BS EN ISO 19900:2013

BSI Standards Publication

Petroleum and natural gas industries — General requirements for offshore structures

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National foreword

This British Standard is the UK implementation of EN ISO 19900:2013. It supersedes BS EN ISO 19900:2002 which is withdrawn.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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Erdöl- und Erdgasindustrie - Allgemeine Anforderungen an Offshore-Bauwerke (ISO 19900:2013)

This European Standard was approved by CEN on 19 October 2013.

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Foreword

This document (EN ISO 19900:2013) 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 AFNOR.

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of an identical text or by endorsement, at the latest by June 2014, and conflicting national standards shall be withdrawn at the latest by June 2014.

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

This document supersedes EN ISO 19900:2002.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 19900:2013 has been approved by CEN as EN ISO 19900:2013 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.

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

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

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

ISO 19900 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 19900:2002), which has been technically revised.

ISO 19900 is one of a series of standards for offshore structures. The full series consists of the following International Standards:

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

— ISO 19901 (all parts), *Petroleum and natural gas industries — Specific requirements for offshore structures*

— ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*

— ISO 19903, *Petroleum and natural gas industries — Fixed concrete offshore structures*

— ISO 19904 (all parts), *Petroleum and natural gas industries — Floating offshore structures*

— ISO 19905 (all parts), *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units*

— ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures*

Introduction

The series of International Standards applicable to types of offshore structure, ISO 19900 to ISO 19906, constitutes a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the nature or combination of the 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 offshore structures International Standards are intended to provide wide latitude in the choice of structural configurations, materials and techniques and to allow for innovative solutions. Sound engineering judgement is, therefore, necessary in the use of these International Standards.

ISO 19900 applies to offshore structures and is in accordance with the principles of ISO 2394. ISO 19900 includes, where appropriate, additional provisions that are specific to offshore structures.

Figure 1 gives a general indication of the relationship among the various International Standards applicable to types of offshore structure. ISO 19900 is the core of this set.

The ISO 19901 series of parts provides provisions on particular aspects of the design, construction, and operation of offshore platforms for the petroleum and natural gas industries, whose provisions can be applicable to platforms of different types, materials and operating environments. ISO 19901-7 has specific relevance to floating structures.

In addition to the relationship among the specific provisions of the parts of ISO 19901 and the International Standards for bottom-founded, floating, or Arctic structures, there is also some interdependence among these latter International Standards, in that one International Standard can reference the design provisions of one of the other International Standards in this set. Users need to be aware of these cross-references when using any member of this set of International Standards.

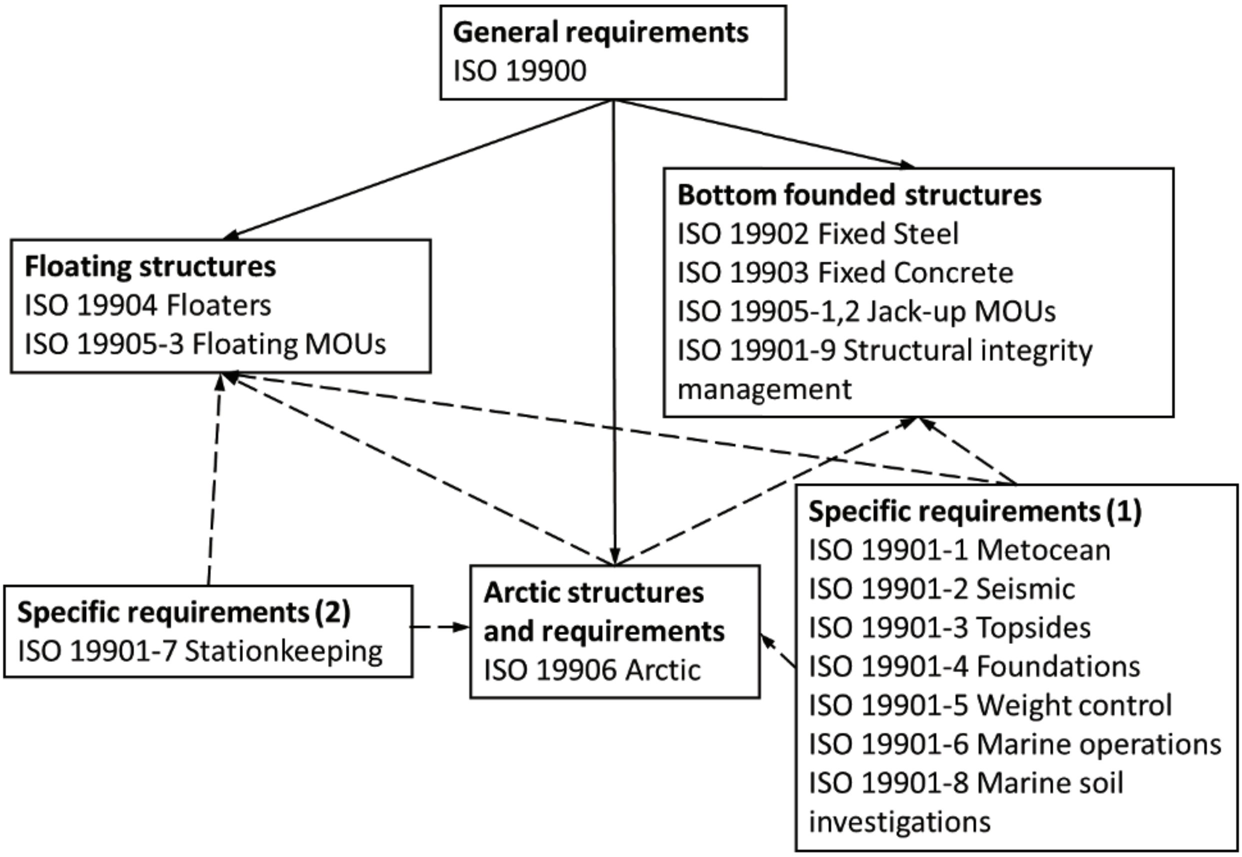


Figure 1 — Relationship among standards

Petroleum and natural gas industries — General requirements for offshore structures

1 Scope

This International Standard specifies general principles for the design and assessment of offshore structures subjected to known or foreseeable types of actions. These general principles are applicable worldwide to all types of offshore structures, including, bottom-founded structures as well as floating structures, and to all types of materials used including steel, concrete and aluminium.

This International Standard specifies design principles that are applicable to:

— the successive stages in the construction of the structure (i.e. fabrication, transportation and installation);

— use during its intended life; and

— its decommissioning.

The principles are also generally applicable to the assessment or modification of existing structures. Aspects related to quality control are also addressed.

This International Standard is applicable to the design of complete structures, including substructures, topsides structures, vessel hulls, foundations and mooring systems.

2 Normative references

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

ISO 2394:1998, *General principles on reliability for structures*

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

ISO 19901-2, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 2: Seismic design procedures and criteria*

ISO 19901-4, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 4: Geotechnical and foundation design considerations*

ISO 19901-5, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 5: Weight control during engineering and construction*

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 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.

3.1
abnormal value
design value of a parameter of abnormal severity used in accidental limit state checks in which a structure is intended not to suffer complete loss of integrity

Note 1 to entry: Abnormal events are typically accidental and environmental (including seismic) events having probabilities of exceedance of the order of 10^{-3} to 10^{-4} per annum.

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

EXAMPLE Impact, fire, explosion, loss of intended differential pressure.

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

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

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

3.4
action effect
effect of actions on structural components

EXAMPLE Internal force, moment, stress or strain.

3.5
air gap
clearance between the highest water or ice surface that occurs during the extreme environmental conditions and the lowest exposed part not designed to withstand wave or ice impingement

3.6
appurtenance
part of the structure that is installed to assist installation, to provide access or protection

3.7
basic variable
one of a specified set of variables representing physical quantities which characterize actions, environmental influences, geometric quantities, or material properties, including soil properties

3.8
calibration
process used to determine partial factors using structural reliability analysis and target reliabilities

3.9
catenary mooring
mooring system where the restoring action is provided by the distributed weight of mooring lines

3.10
characteristic value
value assigned to a basic variable associated with a prescribed probability of not being violated by unfavourable values during some reference period

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

3.11
compliant structure
structure that is sufficiently flexible that applied lateral dynamic actions are substantially balanced by inertial reactions

3.12
conductor
tubular pipe extending upward from or beneath the sea floor containing pipes that extend into the petroleum reservoir

3.13
consequence category
classification system for identifying the environmental, economic, and indirect personnel safety consequences of failure of a platform

3.14
decommissioning
process of shutting down a platform and removing it from its current location at the end of its service life

3.15
design criteria
quantitative formulations that describe the conditions to be fulfilled for each limit state

3.16
design service life
assumed period for which a structure is used for its intended purpose with anticipated maintenance, but without substantial repair being necessary

3.17
design situation
set of physical conditions representing real conditions during a certain time interval, for which the design demonstrates that relevant limit states are not exceeded

3.18
design value
value derived from the representative value for use in the design verification procedure

3.19
durability
ability of a structure or structural component to maintain its function throughout its design service life

3.20
exposure level
classification system used to define the requirements for a structure based on consideration of life-safety and consequences of failure

3.21
fit-for-purpose
meeting the intent of an International Standard although not meeting all provisions of that International Standard, such that not meeting the specific provisions does not cause unacceptable risk to life-safety or the environment

3.22
fixed structure
structure that is bottom founded and transfers most of the actions on it to the seabed

3.23
floating structure
structure where the full weight is supported by buoyancy

3.24
hazard
situation or event with the potential to cause any, or all, of human injury, damage to the environment, and damage to property

3.25
jack-up
mobile offshore unit with a buoyant hull and one or more legs that can be moved up and down relative to the hull

Note 1 to entry: A jack-up reaches its operational mode by lowering the leg(s) to the seabed and then raising the hull to the required elevation. The majority of jack-ups have three or more legs, each of which can be moved independently and which are supported in the seabed by spudcans.

3.26
life-safety category
classification system for identifying the applicable level of life-safety for a platform

3.27
mobile offshore unit
offshore structure designed such that it can be routinely relocated

Note 1 to entry: Mobile offshore unit is also known as MOU.

3.28
limit state
state beyond which the structure no longer satisfies the relevant design criteria

3.29
nominal value
value assigned to a basic variable determined on a non-statistical basis, typically from acquired experience or physical conditions

3.30
normal conditions
permanent, variable and environmental actions associated with operating conditions of the platform

Note 1 to entry: Normal conditions are sometimes referred to as persistent conditions.

3.31
offshore structure
structure used for the development and production of offshore petroleum and natural gas fields in offshore areas

3.32
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.

3.33
operations manual
manual that defines the operational characteristics, procedures and capabilities of an offshore platform and associated essential systems

3.34
owner
representative of the company or companies owning or leasing a development

3.35
platform
complete assembly, including structure, topsides, foundations and stationkeeping systems

3.36
reference period
period of time used as the basis for determining values of basic variables

3.37
reliability
ability of a structure or a structural component to fulfill the specified requirements

3.38
representative value
value assigned to a basic variable for verification of a limit state

3.39
resistance
capacity of a component, or a cross-section of a component, to withstand action effects without failure

3.40
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.

3.41
riser
tubular used for the transport of fluids between the sea floor and a termination point on the platform

Note 1 to entry: For a fixed structure, the termination point is usually the topsides. For floating structures, the riser can terminate at other locations of the platform.

3.42
robustness
ability of a structure to withstand accidental and abnormal events without being damaged to an extent disproportionate to the cause

3.43
scour
removal of seabed soils caused by currents, waves and ice

3.44
splash zone
part of a structure that is intermittently exposed to air and immersed in the sea

3.45
structural system
load-bearing components of a structure and the way in which these components function together

3.46
structural component
physically distinguishable part of a structure

EXAMPLE Column, beam, stiffened plate, tubular joint, or foundation pile.

