purposes.

2.5.2 Design of Valves and Accessories

a) Materials of valve and accessory bodies are to comply with the provisions of 2.1.

b) Connections of valves and accessories with pipes are to comply with the provisions of 2.3.

c) All valves and accessories are to be so designed as to prevent the loosening of covers and glands when they are operated.

d) Valves are to be so designed as to shut with a right-hand (clockwise) motion of the wheels.

e) Valves are to be provided with local indicators showing whether they are open or shut, unless this is readily apparent.

2.5.3 Remote Controlled Valves

a) All valves which are provided with remote control are also to be designed for local manual operation.

b) The remote control system and means of local operation are to be independent.

c) In the case of valves which are to be provided with remote control in accordance with the Rules, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

d) Power failure of the remote control system is not to cause an undesired change of the valve position

Table 7.27 : Use of flexible hoses yachts having $L_C \geq 24$ m

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Fuel oil system	Flexible hoses shall comply with the following requirements: • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4, they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541 • For yachts of not more than 300 GT, flexible hoses can be accepted for the whole length of the system, fire resistant in compliance with ISO 15540/15541 and certified suitable for use by the manufacturer in compliance with national or international recognized standards. End connections of flexible hoses different from the crimped type may be accepted, provided that in any case, the end attachments are to **TL** satisfaction, and hoses complete with end connections are to be tested to verify fire resistance.	Flexible hoses shall comply with the following requirements: • For yachts of more than 500 GT, the requirements in 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541 • For yachts of not more than 300 GT, flexible hoses can be accepted for the whole length of the system and fire resistant A1/A2 in compliance with ISO 7840
Hydraulic oil system	Flexible hoses can be used, whatever the gross tonnage of the yacht, according to the following requirements. • Flexible hoses used for non essential services are not required to be fire resistant, but they are to be certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Flexible hoses used for essential services (services whose failure can impair the safety of navigation); flexible hoses in compliance with 2.4 can be accepted: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO15540/15541.	Flexible hoses can be used, whatever the gross tonnage of the yacht, according to the following requirements. Flexible hoses are not required to be fire resistant, but they are to be certified suitable for use by the manufacturer in compliance with national or international recognized standards

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Fixed water fire extinguishing system	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541. • For yachts of not more than 300 GT, flexible hoses can be accepted for the whole length of the system, fire resistant in compliance with ISO 15540/15541 and certified suitable for use by the manufacturer in compliance with national or international recognized standards or equivalent. End connections of flexible hoses different from the crimped type may be accepted, provided that in any case, the end attachments are to **TL** satisfaction, and hoses complete with end connections are to be tested to verify fire resistance.	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541 • For yachts of not more than 300 GT, flexible hoses can be accepted for the whole length of the system, fire resistant and certified suitable for use by the manufacturer in compliance with national or international recognized standards. Fire resistance shall be ascertained by a fire test in compliance with ISO 7840 (or equivalent standard) for a period of not less than 10 min. End connections of flexible hoses different from the crimped type may be accepted, provided that in any case, the end attachments are to **TL** satisfaction, and hoses complete with end connections are to be tested to verify fire resistance.

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Bilge system	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541. • For yachts of not more than 300 GT flexible hoses can be accepted for the whole length of the system, fire resistant and certified suitable for use by the manufacturer in compliance with recognized national or international standards. Fire resistance shall be ascertained by a fire test in compliance with ISO 7840 (or equivalent standard) for a period of not less than 10 min. End connections of flexible hoses different from the crimped type may be accepted, provided that in any case, the end attachments are to **TL** satisfaction, and hoses complete with end connections are to be tested to verify fire resistance. • Reference is to be made to **(2).**	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541 • For yachts of not more than 300 GT, flexible hoses can be accepted made of material suitable for bilge use and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C.

(1) *End connections different from the crimped type may be adopted only for Class III piping*
(2)
a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.
b) The above valve may be omitted provided that:
• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;
• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;
• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.
c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.
d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Cooling system	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541 • For yachts of not more than 300 GT, with the exclusion of the part of piping indicated in Section 2,A.5.4.2, flexible hoses in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards can be accepted • Reference is to be made to **(2).**	Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, the requirements of 2.4 are to be complied with • For yachts of not more than 500 GT, flexible hoses can be accepted for the whole length of the system, in compliance with 2.4: they shall be type approved according to 2.4.1 and fire resistant in compliance with ISO 15540/15541. • For yachts of not more than 300 GT, with the exclusion of the part of piping indicated in Section 2,A.5.4.2, flexible hoses in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards can be accepted • Reference is to be made to **(2).**

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Exhaust system	The requirements of Section A.5.4.3 are to be complied with.	The requirements of Section A.5.4.3 are to be complied with..
Drinking water, black water and drainage of air-conditioning systems	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, for piping not connected to the sea through the side of the hull, flexible hoses can be accepted, certified suitable for the service by the manufacturer in compliance with national or international recognized standards. For piping connected to the sea through the side of the hull, flexible hoses certified fire resistant in compliance with ISO 15540/15541 can be accepted, provided that they are certified suitable for the service by the manufacturer • For yachts of not more than 500 GT, the requirements for yachts of more than 500 GT are applicable • For yachts of not more than 300 GT, the requirements for the scuppers are applicable to piping connected to the sea through the side of the hull. In any case, the hoses are to be certified suitable for use by the manufacturer. • Reference is to be made to **(2).**	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements: • Whatever the gross tonnage of the yacht, the requirements of Section 2,A.5.4 are to be complied with • For yachts of more than 500 GT, for piping not connected to the sea through the side of the hull, flexible hoses can be accepted, certified suitable for the service by the manufacturer in compliance with national or international recognized standards. • For yachts of not more than 500 GT, the requirements for yachts of more than 500 GT are applicable • For yachts of not more than 300 GT, the requirements for the scuppers are applicable to piping connected to the sea through the side of the hull. • In any case, the hoses are to be certified suitable for use by the manufacturer. Reference is to be made to **(2).**

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be not less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Table 7.28 : Use of flexible hoses : yachts having L_C < 24 m

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Fuel oil system	Flexible hoses shall comply with the following requirements: • Hoses are to be in compliance with the ISO 7840 standard, type A1 or A2. • Hoses shall be used in agreement with the application limits required in the standard.	Flexible hoses shall comply with the following requirements: • as for machinery space; alternatively, hoses may be in compliance with the ISO 8461 standard, type B1 or B2. • Hoses shall be used in agreement with the application limits required in the standard
Hydraulic oil system	As per $L_C \geq$ 24 m (see Table 7.27)	
Fixed water fire extinguishing system	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements of Section 2,A.5.4.2 are to be complied with • Reference is to be made to **(2)**	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements of Section 2,A.5.4.2 are to be complied with • Reference is to be made to (2)
Bilge system	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements Section 2,A.5.4.2 are to be complied with • In any case, the flexible hose is to be certified suitable for use by the manufacturer • Reference is to be made to **(2).**	Flexible hoses shall comply with the following requirements: • flexible hoses built in PVC reinforced with embedded steel wire and additional fiber reinforcement or equivalent can be accepted. In any case, the flexible hose is to be certified suitable for use by the manufacturer • In addition, the requirements of Section 2,A.5.4.2 are to be complied with • Reference is to be made to (**2**).

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

Requirements for each service and locations **(1)**		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Cooling system	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Section 2,A.5.4.2, flexible hoses can be accepted in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Reference is to be made to **(2).**	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Section 2,A.5.4.2, flexible hoses can be accepted in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Reference is to be made to **(2).**
Scupper pipe	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Section 2,A.5.4.2, flexible hoses made of material suitable to be used for this service, and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C can be accepted. • Reference is to be made to **(2).**	Flexible hoses shall comply with the following requirements: • Section 2,A.5.4.2, flexible hoses built in PVC reinforced with embedded steel wire and additional fiber reinforcement or equivalent can be accepted. In any case, the flexible hose is to be certified suitable for use by the manufacturer. • Reference is to be made to **(2).**
Exhaust system	As per $\mathbf{L_C} \geq$ 24 m (see Table 7.27)	
Drinking water, black water and drainage of air conditioning systems	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements: • Any parts connected to the external discharge through the side of the hull shall comply with the requirements for the scuppers. • In any case, the flexible hose is to be certified suitable for use by the manufacturer. • Reference is to be made to **(2).**	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements: • Any parts connected to the external discharge through the side of the hull shall comply with the requirements for the scuppers. • In any case, the flexible hose is to be certified uitable for use by the manufacturer. • Reference is to be made to **(2).**

(1) *End connections different from the crimped type may be adopted only for Class III piping*

(2)

a) All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull.

b) The above valve may be omitted provided that:

• for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater;

• for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser;

• for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater.

c) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

d) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.

2.6 Sea Inlets and Overboard Discharges

2.6.1 General

The requirements of this item do not apply to scuppers and sanitary discharges.

2.6.2 Design of Sea Inlets and Overboard Discharges

a) All inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the ship.

b) Sea inlets and overboard discharges are to be fitted with valves complying with 2.5 and 2.6.3

c) Machinery space main and auxiliary sea inlets and discharges in connection with the operation of machinery are to be fitted with readily accessible valves between the pipes and the shell plating or between the pipes and fabricated boxes attached to the shell plating. The valves may be controlled locally and are to be provided with indicators showing whether they are open or closed.

d) Sea inlets are to be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the ship.

e) Sea inlets are to be fitted with gratings complying with 2.6.4.

f) Sea chests are to be suitably protected against corrosion.

2.6.3 Valves

a) Sea inlet and overboard discharge valves are to be secured:

- directly on the shell plating, or
- on sea chests built on the shell plating, with the same scantlings, or
- on extra-reinforced and short distance pieces attached to the shell.

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings.

c) Valves are to be secured by means of:

- bolts screwed through the plating with a countersunk head, or
- studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

d) The use of butterfly valves will be specially considered by **TL.** In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provision is made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

e) The materials of the valve bodies and connecting pieces are to comply with Table 7.11.

2.6.4 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in -the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

2.6.5 Through Hull Fittings

When the passage through the hull of sea inlets and overboard discharge is directly connected to the plating, the minimum wall thickness of the pipe is given in Table 7.29.

This connection may be a metallic cylindrical stem, provided with flanges fixed or screwed, or a short pipe fitted between the side valve and the hull, and directly welded to the plating.

A different wall thickness may be considered by **TL** on a case-by-case basis, provided that it complies with recognised standards.

Where the through hull fittings are built in metals resistant to corrosion, or are protected against corrosion by means of coating, etc., thickness may be reduced at the discretion of **TL**.

Table 7.29

External diameter (mm)	Minimum wall thickness (mm)
20,0	2,0
21,3 - 25,0	3,2
26,9 - 33,0	3,2
38,0 - 44,5	7,6
48,3	7,6
51,0 - 63,5	7,6
70,0	7,6
76,1 - 82,5	7,6
88,9 - 108,0	7,8
114,3 - 127,0	8,8
133,0 - 139,7	9,5
152,4 - 168,3	11
177,8	12,7
193,7	12,7
219,1	12,7
244,5 - 273,0	12,7
298,5 - 368,0	12,7
406,4 - 457,2	12,7

2.7 Control and Monitoring

2.7.1 General

Local indicators are to be provided for at least the following parameters:

- Pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves,

- Temperatures, in tanks and vessels, at heat exchanger, inlet and outlet

- Levels, in tanks and vessels containing liquids.

2.7.2 Level Gauges

Level gauges used in flammable oil systems are subject to the following conditions:

- Glass or plastic pipes are not allowed for level gauges; however, plastic pipes are allowed on yachts not more than 24 m under the condition of Annex C of ISO 10088. For yachts more than 24 m the use of oil level gauges with flat glasses and self-closing valves between the gauges and fuel tanks is accepted.

- Their glasses are to be made of heat-resistant material and efficiently protected against shocks.

3. Welding of Steel Pipes

3.1 Application

a) Welded joints on class III piping systems are to be in conformity with sound marine practice.

b) Welded joints on class I and II piping systems are to be specially considered by **TL.**

c) The location of welded joints is to be such that as many as possible can be made in a workshop.

The location of welded joints to be made on board is to be so determined as to permit their joining and inspection in satisfactory conditions.

4. Bending of Pipes

4.1 Application

This item applies to pipes made of alloy or non-alloy steels and copper and copper alloys.

4.2 Bending Process

4.2.1 General

The bending process is to be such as not to have a detrimental influence on the characteristics of the materials or on the strength of the pipes.

4.2.2 Bending Radius

Unless otherwise justified, the bending radius measured on the centreline of the pipe is not to be less than:

- Twice the external diameter for copper and copper alloy pipes,

- 3 times the external diameter for cold bent steel pipes.

4.2.3 Acceptance Criteria

a) The pipes are to be bent in such a way that, in each transverse section, the difference between the maximum and minimum diameters after bending does not exceed 10% of the mean diameter; higher values, but not exceeding 15%, may be allowed in the case of pipes which are not subjected in service to appreciable bending stresses due to thermal expansion or contraction.

b) The bending is to be such that the depth of the corrugations is as small as possible and does not exceed 5% of their length.

4.2.4 Hot Bending

a) In the case of hot bending, all arrangements are to be made to permit careful checking of the metal temperature and to prevent rapid cooling, especially for alloy steels.

b) Hot bending is to be generally carried out in the temperature range 850°C-1000°C for all steel grades; however, a decreased temperature down to 750°C may be accepted during the forming process.

4.3 Heat Treatment After Bending

4.3.1 Copper and Copper Alloys

Copper and copper alloy pipes are to be suitably annealed after cold bending if their external diameter exceeds 50 mm.

4.3.2 Steels

a) After hot bending carried out within the temperature range specified in 4.2.4, the following applies:

- For C, C-Mn and C-Mo steels, no subsequent heat treatment is required,

- For Cr-Mo and Cr-Mo-V steels, a subsequent stres relieving heat treatment in accordance with Tab 22 is required.

b) After hot bending performed outside the temperature range specified in 4.2.4, a subsequent new heat treatment is required for all grades.

c) After cold bending at a radius lower than 4 times the external diameter of the pipe, a heat treatment is required.

5. Arrangement and Installation of Piping Systems

5.1 General

Unless otherwise specified, piping and pumping systems covered by the rules are to be permanently fixed on board yachts.

5.2 Location of Tanks and Piping System Components

5.2.1 Pipes Located Inside Tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness or tunnels, in particular for:

- bilge pipes
- ballast pipes
- scuppers and sanitary discharges
- air, sounding and overflow pipes
- fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or flange connections.

5.2.2 Piping and Electrical Apparatus

As far as possible, pipes are not to pass near switchboards or other electrical apparatus. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid or steam on live parts.

5.3 Passage Through Watertight Bulkheads or Decks

5.3.1 Penetration of Watertight Bulkheads and Decks

a) Where penetrations of watertight bulkheads and internal decks are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity.

b) Penetrations of watertight bulkheads or decks by plastic pipes are to comply with Section 7, App. 3.5.2.

5.3.2 Passage Through the Collision Bulkhead

Pipes passing through the collision bulkhead below the main deck are to be fitted with suitable valves abaft the collision bulkhead. All valves are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. The valves are to be always readly accessible for prompt use.

5.4 Provision for Expansion

5.4.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the yacht's structure, having due regard to:

- the temperature of the fluid conveyed
- the coefficient of thermal expansion of the pipe material
- the deformation of the yacht's hull.

5.4.2 Fitting of Expansion Devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.5 Supporting of the Pipes

5.5.1 General

Unless otherwise specified, the fluid lines referred to in this item are to consist of pipes connected to the yacht's structure by means of collars or similar devices.

5.5.2 Arrangement of Supports

Shipyards are to ensure that:

a) The arrangement of supports and collars is such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected;

b) Heavy components in the piping system, such as valves, are independently supported.

5.6 Protection of Pipes

5.6.1 Protection Against Corrosion and Erosion

a) Pipes are to be efficiently protected against corrosion, either by selection of their constituent materials, or by an appropriate coating or treatment.

b) The layout and arrangement of sea water pipes are to be such as to prevent sharp bends and abrupt changes in section as well as zones where water may stagnate. The inner surface of pipes is to be as smooth as possible, especially in way of joints. Where pipes are protected against corrosion by means of galvanising or other inner coating, arrangements are to be made so that this coating is continuous, as far as possible, in particular in way of joints.

c) If galvanised steel pipes are used for sea water systems, the water velocity is generally not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is generally not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

5.6.2 Protection Against Frosting

Pipes are to be adequately insulated against cold wherever deemed necessary to prevent frost.
This applies specifically to pipes passing through refrigerated spaces and which are not intended to ensure the refrigeration of such spaces.

5.7 Valves, Accessories and Fittings

5.7.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

5.7.2 Valves and Accessories

In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:

- Above the floor,

- or, when this is not possible, immediately under the floor, provided provision is made for their easy Access and control in service.

5.7.3 Flexible Hoses and Expansion Joints

a) Flexible hoses and expansion joints are to be so arranged as to be accessible at all times.

b) Flexible hoses and expansion joints should be kept as short as possible.

c) The radius of curvature of flexible hoses is not to be less than the minimum recommended by the Manufacturer.

d) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

e) Expansion joints are to be protected against over extension or over compression.

f) Where they are likely to suffer external damage, flexible hoses and expansion joints of the bellows type are to be provided with adequate protection.

5.7.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.7.5 Pressure Gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.7.6 Nameplates

a) Accessories such as cocks and valves on the fluid lines are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.8 Additional Arrangements for Flammable Fluids

5.8.1 General

The requirements in 5.8.2 and 5.8.3 apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.8.2 Prevention of Flammable Oil Leakage Ignition

a) As far as practicable, parts of the fuel oil and lubricating oil systems containing heated oil under pressure exceeding 0,18 MPa are to be placed above the platform or in any other position where defects and leakage can readily be observed.

The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:

- hot surfaces, including those of heaters, exhaust manifolds and silencers
- electrical equipment
- air intakes
- other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 0,18 MPa such as pumps, filters and heaters are to comply with the provisions of b) above.

d) Flammable oil lines are not to be located immediately above or near units of high temperature including exhaust manifolds, silencers or other equipment required to be insulated. As far as practicable, flammable oil lines are to be arranged far from hot surfaces, electrical installations or other sources of ignition and to be screened or otherwise suitably pro tected to avoid oil spray or oil leakage onto the sources of ignition.
Precautions are to be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

e) Any relief valve of fuel oil and lubricating oil systems is to discharge to a safe position, such as an appropriate tank.

5.8.3 Provisions for Flammable Oil Leakage Containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling and leakages on heated surfaces.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:

- under independent tanks
- under purifiers and any other oil processing equipment

- under pumps, heat exchangers and filters

- under valves and all accessories subject to oil leakage

- surrounding internal combustion engines.

c) The coaming height of drip trays is to suit the amount of potential oil spillage.

d) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

5.8.4 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions.

6. Bilge Systems

6.1 Principle

6.1.1 General

An efficient bilge pumping system is to be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil and for which other efficient means of pumping are to be provided, under all practical conditions.

Bilge pumping system is not intended to cope with water ingress resulting from structural or main sea water piping damage.

If deemed acceptable by **TL,** bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the yacht is not impaired.

6.1.2 Availability of the Bilge System

The bilge pumping units, or pumps, may also be used for ballast, fire or general service duties of an intermittent nature, but they are to be immediately available for bilge duty when required.

6.2 Design of Bilge System

6.2.1 General

The requirements of items 6.2.1 to 6.8.6 apply to yachts according tı ISO 8666, having a length L_H more than 24 metres. For yachts according to ISO 8666, having a length L_H not more than 24 metres, the requirements of ISO 15083 apply

6.2.2 Number and Distribution of Bilge Suctions

a) Draining of watertight spaces is to be possible, when the yacht is on an even keel and either is upright or has a list of up to 10°, by means of at least:

- two suctions in machinery spaces including one branch bilge suction and one emergency bilge suction. An automatic submersible pump may be accepted for the emergency suction;

- one branch bilge suction in other spaces.

b) In the case of compartments of unusual form, additional suctions may be required to ensure effective draining under the conditions mentioned in 6.2.2.a).

c) In all cases, arrangements are to be made such as to allow a free and easy flow of water to bilge suctions.

6.2.3 Prevention of Communication Between Spaces- Independence of the Lines

a) Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

b) Generally, bilge lines are to be entirely independent and distinct from other lines.

c) A non-return valve is to be fitted between each bilge pump and the bilge main.

6.3 Draining of Machinery Spaces

6.3.1 General

Where all the propulsion machinery and main auxiliaries are located in a single watertight space, the bilge suctions are to be distributed and arranged in accordance with the provisions of 6.3.4.

6.3.2 Branch Bilge Suction

The branch bilge suction is to be connected to the bilge main. Non-return valves are to be fitted in each branch bilge suction from the main bilge line.

6.3.3 Emergency Bilge Suction

a) The emergency bilge suction is to be led directly from the drainage level of the machinery space to an adequate pump and fitted with a non-return valve.

b) The emergency bilge suction is to be located at the lowest possible level in the machinery spaces.

6.3.4 Number and Distribution of Suctions in Propulsion Machinery Spaces

a) In propulsion machinery spaces, bilge suctions are to include:

- where the bottom of the space is horizontal or slopes down to the sides, at least two suctions,
- where the shape of the bottom is sufficient to collect the bilge to the centreline, at least one bilge section,
- one emergency bilge suction.

b) If the tank top is of a particular design or shows discontinuity, additional suctions may be required.

c) In electrically propelled yachts, provision is to be made to prevent accumulation of water under electric generators and motors.

6.4 Draining of Dry Spaces Other Than Machinery Spaces

6.4.1 Except where otherwise specified, bilge suctions are to be branch bilge suctions, i.e. suctions connected to a bilge main.

6.4.2 Draining of Cofferdams

a) All cofferdams are to be provided with suction pipes led to the bilge main.

b) Where cofferdams are divided by longitudinal watertight bulkheads or girders into two or more parts, a single suction pipe led to the aft end of each part is acceptable.

6.4.3 Draining of Fore and Aft Peaks

a) Where the peaks are not used as tanks and bilge suctions are not fitted, drainage of both peaks may be effected by hand pump suction provided that the suction lift is well within the capacity of the pump.

b) Drainage of the after peak may be effected by means of a self-closing cock fitted in a well-lighted and readily accessible position.

6.4.4 Draining of Spaces Above Fore and Aft Peaks

a) Provision is to be made for the drainage of the chain lockers and watertight compartments above the fore peak tank by hand or power pump suctions.

b) Steering gear compartments or other small enclosed spaces situated above the aft peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions. However, in the case of rudder stock glands located below the design draught, the bilge suctions of the steering gear compartment are to be connected to the main bilge system.

c) The compartments referred to in b) above may be drained by scuppers discharging to the machinery space in the case of yachts with machinery aft and fitted with self-closing cocks situated in well-lighted and visible positions.

6.5 Bilge Pumps

6.5.1 Number and Arrangement of Pumps

a) At least two fixed and independently powered pumps connected to the main bilge system are to be provided, one of which may be driven by the propulsion machinery. Hand driven pumps are generally not acceptable.

b) Each pump may be replaced by a group of pumps connected to the bilge main, provided their total capacity meets the requirements specified in 6.5.4.

6.5.2 Use of Ejectors

One of the pumps may be replaced by a hydraulic ejector connected to a high pressure water pump and capable of ensuring the drainage under similar conditions to those obtained with the other pump.

6.5.3 Use of Bilge Pumps for Other Duties

Bilge pumps may be used for other duties, such as fire, general service, sanitary service or ballast, provided that:

- such duties are of intermittent nature
- any failure of the other systems connected to the bilge pumps does not render the bilge system inoperable
- pumps are immediately available for bilge duty when necessary.

6.5.4 Capacity of the Pumps

a) The capacity of each pump or group of pumps is not to be less than:

$$Q = 0,0058 \cdot d^2$$

where ;

Q = minimum capacity of each pump or group of pumps [m^3/h],

d = internal diameter of the bilge main [mm].

b) If the capacity of one of the pumps or one of the groups of pumps is less than the Rule capacity, the deficiency may be compensated by an excess capacity of the other pump or group of pumps; as a rule, such deficiency is not permitted to exceed 30% of the Rule capacity.

c) Where an ejector is used in lieu of a driven pump, its suction capacity is not to be less than the required capacity of the pump it replaces.

6.5.5 Choice of the Pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Circulating or cooling water pumps connected to an emergency bilge suction need not be of the self-priming type.

6.6 Dimensioning of Bilge Pipes

6.6.1 Bilge Main Line

The diameter of the bilge main is to be calculated according to the following formula:

$$d = 0,85 \cdot L + 25$$

where ;

d = internal diameter of the bilge main [mm],

L = Rule length of the yacht [m].

6.6.2 Branch Bilge Suction Pipes

The internal diameter of pipes situated between distribution boxes and suctions in holds and machinery spaces is not to be less than the diameter given by the following formula:

$$d = 0,85 \cdot L_1 + 25$$

where ;

L_1 = length of the compartment [m].

6.6.3 Emergency Suctions in Machinery Spaces

Where the emergency suction is connected to a pump other than a main circulating or cooling pump, the suction is to be the same diameter as the main inlet of the pump.

6.6.4 Scuppers in Aft Spaces

Any scupper provided for draining aft spaces is to have an internal diameter not less than 35 mm.

6.7 Bilge Accessories

6.7.1 Drain Valves on Watertight Bulkheads

The fitting of drain valves or similar devices is not allowed on the collision bulkhead.

6.7.2 Screw-down Non-return Valves

Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another. For this purpose, screw-down non-return devices are to be fitted:

- on the pipe connections to bilge distribution boxes or to the alternative valves, if any

- on direct and emergency suctions in machinery spaces

- on the suctions of pumps which also have connections from the sea or from compartments normally intended to contain liquid

- on each branch bilge

- at the open end of bilge pipes passing through deep tanks.

6.7.3 Mud Boxes

In machinery spaces of yachts having GT > 500, termination pipes of bilge suctions are to be straight and vertical and are to be led to mud boxes so arranged as to be easily inspected and cleaned.

The lower end of the termination pipe is not to be fitted with a strum box.

6.7.4 Strum Boxes

a) In compartments other than machinery spaces, the open ends of bilge suction pipes are to be fitted with strum boxes or strainers having holes not more than 10 mm in diameter. The total area of such holes is to be not less than twice the required cross-sectional area of the suction pipe.

b) Strum boxes are to be so designed that they can be cleaned without having to remove any joint of the suction pipe.

6.8 Bilge Piping Arrangement

6.8.1 Passage Through Double Bottom Compartment

Bilge pipes are not to pass through double bottom compartments. If such arrangement is unavoidable, the parts of bilge pipes passing through double bottom compartments are to have reinforced thickness, as per Table 7.12 for steel pipes.

The thickness of pipes made from materials other than steel will be specially considered.

6.8.2 Passage Through Tanks

The parts of bilge pipes passing through deep tanks intended to contain water ballast, fresh water, or fuel oil are normally to be contained within pipe tunnels.

Alternatively, such parts are to have reinforced thickness, as per Table 7.12 for steel pipes, and are to be made either of one piece or several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered; the number of joints is to be as small as possible.

6.8.3 Provision for Expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends.

6.8.4 Connections

Connections used for bilge pipes passing through tanks are to be welded joints or reinforced welded flange connections.

6.8.5 Access to Valves and Distribution Boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement are to be in positions which are accessible under ordinary circumstances.

Hand-wheels of valves controlling emergency bilge suctions are to be readily accessible and easily manouvrable. They are preferably to rise above the moneuvering floor.

6.8.6 Piping Materials

In general, pipe and bilge accessories are to be metallic. The use of non-metallic pipes may be accepted under the conditions listed in Section 7, Appendix.

7. Air, Sounding and Overflow Pipes

7.1 Air Pipes

7.1.1 General

The requirements of this item generally apply to yachts L_H more than 24 metres according to ISO 8666. For yachts L_H not more than 24 metres according to ISO 8666 (and with special reference to fuel systems), the requirements ISO 10088 are to be applied. In addition, compliance with items 7.1.6, 7.1.7 and 7.1.8 is to be ensured.

7.1.2 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments. Their open ends are to be so arranged as to prevent the free entry of sea water in the compartments.

7.1.3 Number and Position of Air Pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration.

7.1.4 Location of Open Ends of Air Pipes

Generally, the air pipes are to be positioned above the main deck at sufficient height capable of preventing the ingress of water in the tanks and the possibility of ignition of gasses issuing from them.

For yachts of not more than 500 GT, air pipes fitted on the side of the vessel may be accepted provided that the pipe is raised to a point close to the main deck. In any case, means are to be adopted to prevent oil spillage.

7.1.5 Fitting of Closing Appliances

Satisfactory appliances which are permanently attached are to be provided for closing the openings of air pipes in order to ensure a watertight closure. Means of closure may be omitted if it can be shown that the open end of an air pipe is afforded adequate protection by other superstructure which will prevent the ingress of water.

Automatic watertight closing appliances are to be fitted where, with the yacht at its design draught, the openings are immersed at an angle of heel of 40° or the angle of down flooding if it is less than 40°.

7.1.6 Design of Closing Appliances

When closing appliances are requested to be of an automatic type, they are to be of a type acceptable to **TL** and are to be tested in accordance with a recognised national or international standard.

7.1.7 Special Arrangements for Air Pipes of Flammable Oil Tanks

a) Air and overflow pipes and relief valves of fuel oil systems are to discharge to a position where there is no risk of fire or explosion from the emergence of oils and vapour and are not to lead into accommodation and crew spaces, machinery spaces or similar spaces.

The open ends are to be fitted with wire gauze diaphragms made of corrosion-resistant material and readily removable for cleaning and replacement. The clear area of such diaphragms is not to be less than the crosssectional area of the pipe.

b) Air pipes of lubricating or hydraulic oil storage tanks not subject to flooding in the event of hull damage may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

7.1.8 Construction of Air Pipes

a) Where air pipes to ballast and other tanks extend above the main deck, the exposed parts of the pipes are to be of substantial construction, and in any case the strength of the air pipes is to be equivalent to that of the surrounding hull structures.

b) Air pipes with height exceeding 900 mm are to be additionally supported.

c) In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

d) The internal diameter of air pipes is not to be less than 38 mm.

e) Air pipes to fuel oil, lubricating oil and other tanks containing flammable liquids which are located in or pass through compartments of high fire risk are to be steel or other material recognised suitable for that location.

