

BS EN ISO 19901-3:2014



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Petroleum and natural gas industries — Specific requirements for offshore structures

Part 3: Topsides structure

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National foreword

This British Standard is the UK implementation of ISO 19901-3:2014. It supersedes BS EN ISO 19901-3:2010 which is withdrawn.

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

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

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CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 19901-3:2014) 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of an identical text or by endorsement, at the latest by June 2015, and conflicting national standards shall be withdrawn at the latest by June 2015.

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 19901-3:2010.

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 19901-3:2014 has been approved by CEN as EN ISO 19901-3:2014 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 19901-3 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 19901-3:2010), which has been technically revised.

ISO 19901 consists of the following parts, under the general title *Petroleum and natural gas industries — Specific requirements for offshore structures*:

- *Part 1: Metocean design and operating considerations*
- *Part 2: Seismic design procedures and criteria*
- *Part 3: Topsides structure*
- *Part 4: Geotechnical and foundation design considerations*
- *Part 5: Weight control during engineering and construction*
- *Part 6: Marine operations*
- *Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*
- *Part 8: Marine soil investigations*

A future Part 9 dealing with structural integrity management is under preparation.

The first edition of ISO 19901-3:2010 included a number of serious typographical errors. A 'Corrected' version of the first edition was issued in December 2011. This 'Corrected' version first edition was subsequently issued by some national standards organisations. To ensure all national standards bodies issue a 'Corrected' version of the document, TC 67/SC 7 decided to produce a second edition of 19901-3 which incorporates the following changes from the original issue in 2010:

- in [4.1](#), the symbol S_d for design internal force or moment has been added;
- in [8.1](#), Formulae (7), (8) and (9) have been amended to include symbol S_d and the second paragraph has been reworded to reflect the changes in the equations;
- in [9.18](#), first paragraph, new values have been given for variable action for the grating and plating as well as for the contribution of personnel to the total variable action allowance;

- in [A.7.10.4.2.2](#), the text has been reworded and Formula (A.1) has been amended, in line with the modifications in [8.1](#);
- in [A.8.1](#), Formula (A.5) has been corrected by changing “max” to “min”;
- in [B.2](#), [Table B.1](#), the value of Young’s modulus has been amended so as to be in accordance with the default value recommended in ISO 19902;
- in [Tables B.3](#), [B.4](#), [B.5](#), [B.7](#), [B.8](#) and [B.9](#), some values have been updated to reflect the change in Young’s modulus;
- in [B.3.3](#), [Table B.4](#), the symbol for utilization has been corrected;
- in [B.4.5](#), [Table B.10](#), all values for compression and for compression and bending have been amended, as well as the value for the minimum ratio;
- in [B.4.5](#), first and second paragraphs, the building code correspondence factor has been amended and a sentence about its applicability has been added;
- in [Annex C](#), [Table C.1](#), the existing building code correspondence factor has been amended and a second correspondence factor, relating to CSA S16-09, has been added;
- in the Bibliography, Reference^[3] has been updated with a more recent edition; references in the text (see [A.5.2](#), [A.8.3.1](#), [A.8.3.2](#), [A.8.3.3](#) and [A.8.3.4](#)) have been updated accordingly.

In producing the second edition the following additional minor corrections have been applied to the 2011 ‘Corrected’ version of the first edition:

- in [9.5.3.4](#) the units of the area-imposed action corrected to kN/m²;
- in [9.6.2](#) the description of off-lead and side-lead in [Table 5](#) improved;
- in [A.7.10.4.2.3](#) the reference to section [A.7.10.2.4](#) changed to [A.7.10.4.2.4](#);
- in [A.11.3](#) minor text correction;
- in [Annex B Table B.1](#), symbols for bending amplification reduction factor corrected to $C_{m,y}$ and $C_{m,z}$

ISO 19901 is one of a series of International 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 19904-1, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Monohulls, semi-submersibles and spars*
- ISO 19905-1, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 1: Jack-ups*
- ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary and detailed sample calculation*
- 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 type of structure and 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 series of International Standards applicable to types of offshore structure is intended to provide wide latitude in the choice of structural configurations, materials and techniques, without hindering innovation. Sound engineering judgement is therefore necessary in the use of these International Standards.

This part of ISO 19901 has been prepared for those structural components of offshore platforms which are above the wave zone and are not part of the support structure or of the hull. Previous national and international standards for offshore structures have concentrated on design aspects of support structures, and the approach to the many specialized features of topsides has been variable and inconsistent, with good practice poorly recorded.

Historically, the design of structural components in topsides has been performed to national or regional codes for onshore structures, modified in accordance with experience within the offshore industry, or to relevant parts of classification society rules. While this part of ISO 19901 permits use of national or regional codes, and indeed remains dependent on them for the formulation of component resistance equations, it provides modifications that result in a more consistent level of component safety between support structures and topsides structures.

In some aspects, the requirements for topsides structures are the same as, or similar to, those for fixed steel structures; in such cases, reference is made to ISO 19902, with modifications where necessary. [Annex A](#) provides background to, and guidance on, the use of this part of ISO 19901, and is intended to be read in conjunction with the main body of this part of ISO 19901. The clause numbering in [Annex A](#) follows the same structure as that in the body of the normative text in order to facilitate cross-referencing.

[Annex B](#) provides an example of the use of national standards for onshore structures in conjunction with this part of ISO 19901.

Regional information on the application of this part of ISO 19901 to certain specific offshore areas is provided in [Annex C](#).

In International Standards, the following verbal forms are used:

- “shall” and “shall not” are used to indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted;
- “should” and “should not” are used to indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited;
- “may” is used to indicate a course of action permissible within the limits of the document;
- “can” and “cannot” are used for statements of possibility and capability, whether material, physical or causal.

Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 3: Topsides structure

1 Scope

This part of ISO 19901 gives requirements for the design, fabrication, installation, modification and structural integrity management for the topsides structure for an oil and gas platform. It complements ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, which give requirements for various forms of support structure. Requirements in this part of ISO 19901 concerning modifications and maintenance relate only to those aspects that are of direct relevance to the structural integrity of the topsides structure.

The actions on (structural components of) the topsides structure are derived from this part of ISO 19901, where necessary in combination with other International Standards in the ISO 19901 series. The resistances of structural components of the topsides structure can be determined by the use of international or national building codes, as specified in this part of ISO 19901. If any part of the topsides structure forms part of the primary structure of the overall structural system of the whole platform, the requirements of this part of ISO 19901 are supplemented with applicable requirements in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906.

This part of ISO 19901 is applicable to the topsides of offshore structures for the petroleum and natural gas industries, as follows:

- topsides of fixed offshore structures;
- discrete structural units placed on the hull structures of floating offshore structures and mobile offshore units;
- certain aspects of the topsides of arctic structures.

This part of ISO 19901 is not applicable to those parts of the superstructure of floating structures that form part of the overall structural system of the floating structure; these parts come under the provisions of ISO 19904-1. This part of ISO 19901 only applies to the structure of modules on a floating structure that do not contribute to the overall integrity of the floating structural system.

This part of ISO 19901 is not applicable to the structure of hulls of mobile offshore units.

This part of ISO 19901 does not apply to those parts of floating offshore structures and mobile offshore units that are governed by the rules of a recognized certifying authority and which are wholly within the class rules.

Some aspects of this part of ISO 19901 are also applicable to those parts of the hulls of floating offshore structures and mobile offshore units that contain hydrocarbon processing, piping or storage.

This part of ISO 19901 contains requirements for, and guidance and information on, the following aspects of topsides structures:

- design, fabrication, installation and modification;
- in-service inspection and structural integrity management;
- assessment of existing topsides structures;

- reuse;
- decommissioning, removal and disposal;
- prevention, control and assessment of fire, explosions and other accidental events.

