



BSI Standards Publication

Oil and gas industries including lower carbon energy — Specific requirements for offshore structures

Part 3: Topsides structure

National foreword

This British Standard is the UK implementation of EN ISO 19901-3:2024. It is identical to ISO 19901-3:2024. It supersedes BS EN ISO 19901-3:2014, which is withdrawn.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 committee manager.

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Specific requirements for offshore structures - Part 3:
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à faible teneur en carbone - Exigences spécifiques
relatives aux structures en mer - Partie 3: Structures
Top Sides (ISO 19901-3:2024)

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an Offshore-Anlagen - Teil 3: Topsides structure (ISO
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European foreword

This document (EN ISO 19901-3:2024) has been prepared by Technical Committee ISO/TC 67 "Oil and gas industries including lower carbon energy" in collaboration with Technical Committee CEN/TC 12 "Oil and gas industries including lower carbon energy" the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2024, and conflicting national standards shall be withdrawn at the latest by July 2024.

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Endorsement notice

The text of ISO 19901-3:2024 has been approved by CEN as EN ISO 19901-3:2024 without any modification.

Contents

Page

Foreword	vii
Introduction	x
1 Scope	1
2 Normative references	2
3 Terms and definitions	3
4 Symbols and abbreviated terms	5
4.1 Symbols	5
4.2 Abbreviated terms	6
5 Overall requirements	7
5.1 Conceptual design	7
5.2 Codes and standards	7
5.2.1 Limit states and allowable stress philosophies	7
5.2.2 Use of national building standards	8
5.3 Deck elevation	8
5.4 Exposure level	8
5.5 Operational requirements	9
5.5.1 Functional requirements	9
5.5.2 Spillage and containment	9
5.6 Design physical environmental conditions	9
5.7 Critical structure	9
5.8 Assessment of existing topsides structure	10
5.9 Reuse of topsides structure	10
5.10 Repairs, modifications and refurbishment	10
6 Design requirements	11
6.1 General	11
6.2 Design/assessment situations	11
6.3 Material selection	11
6.4 Structural interfaces	11
6.5 Design for serviceability	11
6.5.1 Serviceability limits	11
6.5.2 Vibrations	12
6.5.3 Deflections	13
6.6 Design for strength	14
6.7 Design for fatigue	14
6.8 Robustness	14
6.8.1 General	14
6.8.2 Ductility	14
6.9 Confirmation of execution of design requirements	15
6.10 Corrosion control	15
6.11 Design for fabrication and inspection	16
6.12 Design for loadout, transportation and installation	16
6.13 Design for structural integrity management	17
6.14 Design for decommissioning, removal and disposal	17
6.14.1 General	17
6.14.2 Structural releases	17
6.14.3 Lifting appurtenances	17
6.14.4 Heavy lift and set-down operations	17
7 Actions and analysis methods	18
7.1 General	18
7.2 In-service actions	19
7.3 Action factors	20
7.3.1 Design actions for operational design/assessment situations in still water	20

7.3.2	Design actions for operational design/assessment situations with operating environmental actions	20
7.3.3	Design actions for extreme design/assessment situations	21
7.4	Vortex-induced vibrations	21
7.5	Indirect actions and resulting forces (action effects)	21
7.6	Metoccean and ice actions	22
7.6.1	Wave, current and ice actions	22
7.6.2	Wind actions	23
7.6.3	Cold regions effects	24
7.7	Seismic actions	24
7.7.1	General	24
7.7.2	Minimum lateral acceleration	24
7.7.3	Equipment and appurtenances	24
7.8	Actions during fabrication, loadout, transportation, and installation	25
7.9	Actions arising from accidental events	25
7.9.1	General	25
7.9.2	Structural design for fire hazard	27
7.9.3	Structural design for explosion hazard	28
7.9.4	Explosion and fire interaction	32
7.9.5	Cryogenic spill	33
7.9.6	Actions due to vessel collision	33
7.9.7	Actions due to dropped and swinging objects and projectiles	33
7.9.8	Actions due to loss of buoyancy	33
7.9.9	Actions due to topsides acceleration	34
7.10	Other actions	34
7.10.1	Drilling	34
7.10.2	Conductors	35
7.10.3	Risers	36
7.10.4	Caissons	36
7.10.5	Maintenance, mechanical handling and lifting aids	36
7.10.6	Bridge supports	36
8	Strength and resistance of structural components	37
8.1	Correspondence factor K_c	37
8.2	Design of cylindrical tubular sections	37
8.3	Design of non-cylindrical sections	37
8.3.1	Rolled and welded non-circular prismatic members	37
8.3.2	Plate girder	38
8.3.3	Box girder	38
8.3.4	Stiffened plate components and stressed skin structures	38
8.4	Connections	39
8.4.1	General	39
8.4.2	Restraint and shrinkage	39
8.4.3	Bolted connections	39
8.5	Castings and forgings	43
8.6	Design for structural stability	43
9	Limit state verification	44
9.1	Limit state verification approach	44
9.2	Limit state verification for fire and explosion events	45
9.3	Approaches for limit state verification for fire and explosion events	45
9.4	Risk and risk targets	46
9.5	Limit state verification for fire and explosion events by semi-probabilistic approach	48
9.5.1	DL limit state verification	48
9.5.2	NC limit state verification	48
9.5.3	Representative values of accidental actions	49
10	Structural systems	49
10.1	Topsides design	49
10.1.1	General	49

10.1.2	Topsides on concrete substructures.....	49
10.1.3	Topsides on floating structures.....	50
10.1.4	Equipment supports.....	50
10.2	Topsides structure design models.....	50
10.2.1	General.....	50
10.2.2	Substructure model for topsides design.....	51
10.2.3	Topsides model for topsides design.....	51
10.2.4	Modelling for design of equipment and piping supports.....	52
10.3	Substructure interface.....	52
10.3.1	Responsibility.....	52
10.3.2	Strength design.....	52
10.3.3	Fatigue design.....	52
10.4	Flare towers, booms, vents and similar structure.....	52
10.5	Helicopter landing facilities (helidecks).....	53
10.5.1	General.....	53
10.5.2	Construction.....	54
10.5.3	Helideck design verification.....	54
10.5.4	Reassessment of existing helidecks.....	58
10.6	Crane support structure and crane boom rest.....	59
10.6.1	General.....	59
10.6.2	Design requirements.....	59
10.6.3	Static design.....	60
10.6.4	Fatigue design.....	62
10.6.5	Seismic/Earthquake design.....	63
10.6.6	Dynamic design.....	63
10.6.7	Fabrication.....	64
10.6.8	Crane boom rest design.....	64
10.7	Derrick equipment set.....	64
10.8	Bridges.....	65
10.9	Bridge bearings.....	65
10.10	Anti-vibration mountings for modules and major equipment skids.....	66
10.11	System interface assumptions.....	66
10.12	Fire protection systems.....	66
10.13	Penetrations.....	67
10.14	Difficult-to-inspect areas.....	67
10.15	Drainage.....	67
10.16	Strength reduction due to heat.....	67
10.17	Walkways, laydown areas and equipment maintenance.....	67
10.18	Muster areas and lifeboat stations.....	68
11	Materials.....	68
11.1	General.....	68
11.2	Carbon steel.....	69
11.3	Stainless steel.....	74
11.3.1	General.....	74
11.3.2	Types of stainless steel.....	74
11.3.3	Material properties.....	75
11.4	Aluminium alloys.....	75
11.4.1	General.....	75
11.4.2	Types of aluminium.....	75
11.4.3	Material properties.....	75
11.4.4	Thermite sparking.....	76
11.5	Fibre-reinforced polymers (FRP).....	76
11.6	Timber.....	76
12	Fabrication, quality control, quality assurance and documentation.....	77
12.1	Assembly.....	77
12.1.1	General.....	77
12.1.2	Grating.....	77
12.1.3	Landing and stairways.....	77

ISO 19901-3:2024(en)

12.1.4	Temporary attachments.....	77
12.2	Welding.....	77
12.3	Fabrication inspection.....	78
12.4	Quality control, quality assurance and documentation.....	78
12.5	Corrosion protection.....	78
12.5.1	Coatings.....	78
12.5.2	Under deck areas.....	78
12.5.3	Dissimilar materials.....	78
12.6	In-service inspection, monitoring and maintenance of corrosion control.....	79
13	Loadout, transportation and installation.....	79
14	In-service inspection and structural integrity management.....	79
14.1	General.....	79
14.2	Requirements applying to topsides structures.....	79
14.2.1	Corrosion protection systems.....	79
14.2.2	Critical structures.....	79
14.2.3	Control of hot work (e.g. welding and cutting).....	79
14.2.4	Accidental events and incidents.....	80
14.2.5	Change control.....	80
Annex A (informative) Additional information and guidance.....		81
Annex B (informative) Example calculation of correspondence factor.....		141
Bibliography.....		147

Foreword

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

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

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 7, *Offshore structures*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Oil and gas industries including lower carbon energy*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 19901-3:2014), which has been technically revised.

The main changes are as follows:

- alignment of terminology with that of ISO 19900;
- a rational re-arrangement of the clauses content and numbering;
- adoption with modifications of IOGP supplementary requirements (S-631-04);
- ‘national or regional codes’ and ‘national or regional building codes’ have been replaced by ‘national building standards’ throughout the whole document;
- ‘supporting structure’ has been replaced by ‘substructure’ and definition of ‘substructure’ has been added to [Clause 3](#);
- ‘wave, wind and current’ has been replaced by ‘metocean’;
- ‘design assessment/situations’ has replaced ‘design situations’ according to ISO 19900;
- [5.2.1](#) has been updated distinguishing between ASD (Allowable strength design) associated to ANSI/AISC 360-22 and WSD (Working stress design) associated to AISC 335-89 and API RP 2A-WSD. Further guidance is provided for floating structures where the hull is typically designed using the WSD method. In [5.2.2](#) guidance on the application of K_c is given in case of WSD method.
- [subclause 5.7](#) on critical structures has been added;

