

Common Structural Rules for Bulk Carriers and Oil Tankers



01 JAN 2021

Foreword

These Rules enter into force on 1st July 2021 and supersede the following Rules:

- Common Structural Rules for Bulk Carriers and Oil Tankers, January 2020

These Common Structural Rules consist of two parts. Part One provides requirements common to both Double Hull Oil Tankers and Bulk Carriers and Part Two provides additional requirements applied to either Double Hull Oil Tankers or Bulk Carriers.

Summary of changes from the 01 JAN 2020 Rules

	Amendment Type / No.	Adoption Date	Rule Version Date	Effective Date
1	Rule Change Notice 1	24 DEC 2020	01 JAN 2020	01 JULY 2021

Note: Full revision history for Common Structural Rules is available on IACS website, including all previous RCNs and associated TBs.

Guideline of RCN Label

1. RCN (Rule Change Notice) label is used to identify the rule change made since last rule version with the format of "RCN {Number} to {Rule Version Date}", e.g. RCN1 to 01 JAN 2020.
2. For corrigenda update, the same format will be followed, e.g. CORR1 to 01 JAN 2020.
3. Modification and addition of rule texts:
 - RCN label is inserted at the end of modified contents.
4. Modification and addition of titles, figures and tables:
 - RCN label is inserted at the end of modified contents.
5. Deletion of rule texts and titles:
 - Replace contents by the word "DELETED".
 - RCN label is inserted at the end of the word "DELETED".
6. Deletion of Table:
 - Replace contents of Table by the word "DELETED" (only shown first row).
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7. Deletion of Figure:
 - Replace Figure by a generic graphic marked "DELETED".
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PART 1 CHAPTER 1

RULE GENERAL PRINCIPLES

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SECTION 1

APPLICATION

1 SCOPE OF APPLICATION

1.1 General

1.1.1

These Rules apply to the following ships:

- a) Bulk carriers and double hull oil tankers and;
- b) Being self-propelled ships with unrestricted navigation, and;
- c) Contracted for construction on or after 1st July 2015.

Note 1: Unrestricted navigation means that the ship is not subject to any geographical restrictions (i.e. any oceans, any seasons) except that limited by the ship's capability for operation in ice.

Note 2: The 'contracted for construction' means the date on which the contract to build the ship is signed between the prospective owner and the builder. For further details regarding the date of 'contracted for construction', refer to IACS Procedural Requirement (PR) No. 29.

1.1.2

These Rules apply to ships constructed of welded steel structures and composed of stiffened plate panels. The ship's structure is to be longitudinally or transversely framed with full transverse bulkheads and intermediate web frames.

The typical arrangements of ships covered by the rules assume that the structural arrangements include:

- Double bottom, the depth of which is to be in accordance with applicable statutory requirements.
- Engine room located aft of the cargo tank/hold region.

1.1.3

Ships for which these Rules are not applicable are to comply with the relevant Rules of the Society.

1.2 Scope of application for bulk carriers

1.2.1

These Rules apply to the hull structures of single side skin and double side skin bulk carriers having a length L of 90 m or above.

Bulk carriers are ships which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks and with single or double side skin construction in cargo hold region and intended primarily to carry dry cargoes in bulk. Typical arrangements of bulk carriers are shown in Figure 1.

Hybrid bulk carriers, where at least one cargo hold is constructed with hopper tank and topside tank, see typical arrangements in Figure 1, and other cargo holds are constructed without hopper tank and/or topside tanks, see examples of a transverse section in Figure 2, are to comply with the strength criteria defined in these Rules.

These Rules are not applicable to the following ship types:

- Ore carriers.
- Combination carrier.
- Woodchip carrier.
- Cement, fly ash and sugar carriers provided that loading and unloading is not carried out by grabs heavier than 10 tons, power shovels and other means which may damage cargo hold structure.
- Ships with inner bottom construction adapted for self-unloading.

Figure 1 : Typical arrangements of bulk carriers

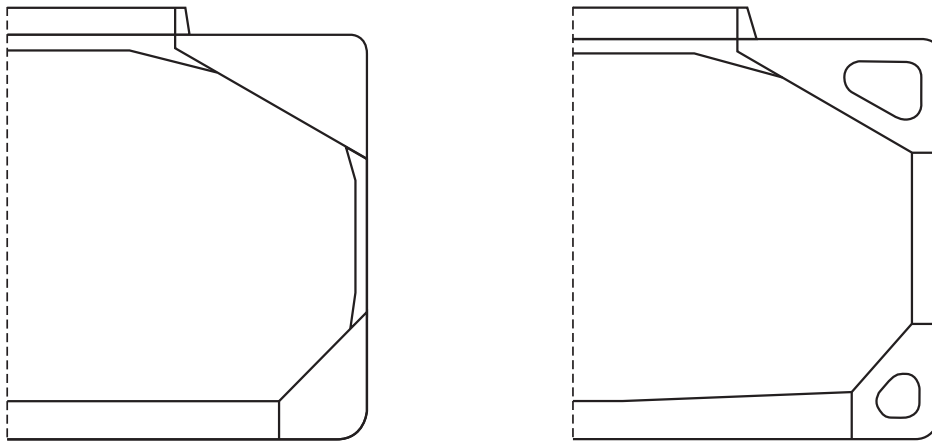
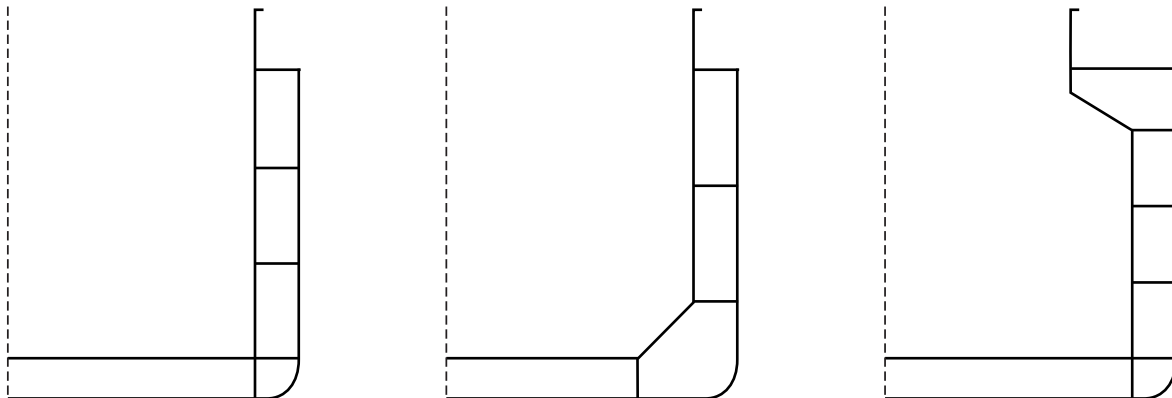


Figure 2 : Examples of transverse sections of cargo hold without hopper tank and/or topside tank



1.3 Scope of application for oil tankers

1.3.1 Length and structural arrangement application

These Rules apply to the hull structures of double hull oil tankers having length L of 150 m or above. Oil tanker is defined as a ship which has to comply with Annex I of MARPOL73/78.

The typical arrangements of oil tankers covered by the rules are shown in Figure 3 and assume that the structural arrangements include:

- Double side structure with breadth in accordance with statutory requirements.
- Side longitudinal, centreline longitudinal or transverse bulkheads of plane, corrugated or double skin construction.
- Single deck structure.

