



BSI Standards Publication

Petroleum and natural gas industries - Floating offshore structures

Part 1: Ship-shaped, semi-submersible, spar and
shallow-draught cylindrical structures

National foreword

This British Standard is the UK implementation of EN ISO 19904-1:2019. It is identical to [ISO 19904-1:2019](#). It supersedes [BS EN ISO 19904-1:2006](#), which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/525/12, Design of offshore structures.

A list of organizations represented on this committee can be obtained on request to its secretary.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN ISO 19904-1:2019) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2019, and conflicting national standards shall be withdrawn at the latest by December 2019.

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

This document supersedes EN ISO 19904-1:2006.

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The text of [ISO 19904-1:2019](#) has been approved by CEN as EN ISO 19904-1:2019 without any modification.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

This second edition cancels and replaces the first edition (ISO 19904-1:2006), which has been technically revised. The main changes compared to the previous edition are as follows:

- title has been modified by replacing 'monohulls' with 'ship-shaped' and adding 'shallow-draft cylindrical structures';
- list of normative references (Clause 2) has been expanded;
- some definitions have changed and some new terms and definitions (Clause 3) have been added;
- subclause on planning requirements (5.3) has been expanded by addressing inspection and maintenance philosophy (5.3.5), documentation (5.3.6), extreme weather preparedness (5.3.7), and disconnectible floating platforms (5.3.8);
- subclause on use for project application (5.4.2) has been expanded with a paragraph regarding documentation for disconnectable floating platforms;
- new subclause on topsides arrangement and layout (5.5.9) has been added;
- subclause on air gap (8.10) has been renamed to air gap and wave crest assessment, and a new subclause addressing wave crest effects (8.10.2) has been added;
- subclause on material (9.9) has been expanded by addressing cement grout (9.9.5) and elastomeric materials (9.9.6);
- subclause on corrosion protection of steel (9.10) has been rewritten substantially;
- subclause on fabrication and constructions (9.11) has been expanded by addressing fabrication details (9.11.3) and welding (9.11.4);

- subclause on general aspects of fatigue analysis and design ([10.1](#)) has been expanded by adding a discussion on fatigue strength and actions;
- subclause on general aspects of ship-shaped structures ([11.1](#)) has been expanded;
- subclause on sloshing ([11.2.3](#)) has been expanded by addressing general configuration of tanks and resonance due to sloshing;
- subclause on green water ([11.2.4](#)) has been expanded;
- subclause on structural strength ([11.3](#)) has been expanded by elaborating on the evaluation of hull girder strength ([11.3.1](#)) and local strength and details ([11.3.4](#));
- subclause on general design criteria for semi-submersibles ([12.2](#)) has been expanded;
- new clause addressing shallow-draft cylindrical structures ([Clause 14](#)) has been added;
- subclause on watertight and weathertight appliances ([16.4](#)) has been expanded;
- subclause on hull systems ([17.2](#)) has been expanded by addressing atmospheric tanks ([17.2.5.2](#)) and water displaced tanks ([17.2.5.3](#)), elaborating on inert gas systems ([17.2.6](#)) and addressing production vent/flare system ([17.2.8](#)) and electrical systems ([17.2.9](#));
- subclause on import and export systems ([17.3](#)) has been expanded by elaborating on general aspects ([17.3.1](#)), alongside transfer ([17.3.3.3](#)) and tandem transfer ([17.3.3.4](#)) and addressing direct transfer ([17.3.3.5](#));
- clause on stationkeeping systems ([18](#)) has been expanded by addressing disconnectable structures ([18.4](#));
- subclause on structural integrity management system philosophies ([19.2](#)) has been expanded by elaborating on general aspects, including the addition of a figure ([19.2.1](#));
- new clause addressing assessment of existing floating structures ([Clause 20](#)) has been added;
- additional information and guidance ([Annex A](#)) has been modified with additions and changes in line with modifications to the main text;
- the list of informative references (Bibliography) has been updated and expanded as needed.

A list of all parts in the ISO 19904 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The International Standards on offshore structures prepared by TC 67 (i.e., [ISO 19900](#), the ISO 19901 series, [ISO 19902](#), [ISO 19903](#), the ISO 19905 series and [ISO 19906](#)) constitute a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum, petrochemical and natural gas industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the type of structure and the nature or combination of materials used.

It is important to recognize that structural integrity is an overall concept comprising models for describing actions, structural analyses, design rules, safety elements, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one aspect of design in isolation can disturb the balance of reliability inherent in the overall concept or structural system. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

The International Standards on offshore structures prepared by TC are intended to provide wide latitude in the choice of structural configurations, materials and techniques without hindering innovation. Sound engineering judgement is therefore necessary in the use of these documents.

This document was developed in response to the offshore industry's demand for a coherent and consistent definition of methodologies to design, analyse and assess floating offshore structures of the class described in [Clause 1](#). Further applicable requirements are found in national and international codes and standards, and RCS rules.

Some background to, and guidance on, the use of this document is provided in informative [Annex A](#). The clause numbering in [Annex A](#) is the same as in the normative text to facilitate cross-referencing.

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Petroleum and natural gas industries - Floating offshore structures —

Part 1: Ship-shaped, semi-submersible, spar and shallow-draught cylindrical structures

1 Scope

This document provides requirements and guidance for the structural design and/or assessment of floating offshore platforms used by the petroleum and natural gas industries to support the following functions:

- production;
- storage and/or offloading;
- drilling and production;
- production, storage and offloading;
- drilling, production, storage and offloading.

NOTE 1 Floating offshore platforms are often referred to using a variety of abbreviations, e.g. FPS, FSU, FPSO (see [Clauses 3](#) and [4](#)), in accordance with their intended mission.

NOTE 2 In this document, the term “floating structure”, sometimes shortened to “structure”, is used as a generic term to indicate the structural systems of any member of the classes of platforms defined above.

NOTE 3 In some cases, floating platforms are designated as “early production platforms”. This term relates merely to an asset development strategy. For the purposes of this document, the term “production” includes “early production”.

This document is not applicable to the structural systems of mobile offshore units (MOUs). These include, among others, the following:

- floating structures intended primarily to perform drilling and/or well intervention operations (often referred to as MODUs), even when used for extended well test operations;
- floating structures used for offshore construction operations (e.g. crane barges or pipelay barges), for temporary or permanent offshore living quarters (floatels), or for transport of equipment or products (e.g. transportation barges, cargo barges), for which structures reference is made to relevant recognized classification society (RCS) rules.

This document is applicable to all possible life-cycle stages of the structures defined above, such as:

- design, construction and installation of new structures, including requirements for inspection, integrity management and future removal,
- structural integrity management covering inspection and assessment of structures in-service, and
- conversion of structures for different use (e.g. a tanker converted to a production platform) or re-use at different locations.

The following types of floating structure are explicitly considered within the context of this document:

- a) ship-shaped structures and barges;
- b) semi-submersibles;
- c) spars;
- d) shallow-draught cylindrical structures.

In addition to the structural types listed above, this document covers other floating platforms intended to perform the above functions, consisting of partially submerged buoyant hulls made up of any combination of plated and space frame components. These other structures can have a great range of variability in geometry and structural forms (e.g. tension leg platforms) and, therefore, can be only partly covered by the requirements of this document. In other cases, specific requirements stated in this document can be found not to apply to all or part of a structure under consideration.

NOTE 4 Requirements for topsides structures are presented in [ISO 19901-3](#).

In the above cases, conformity with this document requires the design to be based upon its underpinning principles and to achieve a level of safety equivalent, or superior, to the level implicit in it.

NOTE 5 The speed of evolution of offshore technology often far exceeds the pace at which the industry achieves substantial agreement on innovation in structural concepts, structural shapes or forms, structural components and associated analysis and design practices, which are continuously refined and enhanced. On the other hand, International Standards can only capture explicit industry consensus, which requires maturation and acceptance of new ideas. Consequently, advanced structural concepts can, in some cases, only be partly covered by the requirements of this document.

This document is applicable to steel floating structures. The principles documented herein are, however, considered to be generally applicable to structures fabricated in materials other than steel.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 13702](#), *Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines*

[ISO 19900](#), *Petroleum and natural gas industries — General requirements for offshore structures*

[ISO 19901-1](#), *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations*

[ISO 19901-3](#), *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 3: Topsides structure*

[ISO 19901-6](#), *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 6: Marine operations*

[ISO 19901-7](#), *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

[ISO 19902](#), *Petroleum and natural gas industries — Fixed steel offshore structures*

[ISO 19906](#), *Petroleum and natural gas industries — Arctic offshore structures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

abnormal value

value of an environmental parameter used in accidental limit state verification in which a *structure* (3.59) is not expected to suffer significant loss of integrity

Note 1 to entry: Abnormal situations are used to provide robustness against events with an annual probability of exceedance typically between 10^{-3} and 10^{-4} to avoid, for example, excessive deformations.

Note 2 to entry: In ALS verification, all the partial factors are set to 1,0.

[SOURCE: ISO 19901-1:2015, 3.1, modified]

3.2

accidental event

event involving exceptional conditions of the *structure* (3.59) or its exposure

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

3.3

action

external load applied to the *structure* (3.59) (direct action) or an imposed deformation or acceleration (indirect action)

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

Note 1 to entry: An earthquake typically generates imposed accelerations.

[SOURCE: ISO 19900:2013, 3.3]

3.4

action combination

values of different *actions* (3.3) considered simultaneously in *verification* (3.61) of the *structure* (3.59)

3.5

action effect

effect of *actions* (3.3) on a *structure* (3.59) or on *structural components* (3.57)

EXAMPLE Internal force, moment, stress, strain, rigid body motion or elastic deformation.

[SOURCE: ISO 19900:2013, 3.4, modified — "on a structure or" has been added to the definition and examples have been added.]

Note 1 to entry: Can be used interchangeably with the word "response".