- in [6.5.2.4](#) the frequency range to avoid structural resonance has been changed according to NORSOK N-004:2022, F-2-9-6;
- [Table 2](#) has been updated with the introduction of ‘restricted access for inspection, maintenance and repair’ partial damage factors and reduction in case of full accessibility (with reference to ISO 19904-1, NORSOK N-004,^[32] Reference [\[30\]](#) and DNV-OS-C101^[31]). Guidance in case of dissimilar materials has been added;
- subclause [6.8.2](#) on ductility has been introduced, adapted from NORSOK N-004:2022, 7.2;
- addition of [Table A.1](#) with typical minimum values for local, primary and global design of operational actions (*Q*);
- subclause [7.3](#) has been re-ordered and updated;
- subclause [7.5](#) has been renamed ‘Indirect actions and resulting forces’ and updated according to the modifications and assumptions in [10.1](#) and [10.2](#);
- wind actions, [7.6.2](#) and [A.7.6.2](#), introduction of national building standards for the evaluation of the representative wind actions; alignment with ISO 19900 and ISO 19901-1 and addition of more guidance;
- alignment of minimum lateral acceleration for seismic ([7.7.2](#) and [A.7.7.2](#)) with ANSI/API RP 2TOP^[82].
- all sources of topsides accelerations collected ([7.9.9](#) and [A.7.9.9](#)) and aligned;
- technical review of the accidental events ([7.9](#) and [A.7.9](#)), with introduction of risk-informed and reliability-based approaches for fire and explosion in addition to the default semi-probabilistic approach;
- K_c correspondence factor ([8.1](#) and [A.8.1](#)) defined according to an equivalent reliability procedure for ANSI/AISC 360-22,^[12] CSA-S16:19^[14] and EN 1993-1-1^[13];
- bolted connection ([8.4.3](#) and [A.8.4.3](#)) have been modified according to IOGP supplementary specification S-631-04;
- [8.5](#) has been renamed as ‘Castings and forgings’, adding references to forgings;
- addition of [8.6](#) and [A.8.6](#) on design for structural stability in alignment with ANSI/API RP 2TOP^[82] and based on ANSI/AISC 360-22^[12] and EN 1993-1-1^[13] criteria;
- addition of [Clause 9](#) dedicated to the description of the limit state verification approaches including risk-informed and reliability-based approaches for fire and explosion ([9.2](#), [9.3](#), [A.9.2](#) and [A.9.3](#)) in addition to the default semi-probabilistic approach;
- in [10.2.1](#), an alternative method (method b) for the analysis of the topsides structures has been introduced with further guidance in [A.10.2.1](#). The associated [6.4](#), [7.5](#), [7.8](#) and [10.1](#) and [A.6.4](#), [A.7.5](#), [A.7.8](#) and [A.10.1](#) have been updated accordingly;
- helicopter landing facilities ([10.5](#)) updated according to CAP 437^[21] for emergency landing and addition of design load combinations ([Table 7](#)) adapted from NORSOK N-004:2022, Table F.5.^[32] Deletion of the previous Table A.5;
- crane support structure clauses, [10.6](#) and [A.10.6](#) have been reviewed. Crane support structure is to be designed according to API Spec 2C or EN 13852-1 and additional provisions reported. The simplified fatigue method has been aligned with ANSI/API RP 2TOP^[82];
- [Table 9](#) adapted with modifications from NORSOK N-004:2022, Table F.1^[32] and addition of some example figures for DC;
- former 12.1 to 12.3.5 have been deleted and moved to ISO 19902:2020, Clause 18.
- in [12.2](#) Welding requirements have been reviewed;
- in [12.5](#) provisions for dissimilar materials have been added, adapted from NORSOK N-004:2022, F.4.4;

ISO 19901-3:2024(en)

- the previous Clause 12 and A.12 “Corrosion control” in ISO 19901-3:2014 has been removed because it is now included in ISO 19902:2020; in [Clause 14](#), reference to ISO 19901-9 has been added and the previous Clause 14 in ISO 19901-3:2014 on “Topsides structure default inspection scope” has been removed, being now covered by ISO 19901-9; in [Clause 14](#) and [A.14](#), the subclauses [14.2.2](#) and [A.14.2.2](#) on “Critical structures” have been added;
- in [Annex B](#), updated example of K_c calculations by utilization ratio for ISO 19902 and ANSI/AISC 360-22^[12].
- removal of former Annex C. K_c is now reported as normative value in Table 4 for ANSI/AISC 360-22^[12], CSA-S16:19^[14] and EN 1993-1-1^[13].

A list of all parts in the ISO 19901 series can be found on the ISO website.

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

Introduction

The International Standards on offshore structures prepared by TC 67 (i.e. ISO 19900, the ISO 19901 series, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 and ISO 19906) constitute a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries including lower carbon energy 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 International Standards on offshore structures prepared by TC 67 are intended to provide wide latitude in the choice of structural configurations, materials and techniques, without hindering innovation. Sound engineering judgement is therefore necessary in the use of these International Standards.

This document has been prepared for those structural components of offshore platforms which are above the wave zone and are not part of the substructure or of the hull.

Historically, the design of structural components in topsides has been performed to national building standards for onshore structures, modified in accordance with experience within the offshore industry, or to relevant parts of classification society rules. While this document permits use of national building standards, 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 substructures 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 document.

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

Oil and gas industries including lower carbon energy — Specific requirements for offshore structures —

Part 3: Topsides structure

1 Scope

This document provides requirements, guidance and information for the design and fabrication of topsides structure for offshore structures, including in-service, pre-service and post-service conditions.

The actions on topsides structure and the action effects in structural components are derived from this document, where necessary in combination with other International Standards in the ISO 19901 series (e.g. ISO 19901-1 for wind actions - see [7.6.2](#), ISO 19901-2 for seismic actions - see [7.7](#)) and ISO 19902 for fatigue design (see [6.7](#)).

This document is applicable to the following:

- topsides of fixed offshore structures;
- discrete structural units placed on the hull structures of floating offshore structures and mobile offshore units;
- topsides of arctic offshore structures, excluding winterization (see ISO 19906).

If any part of the topsides structure forms part of the primary structure of the overall structural system which resists global platform actions, the requirements of this document are supplemented with applicable requirements in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 and ISO 19906.

For those parts of floating offshore structures and mobile offshore units that are chosen to be governed by the rules of a recognized classification society, the corresponding class rules supersede the associated requirements of this document.

This document also addresses prevention, control and assessment of fire, explosions and other accidental events.

The fire and explosion provisions of this document can be applied to those parts of the hulls of floating structures and mobile offshore units that contain hydrocarbon processing, piping or storage.

NOTE Requirements for structural integrity management are presented in ISO 19901-9.

This document 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.

This document provides requirements for selecting and using a national building standard with a correspondence factor for determining the resistance of rolled and welded non-circular prismatic components and their connections.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Spec 2C, *Offshore Pedestal-mounted Cranes*

API Spec 2SC, *Manufacture of Structural Steel Castings for Primary Offshore Applications*

API Spec 2SF, *Manufacturer of Structural Steel Forgings for Primary Offshore Applications*, 1 edition, August 2013, reaffirmed 2020

ASTM F2329/F2329M, *Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners*

ASTM F3125/F3125M, *Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 Mpa and 1 040 Mpa Minimum Tensile Strength*

EEMUA PUB NO 176, *Specification for structural castings for use offshore*

EN 13852-1, *Cranes — Offshore cranes — Part 1: General-purpose offshore cranes*

EN 1993-1-8, *Eurocode 3: Design of steel structures – Part 1-8: Design of joints*

ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

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 10684, *Fasteners — Hot dip galvanized coatings*

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

ISO 17776, *Petroleum and natural gas industries — Offshore production installations — Major accident hazard management during the design of new installations*

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 19901-9, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 9: Structural integrity management*

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

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

ISO 19904-1, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Ship-shaped, semi-submersible, spar and shallow-draught cylindrical structures*

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

ISO 19905-3, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 3: Floating units*

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

ISO 20088-1, *Determination of the resistance to cryogenic spillage of insulation materials — Part 1: Liquid phase*

ISO 20088-2, *Determination of the resistance to cryogenic spill of insulation materials — Part 2: Vapour exposure*

ISO 20088-3, *Determination of the resistance to cryogenic spillage of insulation materials — Part 3: Jet release*

ISO 22899-1, *Determination of the resistance to jet fires of passive fire protection materials — Part 1: General requirements*

ISO 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

NORSOK M-122, *Cast structural steel, rev. 2, October 2012*

NORSOK M-123, *Forged structural steel, rev. 2, October 2012*

3 Terms and definitions

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

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

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

3.1

active fire protection

equipment, systems, and methods which, following initiation, can be used to control, mitigate, and extinguish fires

[SOURCE: ISO 13702:2015, 3.1.3]

3.2

caisson

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

3.3

critical structure

structural components, forming parts of the topsides structure, that provide support to safety and environmental critical elements (SECE), loss of which can cause specific life-safety, environmental or business consequences

Note 1 to entry: [Subclause 5.7](#) provides details and examples.

Note 2 to entry: Critical structure also includes structures which support safety and environmental critical elements (SECE) previously termed safety-critical elements (SCE), see ISO 19901-9:2019, 9.4 and A.9.4.

Note 3 to entry: SECE includes all relevant equipment and systems.

3.4

endurance period

time estimated for evacuation as defined by the Emergency Evacuation Rescue Analysis (EERA)

Note 1 to entry: The endurance period is specified in the basis of design.

3.5

major accident

MA

hazardous event that results in

- multiple fatalities or severe injuries; or
- extensive damage to structure, installation or plant; or
- large-scale impact on the environment (e.g. persistent and severe environmental damage that can lead to loss of commercial or recreational use, loss of natural resources over a wide area or severe environmental damage that will require extensive measures to restore beneficial uses of the environment)

Note 1 to entry: In this document, a major accident is the realization of a major accident hazard.

[SOURCE: ISO 17776:2016, 3.1.12, modified — Note 2 to entry deleted.]

3.6

passive fire protection

PFP

coating or cladding arrangement or free-standing system which, in the event of fire, provides thermal protection to restrict the rate at which heat is transmitted to the object or area being protected

[SOURCE: ISO 13702:2015, 3.1.36]

3.7

risk curve

probability of consequences exceeding a defined limit during a reference period

3.8

substructure

structure supporting the topsides

Note 1 to entry: The substructure can take many forms including fixed steel (see ISO 19902), concrete (see ISO 19903), floating (see ISO 19904-1 and ISO 19905-3), jack-up (see ISO 19905-1), or the various forms of arctic structures (see ISO 19906).

3.9

ideal hinge

pinned connection

idealisation by which no moments are transferred

Note 1 to entry: Plastic strain in an ideal hinge is typically a fraction of a percent.

4 Symbols and abbreviated terms

4.1 Symbols

a	acceleration
A	accidental action
b	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	environmental action
E_e	extreme quasi-static environmental action due to metocean and ice
E_o	environmental action due to metocean and ice for the operator defined operating conditions
F_d	design action
F_r	representative action
g	acceleration due to gravity
G	permanent action
I	explosion impulse
l	span or length
K_c	correspondence factor
p	instantaneous explosion overpressure
$p(t)$	variation of overpressure with time
P	probability
Q	operational action
R	resistance
R_d	design value of resistance
R_k	characteristic value of resistance, or value based on characteristic values of material properties
S_d	total design action effect
t	time from ignition of an explosion
t_d	duration of positive 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

ALARP	as low as reasonably practicable
ALE	abnormal level earthquake
ALS	abnormal/accidental limit state
APoE	annual probability of exceedance
ASD	allowable stress design
AVM	anti-vibration mounting
CFD	computational fluid dynamics
CoG	centre of gravity
CTOD	crack tip opening displacement
DL	damage limitation limit state
DLB	ductility level blast
DES	derrick equipment set
ELE	extreme level earthquake
EER	escape, evacuation and rescue
FEA	finite element analysis
FEED	front end engineering design
FPSO	floating production storage and off-loading structure
FRP	fiber reinforced polymer
IRPA	Individual risk per annum
ISD	inherently safer design
LRFD	load and resistance factor design
MA	major accident

MPI	magnetic particle inspection
MTOM	maximum take-off mass
MTOW	maximum take-off weight
NC	near collapse limit state
NTE	not-to-exceed
PFP	passive fire protection
SDOF	single degree of freedom
SECE	safety and environmental critical elements
SLB	strength level blast
SRPA	societal risk per annum
SWL	safe working load
TR	temporary refuge
U	utilization
UTS	ultimate tensile strength
VIV	vortex induced vibration
WSD	working stress design

5 Overall requirements

5.1 Conceptual design

Conceptual design shall include the determination of functional requirements and design criteria to obtain a workable and economical topsides layout and structure to perform its mission for a specified length of time (design service life).

