

DIN EN ISO 19901-3



ICS 75.180.10

Entwurf

Einsprüche bis 2022-09-15
Vorgesehen als Ersatz für
DIN EN ISO 19901-3:2015-04

**Erdöl- und Erdgasindustrie –
Spezielle Anforderungen an Offshore-Anlagen –
Teil 3: Topsides structure (ISO/DIS 19901-3:2022);
Englische Fassung prEN ISO 19901-3:2022**

Petroleum and natural gas industries –
Specific requirements for offshore structures –
Part 3: Topsides structure (ISO/DIS 19901-3:2022);
English version prEN ISO 19901-3:2022

Industries du pétrole et du gaz naturel –
Exigences spécifiques relatives aux structures en mer –
Partie 3: Superstructures (ISO/DIS 19901-3:2022);
Version anglaise prEN ISO 19901-3:2022

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2022-07-15 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal von DIN unter www.din.de/go/entwuerfe bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an noeg@din.de möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/go/stellungnahmen-norm-entwuerfe oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG), 10772 Berlin oder Am DIN-Platz, Burggrafenstr. 6, 10787 Berlin.

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 166 Seiten

DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)

Nationales Vorwort

Dieses Dokument (prEN ISO 19901-3:2022) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ erarbeitet, dessen Sekretariat von NEN (Niederlande) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitskreis NA 109-00-01-07 AK „Offshore Bauwerke“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG).

Dieses Dokument enthält unter Berücksichtigung des Präsidialbeschlusses 1/2004 nur die englische Originalfassung von prEN ISO 19901-3:2022.

Der Bedarf für eine Deutsche Fassung wird derzeit beraten.

Für die in diesem Dokument zitierten Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

ISO 898-1	siehe	DIN EN ISO 898-1
ISO 13626	siehe	DIN EN ISO 13626
ISO 13702	siehe	DIN EN ISO 13702
ISO 17776	siehe	DIN EN ISO 17776
ISO 19900	siehe	DIN EN ISO 19900
ISO 19901-1	siehe	DIN EN ISO 19901-1
ISO 19901-2	siehe	DIN EN ISO 19901-2
ISO 19901-4	siehe	DIN EN ISO 19901-4
ISO 19901-5	siehe	DIN EN ISO 19901-5
ISO 19901-6	siehe	DIN EN ISO 19901-6
ISO 19901-9	siehe	DIN EN ISO 19901-9
ISO 19902	siehe	DIN EN ISO 19902
ISO 19903	siehe	DIN EN ISO 19903
ISO 19904-1	siehe	DIN EN ISO 19904-1
ISO 19905-1	siehe	DIN EN ISO 19905-1
ISO 19906	siehe	DIN EN ISO 19906
ISO 20088-1	siehe	DIN EN ISO 20088-1
ISO 20088-2	siehe	DIN EN ISO 20088-2
ISO 20088-3	siehe	DIN EN ISO 20088-3
ISO/TS 35105	siehe	DIN CEN ISO/TS 35105

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN ISO 19901-3:2015-04 wurden folgende Änderungen vorgenommen:

- a) eine Angleichung der Terminologie an ISO 19900;
- b) eine rationelle Neuordnung des Inhalts und der Nummerierung der Abschnitte;
- c) Übernahme der IOGP-Zusatzanforderungen (S-631-04) mit Änderungen;
- d) die Begriffe „nationale oder regionale Vorschriften“ und „nationale oder regionale Bauvorschriften“ wurden im gesamten Dokument durch „nationale Baunormen“ ersetzt;
- e) der Begriff „Tragwerk“ wurde durch „Unterbau“ ersetzt und eine Definition des Begriffs „Unterbau“ wurde in Abschnitt 3 hinzugefügt;
- f) „Wellen, Wind und Strömung“ wurde durch „Metocean“ ersetzt;
- g) „Entwurfsbewertung/Situationen“ wurde durch „Entwurfssituationen“ nach ISO 19900 ersetzt;
- h) in Abschnitt 3 wurden Begriffe, die bereits in ISO 19900 und ISO 19902 definiert sind, in Abschnitt A.3 verschoben;
- i) es wurde ein neuer Abschnitt 5.7 „Kritische Strukturen“ hinzugefügt;
- j) in 6.7 und A.6.7, Auslegung für Ermüdung, wurde Tabelle 2 überarbeitet durch die Einführung des Begriffs „eingeschränkter Zugang für Inspektion, Wartung und Instandsetzung“ und Reduktion im Falle vollständiger Zugänglichkeit (mit Bezug auf ISO 19904-1, Norsok N-004 und DNVGLOS-C101);
- k) in A.7.2, Hinzufügung von Tabelle A.1 mit typischen Mindestwerten für lokale, primäre und globale Bemessung von Betriebseinwirkungen (Q), in Übereinstimmung mit ISO 19904-1;
- l) Windeinwirkungen, 7.6.1.4 und A.7.6.1.4, Einführung von nationalen Baunormen für die Bewertung der repräsentativen Windeinwirkungen; Angleichung an ISO 19900 und ISO 19901-1 und Hinzufügung von weiteren Leitlinien;
- m) Angleichung der Mindest-Querbeschleunigung für seismische Einwirkungen (7.7.2 und A.7.7.2) an ANSI/API RP 2TOP;
- n) Erfassung und Angleichung aller Quellen für Beschleunigungen an der Oberseite (7.9.9 und A.7.9.9);
- o) technische Überarbeitung der normativen und informativen Abschnitte über Störfälle (7.9 und A.7.9), mit Einführung von risikoinformierten und zuverlässigkeitsbasierten Ansätzen für Brände und Explosionen zusätzlich zu dem semiprobabilistischen Standardansatz;
- p) Hinzufügung des Abschnitts 9 zur Beschreibung der Ansätze zur Überprüfung des Grenzzustands, einschließlich der risikoinformierten und zuverlässigkeitsbasierten Ansätze für Brand und Explosion (siehe 9.2, 9.3, A.9.2 und A.9.3), zusätzlich zu dem semiprobabilistischen Standardansatz;
- q) K_c -Entsprechungsfaktoren (8.1 und A.8.1), die nach einem gleichwertigen Zuverlässigkeitsverfahren für ANSI/AISC 360-16, CSA-S16:19 und EN 1993-1-1 definiert sind;
- r) Hinzufügung von 8.6 und A.8.6 über die Bemessung der strukturellen Stabilität in Anlehnung an ANSI/API RP 2TOP und basierend auf ANSI/AISC 360-16 und Kriterien nach EN 1993-1-1;

