DEUTSCHE NORM **Entwurf** September 2013

DIN EN ISO 19901-1

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DIN EN ISO 19901-1:2006-03

Entwurf

Erdöl- und Erdgasindustrie – Spezielle Anforderungen für Offshore-Anlagen – Teil 1: Grundsätze für die Auslegung und den Betrieb auf dem offenen Meer (ISO/DIS 19901-1:2013); Englische Fassung prEN ISO 19901-1:2013, nur auf CD-ROM

Petroleum and natural gas industries –
Specific requirements for offshore structures –
Part 1: Metocean design and operating considerations (ISO/DIS 19901-1:2013);
English version prEN ISO 19901-1:2013, only on CD-ROM

Industries du pétrole et du gaz naturel –
Exigences spécifiques relatives aux structures en mer –
Partie 1: Dispositions océano-météorologiques pour la conception et l´exploitation (ISO/DIS 19901-1:2013);
Version anglaise prEN ISO 19901-1:2013, seulement en CD-ROM

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2013-09-27 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

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

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal des DIN unter www.entwuerfe.din.de 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/stellungnahme oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN, 10772 Berlin (Hausanschrift: 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 299 Seiten

Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

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Nationales Vorwort

Dieses Dokument (prEN ISO 19901-1:2013) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Subkomitee SC 7 „Offshore structures“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet.

Für Deutschland hat hieran der Arbeitsausschuss NA 109-00-01 AA „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie - Spiegelausschuss zu CEN/TC 12 und ISO/TC 67“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) des DIN Deutsches Institut für Normung e. V. mitgearbeitet.

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

Das Ausgabedatum des Europäischen Norm-Entwurfs stand zum Zeitpunkt der Veröffentlichung dieses DIN-EN-ISO-Entwurfs noch nicht fest; der prEN ISO wird jedoch vom CMC unter der angegebenen prEN-Nummer demnächst zur CEN-Umfrage verteilt. Um der deutschen Öffentlichkeit eine möglichst lange Einspruchsfrist einzuräumen, wurde dieser Norm-Entwurf bereits vorab veröffentlicht.

Dieser Norm-Entwurf enthält neben den gesetzlichen Einheiten auch die Einheit „°F“ die in Deutschland nicht zugelassen ist. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	**SI-Einheit**	**Umrechnung**	
°F	°C	°C	= (5/9) (°F-32)

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 19900,	siehe	DIN EN ISO 19900
ISO 19901 (all parts),	siehe	DIN EN ISO 19901 (alle Teile)
ISO 19902,	siehe	DIN EN ISO 19902
ISO 19903,	siehe	DIN EN ISO 19903
ISO 19904-1,	siehe	DIN EN ISO 19904-1
ISO 19905-1,	siehe	DIN EN ISO 19905-1
ISO 19906,	siehe	DIN EN ISO 19906

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Änderungen

Gegenüber DIN EN ISO 19901-1:2006-03 wurden folgende Änderungen vorgenommen:

a) Aktualisierung der normativen Verweisungen;

b) neuer informativer Anhang B „Northwest Europe“;

c) neuer informativer Anhang C „West coast of Africa“;

d) neuer informativer Anhang D „United States“;

e) neuer informativer Anhang E „Offshore Canada“;

f) neuer informativer Anhang F „Sakhalin/Sea of Okhotsk“;

g) neuer informativer Anhang G „Caspian Sea“;

h) neuer informativer Anhang H „Southern East Asian Sea“.

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Nationaler Anhang NA
(informativ)

Begriffe, Symbole und Abkürzungen

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

3 Begriffe

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

3.1
anormaler Wert
ungewöhnlicher Wert
Bemessungswert für einen besonders strengen Parameter, der angewendet wird, um Überprüfungen zufälliger Grenzzustände vorzunehmen, unter denen nicht gewollt ist, dass ein kompletter Verlust der Integrität einer Offshore-Anlage eintritt

ANMERKUNG Die Wahrscheinlichkeit für das Auftreten ungewöhnlicher Ereignisse bewegt sich in einer Größenordnung von 10^{-3} bis 10^{-4} je Jahr. Für die Überprüfung von Grenzzuständen wird für alle oder einige Teilsicherheitsbeiwerte ein Wert von 1,0 festgelegt.

3.2
Seekartennull
Kartennull
SKN
lokale Bezugsfläche zur Festlegung der Wassertiefen auf Seekarten oder zur Festlegung der Fluthöhen in einem bestimmten Bereich

ANMERKUNG Seekartennull ist im Allgemeinen etwa gleich dem niedrigsten Gezeitenwasserstand (gleich der niedrigsten zu erwartenden Wassertiefe).

3.3
konditionale Wahrscheinlichkeit
bedingte Wahrscheinlichkeit
konditionale Verteilung
bedingte Verteilung
statistische Verteilung (Wahrscheinlichkeit) für das Auftreten einer Variablen A unter der Bedingung, dass weiteren Variablen B, C … bestimmte Werte zugeordnet sind

ANMERKUNG Die konditionale Wahrscheinlichkeit für eine Variable A, dass die Variablen B, C … auftreten, wird schriftlich dargestellt als P ($A|B$, C …). Dieses Konzept gilt sowohl für meteorologische/ozeanographische Parameter als auch für Wirkungen und für die Einflüsse dieser Wirkungen.

BEISPIEL Bei Betrachtung von Wellen-Parametern kann A die individuelle Höhe eines Wellenbergs sein, B die Wassertiefe und C die signifikante Wellenhöhe usw.

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3.4
Bemessungswert für die (geographische) Höhe eines Wellenbergs (Wellenkamms)
Extremwert der Wellenberghöhe, gemessen unter Bezug auf den Ruhewasserspiegel

ANMERKUNG Die Bemessungshöhe eines Wellenbergs wird in Verbindung mit Angaben zu astronomischer Tide, Sturmflut, Absacken einer Plattform, Absenkung von Lagerstätten und zur Unsicherheit der Wassertiefe angewendet; sie wird mit Hilfe einer Extremwertanalyse bestimmt. Wenn vereinfachte Modelle zur Bestimmung der Kinematik von Bemessungswellen angewendet werden, kann der Bemessungswert für die (geographische) Höhe eines Wellenbergs von der geographischen Höhe der Bemessungswelle, die zur Berechnung von Wirkungen auf die Offshore-Anlage verwendet wird, abweichen (im Allgemeinen ist sie etwas größer). Tatsächlich sind die Welle mit der größten Höhe zwischen Wellental und -berg und die Welle mit dem höchsten Wellenberg unterschiedliche Wellen.