3.47
structural integrity management system
structured methodology, consisting of a multi-step cyclic activity, including feedback, intended to assure the life and functionality of a structure

Note 1 to entry: Typical steps include data collection, data evaluation, development of an inspection strategy, development and execution of an inspection programme, and consequent remedial works.

Note 2 to entry: Structural integrity management is also known as SIM.

3.48
structural reliability analysis
procedure for the determination of the level of safety against failure of a structure or structural component

3.49
structure
organized combination of connected components designed to withstand actions and provide adequate rigidity

3.50
structure orientation
position of a structure in plan referenced to a fixed direction, such as true north

3.51
taut-line mooring
mooring system where the restoring action is predominately provided by elastic deformation of mooring lines

3.52
topsides
structures and equipment placed on a supporting structure (fixed or floating) to provide some or all of a platform's functions

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

Note 2 to entry: For a jack-up, the hull is not part of the topsides.

Note 3 to entry: A separate fabricated deck or module support frame is part of the topsides.

4 Symbols and abbreviated terms

4.1 Symbols

A accidental action

a_d design value of geometric parameter

a_k characteristic value of geometric parameter

a_r representative value of geometric parameter

E environmental action

F_d design value of action

F_r representative value of action

f_d design value of material property, for example strength

f_k characteristic value of material property, for example yield strength

G permanent action

G_k characteristic value of permanent action

G_r representative value of permanent action

L_1, L_2, L_3 exposure levels of structures

p annual probability of occurrence

p_f probability of failure

Q variable action

Q_1 variable action of long duration

Q_2 variable action of short duration

Q_k characteristic value of variable action

R reliability of a structural system

R_d design value of component resistance

R_k characteristic value of component resistance, based on characteristic values of material properties

R_r representative value of component resistance

S_d action effect

T annual return period of an action

γ_d factor related to model uncertainty or other circumstances that are not taken into account by the other γ values

γ_f partial action factor the value of which reflects the uncertainty or randomness of the action (see 9.2.3)

γ_m partial material factor the value of which reflects the uncertainty or variability of the material property (see 9.3.2)

γ_R partial resistance factor the value of which reflects the uncertainty or variability of the component resistance including those of material properties (see 9.3.2)

Δ_a additive partial geometric quantity the value of which reflects the uncertainties of the geometric parameter (see 9.4.2)

4.2 Abbreviated terms

ALS accidental limit state

ALE abnormal level earthquake

EER escape, evacuation and rescue

ELE extreme level earthquake

FLS fatigue limit state

PFD partial factor design

QA quality assurance

QC quality control

QMS quality management system

SLS serviceability limit state

ULS ultimate limit state

5 General requirements and conditions

5.1 General

Offshore structures shall be designed/assessed in accordance with this International Standard, with the relevant parts of ISO 19901, and the appropriate ISO standard for the actual platform type.

This International Standard describes a limit state based design procedure that, in combination with construction and operational guidance, is intended to result in a structure with an appropriate level of reliability. The owner, designer and/or national authorities can apply more stringent criteria.

The limit state design methodology inherent to the series of International Standards applicable to offshore structures is based on the partial factor design (PFD) approach with specified factors. There are some aspects of design for which the PFD design formulations have not been developed and for these, other approaches are used. Although reliability concepts are discussed in this International Standard, a full reliability-based approach is only recommended in certain defined situations (see 7.1.1).

The structure shall be designed, constructed, transported, installed, and operated in such a way that the structure meets the intended performance requirements and that all functional and structural requirements are met. In addition to this International Standard, designers shall comply with national regulations and standards applicable to the location under consideration when making design decisions related to safety, reliability and durability for all phases of planning, design, construction, transportation, installation, service in-place and possible removal.

5.2 Fundamental requirements

A structure and its structural components shall be designed, constructed and maintained so that they are suited to their intended use for the design service life. In particular, the structure and its structural components shall

a) withstand extreme actions liable to occur during their construction and anticipated use;

b) perform adequately under all expected normal actions during their operation;

c) not fail under repeated actions ;

d) provide an appropriate level of robustness against damage and failure (see 5.3) taking due account of

- the cause and mode of failure,
- the possible consequences of failure in terms of risk to life, environment and property,

e) meet the requirements at national, regional or local level.

5.3 Robustness

A structure design shall incorporate sufficient robustness to ensure that consequent damage is not disproportionate to the cause. For a robust structure, local damage does not lead to complete loss of integrity of the structure. Robustness can also ensure that structural integrity in a damaged state is sufficient to allow a process system shutdown, isolation of the reservoir and a safe evacuation where applicable

Robustness can be achieved

a) by ensuring (by design or by protective measures) that no critical component exposed to hazard can be made ineffective; or

b) by providing alternate load-carrying paths (structural redundancy) in such a way that any single load-bearing component exposed to a hazard can be made ineffective without causing collapse, sinking, or capsize of the structure or any significant part of it; or

c) by a combination of a) and b).

A floating structure shall incorporate sufficient damaged stability and reserve of buoyancy to ensure that credible scenarios of unintended flooding do not result in loss of the structure.

The stationkeeping systems of floating structures shall incorporate sufficient redundancy to ensure that the structure can withstand loss of a stationkeeping component (e.g. mooring line(s)) in accordance with the provisions of ISO 19901-7.

5.4 Planning

Adequate planning shall be done before design is started in order to have sufficient basis to obtain a safe, workable and economical structure that fulfils the required operational functions. Planning shall also consider all relevant and related sustainability aspects impacting the environment, the economy and society along with their interdependence and interrelationships.

The initial planning shall include specification of operational functions, design requirements and design criteria for the structure. Site-specific data, such as water depth, physical environmental conditions and soil properties, shall be sufficiently known and documented to serve as a basis for the design. The functional and operational requirements in temporary and in-service phases, as well as robustness against accidental situations and earthquakes that can influence the layout and the structural design, shall be considered.

The functional requirements affecting the layout and design of the structure shall be established in a clear format such that these can form the basis for the engineering process and the structural design.

Investigation of site-specific data, such as seabed topography, geohazards, soil conditions and environmental conditions including ice, as appropriate, shall be carried out in accordance with the requirements of ISO 19901-1, ISO 19901-2, ISO 19901-4 and ISO 19906.

5.5 Durability, maintenance and inspection

The durability of the structure in its environment shall be such that the general state of the structure is kept at an acceptable level during its design service life. Account shall be taken of the effects of corrosion, loss of material by abrasion, and other forms of degradation that can affect the resistance of the structure or structure components.

A maintenance and inspection program shall be consistent with the design and function of the structure and the environmental conditions to which it is exposed. Maintenance should include the performance of appropriately scheduled inspections, inspections on special occasions (e.g. after an earthquake or other severe or abnormal environmental or accidental event), the upgrading of protection systems and repair of structural components.

Durability of the structure shall be achieved by

a) a maintenance program; or

b) by designing the structure so as to allow for deterioration in those areas that cannot be, or are not expected to be, maintained during the planned life of the structure; or

c) a combination of a) and b).

In the case of a) or c), the structure, or components of the structure, shall be designed and constructed so that degradation remains below defined thresholds within the time intervals between inspections. The necessity of relevant parts of the structure being available for inspection, without unreasonably complicated dismantling, shall be considered during design. Degradation can be reduced or prevented by providing a suitable protection system.

The rate of deterioration can be estimated on the basis of calculations, experimental investigations, experience from other structures or a combination of these.

NOTE Structural integrity, serviceability throughout the design service life and durability are not simply functions of the design calculations but are also dependent on the quality control exercised in construction, the supervision on site and the manner in which the structure is used and maintained.

5.6 Hazards

Hazardous circumstances, that alone or in combination with normal conditions can cause the limit states (see 7.1) to be exceeded, shall be taken into account.

All hazards that can be anticipated during the design service life, including decommissioning, of the structure shall be established and evaluated.

Hazards are situations or events with the potential to cause human injury, damage to the environment, damage to property, or a combination of these. Hazards of relevance to structural design are usually divided but not limited to the following three main groups:

a) extreme environmental events;

b) accidental events;

c) abnormal environmental events.

The following measures should be considered to counter such hazards:

— careful planning at all phases of development and operation;

— avoiding the structural effects of the hazards by either eliminating the source or by provision of a barrier;

— minimizing the consequences;

— designing for the hazards.

When considering a specific hazard, a design situation shall be defined (see 7.2.2). This design situation is generally dominated by one hazardous occurrence and associated concurrent normal operating conditions.

5.7 Design basis

The conditions arising from the intended use of the structure and from the associated environmental conditions shall be described as the design situations associated with normal use of the structure. The conditions arising during construction, including transportation, installation, etc., and decommissioning of the structure and the associated environmental conditions shall also be covered by suitable design situations (see 7.2.2).

All relevant conditions shall be considered in order to establish the design basis for the structure. The principal situations and conditions that should be considered to establish the design basis for offshore structures are described in 5.8 to 5.15.

5.8 Service requirements

The service requirements and the design service life shall be specified. An offshore structure can be used for drilling, producing, processing, storage, offloading, personnel accommodation, or other function or combination of functions in support of the petroleum industry.

5.9 Operating requirements

5.9.1 Manning

The manning level for each design situation, including access and egress layouts, shall be specified.

5.9.2 Conductors and risers

The number, location, size, spacing and operating conditions of all conductors and risers shall be specified and taken into account in the structural design. The design and/or layout shall either protect the conductors and risers from accidental damage, or mitigate the adverse consequences of such damage.

5.9.3 Equipment and material layouts

Equipment and material layouts and their associated weights, centres of gravity and exposure to environmental actions shall be specified. Consideration should be given to planned future operations.

5.9.4 Personnel and material transfer

Situations utilized for personnel and material transfer and movement shall be specified. Components and systems such as the following shall be designed in accordance to the specified situations:

a) types, sizes and weights of helicopters;

b) types, sizes and displacements of supply and other service vessels;

c) number, types, sizes and locations of the deck cranes, laydown areas and other materials handling systems;

d) planned emergency personnel evacuation.

5.9.5 Motions and vibrations

Structures and parts of structures shall be designed so that accelerations, velocities and displacements do not impair safety, health and serviceability within defined operational limits.

5.10 Special requirements

All special operational, construction and maintenance requirements not covered under 5.9.1 to 5.9.5 that can affect the safety of the structure shall be specified, together with their expected concurrent environmental conditions.

The limiting environmental conditions specific for certain operations should be specified.

EXAMPLE Limiting environmental conditions can apply to floating structures for certain drafts and for jack-ups when the cantilever is fully extended.

5.11 Location and orientation

The site location and structure orientation shall be specified.

The structure should be positioned and oriented on site such that its orientation and the position of any ancillary systems (piles, mooring lines, anchors, risers, tendons, berms, movable protections barriers, etc.) take appropriate account of:

— the reservoir geometry,

— construction requirements (including access for drilling and/or construction vessels, their stationkeeping systems and their support spread),

— the physical environment, including prevailing wind, wave and ice drift directions,

— other platforms and infrastructure in the vicinity (subsea wells, manifolds, flowlines, pipelines, etc.),

— accessibility by ships and helicopters, and

— implementation of safety measures in case of fire or leakages of hydrocarbons.

Position tolerance shall be defined by the operator.

Minimum clearances between any combination of surface facilities and subsea infrastructures and components are in some cases addressed by specific standards of the series of International Standards applicable to offshore structures. For circumstances not covered by specific standards, the minimum clearance requirements should be identified through a suitable risk assessment.

The site for the structure in latitude and longitude should be identified at the beginning of the design process to facilitate development of site specific design parameters such as environmental conditions, geotechnical and geophysical parameters, seismic exposure, etc.

5.12 Structural configuration

5.12.1 General

The configuration of the structural system shall be such that the structure is able to maintain adequate structural integrity with respect to all defined limit states.

5.12.2 Deck elevation

The topsides structure shall have clearance margins above wave and/or ice conditions. Any topsides structural component, piping or other element not having adequate clearance shall be designed for actions caused by immersion/impact.