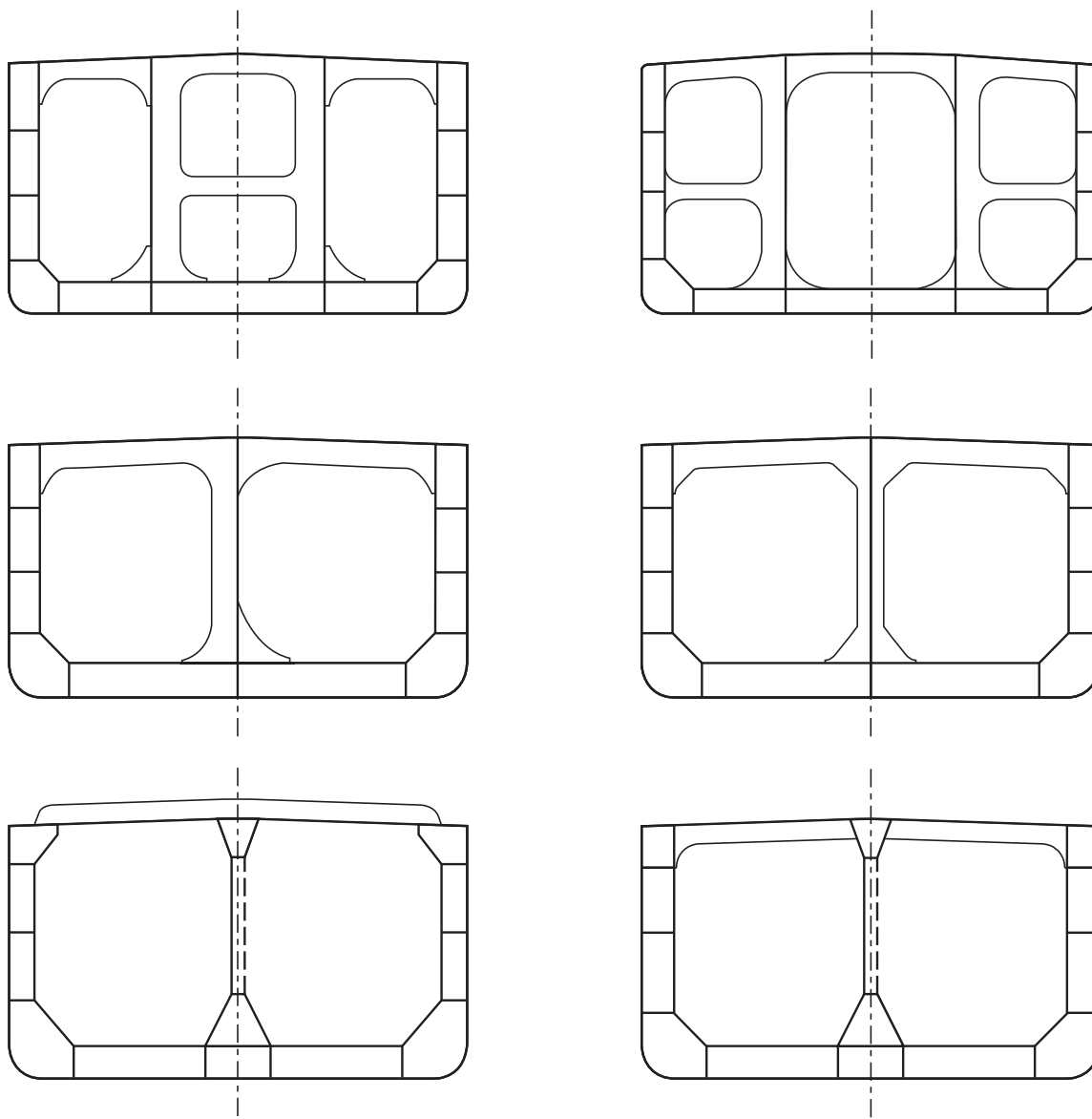
The cross sections shown in Figure 3 are typical examples only and other variations of cross tie and web frame arrangements are also covered.

1.3.2 Cargo temperature application

The Rules are based on the following design temperatures for the cargo:

- a) maximum temperature: 80 °C
- b) minimum temperature: 0 °C.

Figure 3 : Typical arrangements of double hull oil tankers



2 RULE APPLICATION

2.1 Rule description

2.1.1 Rule structure

The rules contain 2 parts:

- Part 1: General hull requirements.
- Part 2: Ship types.

The parts are structured in chapters giving instructions for detail application and requirements which are applied in order to satisfy the rule objectives.

2.1.2 Numbering

The system of numbering is given in Table 1.

Table 1 : Rule numbering and abbreviations

Order	Levels	Example	Abbreviations
1	Part	Part 1 – General Hull Requirements	Pt 1
2	Chapter	Chapter 1 – Rule General Principle	Ch 1
3	Section	Section 1 – Application	Sec 1
4	Article	1. Scope of Application	[1]
5	Sub-article	1.1 General	[1.1]
6	Requirements	1.1.1 These Rules apply to...	[1.1.1]

2.2 Rule Requirements**2.2.1** Part 1

Part 1 of the Rules provides requirements common to all ship types as follow:

- Chapter 1: Rule General Principles.
- Chapter 2: General Arrangement Design.
- Chapter 3: Structural Design Principles.
- Chapter 4: Loads.
- Chapter 5: Hull Girder Strength.
- Chapter 6: Hull Local Scantling.
- Chapter 7: Direct Strength Analysis.
- Chapter 8: Buckling.
- Chapter 9: Fatigue.
- Chapter 10: Other Structure.
- Chapter 11: Superstructure, Deckhouses and Hull Outfitting.
- Chapter 12: Construction.
- Chapter 13: Ship in Operation - Renewal Criteria.

The provisions of the Ch 1, 2, 3, 4, 5, 6, 8, 12, 13 and Ch 10, Sec 4 are applicable all over the ships length.

The Ch 7, 9, 10 and 11 define their own scope of application.

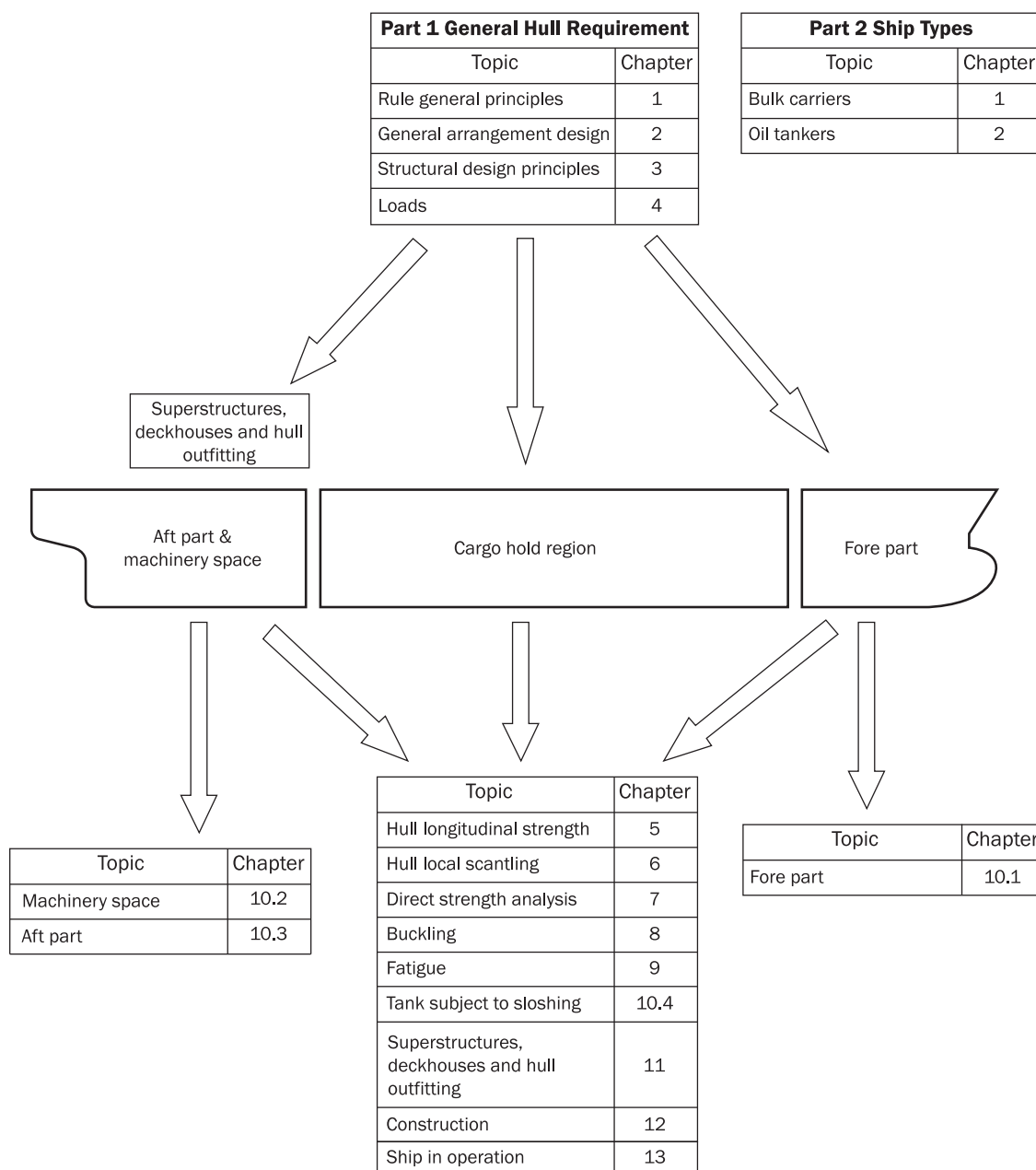
2.2.2 Part 2

Part 2 of the Rules provides requirements coming in addition to those of Part 1 specific for ship types and is divided as follow:

- Chapter 1: Bulk Carriers.
- Chapter 2: Oil Tankers.