3.5
Bemessungswelle
deterministische Welle, die zur Auslegung einer Offshore-Anlage verwendet wird

ANMERKUNG 1 Die Bemessungswelle ist eine technische Abstraktion. Meist handelt es sich um eine periodische Welle mit geeigneten Kennwerten (z. B. Wellenhöhe H, Periodendauer T, Wellensteilheit, Wellenkammhöhe). Die Auswahl einer Bemessungswelle ist abhängig von

— dem/den jeweiligen Auslegungszweck(en);

— der Wellenumgebung;

— den geometrischen Bedingungen der Offshore-Anlage;

— der Art der ausgeübten Wirkung(en) oder des ausgeübten Einflusses/der ausgeübten Einflüsse dieser Wirkungen.

ANMERKUNG 2 Üblicherweise ist eine Bemessungswelle nur mit den Bemessungssituationen kompatibel, in denen der Einfluss/die Einflüsse einer Wirkung quasistatisch bezüglich der zugehörigen Wellenwirkungen auf die Offshore-Anlage sind.

3.6
Fachmann
Experte
<meteorologisch/ozeanographisch> Person, die aufgrund ihrer Ausbildung und Erfahrung für einen bestimmten Bereich oder für ein bestimmtes Thema die Kompetenz zu einer Beratung bei spezifischen meteorologischen/ozeanographischen Problemen erworben hat

3.7
extremer Wasserstand
EWL
Kombination von „Bemessungshöhe des Wellenbergs“, astronomischer Tide und „Sturmflut“ unter Bezug auf die niedrigste astronomische Tide (LAT) oder die mittlere Meereshöhe (MSL)

3.8
Extremwert
Bemessungswert für einen Parameter, der zur Überprüfung von Grenzzuständen angewendet wird

Anmerkung 1 zum Begriff: Die Wahrscheinlichkeiten für das Auftreten extremer Ereignisse liegen in der Größenordnung von 10^{-2} je Jahr.

3.9
Schwerewelle
Welle in einem strömenden Medium oder an der Grenzfläche zwischen zwei strömenden Medien, für die Schwerkraft und Auftrieb die grundlegenden Rückstellkräfte sind

ANMERKUNG Ein Beispiel für Schwerewellen sind durch Wind erzeugte Oberflächenwellen.

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3.10
Bö
Böe
Windstoß
kurzzeitiges An- und Abschwellen der Windgeschwindigkeit mit einer Dauer von weniger als 1 min

ANMERKUNG In einigen Ländern wird in meteorologischen Beobachtungen von Windböen gesprochen. wenn die maximale Windgeschwindigkeit etwa 8 m/s überschreitet.

3.11
Windböengeschwindigkeit
maximaler Wert der Geschwindigkeit einer Windböe, der innerhalb einer festgelegten längeren Dauer (1 min bis 1 h) über eine festgelegte kurze Dauer (3 s bis 60 s) gemittelt wird

ANMERKUNG 1 Für den jeweiligen Auslegungszweck hängt die festgelegte Dauer von den Maßen und der Eigenperiode der Offshore-Anlage (oder eines Teils der Anlage) ab, die so bemessen ist, dass sie für die ungünstigsten Bedingungen geeignet ist; daher ist eine kleine Anlage oder ein kleiner Teil einer Anlage für eine Windböengeschwindigkeit mit kürzerer Dauer (und folglich einer höheren Windböengeschwindigkeit) ausgelegt als eine größere Anlage (oder ein Teil der Anlage).

ANMERKUNG 2 Die Höhe der gemessenen Windböen sollte ebenfalls festgelegt werden.

3.12
höchste astronomische Tide
HAT
Wasserstand bei hoher Tide, wenn alle harmonischen Komponenten, die eine Tide verursachen, in Phase sind

ANMERKUNG Die harmonischen Komponenten befinden sich ungefähr einmal alle 19 Jahre in Phase, eine angenäherte Phasengleichheit wird jedoch mehrere Male in einem Jahr erreicht.

3.13
Hindcasting
Analyse früher erfolgter Aktivitäten
Verfahren zur Simulation historischer (meteorologischer/ozeanographischer) Daten eines Bereichs mit Hilfe numerischer Modelle

3.14
Infraschwerewelle
Schwerewelle an der Oberfläche mit einer Periode von etwa 25 s bis 300 s

ANMERKUNG Grundsätzlich wird eine Infraschwerewelle durch andere physikalische Prozesse erzeugt, wird jedoch meistens mit Wellen in Verbindung gebracht, die auf Wechselwirkungen nichtlinearer Differenzfrequenzen der zweiten Ordnung zwischen unterschiedlichen Seegangs-Wellenkomponenten zurückzuführen sind.

3.15
interne Welle
Schwerewelle, die sich innerhalb der Schichtung einer Wassersäule fortpflanzt

3.16
Langzeitverteilung
Wahrscheinlichkeitsverteilung einer Variablen über eine lange Zeitskala

ANMERKUNG Die Zeitskala überschreitet die Dauer eines Seegangs, in dem die Statistik als konstant anzusehen ist (siehe 3.34 Kurzzeitverteilung). Diese Zeitskala ist folglich mit einer Saison oder mit der Bemessungs-Nutzungsdauer einer Offshore-Anlage vergleichbar.

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BEISPIEL Langzeitverteilungen von

— signifikanten Wellenhöhen (basierend auf z. B. Sturmspitzen oder auf allen Seegängen);

— signifikanten Wellenhöhen in den Monaten Mai bis September;

— individuellen Wellenhöhen;

— den aktuellen Geschwindigkeiten (z. B. für die Bewertung von durch Kreisströmungen induzierten [vortexinduzierten] Schwingungen von Risern);

— Streudiagrammen mit der gemeinsamen Verteilung von signifikanten Wellenhöhen und Wellenperioden (z. B. für die Anwendung bei Ermüdungsuntersuchungen);

— einem besonderen Einfluss einer Wirkung;

— einer signifikanten maximalen Sturmwellenhöhe.