Conceptual design shall include the development of structural and equipment layouts with due regard to congestion and confinement, which are important factors influencing the extent and magnitude of possible fire and explosion events and actions. Configuration of the facilities should be based on Inherently Safer Design (ISD) principles to eliminate or minimize the risks from hazards.

5.2 Codes and standards

5.2.1 Limit states and allowable stress philosophies

In general, the International Standards on offshore structures follow the approach of ISO 2394^[1] and as such are intended to be limit state design standards.

NOTE 1 Limit state methods are also known as load and resistance factor design (LRFD) methods.

The intent of this document is that partial factor methods in accordance with ISO 19900, see 9.1, should be used where possible, but, where the substructure is designed using the WSD (Working Stress Design)

method, such as for floating structures, the WSD method may also be used for the design of the topsides structure (e.g. AISC 335-89^[72]). ASD may also be used where WSD is acceptable.

Note 2 In the more recent versions of AISC, i.e. AISC 360, ASD (Allowable Strength Design) has replaced WSD. ASD is a hybrid design approach using factored action combinations along with a safety factor applied to the resistance.

Where WSD methodology is used for the hull design in a floating facility and where partial factor design is used for the topsides, the appropriate partial action factors should be applied to the individual unfactored dead, imposed/live, and metocean actions applied to the hull.

Any dynamic response should be calculated using non-factored actions, and the resulting action effects should then be subjected to the appropriate partial factors.

The specific requirements and guidance in this document apply to the use of limit state (or LRFD) codes. Where an WSD or ASD code or standard is used, the requirements for allowable stresses and other factors shall be in accordance with the selected national building standard.

5.2.2 Use of national building standards

Topsides structures shall be designed and fabricated in accordance with this document and supplemented by the specific requirements from a national building standard as specified in this document. The national building standard shall be selected and agreed with the operator and regulator.

If the substructure is designed using the WSD method, as is often the case with hulls in floating facilities, and the topsides or any modules or assemblies are similarly designed using the WSD method, then no correspondence factor shall be applied.

5.3 Deck elevation

Air gap requirements are addressed in ISO 19901-1, ISO 19902, ISO 19904-1 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 substructure. These actions should be communicated to the substructure designer as early as possible.

For floating structures, and for ship-shaped 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 structure shall be designed to withstand these actions according to ISO 19904-1.

Deck elevation for platforms in arctic and cold regions with sea ice and iceberg hazards is addressed in ISO 19906.

5.4 Exposure level

The exposure level for topsides structure shall be determined in accordance with the criteria given in ISO 19900. Additional guidance is provided in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 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 structures are not expected to be manned during governing design conditions and have medium consequences of failure; and L3 structures are normally unmanned and have low consequences of failure. These are more fully described in ISO 19900.

5.5 Operational requirements

5.5.1 Functional requirements

The functional requirements of the platform including drilling, process, access, safety and auxiliary systems, shall be established and documented, and communicated to design and operating personnel. In particular, the integrity of the structure shall conform 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 provided that collects and stores liquid spillages and overflows for subsequent handling (see [10.15](#)).

Accumulation of combustible liquids in containment areas and on plated decks shall be mitigated through drainage systems and applied in fire risk studies.

5.6 Design physical environmental conditions

The topsides design physical environmental conditions (metocean, ice and seismic, see ISO 19900) for use in the relevant design/assessment situations shall correspond to those of the substructure. Specific short-duration design/assessment situations may adopt less onerous physical environmental conditions.

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

5.7 Critical structure

The following structural components shall be identified and recorded in design documentation as critical structure:

- a) structural barriers, such as blast walls, that are intended to prevent a hazardous event from causing a major accident, or used to provide mitigation of the consequences.
- b) structural components that support the weight of the TR (Temporary Refuge), including anti-vibration mounting (AVM), structural components that comprise the external surface of the TR, and structural components that comprise and support permanently occupied buildings;
- c) structural components that support equipment required for EER (Escape, Evacuation and Rescue) including escape from the location of the hazardous event to the TR or muster location, and evacuation from the TR and muster location during the endurance period following a hazardous event;

NOTE 1 Endurance period for environmental risk in a fire event can be much longer than that required for personnel evacuation (life-safety risk). In such instances, mitigation can involve measures to reduce the blow-down time of systems containing hazardous inventories.

NOTE 2 Equipment required for EER typically includes:

- primary escape routes;
- lifeboats, life rafts, and means of escape to sea;
- fire, gas, and smoke detection in the TR;
- active fire protection (pumps and pipes);
- emergency generators.

- d) structural components that prevent escalation (including supports for hydrocarbon-containing equipment and process safety critical piping systems, blast walls preventing escalation to the TR and fire walls preventing escalation to the TR, dropped object protection structure, riser impact protection structure, etc).

NOTE 3 Hydrocarbon-containing equipment typically includes:

- emergency shut-down valves/equipment (ESDVs);
- blowdown (venting and flare) equipment and piping;
- well isolation equipment;
- derrick equipment set (DES);
- hydrocarbon vessels and equipment (including all hydrocarbon-containing pipework and equipment such as generators that are fed gas);
- crane pedestals.

Other examples of structural components critical to topside structural integrity and/or business consequence are:

- topside deck post and brace framing into posts;
- drilling rig foundations;
- riser top tensioner foundation;
- flare boom foundation;
- helideck foundation.

NOTE 4 Further examples of critical structure are provided in ISO 19901-9:2019, A.9.4.

5.8 Assessment of existing topsides structure

Any assessment of existing topsides structure and structural components shall be performed in accordance with ISO 19900 and ISO 19901-9.

5.9 Reuse of topsides structure

Existing topsides structure or part of the structure can be removed and relocated for use at a new location. In such cases, the structure shall be assessed in accordance with ISO 19900 and ISO 19901-9, and for use (accounting for exposure level) and conditions applicable at the new location.

NOTE 1 Topsides structures present particular challenges as access for inspection is likely to be restricted by the plant and equipment and modifications can have been made to both the topsides structure and the equipment during the platform's original service life.

NOTE 2 In addition to survey work, all of the provisions applicable to a new design are likely to be relevant.

5.10 Repairs, modifications and refurbishment

Where repairs, modifications or refurbishment of an existing topsides structure are planned, the structure shall be assessed for the revised configuration in accordance with the basis of design and the assessment requirements of ISO 19901-9.

6 Design requirements

6.1 General

This clause presents the overall requirements for design of topsides structure.

The topsides design shall satisfy the fundamental requirements set out in ISO 19900.

6.2 Design/assessment situations

Design/assessment situations shall be established as specified in ISO 19900. They shall include all operational requirements, temporary conditions, physical environmental conditions, accidental conditions and post-damage conditions which could affect the design or assessment.

Each phase of the life of the structure and each mode of operation of the platform, such as drilling, production, work-over, or anticipated combinations thereof, shall be explicitly evaluated in design/assessment situations.

6.3 Material selection

Materials shall be selected that have a performance compatible with the design standard applicable for the structural components. ISO 19902 gives specific requirements and guidance for the selection of carbon steels that are applicable to topsides structure. [Clause 11](#) addresses further requirements and alternative materials, including FRP, in [11.5](#).

6.4 Structural interfaces

Particular attention shall be paid to the following:

- interfaces between different structures in order to ensure adequate alignment when fabrication and installation tolerances are taken into account;
- distortions and displacements during fabrication, loadout, transportation, installation and in-service conditions;
- effects of relative displacements of different structures supported on one or more separate structures;
- consistency of forces (action effects) on both sides of interface.

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

NOTE Small displacements can be tolerated by adopting ductile design (see [10.2.2](#)).

If a jack-up is to be located in close proximity to a topsides structure, its design shall ensure that under design metocean and seismic conditions there is no clash with primary steelwork and potentially manned areas (e.g. LQ, muster areas, emergency escape routes).

6.5 Design for serviceability

6.5.1 Serviceability limits

Design for serviceability shall include establishing design/assessment situations as specified in ISO 19900.

The serviceability of the topside structures can be affected by excessive relative displacement or vibration (vertical or horizontal). Serviceability limit states shall be established with respect to:

- 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,
- e) operational requirements for drainage (free surface or piped fluids).

Vibration limits are specified in [6.5.2](#) and 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 identified 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) transient fluid flow in piping systems, in particular slugging;
- c) wind-induced vibrations (VIV) on slender elements (see [7.4](#));
- d) global motions due to environmental actions on the facility;
- e) earthquake and accidental events.

6.5.2.2 Design limits on vibrations

Design limits for vibration shall be established from operational limits set by equipment suppliers and by the requirements for 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 operator 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, should be proportioned to have a natural period of less than 1 s (see Reference [[110](#)]).

6.5.2.4 Dynamic analysis and avoidance of resonance

Dynamic analysis shall be used to assess the response of various parts of the topsides to ensure resonance is avoided. Such analysis shall include unfactored static and imposed actions.

To avoid resonance, the applicable frequency range is typically from 20 % below to 20 % above the excitation frequency range. For each frequency, the dynamic stiffness may approximately be taken as the force amplitude divided by the displacement amplitude in the direction of the force.

NOTE 20 % is considered sufficient to avoid resonances based on:

- theoretical margin to the resonance frequency to limit amplification;
- normal accuracy of actual excitation frequency compared to nominal;
- normal accuracy of predicted eigenfrequencies compared to actual eigenfrequencies;
- rotating machinery codes typically use a 15 % margin for rotor dynamic design, however, the 3 DOF rotor dynamic system is a less complex system and some more margin is needed.

Where heavy rotating machinery is installed (such as variable speed pump skids, compressors, etc.), three-dimensional vibration analysis should be performed. Simplified two-dimensional vibration analysis may be used for stand-alone components such as cantilevers.

6.5.3 Deflections

6.5.3.1 Vertical deflections

The final maximum deflection, $\Delta_{\max}$, of any element, structural component or structure comprises three parts as given in [Formula \(1\)](#):

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

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

Table 1 — Serviceability limits for 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	—	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 operator 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. Cambering deck plating in areas susceptible to icing of any surface water can be used to avoid ponding.

Tolerances required for telecommunications equipment should be verified and maintained.

NOTE The alignment of telecommunications equipment can be critical for their reliable operation.

6.5.3.2 Horizontal deflections

Horizontal deflections shall be limited to 0,3 % of the height between floors. For multi-floor modules or structures, the total horizontal deflection shall not exceed 0,2 % of the total height of the modules or 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 strength

Design for strength shall include establishing operational, extreme, abnormal, accidental, and short duration design/assessment situations as specified in ISO 19900.

Methods of limit state verification are described in [Clause 9](#).

6.7 Design for fatigue

Topsides fatigue design shall be in accordance with ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 and ISO 19906, whichever is relevant, supplemented by the additional provisions given in [Clause 10](#), particularly with respect to actions.