This part of ISO 19901 applies to structural components including the following:

- primary and secondary structure in decks, module support frames and modules;
- flare structures;
- crane pedestal and other crane support arrangements;
- helicopter landing decks (helidecks);
- permanent bridges between separate offshore structures;
- masts, towers and booms on offshore structures.

2 Normative references

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

ISO 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 2631-2, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 2: Vibration in buildings (1 Hz to 80 Hz)*

ISO 13702, *Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines*

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

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

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

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

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

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

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

ISO 19905-1, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 1: Jack-ups*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19900, ISO 19902 and the following 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.

[SOURCE: ISO 19900:2013, definition 3.1]

3.2

accidental situation

design situation involving exceptional conditions of the structure or its exposure

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

[SOURCE: ISO 19900:2013, definition 3.2]

3.3

active fire protection

system of fire protection that reacts to a fire by discharging water or an inert or reactive substance in the vicinity of the fire to extinguish it

Note 1 to entry: There is a possibility that such a system fails to operate as designed.

3.4

caisson

appurtenance used for abstracting water from the sea or as a drain

3.5

conductor

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

[SOURCE: ISO 19900:2013, definition 3.12]

Note 1 to entry: A conductor is generally vertical, and is continuous from below the sea floor to the wellbay in the topsides and can be laterally supported in both the support structure and topsides structure. The vertical support is in the seabed.

Note 2 to entry: In a few cases, conductors are rigidly attached to the topsides or to the support structure above sea level. In these cases, the conductor's axial stiffness can affect the load distribution within the overall structure.

3.6

critical component

structural component, failure of which would cause failure of the whole structure, or a significant part of it

Note 1 to entry: A critical component is part of the primary structure.

[SOURCE: ISO 19902:2007, definition 3.12]

3.7

design accidental action

accidental action with a probability of occurrence greater than 10^{-3} to 10^{-4} per year

3.8

design service life

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

[SOURCE: ISO 19900:2013, definition 3.16]

3.9 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

[SOURCE: ISO 19900:2013, definition 3.17]

3.10 design value

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

[SOURCE: ISO 19900:2013, definition 3.18]

3.11 explosion

rapid chemical reaction of gas or dust in air

Note 1 to entry: An explosion results in increased temperatures and pressure impulses. A gas explosion on an offshore platform is usually a deflagration in which flame speeds remain subsonic.

[SOURCE: ISO 19902:2007, definition 3.17]

3.12 exposure level

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

Note 1 to entry: An exposure level 1 platform is the most critical and exposure level 3 the least. A normally manned platform which cannot be reliably evacuated before a design event will be an exposure level 1 platform.

[SOURCE: ISO 19900:2013, definition 3.20]

3.13 extreme value

value of a parameter used in ultimate limit state checks, in which a structure's global behaviour is intended to stay in the elastic range

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

[SOURCE: ISO 19902:2007, definition 3.19]

3.14 load case

compatible load arrangements, sets of deformations and imperfections considered simultaneously with permanent actions and fixed variable actions for a particular design or verification

[SOURCE: ISO 19902:2007, definition 3.29]

Note 1 to entry: Load arrangements are the identification of the position, magnitude and direction of a free action.

3.15 mitigation

action taken to reduce the consequences of a hazardous event

EXAMPLE Provision of fire or explosion walls; use of water deluge on gas detection; structural strengthening.

3.16 nominal value

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

[SOURCE: ISO 19900:2013, definition 3.29]

3.17

owner

representative of the company or companies owning or leasing a development

[SOURCE: ISO 19900:2013, definition 3.34]

3.18

passive fire protection

PFP

coating on the surface of a structural component that improves the structural component's resistance to fire

Note 1 to entry: Some PFP can produce toxic fumes in fires.

3.19

platform

complete assembly including structure, topsides, foundations and stationkeeping systems

[SOURCE: ISO 19900:2013, definition 3.35]

3.20

regulator

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

Note 1 to entry: The term *regulator* can encompass more than one agency in any particular territorial waters.

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

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

[SOURCE: ISO 19902:2007, definition 3.40]

3.21

representative value

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

[SOURCE: ISO 19900:2013, definition 3.38]

3.22

return period

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

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

[SOURCE: ISO 19900:2013, definition 3.40]

3.23

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.

[SOURCE: ISO 19900:2013, definition 3.41]

Note 2 to entry: A riser can be supported both laterally and vertically in the topsides structure and transmit actions from thermal effects, wave action, permanent and variable actions and variations in fluid flow to the topsides structure.

3.24

robustness

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

[SOURCE: ISO 19900:2013, definition 3.42]

3.25

safety-critical element

SCE

item of structure, piping or equipment, the failure of which can result in major accidents or which is provided to prevent or mitigate against them

EXAMPLE Primary structure, pressure-containing equipment, blow-down and other safety systems, vessels and pipework containing hazardous materials, fire and gas detection systems, supports for SCE.

3.26

structural component

physically distinguishable part of a structure

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

[SOURCE: ISO 19900:2013, definition 3.46]

3.27

support structure

structure supporting the topsides

Note 1 to entry: The support structure can take many forms including fixed steel (see ISO 19902), fixed concrete (see ISO 19903), floating (see ISO 19904-1), mobile offshore units (see ISO 19905-1), or the various forms of arctic structures (see ISO 19906).

3.28

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.

[SOURCE: ISO 19900:2013, definition 3.52]

4 Symbols and abbreviated terms

4.1 Symbols

<i>a</i>	acceleration
<i>A</i>	accidental action
<i>b</i>	spacing of stiffeners

D_e	equivalent quasi-static action representing dynamic response effects to the extreme environmental action, E_e
D_o	equivalent quasi-static action representing dynamic response effects to the operating environmental action, E_o
E	quasi-static environmental action
E_e	extreme quasi-static environmental action due to wind, waves and current
E_o	quasi-static environmental action due to wind, waves and current for an operating condition under consideration (see 7.3.4)
F_d	design action
F_G	vertical action due to self-weight of a crane
F_H	horizontal action due to off-lead and side-lead on a crane
F_r	representative action
F_{rhl}	representative hook load of a crane
F_W	maximum operating wind action on a crane
$F_{W,ext}$	extreme wind action on a crane
g	acceleration due to gravity
G	permanent action
I	explosion impulse
l	span or length
K_c	building code correspondence factor
p	instantaneous explosion overpressure
$p(t)$	variation of overpressure with time
P	probability
Q	variable action
R	resistance
R_D	design resistance
R_K	representative resistance
S	internal force or moment
S_d	design internal force or moment
t	time from ignition of an explosion
t_d	duration of explosion pressure pulse
T	fundamental period of vibration of a component or structure

$T_{C,max}$	maximum allowable temperature in a component
δ	thickness of a structural component, plate, or finite element
γ	partial safety factor
γ_f	partial action factor
γ_{FD}	partial damage design factor
γ_R	partial resistance factor
Δ	deflection
ϵ_{cr}	critical average strain
σ	stress
θ	temperature

4.2 Abbreviated terms

AISC	American Institute of Steel Construction
ALARP	as low as reasonably practicable
ALE	abnormal level earthquake
ALS	accidental limit states
API	American Petroleum Institute
ASD	allowable stress design
AVM	anti-vibration mounting
CFD	computational fluid dynamics
CTOD	crack tip opening displacement
CVI	close visual inspection
DAF	dynamic amplification factor
DLB	ductility level blast
ELE	extreme level earthquake
FEA	finite element analysis
FLS	fatigue limit states
FPSO	floating production storage and off-loading
FSO	floating storage and off-loading
GVI	general visual inspection
LRFD	load and resistance factor design
MPI	magnetic particle inspection

MTOW	maximum take-off weight
PFP	passive fire protection
SCE	safety-critical element
SDOF	single degree of freedom
SLB	strength level blast
SLS	serviceability limit states
ULS	ultimate limit states
UR	utilization ratio
WSD	working stress design

5 Overall considerations

5.1 Design situations

Design situations include all operational requirements, temporary conditions, environmental conditions and accidental and abnormal conditions which could affect the design. Adequate planning shall be undertaken before detailed design is started in order to obtain a workable and economical topsides layout and structure to perform its functions. The initial planning shall include the determination of all criteria upon which the design of the topsides will be based.

