

DIN EN ISO 19906

ICS 75.180.10

Entwurf

Einsprüche bis 2017-12-27
Vorgesehen als Ersatz für
DIN EN ISO 19906:2011-04

**Erdöl- und Erdgasindustrie –
Offshore-Bauwerke für den Arktis-Bereich (ISO/DIS 19906:2017);
Englische Fassung prEN ISO 19906:2017, nur auf CD-ROM**

Petroleum and natural gas industries –
Arctic offshore structures (ISO/DIS 19906:2017);
English version prEN ISO 19906:2017, only on CD-ROM

Industries du pétrole et du gaz naturel –
Structures arctiques en mer (ISO/DIS 19906:2017);
Version anglaise prEN ISO 19906:2017, seulement en CD-ROM

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2017-10-27 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, 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 531 Seiten

DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)

Nationales Vorwort

Dieses Dokument (prEN ISO 19906:2017) 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“ (Sekretariat NEN, Niederlande) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-07 AK „Offshore Bauwerke“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO-Norm.

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

ISO 17776	siehe	DIN EN ISO 17776
ISO 19900:2013	siehe	DIN EN ISO 19900:2014
ISO 19901-1	siehe	DIN EN ISO 19901-1
ISO 19901-2	siehe	DIN EN ISO 19901-2
ISO 19901-3	siehe	DIN EN ISO 19901-3
ISO 19901-4	siehe	DIN EN ISO 19901-4
ISO 19901-6	siehe	DIN EN ISO 19901-6
ISO 19901-7	siehe	DIN EN ISO 19901-7
ISO 19901-8	siehe	DIN EN ISO 19901-8
ISO 19902	siehe	DIN EN ISO 19902
ISO 19903	siehe	DIN EN ISO 19903
ISO 19904-1	siehe	DIN EN ISO 19904-1

Änderungen

Gegenüber DIN EN ISO 19906:2011-04 wurden folgende Änderungen vorgenommen:

- a) Überarbeitung des Anwendungsbereichs;
- b) Überarbeitung der Normativen Verweisungen;
- c) umfangreiche technische Überarbeitung von 3 bis 18;
- d) umfangreiche technische Überarbeitung der Anhänge A und B sowie der Bilder und Tabellen;
- e) redaktionelle Überarbeitung.

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benummerung der folgenden Begriffe, Symbole und Abkürzungen sind identisch mit der Benummerung in der englischen Fassung.

3 Begriffe

Für die Anwendung dieses Dokuments gelten die Begriffe nach ISO 19900:2013, ISO 19901-1, ISO 19901-2, ISO 19901-4, ISO 35102, ISO 35104, ISO 35106 und die folgenden:

3.1

Abrieb

Wirkung von Eis, das an der Oberfläche eines Bauwerks Farbe, vorstehende Teile und Beschichtungen, Oxidationsprodukte oder Betonteilchen und Zuschläge abschleift

3.2

kombinierte (Ein-)Wirkung

Ausdruck, in dem Bemessungswerte für einzelne gleichzeitige Wirkungen in einer Bemessungssituation zusammengefasst werden, um die Gesamt-Bemessungswirkung für die Verifizierung der Zuverlässigkeit eines Bauwerks für einen bestimmten Grenzzustand zu ermitteln

3.3

zusammenfrieren

anfrieren

Anfrieren von Eis oder Erdboden an der Oberfläche eines Bauwerks

3.4

Verhältniszahl

Seitenverhältnis

Verhältnis Höhe / Breite

Verhältnis des Durchmessers oder der Breite des Bauwerks zur Dicke des Eises

3.5

gebrochenes Eis

Eisstücke unterschiedlicher Größe, aufgebrochen als Ergebnis natürlicher Prozesse oder durch aktive oder passive Eingriffe

Anmerkung 1 zum Begriff: Aktive Eingriffe umfassen Eismanagement mit dem Ergebnis von manipuliertem Eis; passive Eingriffe umfassen Fahr- oder Heckwasser, verursacht durch ein feststehendes Bauwerk in einer beweglichen Eisdecke.

3.6

Begleit-Umweltaktion

Umweltaktion, die gleichzeitig mit der Haupt-Umweltaktion auftritt

3.7

erstarren

fest werden

Vorgang, bei dem Porenwasser in Hohlräumen im Trümmereis oder zwischen Eisschollen gefriert

Anmerkung 1 zum Begriff: Für Böden schließt das Erstarren ein, dass die durch Überlagerungsdrücke austretende Porenflüssigkeit abgeleitet wird.

3.8

erstarrte Schicht

erstarrte Lage

der beim Erstarrungsprozess des Eises gebildete Anteil eines Eisrückenkiels, Trümmereishaufens, Trümmereisfelds oder einer Stamukha (aufgetürmten Eismasse) unterhalb der Wasserlinie

3.9

Bemessungseinwirkung

Summe der Bemessungswerte einzelner gleichzeitiger Einwirkungen bei einer kombinierten Einwirkung

3.10

Bemessungsbeständigkeit

Grenzbeständigkeit, die aus faktoriellen repräsentativen Werten von Grundvariablen oder aus faktoriellen Ausdrücken auf Basis nicht faktorieller repräsentativer Werte von Grundvariablen berechnet wird

Anmerkung 1 zum Begriff: Werkstoffeigenschaften sind Beispiele für Grundvariablen, die für die Beständigkeit maßgebend sind.

3.11

Lösen einer Verbindung

Abtrennen

planmäßige Abtrennung der Riser (und der Verankerung, falls zutreffend) von einer schwimmenden Plattform

3.12

Duktilität

Verformbarkeit

Fähigkeit eines Werkstoffs, sich zu verformen und nach Überschreiten seiner Elastizitätsgrenze weiter Energie aufzunehmen, oder die Fähigkeit einer Komponente, Einwirkungen bei Überschreitung ihrer Streckgrenze zu ertragen

Anmerkung 1 zum Begriff: Siehe auch Systemverformbarkeit (3.67).

3.13

dynamische Wirkung

Aktivität, die eine Beschleunigung für ein Bauwerk oder eine strukturelle Komponente in einem so ausreichenden Umfang hervorruft, dass eine bestimmte Beachtung dieser Aktivität erforderlich ist

3.14

dynamische Positionierung

Positionserhaltungstechnik, die hauptsächlich aus einem System an Bord befindlicher automatisch gesteuerter Strahlruder besteht, die entsprechende Schubvektoren erzeugen, welche den mittleren und langsam veränderlichen Einwirkungen entgegenwirken

[QUELLE: ISO 19901-7:2013]

3.15

Lösen einer Verbindung im Notfall

Notfall-Abtrennung

planmäßige Abtrennung der Riser (und der Verankerungen, falls zutreffend) von einer schwimmenden Plattform, ohne dass eine Druckentlastung der Riser erfolgt

3.16

einjähriges Eis

FY-Eis

(en: first-year ice)

während des gegenwärtigen oder vorigen Winters gebildetes Meereis, das keine Sommer-Schmelzsaison überstanden hat

3.17

Scholle

relativ flaches Stück Meereis, das quer über die Scholle mehr als 20 m misst

Anmerkung 1 zum Begriff: Typische Schollenklassen sind: kleine Schollen (Quermaß 20 m bis 100 m), mittlere Schollen (Quermaß 100 m bis 500 m), große Schollen (Quermaß 500 m bis 2 000 m), sehr große Schollen (Quermaß 2 km bis 10 km) und riesig große Schollen (Quermaß mehr als 10 km).

3.18

Förderleitung

Rohrleitung auf dem Meeresboden, die ein Unterwasserbohrloch / mehrere Unterwasserbohrlöcher mit dem Fördersystem verbindet

Anmerkung 1 zum Begriff: Zu den Funktionen einer Förderleitung können neben der Förderung gehören: Injektion (Einpressen), Kontrolle von Unterwassersystemen und Export der geförderten Fluide.

3.19 Freibord

3.19.1

Freibord (Meereisforschung)

senkrechter Abstand zwischen der Wasseroberfläche und der höher liegenden Eisfläche

3.19.2

Freibord (Schiffsmaße)

bei einem bestimmten Tiefgang der senkrechte Abstand von der mittleren Wasseroberfläche bis in Höhe des Freiborddecks, gemessen am niedrigsten Punkt, an dem Wasser in die Plattform oder in das Schiff eindringen kann

3.20

Auftau-Gefrier-Zyklus

möglicher degradierender Einfluss wiederholter Gefriertemperaturzyklen auf Betonoberflächen und Bodeneigenschaften

3.21

Eiswarnung

Eisalarm

vorgeschriebene Reaktion auf vorhergesagte gefährliche Ereignisse unter Mitwirkung von Eis

Anmerkung 1 zum Begriff: Gewöhnlich wird zwischen mehreren Klassen hinsichtlich der zeitlichen Nähe der Gefährdung unterschieden.

Anmerkung 2 zum Begriff: Dieses Dokument ist strikt fokussiert auf Warnungen in Zusammenhang mit Gefährdungen durch Eis. Eiswarnungen stehen in engem Zusammenhang mit anderen Einschränkungen von Betriebsabläufen, einschließlich solcher aufgrund von metocean-, ausrüstungs- oder förderungsbezogenen Betrachtungen, siehe beispielsweise ISO 19905-3.

3.22

Eisgürtel

verstärkter Bereich der Hülle um die Wasserlinie herum wie in Eisklassenanforderungen festgelegt

3.23

Eisberg

großes Eisstück (Höhe über dem Meeresspiegel größer als 5 m), das von einem Gletscher oder vom Schelfeis abgebrochen ist (der Gletscher hat gekalbt)

Anmerkung 1 zum Begriff: Eisberge können frei schwimmen oder aufgelaufen sein; sie werden als Tafelberg, Kuppelberg, als spitznadelige, keil- oder blockförmige Eisberge bezeichnet.

3.24

Eisbedeckungsgrad

Anteil der Wasseroberfläche mit Eisbedeckung

Anmerkung 1 zum Begriff: Der Anteil der Oberflächenbedeckung wird gewöhnlich in Zehnteln ausgedrückt.

3.25

Eiserkennung

Eisdetektion

Unterscheidung (Wahrnehmung) der besonderen Eiseigenschaften (Eiswirkungen) oder der damit verbundenen Bedingungen für die nähere Umgebung

3.26

Vordringen von Eis

Bewegung von Meereis auf die Oberfläche einer Plattform oder künstlichen Insel

Anmerkung 1 zum Begriff: Vordringen von Eis kann aus Vorgängen wie Auflaufen, Auftürmen und Ablaufen von Eis resultieren.

Anmerkung 2 zum Begriff: Vordringen von Eis wird gewöhnlich mit Betriebs- oder Auslegungskriterien in Zusammenhang gebracht.