NOTE Pre-service fatigue damage during transportation can be significant depending on the length and severity of the environment of the transportation route (see [A.6.7](#) for further guidance).

Pre-service (e.g. transportation) and in-service fatigue damage shall be combined to evaluate the total fatigue damage.

Where the substructure standard does not provide adequate fatigue guidance for a topsides structure, other suitable standards may be applied (see [A.6.7](#)).

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

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

Classification of components based on damage consequence	Not accessible for inspection or not repairable	Restricted access for inspection, maintenance and repair	Fully accessible for inspection, maintenance and repair
Substantial consequences	10	3	2
Without substantial consequences	5	2	1

NOTE 1 The γ_{FD} factors assume that inspections and maintenance intervals (see [6.13](#)) are planned for all accessible areas, even if restricted, however the interval between inspections can be larger if the factor is higher. Inspection intervals and inspection methods are typically considered for the design for welds that are likely to crack at the weld roots.

NOTE 2 Restricted access can be for example flare structures, joints under removable passive fire protection, areas requiring rope access and areas with restricted access during normal operations.

NOTE 3 The γ_{FD} are associated to appropriate inspection intervals (see [A.6.7](#)).

When combining different materials such as steel and aluminium, the cyclic thermal effect shall not cause the fatigue limit state to be exceeded.

NOTE 4 The different materials will expand differently due to thermal effects.

NOTE 5 Fatigue damage for solar heating when using same material is generally negligible.

6.8 Robustness

6.8.1 General

Qualitative assessments to evaluate measures to improve the robustness of critical structure (see [5.7](#)) shall be performed before detailed analysis.

6.8.2 Ductility

All failure modes shall be ductile.

Ductile failure modes ensure the structural behaviour will be in accordance with the anticipated model used for determination of the responses. In general, all design procedures, regardless of analysis method, will not capture the true structural behaviour. Ductile failure modes will allow the structure to redistribute forces in accordance with the presupposed static model. Brittle failure modes shall therefore be avoided or shall be verified to have excess resistance compared to ductile modes, and in this way protect the structure from brittle failure.

The following sources for brittle structural behaviour shall be considered for a steel structure:

- a) unstable fracture caused by a combination of the following factors:
 - 1) brittle material,
 - 2) a design resulting in high local stresses,
 - 3) the possibilities for weld defects, and
 - 4) presence of fatigue cracks.
- b) structural details where ultimate resistance is reached with plastic deformations only in limited areas, making the global behaviour brittle, e.g. partial butt weld loaded transverse to the weld with failure in the weld,
- c) shell buckling, and
- d) buckling where interaction between local and global buckling modes occur.

In general, a steel structure will be of adequate ductility if the following is satisfied:

- material toughness requirements are met, and the design avoids a combination of high local stresses with possibilities of undetected weld defects;
- details are designed to develop a certain plastic deflection e.g. partial butt welds subjected to stresses transverse to the weld is designed with excess resistance compared with adjoining plates;
- member geometry is selected such that the resistance does not show a sudden drop in capacity when the member is subjected to deformation beyond maximum resistance;

NOTE An unstiffened shell in cross section class 4, is an example of a member that can show such an unfavourable resistance deformation relationship (for definition of cross section class see EN 1993-1-1^[13]).

- local and global buckling interaction effects are avoided; and
- adequate fatigue strength is ascertained to keep the probability of cracks sufficiently low.

6.9 Confirmation of execution of design requirements

For a new topsides, a walk-down survey shall be carried out in the fabrication yard prior to loadout. Remaining work which is missing from the walk-down survey and is performed post loadout shall be surveyed after installation (see baseline inspection in ISO 19901-9), but before production starts, in order to confirm that specific design requirements have been executed in the detailed fabrication and construction.

NOTE Walk-downs are methodical, on-site, visual evaluations of existing structures and equipment as installed.

6.10 Corrosion control

Corrosion control of topsides structure and structural components shall be performed in accordance with ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 and ISO 19906, whichever is relevant.

In addition, 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 and operating criteria for the topsides structure. These criteria include:

- a) the corrosion allowance (if any) used in the design,
- b) the design service 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 ISO 19901-9).

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

NOTE Coating breakdown typically occurs a few years after installation on painted steel deck and corrosion thickness allowance can be considered as mitigation.

6.11 Design for fabrication and inspection

The designers shall be familiar with or anticipate likely methods of fabrication, welding and erection to execute the design and 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 service 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 operator.

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 document for materials (see [Clause 11](#)), quality control, quality assurance and documentation, welding and fabrication inspection (see [Clause 12](#)).

6.12 Design for loadout, transportation and installation

The objective of these design requirements is to ensure that a topsides structure begins its in-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 substructure and installing them to form the completed platform. [Clause 13](#) contains further details on installation procedures.

Specific requirements, recommendations and guidance for marine operations, including loadout, transportation and installation are given in ISO 19902 and ISO 19901-6.

6.13 Design for structural integrity management

Structural integrity management shall be in conformance with ISO 19901-9.

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 the structures should provide access to the structural components to facilitate inspection and maintenance.

6.14 Design for decommissioning, removal and disposal

6.14.1 General

Decommissioning and removal shall be in accordance with ISO 19901-6 and ISO 19901-9, with the additional requirements given in this document.

Decommissioning and removal requirements shall be addressed during the topsides structure design phase, particularly for fixed platforms and floating platforms.

6.14.2 Structural releases

If practical, secondary structures between modules and elsewhere should be designed to be 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 take into account access for future disconnection.

6.14.3 Lifting appurtenances

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

The design should allow for periodic access for inspection.

6.14.4 Heavy lift and set-down operations

Dynamic impact during the operation of set-down onto a transportation vessel or barge shall be assessed in the design for decommissioning.

7 Actions and analysis methods

7.1 General

Topsides structure design/assessment situations (see [6.2](#)) shall include:

- maximum (and minimum) operating conditions including drilling, variable inventory, and other operational actions;
- extreme and abnormal metocean and ice conditions, including the survival draft for floating structures;
- accidental situations including fire, explosions, ship impact, dropped and swinging objects;
- earthquakes;
- post-damage conditions, e.g. after abnormal or accidental events;
- fatigue: pre-installation and during the design service life;
- fabrication;
- loadout;
- transportation;
- installation;
- decommissioning;
- removal and disposal.

Each design/assessment situation comprises several types of actions such as permanent, operational and environmental actions, deformations, temperature effects and accidental events, each with appropriate partial action factors.

These actions shall include both actions directly applied to the topsides and also the effects of actions on the supporting structure (such as metocean, ice and earthquakes). In addition, actions due to the motions of the supporting structure shall be assessed; these are particularly significant for floating structures.

Classification of topsides equipment and structure weights shall be in accordance with ISO 19900 supplemented by the provisions of this document. Guidance on weight management can be found in ISO 19901-5. Permanent actions (*G*) and operational actions (*Q*) shall be quantified for relevant weight items. In the early stages of the design process, such as in conceptual design and the early stages of FEED, weights are typically quantified by using top-down estimates and uniform area loads (UALs), with weight reserve. Uncertainty in these estimates is reduced during FEED as weights and associated CoG envelopes are more firmly established from weight take-offs, combined with weight allowance and estimate-to-complete.

Detailed engineering shall use not-to-exceed-weights (NTE weights) and associated CoG envelopes.

NOTE 1 Detailed engineering refers to project activities after FEED when the design is typically developed and refined to allow commencement of construction activities.

NOTE 2 Any UALs used in detailed engineering are typically calculated to represent the NTE weight and the CoG envelope.

NOTE 3 NTE weights are described in ISO 19901-5.

A description of operational actions (*Q*) is provided in ISO 19900 and is further described for Q_1 and Q_2 in [7.2](#). Specific requirements for operational loads are provided in each relevant subclause.

Specific structural response analysis methods are provided in this clause for certain categories of accidental actions.

7.2 In-service actions

Action types are described in ISO 19900, with more detail provided below.

Each topside structural component shall be assessed for total design action effect, S_d , resulting from the design action, F_d . The design action shall be derived from action types for which principal actions are combined with appropriate companion actions as generally described in ISO 19900 and supplemented by the additional details of this [Clause 7](#).

For operational design/assessment situations, design actions shall be derived for the following combinations of actions (see [7.3.1](#) and [7.3.2](#)):

- a) maximum permanent and operational actions, G_1 , G_2 , Q_1 , and Q_2 , with and without accompanying environmental actions E_o and D_o ;
- b) minimum permanent and operational actions, G_1 , G_2 , Q_1 , and Q_2 , with and without accompanying environmental actions E_o and D_o .

For extreme design/assessment situations, design actions shall be derived for the following combinations of actions (see [7.3.3](#)):

- a) extreme environmental actions, E_e and D_e , combined with maximum permanent and operational actions G_1 , G_2 , Q_1 ;
- b) extreme environmental actions E_e and D_e , combined with minimum permanent and operational actions G_1 , G_2 , Q_1 ,

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; in addition, any actions due to the misalignment of structures, such as between the topsides structure and the substructure, 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;
- Q_1 is the operational 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; in addition, any actions due to the movement of substructures 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 substructure due to such effects, are part of Q_1 ;
- Q_2 is the short-duration operational action imposed on the topsides structure from operations such as the lifting of drill string, lifting by cranes, weight of liquids in tanks, pipes and process vessels for hydrostatic and pressure testing, machine operations, mooring of an adjacent ship to the platform, and helicopters;
- E_e is the extreme quasi-static environmental action on the topsides structure and any environmental action effects transmitted through the substructure (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 substructures due to extreme environmental effects, such as roll of an FPSO, including any consequent flexure of the substructure 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 substructure due to operator-defined operating environmental conditions; for particular operations these can be the limiting environmental conditions for the particular operation (see 7.3.2); in addition, any actions due to the movement of substructures due to the operating environmental effects, such as roll of an FPSO, including any consequent flexures of the substructure 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 .

NOTE Operational actions (Q) include all variable actions that are neither environmental (including earthquakes) nor accidental.

For all design/assessment situations, any action resulting from associated substructure movement shall be included.

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 shall 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 evaluated, particularly with respect to design for loadout, transportation and installation of the topsides.

General guidance on operational actions (Q) on deck areas is provided in A.7.2.

7.3 Action factors

7.3.1 Design actions for operational design/assessment situations in still water

Design action, F_d , for operational design/assessment situations in still water, with maximum permanent and operational actions only, shall be calculated using Formula (2).

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

The partial action factors, γ_f , shall be the same as those used for the substructure design or assessment, in accordance with ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 or ISO 19906, as appropriate.

For components where relevant, design actions shall also be calculated using maximum and minimum values of G and Q positioned spatially in loading patterns to cause the most onerous action effects in the component.

7.3.2 Design actions for operational design/assessment situations with operating environmental actions

Each operation shall be assessed in an operational design/assessment situation using Formulae (3) and (4), in which E_o and D_o represent the operating environmental actions defined by the operator either generally or as the limit for that particular operation.