- s) Hubschrauberlandeereinrichtungen (10.5), aktualisiert nach CAP 437 für Notlandungen und Definition von Bemessungslastkombinationen, angepasst an Norsok C-004; Streichung der Tabelle A.5;
- t) die 10.6 und A.10.6 über die Kranstützstruktur wurden überarbeitet; die Kranstützkonstruktion ist nach API Spec 2C oder EN 13852-1 zu entwerfen und zusätzliche Bestimmungen sind anzugeben; die vereinfachte Ermüdungsmethode wurde an ANSI/API RP 2TOP angeglichen;
- u) Werkstoff in 11.2, Aktualisierung der Tabelle 7 in Anlehnung an den Topsides-Anhang der in Überarbeitung befindlichen Norsok N-004 und Hinzufügung einiger Beispielzahlen für Design Class;
- v) Reduzierung oder Streichung der Abschnitte über die strukturelle Integrität (12.5, Abschnitt 14, A.12.5 und A.14) in Übereinstimmung mit den Inhalten von ISO 19901-9 und ISO 19902;
- w) in Anhang B, aktualisiertes Beispiel für K_c -Berechnungen nach Nutzungsverhältnis für ISO 19902 und ANSI/AISC 360-16;
- x) Streichung von Anhang C, K_c wird als normativer Wert in Tabelle 4, in 8.1 für ANSI/AISC 360-16, CSA-S16:19 und EN 1993-1-1 angegeben.

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen im Abschnitt Begriffe der englischen Fassung.

3 Begriffe

Für die Anwendung dieses Dokuments gelten die Begriffe nach ISO 19900, ISO 19902 und die folgenden Begriffe.

In A.3 sind die Schlüsselbegriffe aufgeführt, die bereits in ISO 19900 und ISO 19902 definiert sind.

ISO und IEC stellen terminologische Datenbanken für die Verwendung in der Normung unter den folgenden Adressen bereit:

- ISO Online Browsing Platform: verfügbar unter <https://www.iso.org/obp>
- IEC Electropedia: verfügbar unter <http://www.electropedia.org/>

3.1

aktiver Brandschutz

Ausrüstungen, Systeme und Verfahren, die, nachdem sie initiiert wurden, zum Überwachen, Eindämmen und Löschen von Bränden angewendet werden können

[QUELLE: ISO 13702]

3.2

Caisson

Senkkasten

Armatur, mit der Wasser aus dem Meer zu entnehmen oder in das Meer abzulassen ist

3.3

kritisches Bauwerk

CS, en: critical structure

tragende Bauteile, die Teile der Aufbauten bilden und die sicherheits- und umweltkritische Elemente (SECE, en: safety and environmental critical elements) abstützen, deren Verlust spezifische Auswirkungen auf den Personenschutz sowie spezifische ökologische oder wirtschaftliche Auswirkungen haben kann

Anmerkung 1 zum Begriff: 5.7 enthält Einzelheiten und Beispiele.

Anmerkung 2 zum Begriff: CS umfasst auch Strukturen, die sicherheits- und umweltkritische Elemente (SECE) abstützen, die früher als sicherheitskritische Elemente (SCE) bezeichnet wurden, siehe ISO 19901-9.

Anmerkung 3 zum Begriff: SECE schließt alle relevanten Ausrüstungen und Systeme ein.

3.4

Belastungsdauer

Belastungsdauer ist die für die Evakuierung veranschlagte Zeit, wie sie in der Analyse der Evakuierung und Rettung im Notfall (EERA, en: Emergency Evacuation Rescue Analysis) definiert ist

Anmerkung 1 zum Begriff: Die Belastungsdauer wird in der Bemessungsprämisse für den Entwurf festgelegt.

3.5

schwerer Störfall

MA, en: major accident

Gefährdungsereignis,

- das mehrere Tote oder Schwerverletzte; oder
- umfangreiche Schäden an Bauwerken, Plattformen oder Anlagen zur Folge hat, oder
- das signifikant umweltschädliche Auswirkungen hat (z. B. bleibende und schwere Umweltschäden, die zu einem Verlust der kommerziellen Nutzung oder der Freizeitnutzung, zu einem Verlust der natürlichen Ressourcen in einem weiten Bereich oder zu schweren Umweltschäden führen können, die umfangreiche Maßnahmen erfordern, um eine erneute Nutznießung der Umwelt zu ermöglichen)

Anmerkung 1 zum Begriff: In diesem Dokument ist ein schwerer Störfall die Realisierung einer Gefährdung durch einen schweren Störfall.

Anmerkung 2 zum Begriff: Es ist vorgesehen, dass diese Definition weitere Benennungen einbezieht, z. B. „schwerer Störfall“, definiert in UK HSE.

[QUELLE: ISO 17776]

3.6

passiver Brandschutz

PFP, en: passive fire protection

Aufbringung einer Beschichtung oder Verkleidung oder eine freistehende Schutzeinrichtung, die im Brandfall Wärmeschutz bietet, indem sie die Wärmemenge begrenzt, die auf den zu schützenden Gegenstand oder Bereich übertragen wird

[QUELLE: ISO 13702]

3.7

Risikokurve

stellt die Wahrscheinlichkeit von Auswirkungen dar, die einen festgelegten Grenzwert während eines Bezugszeitraums überschreiten

3.8

Unterkonstruktion

Bauwerk, das die Aufbauten trägt

Anmerkung 1 zum Begriff: Die Unterkonstruktion kann in unterschiedlichen Formen vorliegen, darunter gegründete Stahlplattformen (siehe ISO 19902), Betonkonstruktionen (siehe ISO 19903), schwimmende Offshore-Anlagen (siehe ISO 19904-1), mobile Offshore-Einheiten (siehe ISO 19905-1) oder verschiedene Formen von Bauwerken für den Arktis-Bereich (siehe ISO 19906).