7.2 Sounding Pipes

7.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) The following systems may be accepted in lieu of sounding pipes for compartments that are readily accessible at all times:

- a level gauge efficiently protected against shocks, or

- a remote level gauging system.

c) Level gauges used in flammable oil systems are to meet the requirements of item 2.7.2. Remote level gauging systems are to be submitted to **TL** for acceptance.

7.2.2 Position of Sounding Pipes

Sounding pipes are to be located as close as possible to suction pipes.

7.2.3 Termination of Sounding Pipes

a) As a general rule, sounding pipes are to end above the main deck in easily accessible places and are to be fitted with efficient, permanently attached, closing appliances.

b) In machinery spaces where the provisions of a) cannot be satisfied, short sounding pipes led to readily accessible positions above the floor and fitted with efficient closing appliances may be accepted.
In yachts required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

7.2.4 Special Arrangements for Sounding Pipes of Flammable Oil Tanks

Where sounding pipes are used in flammable oil systems, they are to terminate where no risk of ignition of spillage from the sounding pipe might arise. As a general rule, they are not to terminate in machinery spaces. However, where **TL** considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the following provisions are satisfied:

The terminations of sounding pipes are fitted with self-closing blanking devices and with a small diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that fuel oil is not present. Provision is to be made so as to ensure that any spillage of fuel oil through the control cock involves no ignition hazard.

Sounding pipes may terminate in accommodation and crew spaces provided that the relevant tank is fitted with a remote gauging system and the sounding pipe is used in emergency only.

7.2.5 Construction of Sounding Pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) The sounding arrangement of compartments by means of bent pipes passing through other compartments will be given special consideration by **TL.** Such an arrangement is normally accepted only if the compartments passed through are cofferdams or are intended to contain the same liquid as the compartments served by the sounding pipes.

c) Bent portions of sounding pipes are to have reinforced thickness and be suitably supported.

d) The internal diameter of sounding pipes is not to be less than 32 mm.

e) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantlings.

7.3 Overflow Pipes

7.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or

- where the cross-sectional area of air pipes is less than that prescribed in 7.1.8.d).

7.3.2 Design of Overflow Systems

a) Overflow pipes are to be led:

- either outside,

- or, in the case of fuel oil or lubricating oil or flammable oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Where tanks are connected to a common overflow system, the arrangement is to be such as to prevent any risk of overfilling of any tank from another assumed flooded due to hull damage.

For this purpose, overflow pipes are to be led to a high enough point above the design draught or, alternatively, non-return valves are to be fitted where necessary.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the design draught and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the design draught.

7.3.3 Overflow Tanks

a) Overflow tanks are to have an adequate capacity sufficient to receive the delivery of the pumps.

b) Overflow tanks are to be fitted with an air pipe complying with 7.1 which may serve as an overflow pipe for the same tank.

When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

Such means are to discharge to a position which is safe in the opinion of **TL.**

c) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing.
Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

7.3.4 Specific Requirements for Construction of Overflow Pipes

a) The internal diameter of overflow pipes is not to be less than 38 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

7.4 Constructional Requirements Applying to Sounding, Air and Overflow Pipes

7.4.1 Materials

The use of non-metallic material may be considered outside the machinery space or spaces without fire risk provided that the material meets the requirements listed in Appendix.

7.4.2 Passage of pipes through certain spaces

When sounding, air and overflow pipes made of steel are permitted to pass through ballast tanks or fuel oil tanks, they are to be of reinforced thickness.(see Table 7.12).

7.4.3 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the yacht is on an even keel.

7.4.4 Name-plates

Name-plates are to be fixed at the upper part of air pipes and sounding pipes.

8. Cooling Systems

8.1 Application

8.1.1 This item applies to all cooling systems using the following cooling media:

- sea water
- fresh water

Air cooling systems will be given special consideration.

For additional requirements on ice classed vessels, see Chapter 4, Machinery, Section 16,I.2.

8.2 Principle

8.2.1 General

Sea water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the Manufacturers' recommended limits during all operations, including starting and manoeuvring.

8.3 Design of Sea Water Cooling Systems

8.3.1 General

a) For single engine installations, sea water is to be capable of being supplied by two different means. For installations with more than one engine the same requirement is to be applied if each engine is not supplied by its own means.

b) Where required, standby pumps are not to be connected to the sea inlet serving the other sea water pumps, unless permitted under 8.5.1.b).

8.3.2 Centralised Cooling Systems

a) In the case of centralised cooling systems, i.e. systems serving a group of propulsion engines and/or auxiliary engines, reduction gears, compressors and other essential equipment, the following sea water pumps are to be arranged:

- one main cooling water pump, which may be driven by the engines, of a capacity sufficient to provide cooling water to all the equipment served
- one independently driven standby pump of at least the same capacity as for the main cooling pump

b) Where the cooling system is served by a group of identical pumps, the capacity of the standby pump needs only to be equivalent to that of each of these pumps.

8.3.3 Individual Cooling of Propulsion Engines

a) The requirements of this item apply to yachts fitted with propulsion engines with their own cooling circuit.

b) When at least two engines are installed and the main sea cooling pump is driven by the engine, a suitable spare kit is to be provided for the cooling pump.

c) When the propulsion plant consists of one engine with its own sea cooling pump, a complete spare pump is requested.

d) The above requirements do not apply to sailing yachts.

8.3.4 Individual Cooling of Auxiliary Engines and Other Essential Equipment

Where each auxiliary engine is served by its own cooling circuit, no second means of cooling is required.

8.4 Design of Fresh Water Cooling Systems

8.4.1 General

For vessels having a fresh water cooling system external to the engine, the same requirements as for 8.3.2 and 8.3.3 are to be applied.

Fresh water cooling systems are to be designed according to the Manufacturer's technical specification.

8.5 Arrangement of Cooling Systems

8.5.1 Sea Water Inlets

a) At least two sea water inlets complying with item 2.6 are to be provided for cooling system.

b) Two sea water inlets may be crossed-over to supply both main cooling pump and stand-by cooling pump.

c) Sea water inlets are to be arranged as low as possible and as submerged under all normal navigation conditions. In general, one sea water inlet is to be arranged on either side of the yacht.

8.5.2 Materials

In general, piping and associated accessories are to be made of steel resistant to salt water corrosion and to be galvanically compatible. The use of piping made of non-metallic materials may be accepted under the conditions listed in Section 7, table 7.27 and Table 7.28.

9. Fuel Systems

9.1 Application

9.1.1 Scope

The requirements of this item apply to yachts having a length L_H more than 24 metres according to ISO 8666. For yachts having a length L_H not more than 24 metres according to ISO 8666, the requirements of ISO 10088 apply.

This item applies to all fuel oil systems supplying any kind of installation.

9.1.2 Requirements applying to fuel oil systems and not contained in this Item

Additional requirements are given:

- for the location and scantling of tanks forming part of the yacht’s structure, in Section 2,D.

9.2 Principle

9.2.1 General

a) Fuel oil systems are to be so designed as to ensure the proper characteristics (purity, viscosity, pressure) of the fuel oil supply to engines.

b) Fuel oil systems are to be so designed as to prevent:

- overflow or spillage of fuel oil from tanks, pipes, fittings, etc.

- fuel oil from coming into contact with sources of İgnition

- overheating of fuel oil.

9.3 General

9.3.1 Arrangement of Fuel Oil Systems

a) In a yacht in which fuel oil is used, the arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the yacht and persons on board.

b) The provisions of 5.8 are to be complied with.

9.3.2 Provision to Prevent Overpressure

Provision is to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

9.3.3 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

9.3.4 Access

Spaces where fuel oil is stored or handled are to be readily accessible.

9.4 Design of Fuel Oil Filling and Transfer Systems

9.4.1 General

a) A system of pumps and piping for filling and transferring fuel oil is to be provided.

b) Provision is to be made to allow the transfer of fuel oil from any storage, settling or service tank to another tank.

9.4.2 Filling Systems

a) Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

b) Arrangements are to be made to avoid overpressure in the filling lines which are served by pumps on board. Where safety valves are provided for this purpose, they are to discharge to the overflow tank referred to in 7.3.3 or to other safe positions deemed satisfactory.

9.4.3 Independence of Fuel Oil Transfer Lines

The fuel oil transfer piping system is to be completely separate from the other piping systems of the yacht.

9.4.4 Transfer Pumps

a) At least one means of transfer is to be provided, which may be a manual pump.

Note: Where provided, purifiers may be accepted as means of transfer.

b) Where fitted, mechanical transfer pumps are to be fitted on the discharge side with a relief valve leading back to the suction of the pump or to any other place deemed satisfactory.

9.5 Arrangement of Fuel Oil Tanks

9.5.1 Location of Fuel Oil Tanks

a) No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces and electrical apparatus.

b) Fuel oil tanks are not to be situated in locations where they could be subjected to high temperatures, unless specially agreed by **TL**.

9.6 Design of Fuel Oil Tanks

9.6.1 General

Tanks such as collector tanks, de-aerator tanks etc. are to be considered as fuel oil tanks for the purpose of application of this item 9.6, and in particular regarding the valve requirements.

9.6.2 Filling and Suction Pipes

a) All suction pipes from fuel oil tanks, including those in the double bottom, are to be provided with valves.

b) For storage tanks, filling pipes may also be used for suction purposes.

c) Where the filling pipes to fuel oil tanks are not led to the upper part of such tanks, they are to be provided with non-return valves at their ends, unless they are fitted with valves arranged in accordance with the requirements stated in 9.6.3.

9.6.3 Remote Control of Valves

a) Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom, is to be fitted with a cock or valve directly on the tank. Such cock or valve is to be capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space. When a cross connection between two tanks is provided and it is made of material having strength equivalent to the tank material, no remote valves are required on the connection with the tanks.

b) Such valves and cocks are also to include local control and indicators are to be provided on the remote and local controls to show whether they are open or shut.

9.6.4 Drain Pipes

Fuel oil tanks are to be fitted with a drain pipe, provided with self-closing valves or cocks.

9.6.5 Air and Overflow Pipes

Air and Overflow pipes are to comply with 7.1 and 7.3.

9.6.6 Sounding Pipes and Level Gauges

Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided, (see also 7.2.4).

9.7 Control and Monitoring

9.7.1 Remote Controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with 9.6.3.

b) The power supply to transfer pumps and other pumps of the fuel oil system • and fuel oil purifiers, (if any) is to be capable of being stopped from a position within the space containing the pumps and from another position located outside such space and always accessible in the event of fire within the space.

Remote control of the valve fitted to the emergency generator fuel tank is to be in a separate location from that of other valves fitted to tanks in the engine room.

9.8 Construction of Fuel Oil Piping Systems

9.8.1 Materials

a) Fuel oil pipes and their valves are to be metallic or made of material having the same fire resistance. Outside the engine room and in space without fire risk the use of rigid plastic for piping meeting the requirements of Section 7, Appendix may be accepted.

b) Internal galvanisation of fuel oil pipes and tank or bunker walls is to be avoided

9.9 Arrangement of Fuel Oil Piping Systems

9.9.1 Passage of Fuel Oil Pipes Through Tanks

a) Fuel pipes are not to pass through tanks containing fresh water or other flammable oil, unless they are contained within tunnels.

b) Transfer pipes passing through ballast tanks are to have a reinforced thickness complying with Table 7.12. Material other than steel will be specially considered **.**

9.9.2 Passage of Pipes Through Fuel Oil Tanks

Boiler feed water and fresh water pipes are not to pass through fuel oil tanks, unless such pipes are contained within tunnels.

10. Lubricating Oil Systems

10.1 Application

This item applies to lubricating oil systems serving diesel engines, gas turbines, reverse and reduction gears, clutches and controllable pitch propellers, for lubrication or control purposes.

10.2 Principle

10.2.1 General

In the following paragraphs only engines with internal lubrication systems will be considered. In this way is considered that each engine is provided with its own lubrication oil pump driven by the same engine.

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines, turbines and other equipment, including electric motors, intended for propulsion:

b) Lubricating oil systems are to be so designed as to ensure sufficient and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

10.3 General

10.3.1 Arrangement of Lubricating Oil Systems

a) The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems are to be such as to ensure the safety of the yacht and persons on board.

b) The provisions of 5.8 are to be complied with, where applicable.

10.3.2 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) Where filters are fitted on the discharge side of lubricating oil pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

10.3.3 Purification

Where provided, lubricating oil purifiers are to comply with 9.7.2.

10.4 Construction of Lubricating Oil Piping Systems

10.4.1 Materials

Materials used for oil piping system in machinery spaces are to comply with the provisions of 9.8.1.

10.4.2 Sight-flow Glasses

The use of sight-flow glasses in lubricating systems is permitted, provided that they are shown by testing to have a suitable degree of fire resistance.

11. Exhaust Gas Systems

11.1 General

11.1.1 Application

This item applies to exhaust gas pipes from engines and gas turbines and smoke ducts from boilers and incinerators.

11.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

11.2 Design of Exhaust Systems

11.2.1 General

Exhaust systems are to be so arranged as to minimise the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes.

In addition, exhaust engine arrangements are to meet the requirements of Section 2, A.5.4 and those listed in Section 7, Table 7.27 and Table 7.28. In any case the exhaust elbow is to be fitted at sufficient height above the vessel's waterline.

Alternatively a reduced height may be accepted provided that the exhaust pipe is fitted with a continuous download pitch with a suitable non-return valve fitted at the overboard discharge.

The exhaust pipes are to be fitted in such a way that between them and the nearest hull structures or fittings, a suitable gap is provided, in general not less than 200 mm.

11.2.2 Limitation of Exhaust Line Surface Temperature

Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:

- their surface temperature may exceed 220°C, or,

- they pass through spaces of the ship where a temperature rise may be dangerous.

11.2.3 Limitation of Pressure Losses

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine or boiler Manufacturers.

11.2.4 Intercommunication of engine exhaust gas lines or boiler smoke ducts

Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas boiler or economiser, unless each exhaust pipe is provided with a suitable isolating device.

11.2.5 Exhaust Gas Pipe Terminations

a) Where exhaust pipes are led overboard close to the load waterline, means are to be provided to prevent water from entering the engine or the ship.

b) Where exhaust pipes are water-cooled, they are to be so arranged as to be self-draining overboard.

11.3 Materials

11.3.1 General

Materials of exhaust gas pipes and fittings are to be resistant to exhaust gases and suitable for the maximum temperature expected.

The use of flexible hoses in water-cooled exhaust systems may be accepted provided that the requirements listed in Section 7, Appendix are satisfied.

11.4 Arrangement of Exhaust Piping Systems

11.4.1 Provision for Thermal Expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction

11.4.2 Provision for Draining

a) Drains are to be provided where necessary in exhaust systems, and in particular in exhaust ducting below exhaust gas boilers, in order to prevent water flowing into the engine.

b) Where exhaust pipes are water-cooled, they are to be so arranged as to be self-draining overboard.

11.4.3 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

12. Certification, Inspection and Testing of Piping Systems

12.1 Application

Items 12.2 to 12.6 define the certification, inspection and testing program to be performed on piping systems to be fitted on board yachts for which + M is required.

In addition, all yachts are to be subjected to the on board testing as defined in G.

12.2 Type Tests

12.2.1 Type Tests of Flexible Hoses and Expansion Joints

Flexible hoses and expansion joints are to be **TL** type approved.

a) Type approval tests are to be carried out on flexible hoses or expansion joints of each type and of sizes in accordance with Table 7.30.

b) The flexible hoses or expansion joints subjected to the tests are to be fitted with their connections.

12.3 Material Tests

12.3.1 General

Detailed specification for material tests are given in **TL** Material Rules, requirements for the inspection of welded joints are given in **TL** Welding Rules.

12.3.2 Material Tests

a) Where required in Table 7.31, materials used for pipes, valves and other accessories are to be subjected to the following tests:

- tensile test at ambient temperature
- flattening test or bend test, as applicable
- tensile test at the design temperature, except if one of the following conditions is met:
  - the design temperature is below 200°C
  - the mechanical properties of the material at high temperature have been approved
  - the scantling of the pipes is based on reduced values of the permissible stress.

b) Plastic materials are to be subjected to the tests specified in Section 7, Appendix.

Table 7.30 Type Tests to be Performed for Flexible Hoses and Expansion Joints

Test	Flexible hoses and expansion joints in non-metallic material	Flexible hoses and expansion joints in metallic material
Bursting test	x	x
Fire-resistance test	x **(1)**	-
Vibration test **(2)**	x	x
Pressure impulse test	x **(6)**	-
Flexibility test	x **(3)**	-
Elastic deformation test	-	x
Cyclic expansion test **(4)**	-	x
Resistance of the material **(5)**	x	x

(1) *only for flexible hoses and expansion joints used in flammable oil systems and, when required, in sea water systems.*
(2) ***TL*** *reserves the right to require the vibration test in the case of installation of the components on sources of high vibrations.*
(3) *only for flexible hoses conveying low temperature fluids.*
(4) ***TL*** *reserves the right to require the cyclic expansion test for piping systems subjected to expansion cycles*
(5) *internal to the conveyed fluid to be demonstrated by suitable documentation and / or tests.*
(6) *only for flexible hoses.*
(7) ***Note 1****: x = required, - = not required.*

12.4 Hydrostatic Testing of Piping Systems and Their Components

12.4.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to **TL** for acceptance prior to testing.

12.4.2 Hydrostatic Pressure Tests of Piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor's satisfaction for:

- all class I and II pipes and their integral fittings

- all compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) Where the design temperature does not exceed 300°C, the test pressure is to be equal to 1,5 p. Where the design temperature exceeds 300°C, the test pressure is to be calculated according to the requirements of **TL** Machinery Rules, Section 11, B.4 (p = design pressure).

e) Where it is necessary to avoid excessive stress in way of bends, branches, etc., **TL** may give special consideration to the reduction of the test pressure to a value not less than 1,5 p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

f) When the hydrostatic test of piping is carried out on board, these tests may be carried out in conjunction with the tests required in 12.4.7.

Table 7.31 Inspection and Testing at Works for Piping Systems and Their Components

No	Item	Material tests (1)		Inspection and tests for the product (1)			Reference to the rules
		Tests required	Type of material certificate (2)	During manufacturing (NDT)	After completion	Type of product certificate	
1	Valves, pipes and fittings **a)** Class I, d ≥ 32 mm or Class II, d ≥100 mm.	X	K	X (5)	X	K(3)	12.3.2 12.4.2
	b) Class I, d < 32 mm or Class II, d <100 mm.	X	Ü	X (4)	X	Ü	12.3.2 3.6.2, 3.6.3 12.4.2
2	Flexible hoses and expansion joints	X (5)	Ü		X	K(3)	12.3.2 12.4.6
3	Pumps and compressors **a)** All				X	K(3)	12.4.5
	b) Bilge and fire pumps				X	K(3)	12.5.1
4	Centrifugal separators				X	K(3)	12.5.2

(1) *X = Test is required.*
(2) *K = Class certificate.*
Ü = Work's certificate.
(3) *or alternative type of certificate.*
(4) *If of welded construction.*
(5) *If metallic.*

12.4.3 Hydrostatic Tests of Valves, Fittings and Heat Exchangers

a) Valves and fittings non-integral with the piping system and intended for class I and II pipes are to be subjected to hydrostatic tests in accordance with standards recognised by **TL,** at a pressure not less than 1,5 times the design pressure p defined in 1.3.2.

b) Valves and through hull fittings intended to be fitted on the yacht side are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in **TL** Machinery Rules, Section 8.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

12.4.4 Hydrostatic Tests of Fuel Oil Tanks not Forming Part of Yacht's Structure

Fuel oil tanks not forming part of the yacht's structure are to be subjected to a hydrostatic test under a pressure corresponding to 2 m above the tank top or the height of the overflow pipe, whichever is the greater.

12.4.5 Hydrostatic Tests of Pumps and Compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the pressure p_H determined by the following formulae:

- $p_H = 1{,}5\ p$, where $p \le 4$
- $p_H = 1{,}4\ p + 0{,}4$, where $4 < p \le 25$ ise
- $p_H = p + 10{,}4$, where $p > 25$ ise

where;

p_H = Test pressure [MPa]

p = Design prssure [MPa]

P_H , is not to be less than 0,4 MPa.

b) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure defined in a). When determining p_H, the pressure p to be considered is that which may result from accidental communication between the cooler and the adjoining stage of higher pressure, allowance being made for any safety device fitted on the cooler.

c) The test pressure for water spaces of compressors and their intermediate coolers is not to be less than 1,5 times the design pressure in the space concerned, subject to a minimum of 0,2 MPa.

12.4.5 Hydrostatic Tests of Flexible Hoses and Expansion Joints

a) Each flexible hose or expansion joint, together with its connections, is to undergo a hydrostatic test under a pressure at least equal to twice the maximum service pressure, subject to a minimum of 1 MPa.

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

12.4.7 Pressure Tests of Piping After Assembly on Board

After assembly on board, the following tightness tests are to be carried out in the presence of the **TL** Surveyor.

In general, all the piping systems covered by these requirements are to be checked for leakage under operational conditions and, if necessary, using special techniques other than hydrostatic testing.

In particular, liquid fuel lines are to be tested to not less than 1,5 times the design pressure but in no case less than 0,4 MPa.

12.5 Testing of Piping System Components During Manufacturing

12.5.1 Pumps

Bilge and fire pumps are to undergo a performance test.

12.5.2 Centrifugal Separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

12.6 Inspection and Testing of Piping Systems

The inspections and tests required for piping systems and their components are summarised in Table 7.31.

F. Steering Gear

1. General

1.1 Application

1.1.1 Scope

Unless otherwise specified, the requirements of this item apply to the steering gear systems of the yachts and to the steering mechanism of thrusters used as means of propulsion.

In ice classed vessels, constructional members of steering gears are to be dimensioned according to rudder stock diameter specified in Chapter 1, Hull Rules, Section 14 and 18.

1.2 General

Unless expressly provided otherwise, every yacht is to be provided with main steering gear and independent auxiliary steering gear.

1.3 Definitions

1.3.1 Main Steering Gear

Main steering gear is the machinery, actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque necessary for effecting movement of the rudder for the purpose of steering the yacht under design conditions.

1.3.2 Steering Gear Power Unit

Steering gear power unit is:

- in the case of electric steering gear, an electric motor and its associated electrical equipment
- in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump
- in the case of other hydraulic steering gear, a driving engine and connected pump

1.3.3 Auxilary Steering Gear

Auxiliary steering gear means a power unit independent from the main steering gear and its associated piping systems to the actuator(s). The actuator, tiller and other components beyond the tiller need not be duplicated.

Auxiliary steering gear may be activated by a hand-operated system, provided that the requirements of 2.1.2 are complied with.

1.3.4 Power Actuating System

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator.

1.3.5 Rudder Actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.6 Steering Gear Control System

Steering gear control system is the equipment by which orders are transmitted from the control station to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3.7 Maximum Working Pressure

Maximum working pressure is the maximum expected pressure in the system when the steering gear is operated to comply with the provisions of 2.1.1.

1.4 Symbols

1.4.1 The following symbols are used for strength criteria of steering gear components:

d_s = Rule diameter of the rudder stock subject to torque only [mm], as defined in Section 2,B. 1.2.1, assuming e = 1;

d_{se} = Actual diameter of the upper part of the rudder stock in way of the tiller [mm] (in the case of a tapered coupling, this diameter is measured at the base of the assembly);

R = Value of the minimum specified yield strength of the material at ambient temperature [N/mm^2];

R_e = Value of the minimum specified yield strength of the material at ambient temperature [N/mm^2],

R'_e = Design yield strength determined by the following formulea [N/mm^2] :

$R'_e = R_e$, where $R = 1{,}4 \cdot R_e$

$R'_e = 0{,}417\ (R_e + R)$, where $R < 1{,}4 \cdot R_e$

T_R = Rule design torque of the rudder stock given by the following formula [kN.m] :

$$T_R = 13{,}5 \cdot d_s^3 \cdot 10^{-6}$$

2. Design and Construction

2.1 Strength, Performance and Power Operation of the Steering Gear

2.1.1 Main Steering Gear

The main steering gear is to be:

a) Capable of putting the rudder from 35° on one side to 35° on the other side with the yacht at its deepest seagoing draught and running ahead at maximum ahead service speed. In addition, the main steering gear is to be capable of putting the rudder from 35° on either side to 30° on the other side in not more than 28 seconds;

b) Operated by power where necessary to meet the requirements of a),

c) So designed that it will not be damaged at maximum astern speed.

2.1.2 Auxiliary Steering Gear

The auxiliary steering gear is to be of adequate strength and capable of steering the yacht at navigable speed and of being brought speedily into action in an emergency.

An auxiliary means of steering will not be required for the following arrangements:

- when the main steering gear comprises two or more identical power units, provided that the main steering gear is so arranged that after a single failure in its piping system or in one of the power units, the defect can be isolated so that steering capability can be maintained or speedily regained;
- when non-power-operated mechanical main steering gear is provided;
- when steering may be carried out by positioning the propulsion unit (i.e. surface propellers).

Steering gear other than of the hydraulic type is to achieve standards equivalent to the requirements of this paragraph to the satisfaction of **TL.**

2.1.3 When the auxiliary steering gear is power operated it is to be capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60s with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.

2.1.4 Hand Operation

Hand operated auxiliary steering gear is acceptable when the rudder stock in way of the tiller is less than 150 mm.

2.2 Mechanical Components

2.2.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of **TL.**

b) All steering gear components transmitting mechanical forces to the rudder stock which are not protected against overload by structural rudder stops or mechanical buffers are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

2.2.2 Materials and Welds

a) All steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material complying with the requirements of **TL** Material Rules. In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm2.

b) The use of grey cast iron is not permitted, except for redundant parts with low stress level, subject to special consideration by **TL.** It is not permitted for cylinders. The use of other metallic material will be considered by **TL**, on a case-by-case basis.

c) The welding details and welding procedures are to be submitted.

d) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

2.2.3 Tillers, Quadrants and Rotors

a) The scantling of the tiller is to be determined as follows:

- the depth H_0 of the boss is not to be less than d_s

- the radial thickness of the boss in way of the tiller is not to be less than $0,4.d_s$

- the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value calculated from the following formula:

$$Z_b = [(0,147\ d_s^3)/1000] \cdot (L'/L) \cdot (235/R_e') \quad [cm^3]$$

L = Distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Figure 7.6)

L' = Distance between the point of application of the above load and the root section of the tiller arm under consideration (see Figure 7.6)

- the width and thickness of the tiller arm in way of the point of application of the load are not to be less than one half of those required by the above formula

- in the case of double arm tillers, the section modulus of each arm is not to be less than one half of the section modulus required by the above formula.

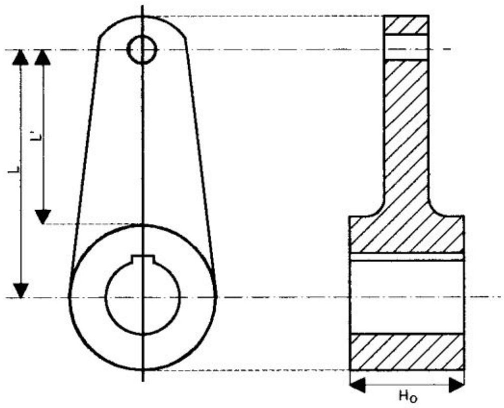


Figure 7.6 Tiller arm

b) The scantling of the quadrants is to be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm is not to be less than one half or one third, respectively, of the section modulus required for the tiller.

Arms of loose quadrants not keyed to the rudder stock may be of reduced dimensions to the satisfaction of **TL,** and the depth of the boss may be reduced by 10 per cent.

c) Keys are to satisfy the following provisions:

- the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm^2.

- the width of the key is not to be less than 0,25.d_s

- the thickness of the key is not to be less than 0,10.d_s

- the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5 per cent of the key thickness.

d) Bolted tillers and quadrants are to satisfy the following provisions:

- the diameter of the bolts is not to be less than the value calculated from the following formula:

$$d_b = 153\sqrt{\frac{T}{n(b+0{,}5d_{se})}\cdot\frac{235}{R_{eb}}} \quad \text{[mm]}$$

where;

n = Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2),

b = Distance between bolts and stock axis [mm], (see Figure 7.7),

R_{eb} = Yield stress of the bolt material [N/mm^2]:

- the thickness of the coupling flanges is not to be less than the diameter of the bolts

- in order to ensure the efficient tightening of the coupling around the stock, the two parts of the tiller are to bored together with a shim having a thickness not less than the value calculated from the following formula:

$j = 0{,}0015 \cdot d_s$ [mm]

e) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:

- the safety factor based on the Rule design torque T_R against slippage is not to be less than:

  - 1 for keyed connections

  - 2 for keyless connections

- the friction coefficient is to be taken equal to:

  - 0,15 for steel in the case of hydraulic fit

  - 0,13 for spheroidal graphite cast iron, in the case of hydraulic fit

- 0,17 in the case of dry shrink fitting

- the combined stress according to the von Mises criterion, due to the maximum pressure induced by the shrink fitting and calculated in way of the most stressed points of the shrunk parts, is not to exceed 80 per cent of the yield stress of the material considered.

- the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

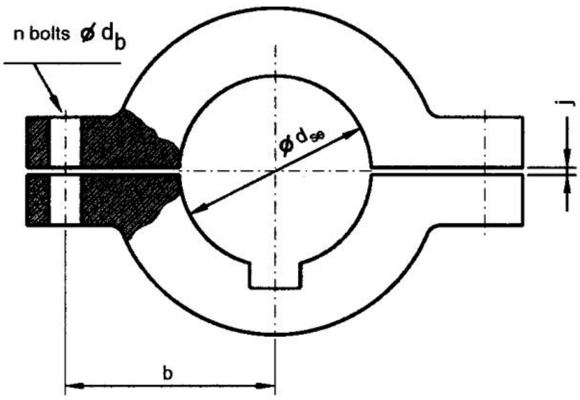


Figure 7.7 Bolted Tillers

2.3 Hydraulic System

2.3.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure is to be at least 1,25 times the maximum working pressure to be expected under the operational conditions specified in item 3. taking into account any pressure which may exist in the low pressure side of the system.

b) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

c) The hydraulic system intended for main and auxiliary steering gear is to be independent of all other hydraulic systems of the yacht.

d) The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirments for class I piping systems.