2.2.3 Application of the Rules

The ship arrangement and scantlings are to comply with the relevant parts and chapters of the Rules as it is given in Figure 4.

Figure 4 : Application of the Rules

2.2.4 General criteria

The ship arrangement, the proposed details and the offered scantling in net or gross, as the case may, are to comply with the requirements and the minimum scantling given in the Rules.

2.3 Structural requirements

2.3.1 Materials and welding

The Rules applies to welded hull structures made of steel having characteristics complying with requirements in Ch 3, Sec 1. The Rules applies also to welded steel ships in which parts of the hull, such as superstructures or small hatch covers, are built in material other than steel, complying with requirements in Ch 3, Sec 1.

Ships whose hull materials are different than those given in the first paragraph are to be individually considered by the Society, on the basis of the principles and criteria adopted in the present rules.

2.4 Ship parts

2.4.1 General

For the purpose of application of the present rules, the ship is considered as divided into the following five parts:

- Fore part.
- Cargo hold region.
- Machinery space.
- Aft part.
- Superstructures and deckhouses.

2.4.2 Fore part

The fore part is that part of the ship located forward of the collision bulkhead, i.e.:

- The fore peak structures.
- The stem.

2.4.3 Cargo hold region

The cargo hold region is the part of the ship that contains cargo holds, cargo tanks, and slop tanks. It includes the full breadth and depth of the ship, the collision bulkhead and the transverse bulkhead at its aft end. The cargo hold region does not include the pump room, if any.

2.4.4 Machinery space

The machinery space is the part of the ship between the aft peak bulkhead and the transverse bulkhead at the aft end of the cargo hold region and includes the pump room, if any.

2.4.5 Aft part

The aft part includes the structures located aft of the aft peak bulkhead.

2.4.6 Superstructures and deckhouses

A superstructure is a decked structure on the freeboard deck extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 0.04 *B*.

A deckhouse is a decked structure on the freeboard or superstructure deck which does not comply with the definition of a superstructure.

2.5 Limits of application to lifting appliances

2.5.1 Definition

The fixed parts of lifting appliances, considered as an integral part of the hull, are the structures permanently connected by welding to the ship's hull (for instance, crane pedestals, masts, king posts, derrick heel seatings, etc, excluding cranes, derrick booms, ropes, rigging accessories, and, generally, any removable parts), only for that part directly interacting with the hull structure.

2.5.2 Rule application for lifting appliances

The fixed parts of lifting appliances and their connections to the ship's structure may be covered by the Society's rules for lifting appliances, and/or by the certification (especially the issuance of the Register of ship's lifting appliances and cargo handling gear) of lifting appliances when required.

2.5.3 Structures supporting fixed lifting appliances

The design of the structure supporting fixed lifting appliances and the structure that might be called to support a mobile appliance is to be designed taking into account the additional loads that may be imposed on them by the operation of the appliance and environmental conditions as declared by the builder or its sub-contractors.

2.6 Novel designs

2.6.1

Ships with novel features or unusual hull design are to comply with Ch 1, Sec 3, [6.2].

3 CLASS NOTATIONS

3.1 Class notation CSR

3.1.1 Application

In addition to the class notations granted by the Society and to the service features and additional class notations defined hereafter, ships fully complying with these Rules are assigned the notation CSR.

3.2 Class notation for bulk carriers

3.2.1 Additional service features BC-A, BC-B and BC-C

The following requirements apply to ships, as defined in [1.2.1], having length L of 150 m or above.

Bulk carriers are to be assigned one of the following additional service features:

- a) BC-A: For bulk carriers designed to carry dry bulk cargoes of cargo density 1.0 t/m^3 and above with specified holds empty at maximum draught in addition to BC-B conditions.
- b) BC-B: For bulk carriers designed to carry dry bulk cargoes of cargo density of 1.0 t/m^3 and above with all cargo holds loaded in addition to BC-C conditions.
- c) BC-C: For bulk carriers designed to carry dry bulk cargoes of cargo density less than 1.0 t/m^3 .

The following additional service features are to be provided giving further detailed description of limitations to be observed during operation as a consequence of the design loading condition applied during the design in the following cases:

- {Maximum cargo density in t/m^3 } for additional service features BC-A and BC-B if the maximum cargo density is less than 3.0 t/m^3 , see also Ch 4, Sec 8, [4.1].
- {No MP} for all additional service features when the ship has not been designed for loading and unloading in multiple ports in accordance with the conditions specified in Ch 4, Sec 8, [4.2.2].
- {Holds a, b, ... may be empty} for additional service feature BC-A, see also Ch 4, Sec 8, [4.1].
- {Block loading} for additional service feature BC-A, when the ship is intended to operate in alternate block load condition, see also Ch 4, Sec 8, [4.2.3], item d.

3.2.2 Additional class notation GRAB [X]

The additional class notation GRAB [X] is mandatory for ships having one of the additional service features BC-A or BC-B, according to [3.2.1]. For these ships, the requirements for the GRAB [X] notation given in Pt 2, Ch 1, Sec 6 are to comply with for an unladen grab weight X taken not less than:

- 35 t for ships with $L \geq 250 \text{ m}$,
- 30 t for ships with $200 \text{ m} \leq L < 250 \text{ m}$,
- 20 t otherwise.

For all other ships, the additional class notation GRAB [X] is voluntary.

4 APPLICATION OF THE RULES OF THE SOCIETY

4.1 Structural parts not covered by these Rules

4.1.1

Designer should take care that parts of the structure that these Rules do not cover comply with the relevant requirements of the Society's Rule.

SECTION 2

RULE PRINCIPLES

1 GENERAL

1.1 Rule objectives

1.1.1

The objectives of the Rules are to establish the classification minimum requirements to mitigate the risks of major hull structural failure in order to help improve the safety of life, environment and property and to contribute to the durability of the hull structure for the ship's design life.

1.1.2

The sub-sections contain:

- The general assumptions pertaining to the design, construction and operation of the ship and give information on the assumed roles of the Society, builders, designers and owners.
- The design basis which specifies the premises on which the Rules are based in terms of design parameters and assumptions about the ship operation.
- The design principles which define the fundamental principles used for the structural requirements in the Rules with respect to loads and structural capacity.
- The rule design methods which describe how the design principles are applied and the criteria are used in view of [1.1.1].

2 GENERAL ASSUMPTIONS

2.1 International and national regulations

2.1.1

Ships are to be designed, constructed and operated in compliance with the regulatory framework prescribed by the International Maritime Organisation (IMO) and implemented by National Administrations or the Society on their behalf. The builder is to give due consideration to the influence on the structural design and arrangement from the relevant requirements of the International Labour Organization (ILO) implemented by National Administrations or the Society on their behalf.

2.1.2

The Rules are based on the assumption that the applicable statutory requirements are complied with.

2.2 Application and implementation of the Rules

2.2.1

The Society develops and publishes the rules for classification of ships, containing minimum requirements for the hull structure and essential engineering systems. The Society verifies compliance with the classification requirements and the applicable international regulations when authorised by a National Administration during design, construction and operation of the ship.

2.2.2

These Rules address the hull structural aspects of classification and do not include requirements related to the verification of compliance with the Rules during construction and operation. In order to achieve the safety level targeted by the Rules, a number of aspects related to design, construction and operation of the ship are assumed to be adhered to by the parties involved in the application and implementation of the Rules. A summary of these assumptions are given in the following:

a) General aspects:

- Relevant information and documentation involved in the design, construction and operation is communicated between the builder, the designer, the Society and the owner as agreed between builder and owner. Design documentation according to Rule requirements is provided.
- Quality systems are applied to the design, construction, operation and maintenance activities by owners and other relevant parties to ensure the compliance with the requirements of the Rules.

b) Design aspects:

- The owner specifies the intended use of the ship, and the ship is designed according to operational requirements as well as the structural requirements given in the Rules.
- The builder identifies and documents the operational limits for the ship so that the ship can be safely and efficiently operated within these limits.
- Verification of the design is performed by the builder to check compliance with provisions contained in the Rules in addition to national and international regulations.
- The design is performed by appropriately qualified, competent and experienced personnel.
- The Society performs a technical appraisal of the design plans and related documents for a ship to verify compliance with the appropriate classification Rules.
- For spaces where lighting and ventilation are to be fitted, the builder is to give consideration to the influence on the structural design and arrangement from the relevant requirements of International Conventions such as SOLAS and MLC2006 Regulation 3.1 - Accommodation and recreational facilities, and Society's rules if any. Human element considerations, including enhanced safety and productivity, may be considered using Recommendation No. 132 or other ergonomic standards accepted by the Society.
- For continually manned spaces where noise is to be minimised, the builder is to give consideration to the influence on the structural design and arrangement from the relevant requirements of SOLAS Ch II-1, Reg.3-12 and "The Code on Noise Levels Onboard Ships" adopted at MSC.337(91).
- For continually manned spaces where vibration is to be minimised, the builder is to give consideration to the influence on the structural design and arrangement from the relevant requirements of relevant statutory requirements such as MLC 2006 Regulation 3.1 - Accommodation and recreational facilities. Human element considerations, including enhanced safety and productivity, may be considered using Recommendation No. 132 or other ergonomic standards accepted by the Society.

c) Construction aspects:

- The builder provides adequate supervision and quality control during the construction.
- Construction is carried out by qualified and experienced personnel.
- Workmanship, including alignment and tolerances, is in accordance with acceptable shipbuilding standards.
- The Society performs surveys to verify that the construction and quality control are in accordance with the classification features of approved plans and procedures.

d) Operational aspects:

- Personnel involved in operations are aware of, and comply with, the operational limitations of the ship.