3.17
niedrigste astronomische Tide
LAT
Wasserstand bei niedriger Tide, wenn alle harmonischen Komponenten, die eine Tide verursachen, in Phase sind

ANMERKUNG Die harmonischen Komponenten befinden sich ungefähr einmal alle 19 Jahre in Phase, eine angenäherte Phasengleichheit wird jedoch mehrere Male in einem Jahr erreicht.

3.18
Randverteilung
marginale Verteilung
Randwahrscheinlichkeit
marginale Wahrscheinlichkeit
statistische Verteilung (Wahrscheinlichkeit) für das Auftreten einer Variablen A unabhängig von allen anderen Variablen

ANMERKUNG Die Randverteilung wird durch Integration der gesamten Verteilung über alle Werte der übrigen Variablen B, C … erhalten und schriftlich dargestellt als $P(A)$. Dieses Konzept gilt sowohl für meteorologische/ozeanographische Parameter als auch für Wirkungen und die Einflüsse dieser Wirkungen.

BEISPIEL Bei Betrachtung der Wellenbedingungen kann A die individuelle Höhe eines Wellenbergs für alle mittleren Nulldurchgangsperioden B und alle signifikanten Wellenhöhen C sein, die an einer bestimmten Stelle auftreten.

3.19
marines Wachstum
lebende Organismen, die sich an einer Offshore-Anlage ansiedeln

3.20
mittlere Meereshöhe
MSL
arithmetischer Mittelwert aus allen Meereshöhen, die über eine lange Dauer gemessen wurden

ANMERKUNG Es kann davon ausgegangen werden, dass in einigen Gebieten saisonbedingte Änderungen der mittleren Meereshöhe auftreten, und Änderungen der mittleren Meereshöhe können auch über eine Dauer von einigen Jahren auftreten.

3.21
mittlere Windgeschwindigkeit
über der Zeit gemittelte Windgeschwindigkeit, wobei ein festgelegtes Zeitintervall und eine festgelegte geographische Höhe zugrunde liegen

ANMERKUNG Die mittlere Windgeschwindigkeit schwankt mit der geographischen Höhe über der mittleren Meereshöhe und dem gemittelten Zeitintervall; eine genormte Bezugshöhe liegt bei 10 m, und ein genormtes Zeitintervall ist 1 h. Siehe auch 3.11 Windböengeschwindigkeit und 3.43 anhaltende Windgeschwindigkeit

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3.22
mittlere Periode des Nulldurchgangs
mittlere Periode zwischen dem Nulldurchgang von Wellen (nach oben oder nach unten) bei Seegang

ANMERKUNG In der Praxis wird die mittlere Periode des Nulldurchgangs häufig aus dem nullten Moment und dem zweiten Moment des Wellenspektrums abgeschätzt als $T_z = T_2 = \sqrt{m_0(f)/m_2(f)} = 2\pi\sqrt{m_0(\omega)/m2(\omega)}$.

3.23
Monsun
saisonbedingte Umkehr der Windrichtung mit zugehörigem Regenmengenmuster

ANMERKUNG Die Benennung Monsun wurde zunächst auf Winde über dem Arabischen Meer angewendet, die sechs Monate lang aus nordöstlicher Richtung und sechs Monate aus sudwestlicher Richtung wehen; die Benennung wurde später auf ähnliche Winde in anderen Teilen der Welt erweitert.

3.24
wahrscheinlichstes Maximum
Wert für das Maximum einer Variablen, der die höchste Auftretens-Wahrscheinlichkeit hat

ANMERKUNG Das wahrscheinlichste Maximum ist der Wert, für den die Wahrscheinlichkeitsdichtefunktion der Maxima einer Variablen ihren Höchstwert erreicht. Es wird auch als Mode oder Modus der statistischen Verteilung bezeichnet.

3.25
Betriebsbedingungen
strengste Kombination der Umgebungsbedingungen, unter denen eine Fortsetzung eines bestimmten Arbeitsgangs zulässig ist

ANMERKUNG Betriebsbedingungen werden für die Arbeitsgänge bestimmt, die signifikante Wirkungen auf Offshore-Anlagen ausüben. Die Betriebsbedingungen stellen im Allgemeinen einen Kompromiss dar: Sie sind so ausreichend streng, dass der Arbeitsgang im Allgemeinen ohne übermäßig lange Stillstandszeit durchgeführt werden kann, sie sind jedoch nicht so streng, dass sie einen ungünstigen Einfluss auf die Auslegung haben.

3.26
polares Tiefdruckgebiet
Tief, das sich in polarer Luft bildet, häufig im Grenzbereich zwischen Eis und Meer

3.27
Restströmung
Teil der gesamten Strömung, der nicht aus harmonischen tidalen Komponenten (d. h. aus der Gezeiten-strömung) gebildet wird

ANMERKUNG Restströmungen werden durch eine Vielzahl physikalischer Erscheinungen hervorgerufen; sie umfassen einen großen Bereich von Eigenfrequenzen und Größen in unterschiedlichen Teilen der Welt.

3.28
Wiederkehrperiode
mittlere Dauer zwischen dem Auftreten eines Ereignisses oder der Überschreitung eines bestimmten Wertes

ANMERKUNG In der Offshore-Industrie wird im Allgemeinen eine Wiederkehrperiode angewendet, die für Umgebungsereignisse in Jahren gemessen wird. Für ein seltenes Ereignis ist die Wiederkehrperiode in Jahren gleich dem Kehrwert der jährlichen Wahrscheinlichkeit der Überschreitung eines Ereignisses.

3.29
Streudiagram
gemeinsame Wahrscheinlichkeit für zwei oder mehr (meteorologische/ozeanographische) Parameter

ANMERKUNG Ein Streudiagram wird besonders für Wellenparameter im Kontext mit meteorologischen/ozeano-graphischen Kenngrößen angewendet (beispielsweise zur Bewertung der Ermüdung). Das Wellen-Streudiagramm wird im Allgemeinen verstanden als Wahrscheinlichkeit für ein gemeinsames Auftreten der signifikanten Wellenhöhe (H_s) und einer repräsentativen Periode (T_z oder T_p).