The deck elevation and air gap shall be determined taking into account the values and uncertainties of the site specific parameters as applicable:

a) water depth;

b) tides and surges;

c) crest elevation of extreme waves;

d) wave-structure interaction;

e) extreme height and shape of ice features at the structure;

f) ice build-up, ride-up, or run-up;

g) structure motion and draft (e.g. the setdown associated with TLPs);

h) initial and long-term settlements and inclination;

i) subsidence.

5.12.3 Splash zone

The splash zone extent shall be established taking into account the values of the platform elevation, motions of floating vessels, tidal ranges, platform subsidence, wave crests and wave troughs.

For floating structures with possibilities for draught adjustment, the splash zone shall be defined relative to the maximum and minimum draft levels expected.

NOTE The splash zone is important in relation to inspection and maintenance considerations and can have an impact on design for corrosion and fatigue, and the extent of marine growth.

5.12.4 Stationkeeping systems

Floating structures shall be provided with a stationkeeping system, which can be either passive or active or a combination of both passive and active.

The stationkeeping system shall be designed to maintain position reference and directional control within specified tolerances.

Passive stationkeeping systems do not require real-time or active control. Active stationkeeping systems involve continuous or defined condition adjustments.

A mooring system for floating structures can be designed to be disconnectable to mitigate the effects of severe storms or other hazards, if the disconnection can be accomplished in a controlled manner without

a) impairing the safety of personnel on board the unit or a neighbouring infrastructure, or

b) creating undue risk to the environment.

c) risk of drift off causing impact to neighbouring infrastructure

NOTE Examples of passive stationkeeping systems include catenary mooring, taut-line mooring, spring buoy, catenary-anchored buoy, articulated leg and tension leg systems. Examples of active stationkeeping systems include dynamic positioning based on thrusters or catenary systems based on dynamic adjustment of mooring line tensions

5.12.5 Stability and compartmentation of floating structures

Any structure that is in a floating state, whether during construction, transportation, installation, in-place or during decommissioning, shall be designated as a floating structure with respect to the requirements of 5.12.5. The requirements of 5.12.5 may be achieved through temporary measures.

Floating structures shall be designed to have adequate stability in all relevant in-service and temporary phases. This shall include consideration of both intact and damaged conditions.

Floating structures or structures for which buoyancy is important should be subdivided into compartments to limit the consequences of unintended flooding (see 7.1.6).

The compartmentation configuration should be determined after considering special conditions and protection measures (including operation of those measures) that can be used to prevent flooding.

5.12.6 Marine operations

ISO 19901-6 shall be used to provide requirements and guidance for the planning, engineering and safe execution of marine operations for all types of offshore structures except for mobile jack-ups, pipe-laying barges and diving support vessels. ISO 19901-6 applies to those parts of the construction, operation, decommissioning, redeployment, and removal, phases, in which the structure is at risk from the marine environment.

5.13 Environmental conditions

5.13.1 Meteorological, oceanographic, and ice information

5.13.1.1 General

The environmental conditions listed in 5.13.1.2 to 5.13.1.10 shall, where appropriate to the region, be taken into account in the design. More information on meteorological and oceanographic data is available in ISO 19901-1.

These environmental conditions shall be described by physical characteristics and, where available, by statistics of key parameters. The joint occurrence of different values of parameters should also be defined when suitable data are available. From this information, appropriate environmental design conditions shall be established to consider the following:

a) type of structure being designed;

b) phase of development (e.g. construction, transportation, installation, drilling, production, etc.);

c) limit state considered.

Usually it is necessary to establish several sets of conditions that take into consideration the following:

— normal physical environmental conditions that are expected to occur frequently during the life of the structure; these conditions are required to plan field operations such as installation and to develop environment actions associated with particular operations, serviceability or fatigue checks;

— extreme and abnormal physical environmental conditions that recur with a given return period or annual probability of occurrence.

Extreme, normal and other meteorological and oceanographic parameters should utilize data from actual measurements at the site or by suitably validated model data such as from hindcast models. ISO 19901-1 shall be utilized in establishing metocean conditions.

The environmental action(s) (associated with ULS and ALS conditions) should be determined on the basis of a specified return period. Alternatively, the action(s) can be derived from specified design environmental conditions associated with defined return periods. To reliably determine the action(s) for return period values, the joint occurrence of physical environmental conditions occurring at the site should be utilized.

NOTE 1 Normally, the structure's response to actions caused by the environment is investigated for a range of potential combinations of environmental parameters and consideration is given to the closeness of the period of the action to the structure's natural period of motion or vibration. For example, for two different seastate conditions, each having the same composite return period, it is possible that the seastate having lower wave heights but a longer or shorter associated period develops more severe action effects on some components.

NOTE 2 Compliant and floating structures are generally more sensitive to environmental parameters than fixed or bottom-founded structures, since dynamic effects are more significant for such structures.

NOTE 3 Dynamic effects are relevant for all structures in sea ice environments.

NOTE 4 Normally, consideration is given to specific problems such as the tuning of a characteristic dimension of the structure with respect to wavelengths, for example, the distance between the main legs of gravity-based structures or semi-submersible structure, or the length of the hull of a ship-shaped barge.

5.13.1.2 Wind

Actions caused by wind acting on a structure shall be considered for both global and local design. Site-specific information on wind speed, direction and duration shall be determined.

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. In specific cases (for example, design of compliant structures), the frequency content is of importance and the dynamic effects should be taken into account.

The variability with elevation and the spatial coherence should be considered.

NOTE Generally, the sustained wind speed at the time of peak actions caused by waves is used for global design in conjunction with wave actions. Maximum gust conditions during the design storm are used to design topsides and individual members.

5.13.1.3 Waves

Actions caused by waves acting on a structure shall be considered for both global and the local design. Site-specific information shall be established to consider the following:

a) seastate characteristics in terms of wave height, period, duration, directions and spectra;

b) long-term statistics of these characteristics.

5.13.1.4 Water depth and sea level variations

The water depth shall be determined. The magnitude of the low and high tides and positive and negative storm surges shall be determined.

The possibility of ground subsidence shall be considered when determining the water depth.

Changes in water depth throughout the design service life shall be considered.

5.13.1.5 Currents

Tidal, wind driven, global circulation, loop and eddy currents shall be considered when relevant.

Currents shall be described by their velocity (magnitude and direction), variability with water depth and persistence.

The occurrence of fluid motion caused by internal waves should be considered.

5.13.1.6 Marine growth

In most offshore areas, marine growth occurs on submerged platform members. Marine growth, characterized by its thickness, roughness, density and variation with depth and time, shall be considered in the design since it increases surface roughness, member diameter and mass, which in turn affect actions caused by waves, earthquakes and structural motions.

The design may rely on periodic marine growth cleaning or anti-fouling systems during the platform life. Any such reliance shall be documented and the cleaning program defined over the life of the platform.

5.13.1.7 Ice and snow accumulation

Ice and snow accumulations shall be considered when relevant. The accumulation of snow on horizontal and vertical surfaces (thickness and density) shall be defined. The possibility of ice build-up through freezing of sea spray, rain or fog shall also be considered.

Ice and snow accumulations shall be included in combination with other physical environmental conditions.

5.13.1.8 Temperatures

Air and sea temperatures are likely to be relevant to structural design and can affect the material selection. Maximum, average and minimum air and sea temperatures should be determined for the field location, fabrication site and during transport, and estimates should be made of the probability distributions of the air and sea temperatures that are likely encountered during the life of the structure.

NOTE Air and sea temperatures can affect the characteristics of materials.

5.13.1.9 Sea ice and icebergs

Actions caused by ice acting on a structure shall be considered for both the global and the local design. Site-specific information shall be established to consider the following:

a) sea ice occurrence and properties in terms of type, thickness, presence of ridges, stamukhi (grounded rubble features), interaction frequency, event duration, drift speed and drift direction;

b) occurrence and characteristics of icebergs and other massive ice features in terms of mass, thickness (as well as draft and height), extent, drift speed and drift direction;

c) interaction of the ice features in a) and b) with winds, waves and ocean currents;

d) long-term statistics of a), b) and c).

Detailed information is provided in ISO 19906.

5.13.1.10 Other meteorological and oceanographic information

Other environmental information such as precipitation, fog, wind chill, water salinity and variability of the density and oxygen content of the sea water shall be determined when relevant.

5.13.2 Active geological processes

5.13.2.1 General

The nature, magnitude and return periods of potential seabed movements shall be evaluated by one of the following:

a) site investigations and analysis;

b) model testing;

c) combination of a) and b).

Seabed behaviour and its influence on the overall integrity of the structure and foundation shall be documented. Information should include such items as relict permafrost in cold regions, the potential for subsidence and slides.

NOTE In most offshore areas, geological processes associated with movement of the near surface sediments can occur within time periods relevant to platform design.

5.13.2.2 Earthquakes

Actions resulting from seismic activity shall be considered in the structure design for regions that are considered to be seismically active. Additional requirements are provided by ISO 19901-2.

The seismic hazard should be determined by detailed site-specific investigations. The investigation should include

a) seismo-tectonic and site characterization, including location of potential causative faults and fault slip history, if available;

b) seismic exposure assessment, including long-term event occurrence probabilities;

c) ground motion characterization, including attenuation;

d) definition of the design ground motion;

e) previous records of seismic activity, both in magnitude and probability of occurrence;

f) review of deep seismic records if available.

5.13.2.3 Faults

The magnitude and time scale of expected fault movements shall be estimated on the basis of a geological study and demonstrated to lead to acceptable consequences and/or low risk of occurrence.

NOTE In some offshore areas, faults can extend to the sea floor with potential for either vertical or horizontal movement. Fault movement can occur as a result of seismic activity, removal of fluids from deep reservoirs or long-term creep related to large-scale sedimentation or erosion.

5.13.2.4 Shallow gas

The presence of shallow gas shall be determined as part of the site-specific investigations.

NOTE If either biogenic or petrogenic gas is present, it can have a serious effect on the foundation behaviour and drilling operations. The presence of shallow gas can be determined by shallow seismic measurements.

5.13.2.5 Tsunamis

Waves and currents of seismic origin shall be considered in the design, with due account for the frequency and magnitude of seismic activity, exposure, water depth and local bathymetry on incident waves and currents. Potential risks from displaced material and other structures should also be assessed.

5.13.3 Geotechnical information

5.13.3.1 Soil properties

Site investigations shall be performed at the structure location to adequate depth and areal extent to

— define the various soil strata;

— characterize the physical and engineering properties throughout the zone of influence of the structure's foundation;

— identify potential hazards to the structure.

Geophysical surveys should be performed in advance and be used to define subsequent geotechnical site investigation programs (*in situ* testing and soil sampling for laboratory testing). The number of geotechnical boreholes and their depth depends on the lateral soil variability of the site, the structure configuration and the expected actions. The data obtained should be considered in combination with an evaluation of the shallow geology of the region.

Previous soil investigations and experience at the site can be used to adapt the number and extent of investigations or studies required. Additional requirements are provided by ISO 19901-4

5.13.3.2 Seabed instability

The scope of site investigations in areas of potential instability shall focus on

a) identification of metastable geological features surrounding the site;

b) definition of the geotechnical properties required for modelling and estimating seabed movement.

NOTE Movements of the seabed can be caused by ocean wave pressures, earthquakes, weight of seabed soils, mud volcanoes or a combination of these phenomena. Weak under-consolidated sediments can be unstable at very shallow angles of slope. Earthquakes can induce failure of sea floor slopes that are otherwise stable under existing forces.

5.13.3.3 Scour

The possibility of scour shall be accounted for in the design. The extent of scour shall be determined

a) on the basis of previous records from sites with similar seabed features,

b) from model tests, or

c) from calculations calibrated by prototype or model tests.

NOTE Scour is removal of seabed soils by currents, waves and ice. Such erosion can be a geological process or can be caused by structural components or mounds from drilling operations interrupting the natural fluid flow near the sea floor.