- Operations personnel receive sufficient training such that the ship is properly handled so that the loads and resulting stresses imposed on the structure are minimised.
- The ship is maintained in adequate condition and in accordance with the Society survey scheme and international and national regulations and requirements.
- The Society performs surveys to verify that the ship is maintained in class in accordance with the Society survey scheme.

3 DESIGN BASIS

3.1 General

3.1.1

This sub-section specifies the design parameters and the assumptions about the ship operation that are used as the basis of the design principles of the Rules.

3.1.2

Ships are to be designed to withstand, in the intact condition, the environmental conditions as defined in [5.3.2] and [5.3.3] anticipated during the design life, for the appropriate loading conditions. Structural strength is to be determined against buckling and yielding. Ultimate strength calculations have to include ultimate hull girder capacity and ultimate strength of plates and stiffeners.

3.1.3 Residual strength

Ships having a length L of 150 m or above are to be designed to have sufficient reserve strength to withstand the loads in damaged conditions, e.g. collision, grounding or flooded scenarios. Residual strength calculations are to take into account the ultimate reserve capacity of the hull girder, considering permanent deformation and post-buckling behaviour as specified in Ch 5, Sec 3.

3.1.4 Finite element analysis

The scantling of the structural members within the cargo hold region of ships having a length L of 150 m or above is to be assessed according to the requirements specified in Pt 1, Ch 7.

3.1.5 Fatigue life

Ships having a length L of 150 m or above are to be assessed according to the design fatigue life for structural details specified in Pt 1, Ch 9.

3.1.6

The Rules are applicable for ships in compliance with the specified design basis. Special consideration is given to deviations from this design basis.

3.1.7

The design basis used for the design of each ship, as communicated by the builder to the owner, is to be documented and submitted to the Society as part of the design review and approval. All changes of the design basis are to be formally advised to the Society and the owner for approval.

3.2 Hull form limit

3.2.1

The Rules assume the following hull form with respect to environmental loading:

- $L < 500$ m

- $C_B > 0.6$
- $L/B > 5$
- $B/D < 2.5$

For ships over 350 m in length, special consideration is to be made for the wave loads by the Society.

3.3 Design life

3.3.1

A design life of 25 years is assumed for selecting ship design parameters. The specified design life is the nominal period that the ship is assumed to be exposed to operating conditions.

3.4 Environmental conditions

3.4.1 North Atlantic wave environment

The rule requirements are based on a ship trading in the North Atlantic wave environment for its entire design life.

3.4.2 Wind and current

The effects of wind and current with regard to the strength of the structure are not considered.

3.4.3 Ice

The effects of ice and ice accretion are not taken into account by the Rules.

3.4.4 Design temperatures

The Rules assume that the structural assessment of hull strength members is valid for the following design temperatures:

- Lowest mean daily average temperature in air is -10°C .
- Lowest mean daily average temperature in seawater is 0°C .

Ships intended to operate in areas with lower mean daily average temperature, e.g. regular service during winter seasons to Arctic or Antarctic waters are subject to the requirements as specified by the Society.

In the above, the following definitions apply:

Mean : Statistical mean over observation period (at least 20 years).

Daily Average : Average during one day and night.

Lowest : Lowest during year.

For seasonally restricted service the lowest value within the period of operation applies.

3.4.5 Thermal loads

The effects of thermal loads and residual stresses are not taken into account in the Rules.

3.5 Operating conditions

3.5.1

The Rules specify minimum loading conditions that are to be assessed for compliance.

Specification of loading conditions other than those required by the Rules is the responsibility of the owner. These other loading conditions are to be documented and also be assessed for compliance.

3.5.2

The Rules assume the following:

- The ballast cargo hold of bulk carriers is not to be partly filled in seagoing operations.
- Ballasting and deballasting operations in the ballast cargo hold of bulk carriers are not to be performed when the weather is not fair.

3.6 Operating draughts

3.6.1

The design operating draughts are to be specified by the builder/designer subject to acceptance by the owner and are to be used to derive the appropriate structural scantlings. All operational loading conditions in the loading manual are to comply with the specified design operating draughts. The following design operating draughts are as a minimum to be considered:

- Scantling draught for the assessment of structure.
- Minimum ballast draught at midship for assessment of structure.
- Minimum heavy ballast draught at midship for assessment of bulk carrier structure.
- Minimum forward draughts for the assessment of bottom structure forward subjected to slamming loads, T_{F-e} and T_{F-f} , with and without ballast tanks in way filled.

T_{F-e} and T_{F-f} are defined in Ch 4, Sec 5, [3.2.1]

- For oil tankers: maximum draughts amidships for both conditions:
 - with all cargo tanks abreast empty.
 - with centre cargo tank empty and wing cargo tanks full.
 - with centre cargo tank full and wing cargo tanks empty.
- For bulk carriers carrying steel coils: maximum draught amidships for steel coil loading conditions.

3.7 Internal environment

3.7.1 Oil cargo density for strength assessment

A density of 1.025 t/m³, or a higher value if specified by the designer, is to be used for oil cargoes for the strength assessment of all relevant tank structures.

3.7.2 Oil cargo density for fatigue assessment

For the fatigue assessment of cargo tank structures, the mean density is to be taken as 0.9 t/m³, or a higher value if specified by the designer.

3.7.3 Dry cargo density

The density for dry bulk cargo is to be taken according to the specifications in Ch 4, Sec 6, [2.3].

3.7.4 Water ballast density

A density of 1.025 t/m³ is to be used for water ballast.

3.8 Structural construction and inspection

3.8.1

The structural requirements included in the Rules are developed with the assumption that construction and repair follow acceptable shipbuilding and repair standards and tolerances. The Society may require that

additional attention is paid to critical areas of the structure by the builder during construction and by the owner for repair after the ship's delivery.

3.8.2

As an objective, ships are to be built in accordance with controlled quality production standards using approved materials as necessary.

3.8.3

The Rules define the renewal criteria for the individual structural items. The structural requirements included are developed on the assumption that the structure is subject to appropriate monitoring by the owner once the ship is in operation and to periodical survey in accordance with Society rules and regulations.

3.8.4

Tank strength and tightness testing are to be carried out as a part of the verification scheme according to the Rules and/or documents of the individual Society which incorporate IACS UR S14.

3.8.5

Specifications for material manufacturing, assembling, joining and welding procedures, steel surface preparation and coating are to be included in the ship construction quality procedures. It is assumed that the owner has approved these builder specifications.

3.9 Maximum service speed

3.9.1

The maximum service speed is to be specified in the design specification. Although the hull structure verification criteria takes into account the service speed this does not relieve the responsibilities of the owner and personnel to properly handle the ship, see item (d) in [2.2.2].

3.10 Owner's extras

3.10.1

Owner's specification of requirements above the general classification or statutory requirements may affect the structural design. Owner's extras may include requirements for:

- Vibration analysis.
- Maximum percentage of high strength steel.
- Additional scantlings above that required by the Rules.
- Additional design margin on the loads specified by the Rules, etc.
- Improved fatigue resistance, in the form of a specified increase in design fatigue life or equivalent.

Owner's extras are not specified by these Rules. Owner's extras, if any, that may affect the structural design are to be clearly specified in the design documentation.

4 DESIGN PRINCIPLES

4.1 Overall principles

4.1.1 Introduction

This sub-section defines the underlying design principles of the Rules in terms of loads, structural capacity models and assessment criteria and also construction and in-service aspects.

4.1.2 General

The Rules are based on the following overall principles:

- The safety of the structure can be assessed by addressing the potential structural failure mode(s) when the ship is subjected to operational loads and environmental loads/conditions.
- The design complies with the design basis, see Ch 1, Sec 3.
- The structural requirements are based on consistent design load sets which cover the appropriate operating modes of a bulk carrier or oil tanker.