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3.30
Meeresgrund
Grenzfläche zwischen Meer und Meeresboden

3.31
Seegang
Zustand der Meeresoberfläche während einer Periode, in der die statistischen Kenngrößen des Meeres annähernd stationär bleiben

ANMERKUNG Im statistischen Sinn verändert sich der Zustand des Meeres innerhalb dieser Periode nicht merklich. Die Periode, während der dieser Zustand existiert, wird häufig mit drei Stunden angegeben, obwohl die Dauer von der besonderen Wettersituation zum jeweiligen Zeitpunkt abhängig ist.

3.32
Meeresboden
unter dem Meer vorhandene Materialien, auf denen ein Bauwerk unabhängig von den jeweiligen Bodenarten, z. B. Sand, Schlick oder Ton, zementiertes Material oder Fels, errichtet ist

3.33
Seiche (Plural: Seiches)
Schwankungen des Wasserstands in einer Wassersäule bei ihrer Eigenperiode

3.34
Kurzzeitverteilung
Wahrscheinlichkeitsverteilung einer Variablen innerhalb einer kurzen Dauer, während der die Bedingungen als statistisch stationär anzusehen sind

ANMERKUNG Das ausgewählte Intervall entspricht häufig der Dauer eines Seegangs.

3.35
signifikante Wellenhöhe
statistisches Maß für die Höhe der Wellen bei Seegang

ANMERKUNG Die signifikante Wellenhöhe wurde ursprünglich bei Seegang als Mittelwert für das Drittel der höchsten, ab dem Nullpunkt nach oben durchgehenden Wellen definiert. In den meisten Datenerfassungssystemen für Offshore-Anlagen wird gegenwärtig davon ausgegangen, dass die signifikante Wellenhöhe $4\sqrt{m_0}$ beträgt, (wobei m_0 das nullte spektrale Moment ist, siehe **3.37 spektrales Moment**) oder 4σ, wobei σ die Standardabweichung der Zeitreihe der geographischen Höhe der Wasseroberfläche über der Messdauer (im Allgemeinen etwa 30 min) ist.

3.36
Soliton
einzelne (solitäre) Welle oder ein Wellenpaket, die/das sich mit einer internen Dichtediskontinuität ausbreitet und aufgrund fehlender nichtlinearer und dispersiver Einflüsse Gestalt und Geschwindigkeit über längere Distanzen beibehält

BEISPIEL Interne Tides, die innerhalb der Wassersäule am Dichtegradienten entstehen, können mit der Kontinentalabböschung in Wechselwirkung treten und interne Einzelwellenpakete bilden. Es wurde festgestellt, dass Offshore-Bereiche im nordwestlichen Australien, an denen sich interne Solitons brechen, verstärkte Meeresboden-strömungen erzeugen.

3.37
spektrales Moment
n. **spektrales Moment**
Integral über die Frequenz der spektralen Dichtefunktion, multipliziert mit der n. Potenz der Frequenz, entweder angegeben in Hertz (Anzahl sich wiederholender Vorgänge je Sekunde) durch $m_n(f) = \int_0^\infty f^n S(f) df$ oder als Kreisfrequenz (Radiant/Sekunde) durch $m_n(\omega) = \int_0^\infty \omega^n S(\omega) d\omega$

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ANMERKUNG 1 Da $\omega = 2\,\pi f$ ist, ergibt sich für den Zusammenhang zwischen den beiden Moment-Darstellungen: $m_n(\omega) = (2\pi)^n\, m_n(f)$.

ANMERKUNG 2 Die Integration erfasst den gesamten Frequenzbereich von Null bis unendlich. In der Praxis wird die Integration häufig bei einer Frequenz abgebrochen, unter der der Beitrag zum Integral vernachlässigbar ist und/oder der Sensor nicht mehr exakt anspricht. Bei Anwendung von Momenten in einer Größenordnung größer als 2 sollte sorgfältig vorgegangen werden, da für spektrale Standardmodelle das 4. Moment nicht konvergiert; der Wert wird in der Tat durch die Auswahl einer geeigneten Trunkierung bestimmt.

3.38
spektrale Spitzenperiode
Dauer der maximalen Energiedichte (Spitzenenergiedichte) im Spektrum

ANMERKUNG In der Praxis gibt es häufig mehrere Spitzen in einem Spektrum.

3.39
spektrale Dichtefunktion
Energiedichtefunktion
Spektrum
Maß für die Varianz im Zusammenhang mit einer zeitabhängigen Variable je Einheitsfrequenzband und je Einheitsrichtungssektor

ANMERKUNG 1 „Spektrum“ ist eine Kurzbezeichnung, die mitunter anstelle der vollständigen und offiziellen Benennungen „spektrale Dichtefunktion“ oder „Energiedichtefunktion“ benutzt wird.

ANMERKUNG 2 Die spektrale Dichtefunktion ist die Varianz (das quadratische Mittel) der zeitabhängigen Variablen für jedes Frequenzband und jeden Richtungssektor. Daher wird das Spektrum im Allgemeinen mit zwei Argumenten angegeben: ein Argument für die Frequenzvariable und ein Argument für eine Richtungsvariable.

ANMERKUNG 3 Innerhalb des vorliegenden Teils von ISO 19901 gilt das Konzept eines Spektrums für Wellen, Windturbulenzen und Einflüsse von Wirkungen (Reaktionen), die durch Wellen oder Windturbulenzen verursacht werden. Für Wellen ist das Spektrum ein Maß für die Energie, die einen bestimmten Raum durchläuft.

3.40
Sturmbö
starkes Windereignis, das durch einen plötzlichen Ausbruch, eine Dauer in der Größenordnung von Minuten und eine eher plötzliche Verringerung der Geschwindigkeit gekennzeichnet ist

ANMERKUNG Eine Sturmbö ist häufig mit einem Wechsel der Windrichtung, einem Abfall der Lufttemperatur und Starkregen verknüpft.