3.6

air gap

clearance between the highest water or ice surface that occurs during abnormal metocean or ice conditions and the lowest exposed part of the *topsides* (3.60) not designed to withstand wave or ice impingement

[SOURCE: ISO 19900:2013, 3.5, modified — Definition has been rephrased.]

Note 1 to entry: Minimum values of air gap are normally specified for ULS and ALS (abnormal situations).

3.7

basic variable

one of a specified set of variables representing physical quantities which characterize *actions* (3.3), environmental influences, geometrical quantities, or material properties, including soil properties

[SOURCE: ISO 19900:2013, 3.7]

3.8

characteristic value

value of a *basic variable* (3.7), an *action* (3.3) or a strength model associated with a prescribed probability of not being violated by unfavourable values

Note 1 to entry: In some design situations, a variable can have two characteristic values, an upper and a lower value.

[SOURCE: ISO 19900:2013, 3.10, modified — Definition and Note 1 to entry have been rephrased.]

Note 2 to entry: In the case of actions and related properties, the characteristic value normally relates to a reference period.

3.9

classification

class

process by which a classification society defines a vessel's type and permitted use, determines necessary certification, and specifies associated inspection and survey regimes

Note 1 to entry: Vessels that have been subject to this process and that obtained the corresponding certificate are referred to as being in 'class'.

3.10

design criteria

quantitative formulations that describe the conditions to be fulfilled for each *limit state* (3.30)

[SOURCE: ISO 19900:2013, 3.15]

3.11

design format

mathematical description for *verification* (3.61) of non-exceedance of a *limit state* (3.30)

Note 1 to entry: In this document, both partial factor and working stress design (WSD) formats are permitted.

3.12

design service life

assumed period for which a *structure* (3.59) is to be used for its intended purpose with anticipated maintenance, but without substantial repair being necessary

[SOURCE: ISO 19900:2013, 3.16, modified — 'to be' has been added.]

3.13

design situation

set of *actions* (3.3) and combination of actions representing real conditions during a certain time interval, for which relevant *limit states* (3.30) are not exceeded

3.14

design value

value of a *basic variable* (3.7), an *action* (3.3) or a strength model derived from its *representative value* (3.41) for use in *verification* (3.61)

[SOURCE: ISO 19900:2013, 3.18, modified — Definition has been rephrased.]

Note 1 to entry: For action variables, the design value is found by multiplying the representative value by a partial action factor while for strength variables, the design value is found by dividing the representative value by a partial resistance factor.

Note 2 to entry: For FLS, SLS or ALS verification 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 to entry: For verification in accordance with the working stress design format, all partial factors are equal to unity so that, in these cases, a design value is equal to the representative value. Appropriate global safety or utilization factors are applied in verification.

Note 4 to entry: In the case of actions and related properties, the value can relate to a reference period.

Note 5 to entry: For yield strength, the design value is equal to the representative yield strength.

3.15

disconnectable floating structure

floating structure (3.24) capable of discontinuing production and rapidly disconnecting from its ancillary components (e.g. risers, moorings, well systems, umbilicals), in response to the occurrence of a threshold event

Note 1 to entry: Threshold event is a hazardous event that triggers the start of disconnection.

3.16

dynamic action

action (3.3) that induces acceleration of a *structure* (3.59) or a *structural component* (3.57) of a magnitude sufficient to require specific consideration

[SOURCE: ISO 19901-7:2013, 3.8]

3.17

dynamic positioning

DP

stationkeeping technique consisting primarily of a system of on-board thrusters, which generate appropriate thrust vectors to counter the mean and slowly varying induced actions

3.18

environmental action

effect of wind, wave, current, ice and seismic actions on a *structure* (3.59)

Note 1 to entry: In general terms, environmental actions include those due to seismic actions but, for historical reasons, in several places in this document, seismic actions are treated separately from other environmental effects.

3.19

exposure level

classification system used to define the requirements for a *structure* (3.59) based on consideration of life-safety and of environmental and economic consequences of *failure* (3.21)

[SOURCE: ISO 19900:2013, 3.20, modified — Definition has been rephrased.]

3.20

extreme value

value of a parameter used in ULS verification in which a *structure's* (3.59) global behaviour is intended to stay in the elastic range

Note 1 to entry: Extreme values and events have annual probabilities of exceedance of the order of 10^{-2} .

3.21

failure

insufficient strength or inadequate serviceability of a *structure* (3.59) or *structural component* (3.57), or, in limit state verification, a condition in which a structure or component thereof does not fulfil its limit state requirement

3.22

fit-for-service

fitness-for-service

meeting the intent of a standard although not meeting specific requirements of that standard in local areas, such that *failure* (3.21) in these areas cannot cause unacceptable risk to life-safety or the environment

Note 1 to entry: "Fit-for-service" is an adjective and "fitness-for-service" is a noun.

[SOURCE: ISO 19900:2013, 3.21, modified — Definition has been rephrased.]

3.23

flag state

country under whose laws a vessel is registered or licensed

Note 1 to entry: 'Flagging' is the process by which such registration is accomplished.

3.24

floating structure

structure (3.59) where the full weight is supported by buoyancy

[SOURCE: ISO 19900:2013, 3.23]

Note 1 to entry: The full weight includes lightship weight, mooring system pre-tension, riser pre-tension and operating weight.

3.25

freeboard

distance measured vertically between the upper edge of the weathertight deck, at a given draught, and the mean water surface

3.26

green water

water that overtops a deck causing *slamming* (3.49) and pressure actions on the deck and to *structures* (3.59) on the deck

3.27

hazard

potential source of harm

EXAMPLE Large waves, strong winds, hurricanes, earthquakes, icebergs, unstable foundation, excessive topside weight, vessel collision, corrosion, and repetitive actions.

Note 1 to entry: Harm is typically differentiated between harm to personnel, harm to the environment, or harm in terms of costs to organisation(s) or society in general.

3.28

hazardous event

instance of a *hazard* (3.27) acting on a *structure* (3.59)

EXAMPLE Wave impact, iceberg impact, excessive topside weight added to the structure, landslip near structural anchors (piles).

3.29

hull

primary structure or structural subsystem providing buoyancy for a *floating structure* (3.24)

Note 1 to entry: For semi-submersibles, the hull generally consists of columns and pontoons. For spars and shallow-draught cylindrical structures, the hull consists of a single column.

3.30

limit state

state beyond which the *structure* (3.59) or *structural component* (3.57) no longer satisfies the relevant *design criteria* (3.10)

[SOURCE: ISO 19900:2013, 3.28, modified — ‘or structural component’ has been added.]

3.31

marine operations manual

MOM

document that defines the operational characteristics, procedures and capabilities of an offshore platform and associated essential systems

[SOURCE: ISO 19900:2013, 3.33, modified — ‘marine’ has been added to the term.]

3.32

metocean action

effect of wind, wave and current on a *structure* (3.59)

Note 1 to entry: The determination of these effects includes the influence of marine growth, tide, surge, and related processes, as appropriate.

3.33

mobile offshore unit

MOU

structure (3.59) intended to be relocated to perform a particular function

3.34

nominal value

value of a *basic variable* (3.7), *action* (3.3) or strength model determined on a non-statistical basis, typically from acquired experience or physical conditions

[SOURCE: ISO 19900:2013, 3.29, modified — Definition has been rephrased.]

EXAMPLE Value published in a recognized code or standard.

Note 1 to entry: Values of yield strength specified in steel standards and specifications are nominal values

3.35

operator

representative of the company or companies leasing the site

Note 1 to entry: The operator is normally the oil company acting on behalf of co-licensees.

[SOURCE: ISO 19900:2013, 3.32]

3.36

owner

representative of the company or companies owning or leasing a development

[SOURCE: ISO 19900:2013, 3.34]

3.37

platform

complete assembly of structural and non-structural systems for development and production of petroleum and natural gas fields

Note 1 to entry: For floating offshore structures, the structural system generally includes the hull, topsides structure, and stationkeeping system including anchors, while the non-structural systems includes topsides equipment (including accommodation), piping and risers.

Note 2 to entry: The structural system does not include soils.

3.38
recognized classification society
RCS

member of the international association of classification societies (IACS), with recognized and relevant competence and experience in *floating structures* (3.24) used in petroleum or natural gas activities, and with established rules and procedures for *classification* (3.9)/certification of *platforms* (3.37) located at a specific site for an extended period of time

[SOURCE: ISO 19901-7:2013, 3.23, modified — Definition has been rephrased, first and second preferred terms have been swapped.]

3.39
regulator

authority established by a national governmental administration to oversee the activities of the offshore petroleum and natural gas industries within its jurisdiction, with respect to safety of life and protection of the environment

Note 1 to entry: The term "regulator" can encompass more than one agency in given territorial waters.

Note 2 to entry: The regulator can appoint other agencies, such as marine classification societies, to act on its behalf, and in such cases, regulator as it is used in this document includes such agencies.

Note 3 to entry: In this document, the term "regulator" does not include any agency responsible for approval to extract hydrocarbons, unless such agency also has responsibility for safety and environmental protection.

[SOURCE: ISO 19902:2007, 3.40, modified — 'oil' has been changed to 'petroleum'.]

3.40
reliability

ability of a *structure* (3.59) or *structural component* (3.57) to fulfil the specified requirements

[SOURCE: ISO 19900:2013, 3.37]

3.41
representative value

value of a *basic variable* (3.7), *action* (3.3) or strength model, for *verification* (3.61) of a *limit state* (3.30)

[SOURCE: ISO 19900:2013, 3.38, modified — Definition has been rephrased.]

Note 1 to entry: The representative value can be a characteristic value, a nominal value, or other rationally determined value.

Note 2 to entry: 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.

3.42
resistance

capacity of a *structure* (3.59), component or cross-section of a component to withstand *action effects* (3.5) without *failure* (3.21)

[SOURCE: ISO 19900:2013, 3.39, modified — 'structure' has been added.]