5.14 Construction and deployment

Consideration shall be given to all activities and operations required for construction including, where appropriate, fabrication, load-out, transportation, installation and securing in place of the structure. Design requirements shall be established taking into account the type of structure and its location, the environmental conditions, the construction equipment and the nature and duration of the construction operations.

5.15 Decommissioning and removal

Consideration shall be given at the design stage to decommissioning and removal of the structure at the end of its service life.

6 Exposure levels

6.1 General

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 levels are determined by consideration of life-safety and of environmental and economic consequences.

The life-safety category addresses personnel on the platform and the likelihood of successful evacuation before a design environmental event occurs.

The consequence category considers the potential risk to life of personnel brought in to respond to any incident, the potential risk of environmental damage and the potential risk of economic losses.

Since the life-safety category or consequence category of an offshore platform can change during the design service life, the platform shall be designed or assessed to meet the applicable exposure level during each phase of the design service life or shall meet the most stringent category occurring during the design service life.

Unless otherwise permitted by the owner, all components of a structure shall be designed to the exposure level of the platform. In no cases shall a component of an offshore structure be designed to a less stringent exposure level if the failure of the component will impair the function of the remaining structure with respect to the limit states.

6.2 Life-safety categories

The life safety category of a platform shall depend on the characteristics of the design events considered for its design service life. All manned platforms shall be categorized as S1 for seismic actions.

The category for life-safety shall be selected from the following options according to the specific requirements listed.

a) S1 Manned non-evacuated

The manned non-evacuated category refers to the situation where a platform (or an adjacent structure that can be affected by the failure of the platform) is continuously (or nearly continuously) occupied by personnel accommodated and living thereon.

A platform shall be categorized as S1 manned-non-evacuated unless the particular requirements for S2 or S3 are met throughout the design service life of the platform at the location.

b) S2 Manned evacuated

The manned evacuated category refers to a platform that is normally manned except when pre-determined design environmental thresholds are forecast to be exceeded. A platform may be categorized as an S2 manned evacuated platform only if the following requirements are met.

— A reliable forecast of the pre-determined design environmental thresholds being exceeded is technically and operationally feasible, and the weather between any such forecast and the occurrence of the design environmental event is not likely to inhibit an evacuation.

— Documented plans are in place for obtaining forecasts and effecting evacuation prior to the exceedance of the pre-determined design environmental threshold, and these plans shall be included in the operations manual.

— Following the forecast of the exceedance of the pre-determined design environmental threshold, sufficient time and resources exist to safely evacuate all personnel from the platform and any adjacent structure that can be affected by the failure of the platform with due consideration of the other demands on those resources (e.g. the evacuation of other manned platforms in the area).

c) S3 Unmanned

The unmanned category refers to a platform or other structural component that is manned only for occasional inspection, maintenance and modification visits. A platform may be categorized as S3 unmanned if the following requirements are met.

— Visits to the platform are undertaken only for specific planned inspection, maintenance or modification operations on the platform itself.

— Visits are not expected to last more than 24 h duration during seasons when pre-determined design environmental events can potentially occur.

— The three evacuation criteria for S2 manned evacuated platforms are met.

A platform in this category is often referred to as “not normally manned”.

It is recognized that life-safety category definitions include a degree of judgment. The operator of the platform and adjacent facilities shall determine the applicable category prior to the design of a new platform or the assessment of an existing platform and shall obtain the agreement of the regulator where applicable. When locating a platform adjacent to another platform, the life-safety category of the new platform shall be determined considering the requirements of both platforms.

6.3 Consequence categories

Factors that should be considered in determining the consequence category include

— life-safety of personnel either on or near to the platform brought in to respond to any consequence of failure, but not personnel that are part of the normal complement of the platform;

— damage to the environment;

— anticipated losses to the owner, to other installation owners, to industry and/or to other third parties as well as to society in general.

NOTE 1 This classification includes risk of loss of human life for people other than the platform's normal complement and personnel on any adjacent structure that could be affected by failure of the platform. A primary driver for the classification is damage to the environment or to society (e.g. the situation where a community/state/country would suffer significant losses as a consequence of the interruption of production). The classification is based on the assumption that the operator (and if separate, the owner) determines the economic loss category to suit his (their) tolerance of risk, with the agreement of the regulator where applicable.

The consequence category shall be selected from the following options according to the specific requirements listed.

a) C1: High consequence category

Examples of high consequence category platforms are

— platforms with high production rates or large processing capability;

— platforms that have the potential for flow of hydrocarbons from a well in the event of platform failure;

— platforms where the shut-in of the oil or sour gas production is not planned, or not practical, prior to the occurrence of a design event (such as a platform in areas with high seismic activity);

— platforms that support trunk oil transport lines and/or storage facilities for intermittent oil shipment;

— platforms that on failure can damage an adjacent high consequence platform or infrastructures.

A platform shall be categorized as C1, high consequence, unless the particular requirements for C2 or C3 are met throughout the design service life of the platform.

NOTE 2 Adjacent facilities (workover platform, local platforms, transport lines, subsea facilities, etc.) are those that are sufficiently close to the platform for there to be a high probability of impact if the platform collapses or drifts from location.

When considering adjacent facilities, it is possible that they can have been designed to a higher category than required. In such cases, the platform under design or assessment may be categorized considering the category actually required for the adjacent facility.

NOTE 3 The potential for significant unintended release of hydrocarbons from the well(s) or from adjacent major transport lines and/or storage facilities is deemed high consequence.

b) C2: Medium consequence category

The medium consequence category refers to platforms where production can be shut-in during the design event. A platform may be categorized as medium consequence only if the following requirements are met.

— All wells that can flow on their own in the event of platform failure are equipped with fully functional subsurface safety valves, manufactured and tested in accordance with applicable ISO specifications. The possibility of flow should be considered as a result of failure in any part of the system including the riser/conductor.

— Oil storage is limited to process inventory and “surge” tanks for pipeline transfer.

— Pipelines that can be affected by failure of the platform are limited in their ability to release hydrocarbons, either by virtue of inventory and pressure regime, or by check valves or seabed safety valves located at sufficient distance to be unaffected by the failure.

— The failure of the platform is assessed as unlikely to cause damage to a C1 platform it is operating over or to which it is adjacent.

c) C3: Low consequence category

The low consequence category refers to minimal platforms or other structures where production can be shut-in during the design event and there is a low probability of impact with existing surface or subsea infrastructure. These platforms generally support production departing from the platform and low volume infield pipelines. A platform may be categorized as low consequence only if all the following requirements are met:

— All wells that can flow on their own in the event of platform failure are equipped with fully-functional subsurface safety valves, manufactured and tested in accordance with applicable ISO specifications; the possibility of flow should be considered as a result of failure in any part of the system including the riser/conductor.

— Oil storage is limited to process inventory.

— Pipelines that can be affected by failure of the platform are limited in their ability to release hydrocarbons, either by virtue of inventory and pressure regime, or by check valves or seabed safety valves located at sufficient distance to be unaffected by the failure.

— The failure of the platform is assessed as unlikely to cause damage to a C1 or C2 platform it is operating over or to which it is adjacent.

It is recognized that consequence category definitions include a degree of judgment. The operator (and if separate, the owner) of the platform shall determine the applicable category prior to the design of a new platform or the assessment of an existing platform and shall obtain the agreement of the regulator where applicable.

6.4 Determination of exposure level

The exposure level for a platform depends on the life-safety category and the consequence category. The three categories for both life-safety and consequence can, in principle, be combined into nine exposure levels. However, the level used for platform categorization is the more restrictive level for either life-safety or consequence. This results in three exposure levels as illustrated in Table 1.

Table 1 — Determination of exposure level

Life-safety Category	Consequence category		
	C1: High consequence	C2: Medium consequence	C3: Low consequence
S1: Manned non-evacuated	L1	L1	L1
S2: Manned evacuated	L1	L2	L2
S3: Unmanned	L1	L2	L3

The operator (and if separate, the owner) of the platform and adjacent structure or infrastructure shall determine the exposure level applicable to a platform category prior to the design of a new platform or to the assessment of an existing platform, and shall obtain the agreement of the regulator where applicable. Platform categorization may be revised over the design service life of the platform as a result of changes in factors affecting life-safety or consequence category.

7 Limit states design

7.1 Limit states

7.1.1 General

The performance of a whole structure or part of it shall be described with reference to a specified set of limit states beyond which the structure no longer satisfies the design requirements.

Design checks should generally be carried out using a partial factor design approach as presented in the design standards accompanying this International Standard.

Structural reliability analysis (SRA) can be used to determine partial action and resistance factors; the process is known as calibration. SRA can also be used in design cases, provided it can be documented that the method is suitable, and that it provides adequate safety in typical known cases.

7.1.2 Categories of limit states

The limit states are divided into the following four categories:

a) ultimate limit states (ULS) that generally correspond to the resistance to extreme applied actions;

b) serviceability limit states (SLS) that correspond to the criteria governing normal functional use;

c) fatigue limit states (FLS) that correspond to the accumulated effect of repetitive actions;

d) accidental limit states (ALS) that correspond to situations of accidental or abnormal events.

7.1.3 Ultimate limit states

ULS for offshore structures include

a) loss of static equilibrium of the structure, or of a part of the structure, considered as a rigid body (e.g. overturning or capsizing);

b) failure of critical components of the structure caused by exceeding the ultimate strength (in some cases reduced by repetitive actions) or the ultimate deformation of the components;

c) transformation of the structure into a mechanism (collapse or excessive deformation);

d) loss of structural stability (buckling, etc.);

e) loss of stationkeeping (free drifting).

7.1.4 Serviceability limit states

SLS for offshore structures include

a) deformations or movements that affect the efficient use of structural or non-structural components;

b) excessive vibrations producing discomfort or affecting non-structural components or equipment (especially if resonance occurs);

c) local damage (including cracking) that reduces the durability of a structure or affects the use of structural or non-structural components;

d) corrosion that reduces the durability of the structure and affects the properties and geometric parameters of structural and non-structural components;

e) motions that exceed the limitations of equipment.

To control SLS by design, it is often necessary to use one or more constraints (limitations) that describe acceptable deformations, accelerations, crack widths, etc. (see 9.6.3).

7.1.5 Fatigue limit states

FLS for offshore structures refer to cumulative damage due to repeated actions typically from environmental actions.

7.1.6 Accidental limit states

Accidental limit states (ALS) relate to two types of hazards:

— specially identified accidental events;

— abnormal environmental events, including abnormal level earthquake (ALE).

For accidental limit states where the assumed design structural resistance implies reduction in the load carrying ability against ordinary actions, the structural integrity of the structure after the event needs to be checked.

The ALS check ensures that local failure does not lead to complete loss of integrity of the structure. Local failure can involve individual structural members, fluid containment membranes, mooring lines, thrusters and other components. Loss of integrity can include major structural failure, loss of stationkeeping ability, capsizing or sinking.

For ALS, the system ductility and reserve capacity may be taken into consideration in determining the resistance of the structure.

The post-damage integrity of the structure or structural components shall be determined in accordance with their required exposure level (see 6.1). The structure can be in a damaged condition provided system integrity is ensured for a sufficient period of time under specified environmental conditions to enable evacuation and to allow for repair or removal.

7.2 Design

7.2.1 General design requirements

All relevant limit states shall be considered in design. A calculation model should be established that will address each relevant limit state (see Clause 10). This model should incorporate all appropriate variables and also allow for

a) the uncertainties with respect to actions;

b) the response of the structure as a whole;

c) the behaviour of individual components of the structure;

d) the effect on the environment.

The design procedure shall not be refined to a point that is incompatible with the standard of workmanship likely to be achieved and the knowledge of the important design parameters.

7.2.2 Design situations

For any structure, it is generally necessary to consider several distinct design situations. Corresponding to each of these design situations, there can be different structural systems, different design values and different environmental conditions.