2.3.2 Materials

a) Ram cylinders, pressure housings of rotary vane type actuators, hydraulic power piping, valves, flanges and fittings are to be of steel or other approved ductile material.

b) In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

Grey cast iron may be accepted for valve bodies and redundant parts with low stress level, excluding cylinders.

2.3.3 Isolating Valves

Shut-off valves, non-return valves or other suitable devices are to be provided.

In particular, for all yachts with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly fitted on the actuator.

2.3.4 Flexible Hoses

Flexible hoses may be installed between two points where flexibility is required but are not to be subjected to torsional deflexion (twisting) under normal operation. In general, the hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery

2.3.5 Relief Valves

a) Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves is not exceed the design pressure. The valves are to be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

b) The setting pressure of the relief valves is not to be less than 1,25 times the maximum working pressure.

2.3.6 Hydraulic Oil Reservoirs

Hydraulic power-operated steering gear is to be provided with a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms are to be given in the wheel-house.

2.3.7 Filters

a) Hydraulic power-operated steering gear is to be provided with arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system.

b) Filters of appropriate mesh fineness are to be provided in the piping system, in particular to ensure the protection of the pumps.

2.3.8 Rudder Actuators

a) Rudder actuators are to be designed in accordance with the relevant requirements of **TL** Machinery Rules, Section 8, also considering the following provisions.

b) The permissible primary general membrane stress is not to exceed the lower of the following values:

$$\frac{R}{A} \quad or \quad \frac{R_e}{B}$$

Where A and B are given in Table 7.32.

Table 7.32 Value of coefficient A and B

Coefficient	Steel	Cast steel	Nodular cast iron
A	3,5	4	5
B	1,7	2	3

c) Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal or equivalent type.

d) Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted.

2.4 Electrical Systems

2.4.1 The requirements of the following paragraphs apply to electric power-operated steering gear.

2.4.2 General Design

The electrical systems of the main steering gear and the auxiliary steering gear are to be so arranged that the failure of one will not render the other inoperative.

2.4.3 Power Circuit Supply

a) Electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard.

b) The circuits supplying electric or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

2.4.4 Supply of Motor Control Circuits and Steering Gear Control Systems

a) Each control for starting and stopping of motors for power units is to be served by its own control circuits supplied from its respective power circuits.

b) Any electrical main and auxiliary steering gear control system operable from the navigating bridge is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit. The power supply systems are to be protected selectively.

2.4.5 Circuit Protection

a) Short-circuit protection is to be provided for each control circuit and each power circuit of electric or electrohydraulic main and auxiliary steering gear.

b) No protection other than short-circuit protection is to be provided for steering gear control system supply circuits.

c) Protection against excess current (e.g. by thermal relays), including starting current, if provided for power circuits, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

d) Where fuses are fitted, their current ratings are to be two step higher than the rated current of the motors. However, in the case of intermittent service motors, the fuse rating is not to exceed 160% of the rated motor current.

e) The instantaneous short-circuit trip of circuit breakers is to be set to a value not greater than 15 times the rated current of the drive motor.

f) The protection of control circuits is to correspond to at least twice the maximum rated current of the circuit, though not, if possible, below 6 A.

g) Power unit motor controllers and other automatic motor controllers are to be fitted with under-voltage release.

2.4.6 Starting and Stopping of Motors for Steering Gear Power Units

a) Motors for power units are to be capable of being started and stopped from a position on the navigation bridge.

b) Means are to be provided at the position of motor starters for isolating any remote control starting and stopping devices (e.g. by removal of the fuse-links or switching off the automatic circuit-breakers).

c) Main and auxiliary steering gear power units are to be arranged to restart automatically when power is restored after a power failure

2.5 Alarms and Indications

2.5.1 Power Units

a) In the event of a power failure in any one of the steering gear power units, an audible and visual alarm is to be given in the wheel-house**.**

b) Means for indicating that the motors of electric and electrohydraulic steering gear are running are to be installed in the wheel-house.

c) Where a three-phase supply is used, an alarm is to be provided that will indicate failure of any one of the supply phases (only for yachts having GT > 500).

d) An overload alarm is to be provided for each electric motor.

e) The alarms required in c) and d) are to be both audible and visual and situated in a conspicuous position in the wheelhouse.

2.5.2 Hydraulic System

a) Hydraulic oil reservoirs are to be provided with the alarms required in 2.3.6.

b) Where hydraulic locking, caused by a single failure, may lead to loss of steering, an audible and visual alarm, which identifies the failed system, is to be provided on the navigating bridge.

Note1: This alarm is to be activated when, for example:

- the position of the variable displacement pump control system does not correspond with the given order, or

- an incorrect position in the 3-way valve, or similar, in the constant delivery pump system is detected.

This item b) does not apply to units having gross tonnage 500 and less.

2.5.3 Control System

In the event of a failure of electrical power supply to the steering gear control systems, an audible and visual alarm is to be given on the navigating bridge

2.5.4 Rudder Angle Indicator

The angular position of the rudder is to be;

a) indicated on the navigation bridge,

b) recognisable in the steering gear compartment (not applicable for yachts not more than 24 m.).

2.5.5 Summary Table

Displays and alarms are to be provided in the locations indicated in Table 7.33.

3. Control of the Steering Gear

3.1 General

3.1.1 Control of the Main Steering Gear

Control of the main steering gear is to be provided on the navigation bridge. Where the main steering gear is arranged in accordance with 2.1.2 (two or more identical power units), two independent control systems are to be provided, both operable from the navigation bridge. This does not require duplication of the steering wheel or steering lever.

3.1.2 Control of the Auxiliary Steering Gear

a) Control of the auxiliary steering gear is to be provided on the navigation bridge, or in the steering gear compartment or in another suitable position.

b) If the auxiliary steering gear is power-operated, its control system is also to be independent of that of the main steering gear.

4. Requirements for Yachts Equipped with Thrusters as Steering Means

4.1 Principle

4.1.1 General

The main and auxiliary steering gear referred to this item may consist of thrusters of the following types:

- azimuth thrusters
- water-jets
- cycloidal propellers.

4.1.2 Actuation System

Thrusters used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

4.1.3 Control System

Where the steering means of the yacht consists of two or more thrusters, their control system is to include a device ensuring an automatic synchronisation of the thruster rotation, unless each thruster is so designed as to withstand any additional forces resulting from the thrust exerted by the other thrusters.

5. Arrangement and Installation

5.1 Overload Protections

5.1.1 Rudder Angle Limiters

Power-operated steering gear is to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronised with the gear itself and not with the steering gear control.

Table 7.33 Location of displays and alarms

Item	Display	Alarms (audible and visual)	Location	
			Navigation bridge	Steering gear compartment
Power failure of each power unit		X	X	
Indication that electric motor of each power unit is running	X		X	
Overload of electric motor of each power unit		X	X	
Phase failure of electric motor of each power unit		X	X	
Low level of each hydraulic fluid reservoir		X	X	
Power failure of each control system		X	X	
Hydraulic lock (yachts having GT > 500)		X	X	
Rudder angle indicator	X		X	X

5.2 Means of Communication

If steering systems can also be operated from other positions in addition to the wheel-house, then two-way communication is to be arranged between the bridge and these other positions.

6. Certification, Inspection and Testing

6.1 Material Testing

6.1.1 The requirements stated in items 6.1 ÷ 6.3 are to be applied to yachts to be assigned + M class notation. Works' cetificates are accepted for yachts to be assigned (+) M class notation.

6.1.2 Components Subject to Pressure or Transmitting Mechanical Forces

a) Materials of components subject to pressure or transmitting mechanical forces, specifically:

- cylindrical shells of hydraulic cylinders, rams and piston rods
- tillers, quadrants
- rotors and rotor housings for rotary vane steering gear hydraulic pump casings
- and hydraulic accumulators, if any,

are to be duly tested, including examination for internal defects, in accordance with the requirements of **TL** Material Rules.

b) A works' certificate may be accepted for low stressed parts, provided that all characteristics for which verification is required are guaranteed by such certificate.

6.1.3 Hydraulic Piping, Valves and Accessories

Tests for materials of hydraulic piping, valves and accessories are to comply with the provisions of E.

6.2 Inspection and Tests During Manufacturing

6.2.1 Components Subject to Pressure or Transmitting Mechanical Forces

a) The mechanical components referred to in 6.1.2 are to be subjected to appropriate non-destructive tests.

b) Defects may be repaired by welding only on forged parts or steel castings of weldable quality. Such repairs are to be conducted under the supervision of the Surveyor.

6.2.2 Hydraulic Piping, Valves and Accessories

Hydraulic piping, valves and accessories are to be inspected and tested during manufacturing in accordance with E, for a class I piping system.

6.3 Insection and Tests After Completion

6.3.1 Hydrostatic Tests

a) Hydraulic cylinder shells and accumulators are to be subjected to hydrostatic tests.

b) Hydraulic piping, valves and accessories and hydraulic pumps are to be subjected to hydrostatic tests according to the relevant provisions of E.

6.3.2 Shipboard Tests

After installation on board the yacht, the steering gear is to be subjected to the tests detailed in G.

6.3.3 Sea Trials

For the requirements of sea trials, refer to G.

G. Tests on Board

1. General

1.1 Application

This item covers shipboard tests, both during dock trials and sea trials. Such tests are additional to the workshop tests required.

1.2 Purpose of Shipboard Tests

Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in particular in respect of the criteria imposed by the Rules. The tests are to be witnessed by **TL** Surveyor.

2. General Requirements for Shipboard Tests

2.1 Dock Trials

Trials at the moorings are to demonstrate the following:

a) Satisfactory operation of the machinery

b) Quick and easy response to operational commands

c) Safety of the various installations, as regards:

- the protection of mechanical parts

- the safeguards for personnel

d) Accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, **TL** reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Sea Trials

2.2.1 Scope of the Tests

Sea trials are to be conducted after the trials at the moorings and are to include the following:

a) Demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions,

b) Detection of dangerous vibrations by taking the necessary readings when required,

c) Checks either deemed necessary for yacht classification or requested by the Interested Parties and which are possible only in the course of navigation in open sea.

3. Shipboard Tests for Machinery

3.1 Conditions of Sea Trials

3.1.1 Displacement of the Yacht

Except in cases of practical impossibility, or in other cases to be considered individually, the sea trials are to be carried out at a condition as close as possible to the normal condition.

3.1.2 Performance of Machinery

The performance of the propulsion machinery in the course of the sea trials is to be as close as possible to the rated power.

3.2 Navigation and Manoeuvring Tests

3.2.1 Speed Trials

Where required by the Interested Party, the speed of the yacht is to be determined by the average of the speeds taken in not less than two pairs of runs in opposite directions

3.2.2 Astern Trials

The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the yacht to rest within reasonable distance from maximum ahead service speed, is to be demonstrated

3.3 Tests of Diesel Engines

3.3.1 Main Propulsion Engines Driving Fixed Propellers

Sea trials of main propulsion engines driving fixed propellers are to include the following tests:

a) Operation at rated engine speed for at least 1 hour,

b) Operation at minimum load speed,

c) Stopping and reversing manoeuvres,

d) Tests of the monitoring, alarm and safety systems.

Note *: The test in d) may be performed during the dock or sea trials*

3.3.2 Main Propulsion Engines Driving Controllable Pitch Propellers or Reversing Gears

a) The scope of the sea trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of 3.3.1.

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.3 Engines Driving Generators for Propulsion

Sea trials of engines driving generators for propulsion are to include the following tests:

a) Operation at 100% power (rated power) for at least 1 hour,

b) Starting manoeuvres,

c) tests of the monitoring, alarm and safety systems.

Note: *The above tests a) to c) are to be performed at rated speed with a constant governor setting. The powers refer to the rated electrical powers of the driven generators.*

3.3.4 Engines Driving Auxiliaries

Engines driving generators or important auxiliaries are to be subjected to an operational test. It is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account is to be taken of the time needed to actuate the generator's overload protection system.

3.4 Tests of Electric Propulsion System

3.4.1 Dock Trials

a) The dock trials are to include the test of the electricl propulsion system, the power management and the load limitation.

b) A test of the propulsion plant at a reduced power, in accordance with dock trial facilities, is to be carried out. During this test, the followings are to be checked:

- Electric motor rotation speed variation
- Functional test, as far as practicable (power limitation is to be tested with a reduced value)
- Protection devices
- Monitoring and alarm transmission including interlocking system.

c) Prior to the sea trials, an insulation test of the electric propulsion plant is to be carried out.

3.4.2 Sea Trials

Testing of the performance of the electric propulsion system is to be effected.

This test program is to include at least:

- Speed rate of rise
- Endurance test:
  - 1 hour at 100% rated output power
  - 10 minutes at maximum astern running power
- Check of the crash astern operation in accordance with the sequence provided to reverse the speed from full ahead to full astern, in case of emergency. During this test, all necessary data concerning any effects of the reversing of power on the generators are to be recorded, including the power and speed variation
- Test of functionality of electric propulsion, when manoeuvring and during the yacht turning test
- Test of power management performance: reduction of power due to loss of one or several generators to check, in each case, the power limitation and propulsion availability.

3.5 Tests of Main Propulsion Shafting and Propellers

3.5.1 Bearings

For yachts having GT > 500, the temperature of the bearings is to be checked under the machinery power conditions specified in 3.1.2

3.5.2 Stern Tube Sealing Gland

The stern-tube seal system is to be checked for possible leakage through the stern-tube sealing gland.

3.5.3 Propellers

For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

3.6 Tests of Piping Systems

3.6.1 Functional Tests

During the sea trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment Manufacturer.

3.7 Tests of Steering Gear

3.7.1 General

a) The steering gear is to be tested during the sea trials under the conditions stated in 3.1 in order to demonstrate, to the Surveyor’s satisfaction, that the applicable requirements of F. are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

3.7.2 Tests to be Performed

Tests of the steering gear are to include at least:

a) Functional test of the main and auxiliary emergency steering gear for demonstration of the performances

b) Test of the steering gear power units, including transfer between steering gear power units

c) Test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

d) Test of the alarms and indicators.

H. Tools, Stores and Spare Parts

1. General

Tools, stores and spare parts of machinery are left to the determination of the interested parties, depending upon the type of machinery and the service of the concerned pleasure boat or yacht.

SECTION 7 - APPENDIX

PLASTIC PIPES and OTHER NON-METALLIC PIPES

Page

1. General

1.1 Application

These requirements are applicable to all piping systems with parts made of rigid plastic and other non-metallic material.

1.2 Use of Plastic Pipes

1.2.1 Plastic pipes will be used for the different services under the conditions given in this Section.

Plastic pipes are used in the following systems installed in machinery spaces or in other spaces with fire risk. They shall have adequate fire resistance:

- Fuel oil system and lubricating oil system and fuel oil tank vents and lubricating oil tank vents;
- Fixed water fire extinguishing system;
- Cooling system;
- Bilge system;
- Scupper pipe.

1.2.2 Plastic pipes and fittings are to be accepted, in general, for class II and III piping systems.

All systems provided with external discharge through the side of the hull are to be fitted with a suitable metallic valve on the side of the hull.

The said valve may be omitted provided that:

- for non-sailing yachts, the side discharge is positioned at a point above 300 mm of height from the full load waterline or a point corresponding to full load waterline at an angle of heel of not more than 7°, whichever is greater,
- for sailing yachts, the sea discharge is positioned at a point corresponding to full load waterline, at an angle of heel of not more than 30° or at the angle of heel corresponding to the intersection of the deck with the side, whichever is the lesser,
- for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted between a point above 300 mm of height from the full load waterline or a point corresponding to full load waterline at an angle of heel of not more than 7°, whichever is greater.

In any case, an adequate metallic valve is to be fitted on the shell where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided.

1.3 Definitions

1.3.1 Plastic

Plastic includes both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and FRP (reinforced plastics pipes).

1.3.2 Piping systems

Piping systems include the pipes, fittings, joints, and any internal or external liners, coverings and coatings required to comply with the performance criteria.

1.3.3 Joints

Joints include all pipe assembling devices or methods, such as adhesive bonding, laminating, welding, etc.

1.3.4 Fittings

Fittings include bends, elbows, fabricated branch pieces, etc. made of plastic materials.

1.3.5 Nominal pressure

Nominal pressure is the maximum permissible working pressure.

1.3.6 Design pressure

Design pressure is the maximum working pressure which is expected under operation conditions or the highest set pressure of any safety valve or pressure relief device on the system, if fitted.

2. Design of Plastic Piping Systems

2.1 General

2.1.1 Specification

The specification of the plastic is to comply with a recognised national or international standard. In addition, the requirements stated below are to be complied with.

2.2 Strength

2.2.1 General

a) The piping is to have sufficient strength to take account of the most severe concomitant conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

b) The maximum permissible working pressure is to be specified with due regard for the maximum possible working temperature in accordance with the Manufacturer's recommendations.

2.2.2 Permissible Pressure

Piping systems are to be designed for a nominal pressure determined from the following conditions:

a) Internal pressure

The hydrostatic bursting pressure is to be not less than five times the design pressure for thermostatic pipes and thermoplastic pipes and four times the design pressure for reinforced thermosetting resin pipes.

b) External pressure (to be considered for any installation subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe)

The nominal externalpressure is not to exceed $P_{çök}/3$.
Where;

$P_{çök}$ = Collapse pressure

Note : *The external pressure is the sum of the vacuum inside the pipe and the static pressure head outside the pipe.*

c) The collapse pressure is not to be less than 0,3 MPa.

2.2.3 Permissible Temperature

a) In general, plastic pipes are not to be used for media with a temperature above 60°C or below 0°C, unless satisfactory justification is provided to **TL.**

b) The permissible working temperature range depends on the working pressure and is to be in accordance with the manufacturers' recommendations.

c) The maximum permissible working temperature is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A or equivalent.

d) The minimum heat distortion temperature is not to be less than 80°C.

2.3 Pipe and Fitting Connections

a) The strength of connections is not to be less than that of the piping system in which they are installed.

b) Pipes and fittings may be assembled using adhesive bonded, welded, flanged or other joints.

c) When used for joint assembly, adhesives are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

d) Tightening of joints, where required, is to be performed in accordance with the manufacturers' instructions.

2.4 Electrical Conductivity

2.4.1

a) Piping systems conveying fluids with a conductivity less than 1000 pS/m (1pS/m=10^{-12} siemens per metre), such as refined products and distillates, are to be made of conductive pipes.

b) Regardless of the fluid to be conveyed, plastic pipes passing through hazardous areas are to be electrically conductive.

c) Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed: 1 x 10^5 Ohm/m.

d) It is preferred that pipes and fittings are homogeneously conductive. Where pipes and fittings are not homogeneously conductive, conductive layers are to be provided, suitably protected against the possibility of spark damage to the pipe wall.

e) Satisfactory earthing is to be provided

3. Arrangement and Installation of Plastic Pipes

3.1 General

3.1.1 Plastic pipes and fittings are to be installed in accordance with the manufacturers' guidelines.

3.1.2 Pipes are to be protected from mechanical damage where necessary.

3.2 Supporting of the Pipes

3.2.1 Selection and spacing of pipe supports are to be determined as a function of allowable stresses and maximum deflection criteria.

Support spacing is not to be greater than the pipe manufacturers' recommended spacing.

3.2.2 Each support is to evenly distribute the load of the pipe and its content over the full width of the support. Measures are to be taken to minimise wear of the pipes where they are in contact with the supports.

3.2.3 Heavy components in the piping system such as valves and expansion joints are to be independently supported.

3.3 Provision for Expansion

Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

- The high difference in the coefficients of thermal expansion

- Deformations of the yachts's structure.

3.4 Earthing

3.4.1 Where pipes are required to be electrically conductive, the resistance to earth from any point in the piping system is not to exceed 1 x 10^6 ohm.

3.4.2 Where provided, earthing wires are to be accessible for inspection.

3.5 Penetration of Fire Divisions and Watertight Bulkheads or Decks

3.5.1 Where plastic pipes pass through fire class divisions, arrangements are to be made to ensure that fire endurance is not impaired.

3.5.2 When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained.

4. Testing of Plastic Piping

A Manufacturer's declaration of conformity to the approved type is to be supplied.

4.2 Testing After Installation on Board

4.2.1 Hydrostatic Tests

a) Piping systems for fuel oil systems are to be subjected to a test pressure of not less than 1,5 times the design pressure or 0,4 MPa, whichever is the greater.

b) Piping systems for other services are to be checked for leakage under operational conditions.

4.2.2 Earthing Test

For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be performed.

SECTION 8

AUTOMATION SYSTEMS

A. General Requirements

1. General

1.1 These rules are to apply to yachts and small vessels fitted with automated installations enabling periodically unattended operation of machinery spaces and assigned to additional class notatation "AUT".

1.2 **TL**, may consider alternative solutions.

2. Definitions

2.1 Alarms

An alarm gives optical and acoustical warning of abnormal operating conditions.

2.2 Protective devices

Protective devices detect actual values, activate alarms in the event of limit-value violation and prevent machinery and equipment being endangered. They automatically initiate curative measures or call for appropriate ones

2.3 Safety devices

Safety devices detect critical limit-value violations and prevent any prevent any immediate danger to persons, ship or machinery.

2.4 Safety systems

Combination of several safety-devices and/or protective devices into one functional unit.

2.5 Systems

Systems contain all equipment necessary for monitoring, control and safety including the in- and output devices. Systems cover defined functions including behaviour under varying operation conditions, cycles and running

3. Exemptions

For yachts whose gross tonnage is less than 500 GT and propulsive power less than 1 MW, the requirements laid down in "C. Control of Machinery" do not apply. For these yachts items 3.1 and 3.2 apply.

3.1 An alarm signal is to be activated in the following circumstances:

a) for diesel engine propulsion plant

- lubricating oil system low pressure
- cylinder coolant high temperature
- cylinder coolant low pressure or low flow rate
- cylinder coolant make up tank low level
- sea water cooling low pressure or low flow rate

b) for auxiliary internal combustion engines intended for electricity production of a power higher than 37 kW, supplying essential services:

- cylinder coolant high temperature
- lubricating oil system low pressure

3.2 **"**Automatic stop" is to be provided for lubricating oil failure of engines, reduction gears, clutches and reversing gears. A possible override of this automatic stop is to be available at the control stations, and an indication is to be provided at each control station, when override is activated.

4. Communication System

4.1 A reliable means of vocal communication is to be provided between the main machinery control room or the propulsion machinery control position as appropriate, the navigation bridge and the engineer officers' accommodation.

This means of communication is to be foreseen in collective or individual accommodation of engineer officers.

4.2 Means of communication are to be capable of being operated even in the event of failure of supply from the main source of electrical power.

5. Documents to be Submitted for Approval

5.1 The documents indicated the below mentioned items are to be submitted to **TL** for approval in triplicate.

5.2 Description of operation with explanatory diagrams,

- Line diagrams of control circuits,
- List of alarm points,
- Details of the overall system linking control stations, the bridge and accommodation spaces,
- Location and details of control station (e.g. control panels and consoles),
- Means of communication diagram,
- System of protection against flooding,
- Fire detection system (diagram, location and cabling),
- Automation test program (for information),
- The general specification for the automation of the yacht,
- The detailed specification of the essential service automation systems.

B. Main Safety Systems

1. General

Where it is proposed to operate the yacht with the machinery space unattendent, no matter what period is envisaged, the systems specified in items 2 ÷ 4 are to be installed.

2. Fire and Flooding Precautions

2.1 Fire prevention

2.1.1 Where fuel oil heating is necessary, it is to be arranged with automatic control. A high temperature alarm is to be fitted and the possibility of adjusting its threshold according to the fuel quality is to be provided. Such alarm may be omitted if it is demonstrated that the temperature in the tank cannot exceed the flashpoint under the following conditions:

- volume of liquid corresponding to the low level alarm and maximum continuous heating power during 24 hours.

2.2 Fire detection

2.2.1 Means are to be provided to detect and give alarms at an early stage in case of fires, unless **TL** considers this to be unnecessary:

- in boiler air supply casing and exhausts (uptakes); and
- in scavenging air belts of propulsion machinery.

2.2.2 An automatic fire detection system is to be fitted in machinery spaces of category A intended to be unattended.

2.2.3 The fire detection system is to be designed with selfmonitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm.

2.2.4 The fire detection indicating panel is to be located on the navigating bridge, at the fire control station, or in another accessible place where a fire in the machinery space will not render it inoperative.

2.2.5 The fire detection indicating panel is to indicate the place of the detected fire in accordance with the arranged fire zones by means of a visual signal. Audible signals clearly distinguishable in character from any other signals are to be audible throughout the navigating bridge and the accommodation area of the personnel responsible for the operation of the machinery space.

2.2.6 Fire detectors are to be of such type and so located that they will rapidly detect the onset of fire in conditions normally present in the machinery space. Consideration is to be given to avoiding false alarms.

The type and location of detectors are to be approved by **TL** and a combination of detector types is recommended in order to enable the system to react to more than one type of fire symptom.

2.2.7 Except in spaces of restricted height and where their use is specially appropriate, detection systems using thermal detectors only are not permitted. Flame detectors may be installed, although they are to be considered as complementary and are not to replace the main installation.

2.2.8 Fire detector zones are to be arranged in a manner that will enable the operating staff to locate the seat of the fire. The arrangement and the number of loops and the location of detector heads are to be approved in each case. Air currents created by the machinery are not to render the detection system ineffective.

2.2.9 When fire detectors are provided with the means to adjust their sensitivity, necessary arrangements are to be allowed to fix and identify the set point.

2.2.10 When it is intended that a particular loop or detector is to be temporarily switched off, this state is to be clearly indicated. Reactivation of the loop or detector is to be performed automatically after a preset time.

2.2.11 The fire detection indicating panel is to be provided with facilities for functional testing.

2.2.12 The fire detecting system is to be fed automatically from an emergency source of power by a separate feeder if the main source of power fails.

2.2.13 Facilities are to be provided in the fire detecting system to manually release the fire alarm from the following places:

- passageways having entrances to engine and boiler rooms
- the navigating bridge
- the control station in the engine room.

2.3 Fire fighting

2.3.1 Unless otherwise stated, pressurisation of the fire main at a suitable pressure by starting a main fire pump and carrying out the other necessary operations is to be possible from the navigation bridge. Alternatively, the fire main system may be permanently under pressure.

2.4 Protection against flooding

2.4.1 Bilge wells or machinery space bilge levels are to be monitored in such a way that the accumulation of liquid is detected in normal angles of trim and heel.

2.4.2 Where the bilge pumps are capable of being started automatically, means are to be provided to indicate when the influx of liquid is greater than the pump capacity or when the pump is operating more frequently than would normally be expected.

2.4.3 Where the bilge pumps are automatically controlled, they are not be started when the oil pollution level is higher than accepted in **TL** Rules, Part 9, Yachts, Section 7,E.

2.4.4 The location of controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system is to be so sited as to allow adequate time for operation in case of influx of water to the space, having regard to the time likely to be required in order to reach and operate such controls. If the level to which the space could become flooded with the yacht in the fully loaded condition so requires, arrangements are to be made to operate the controls from a position above such level.

2.4.5 Bilge level alarms are to be given at the main control station, the engineers' accommodation area and the navigating bridge.

3. Alarm System

3.1 General

3.1.1 A system of alarm displays and controls is to be provided which readily allows identification of faults in the machinery and satisfactory supervision of related equipment.

This may be arranged at a main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

3.1.2 Unless otherwise justified, separation of monitoring and control systems is to be provided.

3.1.3 The alarm system is to be designed to function independently of control and safety systems, so that a failure or malfunction of these systems will not to prevent the alarm system from operating. Common sensors for alarms and automatic slowdown functions are acceptable as specified in each specific table.

3.1.4 The alarm system is to be continuously powered and is to have an automatic change-over to a standby power supply in the case of loss of normal power supply.

3.2 Alarm system design

3.2.1 The alarm system and associated sensors are to be capable of being tested during normal machinery operation.

3.2.2 Insulation faults on any circuit of the alarm system are to generate an alarm, when an insulated earth distribution system is used.

3.2.3 An engineers' alarm is to be activated when the machinery alarm has not been accepted in the machinery spaces or control room within 2 minutes.

3.2.4 The alarm system is to have a connection to the engineers' public rooms and to each of the engineers' cabins through a selector switch, to ensure connection to at least one of those cabins.

3.3 Machinery alarm system

3.3.1 The local silencing of the alarms on the bridge or in accommodation spaces is not to stop the audible machinery space alarm.

3.3.2 Machinery faults are to be indicated at the control locations for machinery.

3.4 Alarm system on navigation bridge

3.4.1 Alarms associated with faults requiring speed reduction or automatic shutdown are to be separately identified on the bridge.

3.4.2 The alarm system is to activate an audible and visual alarm on the navigation bridge for any situation which requires action by or the attention of the officer on watch.

3.4.3 Individual alarms are to be provided at the navigation bridge indicating any power supply failures of the remote control of propulsion machinery.

4. Safety Systems

4.1 General

4.1.1 Safety systems of different units of the machinery plant are to be independent. Failure in the safety system of one part of the plant is not to interfere with the operation of the safety system in another part of the plant.

4.1.2 In order to avoid undesirable interruption in the operation of machinery, the system is to intervene sequentially after the operation of the alarm system by:

- starting of standby units
- load reduction or shutdown.

4.1.3 The arrangement for overriding the shutdown of the main propelling machinery is to be such as to preclude inadvertent operation.

4.1.4 After stoppage of the propulsion engine by a safety shutdown device, the restart is only to be carried out, unless otherwise justified, after setting the propulsion bridge control level on «stop».

C. Control of Machinery

1. General

1.1 Under all sailing conditions, including manoeuvring, the speed, direction of thrust and, if applicable, pitch of the propeller are to be fully controllable from the navigation bridge.

1.2 All manual operations or services expected to be carried out with a periodicity of less than 24 h are to be eliminated or automated, particularly for: lubrication, topping up of make up tanks and filling tanks, filter cleaning, cleaning of centrifugal purifiers, drainage, load sharing on main engines and various adjustments. Nevertheless, the transfer of “operation” mode may be effected manually.

1.3 A centralised control position is to be arranged with the necessary alarm panels and instrumentation indicating any alarm.

1.4 Parameters for essential services which need to be adjusted to a preset value are to be automatically controlled.

1.5 The control system is to be such that the services needed for the operation of the main propulsion machinery and its auxiliaries are ensured through the necessary automatic arrangements.