Design actions, F_d , for operational design/assessment situations on fixed structures with maximum values of G_2 , Q_1 and Q_2 shall be calculated using [Formula \(3\)](#).

$$F_d = \gamma_{f,G1} \cdot G_1 + \gamma_{f,G2} \cdot G_2 + \gamma_{f,Q1} \cdot Q_1 + \gamma_{f,Q2} \cdot Q_2 + \gamma_{f,Eo} \cdot (E_o + \gamma_{f,D} \cdot D_o) \quad (3)$$

If the internal forces due to minimum G_2 and Q_1 ($Q_2 = 0$) permanent and operational actions oppose those due to environmental actions, design actions, F_d , shall be calculated in accordance with [Formula \(4\)](#) using reduced partial action factors for the permanent and operational actions.

$$F_d = 0,9 \cdot G_1 + 0,9 \cdot G_2 + 0,8 \cdot Q_1 + \gamma_{f,Eo} \cdot (E_o + \gamma_{f,D} \cdot D_o) \quad (4)$$

For this check in [Formula \(4\)](#), G_2 and Q_1 shall exclude any actions associated with the design/assessment situations being assessed that cannot be ensured of being present during the specified operating environmental conditions.

Design actions for floating structures shall be calculated using the same formulation but including rotation of the topsides and inertial actions due to the vessel motions.

7.3.3 Design actions for extreme design/assessment situations

Design actions, F_d , for the extreme design/assessment situations for topsides on fixed structures with maximum values of G_2 and Q_1 shall be calculated using [Formula \(5\)](#).

$$F_d = \gamma_{f,G1} \cdot G_1 + \gamma_{f,G2} \cdot G_2 + \gamma_{f,Q1} \cdot Q_1 + \gamma_{f,Ee} \cdot (E_e + \gamma_{f,D} \cdot D_e) \quad (5)$$

Design actions for floating structures shall be calculated using the same formulation but including rotation of the topsides and inertial actions due to the vessel motions.

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

If the internal forces due to minimum G_2 and Q_1 permanent and operational actions oppose those due to environmental actions, design actions, F_d , shall be calculated in accordance with [Formula \(5\)](#) using reduced partial action factors for the permanent and operational actions as used for the substructure design or assessment (see ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, or ISO 19906, as appropriate).

For the check involving opposing actions, the minimum G_2 and Q_1 shall exclude any actions that cannot be ensured of being present during the extreme environmental conditions in that design/assessment situation.

NOTE The appropriate partial action factors for the extreme 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.

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.

Wind induced fatigue analysis and vortex shedding analysis shall be performed on lattice structures (e.g. flare booms and drilling derricks) and exposed pipework.

7.5 Indirect actions and resulting forces (action effects)

Internal forces due to imposed deformations of fabrication tolerance and foundation settlement may be neglected in the verification of limit states (excluding fatigue) when fabrication requirements (see [12.1](#)) are

satisfied. Internal forces due to differential temperature under normal conditions such as solar heating may also be neglected.

NOTE 1 Internal forces can be divided into two groups, those that react the external actions, and those in internal equilibrium that redistribute and dissipate as the structural system reaches its limit state for strength.

[Subclause 10.2.1](#) gives allowable procedures and simplifications that may be applied when determining the internal forces without altering the global equilibrium.

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 substructure and the topsides structure should be analysed together for the verification of the relevant limit states. If not, consistent forces on both side of the interface shall be applied.

For a floating structure the differences between essentially static behaviour due to ballast and cargo loading, and dynamic behaviour due to environmental effects shall be assessed.

NOTE 2 The hull of a monohull is usually much stiffer than the topsides structure and, as it sags and hogs, significant deformations can be introduced at the topsides structure level.

In case of temperature effects larger than solar expansion, the capability to expand shall be assessed to ensure either ability to expand or to ensure ductility of the structure.

NOTE 3 Sliding bearings can be an effective solution for high-temperature pressure vessels.

7.6 Metocean and ice actions

7.6.1 Wave, current and ice actions

7.6.1.1 General

All wave, current, and ice actions on the substructure, appurtenances (e.g. conductors, risers, caissons, etc.) and the topsides shall be included in the calculation of the metocean and ice effects on the topsides.

NOTE 1 Although wave, current and ice actions mainly affect the substructure directly, there are frequently indirect actions on the topsides due to the displacements and deformations of the substructure.

NOTE 2 For the purposes of this subclause, ice means ice on the sea which includes sea ice and icebergs, as described in ISO 19906 for arctic and cold regions. Such ice can move both horizontally and vertically.

Where insufficient air gap exists to prevent wave or ice run-up or ice ride up against large diameter legs or columns striking the deck, or when water inundates the deck of a floating facility (such as green water effects), all actions resulting from the water or ice 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.

7.6.1.2 Fixed platform

Primary topsides structure on fixed platforms shall be designed for:

- a) reactions on the topsides due to metocean and ice actions on conductors and appurtenances;
- b) framing actions due to horizontal actions on the substructure;

NOTE Wave actions on a multi-leg concrete platforms can act in opposite directions on the legs, resulting in forces and moments applied to the topsides that can be a maximum in conditions that are less than the extreme metocean conditions.

- c) inertial actions resulting from acceleration due to dynamic response of the platform and deck during extreme or abnormal metocean or ice conditions.

Supports for safety and environmental critical elements (SECE) shall be designed using consistent forces for the substructure and the SECE supports.

Cellar deck bottom of steel elevation should be set to avoid wave-in-deck or ice-in-deck actions at the abnormal metocean or ice action probability or return period relevant for the exposure level of the structure. Where this is not possible, topsides primary structure, supports for critical equipment, and the substructure shall be designed for wave-in-deck or ice-in-deck actions.

Bottom of steel elevations of sub-cellar deck structures set below the abnormal wave crest shall be designed for wave-in-deck or ice-in-deck actions.

7.6.1.3 Floating facilities

Primary topsides structure and structural supports for SECE on floating facilities shall be designed for:

- a) inertial actions resulting from motions (sway, surge, heave, roll, pitch and yaw);
- b) rotation of the topsides due to roll and pitch with the consequent effects on the directions of actions;
- c) the actions imposed due to deformation of the substructure.

7.6.2 Wind actions

The physical environmental data for offshore wind speeds and profiles shall be in accordance with ISO 19901-1. Where available, site specific wind speed data shall be used.

The return period of the wind speed shall be consistent with design of the substructure, with partial action factors in accordance with the relevant standard used for the substructure (i.e. ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, ISO 19905-3 and ISO 19906).

Representative wind actions shall be calculated in accordance with a national building standard selected and agreed with the operator and regulator. This standard should be consistent with the national building standard selected and agreed in [5.2.2](#).

The calculation of the representative wind actions, including wind drag coefficients, shielding effects, upward, sideward, windward and leeward factors and any dynamic effects and spatial and temporal coherence (by gust factors or gust duration) on the topsides shall be in accordance with the methodology in the national building standard selected for wind actions.

The time averaged wind speed for the basic wind speeds, which is the reference wind speed that the spatial and coherence factors are applied to, shall be based on the national building standard selected for wind actions.

NOTE The time averaged wind speed for the basic wind speed varies depending on the national building standard selected. As an example, for EN 1991-1-4^[2], the reference is the characteristic 10-minute mean wind velocity for terrain category II, whereas for AISC/ASCE 7-22^[3] it is the 3-second gust speed for exposure category C.

In the absence of more accurate wind tunnel testing or CFD, the same calculation of wind actions used for the topsides should be applied in the design/assessment situations for the substructure as the principal action, to ensure that relevant parts of the substructure are designed to act as an adequate foundation for the topsides.

Wind actions shall be calculated for sufficient directions, including diagonal or quartering directions, to ensure all governing local or global failure modes have been investigated. The calculations for each direction shall take account of the projected area and shape coefficients appropriate for each direction.

Wind actions on items in laydown or storage areas shall also be included in the wind action calculation for local and global effects.

7.6.3 Cold regions effects

7.6.3.1 Snow accumulation

Snow accumulation upon the topsides shall be accounted for in accordance with ISO 19906.

7.6.3.2 Ice accumulation

In areas where icing or icing accumulation can occur, the effects of both the weight of ice accretion and the increase in effective dimensions of components due to the ice shall be included in accordance with ISO 19906.

NOTE Increased wind actions on topsides structure and equipment due to icing can be significant.

7.6.3.3 Effects of cold weather

The effects of cold weather on ballast water, firewater etc. which can freeze shall be taken into account in accordance with ISO 19906.

7.7 Seismic actions

7.7.1 General

The topsides structure shall be analysed and designed for earthquake conditions as part of the overall platform consisting of the substructure with its foundation, where applicable, and the topsides in accordance with ISO 19901-2. Additional guidelines for components of the topsides are given in [7.7.2](#) and [7.7.3](#).

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.

Restraints for SECE and for other piping and equipment whose failure could result in personnel injury, hazardous material spillage, damage to the environment, or hindrance to emergency response shall be designed appropriately.

Design acceleration levels shall include the effects of overall platform dynamic response, and local dynamic response of the deck and any appurtenances as appropriate.

NOTE Due to the platform's dynamic response, the design acceleration levels can be much greater than the ground motions and hence greater than those commonly associated with the seismic design of similar onshore processing facilities.

7.7.2 Minimum lateral acceleration

Topsides primary structure and critical structure shall be designed for inertial actions resulting from acceleration during a seismic event.

A minimum lateral acceleration of $0,05\ g$ shall be adopted as the extreme level earthquake (ELE) to apply to topsides, including equipment and supporting framework, for all fixed structures including those in seismic zone 0.

7.7.3 Equipment and appurtenances

Connections of equipment to the main topsides structure shall be designed for inertial actions resulting from acceleration during a seismic event.

Where the dynamic response of the equipment is independent of the dynamic response of the deck supporting structure, inertial actions may be calculated by the product of the deck acceleration with the mass of the equipment.

The inertial actions shall be calculated by a coupled dynamic analysis when both of the following apply:

- a) the equipment or appurtenance mass is greater than 5 % of the total platform mass;
- b) the natural frequency of the equipment or appurtenance is greater than 50 % of the main topsides lateral natural frequency.

NOTE 1 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.

NOTE 2 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 conformance with API Spec 4F^[22] (see [A.7.7.3](#)) and shall be tied down or always restrained except when being moved.

7.8 Actions during fabrication, loadout, transportation, and installation

Design/assessment situations for each temporary condition shall be established and relevant structure shall be verified to satisfy relevant limit states. See also [6.12](#). In [7.5](#) and [10.2.1](#) allowable simplifications are provided.

NOTE Temporary conditions include jacking and weighing conditions.

Individual support reactions during fabrication, loadout, transportation, and installation depend on the stiffness of the topsides structure and of the supporting foundation or supports.

Topsides structure and structural components shall be designed for inertial actions resulting from acceleration during loadout and transportation.