3.43
return period

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

Note 1 to entry: The offshore industry commonly uses a return period measured in years for environmental events. The return period in years is equal to the reciprocal of the annual probability of exceedance of the event.

[SOURCE: ISO 19900:2013, 3.40]

**3.44
riser**

piping connecting the process facilities or drilling equipment on the *floating structure* (3.24) with the subsea facilities or pipelines, or with a reservoir

Note 1 to entry: Possible functions include drilling and well intervention, production, injection, subsea systems control and export of produced fluids.

**3.45
robustness**

ability of a *structure* (3.59) to withstand accidental and abnormal events without being damaged to an extent disproportionate to the cause

[SOURCE: ISO 19900:2013, 3.42]

**3.46
semi-submersible**

floating structure (3.24) normally consisting of a deck structure with, typically, three or more widely spaced, large cross-section, supporting columns connected to submerged pontoons

Note 1 to entry: Pontoon/column geometry is usually chosen to minimize global motions in a broad range of wave frequencies.

**3.47
shallow-draught cylindrical structure**

floating structure (3.24) having a cylindrical or near cylindrical geometry with a draught comparable to the diameter

**3.48
ship-shaped structure**

floating structure (3.24) having a geometry similar to that of ocean-going ships or barges

**3.49
slamming**

impulsive action with high pressure peaks that occurs during impact between a portion of the *structure* (3.58) and water

Note 1 to entry: Slamming can, for example, be due to emergence and re-entry of a lower section of the hull into the water or to wave impact on a structural component.

**3.50
sloshing**

impact action on the internal surface(s) of partially filled compartments due to internal fluid motion

**3.51
spar**

deep-draught, small water-plane area cylindrical *floating structure* (3.24)

[SOURCE: ISO 19901-7:2013, 3.32, modified]

**3.52
special area**

area identified by the designer as being of critical importance to the structural integrity and safety of the *structure* (3.59)

**3.53
splash zone**

part of a *structure* (3.59) that is intermittently exposed to air and to sea water

[SOURCE: ISO 19900:2013, 3.44, modified — ‘immersed in the sea’ has been changed to ‘to sea water’.]

3.54
stability
hydrostatic stability

ability of a *floating structure* (3.24) to generate restoring moment after deviation from an equilibrium floating position

Note 1 to entry: Generally, verification of stability applies to both intact and damage conditions.

3.55
static action

action (3.3) that does not cause significant acceleration of a *structure* (3.59) or of a *structural component* (3.57)

3.56
stationkeeping system

system capable of limiting the excursions of a *floating structure* (3.24) within prescribed limits

[SOURCE: ISO 19901-7:2013, 3.34]

3.57
structural component

physically distinguishable part of a *structure* (3.59)

[SOURCE: ISO 19900:2013, 3.46, modified — Example has been omitted.]

3.58
structural system

combination of *structural components* (3.57) acting in such a manner that the components function together

3.59
structure

organized combination of connected components designed to withstand *actions* (3.3) and provide adequate rigidity and *stability* (3.54)

[SOURCE: ISO 19900:2013, 3.49, modified — ‘and stability’ has been added.]

3.60
topsides

structure (3.59) and equipment placed on a *hull* (3.29) to provide some or all a of *platform's* (3.37) functions

Note 1 to entry: For a ship-shaped structure, the deck is not part of the topsides.

Note 2 to entry: A separately-fabricated deck or module support frame is part of the topsides.

[SOURCE: ISO 19900:2013, 3.52, modified — Definition has been rephrased, Note 2 to entry has been removed.]

3.61
verification

examination made to confirm that an activity, product or service is in accordance with specified requirements

[SOURCE: ISO 19901-7:2013, 3.39]

3.62
watertight

capable of preventing the penetration of water into or through the *structure* (3.59) with a water pressure head corresponding to that for which the surrounding structure is designed

3.63

weathertight

capable of preventing the penetration of water into the structure during temporary exposure to water

Note 1 to entry: A watertight closing appliance is also considered weathertight.

4 Symbols and abbreviated terms

4.1 Symbols

A	accidental action
A_v	area, or area per unit length, in square metres (m ²), or metres (m)
a_v	vibration amplitude, in metres
B	moulded breadth, in metres (m)
b	width, in millimetres (mm)
C	coefficient (non-dimensional unless otherwise specified)
D	fatigue damage ratio throughout life cycle of platform or duration of particular operational phase
d	component diameter, in metres
E	material (Young's) modulus, in newtons per square metre (N/m ²)
E_e	environmental action
F	action per unit length, in newtons per metre (N/m)
F_d	design value of action effect
f	frequency, in hertz (Hz)
f	distribution factor (non-dimensional)
G	permanent action
K_s	stability parameter for VIV
L	length between perpendiculars
M	bending moment or representative bending strength, in newton metres (Nm)
m	constant related to the slope of an S-N curve
m_e	effective mass per unit length (kg/m)
N	total number of cycles
P	pressure, in newtons per square metre (N/m ²)
P_e	annual probability of exceedance
Q	variable action
Q_s	is the maximum representative still-water shear force, in newtons (N)

Q_u	is the representative ultimate shear strength of the hull girder, in newtons (N)
Q_w	is the maximum representative wave shear force, in newtons (N)
R	strength, in newtons per square metre (N/m ²)
r	strength, in newtons per square metre (N/m ²)
S	stress, in newtons per square metre (N/m ²)
T	time or duration, in years
T_R	return period, in years
t	thickness, in millimetres (mm)
V	volume, or volume per unit length, in cubic metres (m ³), or square metres (m ²)
v	velocity, in metres per second (m/s)
γ	partial action or resistance factor
δ	logarithmic decrement of damping
ξ	fraction of critical damping
η	allowable utilization factor
κ	curvature, 1/m
ρ	density, in kilograms per cubic metre (kg/m ³)

4.2 Abbreviated terms

ACFM	alternating current field measurement
ACPD	alternating current potential drop
ALP	articulated loading platform
ALS	accidental limit state
AP	aft perpendicular
BOD	basis of design
CALM	catenary anchor leg mooring
CBM	conventional buoy mooring
COW	crude oil washing
CP	cathodic protection
CVI	close-up visual inspection
DP	dynamic positioning
EC	eddy current
FE	finite element

FLP	floating loading platform
FLS	fatigue limit state
FMD	flooded member detection
FP	forward perpendicular
FPS	floating production structure
FPSO	floating production, storage and offloading structure
FSU	floating storage unit
GVI	general visual inspection
HAZID	hazard identification
IMO	International Maritime Organization
MMS	minerals management service
MOM	marine operations manual
MOU	mobile offshore unit
MODU	mobile offshore drilling unit
MPI	magnetic particle inspection
MPM	most probable maximum
MWL	mean water level
NDT	non-destructive test
NPSH	net positive suction head
RAO	response amplitude operator
RCS	recognized classification society
ROV	remotely operated vehicle
SALM	single anchor leg mooring
SCIP	structural critical inspection point
SCF	stress concentration factor
SIM	structural integrity management
SLS	serviceability limit state
STL	submerged turret loading
TLP	tension leg platform
TOFD	time-of-flight diffraction
TM	thickness measurements

UCW	ultrasonic creeping wave
ULS	ultimate limit state
VIM	vortex-induced motions
VIV	vortex-induced vibrations
VLCC	very large crude carrier
VOC	volatile organic compound
WI	weld inspection
WSD	working stress design

5 Overall considerations

5.1 General

[Clause 5](#) presents the general requirements for the floating structures described in [Clause 1](#) when used to support the petroleum and natural gas industries functions also listed in [Clause 1](#).

5.2 Safety requirements

Key guiding principles of the activities of the petroleum and natural gas industries are safety of life, environment and property. Within the framework of this document, these principles shall be enforced through the following:

- verification of the floating structure's ability to withstand environmental and other external actions that are likely to occur during the design service life or any extension thereof;
- a robust structural form so that local damage does not lead to complete loss of integrity of the structure;
- definition of safe operating procedures so that risks of injury to personnel are identified and minimized;
- identification and assessment of possible accidental events, as summarized in [ISO 19900](#), and mitigation of their consequences;
- performance of a hazard assessment to ensure that possible malfunctions do not pose a danger to life, to the environment, or to the structure's integrity.

The implications of the above items shall be incorporated in the floating structure's design philosophy and in the development of the operational philosophy as reflected in the MOM.

Some of the items in the above list are usually performed as part of a formal risk assessment, which is an appropriate general procedure for identifying hazards, quantifying the associated risks and determining approaches for the mitigation of their consequences.

For methods used to protect against fires and explosions, the selection of a suitable approach depends upon the function of the platform. Procedures shall conform to [ISO 13702](#). National or regional requirements also apply, where they exist.

Requirements for personnel safety set by flag states and coastal state authorities can have a substantial effect on the design of a floating structure.

5.3 Planning requirements

5.3.1 General

Planning shall be undertaken in the initial stages of the design process to obtain a safe structural solution for performing the desired function.

5.3.2 Exposure level

Offshore platforms can be categorized by various levels of exposure to determine criteria that are appropriate for the intended service, its design and its quality management. This applies to the design of new structures and to the assessment of existing structures. The level relevant for a given platform shall be determined in accordance with the requirements of [ISO 19900](#).

This document (i.e. ISO 19904-1) provides requirements for L1 structures only.

5.3.3 Basis of design

At the outset of the design process, a document (basis of design - BOD) should be created to summarize

- definition of design practices,
- exposure level,
- applicable limit states, design situations and design criteria (see [ISO 19900](#)),
- fabrication, transportation and installation philosophy,
- inspection and maintenance philosophy,
- service and operational philosophy, and
- platform removal philosophy.

5.3.4 Design practices

Regulations, codes, standards and RCS rules (collectively referred to as “standards” hereafter) applicable to the design and construction of the floating structure shall be clearly identified at the commencement of the project – see [5.4.2](#).