An important consideration for most topsides structures is the extent and magnitude of possible fire and explosion actions, which can be affected by the structural and equipment layouts, congestion and containment, and the initial planning shall include these layout considerations.

5.2 Codes and standards

5.2.1 Limit state and allowable stress design philosophies

In general, the ISO 19900 series¹⁾ of International Standards follows the requirements of ISO 2394^[63] and as such is intended to be a limit state design standard. Limit state methods are also known as load and resistance factor design (LRFD) methods, particularly in North America.

Within the ISO 19900 series, ISO 19902 and ISO 19903 are explicit limit state design standards. ISO 19904-1 allows allowable stress design (ASD) or limit state design methods, but limit state methods for ships are only currently being finalized in LRFD formats.

NOTE ASD methods are also known as working stress design (WSD) and permissible stress design methods.

The intent of this part of ISO 19901 is that limit state methods should be used where possible, but, where the supporting structure is designed using ASD methods, such as for floating structures, ASD methods may also be used for the topsides structure using a current ASD code compatible with that used for the supporting structure.

The specific requirements and guidance in this part of ISO 19901 apply to the use of limit state (or LRFD) codes. Where ASD codes are used, the requirements for partial action and partial resistance factors do not apply, but all other requirements still apply.

1) The ISO 19900 series consists of the following International Standards: ISO 19900, ISO 19901 (all parts), ISO 19902, ISO 19903, ISO 19904 (all parts), ISO 19905 (all parts) and ISO 19906. These standards have all been prepared by ISO/TC 67/SC 7 for offshore structures for the petroleum and natural gas industries.

5.2.2 Use of national codes and standards

The detailed design for a topsides structure shall be based on national or regional building codes. These should normally be those for the nation or region in which the platform is to be located, but may, with the agreement of the owner and the regulator, be those from other nations or regions. The standards used for fabrication should be consistent with and compatible with those used for design.

NOTE As stated in [Clause 1](#), this part of ISO 19901 does not apply to those parts of floating offshore structures and mobile offshore units that are governed by the rules of a recognized classification society and which are wholly within the class rules.

In order to realize a similar level of reliability to that implicit in other standards in the 19900 series, the action factors shall be taken from the relevant standard in the ISO 19900 series for the support structure and shall be used unmodified. Resistance factors in the national or regional building code shall be modified by the application of a building standard correspondence factor (see [8.1](#)).

Floating structures and production jack-ups that are registered as vessels are also subject to any requirements of the prospective flag state or any classification society acting on behalf of the flag state.

5.3 Deck elevation and green water

Air gap requirements for fixed structures are addressed in ISO 19901-1, ISO 19902 and ISO 19903. No component of the topsides structure or equipment shall be within the design air gap unless explicitly designed to withstand possible hydrodynamic actions and to transmit such actions through the topsides to the support structure. These actions should be identified to the support structure designer as early as possible.

For floating structures, and for monohulls in particular, increasing the height of topsides modules above the main deck is a trade-off between reducing the potential effects of explosion pressures, increasing accessibility, and reducing stability. These floating structures can also be inundated in severe weather if the top of the wave crest is higher than the deck of the structure. The inundating water, known as green water, can run along the deck and impact equipment and structures on the deck. The actions associated with possible green water shall be evaluated and any vulnerable topsides structures shall be designed to withstand these actions.

5.4 Exposure level

The exposure level for the topsides structure shall be the same as for the support structure and shall be determined in accordance with the criteria given in ISO 19900. Additional guidance is provided in ISO 19902, ISO 19903, 19904-1, ISO 19905-1 and ISO 19906.

NOTE There are three categories of exposure level: L1 structures are manned during design conditions or have high consequences of failure; L2 platforms are not expected to be manned during governing design conditions and have medium consequences of failure; and L3 platforms are normally unmanned and have low consequences of failure.

5.5 Operational considerations

5.5.1 Function

The structural engineer shall be aware of the functional requirements of the platform including drilling, process, access, safety and auxiliary systems. In particular, the integrity of the structure shall comply with the platform's safety philosophy and any defined performance standards.

5.5.2 Spillage and containment

Provision for handling spills, overflows and potential contaminants should be provided. A deck drainage system shall be considered that collects and stores liquid spillages and overflows for subsequent handling.

5.6 Selecting the design environmental conditions

The design environmental conditions (metocean, ice and seismic) for the topsides shall be those selected for the support structure. Less onerous environmental conditions can be acceptable for specific short-term operations.

The wind speed shall be modified depending upon the dimensions and elevation of the part of the structure or the component being considered (see ISO 19901-1).

EXAMPLE The short-term installation of specific pieces of equipment can be considered with lower environmental conditions if an assessment of the risks and consequences of exceeding the environmental criteria are considered.

5.7 Assessment of existing topsides structures

Any assessment of existing topsides structures to confirm that they comply with this part of ISO 19901 or are fit for purpose shall be performed in accordance with the assessment requirements of ISO 19900, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate.

5.8 Reuse of topsides structure

Existing topsides structures may be removed and relocated for use at a new location. When this is considered, the topsides structure shall be evaluated in accordance with the requirements of ISO 19900, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate, for the use (including exposure level) and conditions that are applicable at the new location. Any repairs or modifications that are necessary shall be in accordance with the requirements of this part of ISO 19901.

5.9 Modifications and refurbishment

Where modifications or refurbishment of an existing topsides structure are planned, the structure shall be assessed for the revised configuration in accordance with the assessment requirements of ISO 19900, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate. All changes shall be documented (see [Clause 11](#)). In some cases, more advanced techniques than are usual for design can be required to allow economical strengthening or stiffening schemes to be developed and justified. Such techniques are outside the scope of this part of ISO 19901.

6 Design requirements

6.1 General

This clause presents the overall minimum requirements for design of topsides. The general principles on which structural design requirements are based are given in ISO 19900.

6.2 Materials selection

Materials shall be selected that have a performance compatible with the design code. ISO 19902 gives specific requirements and guidance for the selection of carbon steel for topsides structure. [Clause 10](#) addresses alternative materials.

6.3 Design conditions

The topsides shall be designed to resist permanent and variable actions; wind, wave, and current actions; earthquake actions; temperature and deformation effects, temporary conditions and accidental conditions – all of which can occur during its service life. These actions shall include both actions directly applied to the topsides and also the effects of actions on the supporting structure (such as waves, currents and earthquakes). In addition, actions due to the motions of the support structure shall be considered; these are particularly significant for floating structures.

The nominal values of these actions, or the derivation of these values, are given in [Clause 7](#). Each mode of operation of the platform, such as drilling, production, work-over, or anticipated combinations thereof, shall be explicitly considered. In areas where icing can occur, the effects of both the weight of ice accretion and the increase in effective dimensions of components due to the ice, resulting in increased wind actions, shall be included.

6.4 Structural interfaces

Particular attention shall be paid to the following:

- interfaces between different structures in order to ensure adequate alignment when fabrication tolerances are taken into account;
- compatibility of stiffnesses, distortions and displacements during fabrication, installation and in-service conditions.

The effects of displacements on different structures supported on one or more separate structures shall be considered.

EXAMPLE The flexing of a ship-shaped floating structure can cause significant differential movements between adjacent modules supported on the hull of the structure.

6.5 Design for serviceability limit states (SLS)

6.5.1 General

The serviceability of the topsides structures can be affected by excessive relative displacement or vibration (vertical or horizontal). Limits for either can be dictated by

- a) discomfort to personnel,
- b) integrity and operability of equipment or connecting pipework,
- c) control of deflection of supported structures, e.g. flare structures and telecommunication masts,
- d) damage to architectural finishes, or
- e) operational requirements for drainage (free surface or piped fluids).