3.41
Ruhewasserspiegel
theoretischer Wasserstand, der im Allgemeinen zur Berechnung kinematischer Wellenkennwerte unter globalen Einflüssen und zur Berechnung der geographischen Höhe von Wellenbergen für die kleinste geographische Höhe des Decks verwendet wird

ANMERKUNG Der Ruhewasserspiegel, auch als Sturmwasserstand bezeichnet, ist eine technische Abstraktion; er wird berechnet, indem die Einflüsse durch Tiden und Sturmflut zur Wassertiefe addiert werden, jedoch ohne Berücksichtigung variierender Wellen (siehe Bild 1). Der Ruhewasserspiegel kann über oder unter dem mittleren Meeresspiegel liegen.

3.42
Sturmflut
Veränderung des Wasserstands des Meeres (entweder positiv oder negativ), die eher auf meteorologische Kräfte (als auf Tidenkräfte) zurückzuführen ist

3.43
anhaltende Windgeschwindigkeit
über die Zeit gemittelte Windgeschwindigkeit mit einer mittleren Dauer von 10 min oder länger in einer festgelegten (geographischen) Höhe

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3.44
Dünung
Seegang
Welle, die ursprünglich durch Wind erzeugt war, sich jedoch über ihren Entstehungsbereich hinaus so fortgepflanzt hat, dass zu den örtlichen Winden keine Beziehung mehr besteht

3.45
tropischer Wirbelsturm
geschlossener Luftumlauf um eine Zone mit niedrigem Druck, die über tropischen Ozeanen entsteht

ANMERKUNG 1 Der Luftumlauf erfolgt auf der nördlichen Halbkugel entgegen dem Uhrzeigersinn und auf der südlichen Halbkugel im Uhrzeigersinn.

ANMERKUNG 2 Ein ausgereifter tropischer Wirbelsturm kann einer der weltweit intensivsten Stürme sein, mit Windgeschwindigkeiten über 90 m/s und begleitet von wolkenbruchartigem Regen.

ANMERKUNG 3 In einigen Gebieten gibt es lokale Benennungen für tropische Wirbelstürme. Im Golf von Mexiko und über dem Nordatlantik werden sie beispielsweise als Hurrikane bezeichnet, während sie im Bereich des Japanischen Meeres und über dem nordwestlichen Pazifik als Taifune bekannt sind. Über dem südlichen Pazifik und dem südlichen Indischen Ozean werden sie üblicherweise als Wirbelstürme bezeichnet.

ANMERKUNG 4 Die Benennung Wirbelsturm wird auch verwendet, wenn Bezug auf einen tropischen Sturm mit anhaltenden Windgeschwindigkeiten von mehr als 32 m/s (Beaufort 12) genommen wird.

3.46
Tsunami
Flutwelle
Oberflächenwellen mit großer Periode, die durch Verschiebung einer Wassersäule mit großem Volumen, normalerweise in einem Ozean, verursacht werden

ANMERKUNG Die vertikale Bewegung des Meeresbodens steht häufig im Zusammenhang mit einem Fehlerbruch bei Erdbeben oder mit Schlammlawinen (Vermurrungen) auf dem Meeresboden.

3.47
Wassertiefe
vertikaler Abstand zwischen Meeresboden und Ruhewasserspiegel

ANMERKUNG 1 Da es mehrere Optionen für den Ruhewasserspiegel gibt, können auch mehrere Wassertiefenwerte angegeben werden. Im Allgemeinen wird die Bemessungswassertiefe unter Bezug auf die niedrigste astronomische Tide (LAT) oder auf die mittlere Meereshöhe bestimmt.

ANMERKUNG 2 Die zur Berechnung der kinematischen Kennwerte einer Welle verwendete Wassertiefe schwankt zwischen der maximalen Wassertiefe bei der höchsten astronomischen Tide zuzüglich einer positiven Sturmflut und der geringsten Wassertiefe bei der niedrigsten astronomischen Tide abzüglich einer negativen Sturmflut, sofern zutreffend. Dieselben maximalen und minimalen Wassertiefen sind auf am Meeresboden abgestützte Plattformen und auf schwimmende Plattformen anwendbar, obwohl die Wassertiefe für schwimmende Plattformen im Allgemeinen kein wichtiger Parameter ist. Die Wassertiefe ist jedoch besonders wichtig für Auslegung und Analyse der Verankerungssysteme und für die Riser von schwimmenden Plattformen.

3.48
Wellenspektrum
Maß für den Betrag der Energie in Verbindung mit Schwankungen der Höhe der Meeresoberfläche je Einheitsfrequenzband und je Einheitsrichtungssektor

ANMERKUNG 1 Das (über alle Richtungen integrierte) Wellenfrequenzspektrum wird oft durch Anwendung von parametrischen Formen beschrieben, z. B. Pierson-Moskowitz- oder JONSWAP-Wellenspektrum.

ANMERKUNG 2 Die Fläche unter dem Wellenspektrum ist das nullte spektrale Moment m_0, das ein Maß für die Gesamtenergie beim jeweiligen Seegang ist; m_0 wird in den gegenwärtigen Definitionen für die signifikante Wellenhöhe verwendet.

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3.49
Wellensteilheit
Kenngröße für Einzelwellen, die als Quotient aus Wellenhöhe und Wellenlänge definiert ist

ANMERKUNG Für periodische Wellen ist diese Benennung vereinfacht anzugeben durch H/λ. Für zufällige Wellen wird diese Definition normalerweise für die signifikante Wellenhöhe (H_s) und die Wellenlänge verwendet, die der mittleren Nulldurchgangsperiode (T_z) des Wellenspektrums in tiefem Wasser entspricht. Die signifikante Wellensteilheit wird dann durch die Gleichung $H_s/\lambda_z = H_s/[(g/2\pi)\ T_z^2]$ definiert.

3.50
Windspektrum
Maß für die Varianz in Verbindung mit der schwankenden Windgeschwindigkeit je Einheitsfrequenzband

ANMERKUNG 1 Das Windspektrum ist eine Ausdruck für die dynamischen Eigenschaften des Windes (Turbulenz). Dieses Spektrum stellt die Schwankungen über und in derselben Richtung wie eine bestimmte mittlere Windgeschwindigkeit dar, im Allgemeinen die über 1 h anhaltende Windgeschwindigkeit. Im vorliegenden Teil von ISO 19901 gibt es daher keine Richtungsvariable in Verbindung mit dem Windspektrum.