4 Symbole und Abkürzungen

4.1 Symbole

a	Beschleunigung
A	außergewöhnliche Einwirkung
b	Abstand der Versteifungselemente
D_e	äquivalente quasistatische Einwirkung, repräsentativ für dynamische Responseeffekte auf eine extreme umweltbedingte Einwirkung, E_e
D_o	äquivalente quasistatische Einwirkung, repräsentativ für dynamische Responseeffekte auf eine umweltbedingte Einwirkung während des Betriebs, E_o
E	quasistatische umweltbedingte Einwirkung
E_e	extreme quasistatische umweltbedingte Einwirkung aufgrund von meteorologisch-ozeanischer Einwirkung und Eis
E_o	quasistatische umweltbedingte Einwirkung aufgrund von meteorologisch-ozeanischer Einwirkung und Eis für den jeweils zu berücksichtigenden Betriebszustand
F_d	Bemessungswert einer Einwirkung
F_r	repräsentativer Wert einer Einwirkung
g	Beschleunigung aufgrund der Erdanziehungskraft
G	ständige Einwirkung
I	Explosionsimpuls
l	Spannweite oder Länge
K_c	Baustandard-Korrespondenzfaktor
p	momentaner Explosionsüberdruck
$p(t)$	zeitabhängige Änderung des Überdrucks
P	Wahrscheinlichkeit
Q	betriebsbedingte Einwirkung
R	Widerstand
R_d	Bemessungswert des Widerstands
R_k	charakteristischer Wert für den Widerstand oder Wert, beruhend auf den charakteristischen Werten für Werkstoffeigenschaften
S_d	Gesamt-Bemessungswert für den Einfluss einer Einwirkung
t	Zeit vom Zünden einer Explosion

t_d	Dauer des positiven Druckimpulses bei einer Explosion
T	Grundschwingungsdauer eines Bauteils oder Bauwerks
$T_{C,max}$	maximale zulässige Temperatur in einem Bauteil
δ	Dicke eines tragenden Bauteils, einer Platte oder eines finiten Elements
γ	Teilsicherheitsbeiwert
γ_f	Teilsicherheitsbeiwert für eine Einwirkung
γ_{FD}	Teilsicherheitsbeiwert für einen Bemessungswert nach Beschädigung
γ_R	Teilsicherheitsbeiwert für den Widerstand
Δ	Durchbiegung
ε_{cr}	mittlere kritische Dehnung
σ	Spannung
θ	Temperatur

4.2 Abkürzungen

ALARP	so niedrig wie vernünftigerweise praktikabel (en: as low as reasonably practicable)
ALE	Erdbeben anormaler Stärke (en: abnormal level earthquake)
ALS	Grenzzustand für anormale/außergewöhnliche Einwirkungen (en: abnormal/accidental limit states)
APoE	jährliche Wahrscheinlichkeit der Überschreitung (en: annual probability of exceedance)
ASD	Bemessung mit zulässigen Spannungen (en: allowable stress design)
AVM	schwingungsfreie Anbringung (en: anti-vibration mounting)
CFD	numerische Strömungsdynamik (en: computational fluid dynamics)
CoG	Massenschwerpunkt (en: centre of gravity)
CS	kritisches Bauwerk (en: critical structure)
CTOD	Rissspitzenöffnungsverschiebung (en: crack tip opening displacement)
CVI	engmaschige Sichtprüfung (en: close visual inspection)
DAF	dynamischer Verstärkungsfaktor (en: dynamic amplification factor)
DLB	Explosions-Duktilitätsklasse (en: ductility level explosion)
DES	Bohrkran-Ausrüstungssatz (en: Derrick equipment set)
ELE	Erdbeben extremer Stärke (en: extreme level earthquake)

ER	Rettungsweg (en: escape route)
FEA	Finite-Elemente-Analyse (en: finite element analysis)
FEED	vor Detailplanung und Beschaffung durchzuführende technische Vorplanung (en: front end engineering design)
FLS	Grenzzustand der Ermüdung (en: fatigue limit states)
FPSO	Produktions- und Lagereinheit; schwimmende Einheit zur Förderung, Lagerung und Verladung von Erdöl und Erdgas (en: floating production storage and offloading structure)
FRP	faserverstärktes Polymer (en: fiber reinforced polymer)
FSO	Lagereinheit; schwimmende Einheit zur Lagerung und Verladung von Erdöl und Erdgas (en: floating storage and off-loading structure)
GVI	allgemeine Sichtprüfung (en: general visual inspection)
IRPA	persönliches Risiko pro Jahr (en: Individual risk per annum)
ISD	inhärent sichere Konstruktion (en: inherently safer design)
LRFD	Bemessung mit Teilsicherheitsbeiwerten auf Belastung und Widerstand (en: load and resistance factor design)
MPI	Magnetpulverprüfung (en: magnetic particle inspection)
MTOM	höchstzulässige Startmasse (en: maximum take-off mass)
MTOW	höchstzulässiges Startgewicht (en: maximum take-off weight)
PFP	passiver Brandschutz (en: passive fire protection)
SDOF	mit einem Freiheitsgrad (en: single degree of freedom)
SECE	sicherheits- und umweltkritische Elemente (en: safety and environmental critical elements)
SLB	Explosions-Festigkeitsklasse (en: strength level blast)
SLS	Grenzzustand der Gebrauchstauglichkeit (en: serviceability limit states)
TRIF	Schadenshäufigkeit des Not-Zufluchtsortes (en: temporary refuge impairment frequency)
TR	Not-Zufluchtsort (en: temporary refuge)
ULS	Grenzzustand der Tragfähigkeit (en: ultimate limit states)
UR	Nutzungsgrad (en: utilization ratio)
UTS	Zugfestigkeit (en: ultimate tensile strength)
WLL	Traglastgrenze (en: work limit load)