1.6 It is to be possible for all machinery essential for the safe operation of the yacht to be controlled from a local position, even in the case of failure in any part of the automatic or remote control systems.

1.7 The design of the remote automatic control system is to be such that in the case of its failure an alarm will be given. Unless impracticable, the preset speed and direction of thrust of the propeller are to be maintained until local control is in operation.

1.8 Critical speed ranges, if any, are to be rapidly passed over by means of an appropriate automatic device.

1.9 Propulsion machinery is to stop automatically only in exceptional circumstances which could cause quick critical damage, due to internal faults in the machinery. The design of automation systems whose failure could result in an unexpected propulsion stop is to be specially examined. An overriding device for cancelling the automatic shutdown is to be considered.

1.10 Where the propulsive plant includes several main engines, a device is to be provided to prevent any abnormal overload on each of them.

1.11 Where standby machines are required for other auxiliary machinery essential to propulsion, automatic change over devices are to be provided.

2. Diesel Propulsion Plants

2.1 When a diesel engine is used for the propulsion plant, monitoring and control of equipment are to be performed according to Table 8.1 for slow speed engines or Table 8.2 for medium or high speed engines.

3. Electric Propulsion Plant

3.1 Documents to be submitted

The following additional documents are to be submitted to **TL**:

- A list of the alarms and shutdowns of the electrical propulsion system

- When the control and monitoring system of the propulsion plant is computer based, a functional diagram of the interface between the PLC (programmable logic controller) and computer network.

3.2 Alarm system

The following requirements are applicable to the alarm system of electric propulsion:

- Alarms circuits of electric propulsion are to be connected to the main alarm system on board. As an alternative, the relevant circuit may be connected to a local alarm unit. In any case, a connection between the local alarm unit and the main alarm system is to be provided.

- The alarms can be arranged in groups, and shown in the control station. This is acceptable when a discrimination is possible locally.

- When the control system uses a computer based system, the requirements of **TL** Rules, Part 4-1, Automation are applicable, in particular, for the data transmission link between the alarm system and the control system.

- Individual alarms are considered as critical and are to be individually activated at the control stations, and acknowledged individually.

- "Shutdown" activation is to be considered as an individual alarm.

3.3 Safety functions

The following requirements are applicable to the safety system of electric propulsion:

- As a general rule, safety stop using external sensors such as temperature, pressure, overspeed, main cooling failure and stop of converter running by blocking impulse is to be confirmed by the automatic opening of the main circuit using a separate circuit.

- In order to avoid accidental stop of the propulsion line and limit the risk of blackout due to wire break, the tripping of the main circuit-breaker is to be activated by an emission coil with monitoring of the line wire break.

- In the case of a single line propulsion system, the power limitation order is to be duplicated.

- As a general rule, when the safety stop is activated, it is to be maintained until local acknowledgement

3.4 Transformers

For transformers, parameters according to Table 8.3 are to be controlled or monitored.

3.5 Converters

For converters, parameters accoprding to Table 8.4, Table 8.5 and Table 8.6 are to be monitored or controlled.

3.6 Smoothing coil

For the converter reactor, parameters according to Table 8.7 are to be monitored or controlled.

3.7 Propulsion electric motor

For propulsion electric motors, parameters according to Table 8.8 are to be monitored or controlled.

3.8 All parameters listed in the tables of this item are considered as a minimum requirement for unattended machinery spaces. Some group alarms may be locally detailed on the corresponding unit (for instance loss of electronic supply, failure of electronic control unit, etc.)

4. Shafting, Clutches, CPP, Gears

4.1 For shafting and clutches, parameters according to Table 8.9 are to be monitored or controlled.

4.2 For controllable pitch propellers, parameters according to Table 8.10 are to be monitored or controlled.

4.3 For reduction gears and reversing gears, parameters according to Table 8.11 are to be monitored or controlled.

5. Auxiliary Systems

5.1 Where standby machines are required for other auxiliary machinery essential to propulsion, automatic changeover devices are to be provided.

Change-over restart is to be provided for the following systems:

- cylinder, piston and fuel valve cooling

- cylinder cooling of diesel generating sets (where the circuit is common to several sets)

- main engine fuel supply

- diesel generating sets fuel supply (where the circuit is common to several sets)

- sea water cooling for propulsion plant

- sea water to main condenser (main turbines)

- hydraulic control of clutch, CPP or main thrust unit

- thermal fluid systems (thermal fluid heaters).

5.2 When a standby machine is automatically started, an alarm is to be activated.

5.3 When the propulsion plant is divided into two or more separate units, the automatic standby auxiliary may be omitted, when the sub-units concerned are fully separated with regard to power supply, cooling system, lubricating system etc.

Some of the propulsive plants may be partially used for reasons of economy (use of one shaft line or one propulsion engine for instance). If so, automatic change-over, necessary for this exploitation mode, is to be provided.

5.4 Means are to be provided to keep the starting air pressure at the required level where internal combustion engines are used for main propulsion.

5.5 Where daily service fuel oil tanks are filled automatically, or by remote control, means are to be provided to prevent overflow spillages.

5.6 Arrangements are to be provided to prevent overflow spillages coming from equipment treating flammable liquids.

5.7 Where daily service fuel oil tanks or settling tanks are fitted with heating arrangements, a high temperature alarm is to be provided if the flashpoint of the fuel oil can be exceeded.

5.8 For auxiliary systems, the following parameters, according to Table 8.12 to Table 8.22, are to be monitored or controlled.

6. Control of Electrical Installation

6.1 Where the electrical power can normally be supplied by one generator, suitable load shedding arrangements are to be provided to ensure the integrity of supplies to services required for propulsion and steering as well as the safety of the yacht.

6.2 In the case of loss of the generator in operation, adequate provision is to be made for automatic starting and connecting to the main switchboard of a standby generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the yacht with automatic restarting of the essential auxiliaries including, where necessary, sequential operations.

6.3 The standby electrical power is to be available in not more than 45 seconds.

6.4 If the electrical power is normally supplied by more than one generator simultaneously in parallel operation, provision is to be made, for instance by load shedding, to ensure that, in the case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering, and to ensure the safety of the yacht.

6.5 Following a blackout, automatic connection of the standby generating set is to be followed by an automatic restart of the essential electrical services. If necessary, time delay sequential steps are to be provided to allow satisfactory operation.

6.6 Monitored parameters for which alarms are required to identify machinery faults and associated safeguards are listed in Table 8.23. These alarms are to be indicated at the control location for machinery as individual alarms; where the alarm panel with all individual alarms is installed on the engine or in the vicinity, a common alarm in the control location for machinery is required. For communication of alarms from the machinery space to the bridge area and accommodation for engineering personel, detailed requirements are contained in item 5.

Table 8.1 Main propulsion slow speed diesel engine

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Fuel oil system							
• Fuel oil pressure after filter (engine inlet)	L	R					
						X	
• Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps (for engine running on heavy fuel)	H + L						
					X		
• Leakage from high pressure pipes, where required	H						
Lubricating oil system							
• Lubricating oil to main bearing and thrust bearing pressure	L	R	X				
	LL			X			
						X	
• Lubricating oil to crosshead bearing pressure when separate	L	R	X				
	LL			X			
						X	
• Lubricating oil to camshaft pressure when separate	L						
	LL			X			
						X	

***(1)** Not required, if the coolant is oil taken from the main cooling system of the engine.*

***(2)** Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.*

***(3)** For engines of 220 kW and above.*

***(4)** If separate lubricating oil tanks are installed, then an individual level alarm for each tank is required.*

***(5)** For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.*

(4) *Ayrı ağlama yağı tankları yerleştirildiyse, o zaman her bir tank için ayrı bir seviye alarmı gereklidir.*

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
• Lubricating oil to camshaft temperature when separated	H						
					X		
• Lubricating oil inlet temperature	H						
					X		
• Thrust bearing pads or bearing outlet temperature	H	local	X				
	HH			X			
• Main, crank, crosshead bearing, oil outlet temperature, or oil mist concentration in crankcase **(5)**	H		X				
• Flow rate cylinder lubricator (each apparatus)	L		X				
• Level in lubricating oil tanks or oil sump, as appropriate **(4)**	L						
• Lubricating oil to turbocharger inlet pressure	L						
• Turbocharger lubricating oil outlet temperature on each bearing	H						
Piston cooling system							
• Piston cooling inlet pressure	L		X **(1)**				
						X	
• Piston coolant outlet temperature on each cylinder	H	local	X				
• Piston coolant outlet flow on each cylinder **(2)**	L	local	X				
• Level of piston coolant in expansion tank	L						
Sea water cooling system							
• Sea water cooling pressure	L						
						X	
Cylinder fresh cooling water system							
• Cylinder fresh cooling water system inlet pressure	L	local **(3)**	X				
						X	
• Cylinder fresh cooling water outlet temperature or, when common cooling space without individual stop valves, common cylinder water outlet temperature	H	local	X				
• Oily contamination of engine cooling water system (when main engine cooling water is used in fuel and lubricating oil heat exchangers	H						
• Level of cylinder cooling water in expansion tank	L						
Fuel valve coolant systemi							
• Pressure of fuel valve coolant	L						
						X	
• Temperature of fuel valve coolant	H						
• Level of fuel valve coolant in expansion tank	L						
Scavenge air system							

(1) *Not required, if the coolant is oil taken from the main cooling system of the engine.*

(2) *Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.*

(3) *For engines of 220 kW and above.*

(4) *If separate lubricating oil tanks are installed, then an individual level alarm for each tank is required.*

(5) *For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.*

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
• Scavenging air receiver pressure		R					
• Scavenging air box temperature (detection of fire in receiver)	H	local	X				
• Scavenging air receiver water level	H						
Exhaust gas systemi							
• Exhaust gas temperature after each cylinder	H	R	X				
• Exhaust gas temperature after each cylinder, deviation from average	H						
• Exhaust gas temperature before each turbocharger	H	R					
• Exhaust gas temperature after each turbocharger	H	R					
Miscellaneous							
• Speed of turbocharger		R					
• Engine speed (and direction of speed when reversible)		R					
					X		
• Engine overspeed **(3)**	H			X			
• Wrong way	X						
• Control, safety, alarm system power supply failure	X						

(1) *Not required, if the coolant is oil taken from the main cooling system of the engine.*

(2) *Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.*

(3) *For engines of 220 kW and above.*

(4) *If separate lubricating oil tanks are installed, then an individual level alarm for each tank is required.*

(5) *For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.*

Table 8.2 Main propulsion medium or high speed diesel engine

Symbol convention

H = High **HH** = High high **G** = group alarm

L = Low **LL** = Low low **I** = individual alarm

X = function is required **R** = remote

Identification of system parameter	Monitoring		Automatic control				
			Main engine			Auxiliary	
	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Fuel oil system							
• Fuel oil pressure after filter (engine inlet)	L	R					
						X	
• Fuel oil viscosity before injection pumps or fuel oil temperature before injection pumps (for engine running on heavy fuel)	H +						
					X		
• Leakage from high pressure pipes when required	H						
Lubricating oil system							
• Lubricating oil to main bearing and thrust bearing Pressure	L	R	X				
	L			X			
						X	
• Lubricating oil filter differential pressure	H	R					
• Lubricating oil inlet temperature	H	R					
					X		
• Oil mist concentration in crankcase **(1)**	H			X			
• Flow rate cylinder lubricator (each apparatus)	L		X				
• Lubricating oil to turbocharger inlet pressure **(2)**	L	R					
Sea water cooling system							
• Sea water cooling pressure	L	R					
						X	
Cylinder fresh cooling water system							
• Cylinder water inlet pressure or flow	L	R	X				
						X	
• Cylinder water outlet temperature	H	R					
			X				
• Level of cylinder cooling water in expansion tank	L						
Scavenge air system							
• Scavenging air receiver temperature	H						
Exhaust gas system							
• Exhaust gas temperature after each cylinder **(3)**	H	R	X				
• Exhaust gas temperature after each cylinder, deviation from average **(3)**	H						
Miscellaneous							
• Engine speed		R					
					X		
• Engine overspeed	H			X			
• Control, safety, alarm system power supply failure	X						

(1) *Only for medium speed engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm. One oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown system.*

(2) *If without integrated self-contained oil lubrication system.*

(3) *For engine power > 500 kW/cyl*

Table 8.3 Transformers

Symbol convention
H = High **HH** = High high **G** = group alarm
L = Low **LL** = Low low **I** = individual alarm
X = function is required **R** = remote

Identification of system parameter	Monitoring: Alarm	Monitoring: Indicator	Automatic control, Motor: Slow down	Automatic control, Motor: Shut down	Automatic control, Motor: Control	Automatic control, Auxiliary: Stand-by start	Automatic control, Auxiliary: Stop
Earth failure on main propulsion circuits	I						
Circuit-breakers, short-circuit	I **(2)**			X			
Circuit-breaker, overload	I **(2)**			X			
Circuit-breaker, undervoltage	I **(2)**			X			
Temperature of winding on phase 1, 2, 3 **(1)**	G						
	I, H		X **(3)**				
	I, HH			X			
Temperature sensor failure (short-circuit, open circuit, supply failure)	G						
Cooling pump pressure or flow	G, L						
			X				
						X	
Cooling medium temperature	G, H			X			
Leak of cooling medium	G						
			X				

(1) *A minimum of 6 temperature sensors are to be provided :*

- *3 temperature sensors to be connected to the alarm system (can also be used for the redundant tripping of the main circuit-breaker)*
- *3 temperature sensors connected to the control unit.*

(2) *To be kept in the memory until local acknowledgement.*

(3) *Possible override of slowdown by the operator.*

Table 8.4 Network converter

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Motor			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Short-circuit current I_{max}	I			X			
Overvoltage	G			X			
Undervoltage	G						
Phase unbalanced	I			(X) **(1)**			
Power limitation failure	I						
Protection of filter circuit trip	I						
Circuit-breaker opening operation failure	I						
Communication circuit, control circuits, power supplies, watchdog of control system according to supplier's design	G			X			
(1) *This parameter, when indicated in brackets, is only advisable according to the supplier's requirements.*							

Table 8.5 Motor converter

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Motor			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Short-circuit current I_{max}	I			X			
Overvoltage	G			X			
Undervoltage	G			X			
Phase unbalanced	I						
Protection of filter circuit trip	I						
Communication circuit, control circuits, power supplies, watchdog of control system according to supplier's design	G			X			
Speed sensor system failure	G					X **(1)**	
Overspeed	I			X			
(1) *Automatic switch-over to the redundant speed sensor system.*							

Table 8.6 Converter cooling circuit

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Motor			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Air cooling temperature high	I	R					
Ventilation, fan failure	G						
			X				
Cooling pump pressure or flow low	G	R					
						X	
Cooling fluid temperature high	G						
Leak of cooling medium	G						
			X				
Temperature sensor failure (short-circuit, open circuit, supply failure)	G						

Table 8.7 Smoothing coil

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Motor			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow	Shut	Control	Stand-	Stop
Temperature of coil	I, H	R					
	I, HH						
Cooling air temperature	I, H						
Ventilation fan failure	G						
			X				
Cooling pump pressure or flow low	G	R					
						X	
Cooling fluid temperature high	G						
Leak of cooling medium	G						
			X				
Temperature sensor failure (short-circuit, open circuit, supply failure)	G						

Table 8.8 Propulsion electric motor

Symbol convention

H = High **HH** = High high **G** = group alarm

L = Low **LL** = Low low **I** = individual alarm

X = function is required **R** = remote

Identification of system parameter	Monitoring		Automatic control: Motor			Automatic control: Auxiliary	
	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Automatic tripping of overload and short-circuit protection on excitation circuit	G, H			H			
Loss of excitation	G			X			
Winding current unbalanced	G						
Harmonic filter supply failure	I						
Interface failure with power management system	I		X				
Earthing failure on stator winding and stator supply	I	R					
Temperature of winding on phase 1, 2, 3	G	R					
	I, H		X				
	I, HH			X			
Motor cooling air temperature	I, H	R					
Cooling pump pressure or flow	G ,L	R					
			X				
						X	
Cooling fluid temperature	G, H						
Leak of cooling medium	G						
			X				
Temperature sensor failure (short-circuit, open circuit, supply failure)	G						
Motor bearing temperature	G, H	R					
Bearing lubrication oil pressure (for self-lubricated motor, when the speed is under the minimum RPM specified by the Manufacturer, shutdown is to be activated)	I, L	R					
			X				
						X	
Bearing lubrication oil pressure	G, L						
Turning gear engaged	I						
Brake and key engaged	I						
Shaft reduction gear bearing temperature	I, H						
Shaft reduction gear lubricating oil temperature	I, H						
Shaft reduction gear bearing pressure	I, L						
				X			

Table 8.9 Shafting and clutches of propulsion machinery

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Temperature of each shaft thrust bearing (not applicable for ball or roller bearings)	H		X				
Sterntube bush oil gravity tank level	L						
Clutch lubricating oil temperature	H						
Clutch oil tank level	L						
Clutch control oil pressure	L						
	LL					X	

Table 8.10 Controllable pitch propeller

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Control oil temperature	H						
Oil tank level	L						
Control oil pressure	L						
	LL					X	

Table 8.11 Reduction gears / reversing gears

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Lubricating oil temperature	H	R **(1)**					
Lubricating oil pressure	L **(1)**	R				X	
	L			X			
Oil tank level	L						
Plain bearing temperature	H						
	HH			X			

(1) *May be omitted in the case of restricted navigation notation.*

Table 8.12 Control and monitoring of auxiliary electrical systems

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Main engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Electrical circuit, blackout	X						
Power supply failure of control, alarm and safety system	X						

Table 8.13 Incinerators

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Incinerator			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Combustion air pressure	L			X			
Flame failure	X			X			
Furnace temperature	H			X			
Exhaust gas temperature	H						
Fuel oil pressure	L						
Fuel oil temperature or viscosity, where heavy fuel is used	H + L						

Table 8.14 Auxiliary boilers

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Boiler			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Water level	L + H			X	X		
Fuel oil temperature	L + H			X	X		
Flame failure	X			X			
Combustion air supply fan low pressure				X			
Temperature in boiler casing (fire)	H						
Steam pressure	H **(1)**			X	X		
Steam temperature				X **(2)**			

(1) *When the automatic control does not cover the entire load range from zero load.*

(2) *For superheated steam over 330°C.*

Tablo 8.15 Yakıt sistemi

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Fuel oil tank level, overflow	H **(1)**						
Air pipe water trap level on fuel oil tanks	H **(2)**						
Outlet fuel oil temperature	H **(4)**			X **(5)**	X		
Sludge tank level	H						
Fuel oil settling tank level	H **(1)**						
Fuel oil settling tank temperature	H **(3)**						
Fuel oil centrifugal purifier overflow	H			X			
Fuel oil in daily service tank level	L						
Fuel oil in daily service tank temperature	H **(3)**				X		
Fuel oil in daily service tank level (to be provided if no suitable overflow arrangement)	H **(1)**						

(1) *Or sight-glasses on the overflow pipe.*
(2) *Or alternative arrangement to TL's satisfaction.*
(3) *Applicable where heating arrangements are provided.*
(4) *Or low flow alarm in addition to temperature control when heated by steam or other media.*
(5) *Cut-off of electrical power supply when electrically heated.*

Table 8.16 Lubricating oil system

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Air pipe water trap level of lubricating oil tank	H						
Sludge tank level	H						
Lubricating oil centrifugal purifier overflow	H						
(stop of oil supply)							X

Table 8.17 Thermal oil system

Symbol convention

H = High **HH** = High high **G** = group alarm

L = Low **LL** = Low low **I** = individual alarm

X = function is required **R** = remote

Identification of system parameter	Monitoring		Automatic control				
			System			Auxiliary	
	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Forced draft fan stopped				X			
Thermal fluid temperature	H						
				X			
Thermal fluid pressure							X
Flow through each element	L			X			
Heavy fuel oil temperature or viscosity	H + L				X		
Burner flame failure	X			X			
Flue gas temperature (when exhaust gas heater)	H			X			
Expansion tank level	L						X **(1)**

(1) *Stop of burner and fluid flow.*

Table 8.18 Hydraulic oil system

Symbol convention

H = High **HH** = High high **G** = group alarm

L = Low **LL** = Low low **I** = individual alarm

X = function is required **R** = remote

Identification of system parameter	Monitoring		Automatic control				
			System			Auxiliary	
	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Pump pressure	L + H						
Service tank level	L **(1)**						

(1) *The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 50% of the circuit volume, whichever is the lesser.*

Table 8.19 Boiler feed and condensate system

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Sea water flow or equivalent	L					X	
Vacuum	L						
	L			X			
Water level in main condenser (unless justified)	H + L						
					X		
	H			X			
Salinity of condensate	H						
Feed water pump delivery pressure	L					X	
Feed water tank level	L						
Deaerator inside temperature or pressure	L + H **(1)**						
Water level in deaerator	L + H						
Extraction pump pressure	L						
Drain tank level	L + H						

(1) *In the case of forced circulation boiler.*

Table 8.20 Compressed air system

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by	Stop
Air temperature at compressor outlet	H						
Compressor lubricating oil pressure (except where splash lubrication)	LL			X			
Control air pressure after reducing valves	L + H	R					
					X		
Starting air pressure before main shut-off valve	L **(2)**	local + R **(1)**					
					X		
	X					X	
Safety air pressure	L + H						
					X		

(1) Remote indication is required if starting of air compressor is remote controlled, from wheelhouse for example.

(2) For starting air, the alarm minimum pressure set point is to be so adjusted as to enable at least four starts for reversible propulsion engines and two starts for non-reversible propulsion engines.

Table 8.21 Cooling system

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Sea water pump pressure or flow	X					X	
	L						
Fresh water pump pressure or flow	X					X	
	L						
Level in cooling water expansion tank	L						

Table 8.22 Thrusters

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Thruster			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Control oil temperature (preferably before cooler)	H						
Oil tank level	L						

Table 8.23 Auxiliary reciprocating I.C. engines driving generators

Symbol convention **H** = High **HH** = High high **G** = group alarm **L** = Low **LL** = Low low **I** = individual alarm **X** = function is required **R** = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm	Indicator	Slow down	Shut down	Control	Stand-by start	Stop
Fuel oil viscosity or temperature before injection	L + H	local					
					X		
Fuel oil pressure		local					
Fuel oil leakage from pressure pipes	H						
Lubricating oil temperature	H						
Lubricating oil pressure	L	local				X	
	LL			X **(1)**			
Oil mist concentration in crankcase **(2)**	H			X			
Pressure or flow of cooling water, if not connected to main system	L	local					
Temperature of cooling water or cooling air	H	local					
Level in cooling water expansion tank, if not connected to main system	L						
Engine speed		local					
					X		
	H			X			
Fault in the electronic governor system	X						
Level in fuel oil daily service tank	L						
Starting air pressure	L						
Exhaust gas temperature after each cylinder **(3)**	H						

(1) *Not applicable to emergency generator set.*

(2) *For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.*

(3) *For engine power above 500 kW/cyl.*

D. Tests

1. General

1.1 Tests of automated installations are to be carried out according to Section 9 to determine their operating conditions. The details of these tests are defined, in each case, after having studied the concept of the automated installations and their construction. A complete test program is to be submitted and may be as follows.

1.2 The tests of equipment carried out alongside the quay under normal conditions of use include, for instance:

- the electrical power generating set
- the auxiliary steam generator
- the automatic bilge draining system
- automatic centrifugal separators or similar purifying apparatus
- automatic change-over of service auxiliaries
- detection of high pressure fuel leaks from diesel generating sets or from flexible boiler burner pipes.

1.3 Sea trials are used to demonstrate the proper operation of the automated machinery and systems. For this purpose, the following tests are to be carried out:

1.3.1 Test of the remote control of propulsion:

- checking of the operation of the automatic control system: programmed or unprogrammed starting speed increase, reversal, adjusting of the propeller pitch, failure of supply sources, etc.
- checking of the crash astern sequence, to ensure that the reversal sequence is properly performed from full away, the yacht sailing at its normal operation speed. The purpose of this check is not to verify the nautical performances of the yacht (such as stopping distance, etc.)
- finally, checking of the operation of the whole installation in normal working conditions, i.e. as a general rule without watch-keeping personnel for the monitoring and/or running of the machinery for at least 4 h
- The following procedure may be chosen, for instance, be chosen: «underway» for 2 h, then increasing to «full ahead». Staying in that position for 5 min. Then stopping for 15 min. Then, putting the control lever in the following positions, staying 2 minutes in each one: astern slow, astern half, astern full, full ahead, half ahead, stop, full astern, stop, ahead dead slow, half ahead, then increasing the power until «underway» position.

1.3.2 Test of the operating conditions of the electrical production:

- automatic starting of the generating set in the event of a blackout
- automatic restarting of auxiliaries in the event of a blackout
- load-shedding in the event of generating set overload
- automatic starting of a generating set in the event of generating set overload.

1.3.3 Test of fire and flooding system:

- Test of normal operation of the fire detection system (detection, system faults)
- Test of detection in the scavenging air belt and boiler air duct
- Test of the fire alarm system
- Test of protection against flooding.

1.3.4 Test of operating conditions, including manoeuvring, of the whole machinery in an unattended situation for 4 h.

SECTION 9

ELECTRIC INSTALLATIONS

Page

A. Documents to be Submitted and Applicable International Standards

1.1 Plans and documents

In case of new buildings, plans specified in Section 1, B.2.2.2 are to be submitted to **TL** for approval, in triplicate.

TL reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

In yachts L < 15 m., the scope of plans and documents required to be submitted for approval may be reduced taking into account the opinion of **TL**.

The plans and documents is to schematically indicate the followings:

- supply system of the electrical installation and relevant characteristics (see B.),

- batteries and generating sets, their characteristics, position and feding circuits, with cross-section and capacity of relevant cables (see C.),

- switchboards, distribution boards, protection devices, distribution circuits and earthing system, cross-section and capacity of relevant cables (see E.).

1.2 Applicable international standards

1.2.1 Yachts with length L_H not exceeding 24 m.

For yachts with length L_H not exceeding 24 m according to ISO 8666, the following standards apply:

• for direct current system installations which operate at a rated voltage not exceeding 50 V: ISO 10133;

• for single-phase alternating current installations which operate at a rated voltage not exceeding 250 V: ISO 13297;

• for three-phase alternating current systems which operate at a rated voltage not exceeding 500 V: IEC 60092- 507, edition 2.0.

1.2.2 Yachts with length L_H exceeding 24 m. and not exceeding 500 GT

For yachts with length L_H exceeding 24 m according to ISO 8666, having gross tonnage not exceeding 500, the following standards apply:

• for single-phase alternating current systems which operate at a rated voltage not exceeding 250 V and

• for three-phase alternating current systems which operate at a rated voltage not exceeding 500 V; and

• for direct current systems which operate at a rated voltage not exceeding 50 V:

IEC 60092-507, edition 2.0.

• for single-phase alternating current systems which operate at a rated voltage exceeding 250 V and

• for three-phase alternating current systems which operate at a rated voltage exceeding 500 V; and

• for direct current systems which operate at a rated voltage exceeding 50 V:

TL Rules, Chapter 5, Electric..

B. Supply Systems, Voltage Limits, Environmental Conditions

1. Supply Systems

The supply system with 2 insulated wires (or 3 insulated wires with mid-wire earthed) is to be employed in DC installations, the supply system with 3 insulated wires (or 4 insulated wires with neutral earthed, without hull return) is to be employed in three-phase AC installations. However, the system with one insulated wire (positive pole) is admitted:

a) for DC installations with voltage ≤ 50 V, provided that the fuel of motors on board, if any, has ignition point > 55°C, the hull is not metallic, and the return is effected through a copper wire, preferably tinned or leaded, of adequate size and earthed (see, D.2.3),

b) for electrical installations typical of motors provided that said installations have in general voltage of 12 V and in any case not in excess of 24 V (excepting the motor ignition circuits) and that the return is on the motor (see, E.).

2. Maximum Voltages

a) Voltage of supply systems for all board installations is to be ≤ 250 V, both for DC and AC.

b) Employment of voltages higher than in (a) may be considered by **TL**, case by case, on the basis of particular safety measures.

3. Safety Voltages

Safety voltages (i.e. voltages considered not dangerous for people) are here recalled for information only: 50 V between wires in DC installations, 30 V in respect to earth in AC installations.

4. Environmental Conditions

The following environmental conditions are considered as a reference for electrical installations: air temperature not less than 40°C and sea water temperature (for cooling of certain parts, if should be effected) 30°C.

C. Main Electric Generating System

1. Type of System and Relevant Requirements

1.1 Electrop-generating systems:

a) generator-sets (see,2),

b) accumulator batteries in addition or not to generator sets (see, 3),

c) accumulator battery and generator of the electrical system of IC engines when this system is the sole fitted on board (see, E).

1.2 The power of each electro-generating system is to be sufficient to feed all relevant users foreseen to be working contemporarily, under normal working conditions.

1.3 The main electro-generating set, i.e. that necessary to produce power as per 1.2, is allowed not to be provided with additional electro-generating sets and/or accumulator batteries, that are: stand-by of the main installation in normal working conditions or emergency for supplying a restricted number of users, in case of breakdown of the main installation. Where standby system is accumulator battery, charging facility should be provided.

Emergency source of power (min.3 hours capacity) shall be provided for ships less than 500 GRT. Emergency source of power shall supply the following items min.:

a) VHF,
b) Navigation lights,
c) Emergency lighting,
d) General alarm,
e) Fire alarm,
f) Horn,
g) Fixed gas fire extinguishing systems

2. Generating Sets

2.1 Such sets, consisting in prime movers driving DC or AC generators, are to be generally arranged in the space of propelling machinery.

2.2 **TL** Rules, Chapter 5- Electric are generally valid for generators, while **TL** Rules, Chapter 4, Machinery apply to relevant prime movers.

3. Accumulators

3.1 General

a) These rules apply to lead-acid or alkaline type nickel accumulator batteries, intended for permanent installation.

b) Batteries are to be made in such a way as not to allow liquid overflow even with an inclination up to 40° , generally.

c) Battery charging devices is to, in general, allow buffer working and be sufficient, for batteries on board ships, to charge down batteries in no more than 8 hours.

In relation to the power of the charging device, calculated as product of the rated voltage of the batterey and the maximum possible charging current, batteries are distinguished into three categories A, B, C according to whether the above mentioned power is greater than 2 kW, comprised between 2 and 0,2 kW, smaller than 0,2 kW.

d) A special device (battery disconnector) is to be arranged to section batteries from the network, to be set as near as practicable to batteries themselves.