ANMERKUNG 2 Da die anhaltende Windgeschwindigkeit mit der Höhe schwankt, ist das Windspektrum eine Funktion der Höhe.

4 Symbole und Abkürzungen

4.1 Symbole

$D(\theta)$	Streuungsfunktion der Wellenrichtung
$D(f,\theta)$	allgemeine Form der Streuungsfunktion für die Wellenrichtung
d	Wassertiefe
$F_{coh}(f;P_1,P_2)$	Kohärenzfunktion zwischen Turbulenzschwankungen bei $P_1(x_1, y_1, z_1)$ und bei $P_2(x_2, y_2, z_2)$
f	Frequenz, in sich wiederholenden Ereignissen je Sekunde (Hertz)
f_1	mittlere Wellenfrequenz des Wellenspektrums ($f_1 = 1/T_1 = \omega_1/(2\pi)$)
f_a	scheinbare Wellenfrequenz ($f_a = 1/T_a = \omega_a/(2\pi)$)
f_e	vorhandene Wellenfrequenz ($f_e = 1/T_e = \omega_e/(2\pi)$)
f_i	Eigenfrequenz einer Welle ($f_i = 1/T_i = \omega_i/(2\pi)$)
f_p	Scheitel- oder Modalfrequenz am Scheitel des Spektrums ($f_p = 1/T_p = \omega_p/(2\pi)$)
f_z	mittlere Nulldurchgangsfrequenz für die Höhe der Wasseroberfläche ($f_z = 1/T_z = \omega_z/(2\pi)$)
g	Erdbeschleunigung; Schwerkraftbeschleunigung
H	Höhe einer Einzelwelle
H_b	Höhe einer brechenden Welle
H_N	maximale Höhe einer Einzelwelle mit einer Wiederkehrperiode von N Jahren. In diesem Zusammenhang werden sowohl H_{max} als auch H_{mp} verwendet
H_s	signifikante Wellenhöhe

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$I_u(z)$	Intensität der Windturbulenz bei z m über der mittleren Meereshöhe
k	Wellenzahl $= 2\ \pi/\lambda$
m_n	n. spektrales Moment (entweder angegeben als f oder ω). Im Besonderen ist m_0 das nullte spektrale Moment, das σ^2 entspricht, der Varianz der entsprechenden Zeitreihe
S	spektrale Dichtefunktion, Energiedichtefunktion
$S(f)$, $S(\omega)$	Spektrum der Wellenfrequenz
$S(f,\ \theta)$, $S(\omega,\ \theta)$	Spektrum der Richtungswellen
S_{JS}	JONSWAP-Spektrum für Seegang
S_{PM}	Pierson-Moskowitz-Spektrum für Seegang
S_{OH}	Ochi-Hubble-Spektrum für einen gesamten Seegang, der aus einer Kombination von zwei Seegängen mit einem allgemeinen Ansatz besteht
T	Wellenperiode; auch Periode im Allgemeinen
T_0	über eine genormte Bezugszeit gemitteltes Intervall für die Windgeschwindigkeit von 1 h = 3 600 s
T_a	scheinbare Periode einer periodischen Welle (für die Betrachtung von einem erdgebundenen Bezugssystem)
T_e	vorhandene Periode einer periodischen Welle (für die Betrachtung von einem Bezugssystem, das sich in Bezug auf die Erde sowie auf die Welle bewegt; dieses Bezugssystem befindet sich im Allgemeinen auf einem fahrenden Schiff)
T_i	Eigenperiode einer periodischen Welle (in einem Bezugssystem, das in Bezug auf die Welle stationär ist, d. h. es ist keine Strömung vorhanden)
T_p	Modal- oder Spitzenperiode des Spektrums
T_z	mittlere Nulldurchgangsperiode der geographischen Höhe der Wasseroberfläche bei Seegang
T_1	mittlere Periode der Höhe der Wasseroberfläche bei Seegang, definiert durch spektrale Momente der nullten und der ersten Ordnung
t	Zeit
U_c	Geschwindigkeit der momentanen freien Strömung
U_{c0}	Geschwindigkeit der Oberflächenströmung bei $z = 0$
U_{ref}	Bezugswindgeschwindigkeit, $U_{ref} = 10$ m/s
$U_c(z)$	Strömungsgeschwindigkeit in der geographischen Höhe z ($z < 0$)
$U_w(z,t)$	räumlich und zeitlich schwankende Windgeschwindigkeit in der geographischen Höhe z über der mittleren Meereshöhe und in einem Augenblick t
$U_w(z)$	mittlere Windgeschwindigkeit in der geographischen Höhe z über der mittleren Meereshöhe, gemittelt über ein festgelegtes Zeitintervall

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$U_{w,1h}(z)$	1 h anhaltende Windgeschwindigkeit in der geographischen Höhe z über der mittleren Meereshöhe
$U_{w,T}(z)$	anhaltende Windgeschwindigkeit in der geographischen Höhe z über der mittleren Meereshöhe, gemittelt über das Zeitintervall $T < 1$ h
U_{w0}	1 h anhaltende Windgeschwindigkeit in 10 m Höhe über der mittleren Meereshöhe (genormte Bezugsgeschwindigkeit für anhaltende Winde)
$u_w(z,t)$	schwankende Windgeschwindigkeit in der geographischen Höhe z um $U_w(z)$ und in derselben Richtung wie der mittlere Wind
$V_{in\text{-}line}$	Komponente der momentanen Strömungsgeschwindigkeit in Reihe mit der Wellenausbreitungsrichtung
x,y,z	Koordinaten eines rechtshändigen orthogonalen Koordinatensystems mit der xy-Ebene am ungestörten Ruhewasserspiegel (für Wellen und Strömungen) oder an der mittleren Meereshöhe (für Winde) und mit der positiven z-Achse nach oben zeigend
z	vertikale Koordinate [gemessen am Ruhewasserspiegel nach oben (für Wellen und Strömungen) oder an der mittleren Meereshöhe (für Winde)]
z_r	Bezugshöhe für Winde oberhalb der mittleren Meereshöhe, $z_r = 10$ m
z_s	gestreckte vertikale Koordinate für Wellen und Strömungen (gemessen am Ruhewasserspiegel nach oben)
γ	Formparameter für den Spitzenverstärkungsfaktor im JONSWAP-Spektrum
η	geographische Höhe der Wasseroberfläche über dem Ruhewasserspiegel als Funktion von Zeit und Lage
θ	Wellenrichtungswinkel
$\bar{\theta}$	mittlere Wellenrichtung
θ_c	Richtung der Strömungsgeschwindigkeit bezogen auf die Wellenrichtung
λ	Spitzenverstärkungsfaktor für die Wellenlänge oder das Ochi-Hubble-Spektrum
σ	Standardabweichung für die Höhe der Wasseroberfläche bei Seegang
σ_a, σ_b	Parameter für den Spitzenverstärkungsfaktor im JONSWAP-Spektrum
σ_{sw}	Parameter zur Festlegung der Breite des symmetrischen Seegangspektrums (ist gleich der Standardabweichung der Gauss'schen Funktion)
ϕ	Richtungsverteilungsfaktor
ω	Winkelfrequenz (Radiant je Sekunde $\omega = 2\pi f$)