The vibration limits are specified in [6.5.2](#) and the deflection limits are specified in 6.5.3.

6.5.2 Vibrations

6.5.2.1 Sources of vibration

All sources of vibration shall be considered in the design of the topsides structure. As a minimum, the following shall be reviewed for their effect on the structure:

- a) operating mechanical equipment, including that used in drilling operations;
- b) vibrations from variations of fluid flow in piping systems, in particular slugging;
- c) vortex-induced vibrations on slender tubular structures due to wind;
- d) global motions due to environmental actions on the total platform structure;
- e) vibrations due to earthquake and accidental events.

6.5.2.2 Design limits

Design limits for vibration shall be established from operational limits set by equipment suppliers and the requirements of personnel comfort and health and safety.

The design limits for horizontal and vertical vibration effects on personnel shall not exceed those given in ISO 2631-1 and ISO 2631-2. More onerous limits can be required by the owner or by the regulator.

6.5.2.3 Long-period vibrations

Large cantilevers (whether formed by simple beams or trusses) forming an integral part of the topsides, but excluding masts or booms, shall normally be proportioned to have a natural period of less than 1 s in the operating condition.

6.5.2.4 Dynamic analysis and avoidance of resonance

Where necessary, analytical techniques shall be used to assess the dynamic response of various parts of the topsides to ensure that resonance is avoided. The dynamic behaviour of large cantilevers can be calculated by eigenvalue analysis. Such analysis should include unfactored static and imposed actions. Where heavy rotating machinery is installed (such as variable speed pump skids, compressors, etc.), three-dimensional vibration analysis should be performed. To avoid resonance, the cantilevered local structure should be designed such that the natural frequencies of the deck do not lie between 0,65 times and 1,5 times the operating frequency of the equipment supported.

6.5.2.5 Deflections

The final deflected shape, $\Delta_{\max}$, of any element, structural component or structure comprises three parts as follows:

$$\Delta_{\max} = \Delta_1 + \Delta_2 - \Delta_0 \quad (1)$$

where

- Δ_0 is any pre-camber (hogging) of a beam or element prior to the addition of any permanent or variable actions;
- Δ_1 is the deflection from permanent actions after applying the actions;
- Δ_2 is the deflection from the variable actions and any time-dependent deformations from permanent actions.

The maximum values for vertical deflections are given in [Table 1](#).

Table 1 — Maximum vertical deflections

Structural component	Maximum deflection	
	$\Delta_{\max}$	Δ_2
Floor beams	$\frac{l}{200}$	$\frac{l}{300}$
Cantilever beams	$\frac{l}{100}$	$\frac{l}{150}$
Deck plate thickness	—	2δ or $\frac{b}{150}^a$
l span δ deck thickness b stiffener spacing ^a Whichever is smaller.		

More onerous limits can be required by the owner or by the regulator or can be specified for individual items of equipment.

Lower limits can be necessary to limit ponding of surface fluids and ensure that drainage systems function correctly; ponding should be avoided by cambering deck plating in areas susceptible to icing of any surface water.

The alignment of telecommunications equipment can be critical for their reliable operation and due consideration should be given to maintaining the required tolerances for such equipment.

Horizontal deflections shall generally be limited to 0,3 % of the height between floors. For multi-floor modules, the total horizontal deflection shall not exceed 0,2 % of the total height of the topsides structure. More onerous limits can be necessary to limit pipe stresses.

Higher deflections can be acceptable for cladding panels and other components where serviceability is not compromised by deflection.

6.6 Design for ultimate limit states (ULS)

To obtain design actions, an action factor shall be applied to each of the representative applied actions in the combinations given in [Clause 7](#). The action factors are given in the relevant International Standard in the ISO 19900- series, or other document relevant to the supporting structure, and are described in [Clause 7](#).

The combination of factored representative actions causes amplified internal forces and moments, S .

A resistance factor is applied to the representative strength of each component to determine its design strength. Each component shall be proportioned to have sufficient factored strength to resist S . The appropriate strength and stability criteria shall be taken from the appropriate national or international building code and shall be modified by a correspondence factor to account for any differences in approach between the building code and the International Standards in the ISO 19900- series to become the formulae for the representative strength of the component. This is to ensure that a similar level of reliability for topsides design are achieved to that implied in other International Standards in the ISO 19900- series.

In some conditions, particularly during construction and installation, the internal forces should be computed from unfactored representative actions and then modified by appropriate action factors to arrive at S (see the relevant International Standard in the ISO 19900- series).

6.7 Design for fatigue limit states (FLS)

The design actions to be used in the FLS are addressed in the International Standard in the ISO 19900-series that is applicable to the support structure. Additional considerations for specific systems are given in [Clause 9](#). The fatigue methodology in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate, shall be followed in the design of the topsides structure; in cases where the support structure standard does not provide adequate fatigue guidance for a topsides structure, the requirements of ISO 19902 shall apply.

In place of more detailed assessment, the fatigue damage design factors can be taken from [Table 2](#).

Table 2 — Partial damage design factors, γ_{FD}

Failure critical component	Inspectable	Not inspectable
No	2	5
Yes	5	10

Where the topsides structure is subjected to a long sea transportation prior to installation on the support structure, particular attention shall be given to the fatigue performance of structural details that do not normally see significant fatigue actions.

6.8 Design for accidental limit states (ALS)

ALS are addressed in [7.10](#), where requirements and recommendations are given for determining the conditions and actions, the partial action factors and the partial resistance factors.

6.9 Robustness

The topsides shall incorporate robustness through consideration of the effects of all hazards and their probabilities of occurrence to ensure that damage is not disproportionate to the cause. Damage from an event with a reasonable likelihood of occurrence shall not lead to complete loss of integrity of the structure. In such cases, the structural integrity in the damaged state shall be sufficient to allow a process system close-down, or a safe evacuation, or both. Framing patterns that provide alternative load paths are preferred.

Qualitative assessments to evaluate measures to improve the robustness of critical tertiary structure, such as pipe supports and equipment anchorages, shall be considered before detailed analysis. For a new topsides, a walk-down study shall be carried out in the fabrication yard or shortly after installation, but before production starts.

Walk-downs are methodical, on-site, visual evaluations of existing structures and equipment as installed. The walk-down scope shall include

- planning for the walk-down,
- preparation of walk-down documentation,
- a screening evaluation to determine zones of potential severe vibration and to identify structures and equipment most at risk,
- the walk-down itself,
- post-walk-down assessment, and
- reporting and recommendations.

Planning shall include an assessment to identify areas and components most at risk. Post-walk-down assessment shall include simple calculations to determine the adequacy of anchorages where there is doubt as to their suitability. Any remedial actions necessary shall be identified, reported and implemented as quickly as possible.

6.10 Corrosion control

The design of structural details shall, whenever possible, avoid corrosion traps and provide for free drainage of liquids.

The design of corrosion protection shall be compatible with the design assumptions for the topsides structure. Corrosion-related aspects to be considered include

- a) the corrosion allowance (if any) considered in the design,
- b) the design life and requirement for planned maintenance,
- c) access for maintenance of corrosion protection systems,
- d) the protection of details sensitive to crevice corrosion (e.g. bolted connections and the interface between piping and pipe supports),
- e) the protection of voids vulnerable to corrosion (e.g. by plugging vent holes in pipe supports after welding),
- f) the specification of requirements for corrosion protection, and
- g) the avoidance of galvanic corrosion (e.g. between carbon steel framework and aluminium helidecks and between carbon steel framework and stainless steel process pipework and vessels).

Where structural components are also used for fluid storage, e.g. diesel tanks within crane pedestals, a suitable corrosion control system shall be installed.

Where a corrosion allowance is incorporated in any component, the allowance shall be documented for use in inspection planning and assessment (see [Clause 14](#)).

Particular attention shall be paid to the prevention of water leakage and subsequent corrosion under lagging systems and under passive fire protection (PFP) systems.