3.27

Ereignis unter Mitwirkung von Eis

Auftreten einer Wechselwirkung von Eis und Bauwerk, für welches Eiseinwirkungen berechnet werden

Anmerkung 1 zum Begriff: Ereignisse unter Mitwirkung von Eis können das Auftreten von Wechselwirkungen mit einzelnen Eiseinwirkungen, wie z. B. Eisbergen, Eisinseln, Eisdünen, Stamukhas und Eisschollen, oder das Auftreten von Spitzen innerhalb einer festgelegten Länge oder Dauer des Wechselwirkungsprozesses sein.

3.28

Eisrinne

Eisgraben

Eisgang; Eisauskolkung

Einschnitt auf dem Meeresgrund oder Abtragung von Meeresboden durch eine Eiseinwirkung

Anmerkung 1 zum Begriff: Einschnitte können entweder flächig (Eisloch; Eisgrube) oder linienförmig (Furche; Rille) sein.

3.29

Eisinsel

großes tafelförmig geformtes Eisstück, das von Schelfeis oder von einem Gletscher abgebrochen ist

3.30

Eismanagement

Prozesse und Tätigkeiten zu dem Zweck der Verminderung oder Vermeidung von Eiseinwirkungen

Anmerkung 1 zum Begriff: Eismanagement schließt u. a. Eiserkennung, Eisverfolgung, Eisvorhersage, Gefahrenbewertung, Eiswarnung und physikalisches Eismanagement ein.

3.31

Eismanagementplan

ausführlicher Plan zur Umsetzung eines Eismanagementsystems, der die Zielstellungen, die anzuwendenden aktiven Vorgehensweisen und die einzelnen Verantwortlichkeiten darlegt

3.32

Eismanagementsystem

das Eismanagement und die zu seiner Umsetzung angewendeten Mittel

3.33

Eismodellprüfung

skalierte physikalische Prüfung eines Bauwerks oder Bauteils unter kontrollierten Bedingungen

Anmerkung 1 zum Begriff: Das Bauwerk und die Prüfparameter ist / sind gewöhnlich nach Ähnlichkeitsgrundsätzen skaliert (skalierte Modellprüfungen).

Anmerkung 2 zum Begriff: Eismodellprüfungen werden häufig in besonderen Laboratorien durchgeführt, welche als Eistanks oder Eisbecken bezeichnet werden.

3.34

Eisdüne

Eisrücken

Eisgrat

aus Eisblöcken durch Relativbewegung zwischen Eisplatten gebildetes linienförmiges Eisstück

Anmerkung 1 zum Begriff: Presseisrücken entstehen beim Zusammenstoß von Eisplatten; ein Schereisrücken wird gebildet, wenn Eisplatten an einer gemeinsamen Grenzfläche übereinander gleiten.

3.35

Eisszenarium

Kombination verschiedener Umstände im Zusammenhang mit dem Vorhandensein von Eis, die Ereignisse unter Mitwirkung von Eis verursachen

3.36

Ausfüllung

Material, das sich infolge natürlicher Prozesse in einer Eisrinne, einer Eisausschürfung oder einem Eisgraben absetzt

3.37

Festeis

Eis, das an einer Küste, einer Insel oder an aufgelaufenen Eisstücken hängen bleibt

3.38

ebenes Eis

Eisdecke

Eisfläche mit relativ gleichmäßiger Dicke

3.39

lokaler Ausfall

örtlicher Störfall

eine örtliche Beschädigung der Plattform mit Eskalationspotenzial bis zu einem teilweisen oder vollständigen Ausfall

3.40

niedrigste erwartete Betriebstemperatur

LAST

(en: lowest anticipated service temperature)

über 3 Stunden gemittelte EL-Lufttemperatur in einer Höhe von 30 m

Anmerkung 1 zum Begriff: EL wird in 7.2.2.6 definiert.

Anmerkung 2 zum Begriff: Für die Anwendung dieses Dokuments wird hierin das LAST-Konzept nach ISO 19902 explizit definiert, damit es auf Offshore-Bauwerke im Arktis-Bereich anwendbar ist.

3.41

Matte

künstlich hergestellte beschwerte Plattenkonstruktion, die zur Stabilisierung von Böden oder Unterwasserkomponenten verwendet wird

3.42

Werkstofffaktor

Teilsicherheitsbeiwert, der auf den charakteristischen Wert einer Werkstoffeigenschaft angewendet wird

3.43

Mudline-Keller

künstlicher Ausschachtungsbereich im Meeresgrund zum Schutz von Unterwasserkonstruktionen oder Ausrüstung gegen Beschädigungen durch Eis

3.44

mehrfähriges Eis

MY-Eis

(en: multi-year ice)

Meereis, das mindestens zwei Sommer-Schmelzsaisons überstanden hat

3.45

altes Eis

Meereis, das mindestens eine Sommer-Schmelzsaison überstanden hat

Anmerkung 1 zum Begriff: Altes Eis schließt sowohl zweijähriges als auch mehrjähriges Eis ein.

3.46

Packeis

Meereis, das aus diskreten Schollen besteht, die kein Festeis sind

3.47

Wirkungen von treibendem Packeis

Wirkungen, die von dem umgebenden Meereis auf die Plattform oder auf Eis ausgeübt werden, das mit der Plattform in Kontakt kommt

3.48

Dauerfrost

Erde (Boden oder Gestein), die für mindestens zwei aufeinander folgende Jahre eine Temperatur von 0 °C oder von unter 0 °C beibehält

3.49

Polynja

von Meereis umgebener Bereich offenen Wassers, der durch ständige Winde, Meeresströmungen oder auftreibendes warmes Wasser verursacht wird

3.50

Schiebeeis

Eis, das durch Überlagerung von zwei oder mehr Eisdeckenlagen gebildet wird

3.51

anerkannte Klassifizierungsgesellschaft

RCS

(en: recognized classification society)

Mitglied der International Association of Classification Societies (IACS) mit anerkannter und relevanter Kompetenz und Erfahrung, das zur Klassifizierung / Zertifizierung von Bauwerken in arktischen und kalten Zonen oder für Schiffe der Eisklasse, die für Aktivitäten im Zusammenhang mit Erdöl / Erdgas eingesetzt werden, festgelegte Regeln und Verfahren verfügbar hat

3.52

Zuverlässigkeitsziel

festgelegte mittlere jährliche Zuverlässigkeit in Verbindung mit Ausfallvermeidung

3.53

Eisrückenkiel

Anteil eines Eisrückens, der sich unterhalb der Wasserlinie befindet

Anmerkung 1 zum Begriff: Ein Eisrückenkiel kann aus einer erstarrten und aus einer nicht erstarrten Schicht bestehen.

3.54

Eisrückensegel

Eisrückenturm

Anteil eines Eisrückens, der sich oberhalb der Wasserlinie befindet

3.55

Trümmereisfeld

Bereich mit gebrochenen Eisblöcken, die aufeinander aufschwimmen und einen durchgängigen Körper bilden, im Allgemeinen zusammengefroren

3.56

Brucheisstapel

Trümmereishaufen

aus zerbrochenen, im Allgemeinen zusammengefrorenen Eisblöcken zusammengesetztes Eis mit eher flächigen als linearen Ausmaßen

Anmerkung 1 zum Begriff: Siehe auch Stamukha (3.64), der Benennung für aufgelaufene Trümmereishaufen.

3.57

sicherheitskritisches Element

Ausrüstungsgegenstand, Verfahren oder Bauwerk, dessen Ausfall zu einem schweren Unfall führen kann oder das zu dem Zweck angewendet wird, die Folgen eines schweren Unfalls zu verhindern oder einzugrenzen

3.58

Meeresgrund

Material unterhalb der Höhe des Meeresbodens oder des Ozeanbodens

3.59

Kolk

Unterwaschung

Ausspülung

Abtragung von Boden vom Meeresgrund durch Strömungen und Wellen

3.60

Meeresboden

der Grenzbereich zwischen dem Meer und dem Meeresgrund

3.61

saisonabhängiger Betrieb

Betrieb einer Plattform während einer ausgewählten Dauer im Verlauf des Jahres, im Allgemeinen zur Vermeidung ungünstiger Eisbedingungen

3.62

zweijähriges Eis

Meereis, das die Sommer-Schmelzsaison überstanden hat

3.63

Schelfeis

Meereis, das mit einem im Meer endenden Gletscher fest verbunden ist

3.64

Stamukha

aufgelaufenes Eis, das aus Brucheis oder Trümmereis besteht

3.65

ortsfestes schwimmendes Bauwerk

schwimmende Einheit, die durch Verankerungen oder dynamische Positionierung in ihrer Lage gehalten wird

BEISPIELE Schiffsförmige Wasserfahrzeuge, spieren- und bojenförmige Plattformen.

3.66

Strudelkolk

Strudelausspülung

Einschnitt auf dem Meeresgrund, der als Folge eines natürlichen Wasserabflusses durch Löcher im Eis verursacht wird

Anmerkung 1 zum Begriff: Strudelausspülungen sind im Allgemeinen in Flussdeltas anzutreffen, wenn Süßwasser auf die Oberfläche von Meereis fließt.