8 Basic variables

8.1 General

Each limit state considered shall be represented using a specified set of basic variables. In general, the basic variables correspond to measurable physical quantities.

Normally, the basic variables characterize

a) actions;

b) properties of materials and soils;

c) geometric parameters.

8.2 Actions

8.2.1 Classification of actions

8.2.1.1 General

Actions can be classified by their variation with time, by their point of application and by a structure's response to them. Different partial action factors apply depending on their classification and, hence, a description of each classification is necessary.

8.2.1.2 Permanent actions

Permanent actions (G) are likely to act throughout a given design situation and for which variations in magnitude with time are

a) small in relation to the mean value; or

b) attain some limiting value.

Permanent actions generally include

— self weight of structures;

— weight of topsides, permanent fixtures, and functional equipment;

— actions resulting from earth pressure;

— deformations imposed during construction;

— actions resulting from shrinkage of concrete or distortions due to welding;

— actions resulting from external hydrostatic pressure;

— actions resulting from support and/or subsidence;

— imposed deformations including prestressing and lack-of-fit.

The weight of the structure or part of the structure shall be evaluated using a weight-estimating procedure, and a factor for possible increases in weight based on a weight report should be applied. The centre of gravity of the structure and its components shall be evaluated. Allowances shall be made for uncertainties and potential changes in the centre of gravity position. Requirements on weight control are in accordance with ISO 19901-5.

8.2.1.3 Variable actions

Variable actions (Q) can vary in magnitude, position and direction during the period under consideration, and are related to operations and normal use of the installation but do not include environmental actions. Where relevant, these actions include dynamic effects.

Variable actions generally include

— actions due to use and occupancy, including actions caused by crane loads, drilling hook loads, variable ballast, helicopter loads, etc.; where appropriate, the weight of marine growth, accumulated snow and ice shall be included in Q;

— self weight of temporary structures and equipment,

— actions caused during erection;

— all moving actions such as for movable drilling derricks;

— functional temperature changes, (e.g. process related) as they can induce actions or affect material properties.

Variable actions can be further differentiated as long duration actions, Q_1, and short duration actions, Q_2 (see ISO 19902 and ISO 19906). Depending on this differentiation, different action factors may be applied (see 9.2.3).

8.2.1.4 Environmental actions

Environmental actions (E) can be repeated, sustained or both repeated and sustained.

Environmental actions generally include

— actions caused by wind,

— actions caused by waves;

— actions caused by current;

— the increase in environmental actions resulting from marine growth and/or accumulated snow and ice;

— actions caused by sea ice and icebergs;

— environmental temperature changes as they can induce actions or affect material properties;

— actions caused by seismic effects.

Procedures for the determination of seismic actions are provided in ISO 19901-2 at two levels, ELE and ALE respectively. For the ELE event the structure shall meet the normal ULS requirements. Seismic actions at ALE level may be considered as an abnormal event in design. Unless otherwise specified, the return periods should be as documented in ISO 19901-2.

NOTE The determination of environmental actions is location dependent.

8.2.1.5 Accidental and abnormal actions

Accidental and abnormal actions (A) derive from events that have a low probability of occurrence during the design service life of the structure.

Accidental actions generally result from

— collisions;

— dropped objects;

— fire;

— explosions;

— unintended or unexpected flooding;

— unexpected subsidence of the foundation;

— unexpected erosion or scour.

Abnormal environmental actions due to wind, wave, current and, where applicable, ice, shall be defined for an exposure level L1 and L2 platform. Actions derived from an ALE earthquake shall be abnormal actions for platforms at all exposure levels.

NOTE Abnormal environmental actions are strongly location dependent. Reference should be made to Regional information, as appropriate.

8.2.1.6 Repetitive actions

These actions whose variation in magnitude with time occurs repeatedly can lead to possible fatigue effects. Fatigue refers to the cumulative damage done by repeated time-varying stresses at a specific location in the structure. These time-varying stresses are caused by varying actions, especially, but not exclusively, due to wave action.

8.2.2 Classification of actions according to the structural response

Actions can be further classified according to the way in which the structure responds to an action:

a) static actions that produce static response without causing significant acceleration of the structure or component;

b) dynamic actions that cause significant acceleration of the structure or component, and thereby a dynamic response.

NOTE Whether or not the action is regarded as dynamic is dependent on the structure and the nature of the source of the action. For simplicity, dynamic actions can often be treated as equivalent static actions in which the dynamic effects, which depend on the behaviour of the structure, are taken into account by either an appropriate increase in the magnitude of the primary static action or by the addition of a representative set of inertial actions as appropriate for the type of structure.

8.3 Resistances

8.3.1 General

Resistances shall be determined by application of accepted methods using characteristic material properties and geometric parameters, or by interpretation of appropriate experimental data using empirical methods.

Resistance for limit states that involve cyclic actions should be defined such that the structure will maintain its integrity throughout the cyclic action condition.

8.3.2 Properties of materials and soils

Values describing the properties of materials and their variability shall be based on either specific qualification tests or *in situ* observations in conjunction with other sources of information. Properties relating to special test specimens should be converted to the relevant properties of the actual material in the structure by the use of conversion factors or functions that should take account of any scale effects and any dependence on time and temperature. The uncertainty in the properties of the material in the structure or of the soil should be derived from the uncertainties of the standard test results and of the conversion factor or function.

Selection of a particular material should consider all the material properties relevant to the structure. For information on the selection of steels, see ISO 19902; for information on the selection of concrete and concrete constituent materials, see ISO 19903.

For additional soil considerations, see 5.13.2 and 5.13.3 and ISO 19901-4.

8.3.3 Geometric parameters

Geometric parameters that define the shape, size and overall arrangement of structures, components and cross-sections shall be described (see 9.4) and tolerances as specified in the 19900 set of documents shall be met. When the deviation of any of the geometric parameters from its prescribed value (exceeds tolerance) the formulation of structural resistance and structural response shall take into account such deviations and prescribe modified tolerance limits for the geometric parameters if the deviations are not corrected.

9 Partial factor design approach

9.1 Principles

The partial factor design approach separates the influence of uncertainties and variabilities originating from different causes by means of partial factors.

The principles of the method are described in 9.1. However, in practical application, slight modifications are sometimes necessary or desirable to account for specific design situations (see 9.2.3 and 9.3.2).

For the partial factor design approach, the total design action effect in a limit state shall be derived from an analysis of appropriate combinations of design values of the actions. Representative action values shall be multiplied by partial action factors to obtain the factored or design values. Similarly, representative resistances shall be divided by resistance factors or the representative material properties shall be divided by material factors to obtain the factored or design values.

The total design action effect shall not exceed the factored resistance as given in Formula (1):

$$\sum S_\mathrm{d} \le R_\mathrm{d} \tag{1}$$

where S_d are the action effects resulting from a particular action, F_d:

$$F_\mathrm{d} = \gamma_\mathrm{f} F_\mathrm{r} \tag{2}$$

$$R_\mathrm{d} = \frac{R_\mathrm{r}}{\gamma_\mathrm{R}} \tag{3}$$

In the verification procedure, the values assigned to the basic variables are called design values.

The design values for actions, F_d, (see 9.2.3) shall be determined from Formula (2).

Strengths of materials shall be expressed by their design values, f_d, (see 9.3.2) determined from Formula (5).

Alternatively to Formula (5), the design resistances of components may be determined directly from Formula (3) or Formula (6).

Other relevant properties may be treated in a similar way or by introducing an additive safety margin.

9.2 Actions and their combinations

9.2.1 Characteristic values

The characteristic value of an action shall be the value associated with a prescribed probability of not being exceeded by unfavourable values during some reference period. Commonly used characteristic values are extreme values and abnormal values. In some design situations, an action can have two characteristic values, an upper and a lower value.

Extreme values and extreme events shall be used in design to verify ultimate limit states. In many design situations, the extreme event is closely associated with the extreme value of the action. The global behaviour of the structure is essentially elastic, even though local stress concentrations can exceed yield stresses and nonlinear behaviour (e.g. pile-soil interaction) is expected. Extreme parameter values and events have a probability of being exceeded in the order of 10^{-2} per annum.

Abnormal events and associated acceptance/performance criteria shall be used in design to verify accidental limit states. In design situations, the abnormal event is closely associated with the abnormal value of the action, for which the global behaviour of the structure does not suffer complete loss of integrity. For all exposure levels, for abnormal events when there are life safety implications, the structural integrity shall be ensured to enable evacuation following event exposure. Abnormal parameter values and events have a probability of being exceeded in the order of 10^{-3} to 10^{-4} per annum.

If characteristic values cannot be determined from statistical data or where appropriate data are not available, the corresponding values can be estimated on the basis of available information or from other standards. The resulting value is then a nominal value.

The return period, T, is the average duration between consecutive occurrences of an event or exceedance of a particular value for a basic variable. The event or exceedance occurs once on average during the return period. The return period in years is given by Formula (4):

$$T = \frac{1}{p} \tag{4}$$

where p is the annual probability of exceedance for the event.

The annual probability of exceedance is the probability that an event of a specific magnitude or that a value of a basic variable is exceeded in any one year.

Typical return periods are 10 years, 50 years, 100 years, 1 000 years and 10 000 years, which correspond to annual probabilities of 10^{-1}, 2×10^{-2}, 10^{-2}, 10^{-3} and 10^{-4}, respectively.

This return period is an indication of the order of magnitude rather than a precise number since accurate databases for such small probabilities of exceedance rarely exist. For abnormal ice events, the representative value for actions arising shall be determined based on an annual probability of exceedance for the action or shall be derived from events with the same annual probability of exceedance leading to the action.

9.2.2 Representative values

For different design situations, different values can be assigned to each action. These values are called representative values.

The main representative value is the characteristic value. In situations where the effect of a reduction in an action is more onerous for the structure, the lower characteristic value shall be taken as the representative value.

Other representative values are chosen with regard to some features of the situation, for example, duration of exposure and geological phenomena, and can be expressed as a proportion of the characteristic value.

A permanent action G has, in general, a unique representative value. When the action consists of the self weight of the structure, the value G_r shall be obtained from the intended values of the geometric parameters (in general, taken from drawings) and the mean density of the material.

In cases where the uncertainties in the permanent actions are important, characteristic values should be used. In such cases, both upper and lower characteristic values shall be defined, if necessary.

In treating repetitive actions for fatigue analysis, rather than determining a single representative value, it is necessary to establish their variation in magnitude with time in order to determine the number of repeated actions of each magnitude.

9.2.3 Design values

The design value of an action shall be used for verification of a limit state. Design values shall be obtained from representative values by multiplication by partial action factors (γ_f). Design values can be specified at the extreme level or abnormal level, or at another level used in design (see 9.2.2).

The partial action factors shall take account of:

a) the possibility of unfavourable deviations of the actions from their representative values;

b) uncertainty in the calculations of actions.

The partial action factor should depend on the limit state considered. In particular, the action factors for ULS and for SLS are generally different. The partial action factors can also be different for different action sources within an action type (see 8.2).

9.2.4 Combinations of actions

Design values of the different actions shall be considered simultaneously in the verification of a limit state.

Actions that are mutually exclusive should not be included in the same combination.

The actions shall be combined so that they produce the most unfavourable effect on the structure for the limit state considered.

A reduced probability of simultaneous occurrence of unfavourable values of several independent actions may be used if the probability of exceeding the design action effect achieves the same level of reliability as otherwise achieved by this International Standard.

In the ULS, the following two types of combinations shall be applied, depending on the design condition:

a) operational combinations (i.e. combinations of permanent actions, variable actions and normal environmental actions);

b) extreme combinations (i.e. combinations of permanent actions, variable actions and extreme environmental actions, for example, specified return period climatic conditions).