4.2 Abkürzungen

HAT höchste astronomische Tide (en: highest astronomical tide)

LAT niedrigste astronomische Tide (en: lowest astronomical tide)

MSL mittlere Meereshöhe (en: mean sea level)

PSU praktische Einheit für den Salzgehalt (en: practical salinity unit)

VIV durch Kreisströmungen induzierte (vortexinduzierte) Schwingungen (en: vortex-induced vibration)

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Literaturhinweise

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Foreword

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Endorsement notice

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Foreword

— Part 1: *Metocean design and operating considerations*

— Part 2: *Seismic design procedures and criteria*

— Part 3: *Topsides structure*

— Part 4: *Geotechnical and foundation design considerations*

— Part 5: *Weight control during engineering and construction*

— Part 6: *Marine operations*

— Part 7: *Stationkeeping systems for floating offshore structures and mobile offshore units*

The following part is under preparation:

— Part 8: *Marine soil investigations.*

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

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

— 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*

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

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

— ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary*

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

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Introduction

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

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

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

The overall concept of structural integrity is described above. Some additional considerations apply for metocean design and operating conditions. The term “metocean” is short for “meteorological and oceanographic” and refers to the discipline concerned with the establishment of relevant environmental conditions for the design and operation of offshore structures. A major consideration in the design and operation of such a structure is the determination of actions on, and the behaviour of, the structure as a result of winds, waves and currents.

Environmental conditions vary widely around the world. For the majority of offshore locations there are little numerical data from historic conditions; comprehensive data often only start being collected when there is a specific need, for example, when exploration for hydrocarbons is being considered. Despite the usually short duration for which data are available, designers of offshore structures need estimates of extreme and abnormal environmental conditions (with an individual or joint probability of the order of 1×10^{-2}/year and 1×10^{-3} to 1×10^{-4}/year, respectively).

Even for areas like the Gulf of Mexico, offshore Indonesia and the North Sea, where there are up to 30 years of fairly reliable measurements available, the data are insufficient for rigorous statistical determination of appropriate extreme and abnormal environmental conditions. The determination of relevant design parameters has therefore to rely on the interpretation of the available data by experts, together with an assessment of any other information, such as prevailing weather systems, ocean wave creation and regional and local bathymetry, coupled with consideration of data from comparable locations. It is hence important to employ experts from both the metocean and structural communities in the determination of design parameters for offshore structures, particularly since setting of appropriate environmental conditions depends on the chosen option for the offshore structure.

This part of ISO 19901 provides procedures and guidance for the determination of environmental conditions and their relevant parameters. Requirements for the determination of the actions on, and the behaviour of, a structure in these environmental conditions are given in ISO 19901-3, ISO 19901-6, ISO 19901-7, ISO 19902, ISO 19903, ISO 19904-1, ISO 19905-1 and ISO 19906.

Some background to, and guidance on, the use of this part of ISO 19901 is provided in informative Annex A. The clause numbering in Annex A is the same as in the main text to facilitate cross-referencing.

Regional information, where available, is provided in the Regional Annexes B through H. This information has been developed by experts from the region or country concerned to supplement the guidance provided in this

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part of ISO 19901. Each Regional Annex provides regional or national data on environmental conditions for the area concerned.

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Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations

1 Scope

This part of ISO 19901 gives general requirements for the determination and use of meteorological and oceanographic (metocean) conditions for the design, construction and operation of offshore structures of all types used in the petroleum and natural gas industries.

The requirements are divided into two broad types:

— those that relate to the determination of environmental conditions in general, together with the metocean parameters that are required to adequately describe them;

— those that relate to the characterization and use of metocean parameters for the design, the construction activities or the operation of offshore structures.

The environmental conditions and metocean parameters discussed are

— extreme and abnor mal values of metocean parameters that recur with given return periods that are considerably longer than the design service life of the structure,

— long-term distributions of metocean parameters, in the form of cumulative, conditional, marginal or joint statistics of metocean parameters, and

— normal environmental conditions that are expected to occur frequently during the design service life of the structure.

Metocean parameters are applicable to

— the determination of actions and action effects for the design of new structures,

— the determination of actions and action effects for the assessment of existing structures,

— the site-specific assessment of mobile offshore units,

— the determination of limiting environmental conditions, weather windows, actions and ac tion effects for pre-service and post-service situations (i.e. fabrication, transportation and installation or decommissioning and removal of a structure), and

— the operation of the platform, where appropriate.

NOTE Specific metocean requirements for site-specific assessment of jack-ups are contained in ISO 19905-1, for arctic structures in ISO 19906 and for topsides structures in ISO 19901-3.

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2 Normative references

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

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

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

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

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

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

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

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

WMO-No. 306, *Manual on Codes*

3 Terms and definitions

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

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

NOTE Abnormal events have probabilities of the order of 10^{-3} to 10^{-4} per annum. In the limit state checks, some or all of the partial factors are set to 1,0.

3.2
chart datum
local datum used to fix water depths on a chart or tidal heights over an area

NOTE Chart datum is usually an approximation to the level of the lowest astronomical tide.