7.9 Actions arising from accidental events

7.9.1 General

7.9.1.1 Accidental hazards

The following accidental hazards, including major accident (MA) hazards, shall be identified, and characterized:

- a) hydrocarbon fire or explosion due to an ignited release from topsides piping or equipment (including piping on bridges);
- b) hydrocarbon fire or explosion due to an ignited release from a well;
- c) hydrocarbon fire or explosion due to an ignited release from a riser;
- d) hydrocarbon fire or explosion due to an ignited release from a subsea pipeline within 500 m of the installation;
- e) non-process fire at any location on the installation;
- f) non-process hydrocarbon or flammable material event;
- g) collision (supply vessels, passing vessels and helicopter emergency landing or crash landing);
- h) impact (dropped or swinging mass) resulting in hydrocarbon release escalating to fire and explosion or flooding of a compartment on a floating substructure;
- i) impact from collapse or displacement of adjacent structures;

j) flooding in a floating substructure resulting in loss of stability.

NOTE 1 Adjacent structures include jack-up platforms and bridge-linked platforms and structural components such as derricks, flare towers and cranes.

NOTE 2 Adjacent structures can collapse onto and significantly damage the Temporary Refuge (TR) or its systems, or obstruct escape and evacuation routes.

When characterising hazardous events and accidental actions, close communication should occur between the safety engineers, the hazard expert engineers and the project structural engineers.

The probabilities of exceedance (or return periods) for determining representative values of accidental actions for fire and explosion for each design/assessment situation and limit state shall be determined in accordance with ISO 19900.

7.9.1.2 Design for accidental events

Topsides structure shall be designed for hazardous events arising from accidental hazards as identified in [7.9.1.1](#).

Interaction between the topsides structure and the substructure shall be included if forces in the topsides structure are affected by the deformation of the substructure (see [10.1](#) and [10.2](#)).

Topsides structure shall be designed using ISD in conformance with ISO 17776 to eliminate credible fire and explosion MAs or to reduce their potential consequences by design measures that are inherent in the design, being permanent and inseparable features of the facility.

Topsides structure shall be designed for control and mitigation of fires and explosions in conformance with ISO 13702.

For fire and explosion hazards, the verification to limit states and determination of design controls may use a risk-informed approach or a deterministic (consequence-based) approach.

Tolerable-if-ALARP risk criteria shall be established where a risk-informed approach is used (see example [Figure 5](#)).

7.9.1.3 Intensity of hazardous event

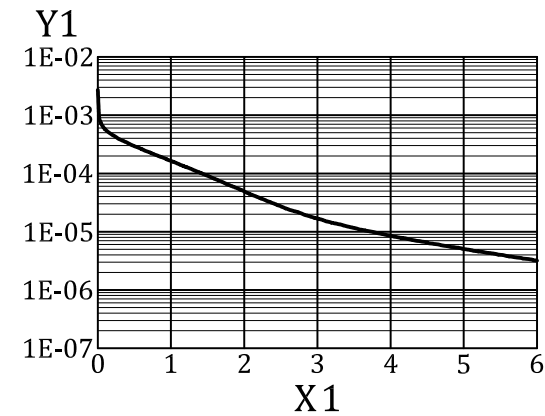
The annual probability of exceedance of a hazardous event with given intensity should be determined from the hazard curve (see Example in [Figure 1](#), which is not intended for use in actual design).

NOTE The hazardous events intensity is also known as the DAL (dimensioning accidental load).

For fire and explosion:

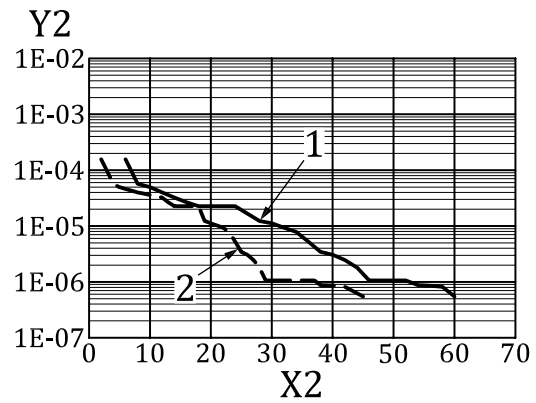
- a) a risk-informed approach may be used rather than using representative actions in a semi-probabilistic approach;
- b) a deterministic (consequence-based) approach, based on the worst credible action, may be used to determine the representative action.

NOTE Option b) above typically applies where the risk resulting from a hazardous event is likely to be tolerable and ALARP; approximate and conservative estimates of the intensity of the hazardous event can be based on worst credible consequence modelling.



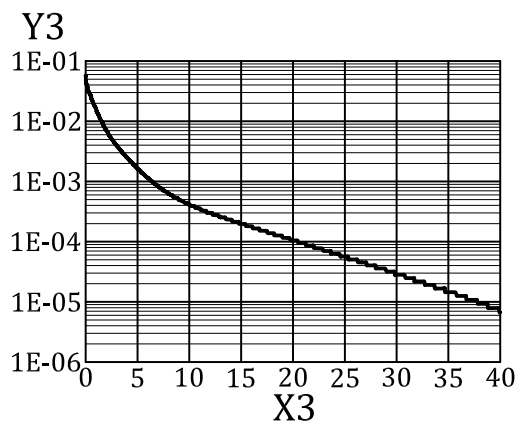
a) explosion hazard curve

X_1 =overpressure (MPa)
 Y_1 =annual probability of exceedance of overpressure



b) fire hazard curve

X_2 =flame length (m)
 Y_2 =annual probability of exceedance of flame length
 1 $t = 0$ min
 2 $t = 2$ mins



c) collision hazard curve - platform/supply vessel

X_3 =collision energy (MJ)
 Y_3 =annual probability of exceedance of collision energy

These example hazard curves are not to be used for design.

Figure 1 — Example hazard curves

7.9.2 Structural design for fire hazard

Design of topsides critical structure shall be based on fire scenarios and hazard curves listed in the Fire Hazard Analysis (FHA), including jet fires and pool fires.

NOTE 1 Magnitude of the fire hazard is described in terms of a hazard curve relating fire sizes to the exceedance probability.

Where FHA is not available, approximate heat flux data for various fire types may be taken from tables 3 to 6 of Reference [4].

Data for steel yield strength and Young's modulus (as a function of temperature) may be taken from tables 8 and 9 in Reference [4] and from References [6] and [7].

PFP or fire walls may be used to achieve tolerable-if-ALARP risks.

A coat-back analysis may be performed to optimise the extent and length of the PFP. Further details are provided in [A.7.9.2.6](#). In any case the minimum coat-back length shall be 150 mm.

NOTE 2 The additional cost of removal and replacement of PFP, to allow inspection and maintenance of topsides critical structure over the service life of the facility, can reduce the perceived cost-benefit of PFP.

NOTE 3 Hydrocarbon fires generate peak temperatures that can exceed 1 400 °C over a large area. At these temperatures unprotected steelwork can collapse in a short time.

7.9.3 Structural design for explosion hazard

7.9.3.1 General

Design of topsides critical structure:

- a) should be based on explosion scenarios and hazard curves (when available in the Explosion Hazard Analysis, EHA);
- b) may be based on industry generic overpressure values [\[8\]](#);
- c) may be based on worst credible overpressure values (where the design of the topsides structure is not sensitive to such overpressure).

NOTE Representative congestion method (RCM) and, more specifically, the anticipated congestion method (ACM) reduces the potential for overpressures determined from CFD models to increase during development of the topsides design (as the congestion increases with greater definition of the design), see Reference [\[104\]](#).

7.9.3.2 Explosion actions

Explosion actions shall be applied:

- a) as a time-varying overpressure to large flat surfaces (e.g. blast walls and decks);
- b) as a time-varying overpressure difference loading on vessels, pipework, steel structures, and other obstructions of 1,0 m diameter or greater.

NOTE 1 Explosion actions on vessels $\geq 1,0$ m diameter due to the 'out of balance loads' and 'peak blast overpressure' are typically determined from the CFD analysis and specified in the EHA.

- c) as a time-varying blast drag load on vessels, pipework, steel structures, and other obstructions of less than 1,0 m diameter.

Blast drag actions on the structure, vessels, or pipework less than 1,0 m diameter shall be determined from [Formula \(6\)](#):

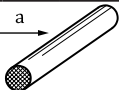
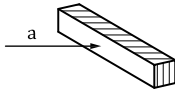
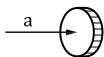
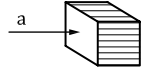
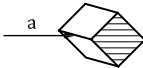
$$F_d = C_d \times q_d \times A \quad (6)$$

where

- F_d blast drag force applied to element (kN);
- C_d drag coefficient (from [Table 3](#));
- q_d blast drag wind pressure (kN/m²);
- A projected area of element (m²) including fire protection.

NOTE 2 In lieu of specific data from CFD analyses, the blast drag wind pressure can be taken as 1/3 of the blast overpressure at the same location. This approximation is based on review of many CFD analyses.

Table 3 — Drag coefficients for component shapes

shape	sketch	C_d
cylinder (side-on)		1,2 to 2,0 ^b
cylinder (end-on)		0,82
rectangular prism (face-on)		2,05
rectangular prism (edge-on)		1,55
disk (face-on)	 or 	1,17
cube (face-on)		1,05
cube (edge-on)		0,80
^a Flow. ^b C_d approximately 2,0 can occur for pipes in a strong explosion with Mach-numbers approaching 1,0. [9]		

Blast drag pressure on grating shall be applied to the total grated area (not the area of the grating bars).

NOTE 3 Loading data for grated deck areas is typically determined from the CFD analysis (taking into account porosity) and specified in the EHA. FRP grating has a lower porosity than steel grating.

7.9.3.3 Overpressure time-history

Overpressure time-history for structural response shall use a simplified form as shown in [Figure 2](#) where the rise time is:

- $t_d/2$ (when within the combustion zone);
- zero (when outside the combustion zone for explosion events that transition to a shock wave).

Where CFD is performed, the overpressure for structural design should be averaged from panels in the CFD model over an area of approximately 3 m².

NOTE 1 Point pressure from the CFD model is not suitable for structural design use as it incorporates very short duration spikes that the structure does not respond to.

For large areas including large blast walls, different blast loads recognizing time delays may be considered.

Explosion hazard curves, that plot the annual probability of exceedance of overpressure and the annual probability of exceedance of impulse on critical structure, should be used to select the peak overpressures (rather than use of deterministic worst credible values).

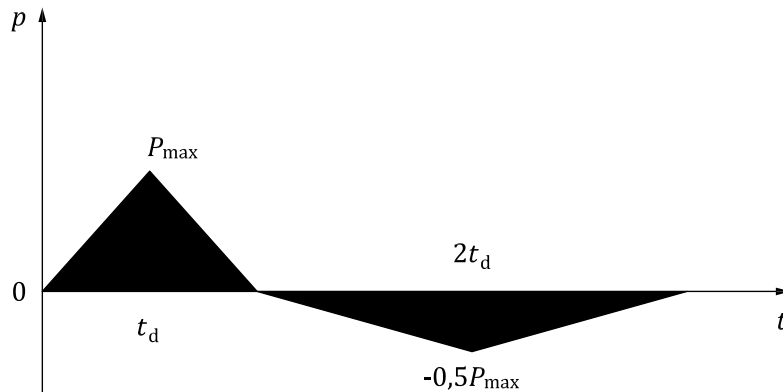
NOTE 2 Impulse exceedance curves can also be useful in selecting the appropriate time-histories for use to determine the structural response. Impulse exceedance is included in the worked example in [A.9.3.3](#).