Mixing of standards should, in general, be avoided. When more than one standard is utilized in the design process, differences in the standards shall be identified and a decision made concerning the appropriate measures to be undertaken. Such a decision shall be based upon sound engineering practice.

The standards used in the design of structures shall be consistent and compatible with those utilized in the fabrication and in-service monitoring of the structure.

For innovative structural forms, or applications of unproven structural concepts where limited or no direct experience exists, appropriate analyses shall be performed to demonstrate that the safety level of the design is no lower than the safety level implicit in this document when applied to traditional structural forms or concepts.

5.3.5 Inspection and maintenance philosophy

At the planning stage, a philosophy for inspection and maintenance should be developed and documented, to ensure full consistency with the BOD of the floating structure and its components. The requirements for fatigue strength, corrosion control, material toughness, and inspection planning shall be consistent with the design service life of the floating structure established as part of the planning activities.

A critical assessment should be made of the ability to achieve the intended inspection and maintenance objectives. Relevant requirements related to inspection and maintenance requirements are given in [Clause 19](#).

General requirements for inspection of structures are given in [ISO 19900](#). For detailed considerations concerning in-service condition monitoring, see [Clause 19](#).

5.3.6 Documentation

During the fabrication, erection, load out and installation phases, data related to the as-built configuration, inspection and maintenance of the platform shall be recorded as the project progresses and compiled in a form suitable for retention as a permanent record.

Any changes made to the design of a floating structure subsequent to the lightship survey and/or inclining experiment shall be accounted for and included in the final documentation and updated during service (see also [5.5.7](#) and [15.2](#)).

A MOM, or equivalent, shall be prepared for use by personnel onboard the floating structure. The MOM should be as concise as reasonably practicable and shall contain pertinent information for safe operation, including all relevant limiting design criteria relating to global structural strength, compartmentation and stability. Marine operations staff on-board the structure should be trained to execute procedures to be followed for storm safe conditions and for extreme weather evacuation.

Different hull configurations can be sensitive to variations in total weight, weight/buoyancy distribution, hydrostatic stability or any combination thereof. The designer shall ensure that weight monitoring, distribution and control procedures are clearly identified in the MOM.

The MOM should be updated to reflect any changes to the marine operations identified by the results of any structural assessment.

Documentation noting any areas built with special steel should be onboard to identify any special welding requirements when carrying out emergency repairs.

5.3.7 Extreme weather preparedness

Advanced planning can assist in reducing extreme weather risks as well as improving post-event response. Owners should develop a written extreme weather preparedness plan describing general activities for their inventory of offshore structures as well as the plans for each specific structure. Checklists and platform-specific guides can assist, e.g. during an evacuation process. Structures with high life safety exposure and/or economic risk can require additional consideration.

5.3.8 Disconnectable floating platforms

Some floating platforms are designed to enable rapid disconnection of some or all the platform's stationkeeping systems and ancillary components to limit exposure to foreseeable hazardous events that could lead to exceedance of applicable limit states (e.g. severe metocean or ice conditions). Rapid disconnection allows the floating structure to move away from the hazard forecast at the installation site, protecting the structure and/or other components (moorings, risers, etc.) from the extreme actions that would be experienced if the platform remained connected.

The ability to forecast a threshold event, the frequency of such events, and the time required for the disconnection should be considered at the design stage when setting the disconnection criteria. These criteria shall be established and stated in the MOM. The means and/or procedures for verifying operability of the quick disconnect system throughout the platform's design service life shall be specified in the MOM.

5.4 Additional standards and specifications

5.4.1 General

The intent of this document is to state explicitly general principles and basic requirements. The designer is then directed, through appropriate references, to make use of existing design practices and standards.

Where the floating structure is to be flagged, the relevant flag state authority requirements also apply.

5.4.2 Use for project application

For a specific project application, the owner shall identify the complete list of standards (see [5.3.4](#)), contractual agreements and company specifications whose requirements shall be met, clarifying areas of possible overlap and specifying the level of precedence in the enforcement of such requirements.

In the case of disconnectable floating structures, when disconnected, different requirements can apply depending on the type of structure. For self-propelled units, design practices additional to the standards identified in [5.3.4](#) can apply. For non-self-propelled units, tow requirements (see [ISO 19901-6](#)) are also applicable.

5.5 General requirements

5.5.1 Functional requirements

A floating platform's functional requirements are generally specified by the owner and shall be satisfied in conjunction with the principles stated in [5.2](#). Consequently, the structure of a floating platform (and its stationkeeping system) shall be designed to allow the platform to

- a) fulfil its intended mission (production, drilling and production, etc.) for a specified length of time (design service life), and
- b) meet specified minimum requirements for serviceability and operability, such as keeping platform motions within prescribed limits, for a specified fraction of time.

The platform shall also be designed to provide

- adequate comfort levels for personnel onboard,
- proper functioning of the topsides equipment,
- access to subsea facilities, where applicable, and
- clearances with respect to other subsea or surface facilities, where applicable,

while, at the same time

- maintaining floating stability,
- maintaining structural integrity,
- maintaining integrity and serviceability of drilling, production, export or other types of risers and
- ensuring platform survival in extreme, abnormal and accidental events.

Conformance of the floating structure design with these requirements shall be verified using the analysis methodologies and design criteria given in [Clauses 8 to 16](#) and in [Clause 18](#). Action effects, such as motions, accelerations, forces and stresses, shall be evaluated for all defined design situations, and shall be compared with the system and component strengths to ensure the existence of reserve against loss of stability, structural failure or other undesirable occurrences.

5.5.2 Structural design philosophy

The structural system, components and details of a floating platform shall be designed, constructed and maintained so that they are suited to their intended use.

The general requirements and conditions stated in [ISO 19900](#) shall be fulfilled. Additionally, the following design principles apply:

- structural systems shall have ductile resistance unless the specified purpose or structural material requires otherwise;
- structures shall be designed to minimize stress concentrations and provide simple stress paths;
- structures shall be designed such that fabrication, including surface treatment, can be accomplished in accordance with accepted techniques and practices;
- heavy, concentrated actions on the structure shall be located such that proper framing to support these actions can be planned;
- effects of fabrication and offshore construction tolerances shall be taken into account;
- adequate allowance shall be made for corrosion when selecting materials, and corrosion shall be minimized by judicious design of structural details, selection of structural profiles and the use of suitable materials, coatings and cathodic protection systems;
- whenever practical, structures shall be designed to enable load redistribution.

A floating structure shall be designed with due consideration to minimizing the adverse effects of accidental events. Such events include fire/blast, collisions, compartmental flooding, mooring line failure, dropped objects, and fluid impacts such as green water or slamming. In this regard, consideration should be given to the layout and arrangement of facilities and equipment.

Cargo tanks and cargo systems shall be separated by oil-tight cofferdams from galleys, living quarters, below-deck general cargo spaces, boiler rooms and machinery spaces where sources of ignition are normally present. Cofferdams shall be adequately vented and wide enough to allow ready access. Ballast tanks or void spaces may be considered as cofferdams.

The floating structure shall be designed to maintain global integrity during abnormal and accidental events. Furthermore, the structure shall be designed so that if structural damage does occur, the damaged structure (possibly with temporary repairs, as applicable) is able to resist action combinations appropriate to these design situations without suffering extensive failure, free drifting, capsizing or sinking, and without causing extensive harm to the environment.

Emergency and other essential equipment (ballast pumps, generators, mooring winches, etc.), shall be designed to continue to operate at the platform attitudes resulting from an abnormal or accidental event. Low-pressure piping and bulkhead penetrations can provide conduits for downflooding (and siphoning) and shall be examined for integrity under the maximum hydrostatic pressure consistent with the damaged condition.

5.5.3 Design criteria

Criteria to be met by the structural design are usually directly related to specific design situations. For factors to be considered – see [ISO 19900](#).

5.5.4 Hydrostatic stability and compartmentation

The floating behaviour of the platform shall be consistent with the requirements for stability in intact and damaged configurations, for both temporary and in-service conditions (see [Clause 16](#)).

When recognized standards are used to verify adequate stability, consideration shall also be given to the consequences of the accidental events identified as being relevant for the structure (see [7.5](#)).

To mitigate the consequences of possible damage, the floating structure's hull shall be subdivided into compartments to facilitate meeting stability requirements and reduce risks of environmental pollution and loss of the platform (see [Clause 16](#)).

5.5.5 Weight control

The hydrostatic stability and the dynamic response of a floating platform are very sensitive to the magnitude and distribution of the mass. These parameters, and the location of the centre of gravity, shall be monitored during the entire life cycle of the platform.

During the design and fabrication process:

- the weight of the structure shall be evaluated;
- the centre of gravity of the structure, or part of the structure, shall be evaluated.

Regular weight and centre of gravity reports should be produced at various stages of the design and fabrication process, with appropriate contingency factors to allow for uncertainties connected with outstanding items to be fabricated or installed.

The weight database shall be updated to an as-built status, to provide accurate information for all pre-service temporary phases, including launch, transportation, upending and lifts.

The mass distribution of a floating platform as-built shall be verified to an appropriate degree of accuracy (see [16.2](#) for requirements for inclining tests).

The MOM shall contain appropriate provisions for handover of the design database to the operations team, and for the continuing in-service weight control process.

NOTE Further guidance on this topic can be found in [ISO 19901-5](#)^[135].

5.5.6 Global response

The floating structure hull shall be designed so that, in conjunction with the effects of the stationkeeping system and the riser system, the predicted excursion and motion response stays within appropriate limits, set in conjunction with the requirements for

- serviceability of all types of risers,
- comfort levels for personnel onboard,
- serviceability of the drilling, production, or other types of equipment, as applicable, and
- maintaining minimum clearances with other surface facilities or subsea infrastructure.

5.5.7 Stationkeeping

The stationkeeping system, which in general consists of a combination of mooring lines, anchors and thrusters, shall be designed to restrain the platform maximum excursion to the envelope defined by the considerations identified in [5.5.6](#). See [Clause 18](#).

