
**Ships and marine technology — Ship
structures —**

**Part 1:
General requirements for their limit state
assessment**

Navires et technologie maritime — Structures des navires —

Partie 1: Exigences générales pour l'évaluation de l'état limite ultime



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18072-1 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Structures*.

ISO 18072 consists of the following parts, under the general title *Ships and marine technology — Ship structures*:

- *Part 1: General requirements for their limit state assessment*
- *Part 2: Requirements for their ultimate strength limit state assessment*

ISO/CD 18072-2 is under development by the same working group as ISO 18072-1 (WG 3 of SC 8), while two separate working groups will be established later to develop the rest of the ISO 18072 series, namely ISO 18072-3, *Requirements for their fatigue limit state assessment* and ISO 18072-4, *Requirements for their accidental limit state assessment*.

Introduction

The ISO 18072 series of standards constitutes a common basis for addressing the limit state assessment of ship structures.

It uses the limit state approach rather than the allowable (working) stress approach, since it is now well recognized that the former is a more rational basis than the latter for determining true safety margins of structures. The ability to correctly determine the safety margin is a key to the ability to design a safe, yet economical structure.

Traditional design methods and standards have been based largely on working stress concepts. The standards used by Classification Societies, shipbuilders, and others have evolved over many years, and incorporate analytical methods, as well as experience gained from ships in service. Because the limit state approach explicitly addresses the concept of safety margin, its results differ in some areas compared to those of the working stress approach. Both approaches provide safe and reliable structures, if used appropriately, although neither will guarantee freedom from failures or structural problems. In either approach, a rigorous programme of inspection and maintenance during construction and periodically thereafter, and operational guidelines, supplement the design criteria and assumptions to provide an acceptable level of structural safety throughout a ship's service life.

The ISO 18072 series of standards is intended to serve as a basis for quantitatively defining a consistent and realistic safety margin for ship structures. An ability to more rationally assess the true margin of safety should also lead to improvements in related regulations and design requirements as well. Through its application, the intention is to achieve levels of structural integrity appropriate for ship structures, whatever the nature or combination of the materials used.

This part of ISO 18072 addresses general requirements for the assessment of ship structures based on four types of limit state, namely, serviceability limit state (SLS), ultimate limit state (ULS), fatigue limit state (FLS) and accidental limit state (ALS), while the other parts of ISO 18072 will address specific requirements for these different limit states.

The assessments in accordance with these limit states necessarily require definitions of loading, analysis, materials and construction standards. In-service inspections are prescribed as appropriate in each part of ISO 18072.

It is clear that a strength assessment is closely related to structural design. However, the initial determination of structural dimensions and scantlings is not included in the ISO 18072 series, it being presumed that procedures and guidelines for these are provided in detail elsewhere, such as in the relevant rules and regulations of classification societies or regulatory bodies' requirements.

While ISO 18072 has been prepared in accordance with the principles described in ISO 2394 and ISO 19900:2002, such principles have been extended as necessary to deal with those specific to ship structures.

Ships and marine technology — Ship structures —

Part 1: General requirements for their limit state assessment

1 Scope

This part of ISO 18072 provides general requirements for the limit state assessment of ship structures primarily used in the transport of commercial goods and cargos. For the purposes of assessment, the effects of actions on ship structures are considered in respect of the following limit states: serviceability, ultimate, fatigue and accidental.

The requirements of this part of ISO 18072 are applicable to global ship structures, as well as the structural components and details forming such structures. The requirements are applicable during the design, construction and operation of ship structures. The requirements are also applicable to the conversion of existing structures. Aspects related to quality control and quality assurance are also addressed.

Whilst the major part of this document assumes the use in an assessment of a partial-factor approach, an approach based on probabilistic methods may also be adopted.

Whilst compliance with the requirements of this and other parts of ISO 18072 may be used to demonstrate the structural adequacy of a ship structure or its component, compliance with other international and national standards, rules and regulations is required, as applicable to the ship considered. The ship owner is responsible for ensuring compliance with all such standards, rules and regulations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2394, *General principles on reliability for structures*

ISO 19900:2002, *Petroleum and natural gas industries — General requirements for offshore structures*

ISO 19904-1:2006, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Monohulls, semi-submersibles and spars*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2394, ISO 19900 and ISO 19904-1 apply, except as provided for below. For convenience, some important terms and definitions given in ISO 2394, ISO 19900 or ISO 19904-1 are repeated below, in which case the source is identified in square brackets.