Further requirements and recommendations for corrosion control are given in [Clause 12](#). In general, the thickness of a painted steel deck will be governed by the need for stiffness and to prevent excessive weld-induced distortion rather than by corrosion considerations.

6.11 Design for fabrication and inspection

The designers shall be familiar with, and anticipate likely methods of, fabrication, welding and erection to execute the design and they shall provide a design which accommodates these through the provision of appropriate material thicknesses, clearances, access and stability at all stages of construction.

The design shall be prepared with a clear understanding of the level of in-service inspection and maintenance planned during the topsides structure's life. Where the integrity of the topsides structure during its design life requires mandatory in-service inspection, provision for access for such inspection shall be included.

The design assumptions with respect to in-service inspection shall be clearly recorded and communicated to the fabricator and owner.

The design intent shall be followed during construction and variances shall be resolved without compromising the design intent.

The designers shall communicate the extent, type and rejection criteria for all non-destructive inspections. Where performance level (e.g. fatigue performance) depends on the achievement of particular standards in construction, the designer shall ensure that these are communicated.

NOTE Requirements are given elsewhere in this part of ISO 19901 for materials (see [Clause 10](#)), quality control, quality assurance and documentation, welding and fabrication inspection (see [Clause 12](#)).

6.12 Design considerations for structural integrity management

During the design, fabrication, inspection, transportation and installation of the topsides structure, sufficient data shall be collected and compiled for use in preparing in-service inspection programmes, possible topsides modifications, etc. Where a topsides structure has fatigue-sensitive components or other critical areas, these shall be identified and the information used in the preparation of in-service inspection programmes.

The design of equipment supports and skids shall provide adequate access to the structure to facilitate inspection and maintenance (e.g. painting) of primary and secondary steelwork and of equipment

6.13 Design for decommissioning, removal and disposal

6.13.1 General

Decommissioning and removal requirements shall be addressed during the topsides structure design phase, particularly for fixed platforms and deep draught floating platforms. Where the preferred removal option requires the use of special features, these should be considered for inclusion in the topsides structure during its fabrication. The platform's structural integrity management system should prevent in-service structural modifications that can prejudice later removal.

6.13.2 Structural releases

Consideration should be given to designing secondary structures between modules and elsewhere that are supported from one side only so as not to depend on temporary supports during dismantling.

The design of module support points, anti-vibration mountings and equipment supports shall consider access requirements for future disconnection.

6.13.3 Lifting appurtenances

Lifting attachments for installation of the topsides structure should be retained for subsequent use during decommissioning. Where attachments are removed during installation or during the service life of the topsides structure, consideration shall be given to facilitating their reattachment or replacement for subsequent removal.

The design should allow for periodic access for inspection.

6.13.4 Heavy lift and set-down operations

The dynamic impact factors used in design should allow for a removal case involving set-down onto a barge that could be more severe than for installation, if this seems probable.

7 Actions

7.1 General

A topsides structure can be exposed to a number of design situations throughout its design service life. These include

- extreme conditions of wind, waves and currents,
- normal operating conditions of wind, waves and currents,
- fabrication,
- transportation,

- installation,
- fatigue: pre-installation and during the design service life,
- accidental situations including fire, explosions, ship impact and dropped objects,
- abnormal conditions of wind, waves and currents,
- earthquakes, and
- dismantling/removal.

Each of these design situations comprises several actions such as permanent, variable and environmental actions, deformations, temperature effects and accidental events, each with appropriate partial action factors.

General guidance on the design situations is given in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate.

7.2 In-place actions

Each topsides structural component shall be assessed for internal force (action effect), S , resulting from the design action, F_d . The design action shall be derived from the following combinations of actions:

- a) maximum permanent and variable actions, G_1 , G_2 , Q_1 , and Q_2 ;
- b) extreme environmental actions, G_1 , G_2 , Q_1 , E_e and D_e , together with any actions resulting from associated support structure movements;
- c) operating environmental actions, G_1 , G_2 , Q_1 , Q_2 , E_o and D_o , together with any actions resulting from associated support structure movements,

where

- G_1 is the permanent action imposed on the topsides structure by the self-weight of the topsides structure with associated equipment and other objects (see ISO 19902); in addition, any actions due to the misalignment of structures, such as between the topsides structure and the supporting structure, are part of G_1 ;
- G_2 is the permanent action imposed on the topsides structure by self-weight of equipment and other objects that remain constant for long periods of time, but which can change from one mode of operation to another, or during a mode of operation (see ISO 19902);
- Q_1 is the variable action imposed on the topsides structure by the weight of consumable supplies and fluids in pipes, process vessels, tanks and stores, the weight of transportable tanks and containers used for delivering supplies, the weight of ice accretions, and the weight of personnel and their personal effects (see ISO 19902); in addition, any actions due to the movement of supporting structures not due to environmental effects, such as trim of a floating production storage and off-loading (FPSO) and the effects of cargo loading, including flexure of the supporting structure due to such effects, are part of Q_1 ;
- Q_2 is the short-duration variable action imposed on the topsides structure from operations such as the lifting of drill string, lifting by cranes, liquids in pipes and process vessels for pressure testing, machine operations, mooring of an adjacent ship to the platform, and helicopters (see ISO 19902);
- E_e is the extreme quasi-static environmental action on the topsides structure and any environmental action effects transmitted through the supporting structure (see ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate); in addition, any actions due to the movement of supporting structures due to extreme environmental effects, such as roll of an FPSO, including any consequent flexure of the supporting structure due to such effects, are part of E_e ;
- D_e is the equivalent quasi-static action on the topsides structure representing dynamic response to the extreme environmental action (see ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate);
- E_o is the environmental action on the topsides structure and any environmental action effects transmitted through the support structure for environmental conditions limiting a particular operation (see 7.3.4); in addition, any actions due to the movement of supporting structures due to the operating environmental effects, such as roll of an FPSO, including any consequent flexures of the supporting structure due to such effects, are part of E_o ;
- D_o is the equivalent quasi-static action on the topsides structure representing dynamic response to the operating environmental action, E_o .

The values of G_1 , G_2 , Q_1 and Q_2 are often not well defined at early stages of the design process, and the potential lack of accuracy should be taken into account (see A.7.2). In a similar manner, potential variation of the centre of gravity of the topsides during the design process should be considered, particularly with respect to design for loadout, transportation and installation of the topsides.

7.3 Action factors

7.3.1 Design action for in-place situations with permanent and variable actions only

The design action, F_d , for the in-place design situation due to maximum permanent and variable actions only shall be calculated using Formula (2).

$$F_d = \gamma_{f,G1}G_1 + \gamma_{f,G2}G_2 + \gamma_{f,Q1}Q_1 + \gamma_{f,Q2}Q_2 \quad (2)$$

The partial action factors, γ_f , shall be the same as those used for the support structure design or assessment. See ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 or ISO 19906, as appropriate.

7.3.2 Design actions for equipment testing

Tanks, pipework and pressure systems can be subjected to hydrostatic and pressure testing at various stages of a platform's life. The additional actions due to any weight of liquid used for the test shall be included in the short-duration variable action, Q_2 .

7.3.3 Design action for in-place situations due to extreme environmental actions

The design action, F_d , for the in-place design situation due to extreme environmental situation actions for topsides on fixed structures shall be calculated using Formula (3).

$$F_d = \gamma_{f,G1}G_1 + \gamma_{f,G2}G_2 + \gamma_{f,Q1}Q_1 + \gamma_{f,Q2}Q_2 + \gamma_{f,Ee} (E_e + \gamma_{f,D}D_e) \quad (3)$$

For this check, G_2 , Q_1 and Q_2 shall be the maximum values associated with the particular operating situation being considered.

The design action for floating structures shall be calculated in a similar manner, which includes allowing for the rotations and accelerations due to the vessel motions.