3.67

Systemverformbarkeit

Fähigkeit einer Plattform zur Verformung und zum Energieverbrauch unter Berücksichtigung der Duktilität der Werkstoffe und der Fähigkeit struktureller Komponenten zur Aufnahme nicht elastischer Lasten und zur strukturellen Redundanz

3.68

nicht erstarrte (nicht verfestigte) Eisschicht

nicht erstarrte (nicht verfestigte) Trümmereisschicht

Teil eines Eistrückenkiels oder Teil von Trümmereis, der unter der erstarrten Schicht liegt, die aus nicht oder nur leicht miteinander verbundenen Eisblöcken besteht

4 Symbole und Abkürzungen

4.1 Symbole

A	unbeabsichtigte (Ein-)Wirkung
E	Umwelt(ein-)wirkung
f_c	Druckfestigkeit des Betons
f_y	charakteristischer Wert für die Streckgrenze
G	Dauer(ein-)wirkung
G_1	schwerkraftbezogene und hydrostatische Dauer(ein-)wirkung
G_2	verformungsbezogene Dauer(ein-)wirkung
Q	veränderliche (Ein-)Wirkung
Q_1	langzeitig veränderliche (Ein-)Wirkung
Q_2	kurzzeitig veränderliche (Ein-)Wirkung
γ_s	Widerstandsbeiwert für Stahl
γ_c	Widerstandsbeiwert für Beton
η	Effizienzfaktor für Beton

4.2 Abkürzungen

AL	anormales Niveau (en: abnormal-level)
ALE	Erdbeben mit anormaler Stärke (en: abnormal-level earthquake)
ALIE	Ereignis unter Mitwirkung von Eis mit anormalem Niveau (en: abnormal-level ice event)
ALS	anormaler (nicht vorgesehener) Grenzzustand (en: abnormal (accidental) limit state)
BWL	Ballast-Wasserlinie (en: ballast waterline)
CPT	Drucksondierprüfung (en: cone penetrometer test)
DP	dynamische Positionierung (en: dynamic positioning)
EER	Flucht, Evakuierung und Rettung (en: escape, evacuation and rescue)
EL	extremes Niveau (en: extreme-level)
ELE	Erdbeben mit extremer Stärke (en: extreme-level earthquake)
ELIE	Ereignis unter Mitwirkung von Eis bei einem extremen Niveau (en: extreme-level ice event)
FE	finites Element (en: finite element)
FLS	Ermüdungs-Grenzzustand; Grenzzustand der Dauerhaftigkeit (en: fatigue limit state)
FPSO	schwimmende Anlage zur Produktion, Lagerung und Verladung (en: floating production, storage and offloading facility)
FSU	schwimmendes Lager (en: floating storage unit)
FY	einjährig, bezogen auf Eis (en: first-year, with reference to ice)
GBS	auf dem Meeresboden stehende Plattform (en: gravity-based structure)
HAZID	Gefahrenerkennung (en: hazard identification)
HPZ	Hochdruckzone (en: high pressure zone)
HSE	Gesundheit, Sicherheit und Umwelt (en: health, safety and environment)
HVAC	Heizung, Lüftung und Klimatechnik (en: heating, ventilating and air conditioning)
IM	Eismanagement (en: ice management)
IMO	Internationale Seeschiffahrtsorganisation (en: International Maritime Organization)
LAST	niedrigste erwartete Betriebstemperatur (en: lowest anticipated service temperature)
MY	mehrfjährig, bezogen auf Eis (en: multi-year, with reference to ice)
MIZ	Eisrandzone (en: marginal ice zone)
NA	nicht anwendbar (en: not applicable)

ND	keine Daten (en: no data)
NDT	zerstörungsfreie Prüfung (en: non-destructive testing)
QC	Qualitätslenkung (en: quality control)
RCS	anerkannte Klassifizierungsgesellschaft (en: recognized classification society)
SAL	Einzelankerbelastung (en: single anchor loading)
SALM	Einzelanker-Leg-Verankerung (en: single anchor leg mooring)
SLIE	Ereignis unter Mitwirkung von Eis beim Gebrauchstauglichkeits-Niveau (en: serviceability-level ice event)
SLS	Grenzzustand der Gebrauchstauglichkeit (en: serviceability limit state)
SPM	Einpunktverankerung (en: single point mooring)
SSI	Boden-Bauwerk-Wechselwirkung (en: soil-structure interaction)
STL	Unterwasser-Drehgestell-Belastung (en: submerged turret loading)
TLP	Tension-Leg-Plattform (en: tension leg platform)
ULS	Grenzzustand der Tragfähigkeit (en: ultimate limit state)
WMO	Weltorganisation für Meteorologie (en: World Meteorological Organization)

Nationaler Anhang NB (informativ)

Literaturhinweise

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

DIN EN ISO 19900:2014, *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 19901-3, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen an Offshore-Anlagen — Teil 3: Topsides structure*

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

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

DIN EN ISO 19901-7, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen an Offshore-Anlagen — Teil 7: Betriebssysteme für das Positionshalten schwimmender Anlagen und mobiler Offshore-Einheiten*

DIN EN ISO 19901-8, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 8: Meeresbodenuntersuchungen*

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

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

DIN EN ISO 19904-1, *Erdöl- und Erdgasindustrie — Schwimmende Offshore-Anlagen — Teil 1: Produktions- und Lagerungsanlagen außer Tension-Leg-Anlagen*

— Leerseite —

Contents

page

Foreword	viii
Introduction.....	x
1 Scope.....	11
2 Normative references	11
3 Terms and definitions	12
4 Symbols and abbreviated terms	19
4.1 Symbols	19
4.2 Abbreviated terms	19
5 General requirements and conditions.....	21
5.1 Fundamental requirements	21
5.2 Design methods.....	21
5.3 Site-specific considerations.....	22
5.4 Construction, transportation and installation.....	23
5.5 Operational considerations	24
5.6 Environmental protection	24
5.7 Serviceability requirements including vibrations	24
5.8 Decommissioning and reclamation.....	25
6 Physical environmental conditions	25
6.1 General.....	25
6.2 Daylight hours.....	26
6.3 Meteorology.....	26
6.4 Oceanography	27
6.5 Sea ice and icebergs.....	28
6.6 Seabed considerations.....	30
7 Reliability and limit states design	30
7.1 Design philosophy.....	30
7.2 Limit states design method	32
8 Events and actions	38
8.1 General.....	38
8.2 Ice events and actions.....	39
8.3 Metocean related actions	44
8.4 Seismic actions	47
9 Foundation design.....	48
9.1 General.....	48
9.2 Geotechnical data acquisition and identification of hazards.....	48
9.3 Characteristic values of soil properties.....	49
9.4 Design considerations	50
9.5 Gravity-based structures.....	52
9.6 Piled structures	53
9.7 Design of anchors for floating structures	53
9.8 Scour	55
9.9 Inspection and performance monitoring	56
9.10 Seismic analysis.....	56
10 Man-made islands	56
10.1 General.....	56
10.2 Island types	57
10.3 Design considerations	57

10.4	Seismic design.....	64
10.5	Construction	64
10.6	Monitoring and maintenance	65
10.7	Decommissioning and reclamation.....	66
11	Fixed steel structures.....	67
11.1	General.....	67
11.2	General design requirements.....	67
11.3	Structural modelling and analysis	68
11.4	Strength of tubular members and joints.....	68
11.5	Strength of stiffened-plate panels	68
11.6	Strength of steel-concrete composite walls.....	69
11.7	Seismic design.....	71
11.8	Fatigue.....	72
11.9	Materials, testing and NDT	72
11.10	Corrosion and abrasion protection.....	73
11.11	Welding.....	73
12	Fixed concrete structures.....	73
12.1	General requirements.....	73
12.2	Actions and action effects	74
12.3	Structural analysis	74
12.4	Concrete works.....	76
12.5	Mechanical systems.....	83
12.6	Marine operations and construction afloat	84
12.7	Corrosion control	84
12.8	Inspection and condition monitoring	84
13	Floating structures.....	84
13.1	General.....	84
13.2	General design methodology	85
13.3	Environment.....	87
13.4	Actions	87
13.5	Hull integrity	91
13.6	Hull stability	93
13.7	Stationkeeping.....	93
13.8	Mechanical systems.....	97
13.9	Operations.....	100
14	Subsea production systems	102
14.1	General.....	102
14.2	Ice and seabed considerations.....	102
14.3	Actions on subsea production systems	104
14.4	Seismic design.....	106
14.5	Risk reduction.....	106
15	Topsides.....	107
15.1	Overall considerations	107
15.2	Design and operational requirements	110
15.3	Seismic design.....	119
16	Other ice engineering topics	121
16.1	Ice roads and supplies over ice.....	121
16.2	Man-made ice islands	124
16.3	Protection barriers	124

16.4	Measurements of ice pressure and actions.....	127
16.5	Ice model tests.....	128
16.6	Offloading in ice.....	129
17	Ice management.....	130
17.1	General.....	130
17.2	Ice management system	131
17.3	Particular considerations for floating structures.....	133
18	Escape, evacuation and rescue	133
18.1	General.....	133
18.2	EER philosophy	133
18.3	EER strategy	134
18.4	Environmental conditions	134
18.5	Hazard and risk analysis.....	134
18.6	EER system.....	134
18.7	Escape design.....	135
18.8	Evacuation design	135
18.9	Rescue design.....	135
	Annex A (informative) Additional information and guidance	136
A.1	Scope	136
A.2	Normative references	136
A.3	Terms and definitions.....	136
A.4	Symbols and abbreviated terms	137
A.5	General requirements and conditions.....	146
A.6	Physical environmental conditions	147
A.7	Reliability and limit states design	166
A.8	Events and actions	175
A.9	Foundation design.....	257
A.10	Man-made islands	264
A.11	Fixed steel structures.....	279
A.12	Fixed concrete structures.....	281
A.13	Floating structures.....	290
A.14	Subsea production systems	308
A.15	Topsides.....	316
A.16	Other ice engineering topics	323
A.17	Ice management.....	367
A.18	Escape, evacuation and rescue	373
	Annex B (informative)	374
B.1	Introduction to regional information	374
B.2	Baffin Bay and Davis Strait.....	375
B.3	Labrador	384
B.4	Newfoundland	387
B.5	Canadian Arctic Archipelago	390
B.6	North East Greenland.....	395
B.7	Beaufort Sea	402
B.8	Chukchi Sea.....	406
B.9	Bering Sea.....	414
B.10	Cook Inlet	419
B.11	Okhotsk Sea	423
B.12	Tatar Strait.....	430

B.13 Bohai Sea 434

B.14 North Caspian 437

B.15 Baltic Sea 442

B.16 Barents Sea 449

B.17 Kara Sea 456

B.18 Laptev Sea 462

B.19 East Siberian Sea..... 470

B.20 Black Sea..... 478

B.21 Sea of Azov 485

Bibliography 492

Foreword

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

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

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

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

ISO 19906 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

This second/third/... edition cancels and replaces the first/second/... edition (ISO 19901-2:2004), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

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 voluntary nature of standards, the meaning of ISO-specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

This second edition cancels and replaces the first edition (ISO 19906:2010), which has been technically revised.

ISO 19906 is one of a series of documents for offshore structures. The full series consists of the following documents.

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

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

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

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

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

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

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

Introduction

The series of documents ISO 19900 to ISO 19906 addresses design requirements and assessments for 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, regardless of 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 documents applicable to the various types of offshore structure is intended to provide wide latitude in the choice of structural configurations, materials and techniques without hindering innovation. Sound engineering judgment is, therefore, necessary in the use of these documents.

This document was developed in response to the offshore industry's demand for a coherent and consistent definition of methodologies to design, analyse and assess arctic and cold region offshore structures within the scope of Clause 1.

Structures capable of resisting ice have been in use in temperate regions for well over a century. These include bridge piers and navigation aids in ice-covered rivers and estuaries. In fact, bridge codes in cold countries have included methods for addressing ice loads dating back many decades. In more severe arctic and cold regions, ice-resistant structures are more recent. But much experience has been gained commencing in the 1960s, and this knowledge is incorporated into this document. Where uncertainties still exist, conservative approaches and methods have been recommended.