The ship's structure is designed such that:

- It has a degree of redundancy. The ship's structure should work in a hierarchical manner and, in principle, failure of structural elements lower down in the hierarchy do not result in immediate consequential failure of elements higher up in the hierarchy.
- It has sufficient reserve strength to withstand the wave and internal loads in damaged conditions that are reasonably foreseeable e.g. collision, grounding or flooding scenarios. Residual strength calculations are to take into account the ultimate reserve capacity of the hull girder, considering permanent deformation and post-buckling behaviour.
- The incidence of in-service cracking is minimised, particularly in locations which affect the structural integrity or containment integrity, affect the performance of structural or other systems or are difficult to inspect and repair.
- It has adequate structural redundancy to survive in the event that the structure is accidentally damaged by a minor impact leading to flooding of any compartment.

4.1.3 Limit state design principles

The rules are based on the principles of limit state design.

Limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design scenarios identified. For each retained failure mode, one or more limit states may be relevant. By consideration of all relevant limit states, the limit load for the structural element is found as the minimum limit load resulting from all the relevant limit states.

The limit states defined in Ch 3, Sec 5 are divided into the four categories: Serviceability Limit State (SLS), Ultimate Limit State (ULS), Fatigue Limit State (FLS) and Accidental Limit State (ALS).

The Rules include requirements to cover the relevant limit states for the various parts of the structure.

4.2 Loads

4.2.1 Design load scenarios

The structural assessment of the structure is based on the design load scenarios encountered by the ship. Refer to Ch 4, Sec 7.

The design load scenarios are based on static and dynamic loads as given below:

- Static design load scenario (S):
Covers application of relevant static loads and typically covers load scenarios in harbour, sheltered water, or tank testing.
- Static plus Dynamic design load scenario (S+D):
Covers application of relevant static loads and simultaneously occurring dynamic load components and typically cover load scenarios for seagoing operations.
- Impact design load scenario (I):
Covers application of impact loads such as bottom slamming and bow impact encountered during seagoing operations.

- Sloshing design load scenario (SL):
Covers application of sloshing loads encountered during seagoing operations.
- Fatigue design load scenario (F):
Covers application of relevant dynamic loads.
- Accidental design load scenario (A):
Covers application of some loads not occurring during normal operations.

4.3 Structural capacity assessment

4.3.1 General

The basic principle in structural design is to apply the defined design loads, identify plausible failure modes and employ appropriate capacity models to verify the required structural scantlings.

4.3.2 Capacity models for ULS, SLS and ALS

The strength assessment method is to be capable of analysing the failure mode in question to the required degree of accuracy.

The structural capacity assessment methods are in either a prescriptive format or require the use of more advanced calculations such as finite element analysis methods.

The formulae used to determine stresses, deformations and capacity are deemed appropriate for the selected capacity assessment method and the type and magnitude of the design load set.

4.3.3 Capacity models for FLS

The fatigue assessment method provides Rule requirements to assess structural details against fatigue failure.

The fatigue capacity model is based on a linear cumulative damage summation (Palmgren-Miner's rule) in combination with a design S-N curve, a reference stress range and an assumed long-term stress distribution curve.

The fatigue capacity assessment models are in either a prescriptive format or require the use of more advanced calculations, such as finite element analysis methods. These methods account for the combined effects of global and local dynamic loads.

4.3.4 Net scantling approach

The objective of the net scantling approach is to:

- Provide a relationship between the thickness used for strength calculations during the newbuilding stage and the minimum thickness accepted during the operational phase.
- Enable the status of the structure with respect to corrosion to be clearly ascertained throughout the life of the ship.

The net scantling approach distinguishes between local and global corrosion. Local corrosion is defined as uniform corrosion of local structural elements, such as a single plate or stiffener. Global corrosion is defined as the overall average corrosion of larger areas, such as primary supporting members and the hull girder. Both the local and global corrosion are used as a basis for the newbuilding review and are to be assessed during operation of the ship.

No credit is given in the assessment of structural capability for the presence of coatings or similar corrosion protection systems.

The application of the net thickness approach to assess the structural capacity is specified in Ch 3, Sec 2.

4.3.5 Intact structure

All strength calculations for ULS, SLS and FLS are based on the assumption that the structure is intact. The residual strength of the ship in a structurally damaged condition is assessed for ALS.

5 RULE DESIGN METHODS

5.1 General

5.1.1 Design methods

Scantling requirements are specified to cover the relevant limit states (ULS, SLS, FLS and ALS) as necessary for various structural parts.

The criteria for the assessment of the scantlings are based on one of the following design methods:

- Working Stress Design (WSD) method, also known as the permissible or allowable stress method.
- Partial Safety Factor (PSF) method, also known as Load and Resistance Factor Design (LRFD).

For both WSD and PSF, two design assessment conditions and corresponding acceptance criteria are given. These conditions are associated with the probability level of the combined loads, A and B.

- The WSD method has the following composition:

$$W_{stat} \leq \eta_1 R \quad \text{for condition A.}$$

$$W_{stat} + W_{dyn} \leq \eta_2 R \quad \text{for condition B.}$$

where:

W_{stat} : Simultaneously occurring static loads (or load effects in terms of stresses).

W_{dyn} : Simultaneously occurring dynamic loads. The dynamic loads are typically a combination of local and global load components.

R : Characteristic structural capacity (e.g. specified minimum yield stress or buckling capacity).

η_i : Permissible utilisation factor (resistance factor). The utilisation factor includes consideration of uncertainties in loads, structural capacity and the consequence of failure.

- The PSF method has the following composition:

$$\gamma_{stat-1} W_{stat} + \gamma_{dyn-1} W_{dyn} \leq \frac{R}{\gamma_R} \quad \text{for condition A.}$$

$$\gamma_{stat-2} W_{stat} + \gamma_{dyn-2} W_{dyn} \leq \frac{R}{\gamma_R} \quad \text{for condition B.}$$

where:

γ_{stat-i} : Partial safety factor that accounts for the uncertainties related to static loads.

γ_{dyn-i} : Partial safety factor that accounts for the uncertainties related to dynamic loads.

γ_R : Partial safety factor that accounts for the uncertainties related to structural capacity.

The acceptance criteria for both the WSD method and PSF method are calibrated for the various requirements such that consistent and acceptable safety levels for all combinations of static and dynamic load effects are derived.

5.2 Minimum requirements

5.2.1

Minimum requirements specify the minimum scantling requirements which are to be applied irrespective of all other requirements, hence thickness below the minimum is not allowed.

The minimum requirements are usually in one of the following forms:

- Minimum thickness, which is independent of the specified minimum yield stress.
- Minimum stiffness and proportion, which are based on buckling failure modes.

5.3 Load-capacity based requirements

5.3.1 General

In general, the Working Stress Design (WSD) method is applied in the requirements, except for the hull girder ultimate strength criteria where the Partial Safety Factor (PSF) method is applied. The partial safety factor format is applied for this highly critical failure mode to better account for uncertainties related to static loads, dynamic loads and capacity formulations.

The identified load scenarios are addressed by the Rules in terms of design loads, design format and acceptance criteria set, as given in Table 2. The table is schematic and only intended to give an overview.

Load based prescriptive requirements provide scantling requirements for all plating, local support members, most primary supporting members and the hull girder and cover all structural elements including deckhouses, foundations for deck equipment.

In general, these requirements explicitly control one particular failure mode and hence several requirements may be applied to assess one particular structural member.

5.3.2 Design loads for SLS, ULS and ALS

The structural assessment of compartment boundaries, e.g. bulkheads, is based on loading condition deemed relevant for the type of ship and the operation the ship is intended for.

To provide consistency of approach, standardised Rule values for parameters, such as GM , R_{roll} , T_{sc} and C_B are applied to calculate the Rule load values.

The probability level of the dynamic global, local and impact loads (see Table 1) is 10^{-8} and is derived using the long-term statistical approach.

The probability level of the sloshing loads (see Table 1) is 10^{-4} .

The design load scenarios for structural verification apply the applicable simultaneously acting local and global load components. The relevant design load scenarios are given in Ch 4, Sec 7.

The simultaneously occurring dynamic loads are specified by applying a dynamic load combination factor to the dynamic load values given in Ch 4. The dynamic load combination factors that define the dynamic load cases are given in Ch 4, Sec 2.

Design load conditions for the hull girder ultimate strength are given in Ch 5, Sec 2.

5.3.3 Design loads for FLS

For the fatigue requirements given in Ch 9, the load assessment is based on the expected load history and an average approach is applied. The expected load history for the design life is characterised by the 10^{-2} probability level of the dynamic load value, the load history for each structural member is represented by Weibull probability distributions of the corresponding stresses.