The partial action factors, γ_f , shall be the same as those used for the support structure design or assessment. See ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, or ISO 19906, as appropriate.

When the internal forces due to permanent and variable actions oppose those due to wind, wave and current actions in extreme environmental conditions, the design action, F_d , shall be calculated in accordance with Formula (4) using reduced partial action factors for the permanent and variable actions.

$$F_d = \gamma_{f,G1}G_1 + \gamma_{f,G2}G_2 + \gamma_{f,Q1}Q_1 + \gamma_{f,Ee} (E_e + \gamma_{f,D}D_e) \quad (4)$$

For this check, G_2 and Q_1 shall exclude any parts associated with the mode of operation considered that cannot be ensured of being present during the operational conditions.

The partial action factors, γ_f , shall be the same as those used for the support structure design or assessment (see ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, or ISO 19906, as appropriate) for the case when the internal forces due to permanent and variable actions oppose those due to wind, wave and current actions in extreme environmental conditions.

NOTE 1 The appropriate partial action factors for the environmental action depends on the exposure level, the long-term environment at the offshore location of the platform, and the geometrical and structural properties of the structure considered.

NOTE 2 ISO 19902 specifies a value of $\gamma_{f,Ee}$ of 1,35 where no other information is available.

7.3.4 Design actions for in-place situations with operating environmental actions

Platform operations are often limited by environmental conditions and differing limits can be set for different operations. Examples of operations that can be limited by environmental conditions include

- drilling and workover,
- crane transfer to and from supply ships,
- crane operations on deck,
- deck and over-the-side working,
- deck access, and
- helicopter operations.

Each operating situation that is restricted by environmental conditions shall be assessed as demonstrated in Formulae (5) and (6), in which E_o and D_o represent the environmental actions limiting the operations.

The design action, F_d , for in-place situations involving platform operations on fixed structures shall be calculated using Formula (5).

$$F_d = \gamma_{f,G1}G_1 + \gamma_{f,G2}G_2 + \gamma_{f,Q1}Q_1 + \gamma_{f,Q2}Q_2 + \gamma_{f,Eo}(E_o + \gamma_{f,D}D_o) \quad (5)$$

For this check, G_2 , Q_1 and Q_2 shall be the maximum values associated with the particular operating situation being considered.

When the internal forces due to permanent and variable actions oppose those due to wind, wave and current actions in operating environmental conditions, the design action, F_d , shall be calculated in accordance with Formula (6) using reduced partial action factors for the permanent and variable actions.

$$F_d = 0,9G_1 + 0,9G_2 + 0,8Q_1 + \gamma_{f,Eo}(E_o + \gamma_{f,D}D_o) \quad (6)$$

For this check, G_2 and Q_1 shall exclude any parts associated with the mode of operation considered that cannot be ensured of being present during the operational conditions.

The design action for floating structures shall be calculated in a similar manner, which includes allowing for the rotations and accelerations due to the vessel motions.

NOTE ISO 19902 allows a value of $\gamma_{f,Eo}$ of $0,9 \times 1,35$ approximately 1,20 where no other information is available.

7.4 Vortex-induced vibrations

For the fabrication, transportation and in-place phases, an assessment of the possibility of vortex-induced vibrations due to wind on exposed structural components shall be undertaken.

The possibility of fatigue due to vortex-induced vibrations on lattice structures (e.g. flare booms and drilling derricks) and exposed pipework shall be considered.

7.5 Deformations

Internal forces due to imposed deformations can arise from the effects of fabrication tolerance, foundation settlement and the indeterminate effects of transportation and lift. Internal forces can also occur from operational or accidental thermal effects.

Where a primary topsides structure is supported by a multi-column gravity base structure, the movements and deformations of the column tops can result in significant indirect actions applied to the

topsides structure. For this reason, the support structure and the topsides structure should normally be analysed together for both the ULS and FLS.

All such actions or action effects shall be considered in combination with appropriate operating and environmental actions to ensure that serviceability and ultimate limit states are not exceeded.

The hull of a monohull is usually much stiffer than the topsides structure and, as it sags and hogs, considerable deformations can be introduced at the topsides structure level. It is important that the differences between essentially static behaviour due to ballast and cargo loading, and dynamic behaviour due to environmental effects are understood.

7.6 Wave and current actions

Although wave and current actions mainly affect the supporting structure, directly, there are frequently indirect actions on the topsides due to the displacements and deformations of the supporting structure. All wave and current effects on the supporting structure, appurtenances (e.g. conductors, risers, caissons, etc.) and the topsides shall be included in the calculation of the environmental actions on the topsides, including those listed below.

a) For fixed platforms:

- lateral accelerations of the topsides due to deformations of the supporting structure;
- framing actions due to horizontal actions on the supporting structure;
- particular attention shall be given to topsides on multi-leg concrete platforms in which the wave actions can act in differing directions on different legs, resulting in various forces and moments through the topsides in conditions well below the extreme wave heights.

b) For floating platforms:

- translational accelerations due to sway, surge and heave of the supporting structure;
- rotational accelerations due to roll, pitch and yaw of the supporting structure;
- rotation of the topsides due to roll and pitch with the consequent effects on the directions of actions;
- particular attention shall be paid to the distortions of the supporting structures and the consequent effects on the support points of the topsides structure.

Large actions can result when sea water strikes a platform's deck and equipment. Where insufficient air gap exists, when wave run-up against large diameter legs and columns strikes the deck, or when water inundates the deck for floating structures (green water effects), then all actions resulting from the water flow including buoyancy, inertia, drag and slam shall be taken into account. See ISO 19901-1, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 or ISO 19906, as appropriate.

7.7 Wind actions

Guidance on wind speeds including wind profiles and gust durations is given in ISO 19901-1. The derivation of the wind action on the topsides should follow the methodology in the selected building code (see [5.2.2](#)).

7.8 Seismic actions

7.8.1 General

The topsides structure shall be considered for earthquake conditions as part of the overall platform consisting of the support structure with its foundation, where applicable, and the topsides. The

requirements are given in ISO 19901-2. Additional guidelines for components of the topsides are given in [7.8.2](#).

Topsides structure, equipment piping, and other deck appurtenances shall be designed and supported such that seismic actions induced by the design seismic event can be resisted and displacements can be restrained so that no unacceptable damage to the equipment, piping, appurtenances and their supporting structures occurs.

Special consideration shall be given to the design of restraints for critical piping and equipment whose failure could result in personnel injury, hazardous material spillage, pollution, or hindrance to emergency response.

Design acceleration levels shall include the effects of overall platform dynamic response, and, if appropriate, local dynamic response of the deck and the appurtenance itself. Due to the platform's dynamic response, the design acceleration levels are typically much greater than the ground motions and hence greater than those commonly associated with the seismic design of similar onshore processing facilities.

7.8.2 Minimum lateral acceleration

A minimum design lateral acceleration of $0,2\ g$ shall be applied as an extreme level earthquake (ELE) to the topsides, including equipment, and supporting framework for all structures (except seismic risk category 1, see ISO 19901-2), including those in seismic zone 0.

7.8.3 Equipment and appurtenances

In general, most types of properly anchored equipment and appurtenances are sufficiently stiff for their lateral and vertical responses to be calculated directly from maximum computed deck accelerations, since local dynamic amplification of the appurtenances themselves is negligible. However, in some circumstances the flexibility of the topsides can affect the natural frequency of equipment and appurtenances.

For relatively stiff equipment and appurtenances, in which the mass is small compared to that of the topsides structure and which can reasonably be treated as single degree of freedom (SDOF), a simplified uncoupled analysis may be performed using the following steps:

- from prior modal analysis of the overall platform (see ISO 19901-2), extract the accelerations, a_s , at the equipment support location;
- multiply the equipment or appurtenance mass by the resulting acceleration and design its supports for the resulting actions.