Weathervaning stationkeeping systems, generally using internal or external turrets, are a common choice for ship-shaped structures and barges in moderate to harsh environments. These stationkeeping systems allow the platform to weathervane and reduce metocean actions and ice actions.

5.5.8 Materials

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

Adequate ductility in the design of a structure shall be facilitated by

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

5.5.9 Topsides layout — safety considerations

Personnel safety is a key consideration in the layout and arrangement of the topsides process equipment. The following requirements or recommendations apply:

- a) Personnel accommodation should not be located directly above or below
 - 1) produced oil and/or gas storage tanks,
 - 2) process vessels,
 - 3) surface trees and wellheads, and
 - 4) portions of risers located on the floating structure.
- b) Personnel accommodation should be positioned as far away as possible from the process facilities and from the flare.
- c) Process vessels, hydrocarbon storage tanks, or other items which could become a source of fuel in the event of a fire, should be located as far away as possible, or otherwise protected, from wellheads and potential ignition sources.
- d) Arrangements and layout of the facilities, accommodation, control rooms, and life-saving appliances should be such that a fire in a process area, hydrocarbon storage area, wellhead area, or other classified areas does not prevent or impede the safe exit of personnel from the accommodation through designated escape routes to boat landings or lifeboat locations.

5.6 Independent verification

Independent verification that the floating structure’s design and construction conforms to the requirements of this document shall be carried out as a combination of independent calculations, document reviews and audits, surveys and inspections, etc., as appropriate. Emphasis shall be placed on the verification of structural systems and components significant to safety.

Verification activities shall be sufficiently detailed and extensive to clearly demonstrate that the design and construction are adequate. Appropriate documentation shall be maintained of the scope and extent of the verification, the procedures employed, and the relevant reports.

The above requirements can be satisfied in part, or in full, by classing by an RCS.

5.7 Analytical tools

Appropriate requirements for analytical tools are given in [ISO 19900](#).

5.8 In-service inspection and maintenance

Comprehensive structural inspection and maintenance programmes shall be developed for the structure and emergency and other essential marine equipment (see [Clause 19](#)) to monitor the integrity

of the floating structure throughout its design service life. Such programmes shall account for the frequency of inspection and the number of tanks open at any one time.

In-service inspection procedures shall be developed and undertaken to confirm that modifications, alterations, repairs, and maintenance are undertaken in conformance with appropriate design drawings, specifications, and procedures.

Tanks that contain hazardous materials, e.g. diesel, methanol, or tanks that contain potable water, should be designed to minimize inspection requirements. Tank piping shall be arranged to allow for the safe isolation of tanks prior to inspection.

5.9 Assessment, re-use and life extension

Various circumstances can lead to a requirement for an existing structure to be assessed – see [ISO 19900](#) Clause 12.

In such cases, the existing structure shall be assessed for conformity with the requirements of [Clauses 15](#) or [20](#), as appropriate. Where the structure or any of its components does not conform to the requirements of this document, adequacy may be demonstrated on a fitness-for-service basis.

6 Basic design requirements

6.1 General

In accordance with [ISO 19900](#), structural design shall be performed with reference to a specified set of limit states. For each limit state, design situations shall be determined and an appropriate calculation model shall be established to ensure that critical action combinations for all main load-bearing structural components are evaluated. Each phase of construction, transportation, installation, operation, and removal shall be complemented by appropriate metocean and ice conditions. Significant effects occurring in one design phase that affect another phase shall be fully considered in the design process. Such effects could be, for example, built-in deflections or fatigue damage.

The reliability of floating structures is highly dependent upon the reliability of emergency and essential marine equipment. Risk assessments shall be conducted to demonstrate that such equipment realizes reliability levels compatible with that demanded for the structure and its components.

6.2 Limit states

6.2.1 General

Verification shall satisfy the limit state design requirements given in [Clauses 7](#) to [14](#). In addition, for each limit state, watertightness and hydrostatic stability shall be ensured in accordance with [Clause 16](#).

6.2.2 Limit states for floating structures

The following limit states shall apply:

- ultimate limit states (ULS), which generally involve verifying the floating structure's strength to resist extreme actions and action effects;
- serviceability limit states (SLS), which generally involve verifying the floating structure's performance under operational (normal) actions and action effects;
- fatigue limit states (FLS), which cover the structure's strength to resist cumulative effects of repeated actions;

- accidental limit states (ALS), which investigate the structure's ability to resist accidental and abnormal events, and the structure's resistance to the effects of specified metocean actions and ice actions after damage has occurred as a consequence of an accidental or abnormal event.

6.3 Design situations

6.3.1 General

Design situations include the service and operational requirements resulting from the intended use of the floating structure in conjunction with the environmental conditions affecting the floating structure's behaviour.

An environmental design situation consists of the set of actions induced by waves, wind, current, and, if applicable, earthquakes or floating ice, on the floating structure and on the mooring system, as appropriate, and is characterized by a given return period.

Criteria to be met by the design can be directly related to the specific formulation or modelling technique used to simulate the design situation. In such cases, design situations and design criteria form one whole and shall not be separated from one another. They are jointly specified in [Clauses 8 to 19](#).

The definition of specific design situations for the floating structure shall be the responsibility of the owner. The requirements of a regulatory authority apply where one exists.

6.3.2 ULS situations

The design actions to be used in the various ULS are specified in [Clause 7](#). The design strengths and the application of the ULS are specified in [Clauses 9, 11, 12, 13 and 14](#).

For ULS conditions, representative metocean actions and ice actions shall be established with the intention to identify the most onerous associated action effects with a return period of 100 years ($P_e = 10^{-2}$). Different structural components can be affected to a different extent by the same design situations. Consequently, a range of design situations shall be used to ensure that the most onerous conditions for all types of structural components are identified.

6.3.3 SLS situations

The identification of SLS design situations for floating offshore structures shall be based on a number of considerations, including the following:

- unacceptable deformations can affect the efficient use of structural or non-structural components or the functioning of equipment relying on them;
- local damage (including corrosion, cracking, wear, deterioration of flex joints) can reduce the durability of the structure or affect the efficiency of structural or non-structural components;
- excessive motions, accelerations, vibrations or noise can cause discomfort to personnel and interfere with their capability to discharge their duties;
- motions, accelerations or vibrations can exceed the range of effective functionality of topsides equipment (e.g. roll and pitch angles can seriously affect the performance of separators, or the serviceability of drilling equipment).

The assessment criteria associated with SLS shall typically be based on motions, deflections or vibration limits during normal use.

The SLS criteria shall be defined by the owner of a structure, established practice, designers, or suppliers of motion-sensitive equipment, the primary aim being efficient and economical in-service performance without discomfort to onboard personnel or excessive routine maintenance.

The acceptable limits necessarily depend on the type, mission and configuration of the structure. Furthermore, in defining such limits, other disciplines such as equipment and machinery designers shall also be consulted.

6.3.4 FLS situations

FLS are addressed in [Clause 10](#), covering methods, actions and resistances.

6.3.5 ALS situations

ALS are addressed in [Clauses 9, 11, 12, 13](#) and [14](#), in respect of actions and in selecting both partial action factors and partial resistance factors. The main goal of ALS verification is to ensure that the structure incorporates robustness so, when exposed to specified accidental and abnormal events, the structure suffers, at worst, limited damage that

- a) does not affect its overall structural integrity, stability and watertightness, and
- b) enables it to maintain adequate structural integrity (residual strength), stability and watertightness for a sufficient period of time and under specified metocean and ice conditions to enable some or all the following activities, as applicable:
 - evacuation of personnel from the structure;
 - control over movement or motion of the structure;
 - temporary repairs;
 - firefighting;
 - control of outflow of cargo or stored material liable to cause environmental damage or pollution.

Different types of accidental or abnormal events can require different methodologies or different levels of the same methodology to assess adequacy of the structural resistance during and following such events.

Post-ALS design situations can include consideration of a reduced extreme environmental condition. This condition should be established with the intention of resulting in the most onerous action effects for, as a minimum, a return period of one year (see [Table 1](#)). For verification, intact components shall be checked to ULS-a and ULS-b combinations (see [9.7.3.2](#) and [Table 3](#)) while for damaged components or structure, recognized structural practices accounting for such damage can be utilized.

6.3.6 Temporary phases

During temporary phases, structural strength is generally limited as a result of partial levels of completion of the structure and/or application of action combinations that differ from those applicable to normal operation. The effects of design situations applicable to temporary phases shall be addressed during design to avoid exceedance of either ULS or SLS, and to assess contributions to FLS.

Detailed planning of erection sequences and construction methods is essential to ensure all critical conditions are identified.

Loadout, transportation, offloading and installation assessments should conform to the requirements of a qualified marine surveyor accustomed to advising on transportation of these types of structures (e.g. an insurance marine warranty surveyor) or equivalent (see [9.12](#)).

When verifying the design of a floating structure during the transportation phase, representative metocean parameters and ice parameters should be established based on an assessment of the probability and consequence of encountering an event during the transportation phase that would cause the design limits of the structure and/or seafastening to be exceeded (see [ISO 19901-6](#) and [ISO 19902](#)).

7 Actions and action effects

7.1 General

This clause addresses actions likely to be experienced by a floating structure during its life cycle and applicable methodologies for their evaluation. Some of the information provided below can be found in [ISO 19900](#) but is included here for completeness.

7.2 Permanent actions (G)

Permanent actions (see [A.7.2](#) for examples) are those likely to act throughout a given design situation and for which variations in magnitude with time, during the design service life of the structure

- a) are small in relation to the mean value, or
- b) attain some limiting value.

The representative value of a permanent action shall be taken as the mean value based on the density of the material, the volume of the structure or component based on its nominal dimensions, calculated reactions, and calculated effects of deflections and deformations, as appropriate.