This document also addresses issues, such as topsides winterization, and escape, evacuation and rescue, that go beyond what is strictly necessary for the design, construction, transportation, installation and decommissioning of the structure. These issues are essential for offshore operations in arctic and cold region conditions and they are not covered in other documents. When future editions of ISO 19906 and other documents are prepared, efforts will be made to avoid duplication of scope.

Annex A provides background to and guidance on the use of this document and it is intended that it be read in conjunction with the main body of this document. The clause numbering in Annex A follows the numbering in the normative text to facilitate cross-referencing.

Annex B provides regional information on the physical environment of specific offshore areas in arctic and cold regions.

Some symbols in this document are not in accordance with the system of quantities on which the International System of Units is based, due to the need to conform with current ice literature. This might change in future editions of this document.

To meet certain needs of industry for linking software to specific elements in this document, a special clause-based numbering system has been permitted for figures, tables and formulae.

Petroleum and natural gas industries — Arctic offshore structures

1 Scope

This document specifies requirements and provides recommendations and guidance for the design, construction, transportation, installation and decommissioning of offshore structures related to the activities of the petroleum and natural gas industries in arctic and cold regions. Reference to arctic and cold regions in this document is deemed to include both the Arctic and other locations characterized by low ambient temperatures and the presence or possibility of sea ice, icebergs, icing conditions, persistent snow cover, and/or permafrost.

The objective of this document is to ensure that complete structures, including substructures, topsides structures, floating production vessel hulls, foundations and mooring systems, in arctic and cold regions provide an appropriate level of reliability with respect to personnel safety, environmental protection and asset value. Value includes value to the owner, to the industry and to society in general.

This document does not contain requirements for the operation, maintenance, service-life inspection or repair of arctic and cold region offshore structures, unless the design strategy imposes specific requirements such as ice management to reduce ice actions.

While this document does not apply specifically to mobile offshore drilling units (see ISO 19905-1), the procedures relating to ice actions and ice management contained herein are applicable to the assessment of such units.

This document does not apply to mechanical, process and electrical equipment or any specialized process equipment associated with arctic and cold region offshore operations except in so far as it is necessary for the structure to sustain safely the actions imposed by the installation, housing and operation of such equipment.

2 Normative references

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

ISO 17776, *Petroleum and natural gas industries — Offshore production installations — Guidelines on tools and techniques for hazard identification and risk assessment*

ISO 19900:2013, *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 19901-3, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 3: Topsides structure*

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

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

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

ISO 19901-8, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 8: Marine soil investigations*

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

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

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

ISO 35101, *Petroleum and natural gas industries — Arctic operations — Working environment*

ISO 35102, *Petroleum and natural gas industries — Arctic operations — Escape, evacuation and rescue from offshore installations*

ISO 35104, *Petroleum and natural gas industries — Arctic operations — Ice management*

ISO 35106, *Petroleum and natural gas industries — Arctic operations — Arctic metocean, ice, and seabed data*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19900:2013, ISO 19901-1, ISO 19901-2, ISO 19901-4, ISO 35102, ISO 35104, ISO 35106 and the following apply.

3.1

abrasion

effect of ice grinding against the surface of a structure thus removing paint, surface protrusions and coatings, oxidized material, or concrete particles and aggregate

3.2

action combination

expression in which design values of individual simultaneous actions for a design situation are summed to obtain the total design action for the verification of the reliability of a structure for a specific limit state

3.3

adfreeze

freezing of ice or soil onto the surface of a structure

3.4

aspect ratio

ratio of structure diameter or width to ice thickness

3.5

broken ice

ice pieces of varying size, broken up as a result of natural processes, or active or passive intervention

Note 1 to entry: Active intervention includes ice management resulting in managed ice; passive intervention includes the channel, or wake, caused by a stationary structure in moving ice cover.

3.6

companion environmental action

environmental action applied simultaneously with the principal environmental action

3.7

consolidation

process of freezing of pore water in voids within ice rubble or between floes

Note 1 to entry: For soils, consolidation involves drainage of pore fluid as a result of overburden pressures.

3.8

consolidated layer

portion of an ice ridge keel, rubble pile, rubble field or stamukha below the waterline formed by the ice consolidation process

3.9

design action

sum of design values of individual simultaneous actions for an action combination

3.10

design resistance

resistance limit calculated from factored representative values of basic variables, or from factored expressions based on unfactored representative values of basic variables

Note 1 to entry: Material properties are examples of basic variables relevant to resistance.

3.11

disconnection

planned separation of the risers (and mooring, if applicable) from a floating structure

3.12

ductility

ability of a material to deform and absorb energy beyond its elastic limit or ability of a component to sustain action effects beyond yield

Note 1 to entry: See also *system ductility* (3.67).

3.13

dynamic action

action that induces acceleration of a structure or a structural component of a magnitude sufficient to require specific consideration

3.14

dynamic positioning

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

[SOURCE: ISO 19901-7:2013]

3.15

emergency disconnection

planned separation of the risers (and mooring, if applicable) from a floating structure, without depressurization of the risers

3.16

first-year ice

FY ice

sea ice formed during the current or prior winter that has not survived one summer melt season

3.17

floe

relatively flat piece of sea ice greater than 20 m across

Note 1 to entry: There are typically sub-categories of floe: small (20 m to 100 m across), medium (100 m to 500 m across), big (500 m to 2 000 m across), vast (2 km to 10 km across) and giant (greater than 10 km across).

3.18

flowline

pipings on the sea floor linking one or more subsea wells to the production system

Note 1 to entry: Flowline functions can include production, injection, subsea systems control and export of produced fluids.

3.19 Freeboard

3.19.1

freeboard

vertical distance from the water surface to the top of the ice

3.19.2

freeboard

vertical distance from the mean water surface at a given draught to the deck level, measured at the lowest point where water can enter the structure or ship

3.20

freeze-thaw

possible degradation effect of repeated freezing temperature cycles on concrete and soil properties

3.21

ice alert

prescribed reaction to a forecast hazardous ice event

Note 1 to entry: Several different levels associated with the time proximity of the hazard are normally recognized.

Note 2 to entry: Focus in this document is strictly on alerts related to ice hazards. Ice alerts are linked closely with other constraints on operating protocols, including those due to metocean, equipment or production considerations, see for example ISO 19905-3.

3.22

ice belt

strengthened hull region around the waterline, as specified in ice class requirements

3.23

iceberg

glacial or shelf ice of greater than 5 m freeboard that has broken (calved) away from its source

Note 1 to entry: Icebergs can be freely floating or grounded, and are sometimes defined as tabular, dome, pinnacle, wedge or block-shaped.

3.24

ice concentration

proportion of the water surface covered by ice

Note 1 to entry: The proportion of surface coverage is usually expressed in tenths.

3.25

ice detection

discrimination of ice features or associated conditions from the surrounding environment

3.26

ice encroachment

movement of sea ice onto the surface of a platform or man-made island

Note 1 to entry: Ice encroachment can result from ice ride-up, pile-up, and ride-down processes.

Note 2 to entry: Ice encroachment is typically associated with operational or design criteria.

3.27

ice event

occurrence of ice-structure interaction for which ice actions are calculated

Note 1 to entry: Ice events can be occurrences of interactions with discrete ice features such as icebergs, ice islands, ice ridges, stamukhi and ice floes, or can be occurrences of peaks within a specified length or duration of the interaction process.

3.28

ice gouge

ice scour

incision in the seabed or removal of seabed soils by an ice feature

Note 1 to entry: Incisions can have the form of either an areal incision (pit) or a linear incision (furrow).

3.29

ice island

large tabular-shaped ice feature that has calved from an ice shelf or glacier

3.30

ice management

processes and activities whose objective is to reduce or avoid ice actions

Note 1 to entry: Ice management includes, but is not limited to, detection, tracking, ice forecasting, threat evaluation, alerting and physical management.

3.31

ice management plan

detailed plan outlining the objectives, active procedures involved and individual responsibilities for the implementation of an ice management system

3.32

ice management system

ice management and the tools used for its implementation

3.33

ice model test

scaled physical testing of a structure or a component under controlled conditions

Note 1 to entry: The structure and test parameters are normally scaled according to some similitude principles (scaled model tests).

Note 2 to entry: Ice model tests are often carried out in special laboratories which are called ice tanks or ice basins.

3.34
ice ridge

linear feature formed of ice blocks created by the relative motion between ice sheets

Note 1 to entry: Ice pressure ridges are formed when ice sheets are pushed together, and a shear ice ridge is formed when ice sheets slide along a common boundary.

3.35
ice scenario

combination of circumstances involving the presence of ice, resulting in ice events

3.36
infill

material deposited in an ice gouge, excavation or trench through natural processes

3.37
landfast ice

fast ice

ice that remains attached to a shoreline, island or grounded ice feature

3.38
level ice
sheet ice

region of ice with relatively uniform thickness

3.39
local failure

localized damage to the structure with the potential for escalating to partial or complete failure

3.40
lowest anticipated service temperature
LAST

3-hourly average extreme-level (EL) low air temperature at 30 m elevation

Note 1 to entry: EL is described in 7.2.2.6.

Note 2 to entry: For the purposes of this document, the concept of LAST presented in ISO 19902 is defined here in an explicit manner for applicability to arctic offshore structures.

3.41
mat

man-made weighted sheet structure used for the stabilization of soils or subsea components

3.42
material factor

partial safety factor applied to the characteristic value of a material property

3.43
mudline cellar

man-made areal excavation in the seabed used to protect subsea structures or equipment from ice damage

3.44
multi-year ice
MY ice

sea ice that has survived at least two summers' melt seasons

3.45
old ice

sea ice that has survived at least one summer's melt season

Note 1 to entry: Old ice includes both second-year ice and multi-year ice.

3.46
pack ice

sea ice consisting of discrete floes that is not landfast

3.47
pack ice driving actions

actions exerted by the surrounding sea ice on the structure or to an ice feature in contact with it

3.48
permafrost

ground (soil or rock) remaining at or below 0 °C for at least two consecutive years

3.49
polynya

area of open water surrounded by sea ice, caused by persistent winds, currents or upwelling of warm water

3.50
rafted ice

ice feature formed from the superposition of two or more ice sheet layers

3.51
recognized classification society
RCS

member of the International Association of Classification Societies (IACS), with recognized and relevant competence and experience, and with established rules and procedures for classification/certification of arctic and cold region structures or ice class vessels used in petroleum and natural gas activities

3.52
reliability target

specified average annual reliability associated with avoiding failure

3.53
ridge keel

portion of an ice ridge that extends below the waterline

Note 1 to entry: A ridge keel can consist of a consolidated layer and an unconsolidated layer.

3.54
ridge sail

portion of an ice ridge that extends above the waterline

3.55
rubble field

region of broken ice blocks floating together as a continuous body, generally frozen together

3.56

rumble pile

ice feature of areal, rather than linear, extent, composed of blocks of broken ice generally frozen together

Note 1 to entry: See also *stamukha* (3.64), the term for a grounded rumble pile.