3.2 Batteries for special uses

a) Starting batteries for propelling machinery are to have sufficient capacity, without paralleling with other batteries, for 10 consecutive starting attempts, each lasting not less than 6 s.

b) Starting batteries for motorsa re to be set as near them as practicable, and connected to them by cables with cross-section sufficient to avoid excessive voltage drops. Such batteries, provided they have adequate capacity, may also feed other user.

c) A special battery, rechargeable, is to be arranged for feding radio-telephone set, if installed, and it is to be set on the highest possible position, and separate from the electrical installation of the vessel.

3.3 Installation on board of batteries

a) Accumulator batteries are to be;

- set in a position protected against inclemency of weather and fall of things, reasonably over the bilge, and ventilated,

- arranged permanently on suitable supports (e.g. open shelvings)Ş and preferably set, for category A batteries, inside proper cubicles or rooms, if the type of batteries is such as to allow casual leaks of electrolyte, the parts contiguous to them are to be protected against consequent corrosion by means of suitable paints or coatings (e.g. lead or GRP in case of lead batteries, iron or GRP in case of alkaline batteries),

- arranged in such a way as to allow the routine maintenance operations,

- if of the lead type, not arranged in case same room of the alkaline ones.

b) The room where the batteries are arranged is to be provided with ventilation, at least natural, to allow outlet of gases produced by batteries themselves, excepting when the outlet is effected through a special tube for batteries of the tight, in container type.

The room or cubicle special for batteries, if should be arranged, is to be in general provided also with mechanical ventilation, to be effected by means of proper pipes, with air coming from belowq and direct outlet to the open, and with fan whose motor is to be set outside the pipng and in the open.

Just for information, the minimum cross-section S [cm^2], of piping for the above mentioned natural ventilation is given herein, in dependence of power P [kW] of the charging device of batteries: $S = K \cdot P$, where K=80 or 120 respectively for lead or alkaline batteries.

c) Inside rooms or cubicles of batteries, neither electric machines or apparatus, nor electric cables, more than the ones of the batteries themselves, which may produce sparks (e.g. socket-outlets and switches), nor lamps, if not of the (Ex) type recognized by **TL**, are to be installed.

D. Cables

1. Cables

1.1 Construction characteristics of cables

a) Cables are to be in accordance with IEC **(1)** rules and to have:

- flexible conductors with round outer shape (small flat cables and cords are not admitted), coated by suitable insulating material **(2)** and protected on the outside by impermeable sheat, at least in case of cables in the open or in damp rooms,

- cables and insulated conductors are to be of flame retardant and not flame-propagating type **(3)**.

b) Insulation of every conductor of cables is to be such as to support the following testing voltage (V_p) in function of the rated voltage (V) of cables themselves, for 5 min. :

Table 9.1: Test voltages at AC and DC cables

Nominal voltage of cable V (Volt)	AC test voltage V_p (Volt)	DC test voltage V_p (Volt)
V ≤ 80	1000	2000
80 < V ≤ 250	1500	3000
250 < V ≤ 750	2500	5000

1.2 Choise of cables and wiring

a) Cables are to have rated voltage at least equal to the voltage of circuits which they are destined to, and cross-section of conductors adequate to the current of circuits themselves.

As to capacity P of cables [ampere] in function of their nominal cross-section [mm^2] the requirements of **TL** Rules, Chapter 5- Electic apply.

b) The cable ways is to be chosen so that it is rectilinear as far as practicable, not subject to risk of mechanical damages, far from heat sources, protected against drippings, if they should occur, expecially of fuel oil and lubricating oil, set over bilges and easily inspectable. Cables are to be laid stationarily.

The bending radius of cables is to be as great as possible and in general, not smaller than:

- 3d, being d the outer diameter of the cable, when d ≤ 9,5 mm.

- 4d, when d is comprised between 9,5 and 25 mm.

- 6d, when d > 25 mm.

Fixing supports of cables (cleats or similar) are to be smooth and rounded arıt o have a suitable pitch to allow cables stretching without tensile stresses.

If cables have to pass through a watertight bulkhead or deck, the penetration is to be effected in a watertight manner.

Where cables pass through a bulkhead or deck which is required to have some degree of fire integrity, penetration is to be so effected as to as to ensure that the required degree of fire integrity is not impaired.

c) Electric cables are not to be set, as far as practicable, near nautical equipment (e.g. magnetic compasses, radio, radio direction finder) anda re to be arranged in such a way as to avoid formation of magnetic fields disturbing the equipment itself.

d) Cables that carry only signals are not required to comply with IEC 60092-507. In this case, they are to be in compliance with other standards recognised by **TL.**

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(1) *Requirements formulated on the basis of **TL** Rules, Chapter 5, Electric and of IEC Publication 60092-350, IEC 60092-352, IEC 60092-353, IEC 60092-354, IEC 60092-360 and IEC/TR 60092-370 relating to construction, testing and installation on board of electric cables.*

(2) *e.g. butylic rubber (B80) or ethylene-propylen (E85) or silicon (S95) or polyvinyl chloride (PVC) (V60 or V75).*

(3) *Relevant testing modalities are contained in TL Rules, Chapter 5- Electric.*

E. Switchboards , Distribution System and Electrical Protection

1. Switchboards and Distribution Boards

Switchboards receives current from another board.

a) The board plate where equipment is arranged is to be metallic and insulated in respect of live parts, or to made of insulating material considered suitable by **TL** (wood excluded).

b) Wires arriving and leaving boards are, in general, to end into a suitably numbered terminal boards, so that any wire may be easily singled out, also on the basis of the electric-installation scheme that is to be supplied on board, with numbers of the terminal boards itself clearly showed.

Terminal boards and other electric equipment of boards are to be, as a rule, easily inspectable and protected against dripping and shocks.

c) Voltage, or voltages when several voltages are distributed from the board, are to be indicated on the board itself.

2. Distribution Circuits and Protection Devices

a) Every circuit is to be provided, in its origin, with fuse on every pole or phase not earthed, and if the current is high (i.e. > 320 A), with circuit breaker, for protection of circuit itself against casual overcurrents including short circuits.

b) Generators of generator-sets are to be protected against short-circuit and overload by mean of circuit breakers, to be arranged on board fed by the generators themselves **(4)**

Relevant TL Rules, Chapter 5 – Electric apply to the protection devices of generators intended to work in paralel.

c) Neither fuses nor circuit breakers are admitted on motor starting circuits.
Motors with rated power ≥ 1 kW are to be protected against overload, short-circuit and undervoltage or to be provided with relevant alarm devices.

d) The circuits of every navigation light is to be protected by proper fuses.

e) Derivations of distribution lines in internal rooms are to be effected by means of distribution board or terminal boards. Uncovered derivations are not admitted.

f) Socket-outlets, connection boxes and lamps arranged in the open are to be of the watertight type.

g) Means are to be provided to stop electric motors of engine room fans and pumps handling flammable liquids. Such means are to be located outside the space where the relevant motors are located.

h) In case of motors fed by fuel with ignition point ≤ 55°C, lamps of machinery and tank rooms or spaces are to be flameproof or at least watertight and switches are to be set outside the room or spaces, or to be flameproof.

3. Earthing

a) Earth connections aim to reduce contact voltages, for protection.

b) Earth means :

1) the hull, in case of metallic hulls,

2) a dispersion plate, made of copper, fixed on the vessel bottom in such a position to be always dipped, in case of not metallic hulls (e.g. hulls in GRP or wooden)

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(4) *However, when a generator has power < 50 kW and is not arranged to work in paralel with others, fuses may be employed for its protection, provided that they have rated current < 320 A.*

3) the block of the propelling machinery of the vessel, provided it is electrically connected to sea water and the voltage of the electrical installation is smaller than the safety one, as it is usual when the only installation existing on board is that of propelling machinery (see, E.).

c) The following parts are to be earthed;

- the metallic parts of electric motors, of boards, of equipments and of coatings of elecric cables with feeding voltage greater than the safety one and which, even if they are not normally live, may be live due to defect of insulation,

- the above mentioned parts in any case when liquid fuel with ignition point ≤ 55°C (e.g. petrol) is employed on board,

- independently of feding voltage and type of employed fuel, all metallic parts (e.g. tanks) electrically insulated and not in contact with sea water,

- electronic ve and radio-telephone equipment; the earth of the radio-telephone equipment is to be arranged as far as practicable on the vertical of the equipment itself and parallelled to the common earth.

d) Cross-section of wires that are earth connections are to be proportionate to electric loads of relevant users and, in this respect, the values of cross-section of the earth connections for installations with voltage greater than the safety one are giveb hereinafter;

- cross-section equal to the one of the main wires, when these have cross-section ≤ 16 mm^2 , with a minimum of 1,5 mm^2,

- cross-section equal to the 50 % of the one of the main wires, when these have cross-section > 16 mm^2 , with a minimum of 16 mm^2 (main wires mean the ones feding the users).

e) Earthing of masts, shrouds, stays and other metallic parts of the hull that, being set in the open, may be subject to lightning is recommended.

The relevant line is not to have sharp deflections, as far as practicable, and is be made of continuous copper bando r cable with cross-section ≥ 50 mm^2. For wooden masts, arrangement of lightning-rod, with copper line having cross-section ≥ 75 mm^2 is recommended.

4. Shore Supply

The shore supply in AC from the quay, if any, is to be arranged into a suitable box, metallic preferably, provided with fuse on each insulated pole to be connected to the earth of the quay system.

Polarity (in DC) or phases (in polyphase AC) of the quay network in respect to the board network are to be indicated on the shore supply.

5. Underwater Lighting

5.1 Type approval of underwater lights to be installed on the stern of yachts is subject to the following documentation being supplied and the following tests being carried out:

a) Documentation:
constructional drawings of the lights, including the materials and their characteristics for all components, are to be supplied to **TL** for examination.

b) Tests to be carried out:
the lights are to have the following degree of protection according to the IEC 60529 standard:

- IP68 for the external part

- IP67 for the internal part.

The tests are to be carried out according to the mentioned standard, having regard to the following.

Degree of protection IP68 (external part): according to the standard, the test pressure and duration of the test are to be agreed with the Maker taking into account the working condition that the lights will be in (depth and position on the submerged part of the hull); dust test not necessary.
The above requirements are valid providing that the lights are not installed in spaces where flammable gas or vapors are liable to accumulate (i.e. gasoline engine compartments, etc.): in such cases, the lights are also to be certified “explosion proof type electrical equipment."

F. Special Electrical Systems for Internal Combustion Engines

1. General

Such systems is generally made of electric starting motor, generator and, for carburation motors, circuits and starting devices (e.g. magnetos and spark plugs).

2. Arrangement

The parts of the electrical system are to be arranged, as far as practicable, in a position far from the bilge, protected against dripping of liquids, are not influenced by high temperatures of the motor.

3. Supply

As to supply system, see B. 1.

4. System Details

4.1 Starting motors and current generators, provided with brushes, are to be such as to avoid firing of fuel vapours that may be near the motor, due to sparking.

4.2 Magnetos, in case of motors arranged into a protection frame of watertight type such as to avoid outlet of fuel vapours, are to be made in such a way that vapours themselves likely to be near the motor, cannot fire due to sparking.

4.3 Spark plugs, generally, are to be provided with protection hoods in order to avoid short circuits that may occur due to accumulation of water, salt sor other foreign materials on the relevant insulator.

5. Tests on Board

At working trials on board of motors and their electrical system, it is to be verified that the system itself complies with the requirements of the above items, in particular the lack of troubles mentioned in item 4.

G. Surveys and Tests on Board

For surveys and tests on board of electric installations, refer to Section 1.

H. Electrical Installations in Hazardous Areas

1. Electrical Equipment

1.1 No electrical equipment is to be installed in hazardous areas unless **TL** is satisfied that such equipment is:

- essential for operational purposes,
- of a type which will not ignite the mixture concerned,
- appropriate to the space concerned, and
- appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

1.2 Where electrical equipment of a safe type is permitted in hazardous areas it is to be selected with due consideration to the following:

a) risk of explosive dust concentration:

- degree of protection of the enclosure
- maximum surface temperature

b) risk of explosive gas atmosphere:

- explosion group

- temperature class.

1.3 Where electrical equipment is permitted in hazardous areas, all switches and protective devices are to interrupt all poles or phases and to be located in a nonhazardous area.

Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

1.4 Electrical equipment which is intended for use in explosive gas atmospheres or which is installed where flammable gases, vapours or explosive dusts are liable to accumulate, such as in spaces containing petrol-powered machinery, petrol fuel tank(s), or joint fitting(s) or other connections between components of a petrol system, and in compartments or lockers containing LPG cylinders and/or pressure regulators, is to conform to IEC 60079 series or equivalent standard.

2. Electrical Cable

2.1 Electrical cables are not to be installed in hazardous areas except as specifically permitted or when associated with intrinsically safe circuits.

2.2 All cables installed in hazardous areas are to be sheathed with at least a non-metallic impervious sheath in combination with braiding or other metallic covering.

SECTION 10

FIRE PROTECTION

Page

A. Fire Prevention

1. Definitions

1.1 Accommodation Spaces

Spaces used for public spaces, corridors, stairs, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

1.2 A class divisions

Divisions formed by bulkheads and decks which comply with the following criteria:

a) They are constructed of steel or other equivalent material or alternative forms of construction to be in compliance with the requirements of this Section.

b) They are suitably stiffened;

c) They are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:

- class "A-60" ....60 min
- class "A-30"..30 min
- class "A-15"..15 min
- class "A-0"..0 min

d) They are so constructed as to be capable of preventing the passage of smoke and flame to the end of the onehour standard fire test;

TL will require a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code (FTP) to ensure that it meets the above requirements for integrity or temperature rise.

1.3 B Class Division

Divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) They are constructed of approved non-combustible materials and all materials entering into the construction and erection of "B" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet the other appropriate requirements of this Section;

b) They have an insulation value such that the average temperature of the unexposed side will not rise more than 140° C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225° C above the original temperature, within the time listed below:

- class "B-15" ....15 min
- class "B-0" ....0 min

c) They are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.

TL will require a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity or temperature rise.

1.4 Bulkhead deck

The uppermost deck up to which the transverse watertight bulkheads are carried

1.5 C Class Divisions

Divisions constructed of approved non-combustible materials. They are not required to comply with either requirements relative to the passage of smoke and flame or limitations relative to the temperature rise. Combustible veneers are permitted provided they meet the requirements of this Section.

1.6 Combustible Material

Any material other than a non-combustible material.

1.7 Continuous B Class Ceilings and Linings

B class ceilings or linings which terminate at an A or B class division.

1.8 Continuously Manned Central Control Station

A central control station which is continuously manned by a responsible member of the crew.

1.9 Control Station

Spaces in which the yacht's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralised.

1.10 Fire Test Procedures (FTP) Code

The "International Code for Application of Fire Test Procedures", as adopted by the Maritime Safety Committee of the IMO by Resolution MSC.61 (67).

1.11 Helideck

Purpose-built helicopter landing area located on a yacht including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

1.12 Helicopter Facility

A helideck including any refueling and hangar facilities.

1.13 Low Flame Spread

When the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code. Non-combustible materials are considered as low flame spread.

1.14 Machinery Spaces

Machinery spaces of category A and other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.15 Machinery Space of Category A

Spaces and trunks to such spaces which contain either:

a) Internal combustion machinery used for main propulsion,

b) Internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW,or

c) Any oil fired boiler or fuel oil unit, or

d) Incinerators, etc., which use oil fire equipment.

1.16 Non-Combustible Material

A material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the FTP Code. In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

1.17 Non-Readily Ignitable

When the surface thus described will not continue to burn for more than 20 seconds after removal of a suitable impinging test flame.

1.18 Fuel Oil Unit

Equipment used for the preparation of fuel oil for delivery to an oil fired boiler or equipment used for the preparation for delivery of heated oil to an internal combustion engine and including any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 MPa.

1.19 Public Spaces

Portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.20 Steel or Other Equivalent Material

Any non-combustible material which, by itself or due to insulation provided, had structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

1.21 Sauna

A hot room with temperatures normally varying between 80°-120°C where the heat is provided by a hot surface (e.g. by an electrically-heated oven). The hot room may also include the space where the oven is located and adjacent bathrooms.

1.22 Alternative Forms of Construction

Any combustible material may be accepted if it can be demonstrated that the material, by itself or due to insulation provided, has structural and fire integrity properties equivalent to A or B Class divisions, or steel as applicable, at the end of the applicable fire exposure to the Standard fire test.

1.23 Service Spaces

Spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces. Main pantries and pantries containing cooking appliances may contain:

- Toasters, induction heaters, microwave ovens and similar appliances each of them with a maximum power of 5 kW;
- Electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 2 kW and a surface temperature not above 150°C;
- Water boilers, regardless of their electrical power;
- Coffee automats, and non-cooking appliances such as dish washers, water boilers, ice-cube machines and fridges without any restriction on their power. A dining room containing such appliances are not to be regarded as a pantry.

Spaces containing any electrically heated cooking plate or hot plate for keeping food warm with a power of more than 2 kW or toasters, induction heaters, microwave ovens and similar appliances each of them with power greater than 5 kW are to be regarded as galleys.

1.24 Standard Fire Test

A test in which the specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve in accordance with the FTP Code. Test methods are to be in accordance with IMO FTP Code, App. 1, Part 3.

2. General

2.1 The requirements of this item apply to yachts with length (L_H) more than 24 metres according to ISO 8666. For yachts not more than 24 metres, the requirements of EN ISO Standard 9094-2 and the specific provisions for these yachts given in this Section are to be applied.

2.2 The boundary of the engine space is to be arranged in order to contain the fire-extinguishing medium so that it cannot escape.

Any fans within or feeding a machinery space are to be capable of being stopped from outside the space.

2.3 Combustible materials and flammable liquid excluding fuel oil necessary for the propulsion engines are not to be stowed in the engine space.

3. Protection of Spaces Containing Vehicles or Craft with Fuel in Their Tanks

General

The requirements contained in the following items apply to yachts having a length L_H more than 24 m. According to ISO 8666. For yachts having a length L_H not more than 24 m. The following requirements apply: ISO 11105 relevant to ventilation, ISO 8846 relevant to electrical equipment and ISO 9094-2 relevant to fire protection.

3.1 Closed spaces for the containment of fuel with a flash-point ≤55 ºC or vehicles (i.e. personal water craft, tenders, motor cars) with petrol in their tanks are to be fitted with one of the following fixed fire-fighting systems:

a) A carbon dioxide system designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space;

b) A dry powder system designed for at least 0,5 kg powder/m^3;

c) A water-spraying or sprinkler system designed for 3,5 l/m^2 x min. The water-spraying system may be connected to the fire main;

d) A system providing equivalent protection as determined by **TL.**

In any case, the system is to be operable from outside the protected space.

In general, if the deck area of the protected space is less than 4 m^2 , or for yachts having tonnage of not more than 300 GT, a carbon portable fire extinguisher or a dry powder fire extinguisher may be acceptable in lieu of a fixed system.

The capacity of the said fire extinguishers shall be such that the above criteria a) or b) are to be satisfied for a carbon portable fire extinguisher or a dry powder fire extinguisher, respectively.

The required portable fire extinguisher is to be stowed adjacent to the access door(s).

Alternatively, fire hoses fitted with a jet/spray nozzle can be accepted. The number and distribution of the fire hoses are to be sufficient to ensure that any part of the protected space can be reached by water.

In order to drain the sprayed water in the space, adequate means are to be provided. Drainage is not to lead to machinery or other spaces where a source of ignition may exist.

3.2 A ducted mechanical continuous supply of air ventilation is to be provided, capable of ensuring at least six changes of air per hour in the protected space. An indication is to be provided in the event of a reduction of the rate of ventilation.

The indication is to be fitted on the bridge deck or in the continuously manned position. Means are to be provided in order to shut down the ventilation in the event of fire.

The system providing the monitoring and indication in the event of a reduction of the rate of ventilation can be based on the check of a reduction of the current supplied to the ventilation motors.

3.3 Electrical equipment is to be fitted at least 450 mm from the bottom of the space and, in any case, outside the areas where flammable gases can accumulate. The electrical equipment is to be constructed in such a way as to prevent the escape of sparks. IP 54 protection is acceptable.

Electrical equipment less than IP 54 is to be provided with an easily accessible and identified means of double pole isolation outside the space.

In addition, an alarm activated by a fixed flammable gas detector is to be provided in case of gas accumulation. The alarm is to be fitted on the bridge deck or in another continuously manned position.

If electrical equipment is fitted at a distance from the bottom of the space less than 450 mm, it is to be of a certified safe type for use in Zone 1. Alternatively, electrical equipment IP 54 can be accepted provided that, in case of gas accumulation, an automatic shut-down device for the equipment activated by the gas detectors is fitted.

The shutdown device is to be operated in conjunction with an alarm fitted on the bridge deck and in the relevant stations.

The system is to include at least two gas sensors and the shut-down device is to be activated in the presence of gas detected by either of the sensors.

3.4 For yachts having a length L_H not more than 24 m, according to ISO8666, the following requirements apply: ISO 11105 relevant to ventilation, ISO 8846 relevant to electrical equipment and ISO 9094-2 relevant to fire protection.

For yachts of not more than 300 GT, a natural ventilation system can be fitted, with the outlet and inlet openings located in the highest and lowest part of the spaces respectively.

The surface of the said openings shall not be less than the area of the ventilation openings, calculated in agreement with ISO 11105, increased by 20%.

In any case, the natural air flow is to be such as to extract any gasoline vapour during normal running conditions. In the case of gas accumulation of the spaces ventilated by means of a natural ventilation system, the fixed flammable gas detector alarm required in 3.3 is activated and, in addition, the mechanical ventilation system of 3.2 is to be activated; the indication of ventilation rate reduction required in 3.2, in this case can be omitted.

When the mechanical ventilation system is not activated automatically, clear instructions shall be affixed for the crew, for the activation of the mechanical system.

For the items not explicitly required in item 3.4, the requirements of 3.1, 3.2 and 3.3 are to be deemed applicable.

4. Miscellaneous

Where some spaces such as saunas and thermal suites are arranged or where frying equipment is installed on board, the fire protections of these spaces will be specially considered by **TL.**

5. Fire Prevention

5.1 General

5.1.1 Application

5.1.1.1 Item 5.2 and subitems 5.3.2 and 5.3.3 are applicable for all yachts.

5.1.1.2 Item 5.3.4.1 are only applicable to yachts having a length not more than 24 m.

5.1.1.3 Items 5.3.1.1, 5.3.4.2 and 5.3.6.1 are only applicable to yachts having a length more than 24 m and not more than 500 GT.

5.2 Probability of Ignition

5.2.1 General

5.2.1.1 For yachts with wooden hulls particular attention is to be paid in order to adopt adequate means to avoid oil absorption into the structures.

5.2.1.2 In order to contain the oil, it may be acceptable to fit dip tray in way of the engine. The use of the engine bearers as a means of containment of the oil may be accepted provided that they are of sufficient height and have no limber holes.

5.2.1.3 Means are to be adopted for the storage, distribution and utilisation of fuel oil in order to minimise the risk of fire.

5.2.1.4 Fuel oil, lubricating oil and other flammable liquids are not to be stored in fore peak tanks.

5.2.1.5 Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom, is to be fitted with a cock or valve directly on the tank. Such cock or valve is to be capable of being closed locally and from a safe position outside the space in which such tanks are fitted in the event of fire occurring in the space.

5.2.1.6 Means are to be provided to stop fuel transfer pumps, fans, oil fired boilers and separators from outside the machinery space.

5.2.1.7 Fuel filter bowls are to be of metal or equivalent fire resistant material.

5.2.1.8 Paints, varnishes and other surface finishes to be used in machinery spaces, galleys and spaces with fire risk are not to be capable of producing excessive quantities of smoke or toxic products when they burn, this being determined in accordance with the FTP Code

5.2.2 Machinery Spaces

5.2.1.1 Machinery Spaces Boundaries

The machinery spaces of category A and the engine spaces, as well as their funnels, are to be separated from accommodation spaces and store rooms containing combustible materials and liquids. Their enclosure should not be permeable to oil fuel and oil fuel vapors.

5.2.1.2 Ventilation

Machinery spaces of category A and engine spaces are to be ventilated to prevent the build-up of explosive gases.

5.2.3 Galley Equipment

5.2.3.1 Open Flame Gas Appliances

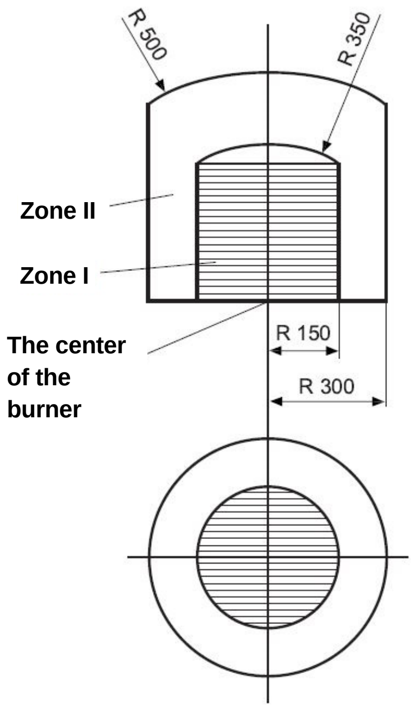
According to ISO 9094 - 1/- 2 [4.3.2.2], for cooking units using fuel which is liquid at atmospheric pressure (see ISO 14895), open-flame burners are to be fitted with a readily accessible drip-pan.

5.2.3.2 Combustible Materials Near Open-Flame Cooking Appliances

5.2.3.2.1 The installation is to be in accordance with Section 10, App. 1. The system is to guarantee the safety of the yacht and the persons on board.

5.2.3.2.2 Materials which are fitted close to open flame cooking and heating appliances are to be non-combustible, except that the exposed surfaces of these materials are to be protected with a finish having a class 1 surface spread of flame rating when tested in accordance with ASTM D 635.

5.2.3.2.3 Materials and finishes used in the vicinity of open-flame cooking devices within the ranges defined in Figure 10.1 are to comply with the following requirements, taking into account the movement of the burner up to an angle of 20˚ for monohull sailboats and 10˚ for multihulls and monohull motorboats, where gimballed stoves are fitted.



Dimensions in mm.
Measurements from the center of the burner.

Figure 10.1 Areas of special material requirements

- Free-hanging curtains or other fabrics are not to be fitted in Zone I and Zone II.

- Exposed materials installed in Zone I are to be glass, ceramics, aluminium, ferrous metals, or other materials with similar fireproof characteristics.

- Exposed materials installed in Zone II are to be glass, ceramics, metal or other material with similar fireproof characteristics. They are to be thermally insulated from the supporting substrate to prevent combustion of the substrate, if the surface temperature exceeds 80 ˚C.

Note : The thermal insulation may be achieved by an air gap or the use of a suitable material.

5.2.3.2.4 After the completion of the installation on board, the system is to be tested at operating pressure by means of a pneumatic test.

When all leakage has been repaired, all appliance valves are to be closed and the cylinder shut-off valve opened.

When the gauge registers that the system is pressurised, the cylinder valve is to be closed.

It is to be verified that the pressure reading value remains constant for at least 15 minutes.

5.2.3.3 Combustible Materials Near Other Cooking Appliances

The location of any electric cooking plate or any oven is to be such that curtains or other similar materials cannot be scorched or set on fire by heat from the element.

5.2.4 Other Ignition Sources

5.2.4.1 Radiators

Electric radiators, if used, are to be fixed in position and so constructed as to reduce fire risks to a minimum. No such radiators are to be fitted with an element so exposed that clothing, curtains, or other similar materials can be scorched or set on fire by heat from the element.

5.2.4.2 Open Flame Gas Appliances Outside Galleys

Open flame gas appliances used as heating or lighting appliances are not permitted.

5.2.4.3 Saunas

Construction and arrangement of saunas is subject to particular requirements as defined below:

- Boundaries of the sauna area (comprising dedicated bathrooms and changing rooms, considered as part of the sauna areas) are to comply with 6.2.3 for yachts of 24 m. in length and over and of less than 500 GT.

- Wooden linings, ceilings and benches are permitted inside the sauna area.

- The ceiling above the oven is to be lined with a non-combustible plate with an air gap of at least 30 mm. The distance from the hot surface to combustible materials is to be at least 500 mm or the combustible materials are to be protected by similar dispositions as for the ceiling.

- The sauna door is to open outwards by pushing.

- Electrically heated ovens are to be provided with a timer.

- All spaces within the sauna area are to be protected by a fire detection and alarm system and an automatic sprinkler system.

5.2.4.4 Hammam Rooms (steam rooms)

Construction and arrangement of hammam rooms is subject to particular requirements as defined below:

- Boundaries of the hammam area (comprising dedicated bathrooms and changing rooms, considered as part of the hammam areas) are to comply with 6.2.3 for yachts of 24 m. in length and over and of less than 500 GT.

- All spaces within the hammam area are to be protected by a fire detection and alarm system and an automatic sprinkler system.

5.3 Fire Growth Potential and Control of Smoke Spread; Requirements for Materials

5.3.1 Material of Hull, Superstructures, Structural Bulkheads, Decks and Deckhouses

5.3.1.1 Yachts of 24 m in Length and Over and of Less Than 500 GT

The hull, superstructure, structural bulkheads and decks other than fire divisions, deckhouses and pillars are to be constructed of approved non-combustible materials having adequate structural properties. Alternatively, the use of combustible materials may be permitted if precautions are taken to preserve the hull integrity in case of fire in machinery spaces of category A. On yachts constructed in materials other than steel, appropriate fire insulation is also to be fitted on lateral exterior boundaries from 300 mm below the water line in the lightweight condition up to the deck forming the upper boundary of the machinery space of category A.

Note: For steel or other equivalent materials, alternative forms of construction and standard fire test, see A.1.

5.3.2 Machinery Spaces Boundaries

5.3.2.1 Composite Structures

When the yacht is constructed in composite structures, the machinery spaces of category A or engine space boundaries are to be so constructed that the smoke is not able to spread outside the machinery spaces of category A or engine space.