Evacuation hazardous events for explosion (also known as ductility level blast, DLB, events) shall have a minimum positive overpressure duration of 40 ms.

Controllable hazardous events for explosion (also known as strength level blast, SLB, events) shall have a minimum positive overpressure duration of 120 ms.

NOTE 3 Peak pressure in the positive phase is typically specified by the EHA. In addition, a range of durations of the positive phase are typically specified in the EHA. Peak negative pressure is typically not specified in the EHA and CFD results are not reliable for negative pressure levels. Peak negative pressure is typically between 20 % and 50 % of the peak positive pressure.

NOTE 4 Rebound of members from passing of blast wave can be a critical design condition due to unsupported compression flanges. Rebound can sometimes produce complex load interactions as the blast duration time can be different to the natural recovery period of the structure, resulting in a severe load combination, e.g. equipment-load and self-weight can be additive to rebound load, vertical walls can develop membrane compression and deck beams can have stress reversals.



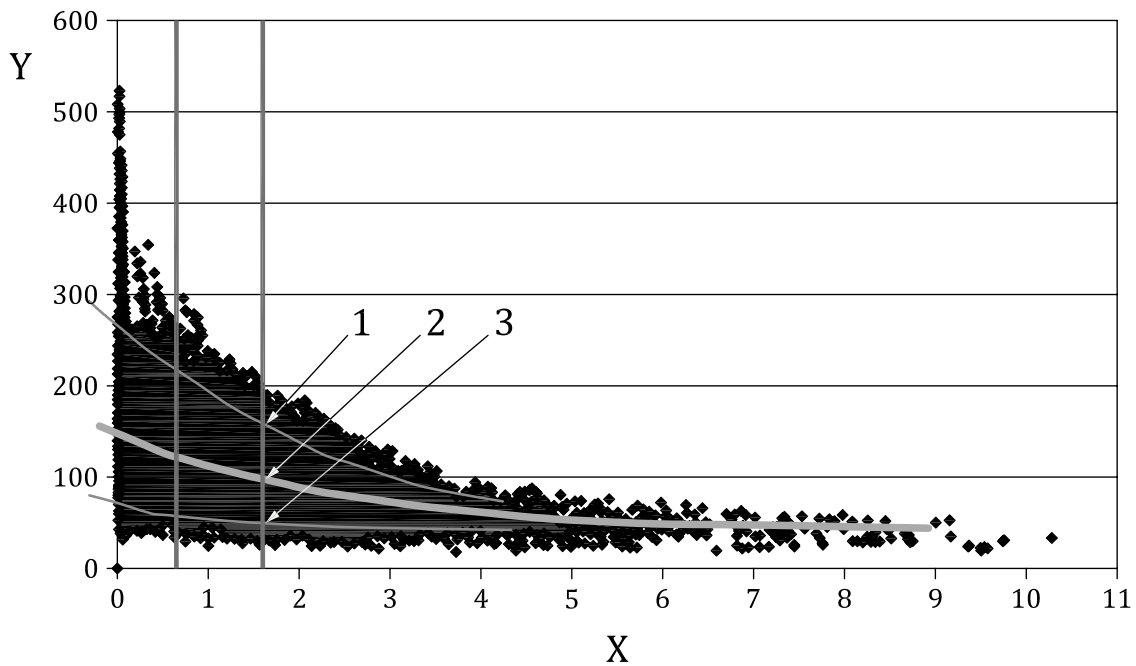
Key

t	time duration
p	overpressure
$P_{\max}$	peak overpressure
t_d	time duration of the positive overpressure

Figure 2 — Overpressure time history

Structural design should account for probability of response severity due to probability of overpressure duration.

In lieu of overpressure duration data provided in the EHA, [Figure 3](#) may be used to estimate the upper, lower, and most probable overpressure duration.



Key

X	overpressure (10^5 Pa)	1	approx upper bound t_d value for $P_{\max} = 1,6 \times 10^5$ Pa
Y	pulse duration (ms)	2	probable t_d value for $P_{\max} = 1,6 \times 10^5$ Pa
		3	approx lower bound t_d value for $P_{\max} = 1,6 \times 10^5$ Pa

Figure 3 — Variability in pulse duration versus peak overpressure

NOTE 5 Selection of the peak pressure, pulse duration, time delay and area over which the pressure is approximately constant, depends on whether the blast wall acts as a single or two-way spanning.

7.9.3.4 Structural response analysis

The structural response shall be determined by non-linear time-history analysis using either:

- SDOF approximation with material non-linearity;
- non-linear FE dynamic analysis with material and geometric non-linearity.

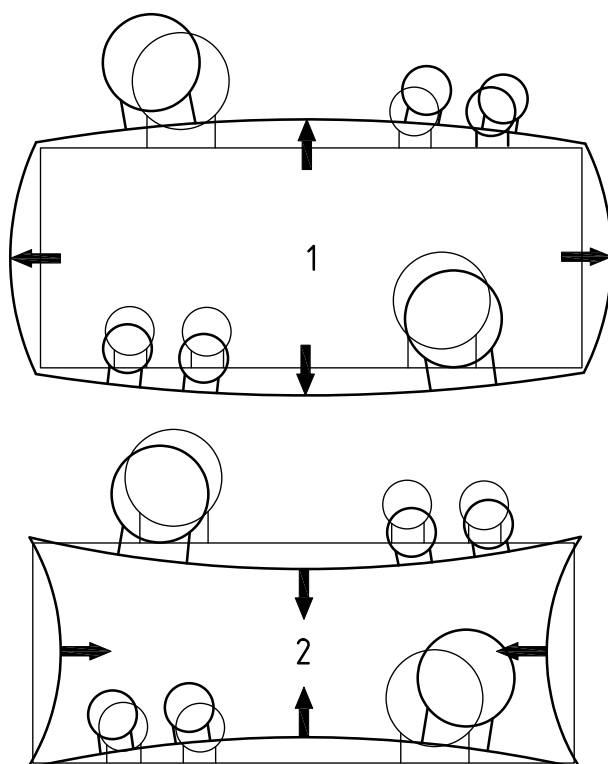
NOTE 1 SDOF for response to blast load is typically used for initial design of primary structure and for detailed design of secondary structure.

Data for steel yield strength, ultimate tensile strength (UTS) and fracture strain may be taken from tables 16 and 17 of Reference [4] and from Reference [10] in clause 5.5, Part 3.

Structural model shall include the roof, adjacent walls and floors of the module or deck if structural interaction is expected and wall reactions shall be included in design of roof and floor beams.

Interaction between components shall be accounted for in the structural analysis.

NOTE 2 [Figure 4](#) illustrates interaction between components where overpressure acting on the roof and/or floor causes membrane tension in the wall that is additive to the bending and membrane tension in the wall due to the direct application of the blast pressure.

**Key**

- 1 blast
- 2 rebound

Figure 4 — Structural interaction between roof, wall, and floor

7.9.3.5 Simplified design methods

Simplified methods, such as equivalent static analysis or response charts, may be used for the design of structural components as described in [A.7.9.3.5](#).

NOTE Simplified methods do not represent the non-linear response and load redistribution effects that can be important for efficient design against large blast loads.

7.9.3.6 Explosion mitigation

Explosion effects should be mitigated as far as reasonably practical.

Barriers such as explosion walls and floors should maintain integrity after the explosion.

7.9.4 Explosion and fire interaction

Topsides design of critical structure shall include the consequences of explosion and fire scenarios with either event occurring first.

NOTE 1 Fires and explosions can both occur during the same overall event, for example a leak can cause a gas cloud to form which can explode when it meets an ignition source; following the resulting explosion, the original leak can remain but as a fire. It is less likely that an explosion follows a fire (as there is little or no unburnt gas cloud in a fire event) unless additional inventory is released due to the fire.

Following an explosion event, the relevant critical structure risks shall be tolerable for the endurance period in a subsequent fire event (to allow a controlled evacuation from the TR).

NOTE 2 An example critical structure risk is the risk of a fire wall collapsing during an explosion or during the following endurance period (resulting in escalation if a fire follows the initial explosion).

NOTE 3 ISO 23693^[1] provides test requirements for PFP to simulate the mechanical loads that could be imparted to PFP materials and systems by explosions resulting from releases of flammable gas, pressurised liquefied gas or flashing liquid fuels perhaps precede a fire.

7.9.5 Cryogenic spill

Structure subjected to cryogenic spill or vapor jet shall be protected using a cryogenic spill protection (CSP) system that is in accordance with ISO 20088-1, ISO 20088-2, ISO 20088-3.

NOTE Cryogenic liquids such as LNG or refrigerants can be present at facilities with liquefaction modules. Cryogenic liquid spill and vapor jets can rapidly cool structural steel members resulting in brittle fracture. Design against exposure to cryogenic temperatures can be performed in a similar way with fires with the difference of adjusting material properties for low temperatures. Cryogenic spills are usually followed by fires and typically dual-purpose systems are specified that can function as CSP and PFP to mitigate both types of risk.

7.9.6 Actions due to vessel collision

The annual probability of exceedance of a collision hazardous event of given intensity should be determined from the hazard curve in conformance with [7.9.1.3](#).

Where the risk resulting from a hazard is likely to be negligible or broadly acceptable, approximate and conservative estimates of the intensity of the hazardous event may be used in lieu of a hazard curve.

Topsides critical structure, as defined in [5.7](#), shall be designed for the inertial actions resulting from the collision (see [7.9.9](#) and [A.7.9.9](#)).

7.9.7 Actions due to dropped and swinging objects and projectiles

The annual probability of exceedance of a dropped object hazardous event of given intensity should be determined from the hazard curve in conformance with [7.9.1.3](#).

Where the risk resulting from a hazard is likely to be negligible or broadly acceptable, approximate and conservative estimates of the intensity of the hazardous event may be used in lieu of a hazard curve (e.g. using the crane operating conditions and following any restrictions on heights of lifts above decks).

Topsides critical structure, as defined in [5.7](#), shall be designed for the actions resulting from the dropped object.

Risk treatment shall be used to mitigate the risk of damage to topsides critical structure and subsequent life-safety risk or operational risk.

Operational procedures should limit the exposure of personnel to overhead material transfer.

7.9.8 Actions due to loss of buoyancy

For floating structures, the minimum criteria for compartment damage (see ISO 19904-1) shall be achieved.

Topsides critical structure, as defined in [5.7](#), should be designed for the actions resulting from loss of buoyancy (i.e. actions resulting from heel and trim or flooding of hull).

See [A.7.9.8](#) for guidance.

7.9.9 Actions due to topsides acceleration

Topsides primary structure, secondary structure, and structural supports for SECE shall be designed for topsides acceleration due to:

- a) wave actions, including breaking waves (see [7.6](#));
- b) ice actions, if applicable (see [7.6](#));
- c) seismic events (see [7.7](#));
- d) pre-service conditions, i.e. fabrication, load-out, transportation and installation (see [7.8](#));
- e) gas explosions (see [7.9.3](#)), ship collision (see [7.9.6](#)), helicopter emergency landing or crash (see [10.5.3.3](#)), sudden failure of loaded cables;
- f) mechanical equipment.