Accidental actions should be included in ALS combinations only. Accidental action (ALS) combinations normally include permanent actions, variable actions and one accidental action. Where accidental actions are assumed to occur simultaneously, the annual probability level shall apply to the combination of these actions. Unless the accidental actions are caused by the same phenomenon (such as hydrocarbon gas fires and explosions), the occurrence of different accidental actions may be assumed to be statistically independent. An ALS combination should also cover effects associated with an accidental situation, such as the decrease of resistance due to fire.

Abnormal environmental actions should be included in ALS combinations only. Abnormal environmental combinations normally include permanent actions, variable actions and the abnormal environmental action or abnormal seismic action under consideration.

For FLS, the cumulative effect of all repetitive actions during the life of the structure shall be considered and taken into account, if relevant.

For special purposes other combinations can also be applied. For each of these types of combination, special sets of combination factors can be specified.

9.3 Properties of materials and soils

9.3.1 Characteristic values

The characteristic resistance or material property generally corresponds to a specified fractile of the statistical distribution. If lower values result in the most onerous design condition, the characteristic value shall generally be defined as the value below which 5 % of the values are expected to fall. If higher values govern the design, the characteristic value can be defined as the value below which 95 % of the values are expected to fall. For guidance on soil properties, see 5.13.3 and ISO 19901-4.

In cases where the material properties vary in time or where environmental condition effects such as corrosion change the material properties or dimensions, the characteristic values used for the design shall be chosen to take such changes into account.

Fatigue design checks are normally based on fatigue endurance curves (SN-curves). The characteristic value is generally defined as the value below which 2,3 % of the values are expected to fall (mean minus two standard deviations). In special cases, fracture mechanics approaches may be applied in fatigue checks. In such cases, the characteristic values of the crack propagation parameters and the value of the initial and failure crack size should be chosen to be consistent with the fatigue endurance curve approach.

9.3.2 Design values

The design value, f_d, of the strength of materials (or other material properties) is generally obtained from the representative value, f_k, using Formula (5):

$$f_d = \frac{f_k}{\gamma_m} \tag{5}$$

The value, γ_m, in Formula (5) takes account of:

a) the possibility of unfavourable deviations of the material property, interpreted as a random variable, from the characteristic value;

b) possible inaccurate assessment of the resistance of sections or action-carrying capacity of parts of the structure (if not included in γ_d);

c) uncertainties in geometric parameters, if they are not taken into account according to 9.4.2 or not included in γ_d;

d) uncertainties in the relationship between the material properties in the structure and those measured by tests on control specimens, for example, uncertainties in the conversion factor or function according to 8.3.

The value of γ_m depends on the material property, the actual limit state and component resistance uncertainty.

The design value, R_d, of a component resistance is generally obtained from its characteristic value, R_k, using Formula (6):

$$R_d = \frac{R_k}{\gamma_R} \tag{6}$$

In this case, the value γ_R takes account of a) to d) and, in addition, uncertainties in the relevant design expression for resistance, i.e. the calculation model (see A.3.5).

9.4 Geometric parameters

9.4.1 Representative values

For geometric parameters the representative values a_r usually correspond to the nominal values specified in the design.

9.4.2 Design values

In cases where deviations of the geometric parameters have insignificant effects or where the effects are accounted for by the partial resistance factor (γ_R) values, the representative value may be used as the design value.

Geometric parameters shall be expressed by their design values, a_d, defined by Formula (7):

$$a_d = a_r \pm \Delta a \tag{7}$$

9.5 Uncertainties of calculation models

The uncertainties in a calculation model are generally accounted for by one or several of the partial factors (generally γ_R). For guidance, see Clause 10.

9.6 Values for partial factors

9.6.1 General

The assessment of the different limit states requires that partial action factors be specified depending on the cause of the action (permanent, variable, environmental, abnormal, etc.) and the nature of the limit state. Partial resistance and material factors are specified depending on the structural response and the nature of the limit state.

9.6.2 Ultimate limit states

9.6.2.1 Actions

Partial action factors are specified for the various types of structures covered in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906. See Clause A.1 for additional information.

9.6.2.2 Resistances and materials

Partial resistance and material factors should account for the variability in material properties and the uncertainties listed in 9.3.2.

Partial resistance and material factors are specified in ISO 19901-4, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906.

9.6.3 Serviceability limit states

Partial action factors in SLS shall be taken to be 1,0. Different safety levels can be achieved by using different values for constraints such as acceptable deformations, accelerations and crack widths. Partial factors for materials and resistances in SLS shall be taken to be 1,0.

9.6.4 Fatigue limit states

All partial action factors for fatigue limit states shall be taken to be 1,0.

9.6.5 Accidental limit states

Partial action factors for accidental or abnormal actions shall be taken to be 1,0. This is because the inherent uncertainty in the action is large and is covered in the determination of the characteristic value for the action. Partial factors for materials and resistances in ALS should be taken to be 1,0.

9.7 Structural reliability analysis

The partial action factors and the resistance factors given in the series of International Standards applicable to offshore structures have been established or calibrated using structural reliability analyses. The reliability models have generally followed the principles given in ISO 2394 and have been calibrated based on relevant test data for structural components and full scale offshore load monitoring programmes.

The following principles for performing structural reliability analyses have generally been used in the development of the series of International Standards applicable to offshore structures, and should also be used in their application (see 5.1).

a) Structural reliability analyses shall not replace sound engineering judgement.

b) Structural reliability analyses shall follow the principles given in ISO 2394 and shall account for the uncertainty associated with important parameters and models.

c) Models used for structural reliability analyses should be calibrated based on relevant test data for structural components and full-scale offshore load monitoring programmes for action parameters.

d) Reliability targets should depend on the consequences of failure, with particular reference to exposure levels L1, L2 and L3.

Clause A.2 provides additional information and guidance on reliability.

10 Models and analysis

The structural analytical procedures and calculations described in the series of International Standards applicable to offshore structures are often performed with the assistance of computer-aided engineering tools, physical scale model tests, or full-scale prototype model testing. A combination of these methods can also be used.

Analytical and physical models employed and the basic formulation of the analytical procedures shall provide adequate representation of the actions and the structural response consistent with the limit state under consideration.

Further high-level guidance on analyses and models is provided in Clause A.3.

Models of the features of the structure that have an important influence on its overall stability and integrity shall be maintained and checked throughout all stages of the structure's life cycle.

The influence of the environmental conditions on the behaviour of materials shall be considered in the analysis when appropriate.

EXAMPLE Environmental conditions that can be included directly in the analysis include the influence of environmental humidity conditions on the shrinkage and creep deformations of concrete and the influence of high temperature during a fire on the strain distribution and the strength of structural components.

Consideration shall be given to the extent of assurance required to quantify the bias and uncertainty in the results supplied from analytical calculations and model tests. These are generally a function of the assumptions specified and agreed, of the novelty of the structural configuration, of the complexity of the calculations performed, of the history of verification and validation of the software or physical tools being used, and of the expertise and experience of the operator or the analyst.

Gross errors can arise in applying reported results due to misunderstandings, mistakes, misuse and inadequate benchmarking.

11 Quality management

11.1 General

This clause provides an overview of the quality management system (QMS) for the design, fabrication, transportation and installation phases of a typical offshore structure construction project. More detailed requirements are presented in structure-specific standards, such as ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906.

A QMS consists of a quality assurance (QA) process that identifies the requirements and a quality control (QC) system that identifies the means of assuring quality.

During the execution of a project, QC inspection and testing shall be performed to ensure that the detailed instructions provided by plans and specifications are followed in order to obtain the desired quality and service performance in the finished product, during all phases of construction, transportation, installation, operation, and removal.

QA/QC, inspection and documentation requirements should be commensurate with the structure's exposure level (L1, L2, or L3), as described in 6.1, and shall be consistent with recognized international, *de facto* international, regional or national standards. Additional requirements and modifications to suit the project application can be specified by the owner or operator. These should be coordinated with the material selection and fracture control philosophy, among others, used in design.

All steps in planning, design, construction and use of a structure shall be controlled to an extent that ensures that

a) the design requirements are fulfilled;

b) the potential for error and unfavourable deviations from the design plans and specifications are mitigated.

An effective QC scheme is one that prevents the introduction of defective materials or workmanship into a structure, rather than depending upon QA and documentation which come after the fact.

Where a platform is one of a series built to a standard design, the quality management procedure may reflect the potential reduced scope afforded by commonality. As a minimum, it shall ensure that the site specific foundation requirements are addressed, that the production system loads are within the design capability of the structure and that the structure is built to the quality requirements of the standard design.

ISO/TS 29001 offers guidance on quality management systems for the oil industry.

11.2 Responsibilities

Responsibilities shall be defined and documented for all activities and their interfaces during all phases of development. Scopes of individual responsibility shall be made known to all concerned.

11.3 Quality management system

All design, fabrication and installation shall be performed under a documented quality management system (QMS), e.g. in accordance with ISO 9001.

The QMS shall, as a minimum, address the applicable items listed in Table 2, in accordance with the structure's exposure level. Some of these items may be covered by reference to the QC plan. The QMS shall relate to the components of the structure and to any additional components that are critical to the fabrication of the structure, e.g. design and testing of lifting beams and lifting procedures.

Table 2 — Quality system requirements

Item description	Exposure level[a]		
	L1	L2	L3
Quality management plan	M	M	M
Quality assurance manual	M	M	R
Organizational chart	M	M	R
Documentation and drawing control procedures	M	M	R
Management of change (MOC) procedures	M	M	R
Design calculations	M	M	M
Fabrication procedures	M	M	M
Lifting procedures	M	M	M
Material tracing control procedures	M	M	R
Dimensional control/survey procedures	M	M	M
Inspection equipment calibration procedures and certificates	M	M	R
Subcontractor quality procedures	M	M	R
Weight reports procedures	M	M	M
Procurement procedures for materials/services	M	M	M
Procedures for handling special processes (e.g. heat treatment)	M	M	R

a M indicates "minimum requirement".
R indicates "recommended requirement".

11.4 Quality control plan

11.4.1 General

QC is normally performed as appropriate prior to and during fabrication, loadout, transportation and installation, operation and removal. The purpose of quality control is to ensure that materials and workmanship meet the specified requirements. QA is generally performed during and after QC activities, to provide records and documents.

As part of the QMS, a QC plan shall be developed which makes reference to procedures for all inspection and NDT techniques, including proposed report formats and the names and qualifications of inspection and NDT personnel.

The QC plan shall define the scope of inspection required for fabrication.

The QC plan shall consider the elements in 11.4.2 to 11.7.5.

11.4.2 Qualifications of personnel

All activities that are performed in the engineering, design, construction, transportation, installation, inspection and maintenance of offshore structures covered by the series of International Standards applicable to offshore structures shall be performed by competent personnel with the qualifications and experience necessary to meet the objectives of these International Standards. Documentation related to qualifications and relevant experience for all key personnel and for personnel performing tasks that normally require special training or certificates shall be part of the QC documentation.

National requirements on qualifications of personnel such as engineers, operators, welders, divers, etc. in the place of use apply.

11.4.3 Materials inspection

Inspection shall verify that materials being incorporated into any portion of the structural system are in accordance with the specified requirements. Inspection procedures should ensure traceability of materials by marking and record keeping.

11.4.4 Fabrication inspection

Fabrication inspection shall address specified design requirements, including the parameters of processes applied to components during different phases of fabrication, dimensional control, alignment, tolerances, orientation, surface treatments, assembly weights, etc.

For composite materials such as concrete, the inspection scope shall include the quality of the materials delivered to site, batching operations, taking and testing of samples, compaction and handling, placing of reinforcement, prestress cable tensioning, etc.

11.5 Installation inspection

At the conclusion of the transportation, and prior to commencement of installation operations, appropriate inspection shall be conducted to confirm the structure is undamaged. Inspections shall verify that all installation aids and appurtenances have been installed and tested in accordance with the specified requirements, including any manufacturer's recommendations. Following installation, the structure shall be re-inspected to confirm that key aspects are in conformance with the design specifications.