The considered wave induced loads include:

- Hull girder loads (i.e. vertical and horizontal bending moments).
- Dynamic wave pressures.
- Dynamic pressure from cargo.

The load values are based on Rule parameters corresponding to the loading conditions, e.g. GM , C_B , and the applicable draughts at amidships.

The simultaneously occurring dynamic loads are accounted for by combining the stresses due to the various dynamic load components. The stress combination procedure is given in Ch 9.

Table 1 : Load scenarios and corresponding rule requirements

Operation	Load type	Design load scenario	Acceptance criteria
Seagoing operations			
Transit	Static and dynamic loads in heavy weather	S + D	AC-SD
	Impact loads in heavy weather	Impact (I)	AC-I
	Internal sloshing loads	Sloshing (SL)	AC-S
	Cyclic wave loads	Fatigue (F)	-
BWE by flow through or sequential methods	Static and dynamic loads in heavy weather	S + D	AC-SD
Harbour and sheltered operations			
Loading, unloading and ballasting	Typical maximum loads during loading, unloading and ballasting operations	S	AC-S
Tank testing	Typical maximum loads during tank testing operations	S	AC-S
Special conditions in harbour	Typical maximum loads during special operations in harbour, e.g. propeller inspection afloat or dry-docking loading conditions	S	AC-S
Accidental condition			
Flooded conditions	Typically maximum loads on internal watertight subdivision structure in accidental flooded conditions	A	AC-SD AC-S

Table 2 : Acceptance criteria - prescriptive requirements

Acceptance criteria	Plate panels and local support members ⁽¹⁾		Primary supporting members ⁽¹⁾		Hull girder members	
	Yield	Buckling	Yield	Buckling	Yield	Buckling
AC-S AC-SD	Permissible stress: Ch 6, Sec 4 Ch 6, Sec 5	Control of stiffness and proportions: Ch 8, Sec 2	Permissible stress: Ch 6, Sec 6 Pt 2, Ch 1, Sec 4 Pt 2, Ch 2, Sec 3	Control of stiffness and proportions: Ch 8, Sec 1 Ch 8, Sec 2 Pillar buckling	Permissible stress: Ch 5, Sec 1	Allowable buckling utilisation factor: Ch 8, Sec 1, [3]
AC-I	Plastic criteria: Ch 10, Sec 1, [3]	Control of stiffness and proportions: Ch 8, Sec 2 Ch 10, Sec 1, [3]	Plastic criteria: Ch 10, Sec 1, [3]	Control of stiffness and proportions: Ch 8, Sec 2 Ch 10, Sec 1, [3]	N/A	N/A

(1) Refer to Ch 10 for Other structures and to Ch 11 for Superstructure, deckhouses and hull outfitting

Table 3 : Acceptance criteria - FE analysis

Acceptance criteria	Cargo hold analysis		Fine mesh analysis
	Yield	Buckling	Yield
AC-S AC-SD	Permissible stress: Ch 7, Sec 2, [5]	Allowable buckling utilisation factor: Ch 8, Sec 1, [3]	Permissible Von Mises stress: Ch 7, Sec 3, [6] Screening criteria: Ch 7, Sec 3, [3.3]

5.3.4 Structural response analysis

In general, the following approaches are applied for determination of the structural response to the applied design load combinations.

a) Beam theory:

- Used for prescriptive requirements.

b) FE analysis:

- Coarse mesh for cargo hold model.
- Fine mesh for local models.
- Very fine mesh for fatigue assessment.

5.4 Acceptance criteria

5.4.1 General

The acceptance criteria are categorised into three acceptance criteria sets. These are explained below and shown in Table 2 and Table 3. The specific acceptance criteria set that is applied in the rule requirements is dependent on the probability level of the characteristic combined load.

The acceptance criteria set AC-S is applied for the static design load combinations, and for the sloshing design loads. The allowable stress for such loads is lower than that for an extreme load to take into account effects of:

- Repeated yield.
- Allowance for some dynamics.
- Margins for some selected limited operational mistakes.

The acceptance criteria set AC-SD is applied for the S+D design load combinations where considered loads are extreme loads with a low probability of occurrence.

The acceptance criteria set AC-I is typically applied for impact loads, such as bottom slamming and bow impact loads.

5.4.2 Acceptance criteria

The specific acceptance criteria applied in the working stress design requirements are given in the detailed Rule requirements in Pt 1, Ch 5 to Ch 8, Ch 10, Ch 11 and Pt 2, Ch 1 and Ch 2.

To provide a general informational summary overview of the acceptance criteria, refer to Table 2 and Table 3 below for the different design load scenarios covered by these Rules for the yield and buckling failure modes. For the yield criteria the permissible stress is proportional to the specified minimum yield stress of the material. For the buckling failure mode, the acceptance criteria are based on the control of stiffness and proportions as well as on the buckling utilisation factor.

5.5 Design verification

5.5.1 Design verification – hull girder ultimate strength

The requirements for the ultimate strength of the hull girder are based on a Partial Safety Factor (PSF) method. A safety factor is assigned to each of the basic variables, the still water bending moment, wave bending moment and ultimate capacity. The safety factors were determined using a structural reliability assessment approach, the long-term load history distribution of the wave bending moment was derived using ship motion analysis techniques suitable for determining extreme wave bending moments.

The purpose of the hull girder ultimate strength verification is to demonstrate that one of the most critical failure modes of a ship is controlled.

5.5.2 Design verification – global finite element analysis

The global finite element analysis is used to verify the scantlings given by the load-capacity based prescriptive requirements to better consider the complex interactions between the ship's structural components, complex local structural geometry, change in thicknesses and member section properties as well as the complex load regime with sufficient accuracy.

A linear elastic three dimensional finite element analysis of the cargo region (a FE model length of three holds is required) is carried out to assess and verify the structural response of the proposed hull girder and primary supporting members and assist in specifying the scantling requirements for the primary supporting members. The purpose with the finite element analysis is to verify that the stresses and buckling capability of the primary supporting members are within acceptable limits for the applied design loads.

5.5.3 Design verification – fatigue assessment

The fatigue assessment is required to verify that the fatigue life of critical structural details is adequate. A simplified fatigue requirement is applied to details such as end connections of longitudinal stiffeners using stress concentration factors (SCF) to account the actual detail geometry. A fatigue assessment procedure using finite element analysis for determining the actual hot spot stress of the geometric detail is applied to selected details. In both cases, the fatigue assessment method is based on the Palmgren-Miner linear damage model.

5.5.4 Relationship between prescriptive scantling requirements and FE analysis

The scantlings defined by the prescriptive requirements are not to be reduced by any form of alternative calculations such as FE analysis, unless explicitly stated.

SECTION 3

VERIFICATION OF COMPLIANCE

1 GENERAL**1.1 Newbuilding****1.1.1**

For newbuildings, the plans and documents submitted for approval, as indicated in [2], are to comply with applicable requirements in these Rules, taking account of the relevant criteria, such as additional service features and classification notations assigned to the ship or the ship length.

1.1.2

When a ship is surveyed by the Society during construction, the Society:

- Approves the plans and documentation submitted as required by the Rules.
- Proceeds with the appraisal of the design of materials and equipment used in the construction of the ship and their inspection at works.
- Carries out surveys or obtains appropriate evidence to satisfy itself that the scantlings and construction meet the Rule requirements in relation to the approved drawings.
- Attends tests and trials provided for in the Rules.
- Assigns the classification character of the Society's notation.

1.1.3

The Society defines in specific Rules which materials and equipment used for the construction of ships built under survey are, as a rule, subject to appraisal of their design and to inspection at works, and according to which particulars.

1.1.4

As part of his/her interventions during ship's construction, the surveyor:

- Conducts an overall examination of the parts of the ship covered by the Rules.
- Examines the construction methods and procedures when required by the Rules.
- Checks selected items covered by the Rule requirements.
- Attends tests and trials where applicable and deemed necessary.

1.1.5

Through all stages of ship construction, it is the builder's responsibility to promptly inform the Society of modifications or departures from approved plans. The builder is to ensure that any deviations from the requirements of the Rules or approved plans are, in any case, accepted by the Society.

1.2 Ships in service**1.2.1**

For ships in service, the requirements in Ch 13 are to be complied with.

2 DOCUMENTS TO BE SUBMITTED

2.1 Documentation and data requirements

2.1.1 Loading information

Loading information containing sufficient information to enable the master of the ship to maintain the ship within the stipulated operational limitations is to be provided on board the ship. The loading information is to include an approved loading manual and loading instrument complying with the requirements given in Ch 1, Sec 5.