3.1
abnormal
condition that exceeds conventionally specified design conditions and which is used to mitigate against very remote events

[ISO 19904-1:2006]

3.2
accidental design situation
design situation involving exceptional conditions of the structure or its exposure

EXAMPLE Impact, fire, explosion, local failure or loss of intended differential pressure (e.g. buoyancy).

[ISO 19904-1:2006]

3.3
action
external load applied to the structure (direct action) or an imposed deformation or acceleration (indirect action)

EXAMPLE An imposed deformation can be caused by fabrication tolerances, settlement or temperature change.

[ISO 19900:2002]

3.4
action effect
effect of actions on a global structure or structural component

EXAMPLE Internal forces, moments, elastic deformations, stresses, strains or rigid body motions.

3.5
aged structure
an existing structure which suffers age-related deterioration such as corrosion and fatigue cracks

3.6
assessment situation
set of physical conditions during a certain reference period for which the structure demonstrates that relevant limit states are not exceeded

3.7
basic variable
one of a specified set of variables representing physical quantities which characterize actions, material properties or geometrical parameters

3.8
characteristic value
value assigned to a basic variable or action or resistance model which has a prescribed probability of not being violated by unfavourable values

NOTE 1 In the case of an action or action variable, the value normally relates to a reference period.

NOTE 2 In some situations, a variable or model can have two characteristic values, an upper and a lower value.

3.9**design criteria**

quantitative formulations that describe the conditions to be fulfilled for each limit state

3.10**design service life**

assumed period for which a structure or a structural component is to be used for its intended purpose with anticipated maintenance, but without substantial repair being necessary

[ISO 19904-1:2006]

3.11**design situation**

set of physical conditions during a certain reference period for which the design demonstrates that relevant limit states are not exceeded

[ISO 19904-1:2006]

3.12**design value**

value of a basic variable or action or strength model derived from a representative value for use in a design verification procedure

NOTE 1 For a ULS design check, a design value for a strength variable or model is found by dividing the representative value of strength by a partial resistance factor, while for an action variable it is found by multiplying the representative value of the action effect by a partial action factor.

NOTE 2 For an FLS, SLS or ALS design check in accordance with the partial-factor design format, all partial factors are equal to unity so that, in these cases, a design value is equal to the representative value.

NOTE 3 In the case of actions and related properties, the value can relate to a reference period.

[ISO 19904-1:2006]

3.13**dynamic action**

action that induces motions and accelerations in a structure or a structural component of a magnitude sufficient to require specific consideration

EXAMPLE Action effects arising from slamming or sloshing.

3.14**extreme action**

maximum action applied to a structure during its design service life

EXAMPLE Extreme environmental action.

3.15

fit-for-purpose, adjective

fitness-for-purpose, noun

meeting the intent of a standard although not meeting specific provisions of that standard in local areas, such that failure in these areas cannot cause unacceptable risk to life-safety or the environment

[ISO 19904-1:2006]

3.16**global structure**

an entire structure or an assembly of structural components

3.17

green water

overtopping of deck by water causing slamming and pressure actions to structures on deck

3.18

limit state

condition beyond which a structure or structural component no longer fulfils relevant design criteria

3.19

merchant cargo ship

a ship carrying merchant cargoes

3.20

nominal value

value assigned to a basic variable or action or strength model determined on a non-statistical basis, typically from acquired experience or physical conditions

EXAMPLE Value published in a recognized code or standard.

NOTE Adapted from ISO 19904-1:2006.

3.21

partial factor

a factor normally greater than unity applied to a representative value of a strength or action to determine its corresponding design value

EXAMPLE Partial action factor, partial resistance factor.

3.22

reference period

period of time used as basis for determining values of basic variables and action models

NOTE This term normally only applies to basic variables related to actions or action effects.