EXAMPLES Deck elevation, air gap, pile penetration, ballast, anchor tensions and cathodic protection.

11.6 In-service inspection, maintenance and repair

The structure shall be maintained in such a way that it can safely fulfil its intended future use according to the provisions of this International Standard and of the relevant structure-specific standard in the series of International Standards applicable to offshore structures.

To meet these requirements, a structural integrity management system should be developed and documented. As a minimum, an inspection strategy shall be established. Maintenance should be specified accounting for the importance and use, knowledge of the durability of the components and the redundancy of the structure, environmental conditions and the protection against external actions.

Structural components that are essential to the stability and resistance of a structure should, as far as possible, be accessible for inspection.

11.7 Records and documentation

11.7.1 General

During the fabrication, erection, load out and installation phases, data related to the 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.

The inspection results and other documents listed in Table 3 shall be prepared insofar as they apply to the particular structure and to its exposure level. All documentation referenced in Table 3 shall be retained on file for the life of the structure unless noted otherwise in the project's approved quality assurance manual, and made available to new owners, where appropriate.

Table 3 — Documentation requirements

Documentation description	Exposure level[a]		
	L1	L2	L3
Material tracing records	M	M	R
Engineering drawings	M	M	M
Shop drawings	M	M	R
Design calculations for construction purposes	M	M	R
Dimensional control/survey records	M	M	R
Material certificates	M	M	R
Inspection records	M	M	R
Equipment operability test reports	M	M	R
Other reports	M	M	R
Weight reports	M	M	M
Foundation verification report	M	M	M
As-built drawings	M	M	R

[a] M indicates "minimum requirement".
R indicates "recommended requirement."

11.7.2 Calculations

The structural integrity of components and adequacy of equipment during all phases of construction shall be addressed.

Calculations should

a) address the structure, attachments, temporary works, cranes, and rigging;

b) address structural strength and stability;

c) address all actions, stresses, deflections, equipment, and rigging;

d) reference appropriate drawings and specifications.

Calculation documentation should provide the source of calculation methods.

11.7.3 Weight and centre of gravity reports

Weight and centre of gravity reports shall be based on design weights and design drawings, shop drawings, or as-built drawings as the job progresses.

NOTE Requirements on weight control are given in ISO 19901-5.

11.7.4 Fabrication inspection documentation

Documentation related to fabrication activities shall be provided in accordance with Table 3, as appropriate.

11.7.5 Drawings and specifications

The drawings and specifications prepared through the course of the project should comprise the following:

a) conceptual drawings;

b) bid drawings and specifications;

c) design drawings and specifications;

d) fabrication drawings and specifications: the contractor shall prepare and provide fabrication procedures and assembly drawings describing and showing the proposed methods and order of assembly on the structure; these procedures and drawings shall include rigging components, rigging configuration, lifting crane capacity and location, temporary aids and attachments to the structure;

e) shop drawings, which shall include all shop details, including material types, cuts, copes, joint details, holes, bolts and piece numbers in accordance with the contract drawings;

f) installation drawings and specifications;

g) as-built drawings and specifications, which shall be prepared and furnish as-built versions of the design drawings that accurately reflect the structure as built.

12 Assessment of existing structures

12.1 General

An assessment shall be conducted according to this International Standard when an existing structure:

— has deteriorated significantly or has been damaged;

— is intended for a use that invalidates the original design assumptions;

— is to have additional topsides equipment, wells or appurtenances not included in the original design;

— has departed from the original basis of design;

— has experienced environmental conditions substantially different from its site-specific or regional extreme storm design parameters, particularly in cyclonic storm areas;

— was originally designed using design criteria that are no longer valid.

The assessment shall determine whether those aspects of the design that have been identified as no longer complying with original design criteria are fit-for-purpose.

This can involve justifying that the design is fit-for-purpose (via a deviation request to the regulator if appropriate) or conducting modifications to operations to achieve compliance with the intent of this

International Standard. Any modification to the structure, however, shall be fully compliant with the provisions of this International Standard.

Where operational experience shows that the acceptability of aspects of design is uncertain, fitness-for-purpose shall be determined by specific assessment and appropriate measures taken to maintain acceptable standards of performance.

If there are changes to the environmental design criteria, it shall be demonstrated that the structure is safe for all limit states. This can involve site-specific calibration of action factors, explicit consideration of the joint distribution of environmental actions or changes to operating procedures that can mitigate the environmental actions.

If the reassessment is performed due to increases in extreme environmental parameters, a reduced partial environmental action factor may be acceptable for exposure level L2 and L3 structures, if survivability under ULS and ALS conditions can be demonstrated, i.e. no failure would occur that could lead to catastrophic loss of the structure.

12.2 Condition assessment

12.2.1 General

When a platform requires assessment, it cannot be assumed that the platform condition and the actions (see 8.2) originally used for design remain valid.

When conducting an assessment, values of physical parameters confirmed by construction (e.g. weight, pile penetration, material properties) should be used in lieu of the values used during the original design.

12.2.2 Service and operating requirements

The actions acting on or resulting from topsides equipment, including additional topsides, wells, or appurtenances not included in the original design, shall be reviewed and reassessed to determine any significant changes in weights and their centres of gravity. Any operational changes that affect the structure shall also be considered.

12.2.3 Environmental conditions

The original design environmental criteria (metocean, ice, geological processes, seabed properties) shall be reviewed based on available data. The extent of the analysis required depends largely on the time elapsed and the additional data available since the original design. The criteria shall be increased or reduced if necessary and used in the reassessment.

Data may be taken from

a) measurements at the site;

b) measurements at nearby sites;

c) hindcast studies.

12.2.4 Inspection, maintenance and repair history

The records of testing, inspection, maintenance and repair maintained during the structure’s operating life shall be reviewed to ascertain whether there are any defects or trends of deterioration that require repair or justification through the assessment process. When the inspection records are insufficient or incomplete, additional inspection shall be considered in order to establish the condition of the structure.

12.3 Action assessment

Current recognized methods of action calculation shall be used. When available, records of measured actions and responses of the structure may be taken into consideration.

Where the structure has been instrumented and the measured actions and responses calibrated against the measured environment, these records shall be used in the reassessment.

NOTE The assessment is normally based on current methods of action calculation. Where appropriate, more advanced methods of action calculation can be used to represent the development of actions in a more realistic and possibly a less conservative manner.

12.4 Resistance assessment

Currently recognized methods of resistance calculation shall be used. The effect of damage, material degradation or modifications on the resistance of the structure shall be taken into account.

If a structure that has been originally designed to meet previous editions of this International Standard or other standards is assessed, it should be checked using the procedures given in this International Standard.

12.5 Component and system failure consequences and mitigation

When considering assessment of existing structures, limited individual component failures may be accepted, provided the reserve against overall system failure remains acceptable.

In some cases, individual components of older existing structures do not meet the requirements of the series of International Standards applicable to offshore structures. In such cases, yielding or failure of individual components may be acceptable, provided the remaining parts of the structural system have sufficient reserve strength to redistribute the action. As an example, a pushover type analysis can be used to demonstrate that the reserve strength of the structural system meets acceptable levels. The effect of such action redistribution on the low as well as high cycle fatigue should be considered. When it is not possible to show that the structure is acceptable by analysis, repairs or strengthening can be required. Alternatively, when strengthening is not a viable option, equivalent reliability to the requirements of this International Standard may be achieved through non-structural measures, e.g. de-manning of platforms to prevent loss of life and installation of safety devices to maximize hydrocarbon containment.

12.6 Fatigue

The adequacy of the fatigue life for the intended remaining life of the structure shall be reviewed by analysis or inspection and shall be taken into account when planning any future inspection or repair requirements.

Fatigue damage that has previously occurred shall be taken into account in the fatigue analysis.

12.7 Mitigation

Mitigation can help extend the life of a structure or improve its chances of survival in a design event if employed early. Mitigation typically involves reducing loads on the structure such as removing unused risers, plugged and abandoned conductors, appurtenances such as boat landings and barge bumpers and increase deck height elevation (deck inundation reduction) or increasing the structure’s strength. Mitigation can also include active programs to minimize the consequence of damage or failure, such as plugging and abandoning unused wells or removing inactive process equipment. Mitigation can also include relocating critical equipment and systems to minimize the consequences of damage or failure.

Annex A
(informative)

Additional information and guidance

A.1 Calibration of partial factors

The derivation of partial factors is generally done over a range of design situations. While the reliability that is achieved can vary from one design situation to another, the individual factors are optimized so that deviations from the target reliability are minimized over a number of situations. Calibration can be done for individual geographical areas and structural configurations, or for the expected range of geographical areas and structure configurations.

Separate calibration is generally required for each limit state and for each exposure level: L1, L2 and L3.

The calibration of partial factors should address the importance of particular components in the overall structure, weighted combinations of action effects, and resistance models. Due account should be taken of different occurrence rates and statistical uncertainties in the basic variables.

A.2 Reliability

A.2.1 General

In this International Standard, the term “reliability” is used primarily in the context of “structural reliability”, which is but one contributor to the overall safety of personnel, risk to the environment and economic risk.

When reliability assessments are based on actual experience, they are referred to as “actuarial” implying that the results can be interpreted as true failure rates. In such cases, uncertainties (including lack of knowledge) are minimal and do not substantially affect the calculated or assumed reliability level. When the modelling uncertainties and assumptions have a significant effect on the results, reliability analyses are considered to be “notional”, implying that failure rates should not be interpreted as being true. The use of actuarial methods is preferable but this is not always possible.

“Notional” structural reliability analyses are often used to establish ULS and FLS criteria, while “actuarial” risk assessments should play a larger role with respect to ALS criteria.

Reliability levels are tied closely to causes, design situations, analysis methods used and uncertainties considered. The different practices used in structural, foundation, seismic and ice engineering should be acknowledged when setting target levels.

To the extent possible, chosen reliability targets should be consistent with established practice so as to maintain acceptable risk values. Life safety, environmental consequences and economic consequences should all be considered when establishing targets. When relevant, consideration should also be given to changes in the parameters influencing the reliability over the design service life or the period of analysis.

The principles outlined in this clause can be used for

— derivation of partial factors;

— demonstration that adequate safety is achieved through a particular design solution;

— demonstration that adequate safety is achieved through operational procedures such as transportation, escape, evacuation and rescue (EER) and ice management.

A.2.2 Reliability and failure probability

Safety can be expressed in terms of

— a failure probability during a specified reference period;

— a reliability, which is the probability of not having a failure during the reference period.

Reliability and failure probability are generally expressed on an annual basis, which implies a reference period of one year. Either measure can be used with equivalent results and the two terms are often used interchangeably.

The relationship between reliability, R, and failure probability, p_f, is given by Formula (A.1):

$$R = 1 - p_f \tag{A.1}$$

A measure of structural reliability that is sometimes used is the reserve strength ratio, which is the ratio of the ultimate capacity of the structure divided by the 100 year extreme action. While correspondence can be made between such measures and reliability, it is emphasized that the comparison is predicated on the specific analysis methods used.

A.2.3 System and component reliability

Reliability can be assessed for individual structure or system components, as well as for entire structures or systems. System reliability should be evaluated when more than one failure state governs the reliability of a structural or system component, or when the structure or system being analysed contains multiple components. Particular emphasis should be placed on the likelihood of system failure following initial component failure.

ALS criteria are often associated with system failure while ULS and FLS criteria typically relate to component failures. With specific reference to fatigue requirements, it is important to relate the component criteria to the likelihood of system failure as a result of fatigue failure.

Reliability targets for structural failure (e.g. for L1 and L2 exposure levels) have been established for the most relevant hazards including storm, seismic and ice hazards. These targets have been established to ensure that the levels of human and environmental risks are acceptable to society.

A.2.4 Single and multiple causes

Reliability assessments can be made for single or multiple causes. Single causes can include specific physical environmental processes such as waves and ice, or other hazards such as fires, explosions and vessel collisions. Reliability targets should reflect the relative contributions of the various causes to the safety of the structure or system.