In cases where the permanent action can have an upper or lower value, the representative value shall be taken as the value that produces the most unfavourable effects in the structure under consideration.

A procedure for monitoring the weight and position of the centre of gravity of the floating platform shall be incorporated into the design process. The mass distribution of a floating platform as-built shall be verified to an appropriate degree of accuracy (see [16.2](#) in connection with requirements to inclining tests). Monitoring of the weight and centre of gravity shall be performed during the life cycle of the floating platform.

NOTE For further guidance, see [ISO 19901-5](#)[135].

7.3 Variable actions (Q)

Variable actions generally vary in magnitude, position and direction during the life of the structure, and are usually related to operations and normal use of the platform. These actions are likely to act throughout a given design situation, but do not include environmental actions (see [A.7.3](#) for examples).

The representative value of a variable action shall be taken as the maximum (or minimum) value that produces the most unfavourable effects in the structure under consideration. The value shall be determined either in the same manner as for permanent actions, i.e. mean or calculated, or as a specified value from a recognized source (e.g. RCS rules or national regulations).

Design local deck actions shall be documented on a load plan. This plan shall clearly show the design uniform and concentrated actions for all deck areas for each relevant mode of operation.

Design limits pertaining to tank capacities shall be documented on a capacity plan. As a minimum, the capacity plan shall clearly show tank layout, intended use of tanks, capacities, and the maximum design relative density of tank fluid.

Crane hook loads should be included in this category.

7.4 Environmental actions (E_e)

7.4.1 General

Environmental actions shall be derived from environmental information appropriate to the specific locations where the floating structure is to be fabricated, transported, installed and operated (see

[ISO 19901-1](#)). The stochastic nature of environmental actions shall be adequately accounted for. Environmental actions can be repeated, sustained, or both repeated and sustained.

The representative value of an environmental action is the maximum or minimum value (whichever is the more unfavourable) corresponding to a prescribed probability of exceedance. Joint probability of occurrence of the various environmental actions may be taken into account if such information is available and can be adequately documented.

Global environmental actions are normally generated by appropriate structural analysis software or mapped from other software packages used to develop the actions, e.g. hydrodynamic software used to generate wave-induced pressures.

Actions arising from earthquakes are not normally of concern for the design of floating structures. However, it can be necessary to assess their effect, for example, on mooring systems particularly in shallow waters, utility systems and equipment, and communication equipment.

7.4.2 Environmental site-specific data

The phenomena and environmental characteristics listed in this subclause shall, where appropriate to the region, be taken into account in the design. These characteristics shall be described by physical parameters and, where available, statistics (see also [ISO 19901-1](#)). For the design of the structure, site-specific environmental conditions shall be selected in accordance with the requirements of [ISO 19901-1](#).

a) Wind

Wind is usually characterized by the mean value of its velocity over a given time interval at a given elevation above the mean water level. The frequency content shall be taken into account by means of a wind spectrum as defined in [ISO 19901-1](#). The variation with elevation (wind profile) and the spatial coherence should be considered.

b) Waves

Site-specific information shall be established to consider sea-state characteristics (wave height, period, duration, directions and spectra) and the long-term statistics of these characteristics, including wind- and swell-generated waves if appropriate for the location of interest.

c) Water depth and sea level variation

The water depth shall be determined together with the magnitude of the low and high tides, and positive and negative storm surges. The possibility of ground subsidence should be considered when determining the water depth. Tidal components for design include astronomical, wind, and pressure differential tides.

d) Currents

Phenomena such as tidal, wind-driven, global circulation, loop and eddy currents shall be considered. Currents shall be described by their velocity variation (in magnitude and direction) with water depth (current profile) and persistence. The occurrence of fluid motion caused by internal waves should be considered.

e) Marine growth

Marine growth shall be defined by its thickness, roughness, density and variation with depth. This information is usually provided by direct measurements and operational experience in the specific area of interest. Additionally, the marine growth thickness to be used in the design is influenced by operational strategy (e.g. regular cleaning, use of anti-fouling coating) as well as structural behaviour (e.g. less marine growth is normally found on slender structures with significant dynamic displacements).

The presence of marine growth causes an effective increase of the component dimensions, a consequent direct increase in structure weight, in hydrodynamic drag and in added mass, and

alters the roughness characteristics of the surface. In structural design, therefore, the mass, buoyancy diameter and effective drag diameter shall be adjusted to account for the specified water depth variation of marine growth. In addition, the values of the hydrodynamic coefficients (drag, C_d , and inertia, C_m) should reflect the roughness associated with the marine growth.

The BOD and the MOM can include a specific provision for periodic marine growth cleaning or anti-fouling systems during the platform life, in which case the design assumptions shall be adjusted accordingly. Any such reliance shall be documented and the cleaning programme defined over the life of the platform. The consequences of not maintaining this programme should be determined and reported.

f) Ice and snow

Ice accretion on structural components from sea spray, snow, rain, and air humidity can cause increases of cross-sectional area (with consequent increase in mass and added mass) and surface roughness. These effects shall be considered when determining wind and hydrodynamic actions.

For floating structures, the effects of snow and ice accretion can affect the hydrostatic stability. Appropriate instructions concerning the need for removal of ice accretion shall be included in the MOM.

The accumulation of ice (icing) and snow on horizontal and vertical surfaces (thickness and density) shall be defined, together with the appropriate parameters for the other metocean phenomena (wind, waves and current) to be considered in conjunction with ice and snow accumulation. In addition, the possibility of ice build-up through freezing of sea spray, rain or fog shall be considered.

Sea ice and iceberg occurrences shall be considered when applicable.

g) Temperatures

The maximum, average and minimum air and sea temperatures at the site shall be determined.

h) Local sea water characteristics

Sea water properties such as oxygen content, salinity and density shall be provided.

i) Geotechnical data

Site investigations shall be performed to define physical and engineering properties of the soil strata and to identify potential hazards (earthquakes, mudslides, etc.).

7.4.3 Wind actions

7.4.3.1 General

Actions on a structure caused by wind shall be considered for both global analysis and local design.

Wind-induced actions shall be determined by means of wind tunnel tests and/or suitable analytical methods. Validated computational fluid dynamic methods may be used where appropriate.

The total wind velocity can be described as the sum of the mean wind component and a gust component.

7.4.3.2 Mean wind action

Mean wind actions on a floating structure can be estimated by calculating the mean wind actions on all exposed components of the structure and summing the contributions from each component. Mean wind actions on individual components can be calculated from [Formula \(1\)](#):

$$P_w = \frac{1}{2} \rho_a C_s v_z^2 \quad (1)$$

where

- P_w is the mean wind pressure;
- ρ_a is the mass density of air;
- C_s is the shape coefficient, which shall be determined from appropriate sources (e.g. RCS rules or [ISO 19902](#));
- v_z is the mean wind velocity at height z above the mean water level.

If C_s is obtained from wind tunnel measurements, all the parameters in [Formula \(1\)](#) shall be used in a manner consistent with the derivation of the wind tunnel results.

The wind velocity is usually given at a reference height of 10 m above the mean water level. To obtain the mean wind velocity at a different elevation, z , this value should be adjusted according to the formulation provided in [ISO 19901-1](#). Wind velocity should be averaged over an appropriate time interval, typically 3 s for a small standard component, 1 min for stability calculations, and 1 h for mean wind actions in conjunction with a frequency or time domain gust analysis.

Solidification effects shall be taken into account in cases where components are located close together in a plane normal to the wind direction.

Shielding effects may be taken into account if it can be adequately documented that the inclusion of such effects is justified.

When calculating wind actions, care shall be taken to decompose the global structure into components of sufficiently small size, so that the local wind velocity can be considered constant over the component without significant error.

For ship-shaped structures, additional information is given in [A.7.4.3](#).

7.4.3.3 Dynamic wind actions

Wind-induced dynamic actions fall into three categories:

- a) long-period variations in the wind intensity, which tend to engulf the whole platform and which can give rise to slow rigid body motions of the platform about its mean position;
- b) medium-period fluctuations affecting large structural components or sub-assemblies, such as flare towers;
- c) shorter-period variations associated with the shedding of vortices and aerodynamic instabilities.

Whenever appropriate data are available, aerodynamic admittance and spatial and temporal correlation of the gusts should be accounted for.

A dynamic analysis considering the time variation of wind actions and their effects shall be performed for the entire platform as well as for wind-exposed equipment and objects sensitive to varying wind actions, e.g. towers, flare booms.

The fluctuating gust component can be calculated in either the time domain or the frequency domain using an appropriate wind gust spectrum (see [ISO 19901-1](#)).

7.4.3.4 Wind-induced instability

Consideration shall be given to local aerodynamic instability. Examples of such instabilities (see [ISO 19901-1](#)) are atmospheric turbulence, gusts and squalls. Additionally, instabilities can arise due to interaction between the air flow and structural components, e.g. vortex-induced vibration of slender components (see [7.4.6](#)) and galloping effects.

7.4.4 Current actions

Current actions on large-volume bodies like floating structures shall be determined by model tests, relevant empirical analytical tools, and/or appropriate sources. In determining the shape coefficients, appendages (bilge keels, strakes, etc.) shall be taken into account. Actions induced by steady currents on ship-shaped structure and semi-submersible structures can be determined by global coefficients, analogous to mean wind actions (see [7.4.3.2](#)). In general, current actions on ship-shaped structures are much larger in shallow water (with small under-keel clearance) than in deep water.

Current actions on slender components can be determined using [Formula \(3\)](#) (see [7.4.5.3](#)). Drag coefficients shall be determined from appropriate sources. In the absence of data indicating otherwise, the drag coefficients provided in [ISO 19902](#) for unshielded circular cylinders are recommended, i.e. 0,65 for smooth surfaces and 1,05 for rough surfaces.

The effects of medium-term and long-term variations of current velocity on moored floating structures shall be considered.