A more rigorous analysis shall be undertaken if any of the following apply:

- a) the equipment or appurtenance mass is greater than 5 % of the total platform mass;
- b) the equipment or appurtenance has dynamic characteristics or its supporting structure affects its vibration;
- c) the SDOF natural period of the equipment or appurtenance exceeds 1,25 times the period of a significant mode of the complete structure.

Where more rigorous analysis is required, it shall be undertaken by

- an uncoupled analysis with deck-level floor response spectra, or
- coupled analysis methods.

Equipment and appurtenances that typically require a more rigorous analysis include drilling rigs, flare booms, vent and communications towers, deck cantilevers, tall process vessels, large unbaffled tanks, bridges and cranes.

Coupled analyses that properly include the dynamic interactions between the equipment or appurtenance and the topsides structure result in more accurate and often lower design accelerations than those derived using uncoupled floor response spectra.

Drilling and well servicing structures shall be designed for earthquake actions in accordance with an appropriate standard (see [A.7.8.3](#)) and shall be tied down or restrained at all times except when being moved.

7.9 Actions during fabrication and installation

7.9.1 General

The primary objective of [7.9](#) is to ensure that a topsides structure begins its design service life with its designed strength and structural integrity intact. Installation encompasses the operations of moving the topsides components from the fabrication site (or prior offshore location) to the support structure, and installing them to form the completed platform. [Clause 13](#) contains further details on installation procedures.

7.9.2 Fabrication

The sequence of construction and any temporary erection conditions, including any jacking and weighing conditions shall be considered to ensure that the ULS requirements are met during all temporary conditions. Individual support reactions during fabrication depend on the stiffness of the topsides structure and of the supporting foundation. Internal forces in the topsides structure due to uneven support points shall be determined.

7.9.3 Loadout, transportation and installation

Specific requirements, recommendations and guidance for marine operations, including loadout, transportation and installation are given in ISO 19901-6.

7.10 Accidental situations

7.10.1 General

Prevention, detection, control and mitigation of accidental situations arising from hazards shall be considered in the design in order to promote inherently safe topsides. Implementing preventive measures has historically been, and will continue to be, the most effective approach in minimizing the probability of occurrence of an event and the resultant consequences of the event. The owner or operator responsible for the overall safety of the platform shall identify the hazard management issues to be considered. Accidental situations shall be identified and assessed by means of hazard analysis performed in accordance with ISO 19900. A suitable screening process is shown in [Figure 1](#). See [7.10.2](#).

For topsides structures, the accidental and abnormal situations considered shall include

- a) explosion,
- b) fire,
- c) vessel collision,
- d) impact from dropped and swinging objects, from projectiles, and from broken cables and wire,
- e) helicopter impact (emergency landing or crash), and
- f) for floating structures, the effects of accidental flooding due to compartment damage, etc.

Methods to prevent accidents and to control and mitigate their consequences shall be considered during the design of the topsides structure and in laying out the facilities and equipment so as to minimize

the probability of occurrence and the effects of accidental events. Control and mitigation measures, including those to protect safety-critical elements (SCE) against fire and explosion actions, shall conform to ISO 13702.

The facilities layout, including equipment positioning, shall be arranged to minimize the exposure of personnel to accidental events and their consequences. Where the process of risk assessment identifies a hazard, the topsides structure shall be designed to have sufficient capability to resist or contain its effects so as to reduce risks to personnel and the environment to as low as reasonably practicable (ALARP). Robustness and inherent safety are important design considerations. Provision of adequate structural strength and ductile deflection capability as inherent safety measures to enhance the survivability of the platform shall be considered for the design of the topsides structure, equipment and SCE attached to it.

The main load-bearing primary structure, which is one of the SCE and is fundamental to the support of the temporary refuge, the life boats and other components essential to the safety of the personnel shall be designed to retain sufficient integrity during accidental situations and to maintain sufficient integrity to provide

- protection to personnel for a duration sufficient to effect their evacuation, and
- protection to the environment for a duration sufficient to effect containment of hydrocarbon spillages from process equipment.

In addition, the protection of the asset and the costs of failure should be considered with respect to importance to the owner and to the relevant national authorities.

An accidental situation can directly or indirectly impose actions, including drag actions, deflections and strong vibration on structural components and SCE, such as blow-down systems, emergency shut-down systems, deluge systems, processing systems and piping. Structural discipline engineers shall work closely with engineers of other disciplines (mechanical, electrical, process, etc.), including safety engineers experienced in performing hazard analyses, as part of the owner or operator's safety management system, as described in ISO 13702, to ensure that the likely response of the topsides structure and equipment is suitably assessed.

Interaction between the topsides structure and the support structure shall be considered. For a floating platform, suitable means of structurally decoupling the topsides structure from the hull and deck shall be provided where this is necessary to reduce the internal forces resulting from accidental and abnormal actions to acceptable levels.

The structural system shall be designed to resist accidental actions to ensure that the main safety functions of the topsides structure are not so impaired as to lead to either unacceptable loss of integrity of the structure or escalation causing its partial collapse. ALS design verification shall be carried out by considering, for each accidental situation, a representative value that reduces risks to ALARP. The probability of exceeding this representative accidental situation shall be no greater than about 10^{-4} per year. This probability level can be taken as indicative of an order of magnitude since the data basis for accurate determination of this small exceedance probability can be limited and include considerable uncertainties.

Items of equipment essential to the survival of the topsides (i.e. SCE) shall be assessed for structural resistance to accidental actions. The assessment shall include supports to such equipment and any associated critical pipework.

Imposed and self-weight actions shall be included in the assessment of the integrity of the structure and its response. Partial action and resistance factors may be set to unity for the ALS. The ALS assessment shall also include appropriate consideration of the integrity of the damaged structure (after-damage design situation) in assessing its capability to resist appropriate environmental actions. An assessment is necessary where the resistance of the structure has been significantly reduced by the structural damage caused by the accident. Criteria for this assessment are given in ISO 19902.

7.10.2 Evaluation of accidental situations

7.10.2.1 General

Three risk levels are considered in this part of ISO 19901, as described in [Table 3](#).

Table 3 — Description of risk levels

Risk level	Description
1. Low risk	Insignificant or minimal risks that can be eliminated from further consideration (risk level 1).
2. Medium risk	Risks shown to be acceptable using ALARP criteria (risk level 2).
3. High risk	Risks requiring further mitigation or modification of platform functions or manning philosophy, to reduce the probability of occurrence or the consequences of an event, or both (risk level 3).

The assessment process is intended to be a series of evaluations of specific events that could occur for the selected platform over its intended service life and service function(s).

A risk assessment process, as shown in [Figure 1](#), shall be undertaken as described in this subclause to

- initially screen those platforms considered to be low risk (risk level 1), thereby not requiring mitigation measures,
- study the probabilities, accidental action magnitudes and consequences, and the costs of mitigating measures, and
- determine which mitigation measures are necessary and re-evaluate the risk levels when ALARP criteria cannot be met without mitigation.

The assessment process as detailed in [Figure 1](#) comprises a series of tasks to be performed to identify the risk to a platform from fire or explosion actions, from impact loading, or from compartment flooding and to perform a suitable structural assessment.

The assessment tasks listed below should be read in conjunction with [Figures 2](#) and [3](#) and with [Table 4](#).

- Task 1: For each accidental situation in turn, estimate the order of magnitude of the probability of the event. Determining the probability of accidental events can be based on a review of statistics of occurrences at other locations, for example the occurrence of leaks from particular types of flanges in pipework coupled with the probability of an ignition, but the limitations and inaccuracies in such estimates should be understood.
- Task 2: For the accidental event, estimate the potential for injury from the descriptions in [Table 4](#) and consequently determine the risk level 1, 2 or 3 for the event under consideration. In many cases, it can be necessary to undertake a structural assessment of the event to determine the potential consequences (see [Figures 2](#) and [3](#)). For events with risk level 1, the assessment is complete and the next accidental event shall be considered.
- Task 3: For risk levels 2 and 3, further studies shall be undertaken to better define the risks, consequences, possible mitigation measures and the costs of those mitigation measures. Mitigation measures can include changes to hardware or to procedures to reduce the likelihood of the event, as well as changes to structure or equipment to reduce the consequences of the event. Having determined and costed possible mitigation measures, the costs shall be compared against the benefit in risk reduction to determine if the ALARP criteria are satisfied.
- Task 4: Where necessary, mitigation measures shall be undertaken and the risk assessment repeated.