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN CEN ISO/TS 35105, *Erdöl- und Erdgasindustrie — Arktisbetrieb — Werkstoffanforderungen für den Arktisbetrieb*

DIN EN ISO 898-1, *Mechanische Eigenschaften von Verbindungselementen aus Kohlenstoffstahl und legiertem Stahl — Teil 1: Schrauben mit festgelegten Festigkeitsklassen — Regelgewinde und Feingewinde*

DIN EN ISO 13626, *Erdöl- und Erdgasindustrie — Bohr- und Förderanlagen — Bohrungen und Bohrloch-Aufbauten*

DIN EN ISO 13702, *Erdöl und Erdgasindustrie — Überwachung und Eindämmung von Feuer und Explosionen auf Offshore-Produktionsplattformen — Anforderungen und Leitlinien*

DIN EN ISO 17776, *Erdöl- und Erdgasindustrie — Offshore-Produktionsanlagen — Management der Gefährdungen durch schwere Störfälle bei der Konstruktion neuer Offshore-Anlagen*

DIN EN ISO 19900, *Erdöl- und Erdgasindustrie — Allgemeine Anforderungen an Offshore-Bauwerke*

DIN EN ISO 19901-1, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 1: Grundsätze für die Auslegung und den Betrieb auf dem offenen Meer*

DIN EN ISO 19901-2, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 2: Seismische Auslegungsverfahren und -kriterien*

DIN EN ISO 19901-4, *Erdöl- und Erdgasindustrie — Besondere Anforderungen an Offshore-Bauwerke — Teil 4: Geotechnische und Fundament-Auslegungsmerkmale*

DIN EN ISO 19901-5, *Erdöl- und Erdgasindustrie — Besondere Anforderungen an Offshore-Bauwerke — Teil 5: Gewichtskontrolle*

DIN EN ISO 19901-6, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 6: Mariner Betrieb*

DIN EN ISO 19901-9, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 9: Integritätsmanagement für Konstruktionen*

DIN EN ISO 19902, *Erdöl- und Erdgasindustrie — Gegründete Stahlplattformen*

DIN EN ISO 19903, *Erdöl- und Erdgasindustrie — Offshore-Betonkonstruktionen*

DIN EN ISO 19904-1, *Erdöl- und Erdgasindustrie — Schwimmende Offshore-Anlagen — Teil 1: Schiffsförmige, teilversenkbare Holme und zylindrische Anlagen mit geringem Tiefgang*

DIN EN ISO 19905-1, *Erdöl- und Erdgasindustrie — Beurteilung von mobilen Offshore-Einheiten bezüglich ihres Einsatzgebietes — Teil 1: Hubinseln*

DIN EN ISO 19906, *Erdöl- und Erdgasindustrie — Offshore-Bauwerke für den Arktis-Bereich*

DIN EN ISO 20088-1, *Bestimmung der Beständigkeit von Isoliermaterialien bei kryogenem Auslaufen — Teil 1: Flüssigkeit*

DIN EN ISO 20088-2, *Bestimmung der Beständigkeit von Isoliermaterialien bei kryogenem Auslaufen — Teil 2: Dampfbelastung*

DIN EN ISO 20088-3, *Bestimmung der Beständigkeit von Isoliermaterialien bei kryogenem Auslaufen — Teil 3: Strahlungsfreisetzung*

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, 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 (2nd edition)), which has been technically revised.

The main changes compared to the previous edition are as follows:

- an alignment of the terminology to 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’ is added to clause 3;
- ‘wave, wind and current’ has been replaced by ‘metocean’;
- ‘design assessment/situations’ has replaced ‘design situations’ according to ISO 19900;
- in clause 3, terms already defined in ISO 19900 and ISO 19902 have been moved to clause A.3;
- a new clause 5.7 “Critical structures” has been added;
- in clause 6.7 and A.6.7, design for fatigue, Table 2 has been updated with introduction of ‘restricted access for inspection, maintenance and repair’ partial damage factors and reduction in case of

- fully accessibility (with reference to ISO 19904-1, Norsok N-004^[32], Reference [30] and DNVGL-OS-C101^[31]);
- in clause A.7.2, addition of Table A.1 with typical minimum values for local, primary and global design of operational actions (Q), in accordance with ISO 19904-1;
 - wind actions, 7.6.1.4 and A.7.6.1.4, 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 normative and informative clauses (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;
 - 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 (see clause 9.2, 9.3, A.9.2 and A.9.3) in addition to the default semi-probabilistic approach;
 - K_c correspondence factors (8.1 and A.8.1) defined according to an equivalent reliability procedure for ANSI/AISC 360-16^[12], CSA-S16:19^[14] and EN 1993-1-1^[13];
 - 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 360-16^[12] and EN 1993-1-1^[13] criteria;
 - helicopter landing facilities (10.5) updated according to CAP 437^[21] for emergency landing and definition of design load combinations adapted from Norsok C-004^[89]. Deletion of 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];
 - material, 11.2, update of Table 7 similarly to the Topsides Annex of the under revision Norsok N-004^[32] and addition of some example figures for DC;
 - reduction or removal of the Structural integrity clauses (12.5, clause 14, A.12.5 and A.14) in accordance with ISO 19901-9 and ISO 19902 content;
 - Annex B – updated example of K_c calculations by utilization ratio for ISO 19902 and ANSI/AISC 360-16^[12].

removal of Annex C, K_c is reported as normative value in Table 4, in 8.1 for ANSI/AISC 360-16,^[12] CSA-S16:19^[14] and EN 1993-1-1^[13].