3.57

safety-critical element

item of equipment, procedure or structure whose failure can lead to a major accident or whose purpose is to prevent or limit the consequences of a major accident

3.58

seabed

material below the elevation of the sea floor or ocean floor

3.59

scour

removal of seabed soils by currents and waves

3.60

sea floor

interface between the sea and the seabed

3.61

seasonal operation

operation of a structure during a selected period during the course of the year, generally to avoid particular ice conditions

3.62

second-year ice

sea ice that has survived one summer's melt season

3.63

shelf ice

sea ice formed adjacent to a glacier terminating in the ocean

3.64

stamukha

grounded ice feature composed of broken ice pieces or rumble

3.65

stationary floating structure

floating unit kept in position by moorings or dynamic positioning

EXAMPLES: Ship-shaped vessels, spar, buoy-shaped platforms.

3.66

strudel scour

incision in the seabed caused by a natural water jet draining through holes in the ice

Note 1 to entry: Strudel scours are usually found in river deltas when freshwater flows on the surface of sea ice.

3.67

system ductility

ability of a structure to deform and dissipate energy which takes into account material ductility, the ability of structural components to maintain inelastic load-carrying capacity and structural redundancy

3.68

unconsolidated layer

unconsolidated rubble layer

part of an ice ridge keel or ice rubble found below the consolidated layer that consists of unbonded or very weakly bonded ice blocks

4 Symbols and abbreviated terms

4.1 Symbols

A	accidental action
E	environmental action
f_c	concrete compressive strength
f_y	characteristic yield strength
G	permanent action
G_1	gravity and hydrostatic permanent action
G_2	deformation permanent action
Q	variable action
Q_1	long-duration variable action
Q_2	short-duration variable action
γ_s	steel resistance factor
γ_c	concrete resistance factor
η	concrete efficiency factor

4.2 Abbreviated terms

AL	abnormal-level
ALE	abnormal-level earthquake
ALIE	abnormal-level ice event
ALS	abnormal (accidental) limit state
BWL	ballast waterline
CPT	cone penetrometer test
DP	dynamic positioning
EER	escape, evacuation and rescue
EL	extreme-level
ELE	extreme-level earthquake

ELIE	extreme-level ice event
FE	finite element
FLS	fatigue limit state
FPSO	floating production, storage and offloading facility
FSU	floating storage unit
FY	first-year, with reference to ice
GBS	gravity-based structure
HAZID	hazard identification
HPZ	high pressure zone
HSE	health, safety and environment
HVAC	heating, ventilating and air conditioning
IM	ice management
IMO	International Maritime Organization
LAST	lowest anticipated service temperature
MY	multi-year, with reference to ice
MIZ	marginal ice zone
NA	not applicable
ND	no data
NDT	non-destructive testing
QC	quality control
RCS	recognized classification society
SAL	single anchor loading
SALM	single anchor leg mooring
SLIE	serviceability-level ice event
SLS	serviceability limit state
SPM	single point mooring
SSI	soil-structure interaction

STL	submerged turret loading
TLP	tension leg platform
ULS	ultimate limit state
WMO	World Meteorological Organization

5 General requirements and conditions

5.1 Fundamental requirements

Offshore structures for use in arctic and cold regions shall be planned, designed, constructed, transported, installed and decommissioned in accordance with ISO 19900 supplemented by this document.

Physical environmental parameters shall be determined in accordance with ISO 19901-1, ISO 35106 and the further requirements of this document. Seismic events shall be characterized in accordance with ISO 19901-2. Marine soil investigations for characterization of the seabed soil conditions and for geohazard evaluation shall be performed in accordance with ISO 19901-4 and ISO 19901-8.

Actions, action effects and resistances for steel, concrete and floating structures shall be determined in accordance with ISO 19902, ISO 19903 and ISO 19904-1 respectively, and according to the further requirements of this document. Foundation behaviour shall be determined in accordance with ISO 19901-4. Requirements for marine operations, stationkeeping and topsides in arctic and cold regions are provided to complement the requirements of ISO 19901-6, ISO 19901-7 and ISO 19901-3 respectively. Seismic actions shall be determined in accordance with ISO 19901-2.

This document provides requirements, recommendations and guidance on ice-related parameters for the above structure types and for particular structures such as man-made islands. The above documents should be used jointly to develop appropriate physical environmental parameters, actions, resistances and designs.

The structure and all its subsystems shall be designed to allow for operation in a safe and environmentally sound manner. Conditions that can influence the functional and operational requirements shall be identified. Design aspects influencing the health and safety of personnel and the state of the biological environment throughout the design service life shall be identified and addressed appropriately.

5.2 Design methods

For designs performed in accordance with the design process and limit states verification procedure provided in this document, levels of safety and performance are established in Clause 7.

An alternative rational design method based on theory, analysis, and recognized engineering practice may be used in lieu of the design process and formulae provided in this document, provided that levels of safety and performance are at least equal to those established in Clause 7.

Where possible, data from full-scale measurements of ice actions shall be used to verify new designs. Physical models and mathematical models may also be used to determine the response of structures to ice actions, in combination with ocean current, wind and wave actions. If ice model tests are used in

design process, the designer is advised to seek independent verification of the results obtained and also seek expert guidance regarding the most appropriate physical ice modelling techniques.

5.3 Site-specific considerations

5.3.1 Hazards

All hazards that can be reasonably foreseen during all phases of the design service life shall be identified and evaluated, see ISO 19900:2013, subclause 5.6.

Identification, investigation and determination of site-specific conditions for sea ice and icebergs shall be made in accordance with ISO 35106, with due consideration to the phenomena and effects described in 6.5 and 8.2.

Hazards can also include low ambient temperature, icing conditions, snow and ice accumulation, ice encroachment and permafrost.

5.3.2 Climate change

Changes in storm frequency and magnitude, ice conditions, ocean circulation, air temperatures, permafrost, wave heights and water levels can occur during the design service life of the structure. Consideration for such changes should be included in the design.

5.3.3 Structural configuration

In addition to functionality, the configuration of the structure should consider the following:

- a) robustness in abnormal and accidental design situations;
- b) protection of risers and conductors;
- c) arrangement and operation of the stationkeeping system;
- d) concept for oil storage and export;
- e) wet or dry storage system;
- f) layout of facilities and separation distances from hazards;
- g) potential for future expansion under phased development;
- h) potential for platform removal;
- i) environmental constraints;
- j) capability of local construction facilities and materials;
- k) available construction season for offshore operations;
- l) marine access, for e.g. re-supply, offloading and EER.

Consideration should be given to choices for structural configuration (e.g. plan shape, profile), orientation, and operational measures where relevant for reducing the frequency of ice events and mitigating ice action effects.

In defining the orientation of the structure at the site, consideration should be given to the ice conditions, prevailing wind and ice drift directions, and the potential for ice rubble build-up. The topsides should be arranged with respect to the functional and operational requirements, such as re-supply, offloading, flaring and EER, and with respect to wind and ice encroachment.

The reliability of EER, platform supply, and offloading systems can potentially be improved through

ice management of large ice features,
methods to reduce ice rubble accumulation,
use of large crane booms to reach over accumulated rubble, and
duplication of facilities on opposite sides of the platform.

5.3.4 Winterization

Winterization measures should be considered to ensure the safe operation of all systems and equipment, thereby ensuring the safety of personnel. Such measures shall also ensure that personnel can conduct the required tasks in an ergonomically sound way with respect to temperature, wind, visibility and restrictions imposed by personal protective equipment. Further guidance is provided in ISO 35101. Selected options should not result in adverse environmental consequences, see 5.1.

5.4 Construction, transportation and installation

5.4.1 General

The construction, transportation and installation of offshore structures shall be planned to minimize the risks to personnel and equipment due to adverse environmental conditions associated with cold regions.

5.4.2 Construction planning

The planning of construction activities shall include adequate consideration for periods of low ambient temperatures. Materials and equipment shall be adequately protected by the provision of heating or insulation.

5.4.3 Transportation and installation

Evaluation of minimal draft limitations shall be performed for all regions through which the structure can be transported in order to reach its final destination.

Consideration shall be given to the specification of all marine spread equipment and the ability of personnel to safely perform the required transportation and installation activities during periods of low ambient temperature, low visibility and other relevant environmental conditions. Limiting environmental conditions shall be specified for all critical offshore activities, and the associated weather windows shall be included in the planning and execution of such work. Contingency planning for all critical offshore activities shall be included to ensure safe transportation and installation.

Marine operations associated with the transportation and installation of the structure shall be in accordance with ISO 19901-6.

5.5 Operational considerations

If operational procedures such as ice management and, for floating structures, disconnection are planned with respect to prevailing or anticipated ice conditions and hazards, ice actions can be mitigated or the frequency of ice events can be reduced, see 8.2.7.

The implementation of an ice alert system, see 13.2.4 (for floating structures) and 17.2.2, and ice alert response plans, see 17.2.3, should be considered in support of the design approach to ice actions if one or more of the following applies:

- a) operational procedures related to ice conditions and hazards are planned;
- b) uncertainties in ice events and actions are significant;
- c) there is a possibility of very unlikely, high consequence ice events.

5.6 Environmental protection

The environment in arctic and cold regions can be more sensitive and vulnerable to pollution than other environments. Structures intended for such environments shall be designed to minimize the potential for polluting the environment as far as is reasonably practicable.

A structure should be designed to contain spills that can result in release of contaminants to the environment. Structural systems requiring active operations to avoid pollution should be kept to a minimum. Harmful environmental impacts should also be minimized in the construction, transportation, installation and decommissioning phases.

Special attention should be given to containing fluids and materials used for commissioning in order to avoid potential harmful releases to the environment.

Fluids and materials that, if released, can pollute the environment shall be contained in tanks having double barriers. The structure shall be designed to facilitate environmental monitoring, which is addressed in ISO 35103. A protocol should be established for inspection, maintenance and repair of any tanks containing fluids or materials that possibly can pollute.

Means for the containment and clean-up of polluting fluids shall be available at the site and be proven to operate under the expected physical environmental conditions.

In the case of permafrost or freezing conditions, provision should be made to ensure the integrity of ballast tanks, and to avoid upheaval buckling of conductors and buried flowlines.

5.7 Serviceability requirements including vibrations

In addition to normal serviceability requirements for structural design such as those described in 7.2.2.2, measures should be taken to ensure that structural vibrations do not cause crew discomfort during normal operations.

5.8 Decommissioning and reclamation

The structure shall be planned, designed, constructed and maintained so that future decommissioning and/or reclamation can be completed safely and with adequate protection of the environment.