To account for accidental actions transmitted to the topsides that are not specifically accounted for otherwise, a minimum lateral acceleration of 0,05 g shall be applied to the topsides, including SECE (safety critical equipment and systems, piping, and supporting framework) in order to ensure a minimum level of anchorage and connectivity for such components. This applies to topsides on both fixed and floating facilities.

Failure or excessive deformation of individual components that could lead to failure of SECE shall be avoided.

See [A.7.9.9](#) for guidance.

7.10 Other actions

7.10.1 Drilling

Platforms with drilling operations contribute a variety of major actions to the topsides. These include actions caused by weights, drilling operations generally, and environmental conditions.

Drilling equipment and materials include the derrick equipment set (DES), see [10.7](#), which moves from well to well, and the normally stationary drilling-related weights installed on the deck, separate from the DES, usually on the drilling deck level.

The CoG of the DES depends on its position over each well slot. The variable weights installed on the deck separate from the DES are typically stationary, but some can also change location depending on the DES position.

The designer should consult and coordinate with project/asset drilling engineers to identify the appropriate moveable and stationary permanent and variable actions and load combinations for each design situation on a given project. ISO 19901-5 provides guidance on typical concurrent weight items for drilling. In particular, ISO 19901-5:2021, Annex D provides guidance on typical variable weights.

Drilling weights can be classed as follows:

- weights of components where weight is constant but CoG varies, such as the drilling derrick itself, typically classed as permanent actions type G_2 (see [7.2](#));
- variable weights from drilling operations, such as weight of drill pipe and casing, weight of well cuttings, weight of consumables including drilling fluids, cement, and powders, typically classed as operational actions, either Q_1 or Q_2 (see [7.2](#)).

Principal and accompanying actions shall be identified and included in design/assessment situations for the following conditions:

- a) drilling actions with variable weights and CoG for a range of derrick positions and storage dispositions for casing and drill pipe to ensure that all maximum action effects in the supporting structures are identified;

NOTE 1 A typical maximum/minimum condition is one where the DES is positioned so that the drilling derrick is over a corner slot farthest from the wind (and wave) direction.

- b) increased (maximum) action from the drilling derrick when it is pulling, including yanking and jarring, on a stuck drill string or stuck casing. The pulling action on stuck casing is typically concurrent with drill string stored in setback;

NOTE 2 Yanking and jarring occur when the drawworks are used to impose repetitive vertical impulse actions on the drill string or casing. (i.e. repetitive shock actions such as when the drill crew attempts to free a casing string or drill string / drill bit that has become stuck downhole).

NOTE 3 The maximum action is usually based on the design rated capacity of the derrick.

- c) minimum actions, with minimum variable weights and without drilling operations occurring (for checking stability and uplift under reverse environmental actions);

NOTE 4 A setback full of 90 ft high drill string increases the effect of the wind overturning actions, thereby further increasing the potential for uplift on the upstream side.

NOTE 5 Setback is the storage area or areas for drill string stacked vertically within the derrick.

- d) actions from skidding the derrick substructure over the skid base and from skidding the skid base on the supporting topsides deck beams/girders, for sufficient locations to identify:

- maximum actions resulting from all possible relative positions of the structures to be evaluated;
- horizontal frictional forces and bearing stresses, including racking actions, that can result from a stuck jack.

- e) actions caused by the temporary support of the casing or drill string from the drill floor rotary table.

Drilling action combinations in operational design/assessment situations shall be with and without accompanying operating environmental actions.

Drilling operational actions accompanying environmental actions in extreme and abnormal design/assessment situations may be reduced but only if drilling operations are suspended under extreme forecast or imminent environmental conditions. Typical reductions in such situations include the elimination of any hook load where the drill string would be stored in setback or supported by the rotary table.

NOTE 6 Drilling actions can be reduced if the relevant operating procedures are documented in the project operations manual or equivalent. For example, drilling-related actions are typically reduced for design situations where the operations manual specifies that drilling be suspended whenever a storm exceeding prescribed criteria is predicted.

Operational actions accompanying accidental actions such as due to dropped objects shall be determined for accidental design/assessment situations.

7.10.2 Conductors

Supports for conductors shall allow for (axial) movement from thermal growth (including the effects of thermal growth of the well string) and differential settlement of the platform and conductor. Radial movement of the conductors within the guides should be minimized to reduce the effects of lateral movements and impacts. Actions from waves and from current and flow-induced vibrations on conductors can be reacted at the cellar deck guide and these actions shall be considered.

Where drilling is performed from a derrick cantilevered from a jack-up through a platform conductor, design/assessment situations shall include forced displacements and any consequent actions on the conductor and its supports due to the relative movement between the structure and a representative drilling jack-up.

Drilling operations can require the temporary support of vertical actions from conductors at the cellar deck. The need to support such actions shall be identified and considered.

7.10.3 Risers

In addition to normal actions due to weight, supports for risers shall consider possible actions resulting from waves, current, flow-induced vibrations, thermal growth and the dynamic reaction to slugs of fluid moving in the risers. Radial movement of the risers within the guides should be minimized to reduce the effects of lateral movements and impacts.

7.10.4 Caissons

In addition to normal actions due to weight, supports for caissons shall consider possible actions resulting from waves, load variations from pump reaction and fluid contents, and the particular actions associated with offshore erection or completion. The effects of internal/external corrosion are a major cause of caisson failure and shall be accounted for. Radial movement of the caissons within the guides should be minimized to reduce the effects of lateral movements and impacts.

7.10.5 Maintenance, mechanical handling and lifting aids

Design of the structure shall take into account the actions resulting from equipment maintenance, operational actions from hydrostatic pressure testing and mechanical handling. In particular, the principal routes and means for moving heavy equipment shall be identified and the supporting structures assessed to ensure that these actions, in combination with those normally acting, do not result in combinations that do not satisfy design criteria. Care shall be taken to ensure that the actions from trolley wheels do not locally yield deck plate, resulting in ponding.

Where lifting aids (runway and lifting beams, padeyes, etc.) are attached to a primary or secondary structure, the effects on the strength and stability of the structure shall be evaluated. These effects include the potential negative influence on local stability of webs and flanges caused, for instance, by differential displacements of beam supports.

7.10.6 Bridge supports

Topsides structure can be required to carry permanent and operational actions from bridges to other structures, including temporary construction, drilling, and other equipment.

The following potential actions shall be evaluated and considered as applicable:

- a) variation in point of application resulting from extreme tolerances in platform position;
- b) actions resulting from any bridge-imposed constraints on differential displacement of linked platforms in all degrees of freedom, taking into account in-phase and out-of-phase wave actions at different wave periods including increased friction over time due to degradation of bearing coatings;
- c) actions from the differential constraint of any pipework carried over the bridge;
- d) any jacking actions that can be applied during maintenance operations, such as bridge-bearing change-out.

When active or passive motion compensated temporary bridges or gangways are used for transfer of personnel or goods from floating support vessels to a topsides structure the designer shall use data from the vendor of a representative bridge or gangway to determine the representative values of actions on the topsides during installation, operation, and removal of the bridge or gangway.

8 Strength and resistance of structural components

8.1 Correspondence factor K_c

A correspondence factor, K_c , shall be applied to the partial resistance factors in the national building standard selected for the limit state verification, in order to realize a similar reliability to that implicit in ISO 19902, consistent with 8.2 and 8.3.

Partial resistance factors (γ_R) to be used in the strength and stability equations of the national building standard shall be in accordance with Formula (7):

$$\gamma_R = \frac{\gamma_{R,code}}{K_c} \quad (7)$$

where

$\gamma_{R,code}$ is the partial resistance factor from the selected national building standard;

K_c is the correspondence factor for the selected national building standard.

K_c values in Table 4 shall be used for all code checks of structural components, (e.g. tension, compression, shear, bending, and combined compression and bending) to the national building standards listed.

Table 4 — Values of correspondence factor K_c

National building standard correspondence factor (K_c)			
ISO 19902	ANSI/AISC 360-22 ^[12]	EN 1993-1-1 ^[13]	CSA S16:19 ^[14]
1,00	1,05	0,95 ^{a,b}	1,00
^a The value of K_c is based on using the values of partial resistance factors γ_{M_i} recommended in EN 1993-2 ^[15] , in accordance with the recommendation in EN 1993-1-1 ^[13] for structures not covered by the code, such as offshore platforms; ^b The value of K_c listed for EN 1993-1-1 is based on the second-generation Eurocode, i.e. EN 1993-1-1:2022. The local buckling criteria for welded box sections in the first generation code, i.e. EN 1993-1-1:2005 are unconservative, see Reference [16].			

National building standards other than listed in Table 4 shall apply a K_c based on a similar reliability to that implicit in ISO 19902.

A.8.1 provides guidance on K_c calculation if required.

8.2 Design of cylindrical tubular sections

The design of cylindrical tubular sections:

- a) should conform to ISO 19902;
- b) may conform to the selected national building standard with K_c where applicable.

NOTE For conical transitions and tubular joints, see 8.4.1.

8.3 Design of non-cylindrical sections

8.3.1 Rolled and welded non-circular prismatic members

Design for the strength and stability of rolled and welded non-circular prismatic members shall conform to the selected national building standard with its partial resistance factors modified by the correspondence factor K_c in accordance with 8.1.

8.3.2 Plate girder

Design of plate girders shall conform to a suitable standard or code of practice (see [A.8.3.2](#)).

Plate girders shall have web thicknesses of not less than 1,25 % of the web depth or 6 mm, whichever is greater, unless the design is justified otherwise based on the procedures and guidelines in the applicable national building standard.

Specific issues that shall be addressed in design include:

- the effect of high local bending forces;
- warping;
- distortion;
- distortional warping; and
- the effect of shear lag upon the distribution of elastic stresses.

Stiffened plate girders, designed based on developing tension fields in the web, shall not be used where the following apply:

- a) web penetrations exist (unless designed by non-linear FE analysis);
- b) the necessary anchorages at the ends of plate girders do not exist (e.g. due to lack of plating continuity through legs).

Plate girders shall be designed for fatigue and fracture at locations where stress concentrations exist, such as abrupt changes in section, penetrations, jacking slots, etc.

Stiffening the web penetrations (coaming) with pipe sleeves or plate should be used where necessary to achieve reduction in stress concentrations and/or sufficient girder strength.

8.3.3 Box girder

Design of box girders shall conform to a suitable standard or code of practice (see [A.8.3.3](#)). Particular attention shall be paid to internal stiffening of the box girder with diaphragms or other components to facilitate a cost-effective fabrication and to mitigate the effects of welding and stress-induced distortions.

Specific issues that shall be addressed in design include:

- the effect of high local bending forces;
- warping;
- distortion;
- distortional warping; and
- the effect of shear lag upon the distribution of elastic stresses.

8.3.4 Stiffened plate components and stressed skin structures

Design of the webs of longitudinally stiffened plate girders and box girders shall conform to an appropriate standard (see [A.8.3.4](#)).

Stressed skin structures may be designed on the basis that the plating resists shear forces only and that all axial forces are carried by the framing (see [10.2.1](#) and [A.8.3.4](#)). If the stressed skin structure is exposed to cyclic actions, the possible detrimental effects shall be evaluated.