Introduction

The series of International Standards applicable to types of offshore structure, ISO 19900 to ISO 19906, constitutes a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the type of structure and the nature or combination of the materials used.

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

The series of International Standards applicable to types of offshore structure is intended to provide wide latitude in the choice of structural configurations, materials and techniques, without hindering innovation. Sound engineering judgement is therefore necessary in the use of these International Standards.

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

Historically, the design of structural components in topsides has been performed to national building standards for onshore structures, modified in accordance with experience within the offshore industry, or to relevant parts of classification society rules. While this part of ISO 19901 permits use of national 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 part of ISO 19901, and is intended to be read in conjunction with the main body of this part of ISO 19901. The clause numbering in Annex A follows the same structure as that in the body of the normative text in order to facilitate cross-referencing.

Annex B provides an example of the use of national building standards for onshore structures in conjunction with this part of ISO 19901.

– *Entwurf* –

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

Part 3: Topsides structure

1 Scope

This part of ISO 19901 provides requirements, guidance, and information for the design and, fabrication of topsides structure for offshore structures. It complements ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, which provide requirements for various forms of substructure.

The actions on topsides structure, and the action effects in the structural components are derived from this part of ISO 19901, where necessary in combination with other International Standards in the ISO 19901 series.

The resistances of non-cylindrical structural components of the topsides structure can be determined by the use of national building standards, as specified in this part of ISO 19901.

The resistance of cylindrical structural components are to be in accordance with ISO 19902 but may be according to national building standards, as specified in this part of ISO 19901.

This part of ISO 19901 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 (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 part of ISO 19901 are supplemented with applicable requirements in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906.

This part of ISO 19901 does not apply to those aspects of topsides structure that form part of the overall structural system of floating offshore structures and mobile offshore units that are governed by the rules of a recognized certifying authority and which are within class rules.

The fire and explosion provisions of this part of ISO 19901 can however be applied to those parts of the hulls of floating offshore structures and mobile offshore units that contain hydrocarbon processing, piping or storage.

This part of ISO 19901 addresses the following aspects of topsides structure:

- design, fabrication, installation and modification;
- prevention, control and assessment of fire, explosions and other accidental events.

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

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

- primary and secondary structure in decks, module support frames and modules;
- flare structures;

- crane pedestal and other crane support arrangements;
- helicopter landing decks (helidecks);
- permanent bridges between separate offshore structures;
- masts, towers and booms on offshore structures.

2 Normative references

The following documents 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*

ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod 60000 PSI Tensile Strength*

ASTM F1136/F1136M, *Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners*

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 F2833, *Standard Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type*

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*

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

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

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 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

3 Terms and definitions

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

Annex A.3 lists key terms already defined in ISO 19900, ISO 19902.

ISO and IEC maintain terminological 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]

3.2

caisson

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

3.3

critical structure

CS

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: Clause 5.7 provides details and examples.

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

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

3.4

endurance period

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

Note 1 to entry: Note to entry: The endurance period is specified in the design premise for design.

3.5

major accident

MA

hazardous event that results in:

- multiple fatalities or severe injures; 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.

Note 2 to entry: This definition is intended to incorporate terms such as “major accident” as defined by UK HSE.

[SOURCE: ISO 17776]

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]

3.7

risk curve

shows the 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), mobile offshore units (see ISO 19905-1), or the various forms of arctic structures (see ISO 19906).

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	quasi-static environmental action
E_e	extreme quasi-static environmental action due to metocean and ice
E_o	quasi-static environmental action due to metocean and ice for an operating condition under consideration
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	building standard 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 States
APoE	annual probability of exceedance
ASD	allowable stress design
AVM	anti-vibration mounting
CFD	computational fluid dynamics
CoG	centre of gravity
CS	critical structure
CTOD	crack tip opening displacement
CVI	close visual inspection
DAF	dynamic amplification factor
DLB	ductility level blast
DES	Derrick equipment set
ELE	extreme level earthquake
ER	escape route
FEA	finite element analysis

FEED	front end engineering design
FLS	fatigue limit states
FPSO	floating production storage and off-loading
FRP	fiber reinforced polymer
FSO	floating storage and off-loading
GVI	general visual inspection
IRPA	Individual risk per annum
ISD	inherently safer design
LRFD	load and resistance factor design
MPI	magnetic particle inspection
MTOM	maximum take-off mass
MTOW	maximum take-off weight
PFP	passive fire protection
SDOF	single degree of freedom
SECE	safety and environmental critical elements
SLB	strength level blast
SLS	serviceability limit states
TRIF	temporary refuge impairment frequency
TR	temporary refuge
ULS	ultimate limit states
UR	utilization ratio
UTS	ultimate tensile strength
WLL	work limit load

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 functions.

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 ISO 19900 series¹⁾ of International Standards follows the approach of ISO 2394^[1] and as such is intended to be a limit state design standard. Limit state methods are also known as load and resistance factor design (LRFD) methods, particularly in North America.

The intent of this part of ISO 19901 is that limit state methods in accordance with ISO 19900, see 9.1, should be used where possible, but, where the substructure is designed using ASD methods, such as for floating structures, ASD methods may also be used for the topsides structure using a current ASD code compatible with that used for the supporting structure.

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

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

5.2.2 Use of national building standards

Topsides structures shall be designed and fabricated in accordance with ISO 19900-series, supplemented by specific requirements as specified in this document from a national building standard selected and agreed with the operator and regulator.

In order to realize a consistent level of reliability for the platform, non-cylindrical sections and their connections not addressed in the ISO 19900-series, shall be designed in accordance with the agreed national building standard using its resistance factors modified by the correspondence factor (see 8.1).

The ISO 19900-series partial action factors applicable to the substructure shall be applied unmodified.

5.3 Deck elevation

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

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

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

5.4 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, 19904-1, ISO 19905-1 and ISO 19906.

NOTE There are three categories of exposure level: L1 structures are manned during design conditions or have high consequences of failure; L2 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 comply with the platform's safety philosophy and any defined performance standards.