6 Physical environmental conditions

6.1 General

6.1.1 Physical environment requirements

General guidelines on metocean information are given in ISO 19900:2013 and specific requirements in ISO 19901-1. Clause 6 of this document outlines the physical environmental parameters necessary for arctic offshore structure design. ISO 35106 specifies requirements and provides recommendations and guidance for the collection, analysis and presentation of relevant physical environmental data for arctic activities, including design and operations. Operations include planning and execution.

Appropriate physical environmental design parameters and operating conditions shall be considered, taking into account applicable regulatory requirements. These requirements can include a minimum duration of site-specific data (according to country regulations), the type of data and a definition of extreme design parameters.

A realistic assessment of the physical environmental parameters affecting the proposed offshore structure shall be made. All relevant environmental data, as well as applicable physical, statistical, mathematical and numerical models, shall be used to develop the appropriate information. When considering these parameters, potential allowance should be made for a changing climate, see 5.3.2.

The following information shall be determined:

- a) normal environmental conditions that are required to carry out checks for serviceability limit states, to develop actions and action effects to determine when particular operations can safely take place, and to plan construction activities (fabrication, transportation and installation) or field operations (e.g. drilling, production, offloading, underwater activities);
- b) long-term distributions of physical environmental parameters, in the form of cumulative conditional or cumulative marginal statistics that are used to perform design checks for the fatigue limit state or to make evaluations of downtime/workability/operability during a certain period of time for the structure or for associated items of equipment;
- c) extreme and abnormal physical environmental parameters which are used to define design situations and which are required for developing extreme-level and abnormal-level environmental actions;
- d) joint probability distributions of relevant physical environmental parameters, for accurate specification of ice events and for determining action combinations;
- e) regional environmental oscillations, cycles, and long-term trends associated with the parameters in a) through c).

The relevant physical environmental parameters can be dependent on the chosen structural form.

Experts in the field of metocean and ice technology shall be involved with the analysis of data and its interpretation in order to ensure that reliable and appropriate physical environmental parameters are obtained. This includes parameters for identifying hazards and hazardous events for developing appropriate design situations, and for determining design values of principal and companion actions.

6.1.2 Physical environmental data monitoring programmes

Appropriate physical environmental parameters shall be monitored and forecast during the design service life of the structure to ensure safe operational procedures. For specific requirements, see ISO 35106.

6.2 Daylight hours

The varying amount of daylight hours in arctic regions is a consideration for initial data collection and for the operations of offshore facilities. Due consideration of the effect of this parameter shall be incorporated in operational planning.

6.3 Meteorology

6.3.1 Air temperature

The effects of temperature shall be accounted for in the selection of structural materials, machinery lubrication, sealants and topsides winterization. The effects of thermal changes on structural behaviour and human capability shall be considered as part of the design and operation of the structure.

Air temperatures will vary both as a function of elevation above sea level and as a function of averaging interval. When considering effects of low air temperatures, relevant elevation and averaging interval for the application in consideration shall be used.

Safety-critical equipment shall be documented to function as intended down to LAST. For material specification and testing, the actual extreme-level low material temperature can be applied.

6.3.2 Wind

Wind-related parameters shall be determined in accordance with ISO 19901-1. When calculating wind actions on structural elements, increase in dimensions, weight and change in the shape and surface roughness of the structure due to snow or ice accumulations shall be taken into account.

6.3.3 Wind chill

The combined effect of air temperature and wind shall be used to calculate wind chill. The effect of wind chill upon human capability, machinery heat loss and topsides winterization shall be considered.

Reference is made to ISO 35101 for requirements and information related to wind chill effects on working environment and to ISO 35106 for data collection requirements.

6.3.4 Snow

Snow accretion shall be assessed in relation to action effects on offshore structures and in relation to safety-critical systems such as EER craft, escape and evacuation routes, ventilation and communication systems.

Estimates of snow accumulation can be obtained from observations on similar existing structures in the same area or from available theoretical models. When theoretical models are used, they shall be suitably calibrated against observations. Snow actions shall be determined based on local conditions (temperature; wind; structure, precipitation). In relation to safety-critical systems, any impact on performance thereof shall be assessed.

The joint effect of snow and ice accretion shall be considered.

General information and further requirements related to actions from snow are given in ISO 35106.

6.3.5 Ice accretion

The extent of ice accretion from sea spray (sea spray icing), freezing rain/sleet/snow or drizzle, freezing fog or cloud droplets (atmospheric icing) shall be considered in the design and operability of the structure.

Ice accretion shall be assessed in relation to action effects on structures and in relation to safety-critical systems such as EER craft, escape and evacuation routes, ventilation and communication systems.

In relation to safety-critical systems, any impact on performance thereof shall be assessed. Further requirements and general information related to actions from sea spray and atmospheric icing are given in ISO 35106.

6.3.6 Visibility

Information on factors affecting visibility (e.g. fog, blowing snow, daylight hours) particular to the site of the offshore structure shall be obtained. Its effect upon operations and physical environmental monitoring shall be considered.

6.3.7 Polar lows

When considering statistics from waves and winds, the effects of polar lows shall be taken into account. Data sources for winds and waves (recorded or hindcast) do not typically include the effects of polar lows.

When considering the frequency and occurrence of polar lows, potential allowance should be made for a changing climate.

6.4 Oceanography

6.4.1 Water depth

The water depth at the site, including its variation, shall be determined. The range of water levels and its effect on ice action location shall be used to determine the most adverse effect on the foundation or structural component under consideration. For shallower water depths, ice can ground around a structure and cause changes in ice design scenarios for the structure and transportation systems, create operational problems and affect EER procedures.

For the purpose of design or assessment, water depth can be considered to consist of a more or less stationary component relative to a reference datum (e.g. lowest astronomical tide or mean sea level) and a variable component being the variations in time relative to this level. The variations are due to astronomical tide, storm surges caused by wind and atmospheric pressure, long-term variations, sea floor subsidence and tsunamis. The design implications of positive and negative storm surges should be

considered in the specification of actions on the structure, in the operation of the structure and for vessel operations planning.

6.4.2 Waves

Wave parameters for open water shall be determined in accordance with ISO 19901-1.

Ice coverage on the sea surface affects wave growth, propagation and decay. The effect of ice cover should be considered when determining extreme and operational wave parameters, especially when numerical models are employed to determine these parameters.

The effect of increased speed and elevation of ice features due to waves shall be taken into account in determining the combined wave-ice actions upon the structure.

6.4.3 Ocean currents

Parameters related to currents, including tidal effects, shall be determined in accordance with ISO 19901-1.

6.4.4 Other oceanographic factors

6.4.4.1 Marine growth

Marine growth shall be determined in accordance with ISO 19901-1.

When calculating the effect of marine growth in ice covered regions, consideration should be given to local conditions and their effect on the periodic cleaning of marine growth on the parts of the structure exposed to ice. Increased marine growth near areas of warm water discharge should be considered.

6.4.4.2 Tsunamis

The design implications of tsunamis shall be determined in accordance with ISO 19901-1.

Consideration should be given to the effect of ice cover on tsunami wave parameters.

6.4.4.3 Dissolved oxygen

Higher dissolved oxygen content can be encountered in cold water regions. Since higher oxygen levels can enhance corrosion, local data should be collected to assess this hazard when relevant for the structural materials used.

6.4.4.4 Water temperature and salinity

The temperature at which water freezes is a function of water salinity. At normal ocean water salinity, considered to be 35 ‰, water freezes at $-1,9^{\circ}\text{C}$. This shall be considered as the coldest water temperature that can be found in regions affected by sea ice.

6.5 Sea ice and icebergs

6.5.1 General

Information required to characterize site-specific ice criteria shall be determined for the location of the structure under consideration. This information should consider all phases of the structure's life, including transportation to and from the site.

Data can be obtained from direct observations at a location, interpretation of satellite imagery, or historical information at the geographic region of the structure, platform or facility. Where local ice data are unavailable or are not representative of relevant severe ice conditions, or where ice incursions are infrequent, data from nearby sites or geographical regions with similar ice environments may be used. Numerical or statistical modelling may be used to extend these data sets, with due account for uncertainties. Long-term trends shall be taken into account.

Interrelationships between the various parameters listed in 6.5.2 through 6.5.5 shall be considered, where relevant for the development of design criteria.

6.5.2 Ice types

The types of ice expected, i.e. first-year (FY), second-year, multi-year (MY), shelf or glacial, shall be determined. If a distinction cannot be made between second-year and MY ice, old ice can be specified. Statistics, such as probability distributions and parameters thereof, shall reflect the occurrence, concentration, dimensions, physical properties and mechanical properties of all relevant ice types.

Inter-annual and seasonal variations in the presence of ice types shall be considered.

6.5.3 Ice morphology

The occurrence and geometry of specific ice features, such as icebergs, ice islands, rafted ice, rubble fields, leads or polynya, pressure and shear ridges, stamukhi, landfast ice, pack ice, shelf ice and glacial ice, shall be determined on the basis of field measurements at the site and historical data from nearby sites. Statistics, such as probability distributions and parameters thereof, and appropriate ice feature frequency and dimensions shall be determined.

The occurrence of grounded ice features, such as grounded rubble piles and beach pile-ups, shall be determined to obtain appropriate ice feature frequency, extent, size, potential ice gouge depth and stability. This information shall be used in the determination of ice actions, design of flowlines and their burial depth, access to facilities, logistics, and evacuation systems.

The consolidated layer thickness of ridges, rubble fields and stamukhi shall be determined directly from regional data or estimated from data for other regions with suitable correction to local conditions.

Inter-annual and seasonal variations in ice morphology shall be considered.

6.5.4 Ice movement

Statistics of movement rates for pack ice, ice floes, floating ridges, rubble fields, icebergs, ice islands and landfast ice, where relevant, shall be determined on the basis of field data. The statistics can include probability distributions, means and extremes. If field data do not exist for these parameters, numerical modelling or analysis of the interaction of winds, waves, ocean currents and ice may be performed to obtain this information, with due account for uncertainties in the data and modelling procedures.

Inter-annual and seasonal variations in ice presence, polynyas and physical parameters shall be considered.

6.5.5 Ice properties

Appropriate mechanical and physical properties of ice shall be used for design and operational procedures. The considerations of 8.2.8 shall apply.

6.5.6 Ice monitoring

Real-time information on ice conditions shall be included in the physical environmental data monitoring programme, for example, to operate ice management systems, and escape, evacuation and rescue (EER) procedures for the platform or facility. See ISO 35106.

6.6 Seabed considerations

6.6.1 Earthquake

The complexity of a seismic action evaluation and the associated design procedure for an arctic offshore structure depends on the structure's seismic risk category as determined in accordance with ISO 19901-2. Acceleration levels taken from the maps provided in ISO 19901-2 define the seismic zones, which can be used to determine the appropriate seismic design procedure. The selection of the procedure depends on the structure's exposure level as well as the severity of ground motion.