For ship-shaped structures, additional information is given in [A.7.4.4](#).

7.4.5 Wave actions

7.4.5.1 General

Actions caused by waves acting on a structure shall be considered for both global analysis and local design. Wave actions shall be determined by appropriate methods, taking into account all relevant parameters, including water depth, marine growth, type of structure, size, shape, and response characteristics.

The simultaneous effect of hydrostatic pressure, hydrodynamic local pressures, and the integrated (global) effect of still-water and wave actions shall be computed.

Adequate consideration shall be given to the relationship between the wave's dominant periods and the structure's natural period of motion or vibration. For example, for two different design situations, each having the same composite return period, it is possible that the situation characterized by lower wave heights, but a longer or shorter associated period, induces more severe action effects on some components.

Local hydrodynamic instability shall be investigated (see [7.4.6](#)).

7.4.5.2 Actions on large-volume bodies

The total pressure acting on submerged structural components includes both static and dynamic contributions. The dynamic pressure at a point on the immersed surface of a structure is expressed as the superposition of the pressure associated with the following:

- incident and scattered waves;
- flow induced by the six degrees-of-freedom radiation potential due to the motion of the structure in still-water;
- the time-varying hydrostatic pressure due to heave, roll and pitch displacements of the structure from its mean position.

For structural components with dimensions of the same order of the wave length (where, typically, the ratio between the wave length and the diameter or other characteristic dimension is <5), the flow disturbance introduced by the large volume body cannot be neglected in the calculation of water particle kinematics. In this case, the current/wave/body interaction shall be considered when deriving resultant actions.

The transfer functions for linear wave actions can be determined by diffraction and radiation theory.

For simple geometrical shapes, analytical solutions may be used. For structural forms where the actions cannot adequately be described by state-of-the-art methods, model tests shall be undertaken.

Hydrodynamic interactions between large-volume components shall be accounted for.

7.4.5.3 Actions on slender components

The computation of the action on a cylindrical component caused by waves, or a combination of waves and currents, depends on the ratio of the wavelength to the component diameter. If this ratio is large (>5), the member does not significantly modify the incident wave. The action can then be computed as the sum of a drag component and an inertia component, as follows [see [Formulae \(2\) to \(5\)](#)]:

$$F = F_d + F_i \quad (2)$$

where

F is the local action vector per unit length acting normal to the component axis;

F_d is the vector for the drag action per unit length acting normal to the component axis in the plane of the component axis and v

$$F_d = \frac{1}{2} \rho_w C_d (v - \dot{x}) |v - \dot{x}| A_v \quad (3)$$

F_i is the vector for the inertia action per unit length acting normal to the component axis in the plane of the component axis and $\partial v / \partial t$

$$F_i = \rho_w C_m V \frac{\partial v}{\partial t} - (C_m - 1) \rho_w V \ddot{x} \quad (4)$$

where

C_d is the hydrodynamic drag coefficient;

C_m is the hydrodynamic inertia coefficient;

ρ_w is the mass density of water;

A_v is the projected effective dimension of the cross-sectional area normal to the cylinder axis per unit length based on an effective diameter that includes marine growth;

V is the effective displaced volume of the cylinder per unit length;

v is the component of the local water particle velocity vector (due to waves and current) normal to the axis of the component;

$\frac{\partial v}{\partial t}$ is the component of local water particle acceleration vector normal to the component axis;

$\dot{x}$ is the velocity of the cylinder normal to the axis of the component;

$\ddot{x}$ is the acceleration of the cylinder normal to the axis of the component;

$||$ denotes the absolute value.

As presented here, [Formula \(2\)](#), in combination with [Formula \(3\)](#) and [Formula \(4\)](#), commonly (albeit incorrectly) referred to as Morison's equation, does not include hydrodynamic lift actions, slam actions and axial Froude-Krylov actions. If the above formulae are used for columns and non-cylindrical

semi-submersible hulls) appropriate additional terms shall be added to account for axial Froude-Krylov actions and added mass. The final analysis shall be performed using a diffraction analysis, in which case the drag effects shall be added.

The combined effect of simultaneous drag and inertia actions is obtained by vectorial addition.

The drag coefficient (C_d) depends on many parameters: Reynolds number, Keulegan-Carpenter number and roughness, amongst others.

For deterministic, global wave action calculations, the drag coefficient for circular cylinders shall not be less than the values provided in [ISO 19902](#), i.e. 0,65 for smooth surfaces and 1,05 for rough surfaces, where the rough surface value shall be used for members with marine growth. The value of C_d can be affected by the occurrence of VIV (see [7.4.6](#)). For fatigue assessment, higher values of C_d can apply, see [ISO 19902](#).

Design assumptions on the absence of marine growth shall be supported by appropriate requirements in the MOM to ensure that the components in question are kept free of marine growth during the structure's life.

Solidification effects shall be taken into account in cases where components are located close together in a plane normal to the wave direction.

Shielding effects can be taken into account if it can be adequately documented that the inclusion of such effects is justified.

The inertia coefficient (C_m) for circular cylinders shall be taken to be no less than 2,0 for actions where the inertia component action is considerably higher than the drag component action. For other shapes, the inertia coefficient can be accurately determined from appropriate calculations and model tests.

The wave actions on structures composed of large-volume components and slender components are generally computed by a combination of wave diffraction and radiation theory and Morison's equation. The effects on water particle velocities and accelerations due to the large volumes shall be considered when using Morison's equation on adjacent slender components.

7.4.5.4 Slamming on slender components

Design of components in the wave zone shall include the effects of slamming ([3.50](#)).

For cylindrical members, the slamming actions can be calculated from [Formula \(5\)](#):

$$F_s = \frac{1}{2} \rho_w C_{sl} d v^2 \quad (5)$$

where

- F_s is the slamming action per unit length in the direction of the relative velocity vector;
- ρ_w is the mass density of water;
- C_{sl} is the slamming coefficient;
- d is the component diameter;
- v is the relative water particle velocity normal to the component axis.

The slamming coefficient C_{sl} can be determined using theoretical and/or experimental methods. For smooth circular cylinders, the value of C_{sl} should be assumed to be no less than 6,0 when performing a quasi-static analysis, and no less than 3,0 when performing a dynamic analysis.

7.4.5.5 Higher-order non-linear wave actions

Some hydrodynamic phenomena, generally represented by higher-order, non-linear numerical models, give rise to actions at frequencies close to resonant frequencies of the floating structure and its

stationkeeping system. These actions shall be assessed and their effects investigated, as they can be important for the design of floating structures. The nature of these phenomena is addressed in [A.7.4.5.5](#).

Examples of the effects due to higher-order hydrodynamics are:

- mean drift (mean second order action);
- slow drift (time varying action).

Wave drift and wave drift damping are affected by the wave/current interaction, which shall also be considered.

7.4.5.6 Wave enhancement effects

In the vicinity of large bodies, the free surface elevation can be enhanced by motions, diffraction, radiation, wave/current interaction effects, and other non-linear wave effects. These shall be accounted for, as appropriate, in the wave action calculation and used to estimate deck clearance and freeboard (see [8.10](#)).

7.4.5.7 Shallow water effects

If the floating structure is located in a shallow water area (i.e. water depth less than half the wavelength), wave amplitude enhancements and/or wave refraction caused by the effect of the sea bottom shall be taken into account in estimating wave actions.

7.4.5.8 Slamming and green water actions

Wave slamming against the shell structure of the hull due to local wave action, water entry slamming and green water action caused by high relative motions of structure and wave surface are local wave action effects and are discussed in more detail in [9.8](#).

7.4.6 Vortex-induced vibrations and motions

A fluid flow (wind or current) past a slender component can cause unsteady flow patterns due to vortex shedding. At certain critical flow velocities, the vortex-shedding frequency coincides with, or is a multiple of, a natural frequency of the component, resulting in harmonic or sub-harmonic excitations normal to the longitudinal axis of the component. This phenomenon is generally referred to as vortex-induced vibrations (VIV).

The vibrations can be in-plane (in the plane of the flow velocity) or transverse (in a plane perpendicular to the flow velocity and the component axis). Transverse vibrations are usually of more concern for most structural components. The effects of VIV include:

- increased drag actions on individual components;
- fatigue damage of individual components.

Furthermore, for flow velocities in certain ranges, the vibrations can affect the platform (e.g. spar and potentially semi-submersible) as a whole and result in transverse rigid body motions, i.e. vortex-induced motions (VIM).

The potential for VIV/VIM shall be assessed. The focus of a VIV analysis is generally to evaluate if the fatigue resistance of the component or system is adequate. Accordingly, the simplified (and conservative) VIV analysis described in [A.7.4.6](#) should suffice if the resulting fatigue damage is acceptable. If the simplified analysis indicates insufficient fatigue resistance, a more sophisticated and less conservative method may be applied to demonstrate adequate fatigue resistance.

The method should be chosen according to the specific case to be investigated. Recognized semi-empirical methods can be applied if the problem characteristics are well within the validity range.

Otherwise, if the problem is of high complexity (e.g. riser bundles, varying diameters or surface waves), more refined assessment methods are required.

For disconnectable structures, calculation of the response of the turret buoy while disconnected shall include all low-frequency motion components, VIM and second-order wave-induced motions.

Waves, especially transverse to a current, can change VIM motions due to current only, dependent on wave frequency, so wave effects should be considered in a VIM analysis, if applicable.

7.4.7 Direct ice action

Where encounter with sea ice or impact with icebergs can occur, collision actions shall be determined through appropriate theoretical models, model laboratory tests or full-scale measurements.

When determining the magnitude and direction of actions, the following factors shall be considered:

- geometry and nature of the ice;
- mechanical properties of the ice;
- velocity and direction of the ice;
- geometry and size of the ice/structure contact area;
- ice failure mode as a function of the structure geometry;
- inertia effects for both ice and structure.

[ISO 19906](#) shall be used for structures in ice conditions.