3.23

reliability

ability of a structure or a structural component to fulfil the specified requirements

[ISO 19900:2002]

3.24

repetitive actions

repeatedly applied actions

3.25

representative value

value assigned to a basic variable or action or strength model for verification of a limit state

NOTE 1 The representative value can equal a characteristic value, a nominal value, or other rationally determined value.

NOTE 2 For actions, this can relate to upper or lower characteristic values, dependent on which causes the more onerous condition. In combinations, it can involve multiplying the chosen value by a factor greater or less than unity.

NOTE 3 Adapted from ISO 19904-1:2006.

3.26**return period**

average period between occurrences of an event or of a particular value being exceeded

NOTE For environmental events, much engineering design and assessment commonly use the return period measured in years. The return period is equal to the reciprocal of the annual probability of exceedance of the event.

[ISO 19904-1:2006]

3.27**safety margin**

a difference between structural strength and maximum value of an action effect, by which a structure or component reserve with respect to failure can be quantified

3.28**scrapping**

process of decommissioning a structure and removing hazardous materials at the end of its service life

3.29**slamming**

impulsive action with high-pressure peaks that occurs during impact between a portion of the structure and water

NOTE 1 Bottom slamming occurs when the ship's bottom emerges from the water because of pitching, possibly combined with the occurrence of a wave trough. Bow-flare slamming occurs when the upper flared portion of the bow plunges into the water.

NOTE 2 A slamming action to the deck structure is generally referred to as green water.

3.30**sloshing**

actions arising from the motion of liquids in partially filled tanks

3.31**stability****hydrostatic stability**

ability of a floating structure to generate righting moment after deviation from the equilibrium floating position

3.32**still-water actions**

differences between weight and buoyancy effects on a stationary structure

3.33**structural component**

structural element, any sub-structure or physically distinguishable part of a structure

EXAMPLE Column, beam, stiffeners, plating, stiffened panel.

3.34**structural failure**

insufficient strength or inadequate serviceability of a structure or structural component or, in a structural check, a condition in which a structure or component thereof does not fulfil its limit state requirement

NOTE Adapted from ISO 19904-1:2006.

3.35

structural resistance

capacity of a structure, component or cross-section of a component to withstand action effects without exceeding a limit state

NOTE 1 Structural resistance is a particular value of structural strength.

NOTE 2 Adapted from ISO 19904-1:2006.

3.36

structural strength

mechanical property of a material indicating its ability to resist actions, usually given in units of stress

3.37

structural system

load-bearing components of a structure and the way in which these components function together

[ISO 19900:2002]

3.38

structure

organized combination of connected parts designed to withstand actions and provide adequate strength, rigidity and stability

3.39

uncertainty

a general description of the randomness of a basic variable or action or strength model which, when quantified, provides a basis by which characteristic values and partial action and strength factors can be determined

EXAMPLE Bias, standard deviation.

4 Symbols and abbreviated terms

NOTE The symbols used generally are listed below. Those which are not general and which are used only in one clause (and are explained there) are not listed.

4.1 Symbols

A	accidental action
a_d	design value of geometrical parameter
a_r	representative value of geometrical parameter
C	SLS constraint
E	environmental action
f_d	design value of material strength
f_r	representative value of material strength
F_d	design value of action
F_r	representative value of action
G	permanent action

G_r	representative value of permanent action
g	limit state function
Q	variable action
Q_k	characteristic value of variable action
Q_r	representative value of variable action
R_d	design value of component strength
R_r	representative value of component strength
γ_d	factor related to model uncertainty or other circumstances that are not taken into account by other γ values
γ_f	partial action factor, the value of which reflects the uncertainty or randomness of the action
γ_m	partial material factor, the value of which reflects the uncertainty or variability of the material property
γ_n	factor by which the importance of the structure and the consequences of failure, including the significance of the type of failure, may be taken into account and whose value depends on the design situation under consideration
γ_R	partial resistance factor, the value of which reflects the uncertainty or variability of the component strength as a function of material properties
Δa	additive partial geometrical quantity, the value of which reflects the uncertainties of the geometrical parameter
ψ_0	knock-down factor to account for the reduced likelihood of independent actions simultaneously achieving their maximum values
ψ_1, ψ_2	factors relating characteristic values to representative values for variable actions

4.2 Abbreviated terms

ALS	accidental limit states
CP	cathodic protection
FLS	fatigue limit states
SLS	serviceability limit states
ULS	ultimate limit states

5 General requirements and conditions

5.1 Fundamental requirements

Ship structures are subjected to various types of actions and action effects during construction, in-service and dry-docking, and during related maintenance activities, that range from normal to extreme, abnormal and accidental.