Where seismic events are a design concern, appropriate site-specific dynamic seabed-structure interaction analyses shall be carried out (see 9.10).

6.6.2 Permafrost

An investigation into the presence of permafrost shall be performed at platform locations and at any sites where structures make contact with the sea floor. Offshore structures founded on permafrost require special studies in order to understand the performance of the soil under time-varying actions induced by earthquakes, waves or sea ice. The potential effects of thaw consolidation of ice-rich permafrost as a result of production of warm hydrocarbons should be considered in the design of all structure foundations.

6.6.3 Ice gouge

Ice gouges occur due to the interaction of ice features such as ridges, icebergs, and stamukhi with the seabed. Data on ice gouges shall be obtained to determine the frequency of ice gouge occurrence as well as depth, width, length, and direction information for individual features. Ice gouge statistics shall be used for design in regions where the seabed is used for the laying and burial of flowlines and umbilicals, subsea facilities and platform tie-ins.

6.6.4 Strudel scours

Strudel scouring shall be investigated for structures and other facilities in regions near the mouths of rivers.

7 Reliability and limit states design

7.1 Design philosophy

7.1.1 Governing principles

The complete structure and its components including foundations shall be designed so that they function with adequate reliability for all physical environmental, accidental and operational actions and design situations to which the structure can be subjected during all phases of the life of the structure. These phases include construction, transportation, installation and decommissioning. The required reliability depends on the exposure level, which is determined by the life-safety category and the environmental and economic consequence category of the complete structure or component.

Design shall be in accordance with the limit states approach as specified in 7.2. This requires that action effects arising from design actions shall not cause the structure or its components including foundations to exceed the limits specified for the relevant limit state. Resistances and their relevant partial factors shall be determined in accordance with this document and its referenced documents. Actions shall include, but not be limited to, ice, seismic, oceanographic, meteorological, permanent and variable actions.

Hazardous events shall be defined and evaluated for the hazards identified in accordance with 5.3.1. Extreme and abnormal environmental events shall each be considered as separate hazardous events. When considering a specific hazardous event, design situations shall be defined as described in ISO 19900:2013, subclause 5.6. A typical design situation is generally dominated by one type of hazardous event with associated companion environmental conditions, and the design is verified for the relevant limit state. Partial factors for the action combination associated with ultimate limit states (ULS) and abnormal limit states (ALS) shall be in accordance with 7.2.4.

7.1.2 Life-safety categories

Life-safety category shall be determined in accordance with ISO 19900:2013, subclause 6.2.

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

7.1.3 Consequence categories

Consequence category shall be determined in accordance with ISO 19900:2013, subclause 6.3.

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

7.1.4 Exposure levels

Exposure level depends on the life-safety and consequence categories. Exposure levels shall be determined in accordance with the process set out in ISO 19900:2013, subclause 6.4.

All manned, non-evacuated platforms and high-consequence platforms or structures are designated L1; unmanned, low-consequence platforms or structures are designated L3; other platforms or structures are designated L2.

NOTE Platform is defined in ISO 19900:2013.

Structural components of arctic and cold regions platforms or structures may be categorized differently from each other and from the overall platform or structure, if different life-safety and consequence categories are demonstrated, in which case their exposure level can be different.

7.1.5 Limit states

Limit states are divided into four categories as described in this document, see 7.2.1.1, and in ISO 19900:2013, subclause 7.1.

Due to the significance of AL ice actions in arctic and cold regions, this document places emphasis on the abnormal aspect of the ALS.

7.1.6 Alternative design methods

Alternative design methods may be used if the reliability of the structure and its components is shown to be equivalent to or better than that of the limit state design approach as set out in 7.2 and Table A.7-1.

7.2 Limit states design method

7.2.1 Limit states

7.2.1.1 Categories of limit states

- a) ultimate limit states (ULS) - for strength and resistance to extreme applied actions;
- b) serviceability limit states (SLS) - for stiffness and adequate performance under normal functional use;
- c) fatigue limit states (FLS) - for adequate endurance for the accumulated effect of repetitive dynamic action effects;
- d) abnormal (accidental) limit states (ALS) - for adequate reserve capacity and energy dissipation capability in situations of abnormal environmental and accidental events.

For the limit states design method, the reliability relevant to the exposure level is achieved through design verification to ultimate limit states (ULS) and abnormal limit states (ALS). These limit states are critical because their violation can directly result in loss of human life, environmental damage or asset loss.

7.2.1.2 Ultimate limit states

The ULS requirement ensures that no significant structural damage occurs for actions with an acceptably low probability of being exceeded during the design service life of the structure. Significant damage is associated with impairment of structure function.

ULS design situations shall be based on environmental events which result in extreme-level environmental actions. For ice, both local and global actions shall be considered.

Characteristic resistances shall be factored by resistance factors to obtain the design resistances. Alternatively, the characteristic material properties shall be factored by material factors to obtain the design material properties.

Design procedures shall be based primarily on linear elastic methods of structural analysis. Some localized inelastic behaviour of the structure and its components is acceptable, for example, as permitted in Clause 11 for fixed steel structures and Clause 12 for fixed concrete structures. Structure interaction with foundation soils may be modelled non-linearly, considering non-linear elastic or plastic behaviour of the soil. Procedures and further provisions for floating structures are described in 13.4 and 13.5.

The safety for each ultimate limit state shall be verified by ensuring that the effect of combined factored actions does not exceed the factored resistance.

7.2.1.3 Serviceability limit states

Exceedance of SLS results in the loss of capability of a structure to perform adequately under normal functional use. The structure shall also satisfy serviceability limits for vibrations and deflections, including limits for habitability and crew comfort.

The specification of actions and limits for SLS is generally the owner's responsibility. SLS shall also include considerations that can lead to long-term structural degradation, such as corrosion of reinforcement in concrete.

For SLS, the structure should satisfy the requirements of this document when structural members are subjected to localized ice damage. Examples include: concrete cracking and shrinkage, for which partial action factors are provided in ISO 19903; loss of concrete cover due to ice abrasion; removal of paint and removal of corroded steel due to ice abrasion; and localized damage due to vibrations induced by ice and other physical environmental factors.

SLS are only assigned quantitative reliability targets under specific circumstances in this document.

7.2.1.4 Fatigue limit states

Exceedance of FLS for offshore structures results from cumulative damage due to repeated actions. All actions over the design service life shall be considered, including the transportation phase to the site. For ice actions, cyclic variations are generally associated with compressive and flexural ice failure.

7.2.1.5 Abnormal (accidental) limit states

The ALS requirement is intended to ensure that the structure and foundation have sufficient reserve strength, displacement or energy dissipation capacity to sustain large actions and other action effects in the inelastic region without complete loss of integrity.

ISO 19900:2013, subclause 7.1.6 identifies two types of hazardous event related to ALS, namely accidental events and abnormal environmental events. Accidental events and accidental situations are described in ISO 19900:2013. For abnormal environmental events, ALS design situations shall be based on events which result in abnormal-level environmental actions. For ice, both local and global actions shall be considered.

Partial factors for structure and foundation resistance, or overall safety factors, may be reduced from their ULS values or set to unity, as permitted by this document and its referenced documents.

Non-linear methods of analysis may be used. Structural components are allowed to behave inelastically (i.e. individual design resistance may be exceeded and/or action effects may be redistributed to other components) if there is sufficient ductility and if the overall structural design is adequately robust. Ductility and reserve strength arising from robustness represent the ability of a structure to reach the ALS without complete loss of integrity even in the event of component failures. Procedures and further provisions for floating structures are described in 13.4 and 13.5.

The safety for each abnormal and accidental limit state shall be verified by ensuring that the effect of combined actions does not cause global failure or collapse.

7.2.2 Actions

7.2.2.1 General

Permanent actions (G), variable actions (Q), environmental actions (E), repetitive actions leading to fatigue, and accidental actions (A) are defined in ISO 19900:2013. Further details on their specification are found in ISO 19902, ISO 19903 and ISO 19904-1.

For structures in arctic and cold regions, the design shall be based on actions arising from design situations that are defined for both extreme-level (EL) and abnormal-level (AL) environmental events. For ice actions, these are termed ELIE (extreme-level ice events) and ALIE (abnormal-level ice events) respectively. Clause 8.2.1 provides definitions for ELIE and ALIE. The environmental action shall comprise a principal action which arises from the hazardous event defining the design situation, combined with relevant companion actions as described in 7.2.3.

Representative values shall be assigned to each EL and AL action. The main representative value is the characteristic value, which is a value associated with a prescribed probability of being exceeded by unfavourable values during a reference period, which is generally one year.

In arctic and cold regions, there can be additional accidental events that should be evaluated, such as ice-driven ship impacts on a structure.

7.2.2.2 Serviceability-level ice actions

Unless the owner has specified otherwise, the representative value of the serviceability-level (SL) ice action used for SLS shall be determined based on an annual probability of exceedance not greater than 10^{-1} .

7.2.2.3 Extreme-level ice actions

The representative value for the EL ice action shall be determined for each ULS design situation based on an annual probability of exceedance not greater than 10^{-2} . This determination shall be based on an analysis of extreme-level ice events (ELIE).

The EL ice action is not applicable for hazardous events with an annual probability of occurrence of less than 10^{-2} .

7.2.2.4 Abnormal-level ice actions

The representative value for the AL ice action shall be determined for each ALS design situation based on an annual probability of exceedance related to the exposure level. For L1 structures, this shall be determined based on an annual probability of exceedance not greater than 10^{-4} . This determination shall be made on the basis of an analysis of abnormal-level ice events (ALIE).

For L2 structures, the annual probability shall be not greater than 10^{-3} . AL ice actions need not be considered for L3 structures.

The AL ice action is not applicable for hazardous events with an annual probability of occurrence of less than 10^{-4} for L1 structures (10^{-3} for L2 structures). Further guidance is provided in A.7.2.2.

7.2.2.5 Dynamic ice actions

If relevant, dynamic ice actions and ice-induced vibration shall be characterized with respect to the SLS and the FLS and dynamic amplification of design actions, with respect to effects on structures and foundations including potential for soil liquefaction, see 8.2.1.

7.2.2.6 Other environmental actions

Representative values of actions for all other environmental events shall be determined at the extreme-level (EL), based on an annual probability of exceedance not greater than 10^{-2} , and at the abnormal-level (AL), based on an annual probability of exceedance not greater than 10^{-4} for L1 structures and 10^{-3} for L2 structures. It is not necessary to consider abnormal-level events for L3 structures. For seismic actions, the extreme-level earthquake (ELE) and abnormal-level earthquake (ALE) event probabilities shall be as specified in ISO 19901-2.