2.1.2 Calculation data and results

Where calculations have been carried out in accordance with the procedures given in the Rules, one copy of the following is to be submitted for information as applicable:

- a) Reference to the calculation procedure and technical program used.
- b) A description of the structural modelling.
- c) A summary of the analysed parameter including properties and boundary conditions for direct analysis, when applicable.
- d) Details of the loading conditions and the means of applying loads for direct analysis, when applicable.
- e) A comprehensive summary of calculation results.
- f) Sample calculations where appropriate.

The responsibility for error free specification and input of program data and the subsequent correct transposal of output resides with the designer.

Reference is made to Ch 7, Sec 1, [4.1] for required reporting of finite element analysis.

2.2 Submission of plans and supporting calculations

2.2.1 Plans and supporting calculations are to be submitted for approval

For the application of these Rules, the plans and supporting calculations to be submitted to the Society for approval are listed in Table 1.

Plans are to be submitted electronically or physically. When physically submitted plans are to be submitted in triplicate, with one copy necessary for supporting documents and calculations. In addition, the Society may request the submission of information, other plans and documents deemed necessary for the review of the design.

Structural plans are to show scantling, details of connection of the various parts and are to specify the design materials including, in general, their grades, manufacturing processes, welding procedures and heat treatments, and are to include information related to the renewal thickness as specified in Ch 13.

For welding requirements, see Ch 12, Sec 2 and Ch 12, Sec 3.

In case there are deviations from the design basis, then these are to be documented and submitted to the Society.

2.2.2 Plans to be submitted for information

In addition to those in [2.2.1], the following plans are to be submitted to the Society for information:

- a) General arrangement.
- b) Capacity plan, indicating the volume and position of the centre of gravity of all compartments and tanks.
- c) Lines plan, when deemed necessary by the Society.
- d) Hydrostatic curves.
- e) Lightweight distribution.
- f) Docking plan.
- g) Arrangement of lifting appliances

Table 1 : Plans and supporting calculation to be submitted for approval

Plan or supporting calculation	Containing also information on
Midship section Transverse sections Shell expansion Decks and profiles Double bottom Pillar arrangements Framing plan Deep tank and ballast tank bulkheads, Wash bulkheads Standard construction details	Class characteristics Ship's main dimensions Minimum ballast draught Frame spacing Maximum service speed Density of cargoes Design loads on decks and double bottom Steel grades Corrosion protection Openings in decks and shell and relevant compensations Boundaries of flat areas in bottom and sides Details of structural reinforcements and/or discontinuities Bilge keel with details of connections to hull structures Welding
Watertight subdivision bulkheads Watertight tunnels	Openings and their closing appliances, if any
Fore part structure	-
Aft part structure	-
Machinery space structures Foundations of propulsion machinery and boilers	Type, power and RPM of propulsion machinery Mass and centre of gravity of machinery and boilers
Superstructures and deckhouses Machinery space casing	Extension and mechanical properties of the aluminium alloy used (where applicable)
Hatch covers and hatch coamings	Design loads on hatch covers Sealing and securing arrangements, type and position of locking bolts Distance of hatch covers from the summer load waterline and from the fore end
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	-
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the freeboard deck and superstructure deck

Plan or supporting calculation	Containing also information on
Windows and side scuttles, arrangements and details	-
Scuppers and sanitary discharges	-
Mooring and towing arrangement	-
Supporting structure and foundations for shipboard fittings associated with mooring and towing operations	Design loads and directions of load actions, rated pull and holding load for mooring winches Reaction forces Details of connection of the foundations to the deck, including specifications for holding down bolts for mooring winches Material specifications and welding
Supporting structure and foundations for windlasses and chain stoppers	Design loads and directions of load actions Reaction forces Details of connection of the foundations to the deck, including specifications for holding down bolts for windlasses Material specifications and welding
Stern frame or sternpost, sterntube Propeller shaft boss and brackets ⁽¹⁾	-
Plan of watertight doors and scheme of relevant closing devices	Closing devices Electrical diagrams of power control and position indication circuits
Plan of weathertight or outer doors and hatchways	-
Supporting structure for lifting appliances	Design loads (forces and moments) SWL and self weight of lifting appliances Maximum sea state in offshore operation, if any Connections to the hull structures
Supporting structure for life saving appliances	Design loads (forces and moments) SWL and self weight of lifting appliances Connections to the hull structure
Sea chests, stabiliser recesses, etc	-
Plan of manholes	-
Plan of access to and escape from spaces	-
Plan of ventilation including ventilators and tank vents	Use of spaces and location and height of air vent outlets of various compartments
Plan of tank testing	Testing procedures for the various compartments Height of pipes for testing
Equipment number calculation	Geometrical elements for calculation List of equipment Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes
Anchoring arrangement	-
Hawse pipes	-
Loading manual and/or trim and stability booklet	-
(1) Where other steering or propulsion systems are adopted (e.g. steering nozzles or azimuth propulsion systems), the plans showing the relevant arrangement and structural scantlings are to be submitted.	

2.2.3 Plans and instruments to be supplied onboard the ship

As a minimum, the following plans and instrument are to be supplied onboard:

- a) One copy of the following plans indicating the newbuilding and renewal thickness for each structural item is to be supplied onboard the ship: plans of midship sections, construction profiles, shell expansion, transverse bulkheads, aft and fore part structures, machinery space structures.

One copy of the following plans indicating the newbuilding thickness for each structural item is to be supplied onboard the ship: plans of superstructures, deckhouses and casing.

- b) One copy of the final approved loading manual, see [2.1.1].
- c) One copy of the final approved loading instrument, see [2.1.1].
- d) Welding.
- e) Details of the extent and location of higher tensile steel together with details of the specification and mechanical properties, and any recommendations for welding, working and treatment of these steels.
- f) Details and information on use of special materials, such as an aluminium alloy, used in the hull construction.
- g) Towing and mooring arrangements plan, see Ch 11, Sec 3.
- h) Structural access manual.
- i) Structural details for which post weld treatment methods are applied, showing the description of the details and their locations.

Other plans or instrument may be required by the Society.

3 SCOPE OF APPROVAL**3.1 General****3.1.1**

The attention of owners, designers and builders is directed to the regulations of international, national, canal, and other authorities dealing with those requirements which may affect structural aspects, in addition to or in excess of the classification requirements.

3.1.2

The documentation, plans and data requirements specified in [2] are to be submitted. The Society is to review such documentation to verify compliance with the requirements.

3.1.3

An appropriate term to indicate that the plans, reports or documents have been reviewed for compliance with these Rules is to be used according to the procedures of the Society.

3.2 Requirements of international and national regulations**3.2.1 Responsibility**

It is the responsibility of the designer to ensure that the design complies with the national and international regulations applicable to the ship.

The Society is not responsible for assessing compliance with international and national regulations as part of the general classification process. However, the Society may enter into an agreement with the flag administration of the ship under which they are explicitly instructed to review and approve a ship design for compliance with specified regulations.

4 WORKMANSHIP

4.1 Requirements to be complied with by the manufacturer

4.1.1

The manufacturing plant is to be provided with suitable equipment and facilities to enable proper handling of the materials, manufacturing processes and structural components. The manufacturing plant is to have at its disposal sufficiently qualified personnel. The Society is to be advised of the names and areas of responsibility of the supervisory and control personnel in charge of the project.

4.2 Quality control

4.2.1

As far as required and expedient, the manufacturer's personnel has to examine all structural components both during manufacture and on completion, to verify that they are complete, that the dimensions are correct and that workmanship is satisfactory and meets the standard of good shipbuilding practice.

Upon inspection and corrections by the manufacturing plant, the structural components are to be shown to the surveyor of the Society for inspection, in suitable sections, normally unpainted condition and enabling proper access for inspection.

The Surveyor may reject components that have not been adequately checked by the plant and may demand their re-submission upon successful completion of such checks and corrections by the plant.

5 STRUCTURAL DETAILS

5.1 Details in manufacturing documents

5.1.1

Significant details concerning quality and functional ability of the component concerned are to be entered in the manufacturing documents (e.g. workshop drawing). This includes not only scantlings but, where relevant, such items as surface conditions (e.g. finishing of flame cut edges and weld seams), and special methods of manufacture involved as well as inspection and acceptance requirements and where relevant permissible tolerances. When a standard is used (works or national standard), it is to be submitted to the Society. For weld joint details, see Ch 12, Sec 2.

If, due to missing or insufficient details in the manufacturing documents, the quality or functional ability of the component is doubtful, the Society may require appropriate improvements to be submitted by the manufacturer. This includes the provision of supplementary or additional parts (for example, reinforcements) even if these were not required at the time of plan approval.

6 EQUIVALENCE PROCEDURES

6.1 Rule applications

6.1.1

These Rules apply to ships of normal form, proportions, speed and structural arrangements. Relevant design parameters defining the assumptions made are given in Ch 1, Sec 2, [3].