A ship structure and its structural components shall be designed, constructed and maintained so that it performs its intended functions against such actions and effects during its design service life while maintaining floating stability. In particular, it shall fulfil the following performance requirements with appropriate degrees of reliability:

- perform adequately under all expected actions (SLS requirement);
- withstand actions liable to occur during its construction and design service life (ULS requirement);
- does not fail under repetitive actions (FLS requirement);
- subsequent to accidental or abnormal events, shall not be damaged disproportionately to the original cause and shall maintain its structural integrity for a sufficient period under specified environmental conditions (ALS requirement).

Appropriate degrees of structural reliability depend upon:

- the cause and mode of structural failure;
- the possible consequences of structural failure in terms of risk to life, environment and property;
- the expense and effort required to reduce the risk of structural failure;
- different requirements at national, regional or local level.

This part of ISO 18072 presents requirements for ship structures and their components so that the above requirements are fulfilled during construction and design service life.

In the process of limit state assessment, this part of ISO 18072 assumes that the ship structure has been well built, operated and maintained in accordance with either classification requirements and/or other standards.

5.2 Functional requirements

Ships can be categorized depending on their primary functions, for example:

- to transport goods and cargoes;
- to transport passengers;
- to provide military capability;
- to provide fishing;
- to provide dredging;
- to provide recreation;
- to provide supporting services to other ships;
- to provide a platform for scientific research or other miscellaneous functions.

This part of ISO 18072 primarily deals with the general requirements for ships that transport goods and cargoes, although it is readily applicable to other categories of ships. The requirements include those associated with the loading and discharging (unloading) of such goods and cargoes.

Particular functional requirements shall be established for each ship taking account of the goods and cargoes to be transported and operational conditions, for which appropriate design situations shall be established and corresponding design criteria provided.

5.3 Materials and structure

Suitable materials shall be specified. In addition to strength, attention shall be paid to ductility or toughness, weldability, and corrosion resistance requirements.

Failure in a structure should occur in a ductile manner rather than a brittle manner. Avoiding brittle failure leads to a structure that does not collapse suddenly, because ductility allows a structure to redistribute internal forces and thus absorbs more energy prior to failure. Adequate ductility in the design of a structure shall be facilitated by:

- meeting requisite material-toughness requirements;
- avoiding failure initiation situations of combined high stress concentrations and undetected weld defects in structural components and details;
- designing structural details and connections, so as to allow a certain amount of plastic deformation, i.e. avoiding “hard spots”;
- arranging the scantlings of structures and their components so as to avoid sudden changes in structural strength or stiffness.

5.4 Structural configuration

5.4.1 General

The choice of the structural system shall be made such that the primary structure is able to maintain adequate structural integrity during normal service and after specified situations that apply actions on the structure. The choice of materials, detailing and method of construction, as well as quality assurance, can influence structural integrity.

5.4.2 Structural scantlings

The initial determination of structural dimensions and scantlings can be made in accordance with the relevant rules and regulations of classification societies or regulatory body requirements.

Calculations based on first principles may also be applied for the structural scantlings.

5.4.3 Hydrostatic stability

Ship floating behaviour shall be consistent with the requirements for stability in intact and damaged configurations, in accordance with recognized standards.

When recognized standards are used to verify stability adequacy, consideration shall also be given to the consequences of the accidental events identified as being relevant for the structure, see 5.9.2.

5.4.4 Compartmentation

Ship structures shall be subdivided into water-/oil-tight compartments by bulkheads to limit the consequences of unintended flooding (see 5.10.4.4). Such bulkheads should be assessed for adequacy to prevent progressive flooding.

The amount of compartmentation shall be determined, based on special conditions and protection measures that can be used to prevent flooding. A risk assessment can assist in this determination.