A.2.5 Failure probability and life safety

Risk levels on offshore installations are often quantified and presented in safety analyses (safety cases) in terms of individual risk per annum (IRPA), defined as the probability of loss of life for an individual per year. Risk tolerability criteria are stated in terms of IRPA and risk mitigation measures are evaluated in terms of their contribution to reducing IRPA.

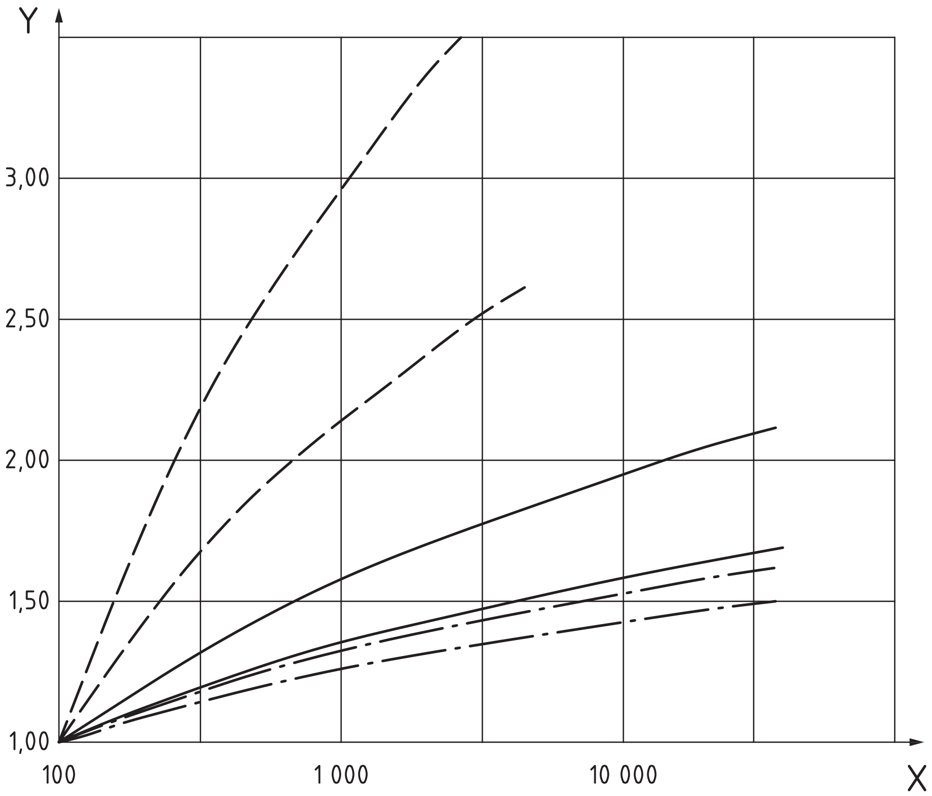
The IRPA contribution is directly proportional to the annual probability of structural collapse due to a given hazard if the installation is manned during such an event (L1 exposure level). Nevertheless, structural failure is only one contributor to individual risk and this proportion can vary substantially based on the type of platform and the geographical area. For manned installations, the IRPA and consequently the annual probability of structural collapse should be minimized.

A.2.6 Hazard curves

Reliability targets for structural failure (e.g. for L1 and L2 exposure levels) have been established for the most relevant hazards including extreme storm risk (see ISO 19902), earthquake risk (see ISO 19901-2) and ice risk (see ISO 19906). For a given exposure level, the differences in these targets largely reflect the differences in the slope of the relevant hazard curves.

The hazard curve describes the variation of hazard magnitude with return period or annual probability of exceedance. This curve provides a measure of the relative difficulty of reducing a given risk. Figure A.1 shows example hazard curves covering wave actions (for steel offshore platforms that are drag dominated), sea ice actions and earthquake actions.

The "slope" of the hazard curves can be defined as the ratio of the 10 000 year hazard intensity divided by 100 year hazard intensity. In the examples given in Figure A.1, the slope of the hazard curve is relatively mild for sea ice actions (1,4 to 1,5) (see Reference [14]), it increases to 1,5 to 1,9 for wave actions on drag dominated structures (see Reference [15]), and it increases significantly to 2,5 to 5 for earthquake hazards (see ISO 19901-2). Hazard curves for iceberg actions (see Reference [14]) are in line with those for earthquake hazards.



Key

Y normalized actions (ERP/E100)[a]

X return period (years)

— — — — — for earthquake actions

———— for wave actions

—— · —— · —— for sea ice actions

[a] ERP/E100 is the ratio of the action at different return periods to the 100 year action

Figure A.1 — Example hazard curves

This difference in slope means that the incremental cost for improving safety depends on the hazard type and geographic location. In an area of high seismicity, this cost can be much higher than the cost of improving safety under extreme storm or sea ice actions.

For sea ice actions, the slope of the hazard curve is similar to the lower limit of the wave hazard curve that is associated with winter storms. As a consequence, the action factors applied to 100 year values for the ULS design, given in ISO 19906:2010, Table 7-4, are indeed very similar to those given in ISO 19902:2007, Table A.9.9-1, for winter storms (North Sea). The return periods for ALS design are also equivalent and the reliability targets are similar.

For other hazards or geographical areas not explicitly covered in the suite of ISO offshore structures standards, consistent action factors can be developed using these same principles and by considering the guidance provided in A.2.7.

A.2.7 Probabilistic analysis

A.2.7.1 General

ISO 2394 contains many details on probabilistic calculation methods. Some general guidance for offshore structures is given in A.2.7.2 to A.2.7.4.

A.2.7.2 Model characterization

Actions and resistances can be represented directly by probability distributions or using mathematical models of their relationship with environmental or structural parameters, which are themselves described by probability distributions.

Uncertainty in the models used to represent actions and resistances should be characterized and incorporated in the methodology.

A.2.7.3 Parameter characterization

The following should be considered in the specification of the probability distributions for basic variables in the models for events, actions and resistances.

— The choice of distribution should reflect the nature of the process.

— Local field data should be used when available to characterize actions. Where direct measurements are insufficient, sound and defensible physical and mathematical reasoning should be made in the application of data from other geographical regions, when merging available data sets and establishing correlations with other local parameters.

— The simplest forms for distributions are often best, particularly where the quantity of data is limited.

— Sampling bias should be corrected.

— Special attention should be given to the tails of parameter distributions that are responsible for larger actions. Extrapolation to extreme or abnormal values from limited data sets can result in significant errors and potentially lead to unsafe or overly conservative designs.

— Extreme-type distributions should be used when distributions of annual values are considered.

— The distributions should reflect uncertainties in the data.

— Seasonal variations should be considered where relevant.

— The statistical description of the parameters should reflect the duration of the events and the consequences.

— Where appropriate, correlations between parameters, as well as auto-correlations and cross-correlations for time series should be considered.

— Average, extreme and abnormal level parameter values associated with actions should be verified to ensure they are realistic physically and make sense in combination.

— When Gaussian or uniform distributions are used to simplify the analysis, their use should be properly justified.

A.2.7.4 Combinations of actions and action effects

Each of the actions should be combined probabilistically with the appropriate companion actions, through their joint probability distributions. It is not necessary to consider simultaneously actions that are mutually exclusive .

For fatigue failure, the cumulative effect of all repetitive actions during the life of the structure should be considered and taken into account in action combinations.

A.3 Guidance on analyses and models

A.3.1 General

This clause provides some general guidance for the application of computer-based analysis and model testing in estimating structural performance.

Requirements and recommendations for determining specific actions (e.g. environmental, seismic, etc.), or response for specific structural components (e.g. moorings, foundations, etc.) and specific platform types (e.g. bottom-founded steel jackets, floating production units, jack-up platforms, etc.), are provided in the relevant standard in the series of International Standards applicable to offshore structures.

A.3.2 Structural analysis

Generally, the analysis procedures used in design or assessment of a structure consist of

a) global behaviour analysis that gives the global action effects (forces, moments, accelerations, displacements, forces acting on the foundations or stationkeeping systems) for the structure as a whole;

b) structural analysis that gives the action effects (forces and moments) on individual structural components;

c) analysis of structural components (cross-sections, joints, etc.) that addresses their resistance and more generally their behaviour (strength and stability) in greater detail;

d) analysis of localized features and details, for example, at discontinuities in cross-sections and at connections. Sufficiently accurate representation of localized features and details is particularly important in FLS where local stress concentrations can arise.

For SLS, ULS and FLS, linear elastic methods of global structural analysis are usually appropriate even though local stress concentrations can exceed yield stresses. Where the structural system behaviour is essentially nonlinear, for example, riser and mooring systems and pile-soil interaction, the analysis should be undertaken using applicable nonlinear methods.

For ALS analysis, proven theories using unconventional representations of actions or resistances can be considered when appropriate (plastic deformation, etc.), providing the results are reasonably insensitive to minor modifications in the definition of the event considered.

Most structural analysis programs consist of recognized commercially available software suites which, when used by experienced and well-trained operators, have been proven to be suitable for their intended purpose. In these cases, the original authors would have performed and recorded adequate validation and verification for their intended application. Similar validation of each new software release should be similarly reported and available for independent verification. However, users should recognize that only a finite subset of possible conditions can be modelled, checked and reported.

In cases where innovative analytical approaches and techniques are used with commercially available software suites or where proprietary software solutions are adopted, the designer or the assessor is expected to validate the adequacy of methodology.

In either case, the results obtained from computer-aided analysis should be complemented by a systematic review and assessment by the user.

A.3.3 Physical model testing

Physical model tests can be used

— to investigate actions or action effects (structural response) induced by the physical environment (wind, wave, current, ice) on a structure or components thereof, for the consideration of FLS, SLS, ULS or ALS;

— to determine hydrodynamic behaviour for complex geometries;

— to investigate operational considerations with respect to the physical environment;

— to determine the resistance of structures or components thereof;

— to investigate complex aspects of material or fluid behaviour;

— to investigate circumstances outside of actual or prototype experience;

— to verify that no unexpected behaviour takes place;

— where analytical or numerical models are inappropriate or not representative;

— to supplement or validate analytical or numerical approaches.

A.3.4 Model test planning

The following issues should be considered in the planning, conduct and interpretation of model tests.

— Scaling should be in accordance with the appropriate similarity theory.

— Scale factors should be within a range for which important properties are well scaled.

— Scaling errors should be minimized.

— Test procedures should be verified.

— All measurements should be properly calibrated.

— The parameters modelled should reflect the intended purpose.

— All relevant test data and related observations should be properly recorded.

— Repeatability should be demonstrated or sufficient tests should be made to capture potential variability in results.

— The interpretation should take due account of uncertainties in modelling relationships and variability in behaviour.

The following cautions should be exercised when conducting model tests.

a) Conclusions should be based on properly scaled parameters and verified test procedures.

b) Due account of scale effects should be taken.

c) Model test results should be supplemented by experience, or by the use of numerical or analytical approaches.

d) The effect of the instrumentation on the measurements should be minimized.

e) Spurious model behaviour should be identified and minimized.

A.3.5 Calculation model uncertainties

A calculation model is a physically based or empirical relation between relevant variables, which are in general random variables. Models should be as complete and exact as possible to ensure that resulting errors are minimized when applied using measured values of the variables. Model complexity should be consistent with the available input data and the accuracy of the intended result. The effect of the uncertainties can also be included in the model itself, for example, the model is chosen so that it is “on the safe side”.

A.3.6 Prototype testing

A structure, or part of a structure, can also be designed on the basis of results from testing prototype units relevant to the particular design situation under consideration, for example, inclining tests for floating stability. Designs based on prototype testing can account for the inherent uncertainties in the tests by using appropriate partial factors.

A structure or part of it can also be designed on the basis of results from an existing structure relevant to the particular design situation under consideration.

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1) Under preparation.

2) Under preparation.

3) Under preparation.

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