5.3.3 Fire Divisions

5.3.3.1 Fire divisions, where required, are to be constructed in accordance with the following requirements.

5.3.3.2 Fire divisions are to be constructed of steel or any equivalent material, if it can be demonstrated by means of a type test that the material by itself, or due to non-combustible insulation provided, has fire resistance properties equivalent to the properties of the A-class (60 minutes fire integrity) or B-class (30 minutes fire integrity) fire division required by these Rules.

5.3.3.3 Fire Divisions Other Than Steel

Aluminium alloy structures:

The insulation is to be such that the temperature of the structural core does not rise more than 200˚C above the ambient temperature at any time during the applicable fire exposure.

Composite structures:

The insulation is to be such that the temperature of the laminate does not rise more than the minimum temperature of deflection under load (HDT) of the resin at any time during the applicable fire exposure. The temperature of deflection under load is to be determined in accordance with a recognized international standard (as for example ISO 75-2004).

Note : Alternatively, the temperature of deflection under load of the complete composite structure, if available, may be taken as a criterion in lieu of the temperature of deflection under load of the resin.

Wood structures:

Wood structures are to be given special consideration by **TL.** As a principle, the insulation is to be such that the temperature of the structural core does not rise more than the minimum temperature of deflection under load (HDT) of the wood at any time during the applicable fire exposure.

For yachts of less than 500 GT, insulation need only be applied on the side of the vertical fire division that is exposed to the greatest fire risk, except if two high fire risk spaces are adjacent (such as, for example, a sauna adjacent to a machinery space of category A).

Special attention is to be given to the fixing of fire door frames in such bulkheads. Measures are to be taken to ensure that the temperature of the fixings when exposed to fire does not exceed the temperature at which the bulkhead itself loses strength.

5.3.3.4 Equivalent A Class Fire Divisions Without Testing

A fire-resisting bulkhead may be considered to be equivalent to A class without testing, if its composition is one of the following:

- An uninsulated steel plate minimum 4,0 mm thick complying with the following table: equivalent to A-0 class

Classification	Product description
Class A-0 bulkhead	A steel bulkhead with dimensions not less than the minimum dimensions given below: thickness of plating: 4 mm stiffeners 60 x 60 x 5 mm spaced 600 mm apart or structural equivalent
Class A-0 deck	A steel deck with dimensions not less than the minimum dimensions given below: thickness of plating: 4 mm stiffeners 95 x 65 x 7 mm spaced 600 mm apart or structural equivalent

- A steel plate minimum 4,0 mm thick insulated with minimum 50 mm of non-combustible rock wool (minimal density: 96 kg/m^3; welded pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class

- An aluminium alloy plate minimum 5,5 mm thick insulated with 80 mm of non-combustible rock wool (minimal density: 96 kg/m^3; welded bi-metallic pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class

- A composite structure insulated with 120 mm of non-combustible rock wool (minimal density: 96 kg/m^3; pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class.

In addition to above mentioned methods, different insulation methods may be accepted as equivalent, provided that conformity is proved to **TL** by certificate.

5.3.3.5 Equivalent B Class Fire Divisions Without Testing

A fire-resisting bulkhead may be considered to be equivalent to B class without testing, if its composition is one of the following:

- An uninsulated steel plate minimum 2,0 mm thick: equivalent to B-0 class

- A steel plate insulated with minimum 30 mm of non-combustible rock wool (minimal density: 96 kg/m^3): equivalent to B-15 and B-0 class

- An aluminium alloy plate with 50 mm of non-combustible rock wool (minimal density: 96 kg/m^3): equivalent to B-15 and B-0 class

- A composite structure insulated with 75 mm of non-combustible rock wool (minimal density: 96 kg/m^3; pins spacing: maximum 300 mm): equivalent to B-15 and B-0 class.

In addition to above mentioned methods, different insulation methods may be accepted as equivalent, provided that conformity is proved to **TL** by certificate.

5.3.4 Insulation Materials

5.3.4.1 Yachts of Less Than 24 m in Length

Materials used for the insulation of the engine space are to be either:

- Self-extinguishing. This property may be determined by means of the oxygen index (OI) method (criteria: OI > 21 at 60˚C) in accordance with ISO 4589-3 or by means of another recognized standard, or

- Covered by an intumescent cover material to the satisfaction of **TL**.

5.3.4.2 Yachts of 24 m in Length and over and of Less Than 500 GT

- Insulating materials used in machinery spaces of category A are to be of non-combustible materials. The surface of insulation fitted on the internal boundaries of machinery spaces of category A is to be impervious to oil or oil vapors.

- Acoustic or thermic insulating materials used in accommodation spaces, service spaces, control stations and auxiliary machinery spaces except in refrigerated compartments are to be at least self-extinguishing. This property may be determined by means of the oxygen index (OI) method (criteria: OI > 21 at 60˚C) in accordance with ISO 4589-3 or by means of another recognized standard.

5.3.6 Surface Materials and Adhesives

5.3.6.1 Yachts of 24 m in Length and over and of Less Than 500 GT

Exposed surfaces of surface materials and adhesives used in conjunction with fire insulation are to have low-flame spread characteristics.

6. Structural Fire Protection

6.1 Structural Fire Protection for Yachts of Less Than 24 m in Length

6.1.1 General

6.1.1.1 To prevent a fire from starting as well as from spreading, preventive measures shall be taken in the area of possible sources of fire.

Possible sources of fire are:

– Machinery

– Electrical installations and appliances

– Heating and cooking appliances

6.1.1.2 Installation of the machinery and the electrical gear in accordance with Sections 7 and 9 of these Rules already provides a certain basic level of required fire protection measures.

6.1.1.3 Compliance with the **TL** Rules which follow, preventive maintenance of the appliances and installations by the owner and the operator of the craft, plus the latter's prudent behaviour and regular checks will contribute to reduce the risk of a fire to a minimum.

6.1.2 Paintwork, Insulation, etc.

6.1.2.1 Paintwork/topcoats in machinery spaces must be hard-to-ignite, e.g. in accordance with DIN 4102.

6.1.2.2 Material used for the insulation of machinery spaces shall be at least hard-to-ignite. The surface of the insulation towards the machinery space shall be oil repellent.

6.1.2.3 In motor yachts whose propulsion power > 400 kW, incombustible material - e.g. in accordance with DIN 4102 - is to be used for insulating the surfaces of the principal partitions, which should in its effect correspond to a B-15 insulation in accordance with Chapter II-2, SOLAS 74. Principal partitions shall be gastight in addition.

Note:
A principal partition is the partition (bulkhead or deck) between machinery space on one hand and the steering position or cabin above or adjoining on the other.

6.1.3 Ventilation System

6.1.3.1 In craft whose propulsive power > 400 kW, all machinery space ventilation inlets and outlets shall be able to be closed from the outside.

6.1.3.2 If machinery space fans are power driven, it must be possible to switch them off from outside the space.

6.1.4 Escape Routes and Emergency Exits

6.1.4.1 Cabins or deckhouses of craft whose L ≥ 7,5 m shall have at least two escape routes, if this is practicable.

6.1.4.2 For craft whose length L is less than 7,50 m, emergency exits are recommended.

6.1.4.3 Emergency exits shall lead to the open deck and shall meet the following requirements:

- Minimum size 400 × 400 mm clear width

- Closures on hatches or on the skylights or side windows unable as emergency exits must be operable from both sides.

6.2 Structural Fire Protection for Yachts of 24 m in length and Over and of Less Than 500 GT

6.2.1 Machinery Spaces of Category A Boundaries

Machinery spaces of category A are to be separated from other adjacent spaces by minimum A-30 class structural gastight bulkheads and decks.

Note 1 : If the hull is made of a material other than steel, refer to 5.3.1.1.

Note 2 : Independent fuel oil tanks are to be made of steel except when permitted in the following items:

- *On yachts of less than 500 tons gross tonnage, independent fuel oil tanks may be made of:*

  - *copper, provided that copper tanks are tin coated internally when intended for first category fuel. They are not considered suitable for other liquid fuels.*

  - *aluminium alloys or composite materials, provided that the tanks are located outside the propulsion machinery spaces or, when located within such spaces, they are fire insulated equivalent to steel or have a capacity of less than 100 l.*

- *Steel tanks, when intended for first category liquid fuel, must be effectively protected internally and externally against corrosion. Where galvanising is used it must be by the hot dipped process (see TS 914 EN ISO 1461). Sheet steel tanks intended for second category liquid fuel need not to be galvanised internally.*

Note:

Liquid fuels are classed in two categories:

First category, liquid fuels of flash point less than 60˚C (closed-cup test), hereafter designed as "gasoline"

- *Second category, liquid fuels of flash point equal or greater than 60˚C (closed-cup test), hereafter designed as "diesel oil".*

6.2.2 Vehicle Spaces

Vehicle spaces are to be separated from adjacent accommodation spaces by bulkheads and decks with the same fire integrity as the machinery spaces of category A boundaries.

6.2.3 Saunas and Hammam Rooms Boundaries

6.2.3.1 Saunas and hammam rooms, are to comply with 5.2.4.3 or 5.2.4.4.

6.2.3.2 Boundaries of the sauna area (comprising dedicated bathrooms and changing rooms, considered as part of the sauna area) are to be of the same fire integrity as the machinery spaces of category A boundaries.

6.2.3.3 Construction of hammam rooms is subject to particular requirements as defined hereafter:

- Boundaries of the hammam area (comprising dedicated bathrooms and changing rooms, considered as part of the hammam area) are to be constructed to an A-0 class standard, if the steam generator is contained within the hammam area. If the steam generator is not contained within the hammam area, the boundaries are to be constructed of B-0 class divisions, and the steam generator is to be protected by A-0 class divisions.

Note : If the steam generator is not contained within the hammam area and if the hammam area is located in a private bathroom containing a limited quantity of combustible materials (i.e. without wardrobe for example), hammam area boundaries are not required to be constructed of B-0 class divisions. However, requirements for steam generator enclosures remain applicable.

- If a sauna is comprised within the hammam area, the requirements of item 6.2.3.2 for saunas are applicable.

6.2.4 Prevention of Heat Transmission

Where the structure or "A" Class divisions are required to be insulated, it is to be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries.

Where the installed insulation does not achieve this, arrangements are to be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 mm (this may be reduced to 380 mm on steel divisions only).

6.2.5 Method of Construction Within Accommodation and Service Spaces

6.2.5.1 Different Methods of Construction

Three methods of construction are possible:

- Method 1: A fixed fire detection and alarm system complying with A.9 is installed and arranged as to provide smoke detection in escape ways.

- Method 2: A fixed fire detection and alarm system complying with A.9 is installed and arranged as to provide smoke detection in escape ways and, in addition, an automatic sprinkler, fire detection and alarm system complying with B. is installed and arranged as to protect all accommodation and service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc.

Note: Coffee automats, toasters, dishwashers, microwave ovens, water boilers and similar appliances each with a maximum power of 5 kW is regarded having no substantial fire risk. Electrically heated cooking plates and hot plates for keeping food warm, each with a maximum power of 2 kW and a surface temperature not greater than 150 °C is regarded having no substantial fire risk. If the spaces containing these appliances can be locked, the energy cutting-off devices are to additionally provide cutting-off from outside the space concerned, all fuels, lubricating oils, cargo oils,hydraulic thermal oil pump purifiers, flammable liquids leading to these spaces point of control view. The positions of these devices is not to be obstructed in case of fire.

Other appliances such as deep fat cooking appliance, open flame cooking appliance, is regarded having substantial fire risk.

- Method 3: A fixed fire detection and alarm system complying with A.9 is installed and arranged as to detect the presence of fire in all accommodation and service spaces and to provide smoke detection in escape ways.

6.2.5.2 Bulkhead Fire Integrity

Fire integrity of bulkheads is to be in accordance with Table 10.1.

Bulkheads required to be B class divisions are to extend from deck to deck or to other B class boundaries.

6.2.5.3 Deck Fire Integrity

Decks are to be generally so constructed as to provide a level of smoke and fire tightness acceptable to **TL.**

If an independent galley (see Table 10.1 **(1)**) is located below an accommodation or service space, deck above the independent galley should be at least of the same fire integrity as the equivalent bulkhead taken from Table 10.1.

For machinery spaces of category A boundaries, refer to 6.2.1.

6.2.6 Protection of Openings and Penetrations in Fire-Resisting Divisions

6.2.6.1 General

6.2.6.1.1 Openings in "A" and "B" Class divisions are to be restricted to the minimum necessary and are to be fitted with permanently attached means of closing that are to be at least as effective for resisting fires as the divisions in which they are fitted.

6.2.6.2 Doors

Doors leading to machinery spaces of category A, to the wheelhouse and to stairways are to be self-closing.

6.2.6.3 Penetrations

6.2.6.3.1 Where "A" Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., arrangements are to be made to ensure that the fire resistance is not impaired.

6.2.6.3.2 Where "B" Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired.

6.2.4 Protection of Openings in Machinery Space Boundaries

6.2.4.1 Windows and Skylights

6.2.4.1.1 Windows and skylights to machinery spaces are to be as follows:

Table 10.1 : Minimal fire integrity of bulkheads within accommodation and service spaces

Bulkhead class required between space/adjacent space	Methods of construction		
	Method 1	**Method 2**	**Method 3**
Independent galley **(1)** / accommodation or service space	B-15	-	B-0
Escape ways / accommodation or service space other than escape ways	B-15	-	-

(1) *Independent galley: closed galley not used for other purpose.*

Note 1 :
Types of spaces and B class divisions are defined in Section 10, A.1.

Note 2 :
Where two or more different fire integrities are possible according to this Table, the most stringent boundary requirement is to be applied.

6.2.4.1.2 Where skylights can be opened, they are to be capable of being closed from outside the space. Skylights containing glass panels are to be fitted with external shutters of steel or other equivalent material permanently attached.

6.2.4.1.3 Glass or similar materials are not to be fitted in machinery space boundaries. This does not preclude the use of wire-reinforced glass for skylights and glass control rooms within the machinery spaces.

6.2.4.1.4 In skylights referred to in item 6.2.4.1.2, wire-reinforced glass is to be used.

7. Means of Escape

The requirements contained in this item are applcable to yachts of 24 m in length L_H and over according to ISO8666. For yachts of less than 24 m in length L_H according to ISO 8666, the requirements of ISO 9094-2 apply.

7.1 Two means of escape are to be provided for the following spaces:

a) Accommodation spaces used for sleeping or rest;

b) Machinery spaces except:

- spaces visited only occasionally or unmanned during normal operation and where the single access gives ready escape, at all times, in the event of fire;

or

- spaces where in any position the person inside is not more than 5 metres from the exit.

Access to the spaces containing the fuel tanks or the engine room is to be from open spaces.

Whenever the fuel oil has a flashpoint > 55°C, access may be from a corridor.

Escape routes are not to be obstructed by furniture.

Whenever a watchman is foreseen in the engine room, the space is to be provided with two escape routes in positions as far apart as possible; one of these routes is to lead to the main deck, through a manhole or a door or a hatchway openable from both sides.

7.2 The two means of escape are to be arranged in such a way that a single hazardous event will not cut off both escape routes.

7.3 One of the exits may be an emergency exit through a small hatchway or through a porthole of dimensions generally not less than 450x450 mm.

All the exits are to be openable from both sides without the use of keys or tools.

7.4 Exceptionally one of the means of escape may be dispensed with, due regard being paid to the nature and location and dimension of spaces and to the number of persons who might normally be accommodated or employed there. In addition efficient fire detectors are to be provided as necessary to give early warning of a fire emergency which could cut off that single means of escape.

The escape route is not to pass through a space with fire risk such as a machinery space, galley or space containing flammable liquids.

7.5 Means of escape are to be clearly identified with appropriate indications.

7.6 All sailing multihulls are to be fitted with an emergency escape hatch in each main inhabited watertight compartment to permit the exit of personnel in the event of an inversion.

8. Ventilation

8.1 Ventilation fans for machinery spaces and enclosed galleys are to be capable of being stopped and main inlets and outlets of the ventilation system closed from outside the spaces being served. This position is not to be readily cut off in the event of a fire in the spaces served.

8.2 For yachts exceeding 300 gross tonnage, ventilation ducts serving category A machinery spaces, galleys, spaces containing vehicles or craft with fuel in their tanks, or lockers containing fuel tanks are not to cross accommodation spaces, service spaces or control stations unless the trunking is constructed of steel (minimum thickness 4 mm) or the walls are equivalent to B-15 class divisions for machinery spaces and B-0 class divisions for galleys to a point at least 5 metres from the space concerned.

8.3 For yachts exceeding 300 gross tonnage, and where the trunking passes from the machinery space or galley into the accommodation, automatic fire dampers are to be provided in the deck or bulkhead within the accommodation. The automatic fire dampers are also to be manually operable from outside the machinery space or galley.

8.4 The requirements in 9.2 and 9.3 also apply to ventilation ducts for accommodation spaces passing within category A machinery spaces.

8.5 Enclosed spaces in which generating sets and freestanding fuel tanks are installed are to be ventilated independently of systems serving other spaces, in order to avoid the accumulation of vapours, to allow discharge into the open air and to supply the air necessary for the service of the installed engine according to the Manufacturer's specifications.

The inlet and outlets of ventilators are to be positioned so that they do not draw from or vent into an area which would cause undue hazard, and are to be fitted with spark arresters.

8.6 Ventilation systems serving machinery spaces are to be independent of systems serving other spaces.

8.7 Ventilation exhaust systems serving galleys are to be independent of systems serving other spaces. The galley ventilation exhaust systems need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces if an automatic fire damper is fitted in the galley ventilation duct near the ventilation unit.

8.8 Adequate means of ventilation are to be provided to prevent the accumulation of dangerous concentrations of flammable gas which may be emitted from batteries.

8.9 All inlet and outlet ducts are to be provided with adequate weathertight means of closure operable from a readily accessible position.

9. Fixed Fire Detection and Fire Alarm System

9.1 For yachts more than 24 m in length L_H according to ISO 8666 on which the total installed power (propulsion and electrical generation) is greater than 735 kW, a fixed fire detection and fire alarm system is to be installed in the engine space(s), service spaces with fire risk and corridors forming escape routes from accommodation spaces. The system is to be in conformity with the requirements of the IMO Fire Safety Systems Code, Chapter 9.

9.2 For yachts not more than 24 m on which the total installed power (propulsion and electrical generation) is greater than 735 kW, a fixed fire detection and fire alarm system is to be installed in the engine space(s), and galley. The system is to be in conformity with the requirements of the IMO Fire Safety Systems Code, Chapter 9.

B. Fire Extinguishing Systems

1. General

1.1 Fire extinguishing appliances are to be in conformity with Table 10.1 and with the requirements of this Section.
The stowage position of fire extinguishing appliances is to be clearly marked.

1.2 The capacity and quantity of the medium are to be in compliance with Table 10.2.

For yachts having a length L_H not more than 24 m. according to ISO 8666, the requirements of ISO 9094-2 apply, as well as the relevant provisions of this Section.

2. Fire Extinguishing System

2.1 Fire Pumps

2.1.1 Number of Fire Pumps

2.1.1.1 Two power-driven fire pumps are to be provided, one of which may be driven by the propulsion system.

2.1.1.2 The two pumps are to be installed in two different spaces together with their own source of power and sea connection.

2.1.1.3 For yachts not more than 24 m.according to ISO 8666, the second pump (additional fire pump) may be hand-operated, provided that it is in compliance with the requirements of 2.1.1.2. Bilge and general services pumps may be accepted as fire pumps.

2.1.1.4 For yachts having more than 24 m. in length L_H according to ISO 8666, and less than 300 GT, one of the two requested pumps may be a portable motor pump, to be stored in a compartment different from the one where the other pump is fitted. Such portable motor pump is to be equipped with a suction hose. The suction hose is to be built so that it will not collapse because of the low pressure on the suction side.

2.2 Provisions of Water Jet

It is to be ensured that at least one jet of water from a single length of hose is capable of reaching any part of the yacht normally accessible to persons and any store-room or storage compartment when empty.

2.3 Pump Capacity

2.3.1 Each mechanically operated primary fire pump is to have a capacity not less than that given in Table 10.3.

In addition when the pump is discharging at full capacity through two adjacent fire hydrants, is to be capable of maintaining a water pressure of 0,1 N/m^2 at any hydrant.

2.3.2 The additional fire pump is to have a capacity not less than 80% of the primary fire pump.

Where for yachts not more than 24 m. in length L_H according to ISO 8666, a hand-operated fire pump is fitted as the additional fire pump, the relevant capacity is to be not less than 1,0 m^3/h at 45 strokes/min.

2.3.3 All the mechanical pumps are to be of the self-priming type. If centrifugal pumps are fitted, they are to be provided with a non-return valve in the connection with the fire main.

2.4 Fire main and hydrants

2.4.1 A fire main, water service pipes and fire hydrants are to be fitted.

2.4.2 The fire main and water service pipe connections to the hydrants are to be sized for the maximum discharge rate of pump(s) connected to the main.

2.4.3 The fire main, water service pipes and fire hydrants are to be constructed such that they will:

a) Not be rendered ineffective by heat;

b) Not readily corrode; and

c) Be protected against freezing.

2.4.4 The fire main is to have no connections other than those necessary for fire fighting or washing down.

2.4.5 Fire hydrants are to be located for easy attachment of fire hoses, protected from damage and distributed so that a single length of the fire hoses provided can reach any part of the vessel

2.4.6 Fire hydrants are to be fitted with valves that allow a fire hose to be isolated and removed when a fire pump is operating.

Table 10.1 Fire extinguishing appliances

No	Appliances	Number and specifications
1	Provision of water jet	1 pc.; sufficient to reach any part of the vessel .
2	Primary power-driven fire pump	1 pc.; is to be driven by the propulsion engines or other different engines.
3	Additional independent power-driven fire pump	1 pc.;the pump, power source and sea connection are not to be fitted in the same space as the pump listed in item 2. The capability of this pump is to be not less than 80% of the capability of the main pump.
4	Fire main and hydrants	The number of hydrants and the arrangement of the fire main are to be capable of supplying at least one water jet to any point of the yacht with a single length of hose.
5	Hose with jet/spray nozzles each fitted with a shut-off facility	At least 2 pcs.(see the requirements of item 4).
6	Portable fire extinguishers	At least one portable fire extinguisher is to be fitted for each deck. The type of medium and quantity are to comply with the following items.
7	Fire extinguishers for a machinery space other than category A containing internal combustion type machinery	The following appliances are to be provided: **a)** One portable fire extinguisher type D-II for each internal combustion engine, gas turbine, oil fired boiler or fuel transfer system. **b)** One portable fire extinguisher type F-II for each switchboard with a power more than 20 kW
8	Fire extinguishers in machinery space of category A	**a)** a fixed fire extinguishing system in conformity with the requirements of item 3. **b)** One portable fire extinguisher type D-II for each internal combustion engine, gas turbine, oil fired boiler or fuel transfer system **c)** One portable fire extinguisher type F-II for each switchboard with a power more than 20 kW
9	Fire extinguishers and appliances in other service spaces	**Radio room or wheelhouse:** 1 portable fire extinguisher type F-II near radio equipment or electrical apparatus; **Galley:** 1 portable fire extinguisher type E-II or F-II fitted near the exit; 1 fire blanket; **Storerooms:** 1 portable fire extinguisher type D-II or E-II fitted near the exit. Fire extinguishers of CO_2 type are not permitted in storerooms.
10	Fire extinguishers in sleeping accommodation	1 portable fire extinguisher type D-II or E-I for each accommodation space occupied by more than 4 persons. Fire extinguishers of CO_2 type are not permitted in accommodation spaces.
11	Fire extinguishers in corridors	1 portable fire extinguisher type D-II or E-II for each corridor more than of 5 meter in length. Fire extinguishers of CO_2 type are not permitted in corridors.

Table 10.2 Type and capacity of extinguishing medium

Type	Foam [litre]	Carbon-dioxide [kg]	Dry chemical powder [kg]	Soda-acid and water [litre]
D-II	9	-	-	-
E-II	9	5	4,5	-
F-II	-	5	4,5	-
E-I	4,7	1,8	0,9	-

Table 10.3

Vessel length (L_H)	Minimum capacity
Below 20 m.	5,5 m^3/h
At least 20 m. but less than 30 m.	11,0 m^3/h
30 m. or greater	14,0 m^3/h

2.5 Fire Hoses

2.5.1 Fire hoses are not to exceed 18 metres in length.

2.5.2 Fire hoses and associated tools and fittings are to be kept in readily accessible and known locations close to hydrants or connections on which they will be used. Hoses supplied from a powered pump are to have jet/spray nozzles (incorporating a shut-off facility) of diameter 19mm, 16mm or 12mm depending on the fire-fighting purposes.

2.5.3 At least one hydrant is to have one hose connected at all times. For use within accommodation and service spaces, proposals to provide a smaller diameter of hoses and jet/spray nozzles will be specially considered.

3. Fixed Fire Extinguishing System

3.1 A fixed fire-extinguishing system is to be provided in machinery space of category A.

3.2 The system is to be in compliance with Section 10, Appendix 2. For yachts not more than 24 m.in length L_H according to ISO 8666, the system may be in compliance with the requirements of EN ISO 9094-2.

SECTION 10 - APPENDIX 1

OPEN FLAME GAS INSTALLATIONS

Page

1. General Information

1.1 Possible dangers arising from the use of liquid petroleum gas (LPG) open flame appliances in the marine environment include fire, explosion and asphyxiation, due to leakage of gas from the installation.

1.2 Consequently, the siting of gas-consuming appliances and storage containers and the provision of adequate ventilation to spaces containing them are most important.

1.3 It is dangerous to sleep in spaces where gas-consuming pen flame appliances are left burning, because of the risk of carbon monoxide poisoning.

1.4 LPG is heavier than air and, if released, may travel some distance whilst seeking the lowest part of a space. Therefore, it is possible for gas to accumulate in relatively inaccessible areas, such as bilges, and diffuse to form an explosive mixture with air, as in the case of petrol vapour.

1.5 A frequent cause of accidents involving LPG installations is the use of unsuitable fittings and improvised 'temporary' repairs.

2. Stowage of Gas Containers

2.1 LPG cylinders, regulators and safety devices are to be stowed on the open deck (where leakage will not accumulate) or in a compartment above the deck protected from bad weather and solar radiation that is vapour-tight to the vessel's interior, and fitted with a vent and drain, so that any gas which may leak can disperse overboard.

2.2 The vent and drain are to be not less 19mm in diameter, run to the outside of the craft and terminate 75mm or more above the 'at rest' waterline. Generally, the drain and locker ventilation is to be 500mm or more from any opening to the interior.

2.3 The cylinders and associated fittings are to be positively secured against movement and protected from damage in any foreseeable event.

2.4 Any electrical equipment located in cylinder lockers is to be certified safe for use in the potentially explosive atmosphere.

3. Cylinders and Attachments

3.1 Each system is to be fitted with a readily accessible, manually operated isolating valve in the supply pressure part of the system.

3.2 In multiple container installations, a non-return valve is to be placed in the supply line near to the stop valve on each container. If a change-over device is used (automatic or manual), it is to be provided with non-return valves to isolate any depleted container.

3.3 Where more than one container can supply a system, the system is not to be used with a container removed unless the unattached pipe is fitted with a suitable gas-tight plug arrangement.

3.4 Containers not in use or not being fitted into an installation are to have the protecting cap in place over the container valve

4. Fittings and Pipework

4.1 For rigid pipework systems, solid drawn copper alloy or stainless steel tube are to be used. Steel tubing or aluminium or any materials having a low melting point should not be used.

4.2 Connection between rigid pipe sections is to be made with hard solder (minimum melting point 450ºC). Appropriate compression or screwed fittings are recommended for general use for pipework in LPG installations.

4.3 Lengths of flexible piping (if required for flexible connections) are to conform to an appropriate standard, be kept as short as possible, and be protected from inadvertent damage. Such hose is to be installed in such a manner as to give access for inspection along its length.

5. Appliances

5.1 All appliances are to be well secured to avoid movement.

5.2 All unattended appliances are to be of the room sealed type, i.e where the gas flames are isolated in a totally enclosed shield where the air supply and combustion gas outlets are piped to open air.

5.3 All gas burners and pilot flames are to be fitted with a flame supervision device which will shut off the gas supply to the burner or pilot flame in the event of flame failure.

5.4 Flueless heaters are to be selected only if fitted with atmosphere-sensitive cut-off devices to shut off the gas supply at a carbon dioxide concentration of not more than 1,5% by volume.

5.5 Heaters of a catalytic type are not to be used.

6. Ventilation

6.1 The ventilation requirements of a space containing an LPG appliance is to be assessed against an appropriate standard and is to take into account gas burning equipment and persons occupying that space.

6.2 Where ventilators required for the LPG appliances in intermittent use can be closed, there are to be appropriate signs at the appliance warning of the need to have those ventilators open before the appliance is used.

7. Gas Detection

7.1 Suitable means for detecting the leakage of gas are to be provided in any compartment containing a gas-consuming appliance, or in any adjoining space of a compartment into which the gas may seep.

7.2 Gas detector heads are to be securely fixed in the lower part of the compartment in the vicinity of the gas-consuming appliance and in other space(s) into which gas may seep. In areas where the detector head is susceptible to damage in the lowest part of the compartment (e.g. engine space bilge), the detector head is at least to be fitted below the lowest point of ignition.

7.3 Any gas detector is to preferably be of a type which will be actuated promptly and automatically by the presence of a gas concentration in air of not greater than 0,5% (representing approximately 25% of the lower explosive limit). The detection system is to incorporate a visible alarm and an audible alarm which can be heard in the space concerned and the control position with the vessel in operation.

7.4 Where electrical detection equipment is fitted, it is to be certified as being flame proof or intrinsically safe for the gas being used.

7.5 The arrangements are to be such that the detection system can be tested frequently whilst the vessel is in service; this is to include a test of the detector head operation as well as the alarm circuit.

7.6 All detection equipment is to be maintained in accordance with the Manufacturers' requirements.

8. Emergency action

8.1 A suitable notice, detailing the action to be taken when an alarm is given by the gas detection system, is to be displayed prominently in the vessel.

8.2 The information given is to include the following:

a) The need to be ever alert for gas leakage; and

b) When leakage is detected or suspected, all gasconsuming appliances are to be shut off at the main supply from the container(s) and no smoking is to be permitted until it is safe to do so.

c) Naked lights are never to be used as a means of locating gas leaks.