5.5.2 Spillage and containment

Provision for handling spills, overflows and potential contaminants should be provided.

A deck drainage system shall be provided that collects and stores liquid spillages and overflows for subsequent handling.

Accumulation of combustible liquids in containment areas and plated decks are to 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) 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 environmental conditions if an assessment of the risks and consequences of exceeding the environmental criteria are assessed.

5.7 Critical structure

The following structural components shall be identified and documented 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 AVMs, structural components that comprise the external surface of the TR, and structural components that comprise and support other 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 generator.
- 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 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 pedestal.

NOTE 4 Examples of critical structure are provided in ISO 19901-9 clause 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 to demonstrate either full compliance with the requirements of this document or fitness-for-service.

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 the use (including exposure level) and conditions that are applicable at the new location.

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

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 assessment requirements of ISO 19901-9 and ISO 19900, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906, as appropriate.

6 Design requirements

6.1 General

This clause presents the overall minimum 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, 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 steel for topsides structure. Clause 11 addresses 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 tolerances are taken into account;
- compatibility of stiffnesses, 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.

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

If a jack up is to be employed, the design shall ensure that the jack up is located such that, under design seismic and metocean 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

The serviceability of the topsides structures can be affected by excessive relative displacement or vibration (vertical or horizontal). Serviceability limit states shall be established from limits relevant 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, or
- 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, situations based on the following shall be reviewed for their effect on the structure:

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

6.5.2.2 Serviceability design limits

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

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

6.5.2.4 Dynamic analysis and avoidance of resonance

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

6.5.3 Deflections

6.5.3.1 Vertical deflections

The final deflected shape, $\Delta_{\max}$, of any element, structural component or structure comprises three parts as follows (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 thickness	—	2δ or $\frac{b}{150}$ ^a
l span δ deck thickness b stiffener spacing ^a Whichever is smaller.		

More onerous limits can be required by the 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; avoid ponding by cambering deck plating in areas susceptible to icing of any surface water.

The alignment of telecommunications equipment can be critical for their reliable operation. Verify and maintain the tolerances required for such equipment.

6.5.3.2 Horizontal deflections

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

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

6.6 Design for strength

Design for strength shall include establishing design/assessment situations for operational, extreme, abnormal, accidental, and short duration as specified in ISO 19900. Ultimate and abnormal/accidental limit states shall be established in accordance with ISO 19900.

The limit state verification is described in 9.1.

6.7 Design for fatigue

The design actions to be used for fatigue assessment verification are addressed in the International Standard in the ISO 19900- series that is applicable to the substructure. Additional provisions for specific systems are given in Clause 9. The fatigue methodology in ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1, as appropriate, shall be followed in the design of the topsides structure; in cases where the support structure standard does not provide adequate fatigue guidance for a topsides structure, 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 factors assume that inspections and maintenance is planned for all accessible areas, even if restricted, however the interval between inspections can be larger if the factor is higher.

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.

Where the topsides structure is subjected to a long sea transportation (greater than 21 days) prior to installation on the support structure, particular attention shall be given to the fatigue performance of structural details that do not normally see significant fatigue actions.

Sea transportation and in place fatigue damage shall be combined.

See A.6.7 for further guidance.

6.8 Design for accidental events

Design/assessment situations shall be established for accidental events as specified in ISO 19900. The relevant limit states shall be established in accordance with ISO 19900.

Requirements and recommendations for determining the conditions and actions are provided in 7.9.

The limit state verification is described in clause 9.

6.9 Robustness

Robustness is defined and discussed in ISO 19900.

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

6.10 Confirmation of execution of design requirements

For a new topsides, a walk-down survey shall be carried out in the fabrication yard or shortly after installation, 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.

The walk-down scope shall include:

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

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

6.11 Corrosion control

Corrosion control of topsides structure and structural components shall be performed in accordance with ISO 19902.

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.

In general, the thickness of a painted steel deck is governed by the need for stiffness and to prevent excessive weld-induced distortion rather than by allowance for corrosion.

6.12 Design for fabrication and inspection

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

Prepare the design 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 part of ISO 19901 for materials (see Clause 11), quality control, quality assurance and documentation, welding and fabrication inspection (see Clause 12).

6.13 Design for loadout, transportation and installation

The objective of these design requirements is to ensure that a topsides structure begins its design service life with its designed strength and structural integrity intact.

Installation encompasses the operations of moving the topsides components from the fabrication site (or prior offshore location) to the 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 19901-6.

6.14 Design for structural integrity management

Structural integrity management shall be in accordance 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 shall provide adequate access to the structure to facilitate inspection and maintenance (e.g. painting).

6.15 Design for decommissioning, removal and disposal

6.15.1 General

Decommissioning and removal shall be in accordance with ISO 19901-9 and ISO 19901-6 with the additional requirements here reported.

Decommissioning and removal requirements shall be addressed during the topsides structure design phase, particularly for fixed platforms and deep draught floating platforms. Where the preferred removal option requires the use of special features, these are to be included in the topsides structure during its fabrication.

6.15.2 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.

6.15.3 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 shall be made for facilitating their reattachment or replacement for subsequent removal.

The design should allow for periodic access for inspection.

6.15.4 Heavy lift and set-down operations

Set-down onto a barge could be more severe than for installation. If this seems probable, dynamic impact factors used in design should allow for this possibility.

7 Actions and analysis methods

7.1 General

Topsides structure can be exposed to a variety of design/assessment situations (see 6.2) throughout its design service life.

Design/assessment situations are established for events and activities which include:

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

Each design/assessment situation comprises several 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 to 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.

Guidance on identification of weight items for topsides structure is provided 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.

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-place actions

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

Each topsides 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 (see Note below) 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 (see Note below) 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 actions resulting from associated substructure movements shall also 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 is to 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. See ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 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

Environmental actions can add to or subtract from still water actions. For the platform generally, operating environmental conditions representing normal conditions, which occur relatively frequently at the platform, can be defined by the operator.