7.10.2.2 Probability of occurrence and severity of accidental events

The probability of occurrence of a fire, explosion, impact loading or flooding event is associated with its origin, point of ignition (fires and explosions), source of impact (other accidental events), location of flooding and escalation potential. The type and presence of a hydrocarbon source can also be a factor in event initiation or event escalation. The significant events requiring consideration and their probability of occurrence levels are normally defined from hazard analysis.

Factors affecting the probability of occurrence and severity of an accidental event include the following.

— Product type

Product type, i.e. gas, condensate, light or heavy crude, shall be considered in evaluating the probability of occurrence.

— Operation type

The types of operations being conducted on the platform shall be considered when evaluating the probability of occurrence. Operations to be considered shall include drilling, production, supply boat operations and personnel transfer. Production operations are defined as those activities that take place after the successful completion of the wells; they include separation, treatment, measurement, transportation to shore, operational monitoring, modification of facilities and maintenance. Simultaneous operations include two or more activities.

— Decks, ceiling and boundary walls

The potential of a platform deck, ceiling, wall or other physical barrier to confine a vapour cloud is important. Whether a platform configuration is open or closed should be considered when evaluating the probability of an event occurring. Most platforms in mild environments, such as the US Gulf of Mexico, are open allowing natural ventilation. Platform decks in more severe climates (e.g. Alaska or the North Sea) are frequently enclosed, resulting in increased probability of containing and confining explosive vapours and higher explosion overpressures if ignited.

— Equipment type

The complexity, amount and type of equipment are important. Separation and measurement equipment, pump and compression equipment, heating equipment, generator equipment, safety equipment and their piping and valves shall be considered when evaluating the probability of occurrence of an event.

— Equipment congestion

Turbulence generated by equipment, structure, piping and cable trays, etc. can cause high overpressures in the event of an explosion with or without the presence of confining boundaries.

— Platform location

The proximity of the platform to shipping lanes can increase the potential for collision with passing vessels.

— Compartmentation

For floating structures, the increase in draught and the degree of listing following the accidental flooding of one or more watertight compartments can be influenced by the size of the compartments and any common-mode failures in the pipework or controls to the compartments.

— Other

Other factors, such as the frequency of supply boat operations, the type and frequency of personnel training, etc., shall be considered, as necessary.

7.10.2.3 Risk assessment

7.10.2.3.1 General

Accidental events of fire and explosion are assigned overall risk levels for a particular platform using Table 4 in accordance with ISO 13702. The risk levels are based on probabilities of accidental events and the likely consequences of those events.

Accidental events for platforms with risk levels 1 and 2 shall be considered as load cases for structural design.

7.10.2.3.2 Risk matrix

The risk level matrix in Table 4 provides a means of determining the acceptability of the risks of particular accidental events and is primarily a means of screening low-risk events that do not need further investigation from those that require more detailed investigation and possibly mitigation measures. Documentation of the screening and detailed assessment processes is required, particularly with regard to the conservatism of the data used and the sensitivity of the results to changes in assumptions.

Table 4 — Indication of risk level for accidental events

Annual frequency of occurrence f	Possible consequences to human safety and to the environment					
	C1	C2	C3	C4	C5	C6
	No significant risk to personnel and No significant risk to environment	Lost time injury but No significant risk to environment	Worst of: Serious harm to individuals or Limited loss of oil or chemicals to the sea	Worst of: Single fatality or Major loss of oil or chemicals to the sea	Worst of: Several fatalities (2 to 5) or Major loss of oil or chemicals to the sea	Worst of: Multiple fatalities (>5) or Loss of platform
Frequent $1 \leq f$	Risk level 2	Risk level 2	Risk level 3	Risk level 3	Risk level 3	Risk level 3
Occasional $10^{-1} \leq f < 1$	Risk level 1	Risk level 2	Risk level 3	Risk level 3	Risk level 3	Risk level 3
Infrequent $10^{-2} \leq f < 10^{-1}$	Risk level 1	Risk level 2	Risk level 2	Risk level 3	Risk level 3	Risk level 3
Rare $10^{-3} \leq f < 10^{-2}$	Risk level 1	Risk level 1	Risk level 2	Risk level 2	Risk level 3	Risk level 3
Very rare $10^{-4} \leq f < 10^{-3}$	Risk level 1	Risk level 1	Risk level 1	Risk level 2	Risk level 2	Risk level 3
Improbable $f < 10^{-4}$	Risk level 1	Risk level 1	Risk level 1	Risk level 1	Risk level 2	Risk level 2

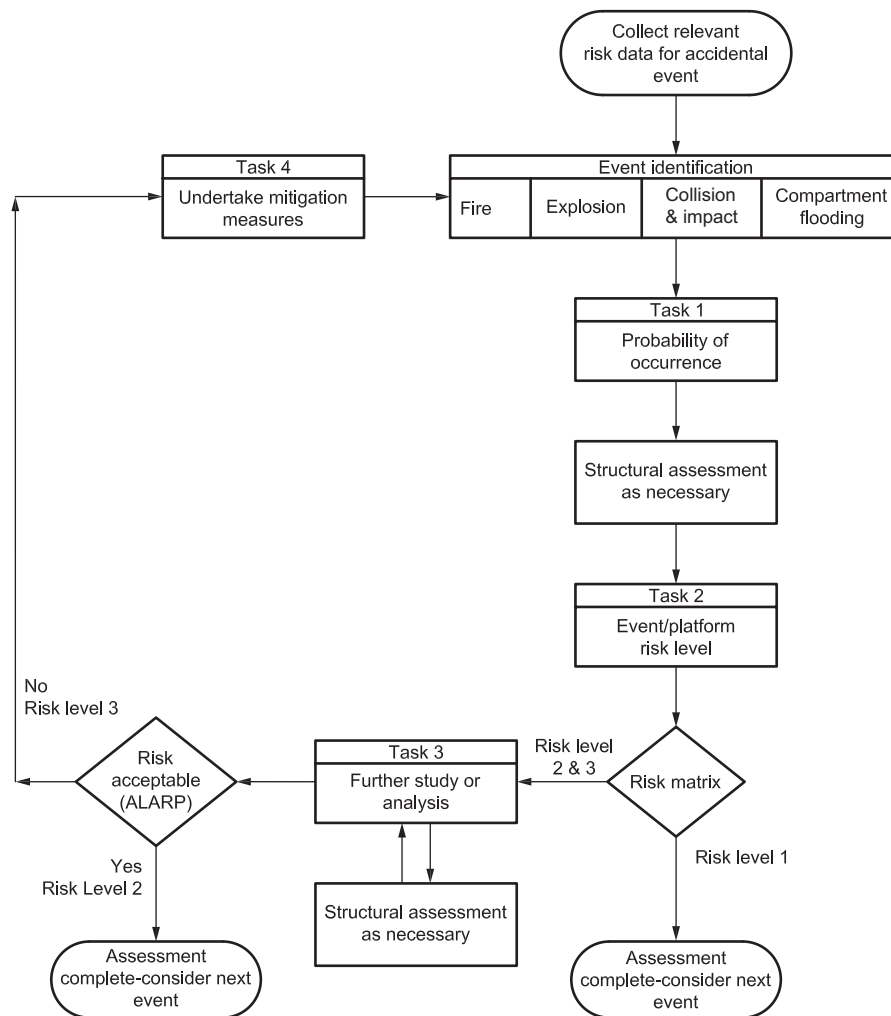


Figure 1 — Assessment of accidental events