SECTION 10 - APPENDIX 2

FIXED GAS FIRE-EXTINGUISHING SYSTEM ADDITIONAL REQUIREMENTS

Page

1. General

Fixed gas fire-extinguishing systems are to be in compliance with the requirements of Chapter 5 of the FSS Code and with the following additional requirements.

2. System Control Requirements

2.1 In general, the control valves are to be located within the medium storage room.

2.2 The arrangement of means of control, whether mechanical, hydraulic or pneumatic, is to be to the satisfaction of **TL.**

3. High Pressure CO_2 System

3.1 Quantity of Fire-Extinguishing System

3.1.1 For spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels, the quantity of carbon dioxide available is, unless otherwise provided, to be sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest protected space in the yacht

3.1.2 For the machinery space, in the calculation of the required 35 % of volume, the net volume of the funnel (if any) is to be considered up to a height equal to the whole casing height if the funnel space is in open connection with the machinery space without inter position of closing means.

3.1.3 For spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels, the fixed piping is to be such that at least 2/3 of the required gas quantity is discharged within 10 minutes (see also Table 10.4).

Table 10.4 Dimensions of the CO_2 piping for the quick discharge

Diameter	Diameter	CO_2 quantity [kg]	
Nominal D_N [mm]	External D_e [mm]	Machinery and boiler spaces	Spaces, other than special category spaces,intended for the carriage of motor vehicles
15	21,3	45	225
20	26,9	100	500
25	33,7	135	675
32	42,4	275	1375
40	48,3	450	2250
50	60,3	1100	5500
65	76,1	1500	7500
80	88,9	2000	10000
90	101,6	3250	16250
100	114,3	4750	23750
110	127,0	6810	34050
125	139,7	9500	47500
150	168,3	15250	76250

3.2 Bottle Room

The bottle room is to be insulated against any excessive increase in temperature.

Direct access, in the form of doors or openings, is not permitted between CO_2 bottle room and engine rooms or accommodation spaces below open deck. The spaces assigned for the use of passengers and crew, e.g. toilets, recreation areas, stairway enclosures and corridors assumed as accommodation spaces.
When CO_2 room is located on the open deck, doors opening to corridors only is permitted.

When in exposed position, the bulkheads and ceiling deck of the bottle room are to be insulated against solar radiation so that the temperature inside the room does not exceed 55°C.

For ships intended to operate in temperate zones, the bottle room temperature may be required to be kept below 45°C, depending on the filling limit accepted for the bottles

3.3 Bottle Arrangement

The bottles are to be arranged in a vertical position and so disposed as to facilitate their weighing. Moreover, in order to avoid corrosion on the bottom of the bottles, they are to be arranged in such a way that ventilation is facilitated and cleaning is possible

3.4 Bottles and Their Fittings

3.4.1 The bottles are to be approved by **TL** and are to have a capacity not greater than 67 l. Bottles having capacity up to 80 l may be accepted by **TL** a case-by-case based on satisfactory handling arrangements.

In general, the bottles of a particular system are to have the same capacity.

3.4.2 Each bottle is to be provided with a valve recognised as suitable by **TL**, built in such a way as to avoid the formation of dry ice inside during gas discharge. This valve is to be fitted with a standard threaded connection, for bottle filling, and with a safety device (rupture disc) set to a pressure value between 17 and 20 MPa. The minimum cross-sectional area of the device is to be not less than 50 mm^2. The valve is to be fitted with a manual opening control which can be easily and readily operated or with another opening device approved by **TL**. If the exhaust of the safety devices is led into the CO_2 collecting main, or into a proper exhaust pipe leading to the open, **TL** may waive the requirement for mechanical ventilation of the CO_2 room; failing this, the discharge of such safety device is to be equipped with a jet breaker.

3.4.3 The bottles are to be permanently connected to a common collecting main by means of a steel pipe or by a flexible pipe recognised as suitable by **TL**. A non-return valve is to be fitted between each bottle and the collecting main.

3.4.4 The filling ratio of the bottles is generally to be not greater than 0,67 kg/l. In exceptional cases, in which the ship's service is restricted to temperate zones, a filling ratio up to 0,75 kg/l may be accepted.

3.5 Safety Devices for the CO_2 Collecting Mains

The CO_2 manifolds located in the bottle room are to be fitted with one or more safety valves or rupture disks set at a pressure value between 17 and 20 MPa with the exhaust pipe led to the open air. The outflow cross-sectional area of these valves or rupture disks is to be not less than 300 mm^2. When the exhaust pipe of the bottle safety devices is led into the CO_2 collecting mains, the minimum total outflow cross-sectional area of the safety valves or rupture disks of the CO_2 collecting main will be given special consideration by **TL** on a case-by-case basis.

3.6 CO_2 Distribution Arrangement

3.6.1 The CO_2 distribution system within protected spaces is to be so designed that, when the gas quantity appropriate to that space is discharged, it is uniformly distributed through all the discharge nozzles. In machinery and boiler spaces at least 20 % of the required quantity of carbon dioxide is to be discharged below the floor.

3.6.2 The minimum piping diameters for the quick discharge in relation to the quantity of carbon dioxide to be discharged are given in Table 10.4; different values may be accepted by **TL** on the basis of the results of detailed hydraulic calculations. For the slow discharge, the piping is to have a nominal diameter not less than 20 mm. A connection for the compressed air piping is to be provided on the collecting main for the purpose of cleaning the system piping and associated nozzles. This connection is to be threaded and closed with a threaded plug. Alternative means for cleaning the system piping will be considered on a case-by-case.

3.6.3 Except as expressly indicated otherwise in these Rules, piping joints are to be made by means of flanges. However, threaded joints may be used within the CO_2 room and within the protected spaces.

3.6.4 The piping, valves and fittings are to be properly secured to the hull structures and, when necessary, they are to be protected against possible damage. Plugs, draining devices and filters, if any, are to be arranged, where necessary, in such a way as to prevent the accumulation of condensation and residues. They are to be situated in easily accessible and controllable positions and, in any case, outside accommodation spaces. For the purpose of reducing friction loss in the piping it is to be arranged as straight as possible and along the shortest path.

3.6.5 The carbon dioxide is to be discharged through nozzles in a nebulised state and for such purpose the utmost care is to be taken in shaping and sizing the nozzle cones to avoid the formation of dry snow or dry ice

3.6.6 The applicator nozzles are not to be located near ventilation outlets and they are to be clear of machinery or devices which could hinder the outflow. The branch pipes on which the nozzles are fitted are to extend at least 50 mm beyond the last nozzle and are to be closed by a threaded plug in order to allow the removal of any residues left in sections of the piping by the gas flow. The total outflow cross-sectional area of the applicator nozzles in machinery and boiler spaces and in spaces intended for the carriage of motor vehicles is to be not less than 50 % or greater than 85 % of the outflow cross-sectional area of the CO_2 collecting main. In general, the actual outflow cross-sectional area of each applicator is to be between 50 and 160 mm^2 and, in the case of multiple hole applicators, the diameter of each hole is to be not less than 4 mm; different values may be accepted by **TL** on the basis of the results of detailed hydraulic calculations. Each vehicle or craft with fuel in their tanks or locker storing such fuels is to be fitted with at least 2 applicator nozzles; the distance between two nozzles is generally not to exceed 12 m.

3.7 Alarm Devices

In addition to the requirements in Chapter 5, (2.1.3.2) of the FSS Code, the alarm system is to be approved by **TL**. it may be of the pneumatic type and operating with a delaying device suitable for achieving the required prealarm time interval, or of the electrical type.

3.8 Electrical Audible Alarm

3.8.1 Where the audible alarm in 3.7 above is electrically operated, the following conditions are to be complied with:

a) The supply to the alarm system is to be continuously powered from the emergency source of electrical power or from a battery suitably located for use in an emergency. An alarm in the event of power failure of the alarm system is to be given in a manned position;

b) Two or more audible alarm devices are to be installed in each protected space, as far away as possible from each other and such that, if one of them goes out of service, the remaining one(s) will be sufficient to give the alarm to the whole space;

c) The circuits supplying the audible alarm devices are to be protected only against short-circuits.

3.8.2 The arrangement of the circuits and their electrical protection are to be such that the failure of one of the audible alarm devices will not impair the operation of the others.

3.8.3 If used for short-circuit protection, the fuses are be of the type fitted with a device indicating the condition.

3.8.4 The electrical cables are to be of the fire-resisting type.

3.8.5 The audible alarm devices and any other equipment located in the space are to be protected within cases ensuring a degree of protection adequate for the space of installation with a minimum of IP44.

3.9 Pilot Bottles

3.9.1 When the simultaneous operation of the bottles is actuated by means of CO_2 pressure from a driver bottle, at least two pilot bottles are to be provided, with valves capable of being locally manoeuvred at all times.

The pipes connecting the pilot bottles to the valves of the other bottles are to be of steel and their arrangement is to allow piping distortion due to thermal variations or, failing this, the connection is to be made by means of a flexible pipe recognised as suitable by **TL.**

3.10 Shut-Off Valves

For systems in which bottle valve opening is actuated using the pressure of carbon dioxide discharged from pilot bottles, a valve, normally to be kept shut, is to placed between the main of the pilot bottles and the main of the other bottles. This valve is to be opened by means of the same actuating device as for the pilot bottles and is to be placed upstream of the device delaying the discharge of the non-pilot bottles.

3.11 Materials

The CO_2 system appliances are to be constructed of materials suitable for resisting corrosion from the marine environment; it is recommended that all important fittings of the system are made of brass, special bronze or stainless steel. The CO_2 piping is to be made of steel, hot galvanised inside and outside. The relevant wall thicknesses are to be not less than those specified in Table 10.5.

Cast iron connections and fittings are not allowed, except for fittings of ductile or globular cast iron which may be installed after the distribution valves.

The distribution valves or cocks are to be of such dimensions as to withstand a nominal pressure of not less than 16 MPa.

The valves, flanges and other fittings of the piping between the bottles and the distribution valves are to have dimensions for a nominal pressure of not less than 16 MPa.

The valves, flanges and their fittings of the piping between the distribution valves and the applicator nozzles are to have dimensions for a nominal pressure of not less than 4 MPa.

3.12 Inspection and Tests

The bottles and associated fittings under pressure are to be subjected to a hydrostatic test pressure of 25 MPa. The piping, valves and other fittings are to be subjected to the following tests witnessed by **TL**:

a) For those between the bottles and the distribution valves:

Hydrostatic test to 20 MPa pressure in the workshop before their installation on board and hydrostatic test to 0,7 MPa pressure after their installation on board,

b) For those led through accommodation spaces:

Hydrostatic test to 5 MPa pressure after their installation on board,

c) For those between the distribution valves and the applicator nozzles:

Pneumatic test, after their installation on board, to a pressure suitable to check gas-tightness and absence of obstructions.

4. Other Systems

The use of other fixed fire-extinguishing systems will be specially considered by **TL.**

Additionally, **TL**'s guideline "Design, Test and Approval of Fixed Fire Extinguishing Systems other than CO_2 installed on Yachts" can be used as a reference.

Table 10.5 Minimum wall thickness for steel pipes for CO_2 fire-extinguishing systems

External diameter of pipes [mm]	Minimum wall thickness [mm]	
	From bottles to distribution station	From distribution station to nozzles
21,3 ÷ 26,9	3,2	2,6
30,0 ÷ 48,3	4,0	3,2
51,0 ÷ 60,3	4,5	3,6
63,5 ÷ 76,1	5,0	3,6
82,5 ÷ 88,9	5,6	4,0
101,6	6,3	4,0
108,0 ÷ 114,3	7,1	4,5
127,0	8,0	4,5
133,0 ÷ 139,7	8,0	5,0
152,4 ÷ 168,3	8,8	5,6

Note :

• Pipes are to be galvanised inside and outside. For pipes fitted in the engine room, galvanising may not be required.

• For threaded pipes, where allowed, the minimum thickness is to be measured at the bottom of the thread.

• For external diameters larger than those given in the table, the minimum wall thickness will be subject to special consideration by ***TL.***

• In general, the thicknesses indicated in the table are the nominal wall thickness.

• The external diameters and thicknesses listed in the table have been selected from ISO Standards for welded and seamless steel pipes. For pipes covered by other standards may be accepted.

SECTION 11

MASTS AND RIGGING

Page

A. General Instructions and Basis for Calculation

1. General

1.1 This section contains design loads and formulae for the approximate dimensioning of the rigs predominantly used in practice for sailing boats and yachts with aluminium alloy masts and booms, plus notes on the constructional configuration of the components.

1.2 The calculation procedures contain static loadings corresponding to the heeling moment of the type of craft in question when heeling 15 deg. The heeling moment corresponds to the wind pressure moment which causes a heel of 15 deg. to the fully equipped craft (including the permitted number of persons). The designer or builder of the boat is free to confirm the specific heeling moment for the type of craft in question either mathematically or by test. The heeling moment calculation is to be submitted to **TL** ready for checking. The test is to be carried out in the presence of a **TL** surveyor.

For large sailing yachts having class notation "SAILING SHIP", see Chapter 32, Rigging for Large Sailing Ships.

2. Assumption for Calculations

2.1 The formulae for dimensioning aluminium alloy components are based on a Young's modulus of 7000 N/mm^2.

It shall be taken into account that the mechanical properties may be impaired by welding.

2.2 Shrouds and stays shall be of stainless steel to DIN material-No. 1.4571 or of equivalent quality.

The minimum diameters listed for wire ropes apply to style 1 x 19 (DIN material-No 1.4571).

If rod material is used, the diameters may be converted in accordance with minimum breaking strengths.

3. Determining the Heeling Moment

In dependence on the craft type and its displacement, the heeling moment is to be determined as follows:

3.1 For sailing "dinghies" with a buoyancy (D') of less than 3000 N, the heeling moment for a heel angle of 15 deg. can be approximately determined as follows:

$$M_{RM} = 0{,}15 \cdot B \cdot \left(D' + 2700 \cdot n\right) \quad [\text{Nm}]$$

M_{RM} = Heeling moment with full deadweight including crew members in their proper places [Nm],

B = Maximum breadth of boat [m],

D' = Bouyancy, but without any person [N],

n = Number of persons for which approval is being requested.

3.2 For sailing dinghies whose buoyancy exceeds 3000 N and for cruising centreboarders up to a buoyancy of 6000 N, the righting moment shall be determined by precise calculation or by test, as a matter of principle. As a first approximation the following formula may be used in the design stage:

$$M_{RM} = 0{,}15 \cdot B \cdot \left(D' + 1400 \cdot n\right) \quad [\text{Nm}]$$

(For definitions see 3.1).

3.3 For keel boats, sailing yachts and keel/ centreboard yachts the heeling moment, as a matter of principle, shall be determined by precise calculation or test with the prototype as follows.The followings are to be indicated in the rigging plan :

- Heeling moment (according to test results), M_{krv}
- Heel angle during test, φ_v
- Number of persons for which approval is being requested, n
- Maximum breadth of boat, B

or

- Maximum curve of righting arm, h(φ)

- Ship displacement - Δ (kg)

Additionally, transversal and longitudinal moments of inertia (I_{xx} , I_{yy}) and transversal and longitudinal section modulus (W_{xx} and W_{yy}) of masts and spreaders of riggings is to be indicated on the drawings.

$$M_{RM} = \frac{M_{krv} \cdot 15°}{\varphi_V} + M_p \qquad [Nm]$$

$$M_p = 180 \cdot n \cdot B \qquad [Nm]$$

When curve of righting arms is given:

$$M_{RM} = h(\varphi) \cdot \Delta \cdot g \qquad [Nm]$$

Δ = Displacement [kg],

g = 9,81 [m/sn²],

$$M_{krv} = \cos \varphi_V \cdot P \cdot e$$

M_{krv} = Heeling moment according to the heel evaluated by the test and the bouyancy in accordance with 3.1 [Nm],

φ_V = Heel during the test [°]. This should be between 12 ÷ 18 °,

P = Weight needed to achieve the heel φ_V either from experience or tests [N],

e = Off centreline position of the weight in accordance with Figure 11.1 [m],

n = See, 3.1,

B = See, 3.1[m].

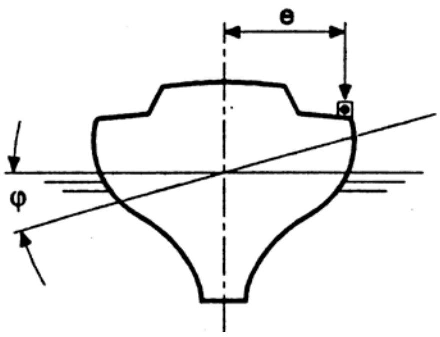


Figure 11.1

B. Dimensioning of Masts and Standing Rigging

1. Type A Rig (Unstayed Mast)

1.1 The section moduli of the mast cross section at the position of constraint are to be determined in accordance with the following formula:

$$W_{xx} = \frac{1{,}25}{\sigma_F} \cdot M_{RM} \cdot \frac{Z_2}{Z_1} \qquad [cm^3]$$

$$W_{yy\,\min} = W_{xx} \qquad [cm^3]$$

W_{xx} = Section modulus of the mast profile referred to the craft longitudinal axis [cm³],

W_{yy} = Section modulus of the mast profile referred to the craft transverse axis [cm³],

Z_1 = Distance of the centre of effort of the sail from the waterline,

Z_2 = Distance of the centre of effort of the sail from the mast position of constraint in the deck,

σ_F = Yield strength of alloy used

1.1.1 The mast may be tapered off linearly above the gooseneck fitting; the section moduli of the cross section at the top of the mast must not be lower than following values:

$$W_{xxh} = 0{,}10 \cdot W_{xx}$$

$W_{yyh} = 0{,}10 \cdot W_{yy}$

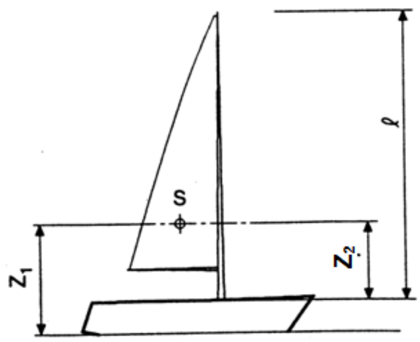


Figure 11.2

2. Type B Rig (Stayed Mast)

2.1 Type B - 1 (1 pair of shrouds, 1 forestay)

2.1.1 The moments of inertia of a mast held free from moments in a step on deck shall be determined in accordance with the following formulae

$$I_{xx} = 0{,}00023 \cdot P_K \cdot h_1^2 \quad [cm^4]$$

$$I_{yymin} = 1{,}3 \cdot I_{xx} \quad [cm^4]$$

I_{xx} = Moment of inertia referred to the craft longitudinal axis [cm^4]

I_{yy} = Moment of inertia referred to the craft transverse axis [cm^4]

$$P_k = 3{,}0 \frac{M_{RM}}{b} \quad [N]$$

b = Distance of chain plates from centreline [m],

h_1 = Unsupported length of mast up to shroud attachment point [m],

h_{1min} = $0{,}75 \cdot \ell$

If the mast is rigidly held between step and deck/ superstructure, both moments of inertia may be reduced by 25 %. If the mast is only constrained transversely, passing through a slot in the deck, only Ixx may be reduced. 100 mm above the shroud attachment point, the mast may be tapered off as with a type A rig.

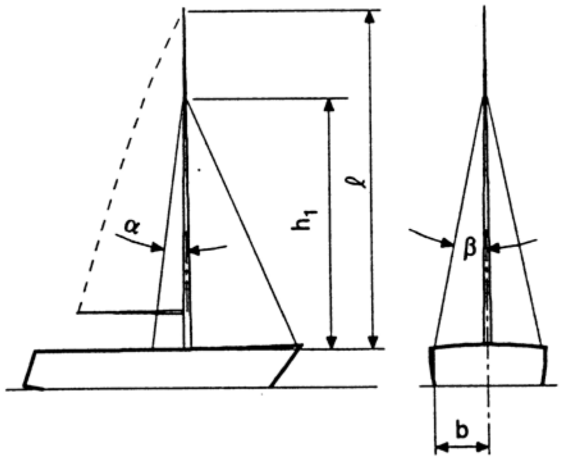


Figure 11.3

2.1.2 Standing Rigging

The shrouds are to have the following minimum spread angle:

$$\alpha = 5°$$

$$\beta = 10°$$

The shroud and forestay diameters depend on the force Pw, the make of the wire rope and the material used; Pw is to be determined in accordance with the following formula:

$$P_w = 2{,}0 \cdot P_k \quad [N]$$

2.2 Type B - 2 (1 pair of shrouds with spreader, 1 forestay)

2.2.1 Mast

The moments of inertia of a mast held free from moments in a step on deck are to be determined in accordance with the following formulae

$$I_{xx} = 0{,}00023 \cdot P_k \cdot h_1^2 \quad [cm^4]$$

$$h_{1min} = 0{,}75 \cdot \ell$$

$$I_{yymin} = 1{,}2 \cdot I_{xx} \quad [cm^4]$$

For definitions, see Type B - 1.

Dimensioning of constrained masts and their taper as for Type B-1 rig.

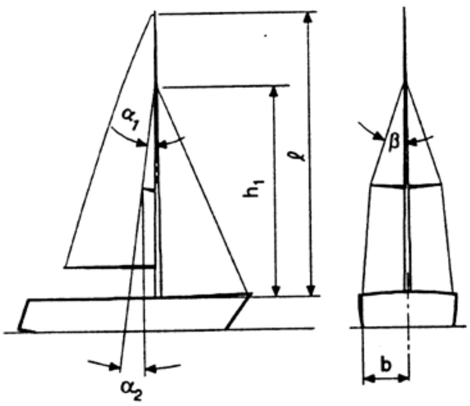


Figure 11.4

2.2.2 Standing Rigging

The shrouds are to have the following minimum spread angle:

$$\alpha_1 = 5°$$

$$\beta = 10°$$

The change of angle of shroud at the spreader may not exceed a value α_2=2° in the longitudinal direction.

The shroud and forestay diameters depend on the force P_w, the make of wire rope and the material used; P_w is to be determined in accordance with the following formula:

$$P_w = 2{,}0 \cdot P_k \quad [N]$$

3. Type C Rig (1 pair of upper shrouds, 1 pair of lower shrouds, 1 spreader)

3.1 Mast

The moments of inertia of a mast held free from moments in a step on deck are to be determined in accordance with the following formulae:

$$I_{xx} = c_1 \cdot 0{,}00023 \cdot P_k \cdot h_2^2 \quad [cm^4]$$
$$I_{yy} = c_2 \cdot P_k \cdot h_1^2 \quad [cm^4]$$

I_{xx} = Moment of inertia referred to the craft longitudinal axis [cm^4],

I_{yy} = Moment of inertia referred to the craft transverse axis [cm^4],

$$P_k = 3{,}0 \cdot \frac{M_{RM}}{b} \quad [N]$$

b = Distance of chain plates from centreline [m],

c_1, c_2 = coefficient of staying,

c_1 = 1,0 for “dinghies” with bouyancy D' = 3000 N,

c_1 = 1,15 for all larger boats

c_2 = 0,00013

h_2 = Unsupported length of mast up to lower shroud attachment point [m],

$h_{1min} = 0{,}75\ \ell$

$h_{2min} = 0{,}50 \cdot h_1$

The cross sections determined in accordance with the above formulae apply to the lower part of the mast. 100 mm above the upper shroud attachment point the mast may be tapered off linearly; the section moduli at the top of the mast must not drop below the following values:

$W_{xxh} = 0{,}10 \cdot W_{xx}$, $W_{yyh} = 0{,}10 \cdot W_{yy}$ — For dinghies with a bouyancy D' = 3000 N

$W_{xxh} = 0{,}20 \cdot W_{xx}$, $W_{yyh} = 0{,}20 \cdot W_{yy}$ — For all larger craft

If the mast is rigidly constrained between step and deck/ superstructure, the moments of inertia shall be calculated in accordance with the following formulae:

$$I_{xx} = 0{,}00017 \cdot P_k \cdot h_2^2 \quad [cm^4]$$

$$I_{yy} = 1{,}125 \cdot I_{xx} \quad [cm^4]$$

I_{xx} = Moment of inertia referred to the craft longitudinal axis [cm^4],

I_{yy} = Moment of inertia referred to the craft transverse axis [cm^4],

$$P_k = 3{,}0 \cdot \frac{M_{RM}}{b} \quad [N]$$

b = Distance of chain plates from centreline [m],

h_2 = Unsupported length of mast up to shroud attacment point [m],

$$h_{1min} = 0{,}75 \cdot \ell$$

100 mm above the upper shroud attachment point, the mast may be tapered off linearly like the mast held free of moments in a step on deck.

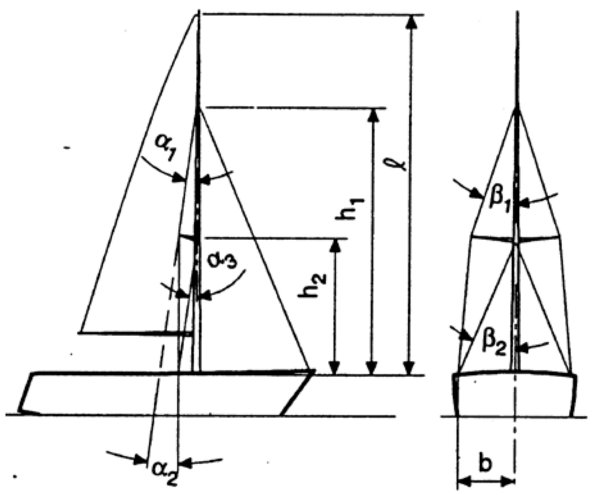


Figure 11.5

3.2 Standing Rigging

The shrouds shall have at least the following spread angle:

$$\alpha_1 = 5°$$

$$\beta_1 = 10°$$

The change of angle of the shroud at the spreader must not exceed a value $\alpha_2 = 2°$ in the longitudinal direction.

The minimum breaking strength of the standing rigging must be greater than the forces determined from the following formulae:

lower shroud $P_{wu} = 1{,}5 \cdot P_k$ [N]

upper shroud $P_{wo} = 1{,}3 \cdot P_k$ [N]

forestay $P_v = 1{,}5 \cdot P_k$ [N]

4. Type D Rigs

Masthead rig boats:

Forestay and backstay shall be attached to the masthead. The upper shroud attachment point may not be more than 0,05 ℓ below the masthead.

$$h_{2min} = 0{,}5 \cdot \ell$$

Fractional rig boats:

The backstay shall be attached to the masthead. The upper shrouds shall be attached not lower down than the forestay.

$$h_{1min} = 0{,}75 \cdot \ell$$

$$h_{2min} = 0{,}5 \cdot h_1$$

200 mm above the attachment point of the upper shroud, the mast may be tapered off linearly; the section moduli at the masthead must not drop below the following values:

$$W_{xxh} = 0{,}2 \cdot W_{xx}$$

$$W_{yyh} = 0{,}2 \cdot W_{yy}$$

4.1 Masts

4.1.1 The moments of inertia of the masts in accordance with D-1 and D-2 rigs must not be less than:

$$I_{xx} = c_3 \cdot P_k \cdot h_2^2 \quad [cm^4]$$

$$I_{yy} = c_4 \cdot P_k \cdot h_1^2 \quad [cm^4]$$

4.1.2 The moments of inertia of the mast in accordance with D-3 rig must not be less than:

$$I_{xx} = c_3 \cdot P_k \cdot h_2^2 \qquad [cm^4]$$

$$I_{yy} = 1{,}4 \cdot c_4 \cdot P_k \cdot h_1^2 \qquad [cm^4]$$

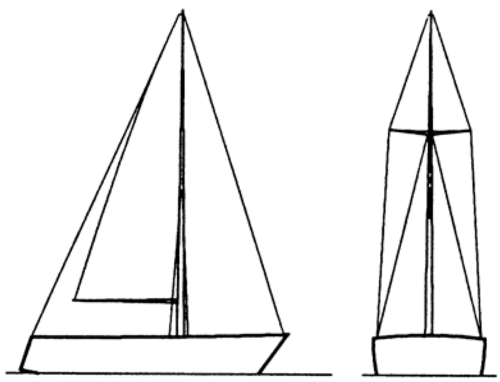
I_{xx} = Moment of inertia referred to the craft longitudinal axis [cm^4],

I_{yy} = Moment of inertia referred to the craft transverse axis [cm^4],

$$P_k = 3{,}0 \cdot \frac{M_{RM}}{b} \qquad [N]$$

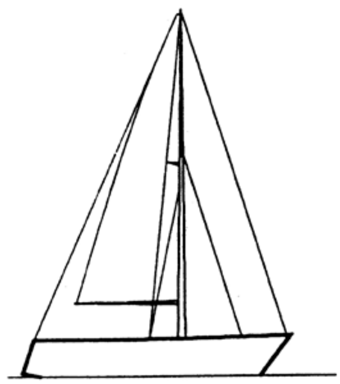
The factors c_3 and c_4 are to be taken from the following table:

	c_3	c_4	
		Masthead rig	**Fractional rig**
Mast standing on deck/ superstructure	0,000265	0,00013	0,00012
Mast standing on keel, rigidly constrained in deck/ superstructure	0,0002	0,000105	0,000095



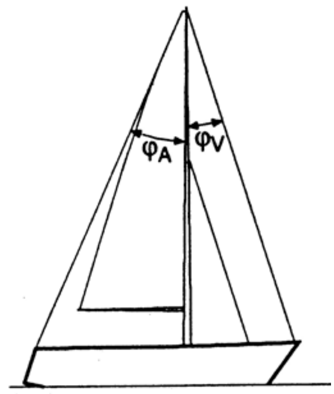
1 forestay, 1 backstay
1 pair of upper shrouds (in the plane of the mast)
2 pair of lower shrouds
(baby stay is permitted instead of lower shrouds)

Figure 11.6 Type D – 1



1 forestay, 1 backstay
1 pair of upper shrouds, swept aft
1 pair of lower shrouds
1 baby stay

Figure 11.7 Type D - 2



1 forestay, 1 backstay
1 pair of upper shrouds in the plane of the mast with spreader
1 pair of lower shrouds in the plane of the mast
1 baby stay

Figure 11.8 Type D - 3

4.2 Standing Rigging

The shrouds and stays shall have the following minimum spread angles:

$$\alpha_{1,2} \geq 5°$$

$$\beta_{1,2} \geq 10°$$

If there is a baby stay, its spread angle α_4 is to be at least 7°. In fractional rig boats, a baby stay may be dispensed with.