Effects due to temperature differences within the structure or component are to be considered in all relevant limit states.

7.2.2.7 Accidental actions

Actions arising from accidental situations shall be addressed in accordance with ISO 19902, ISO 19903 and ISO 19904-1 depending on the structure type. Accidental situations are defined in ISO 19900:2013.

Table 7-1 — Companion EL environmental actions

Principal action (EL or AL)	Companion EL environmental action		
	Stochastically dependent	Stochastically independent	Mutually exclusive
Waves	Wind, wind-driven current	Tidal and background current	Sea ice (for ice concentration $\geq 8/10$)
Waves	Wind, wind-driven current, ice (for ice concentration $< 4/10$)	Sea ice (for ice concentration $< 8/10$)	—
Swell	—	Waves, wind, wind-driven current, tidal and background current, sea ice (for ice concentration $< 8/10$)	Sea ice (for ice concentration $\geq 8/10$)
Tsunami	—	Waves, wind, wind-driven current, tidal and background current, sea ice	—
Wind	Waves, wind-driven current, sea ice	Swell, tidal and background current	—
Wind	Wind-driven current, sea ice	Tidal and background current	Waves, swell (for ice concentration $\geq 8/10$)
Current (tidal and background)	Sea ice	Waves, swell, wind, wind- driven current	Waves, swell (for ice concentration $\geq 8/10$)
Current (wind-driven)	Sea ice, waves, wind	Swell, tidal and background current	Waves, swell (for ice concentration $\geq 8/10$)
Sea ice	Wind, wind-driven current, tidal current	—	Waves, swell (for ice concentration $\geq 8/10$)
Sea ice	Wind, wind-driven current, tidal current, waves (for $< 4/10$ sea ice concentration)	Waves, swell (for ice concentration $< 8/10$)	—

Earthquake ^a	—	Waves, swell, wind, wind-driven current, tidal and background current, persistent ice cover	—
Large icebergs or other large ice features	Wind, wind-driven current, tidal and background current	Waves ^b , swell ^c	—
Isolated ice features (e.g. ice floes, ridge fragments, stamukhi, bergy bits, small icebergs)	Wind, wind-driven current, tidal and background current, waves ^b	Waves ^b	—
Snow	—	Wind, waves, current, sea ice, icebergs ^c	—
Ice accumulation (including icing and ice accretion)	Wind, waves ^c	Wind, waves, current, sea ice ^c	—
^a For the AL earthquake, it is normally sufficient to consider only ice likely to be present when an earthquake occurs. ^b The principal action from small icebergs or ice floes and the companion wave actions can be stochastically dependent. ^c Categorisation of companion actions for snow and icing should be assessed for site-specific conditions.			

7.2.3 Principal and companion environmental actions

Environmental action combinations for each environmental design situation shall be derived by considering the principal action accompanied by companion environmental actions. The principal action is the action arising from the hazardous event that defines the design situation, such as the EL ice action or AL ice action for ELIE and ALIE respectively. Alternatively the joint probability of environmental actions may be used, see below.

Potential combinations of principal and companion environmental actions are given in Table 7-1. Companion environmental actions additional to those listed should be considered based on site-specific conditions.

The effect of varying water level changes, see 6.4.1, shall be considered in the calculation of principal actions and in the specification of companion actions. Storm surges should be considered as stochastically dependent on the wind if the principal action depends on the wind. Tidal elevations should be considered as stochastically dependent on the current where the principal action depends on tidal currents.

Where data are available, the joint probability distribution of the principal and relevant companion actions should be used to determine the magnitude of the combined EL or AL environmental action.

In the absence of specific consideration of joint probabilities, the combination factors provided for companion environmental actions in Table 7-2 shall be used. In this approach, the representative EL value of each relevant companion action shall be multiplied by the relevant factor from Table 7-2 and added to the EL or AL value of the principal action as determined by the design situation. The values specified in Table 7-2 are conservative to account for significant correlations between companion and principal actions. Consequently, site-specific data should be used and joint probabilities calculated whenever possible. Further considerations for floating structures are provided in 13.4.

Table 7-2 — Combination factors for companion EL environmental processes

Principal action	Factor for representative EL companion environmental action	
	Companion action is stochastically dependent on the principal action	Companion action is stochastically independent of the principal action
EL action	0,9	0,6
AL action	0,5	0,4

7.2.4 Combinations of actions and partial action factors

The limit state action combinations specified in Table 7-3 shall be used in design. For each action combination, the design action shall be calculated as follows:

the representative value of a combined environmental action, E , or accidental action, A , shall be multiplied by a partial action factor not less than that specified in Table 7-3;

representative values of permanent and variable actions shall be multiplied by partial action factors which either shall be not less than specified in Table 7-3 or shall be taken from ISO 19902, ISO 19903 or ISO 19904-1 for the respective structure types.

Table 7-3 — ULS and ALS partial action factors and action combinations

Action combination		Limit state partial action factors						
		Permanent action		Variable action		Environmental action		Accident- al action <i>A</i>
		<i>G</i>		<i>Q</i>		<i>E</i>		
		Gravity and hydrostatic (Dead) <i>G</i> ₁	Deform- ation <i>G</i> ₂	Long duration <i>Q</i> ₁	Short duration <i>Q</i> ₂	EL	AL	
Ultimate limit states								
1	Gravity and deformation – long and short duration	1,30 ^a or 0,90 ^b	1,00	1,50 ^a	1,50 ^a	0,70 ^c or 0 ^b	—	—
2	Extreme environmental	1,10 or 0,90 ^b	1,00	1,10 or 0,80 ^b	—	1,35 (L1) ^{c,d} 1,10 (L2) ^{c,d,e}	—	—
3	Damaged condition ^f	1,10 or 0,90 ^b	1,00	1,10 or 0,80 ^b	—	1,00	—	—
Abnormal (accidental) limit states								
4	Abnormal environmental	1,00	1,00	1,00	—	—	1,00 ^c	—
5	Accidental	1,00	1,00	1,00	—	—	—	1,00

- ^a For the gravity and deformation action combination, a partial action factor of 1,20 may be used for permanent hydrostatic pressure and for physically limited variable actions.
- ^b The lower partial action factor applies for permanent G_1 actions when the permanent action resists overturning or uplift, for variable Q_1 actions when there is a reversal of variable action effects, and for environmental actions E if this produces a more unfavourable total design action effect.
- ^c The representative value of the environmental action to which the partial action factor applies shall be calculated as the combination of a principal action and appropriate companion actions, as described in 7.2.3.
- ^d The limit state partial action factor for the extreme-level seismic action (ELE) shall be as defined in ISO 19902 for steel structures and shall be as defined in ISO 19903 for concrete structures. The partial action factor for the ELE shall be 1,0 for all other structures.
- ^e For L2 exposure level, all partial action factors for all action combinations are as for L1 except for the EL factor in the extreme environmental action combination.
- ^f Damaged condition or progressive collapse limit states are defined generally for structures in ISO 19900 and for particular types of structures in ISO 19902, ISO 19903 and ISO 19904-1.

These partial action factors apply to both local and global actions. ISO 19900 provides further information on the classification of types of action.

The combination of actions and the partial action factors for earthquakes shall be in accordance with ISO 19902 for fixed steel structures and in accordance with ISO 19903 for fixed concrete structures. Further guidance is provided in 8.4.

Partial action factors and action combinations for SLS and FLS shall be in accordance with ISO 19902, ISO 19903 or ISO 19904-1 as relevant to the structure type.

Action combination 1 shall include checks for design situations both with and without environmental action, E.

For design situations where an EL action is the principal action, the action effects shall be checked for ULS (action combinations 1 and 2 in Table 7-3), except that in the damaged condition they shall be checked for action combination 3 only.

For design situations where an AL environmental action or accidental action is the principal action, the action effects shall be checked for ALS only (action combinations 4 and 5 in Table 7-3).

The partial action factors for environmental actions other than earthquakes specified in Table 7-3 have been calibrated to the reliability targets given in Table A.7-1. When these partial action factors are applied to ULS and ALS action combinations for arctic offshore structures and their components, including foundations within the scope of this document of exposure levels L1 and L2, the reliability targets given in Table A.7-1 are deemed to be achieved. Further considerations for floating structures are provided in 13.4.4.

As an alternative to Table 7-3, the partial action factors may be derived from a calibration analysis using a full probabilistic description of actions if this analysis demonstrates that the reliability targets of Table A.7-1 are achieved.

8 Events and actions

8.1 General

The events and actions necessary to consider for design depend on the physical environment into which the structure will be placed.

Actions can be classified as described in ISO 19900:2013, subclause 8.2.1. The classification includes

permanent actions,
variable actions,
environmental actions,
accidental actions,
repetitive actions.

Hazards shall be taken into account in accordance with 7.1.1 and ISO 19900:2013, subclause 5.6. Hazardous events can include extreme environmental events, accidental events and abnormal environmental events.

Metoccean events such as wave events, wind events and ocean current events are considered in ISO 19901-1. Seismic events and actions are considered in ISO 19901-2. Actions arising from these events are considered in ISO 19902, ISO 19903 and ISO 19904-1. Provisions for the treatment of ice actions and their combination with other types of actions are given in 7.2.3 with the further requirements of Clause 8.

The design of arctic offshore structures shall include consideration of global ice actions relating to the overall integrity of the complete structure and its components, including, if relevant, foundation and stationkeeping system, and local ice actions for specific components or portions of the structure.

The actions used for design shall consider all phases of the life of the structure, including construction (fabrication, transportation, and installation), operation, and decommissioning. Allowance for possible weight increase and changes in the centre of gravity due to ice accretion during fitting out (if performed in arctic or cold regions) and transportation shall be considered. The allowance shall reflect the time of year and geographical area. Differential strains or lock-in stresses due to temperature changes between construction and permanent locations shall be considered in the design.

8.2 Ice events and actions

8.2.1 General principles for calculating ice actions

Structures or components subjected to ice events with an annual probability exceeding the value specified in 7.2.2.4 appropriate to the limit state and exposure level shall be designed for ice actions. In the absence of data to quantify the potential for ice events, ice actions shall be assessed if there is a reasonable probability of interaction. All reasonably foreseeable interaction scenarios with potentially adverse consequences should be considered in this respect.

Ice scenario, as defined in this document and used in this subclause 8.2, refers to the general description of the conditions in which ice events occur.

Direct ice actions and actions arising from the interaction between the ice and the structure shall be considered for both global and local scales. Such actions can include

- a) static, quasi-static, cyclic and dynamic actions (EL and AL),
- b) cyclic and dynamic actions that can cause structural fatigue, liquefaction and personnel discomfort, and