6.1.2

Special consideration is to be given to the application of the Rules incorporating design parameters which are outside the design basis as specified in Ch 1, Sec 2, [3], for example, increased fatigue life.

6.2 Novel designs

6.2.1

Ships of novel design, i.e. those of unusual form, proportions, speed and structural arrangements outside those specified in Ch 1, Sec 2, [3.2], are specially considered according to the contents of [6.2.2] to [6.2.4].

6.2.2

Information is to be submitted to the Society to demonstrate that the structural safety of the novel design is at least equivalent to that intended by the Rules.

6.2.3

In such cases, the Society is to be contacted at an early stage in the design process to establish the applicability of the Rules and additional information required for submission.

6.2.4

Dependent on the nature of the deviation, a systematic review may be required to document equivalence with the Rules.

6.3 Alternative calculation methods

6.3.1

Where indicated in specific sections of the Rules, alternative calculation methods to those shown in the Rules may be accepted provided it is demonstrated that the scantling and arrangements are of at least equivalent strength to those derived using the Rules.

SECTION 4

SYMBOLS AND DEFINITIONS

1 PRIMARY SYMBOLS AND UNITS

1.1 General

1.1.1

Unless otherwise specified, the general symbols and their units used in these Rules are those defined in Table 1.

Table 1 : Primary symbols

Symbol	Meaning	Units
A	Area	m^2
	Sectional area of stiffeners and primary members	cm^2
C	Coefficient	-
F	Force and concentrated loads	kN
I	Hull girder inertia	m^4
	Inertia of stiffeners and primary members	cm^4
M	Bending moment	kNm
M	Mass	t
P	Pressure	kN/m^2
Q	Shear force	kN
T	Draught of ship, see [3.1.5]	m
Z	Hull girder section modulus	m^3
	Section modulus of stiffeners and primary supporting members	cm^3
a_i	Acceleration for the effect 'i'	m/s^2
b	Width of attached plating	mm
	Width of face plate of stiffeners and primary supporting members	mm
g	Gravity acceleration, taken equal to $9.81 m/s^2$	m/s^2
h	Height	m
	Web height of stiffeners and primary supporting members	mm
ℓ	Length/span of stiffeners and primary supporting members	m
n	Number of items	-
r	Radius	mm
	Radius of curvature of plating or bilge radius	mm
t	Thickness	mm
x	X coordinate along longitudinal axis, see [3.6]	m
y	Y coordinate along transverse axis, see [3.6]	m

Symbol	Meaning	Units
z	Z coordinate along vertical axis, see [3.6]	m
η	Permissible utilisation factor (usage factor)	-
γ	Safety factor	-
δ	Deflection/displacement	mm
θ	Angle	deg
ρ	Density of seawater, taken equal to 1.025 t/m ³	t/m ³
σ	Normal stress	N/mm ²
τ	Shear stress	N/mm ²

2 SYMBOLS

2.1 Ship's main data

2.1.1

Unless otherwise specified, symbols regarding ship's main data and their units used in these Rules are those defined in Table 2.

Table 2 : Ship's main data

Symbol	Meaning	Units
L	Rule length	m
L_{LL}	Freeboard length	m
L_{PP}	Length between perpendiculars	m
L_0	Rule length, L , but not to be taken less than 110 m	m
L_1	Rule length, L , but need not be taken greater than 250 m	m
L_2	Rule length, L , but need not be taken greater than 300 m	m
B	Moulded breadth of ship	m
D	Moulded depth of ship	m
T	Moulded draught	m
T_{SC}	Scantling draught	m
T_{BAL}	Ballast draught (minimum midship)	m
T_{BAL-H}	Heavy ballast draught	m
T_{BAL-E}	Emergency ballast draught or gale ballast draught	m
T_{LC}	Midship draught at considered loading condition	m
T_{F-F} , T_{F-E}	Minimum draught at forward perpendicular for bottom slamming, with respectively all ballast tanks full or with any tank empty in bottom slamming area	m
Δ	Moulded displacement at draught T_{SC}	t
C_B	Block coefficient at draught T_{SC}	-
V	Maximum service speed	knot
x, y, z	X,Y, Z coordinates of the calculation point with respect to the reference coordinate system	m

2.2 Materials

2.2.1

Unless otherwise specified, symbols regarding materials and their units used in these Rules are those defined in Table 3.

Table 3 : Materials

Symbol	Meaning	Units
E	Young's modulus, see Ch 3, Sec 1, [2]	N/mm ²
G	Shear modulus, $G = \frac{E}{2(1 + \nu)}$	N/mm ²
R_{eH}	Specified minimum yield stress, see Ch 3, Sec 1, [2]	N/mm ²
τ_{eH}	Specified shear yield stress, $\tau_{eH} = \frac{R_{eH}}{\sqrt{3}}$	N/mm ²
ν	Poisson's ratio, see Ch 3, Sec 1, [2]	-
k	Material factor, see Ch 3, Sec 1, [2]	-
R_m	Specified minimum tensile strength, see Ch 3, Sec 1, [2]	N/mm ²
R_Y	Nominal yield stress, taken equal to 235/k	N/mm ²

2.3 Loads

2.3.1

Unless otherwise specified, symbols regarding loads and their units used in these Rules are those defined in Table 4.

Table 4 : Loads

Symbol	Meaning	Units
C_w	Wave coefficient	-
T_θ	Roll period	s
θ	Roll angle	deg
T_ϕ	Pitch period	s
ϕ	Pitch angle	deg
a_o	Common acceleration parameter	-
a_z	Vertical acceleration	m/s ²
a_y	Transverse acceleration	m/s ²
a_x	Longitudinal acceleration	m/s ²
f_p	Probability factor	-
k_r	Roll amplitude of gyration	m
GM	Metacentric height	m
λ	Wave length	m
S	Static load case	-
$S+D$	Dynamic load case	-
P_{ex}	Total sea pressure, see Ch 4, Sec 5, [1.1]	kN/m ²

Symbol	Meaning	Units
P_{in}	Total internal pressure due to liquid, see Ch 4, Sec 6, [1], or due to dry bulk cargo, see Ch 4, Sec 6, [2.4.1]	kN/m ²
P_s	Static sea pressure	kN/m ²
P_{ls}	Static tank pressure	kN/m ²
P_w	Dynamic wave pressure	kN/m ²
P_{ld}	Dynamic tank pressure	kN/m ²
P_D	Green sea deck pressure	kN/m ²
P_{slh-j}	Sloshing pressure, j =direction	kN/m ²
P_{dl}	Total pressure due to distributed load on deck or platform, see Ch 4, Sec 5, [2.3] or Ch 4, Sec 6, [5.2]	kN/m ²
P_{SL}	Bottom slamming pressure	kN/m ²
P_{FB}	Bow impact pressure	kN/m ²
P_{fs}	Static pressure in flooded conditions	kN/m ²
P_{fd}	Dynamic pressure in flooded conditions	kN/m ²
P_{ST}	Tank testing pressure (static)	kN/m ²
F_U	Total force due to concentrated load on deck or platform, see Ch 4, Sec 5, [2.3] or Ch 4, Sec 6, [5.3]	kN
M_{sw-j}	Vertical still water bending moment, $j = h, s, p$ (hog, sag, harbour)	kNm
Q_{sw}	Vertical still water shear force	kN
M_{wv-j}	Vertical wave bending moment, $j = h, s$ (hog, sag)	kNm
Q_{wv}	Vertical wave shear force	kN
M_{wt}	Torsional wave moment	kNm
M_{wh}	Horizontal wave bending moment	kNm

2.4 Scantlings

2.4.1

Unless otherwise specified, symbols regarding scantlings and their units used in these Rules are those defined in Table 5.

Table 5 : Scantlings

Symbol	Meaning	Units
I_{y-n50}	Net vertical moment of inertia of hull girder	m ⁴
I_{z-n50}	Net horizontal moment of inertia of hull girder	m ⁴
Z_{D-n50}, Z_{B-n50}	Net vertical hull girder section moduli, at deck and bottom respectively	m ³
z_n	Vertical distance from BL to horizontal neutral axis	m
a	Length of EPP, as defined in Ch 3, Sec 7, [2.1.1]	mm
b	Breadth of EPP, as defined in Ch 3, Sec 7, [2.1.1]	mm
s	Stiffener spacing (see Ch 3, Sec 7, [1.2.1])	mm
S	Primary supporting member spacing (see Ch 3, Sec 7, [1.2.2])	m
ℓ	Span of stiffeners or primary supporting member (see Ch 3, Sec 7, [1])	m
ℓ_b	Bracket arm length	m