The minimum breaking strength of the standing rigging shall be greater than the forces determined from the following formulae:

Lower shroud:

$P_{wu} = 1,3 \cdot P_k$ [N]
If there are two pairs of lower shrouds (Type D- 1)

$P_{wu} = 1,5 \cdot P_k$ [N]
If there is one pair of lower shrouds (Type D - 2 or D - 3)

Upper shroud:

$P_{wo} = 1,3 \cdot P_k$ [N]
Masthead rig boats

$P_{wo} = 1,3 \cdot P_k$ [N]
fractional rig boats with $\alpha_1 = 0°$

$P_{wo} = 1,5 \cdot P_k$ [N]
fractional rig boats with $\alpha_1 > 0$

Where a pair of lower shrouds is fitted (Type D-2 and D-3) it is recommended, for reasons of wire strain, that lower and upper shrouds be made the same strength.

For masthead rig boats:

Forestay: $P_V = \dfrac{2,55 \cdot P_k}{\cos\varphi_V + \dfrac{\sin\varphi_V}{\tan\varphi_A}}$ [N]

Backstay: $P_V = \dfrac{\sin\varphi_V}{\sin\varphi_A} \cdot P_V$ [N]

φ_V = spread angle of forestay [°],

φ_A = spread angle of backstay [°].

For fractional rig boats:

Forestay: $P_v = 1,3 \cdot P_k$ [N]

Backstay: $P_v = 1,0 \cdot P_k$ [N]

If fractional rig boats have the upper shrouds in the plane of the mast (α_1 = 0°), "running" backstays which attach at the level of the upper shroud shall additionally be provided.

Backstay: $P_b = 1,0 \cdot P_k$ [N]

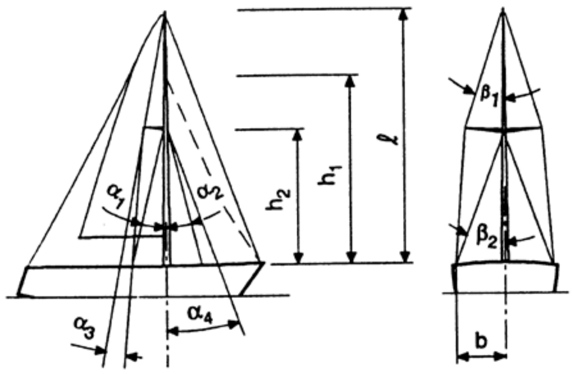


Figure 11.9

5. Dimensioning of Special Rig Designs

As regards the design of masts and standing rigging not in accordance with 1 – 4, **TL** will also accept direct calculations for the verification of compliance of the design with the Rules.

The calculations may be carried out with the aid of computer programs; the programs may be chosen freely.

For the calculations, the calculation model, the boundary conditions and the design loads are to be agreed with **TL**. Documentation allowing verification including inputs and outputs is to be submitted.

C. Dimensioning of Booms and Spreaders

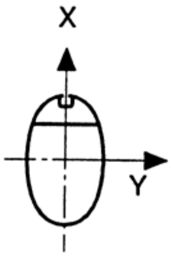
1. Main Boom

The main boom shall be so dimensioned that it is able to absorb bending and buckling loads depending on the main sheet led.

1.1 Standard values for the selection of aluminium main booms are:

$$W_{xx} = 0{,}1 \cdot E^2 \cdot P \cdot c \quad [cm^3]$$

$$W_{yy} = 0{,}15 \cdot E^2 \cdot P \cdot c \quad [cm^3]$$



$W_{xx,yy}$ = Section moduli of the boom profile about the corresponding axes [cm^3],

E = Length of mainsail foot [m],

P = Length of mainsail luff [m],

k = 1,0 for aluminium alloys,

$k = \frac{71000}{E_{mod}}$ for other materials.

1.2 For the main sheet lead, not attached to the boom end:

$$W_{yy} = W_{yy} \cdot 1{,}2$$

1.3 Dimensioning of the main boom can also be done by calculation, taking account of the actual geometry and loading.

2. Spreader Arms

2.1 The spreader moments of inertia at mid length must not be less than:

$$I_{xx} = \frac{P_{ks} \cdot \ell_s^2}{E \cdot \pi^2} \quad [cm^4]$$

$$I_{yy} = c_1 \cdot I_{xx} \quad [cm^4]$$

I_{xx} = Spreader moment of inertia referred to the horizontal axis [cm^4],

I_{yy} = Spreader moment of inertia referred to the vertical axis [cm^4],

P_{ks} = Spreader buckling load,

$P_{ks} = 2{,}0 \cdot P_w \cdot (\cos\delta_u \cdot \cos\delta_o)$ [N]

P_w = Upper shroud breaking strength [N],

δ = See Figure 11.10,

ℓ_s = Spreader length [mm],

E = Young's modulus for the spreader material [N/mm^2],

= 71000 N/mm^2 for aluminium,

c_1 = Coefficient for constraint,

c_1 = 1,0 for hinged connection to the mast

= 2,0 for fixed connection to the mast.

2.2 Spreader arms are to be so arranged that they bisect the angle between the two directions of the shroud.

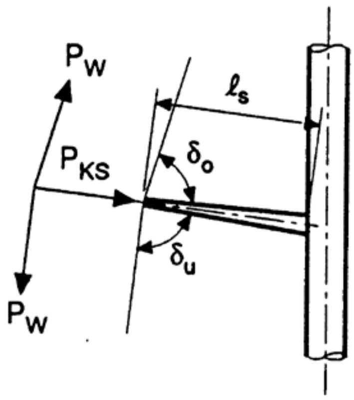


Figure 11.10

2.3 Spreaders must not be swept forward.

2.4 Spreaders may be tapered off to 50 % of their initial dimension towards the outer end.

D. Construction of the Rig

1. Masts and Booms

If masts pass through the deck, halyard outlets are to be avoided in between the constrain in the deck and the level of 25 % of the mast's unsupported length in transverse direction.

Above this height halyard outlets shall be staggered vertically and horizontally.

Where there are larger cut outs for sheave holes, etc., mathematical proof of adequate buckling resistance is required.

The edges of the cut outs are to be chamfered, the corners rounded.

2. Fittings

Fittings and their fastenings to the mast plus all elements of the standing rigging (rigging screws, toggles, shackles, etc.) shall be dimensioned for a load corresponding to 1.5 times the minimum breaking strength of the associated shroud/ stay. Forces from shrouds and stays shall be applied to the mast profile free from any moments. This necessitates the use of suitable fittings.

Chain plates shall be so dimensioned and fastened to the hull that they are capable of absorbing twice the load P_k according to B. of the shroud or stay in question ($\sigma_{müs} = \sigma_{ReH}$). The pull from shrouds and stays must not subject them to a bending stress.

Rigging screws shall be freely movable longitudinally and transversely in the chain plates.

The drillings in the chain plates for the bolts of the rigging srew or shroud terminals are to be made in accordance with ISO 4558.

Bolts and other detachable parts shall be durably secured.

Where fittings are of differing materials, electrolytic corrosion shall be prevented by suitable precautions.

Halyard sheaves are to be fitted into their housings with such small tolerances, and to be made in such a way, that the ropes of the running rigging cannot jam between sheave and housing.

3. Mast Mounting

The mast step is to be dimensioned and joined to the hull of the craft according to the forces arising longitudinally and transversely.

The dimensioning of the mast supporting structure is based on the mast pressure P_k.

Vertical : $P_v = 2 \cdot P_k$

Horizontal : $P_H = \frac{1}{3} \cdot P_k$

4. Standing Rigging

Wire ropes plus associated terminals, thimbles, shackles, and rigging screws shall be of sea water resistant material.

For the rope end fittings, the following systems may be used:

– Eye or claw terminals

– Thimbles pressed-in in accordance with DIN 83319

– Splices in accordance with DIN 83319 with thimbles

– Screw terminals.

In lieu of wire rope, a rod rig may also be used for all or part of the standing rigging. The end fitting of this type of staying must not introduce any notches.

The required minimum breaking strength of the wire ropes is to be confirmed by means of wire rope test certificates.

SECTION 12

STABILITY

A. General

1. This Section outlines the minimum requirements for intact stability for both motor and sailing vessels. This Section deals with the standards for intact stability.

2. An intact stability standard proposed for assessment of a vessel type not covered by the standards defined in this Section is to be submitted to **TL** for approval at the earliest opportunity.

3. If used, permanent ballast is to be located in accordance with a plan approved by **TL** and in a manner that prevents shifting of position. Permanent ballast is not to be removed from the ship or relocated within the ship without the approval of **TL**. Permanent ballast particulars are to be noted in the ship's stability booklet. Attention is to be paid to local or global hull strength requirements from the fitting of additional ballast.

B. Stability Criteria

For yachts up to 24 m in length according to ISO 8666, stability is to be in compliance with ISO 12217-1 or ISO 12217-2.

1. Motor Yachts

1.1 Monohull vessels

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 0,055 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 be 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 vessels intact stability standard fails to comply with the criteria defined in a) to e) **TL** may be consulted for the purpose of specifying alternative but equivalent criteria.

g) Crowding of passengers

The angle of heel on account of crowding of passengers to one side is not to exceed 10° and in any event the freeboard deck is not to be immersed.

1.2 Multi-hull vessels

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_g) is to be taken as follows:

A_g={0,055 + 0,002(30 - q_{max}) metre radians;

where q_{max} is the angle of heel in degrees where the GZ curve reaches its maximum.

b) the area under the GZ curve between the angles of heel of 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 **TL** as a special case.

1.3 For the purpose of assessing whether the stability criteria are met, GZ curves are to be produced for the loading conditions applicable to the operation of the vessel.

1.4 Superstructures

a) The buoyancy of enclosed superstructures complying with regulation 3(10)(b) of the ILLC may be taken into account when producing GZ curves.

b) Superstructures, the doors of which do not comply with the requirements of regulation 12 of ILLC, are not to be taken into account.

1.5 High speed vessels

In addition to the criteria above, Designers and builders are to address the following hazards which are known to effect vessels operating in planing modes or those achieving relatively high speeds:

a) directional instability, often coupled to roll and pitch instabilities;

b) bow diving of planing vessels due to dynamic loss of longitudinal stability in calm seas;

c) reduction in transverse stability with increasing speed in monohulls;

d) porpoising of planing monohulls being coupled with pitch and heave oscillations;

e) generation of capsizing moments due to immersion of chines in planing monohulls (chine tripping).

2. Sailing Yachts

2.1 Monohull vessels

a) Curves of statical stability (GZ curves) for at least the Loaded Departure with 100% consumables and the Loaded Arrival with 10% consumables are to be produced.

b) The GZ curves required by a) should have a positive range of not less than 90º. For vessels of more than 45 m, a range of less than 90º may be considered but may be subject to agreed operational criteria.

c) In addition to the requirements of b), the angle of steady heel is to be greater than 15 degrees (see figure 12.1). 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 12.1:

Merk = the derived wind heeling lever at any angle θ

$= 0{,}5 \cdot RKO \cdot \cos^{1,3}\theta$

where;

$$RKO = \frac{GZ_f}{\cos^{1,3}\theta_f}$$

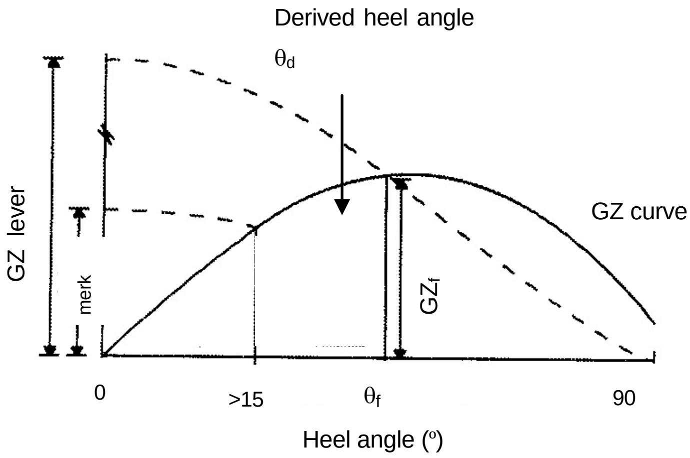


Figure 12.1

Where;

RKO = is the magnitude of the actual wind heeling lever at 0º which would cause the vessel to heel to the 'down flooding angle' θ_f or 60º whichever is the lesser.

GZ_f = is the lever of the vessel's GZ at the down flooding angle (θ_f) or 60º whichever is the lesser.

θ_f = is the angle at which the 'derived wind heeling' curve intersects the GZ curve. (If θ_d is less than 15º the vessel will be considered as having insufficient stability).

θ_d = the 'down-flooding angle' is the angle of heel causing immersion of the lower edge of openings having an aggregate area, in square metres, greater than:

$\Delta/1500$

where Δ = vessels displacement [tonnes]

.

All regularly used openings for access and for ventilation are to be considered when determining the downflooding angle. No opening regardless of size which may lead to progressive flooding is to be immersed at an angle of heel of less than 40º. Air pipes to tanks can, however, be disregarded.

If, as a result of immersion of openings in a superstructure, a vessel cannot meet the required standard, those superstructure openings may be ignored and the openings in the weather deck used instead to determine f). In such cases the GZ curve is to be derived without the benefit of the buoyancy of the superstructure.

It might be noted that provided the vessel complies with the requirements of 1.1, 1.2 and 1.3 and is sailed with an angle of heel which is no greater than the 'derived angle of heel', it should be capable of withstanding a wind gust equal to 1,4 times the actual wind velocity (i.e. twice the actual wind pressure) without immersing the 'down flooding openings', or heeling to an angle greater than 60º.

2.2 Multi-hull vessels

a) Curves of statical 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:

- inclining of complete craft in air on load cells, the VCG being calculated from the moments generated by the measured forces, or

- 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

- detailed calculation of the weight and CG position of all components of the vessel, plus a 15% magrin of the resulting VCG height above the underside of canoe body.

b) If software is used to obtain a curve of pitch restoring moments, then the trim angle must 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)

Trim angle = $tg^{-1} \dfrac{T_{BK} - T_{KK}}{L_{BP}}$

where;

CG' =shift of LCG forward of that required for design trim, measured paralel to base line,

T_{BK} = draught at forward perpendicular,

T_{KK} = 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:

$$v_w = 1{,}5 \cdot \sqrt{\frac{LM_R}{A_s' \cdot h \cdot \cos\phi_R + A_D \cdot b}}$$

$$v_w = 1{,}5 \cdot \sqrt{\frac{LM_p}{A_s' \cdot h \cdot \cos\phi_p + A_D \cdot b}}$$

Where;

v_w = maximum advised apperent 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:

- angle of maximum pitch restoring moment, or
- angle at which foredeck is immersed,or
- 10º from design trim.

A_s' = area of sails set including mast and boom [m^2],

h = height of combined centre of effort of sails and spars above the waterline,

ϕ_R = heel angle at maximum roll righting moment (in conjunction with LM_R),

ϕ_p = limiting pitch angle used when calculating LM_p (in conjunction with LM_p ,

A_D = plan area of the hulls and deck [m^2],

b = distance from centroid of A_D to the centreline of the leeward hull.

d) If the maximum safe wind speed under full fore-and-aft sail is less than 27 knots, it is to be demonstrated by calculation using annex D of ISO 12217-2 (2002) that, when inverted and/or fully flooded, the volume of buoyancy, expressed in cubic metres (m3), in the hull, fittings and equipment is greater than: 1.2 x (fully loaded mass in tonnes) thus ensuring that it is sufficient to support the mass of the fully loaded vessel by a margin. Allowance for trapped bubbles of air (apart from dedicated air tanks and watertight compartments) is not to be included.

e) The maximum safe wind speed with no sails set calculated in accordance with c) above is to exceed 36 knots.

f) Trimarans used for unrestricted operations are to have sidehulls each having a total buoyant volume of at least 150% of the displacement volume in the fully loaded condition.

g) The stability information booklet is to include information and guidance on:

- the stability hazards to which these craft are vulnerable, including the risk of capsize in roll and/or pitch;
- the importance of complying with the maximum advised apparent wind speed information supplied;

- the need to reduce the tabulated safe wind speeds by the vessel speed in following winds;

  - the choice of sails to be set with respect to the prevailing wind strength, relative wind direction, and sea state;

  - the precautions to be taken when altering course from a following to a beam wind.

h) In vessels required to demonstrate the ability to float after inversion (according to c) above), an emergency escape hatch is to be fitted to each main inhabited watertight compartment such that it is above both upright and inverted waterlines.

3. Elements of stability

3.1 Unless otherwise specified, the lightship weight, vertical centre of gravity (KG) and longitudinal centre of gravity (LCG) of a vessel are to be determined from the results of an inclining experiment.

3.2 An inclining experiment is to be conducted in accordance with a detailed standard which is approved by **TL** and, in the presence of a **TL** Surveyor.

3.3 The inclining experiment and the lightweight check are to be conducted in accordance with the provisions of Section 12, Appendix 1.

3.4 The report of the inclining experiment and the lightship particulars derived are to be approved by **TL** prior to their use in stability calculations.

3.5 For sister vessels, in order to verify the stability documentation the following procedure is to be applied:

a) the shipyard declares that a ship is dealt wit as a prototype. An inclining experiment is to be carried out this firts ship (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 ship (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:

- the ship is built by the same shipyard;

- the same drawings are used;

- when the sister ship is built the light ship displacement difference in comparison to the prototype is not greater than ± 2%;

- a sister ship statement is communicated to **TL**, thus formalising the request to waive the inclining experiment for the sister ship.

Should a ship be declared a sister ship of a prototype, the following documentation is to be sent for approval:

a) light-ship weight report (duly signed by the attending **TL** Surveyor and by the shipyard representative);

b) stability booklet as photocopy of the prototype, only updatef for the general description (ship's name, port of registry, flag, etc.).

4. Stability Documents

4.1 A vessel is to be provided with a stability information booklet for the Master, which is to be approved by **TL**.

4.2 The stability information booklet is to be contain the information specified in Section 12, Appendix 2.

4.3 A vessel with previously approved stability information which undergoes a major refit or alterations is to be subjected to a complete reassessment of stability and provided with newly approved stability information.

A major refit or major alteration is one which results in a change in the lightship weight of 2% and above and/or a change in the longitudinal centre of gravity of 1% and above (measured from the aft perpendicular), and/or an increase in the calculated vertical centre of gravity of 0,25% and above (measured from the keel).

4.4 Sailing vessels are to have, readily available, a copy of the Curves of Maximum Steady Heel Angle to Prevent Downflooding in Squalls, or in the case of a multihull, the values of maximum advised mean apparent windspeed. This should be a direct copy taken from that contained in the approved stability booklet.

4.5 The overall sail area and spar weights and dimensions are to be as documented in the vessel's stability information booklet. Any rigging modifications that increase the overall sail area, or the weight/dimensions of the rig aloft, must be accompanied by an approved updating of the stability information booklet.

5. Ice Class

The effect of icing has to be considered in the stability calculations if a class notation for ice class has been requested.

6. Subdivision and Damage Stability

6.1 General

For yachts with a length L exceeding 48 m a damage stability investigation is required.

For yachts with a length L between 48 m and 85 m sufficient damage stability has to be shown by calculating one compartment damages. For yachts with a length L exceeding 85 m a calculation of two compartment damages is required additionally.

6.2 Damage stability calculation

6.2.1 General

Compliance with the damage stability criteria has to be shown in all permitted conditions of loading to withstand all stages of flooding of the main compartments.

6.2.2 Assumptions

The damage stability calculation shall be based on the following assumptions:

1. The assumed extent of damage shall be as follows:

– longitudinal extent: 3 m plus 3 % of the length L of the yacht or 11 m, whichever is less

– transverse extent (to be measured inboard from the ship's side, at right angles to the centre line at the level of the deepest subdivision load line): a distance of one fifth of the breadth of the yacht

– vertical extent: from the base line upwards without limit

– If any damage of lesser extent than that indicated above would result in a more severe condition regarding heel or loss of metacentric height, such damage shall be assumed in the calculations.

2. For damage stability calculations, the permeability for each space or part of a space shall be used as set out in Table 12.1

3. Direct calculation of permeability shall be used where a more onerous condition results.

6.3 Stability criteria

6.3.1 The stability required in the final condition after damage, and after equalization where provided, shall be determined as follows:

1. The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium.

2. The area under the righting lever curve shall be at least 0,015 metre-radians, measured from the angle of equilibrium to the angle at which progressive flooding occurs.

Table 12.1 Values of permeability

Definition of spaces	Permeability [%]
Control stations, accommodation rooms, kitchens, pantries	95
Machinery and ventilation rooms	85
Storage rooms, refrigerating rooms	60
Garages for automobiles and other craft	90
Tanks	0 or 95**(1)**
Void spaces	95
1) *Whichever results in more severe requirements*	

3. A residual righting lever is to be obtained within the range of the positive stability of at least 0,1 m.

6.3.2 Unsymmetrical flooding has to be kept to a minimum. Efficient cross flooding arrangements should correct large angles of heel preferably in a self acting way. If the cross flooding system is not selfacting the required time of equalization shall not exceed 15 minutes. Sufficient time of equalization has to be demonstrated by calculation.

6.4 Final condition of yacht

The final conditions of the yacht after damage and, in case of unsymmetrical flooding, after equalization measures have been taken, shall be as follows:

1. In case of symmetrical flooding there shall be a positive residual metacentric height of at least 50 mm as calculated by the constant displacement method.

2. In case of unsymmetrical flooding, the angle of heel for one-compartment flooding shall not exceed 7°, for the simultaneous flooding of two or more adjacent compartments, a heel of 12° may be permitted by **TL.**

3. In no case shall the final waterline be less than 300 mm below the level of any opening through which further flooding could take place.

6.5 Use of low density foam

Use of low density foam or other media to provide buoyancy in void spaces may be permitted, provided that satisfactory evidence is provided that any such proposed medium is the most suitable alternative and is:

– of closed cell form, or otherwise impervious to water absorption

– structurally stable under service conditions

– chemically inert in relation to structural materials with which it is in contact

– properly secured in place and easily removable for inspection of the void spaces

7. Damage Control Plan

7.1 There shall be permanently exhibited or readily available on the navigating bridge, for the guidance of the officer in charge of the yacht, a plan showing clearly:

– for each deck and compartment the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof

– for doors, a description of degree of tightness, operating mode, normal position, operating circumstances (opened while at sea, not normally used while at sea, not used while at sea)

– arrangements for the correction of any list due to flooding

7.2 General precautions shall consist of a listing of equipment, conditions and operational procedures, considered to be necessary to maintain watertight integrity under normal yacht operations.

7.3 Specific precautions shall consist of a listing of elements (i.e. closures, securing of equipment/ loads, sounding of alarm, etc.) considered to be vital to the survival of the yacht and its crew.

SECTION 12 - APPENDIX 1

INCLINING TEST and LIGHTWEIGHT SURVEY

Page

1. General

1.1 Aim

1.1.1 Prior to the test, **TL'**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 yacht is to be transversely upright and the trim is to be taken not more than 1% of the length between perpendiculars. If this condition is not satisfied, hydrostatic data and sounding tables are to be available for the actual trim;

d) cranes, derrick, lifeboats and liferafts capable of inducing oscillations are to be secured;

e) main and auxiliary boilers, pipes and any other system containing liquids are to be filled;

f) the bilge and the decks are to be thoroughly dried;

g) preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim.

The shape of the tank is to be such that the free surface effect can be accurately determined and remains almost constant during the test. All cross connections are to be closed;

h) the weights necessary for the inclination are to be already on board, located in the correct place;

i) all work on board is to be suspended and crew or personel 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 is to be reduced to an absolute minimum.

2. Inclining Weights

2.1 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. **TL** 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. Re-certification 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.

2.2 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 **TL** 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 must be inserted in transverse manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control must be maintained during the test;

f) all inclining tanks must 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

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 can 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 recordings from individual instruments are kept separate, it is suggested that the pendulums be physically located as far apart as practical.

The use of an inclinometer or U-tube is to be considered in each separate case. Inclinometers or other measuring devices only be used in conjunction with at least one pendulum.

4. Means of Communication

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

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 cargo spaces and tanks. When water ballast is used as inclining weights, the transverse and vertical centres of gravity for the applicable tanks, for each angle of inclination, must be available;

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

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 be taken forward, midship and aft, and the readings averaged. For small yachts, one sample taken from midship is sufficient. The temperature of the water is to be taken and the measured specific gravity corrected for deviation from the standard, if necessary;

d) A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site. Correction is necessary if specific gravity is measured when the sample temperature differs from the temperature at the time of the inclining test. Where the value of the average calculated specific gravity is different from that reported in the hydrostatic curves, adequate corrections are to be made to the displacement curve;

e) all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the yacht's trim and the position of air pipes;

f) it is to be checked that the bilge is dry, and an evaluation of the liquids which cannot be pumped, remaining in the pipes, boilers, condenser, etc., is to be carried out;

g) the entire yacht is to be surveyed in order to identify all items which need to be added, removed or relocated to bring the yacht to the lightship condition. Each item is to be clearly identified by weight and location of the centre of gravity;

h) the possible solid permanent ballast is to be clearly identified and listed in the report.

7. Inclining Procedure

The Standard test generally employs 8 distinct weight movements as shown in Figure 12.2

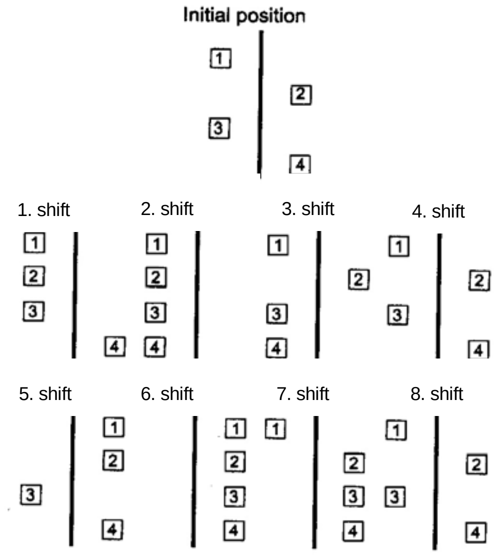


Figure 12.2

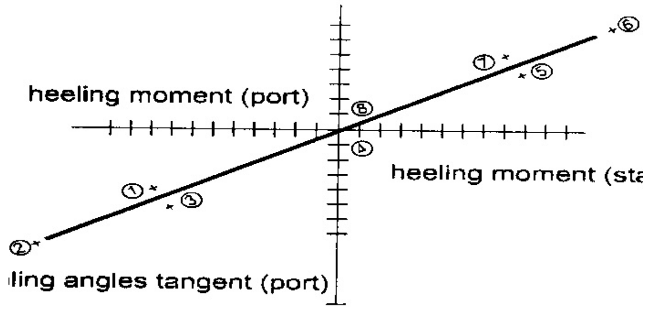


Figure 12.3

The weights are to be transversally shifted, so as not to modify the yacht's trim and vertical position of the centre of gravity.

After each weiht shifting, the new position of the transverse center of gravity of the weihts 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 12.3. The pendulum deflection is to be read when the yacht has reached a final position after each weight shifting.

During the reading, no movements of personnel are allowed.

For yachts with a length equal to or less than 30 m, six distinct weight movements may be accepted.

8. Lightweight Survey

An inclining test for an individual yacht may be ispensed with provided that basic stability data are available from the inclining test of a sister yacht and a satisfactory lightweight check is perfomed in order to prove that the sister yacht corresponds to the prototype yacht.

SECTION 12 - APPENDIX 2

STABILITY INFORMATION BOOKLET

1. Information to be Included

1.1 General

A stability information booklet is a stability manual, to be approved by **TL,** 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

The following information is to be included in the stability information booklet:

a) a general description of the yacht, including:

- the yacht's name and **TL** classification number
- the yacht type and service notation
- the class notations
- the yard, the hull number and the year of delivery
- the flag, the port of registry, the international call sign
- the moulded dimensions
- the design draft
- the displacement corresponding to the above-mentioned draughts;

b) clear instructions on the use of the booklet;

c) general arrangement and capacity plans indicating the assigned use of compartments and spaces (stores, accommodation, etc.);

d) a sketch indicating the position of the draught marks referred to the yacht's perpendiculars;

e) hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the yacht, curves or tables corresponding to such range of trim;

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 **TL** 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 center of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve when applicable, reporting a comparison between the actual and the required values) 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 crossflooding 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

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.

In the stability calculations, free surface effect of fully loaded swimming pool is to be taken into account as a maximum.

3. Stability Curve Calculation

3.1 General

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

Enclosed superstructures complying with the 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

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Deckhouses, the doors of which do not comply with the requirements in the ILCC, are not to be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of the ILCC.

Deckhouses on decks above the freeboard deck are not to be taken into account, but openings within them may be regarded as closed.

Superstructures and deckhouses not regarded as enclosed may, however, be taken into account in stability calculations up to the angle at which their openings are flooded .

Trunks may be taken into account. Hatchways may also be taken into account having regard to the effectiveness of their closures.

3.3 Angle of Flooding

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 **TL** considers this to be a source of significant progressive flooding; therefore, such openings are to be considered on a case by case basis

4. Effect of Free Surface of Liquids in Tanks

4.1 General

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

Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition.

Free surface effects for small tanks may be ignored under the condition in 4.7.

4.3 Categories of Tanks

Tanks which are taken into consideration when determining the free surface correction may be one of two categories:

a) Tanks with fixed filling level (e.g. liquid cargo, water ballast). The free surface correction is to be defined for the actual filling level to be used in each tank;

b) Tanks with variable filling level (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquid cargo and water ballast during liquid transfer operations)., 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

In calculating the free surfaces 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 are to be those where the effect of free surface is the greatest.

4.5 Ballast Tanks

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 surfaces effect is

to be calculated to take account of the most onerous transitory stage relating to such operations.

4.6 GM_o and GZ Curve Corrections

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 0º 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 0º angle of heel, modified at each angle of heel calculated; corrections may be calculated according to the categories indicated 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 Small Tanks

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:

$$\frac{M_{fs}}{\Delta_{min}} \le 0{,}01 \qquad \text{[m].}$$

where;

M_{fs} = free surface moment (mt)

Δ_{min} = minimum yacht displacement calculated at T_{min} [t].

T_{min} = minimum mean service draught of yacht without cargo, with 10% stores and minimum water ballast, if required [m].

4.9 Remainder of Liquid

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 constitude a significant free surface effect.