Some platform operations can be performed only in environmental conditions which are less than the general operating conditions. The combination of the principal operational action with the lesser environmental conditions which limit the operation could govern the design of parts of the structure.

NOTE 1 Different operating environmental limit can be set for different operations.

NOTE 2 Examples of operations that can be limited by environmental conditions include:

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

Each 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 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 in a similar manner, which includes allowing for the rotations and accelerations due to the vessel motions.

NOTE 3 ISO 19902 provides a value of $\gamma_{f,Eo}$ of $0,9 \times 1,35$ (approximately 1,20) where no other information is available.

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 , Q_1 and Q_2 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 in a similar manner, which includes allowing for the rotations and accelerations due to the vessel motions.

The partial action factors, γ_f , shall be the same as those used for the 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 permanent and operational actions oppose those due to environmental actions, design actions, F_d , shall be calculated in accordance with Formula (6) 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).

$$F_d = \gamma_{f,G1} \cdot G_1 + \gamma_{f,G2} \cdot G_2 + \gamma_{f,Q1} \cdot Q_1 + \gamma_{f,Ee} \cdot (E_e + \gamma_{f,D} \cdot D_e) \quad (6)$$

For this check, 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 1 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.

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

7.4 Vortex-induced vibrations

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

Wind induced fatigue analysis and vortex shedding analysis shall be performed on lattice structures (e.g., flare booms and drilling derricks). VIV from exposed pipework shall be included in the design of the supporting structures.

7.5 Deformations

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

Where a primary topsides structure is supported by a multi-column gravity base structure, the movements and deformations of the column tops can result in significant indirect actions applied to the topsides structure. For this reason, the substructure and the topsides structure should be analysed together for the verification of the relevant limit states.

All such actions or action effects shall be combined with appropriate operational and environmental actions to ensure that serviceability and ultimate limit states are not exceeded.

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

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.

Structural supports for SECE shall be designed for actions imposed due to deformation of the substructure.

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.

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.

7.6.1.4 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 ISO 19900-series standards used for the substructure.

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 follow 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 7-16^[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.

7.6.2 Icing

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.

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

7.7 Seismic actions

7.7.1 General

The topsides structure are to 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. The requirements are given in 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, if appropriate, local dynamic response of the deck and the appurtenance itself.

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

As a minimum, lateral design acceleration of 0,05 *g* shall be applied as an extreme level earthquake (ELE) to the 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 sway 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 accordance with an appropriate standard (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 6.13.

The sequence of construction and any temporary erection conditions, including any jacking and weighing conditions shall be considered to ensure that limit states are satisfied during all temporary 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. Internal forces in the topsides structure due to uneven support points shall be determined.

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 500m 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 substructures;
- 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.

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.

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.

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).

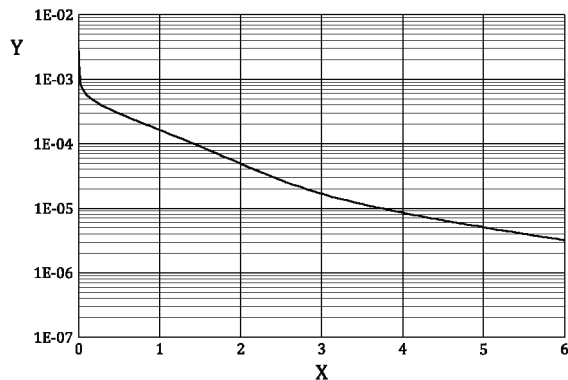
The probabilities of exceedance (or return periods) for determining representative values of accidental actions for fire and explosion for each design/assessment situation and limit state shall be determined in accordance with ISO 19900.

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 acceptable; approximate and conservative estimates of the intensity of the hazardous event can be based on worst credible consequence modelling.

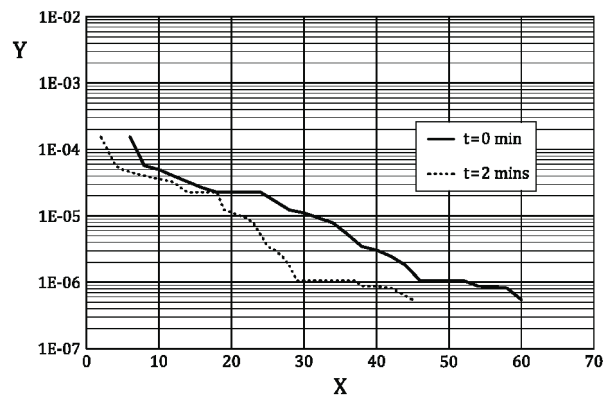
For all risk-informed and reliability-based approaches, close communication and interaction should occur between the hazard expert engineers and the project structural engineers.



a) explosion hazard curve

X=overpressure (bar)

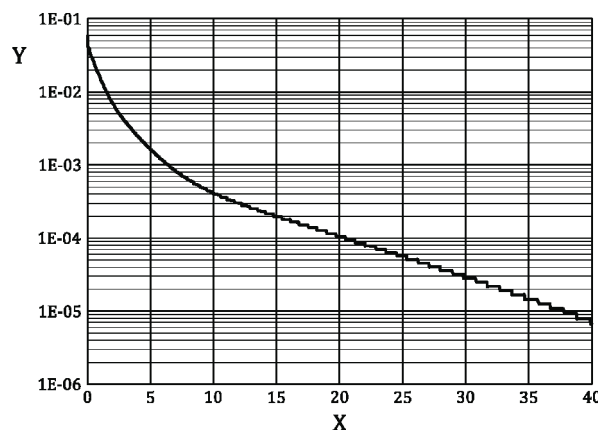
Y=annual probability of exceedance of overpressure



b) fire hazard curve

X=flame length (m)

Y=annual probability of exceedance of flame length



c) collision hazard curve - platform/supply vessel

X=collision energy (MJ)

Y=annual probability of exceedance of collision energy

Figure 1 — Example hazard curves (not to be used for design)

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 table 8 and 9 in^[4] and from^[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, further details are provided in A.7.9.2. In any case the minimum coat-back length shall be 150 mm.