7.4.8 Temperature effects

Floating structures shall be designed for the most onerous temperature differences to which they can be exposed. This applies, but is not limited to:

- storage tanks;
- structural components exposed to radiation from the flare;
- structural components that are in contact with risers or process equipment.

The lowest anticipated sea or air temperature shall be the lowest one-hour average temperature associated with an annual P_e of 10^{-2} .

7.4.9 Tidal effects

For floating structures constrained by stiff mooring systems, tidal effects can significantly affect the mean tensions in the mooring components. Therefore, the choice of tide conditions for a static equilibrium analysis is important. Higher mean water levels tend to increase maximum mooring line tensions, hydrostatic actions, and current actions on the hull, while tending to decrease deck clearances.

The effects of tides can be taken into account by performing a static balance at the various appropriate tide levels to provide a starting point for further analysis, or by making allowances for the appropriate tide level in calculating extreme responses.

7.4.10 Geotechnical hazards

Geotechnical hazards, such as earthquakes, mudslides and other geotechnical phenomena, can affect anchors, mooring lines and risers, and should be considered (see also [ISO 19901-7](#)). Underwater earthquakes (seaquakes) can cause pressure waves the vertical components of which can, for floating

structures located in the vicinity of the earthquake epicentre, damage mechanical systems and impair the performance of production systems, operational systems and safety systems.

7.5 Accidental actions (A)

7.5.1 General

Accidental actions relate to accidental events, abnormal operations or technical failure (see [A.7.5.1](#) for examples).

Both a hazard identification (HAZID) and a risk assessment shall be carried out at the outset of the design of a floating structure to identify potential accidental events, their magnitudes and probabilities of exceedance, and the associated consequences. The methods adopted for the HAZID and for the risk assessment shall take into account the type of structure and the existing operational experience.

The structural configuration and equipment arrangements shall be such that damage resulting from an accidental action shall not lead to an escalation of undesirable events (e.g. as could occur if the flare tower were to be placed in the collision zone) or impair safety-critical functions.

The representative value of an accidental action shall correspond to a value with an annual probability of exceedance, P_e , equal to 10^{-4} .

Values of accidental actions with a P_e less than 10^{-4} may be disregarded.

Accidental events may be assumed to occur independently of extreme environmental design situations, see [Table 1](#).

For temporary phases, accidental actions may normally be omitted from further design verification, provided a HAZID and risk assessment have been conducted to ensure all actions likely to occur during temporary design conditions have been identified and their potential consequences assessed.

7.5.2 Collision

Collision-induced actions shall be considered in the design of all structural components that can be affected by sideways, bow or stern collision with another vessel. The vertical extent of the collision zone shall be based on the depth and draught of the colliding vessel, and on the relative horizontal and vertical motions between the vessel and the floating structure. The magnitude of the collision-induced action shall account for added mass effects. Attention shall be given to collisions that can occur during offloading operations.

Structural components located in areas where marine vessels operate in close proximity to the floating structure shall be capable of absorbing the energy resulting from casual contact due to routine operations.

Emergency and essential marine equipment shall be placed away from possible collision zones.

7.5.3 Dropped objects

Accidental impact actions caused by dropped, swinging or sliding objects from cranes or other lifting devices shall be considered. Critical areas for dropped objects shall be based on the planned movement of crane lifts over the platform.

7.5.4 Fire and blast

As far as practicable, semi-enclosed locations where gas pockets can occur should be avoided in the design of a floating platform. Where this is not possible, for example in moonpool locations, the potential for gas accumulation shall be assessed and appropriate measures shall be taken to reduce the risk of explosion to an acceptable level.

Blast resistance requirements shall be addressed concurrently with fire resistance requirements, taking into account probability of occurrence, blast safety evaluation, layout and area of importance, venting system, access to escape, etc. The resistance to fire after blast shall also be addressed.

The fire/blast scenario shall be defined: for example, fire followed by blast followed by fire; or blast followed by fire. It should be demonstrated that blast wall fire insulation remains effective for the duration of the fire/blast scenario. The overall structural design shall prevent any escalation of the accidental event, including escalation events that could affect emergency and essential marine equipment and/or escape routes.

Structural support of blast walls and the transmission of the blast action into the main structural elements shall be taken into account. The effectiveness of connections and the possible outcome from the blast, such as flying debris, shall be evaluated.

7.6 Other actions

7.6.1 Stationkeeping actions

A floating structure can be kept on station by various methods, depending on site-specific criteria and operational goals. These methods include different types of stationkeeping systems, such as internal and submerged turret systems, external turret, catenary anchor leg mooring (CALM), CALM buoy and hawser, spread mooring, and dynamic positioning (DP), see [Clause 18](#). Each type of stationkeeping system imposes specific actions on the hull structure. These actions shall be considered in the platform's structural design. Specific actions induced by the stationkeeping system on the hull structure shall be consistent with the practices described in [ISO 19901-7](#).

7.6.2 Sloshing actions

Sloshing is the dynamic magnification of internal pressures acting on the boundaries of partially filled tanks due to internal fluid motion. Sloshing occurs if the natural periods of the fluid in a tank and of the motions of the structure are similar (see [9.8.4](#)). In some cases, the fitting of swash bulkheads or other baffle devices can be necessary to minimize sloshing effects.

Sloshing-induced actions shall be considered in the structural design.

7.7 Repetitive actions

Repetitive actions, which can lead to significant fatigue damage, shall be evaluated. As a minimum, the following sources of cyclic action effects should be considered:

- waves, including actions caused by slamming and variable buoyancy;
- wind, especially in conjunction with vortex-induced vibrations;
- motion-induced accelerations;
- currents, especially in conjunction with vortex-induced vibrations;
- low cycle/high stress range variable action fluctuations, such as loading and discharging of cargo/ballast;
- sloshing;
- mechanical vibrations, such as those caused by operation of machinery;
- fluctuating actions imposed by the stationkeeping system.

7.8 Action combinations

The structure's resistance shall be investigated for a range of potential combinations of permanent, variable, environmental and accidental actions (see [Clause 9](#)).

Values of environmental actions to be used in design should always be established with the intention of resulting in the most probable maximum (MPM) (or minimum) response for the limit state under consideration. For different structural components, the most onerous response can arise from different design situations.

8 Global analysis

8.1 General

The combination of risers, stationkeeping system and the floating structure is a complex integrated dynamic system responding to environmental actions (wind, waves, current, etc.). Therefore, the global analysis of the floating structure cannot be separated from the analysis of the stationkeeping system, and overlaps substantially with this activity, which is covered in detail in [ISO 19901-7](#). Accordingly, [Clause 8](#) provides an overview of the general processes, issues and requirements to be fulfilled.

For floating structures, the typical action effects controlling the structure's overall geometry and configuration, as well as the design of the stationkeeping system include structure offset, structure motions, global structural forces, minimum and maximum mooring line and riser tensions, deck clearance (air gap, freeboard) and deck level motions and accelerations.

The representative values of these action effects are usually obtained from the results of global dynamic analyses and/or model tests.

Validation of numerical results by sensitivity studies with respect to key parameters should be performed.

8.2 Static and mean response analyses

8.2.1 General

The objective of static and mean response analyses is to determine the static equilibrium position of a platform with no wind, wave or current present, and, subsequently, the mean position due to steady metocean actions and ice actions on the platform. The mean position is then used as a basis for frequency domain analyses, or as the initial condition for time domain analyses.

8.2.2 Static equilibrium in still-water condition

The determination of the static equilibrium, or weight balance, in the "still-water" condition is fundamental to sizing of the floating structure and is the starting point for further analysis. A static equilibrium analysis shall be performed for each design situation.

Determination of the static equilibrium for each design situation shall include the following:

- the total platform weight;
- the total structure displacement (the total structure buoyancy) for each draught to be analyzed;
- any riser and mooring tensions acting on the structure;
- any applicable crane hook loads.

The structural weight shall include the weight of all structural components, permanent appurtenances, and all equipment permanently mounted on the platform. In addition, the platform weight shall include all weights appropriate to the design situation being analyzed. These variable actions shall include the

weight of crude oil storage in various loading conditions (if applicable), temporary equipment, contents, consumable supplies, ballast, marine growth, ice, and any other appropriate temporary weights.

For floating structures with disconnectable moorings, design situations with and without loading from the moorings and risers shall be analyzed.

NOTE Different design situations can involve significant variations in temporary or removable weights and in actions to be included in the static equilibrium analysis.

8.2.3 Mean response analysis

The mean response is characterized by the position of the platform's centre of gravity, including setdown effects (as applicable), mean orientation of the platform (particularly for ship-shaped structures), and orientation of mooring and riser system.

The estimate of the mean response shall include the same components as the still-water condition discussed in [8.2.2](#), as well as, as a minimum, the following:

- the mean actions due to wind;
- the mean actions due to wave drift and current on the structure;
- current actions on risers and moorings.

Mean response calculations shall be repeated for a variety of design situations.

8.3 Global dynamic behaviour

8.3.1 General

While, for the analysis discussed in [8.2](#), the response of the system (floating structure, risers and moorings) can be approximated by a static or quasi-static analysis, dynamic analyses shall be performed when some natural period of the system or part thereof falls within the range of periods of steady-state actions, or when the structure is exposed to transient actions.

Dynamic effects can be important, for example, in connection with the following:

- wave frequency actions;
- low-frequency effects of wind and wave actions;
- wave slamming, sloshing in tanks, and other transient wave actions;
- mechanical impacts due to ships, icebergs or dropped objects;
- VIV and VIM;
- explosion actions.

Dynamic effects resulting from rigid body motions shall be adequately accounted for in the design process.

The effects of thrusters in terms of restoring forces and possible damping should be included.

Free surface effects in tanks shall be included, where relevant.

8.3.2 Analysis models

The metocean actions and ice actions on the platform are generally a function of both time and platform position. To allow a simple solution, a number of assumptions and linearizations are usually made.