NOTE 2 The additional cost of inspection and maintenance over the service life of the facility due to applying PFP to topsides critical structure can limit 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).

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 > 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 1,0 m diameter or less.

Blast drag load on the structure, vessels, or pipework less than 1,0 m diameter shall be determined from Formula (7):

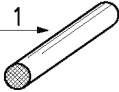
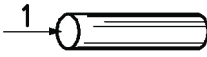
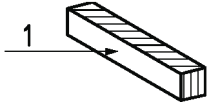
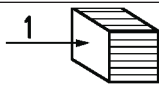
$$F_d = C_d \times q_d \times A \quad (7)$$

where:

- F_d blast drag load 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 (1=Flow)

shape	sketch	Cd
cylinder (side-on)		1,2 to 2,0 ^(a)
cylinder (end-on)		0,82
rectangular prism (face-on)		2,05
rectangular prism (edge-on)		1,55
disk (face-on)		1,17
cube (face-on)		1,05
cube (edge-on)		0,80

(a) Cd~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 and specified in the EHA. FRP grating has a larger drag coefficient 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:

- a) $t_d/2$ (when within the combustion zone);
- b) 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 DLB events) shall have a minimum positive overpressure duration of 40 ms.

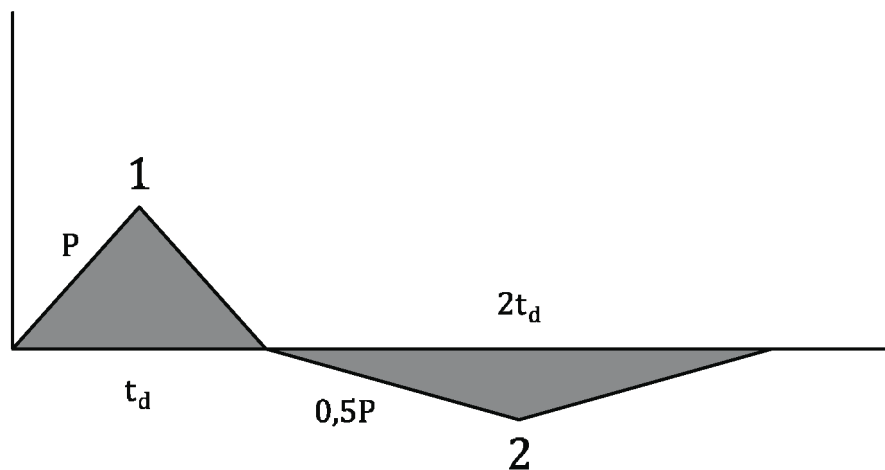
Controllable hazardous events for explosion (also known as SLB events) shall have a minimum positive overpressure duration of 120 ms.

NOTE 3 Peak pressure in the positive and negative is specified by the EHA. In addition, a range of durations of the positive phase and the negative phase are typically specified in the EHA. Negative pressure is not typically 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 compressions, deck beams can have stress reversals.

NOTE 2 Peak pressure in the positive and negative is specified by the EHA. In addition, a range of durations of the positive phase and the negative phase are typically specified in the EHA. Negative pressure is not typically 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 3 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 compressions, deck beams can have stress reversals.



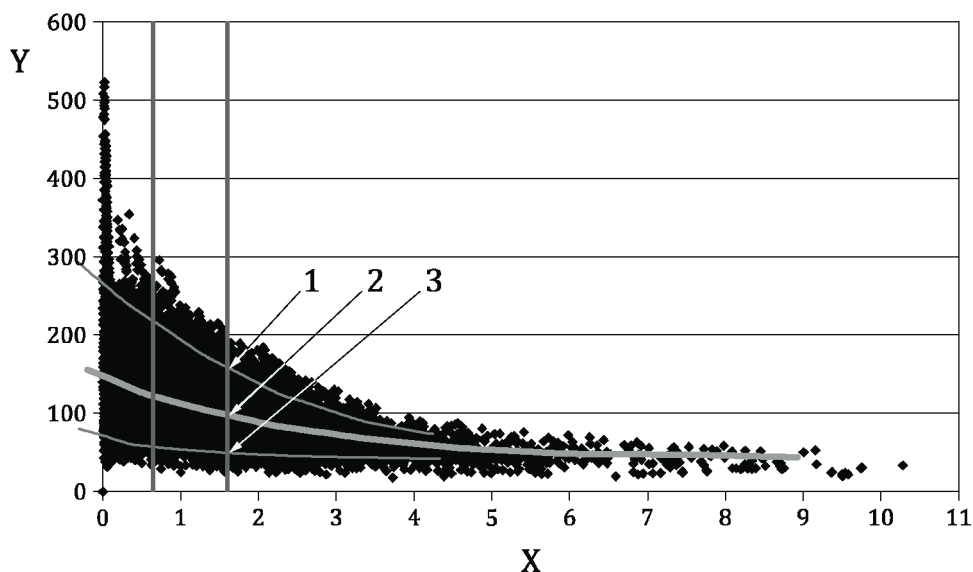
Key

- 1 positive phase
- 2 negative phase

Figure 2 — Overpressure time history

Structural design should include 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	pressure (barg)	1	approx upper bound t_d value for P_{max} 1,6 bar
Y	pulse duration (ms)	2	probable t_d value for P_{max} 1,6 bar
		3	approx lower bound t_d value for P_{max} 1,6 bar

Figure 3 — Variability in pulse duration versus peak overpressure

NOTE 5 Response of the structure is typically accounted for when selecting the peak pressure, pulse duration, time delay and area over which the pressure is approximately constant.

7.9.3.4 Structural response analysis

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 geometry 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 table 16 & 17 of^[4] and Clause 5.5, Part 3 of^[10].

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.