3.3
conditional probability
conditional distribution
statistical distribution (probability) of the occurrence of a variable A, given that other variables B, C, … have certain assigned values

NOTE The conditional probability of A given that B, C, … occur is written as $P(A|B,C,\ldots)$. The concept is applicable to metocean parameters, as well as to actions and action effects.

EXAMPLE When considering wave parameters, A can be the individual crest elevation, B the water depth and C the significant wave height, and so on.

3.4
design crest elevation
extreme crest elevation measured relative to still water level

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NOTE The design crest elevation is used in combination with information on astronomical tide, storm surge, platform settlement, reservoir subsidence and water depth uncertainty and is derived from an extreme value analysis. Where simplified models are used to estimate the kinematics of the design wave, the design crest elevation can be different from (usually somewhat greater than) the crest elevation of the design wave used to calculate actions on the structure. In reality, the wave with the greatest trough-to-crest height and the wave with the highest crest will be different waves.

3.5
design wave
deterministic wave used for the design of an offshore structure

NOTE 1 The design wave is an engineering abstraction. Most often it is a periodic wave with suitable characteristics (e.g. height H, period T, steepness, crest elevation). The choice of a design wave depends on

— the design purpose(s) considered,

— the wave environment,

— the geometry of the structure,

— the type of action(s) or action effect(s) pursued.

NOTE 2 Normally, a design wave is only compatible with design situations in which the action effect(s) are quasi-statically related to the associated wave actions on the structure.

3.6
expert
<metocean> individual who through training and experience is competent to provide metocean advice specific to the area or topic in question

3.7
extreme water level
EWL
combination of 'design crest elevation', astronomical tide and 'storm surge' referenced to either LAT or MSL

3.8
extreme value
design value of a parameter used in ultimate limit state checks

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

3.9
gravity wave
wave in a fluid or in the interface between two fluids for which the predominant restoring forces are gravity and buoyancy

NOTE Wind-generated surface waves are an example of gravity waves.

3.10
gust
brief rise and fall in wind speed lasting less than 1 min

NOTE In some countries, gusts are reported in meteorological observations if the maximum wind speed exceeds approximately 8 m/s.

3.11
gust wind speed
maximum value of the wind speed of a gust averaged over a short (3 s to 60 s) specified duration within a longer (1 min to 1 h) specified duration

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NOTE 1 For design purposes, the specified duration depends on the dimensions and natural period of (part of) the structure being designed such that the structure is designed for the most onerous conditions; thus, a small part of a structure is designed for a shorter gust wind speed duration (and hence a higher gust wind speed) than a larger (part of a) structure.

NOTE 2 The elevation of the measured gust should also be specified.

3.12
highest astronomical tide
HAT
level of high tide when all harmonic components causing the tides are in phase

NOTE The harmonic components are in phase approximately once every 19 y ears, but these conditions are approached several times each year.

3.13
hindcasting
method of simulating historical (metocean) data for a region through numerical modelling

3.14
Infra-gravity wave
surface gravity wave with a period in the range of roughly 25 s to 300 s

NOTE In principal an infra-gravity wave is generated by different physical processes but most commonly associated with waves generated by non-linear second-order difference frequency interactions between different swell wave components.

3.15
internal wave
gravity wave which propagates within a stratified water column

3.16
long-term distribution
probability distribution of a variable over a long time scale

NOTE The time scale exceeds the duration of a sea state, in which the statistics are assumed constant (see **3.34 short-term distribution**). The time scale is hence comparable to a season or to the design service life of a structure.

EXAMPLE Long-term distributions of

— significant wave height (based on, for example, storm peaks or all sea states),

— significant wave height in the months May to September,

— individual wave heights,

— current speeds (such as for use in assessing vortex-induced vibrations of drilling risers),

— scatter diagrams with the joint distribution of significant wave height and wave period (such as for use in a fatigue analysis),

— a particular action effect,

— storm maximum significant wave height.

3.17
lowest astronomical tide
LAT
level of low tide when all harmonic components causing the tides are in phase

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NOTE The harmonic components are in phase approximately once every 19 y ears, but these conditions are approached several times each year.

3.18
marginal distribution
marginal probability
statistical distribution (probability) of the occurrence of a variable A independent of any other variable

NOTE The marginal distribution is obtained by integrating the full distribution over all values of the other variables B, C, … and is written as $P(A)$. The concept is applicable to metocean parameters, as well as to actions and action effects.

EXAMPLE When considering wave conditions, A can be the individual crest elevation for all mean zero-crossing periods B and all significant wave heights C, occurring at a particular site.

3.19
marine growth
living organisms attached to an offshore structure

3.20
mean sea level
MSL
arithmetic mean of all sea levels measured over a long period

NOTE Seasonal changes in mean level can be expected in some regions and over many years the mean sea level can change.

3.21
mean wind speed
time-averaged wind speed, averaged over a specified time interval and at a specified elevation

NOTE The mean wind speed varies with elevation above mean sea level and the averaging time interval; a standard reference elevation is 10 m and a standard time interval is 1 h. See also **3.11 gust wind speed** and **3.43 sustained wind speed**.

3.22
mean zero-crossing period
average period between (up or down) zero-crossing waves in a sea state

NOTE In practice the mean zero-crossing period is often estimated from the zeroth and second moments of the wave spectrum as $T_z = T_2 = \sqrt{m_0(f)/m_2(f)} = 2\pi\sqrt{m_0(\omega)/m_2(\omega)}$.

3.23
monsoon
seasonally reversing wind pattern, with associated pattern of rainfall

NOTE The term was first applied to the winds over the Arabian Sea which blow for six months from north-east and for six months from south-west, but it has been extended to similar winds in other parts of the world.

3.24
most probable maximum
value of the maximum of a variable with the highest probability of occurring

NOTE The most probable maximum is the value for which the probability density function of the maxima of the variable has its peak. It is also called the mode or modus of the statistical distribution.

3.25
operating conditions
most severe combination of environmental conditions under which a given operation is permitted to proceed

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NOTE Operating conditions are determined for operations that exert a significant action on the structure. Operating conditions are usually a compromise: they are sufficiently severe that the operation can generally be performed without excessive downtime, but they are not so severe that they have an undue impact on design.

3.26
polar low
depression that forms in polar air, often near a boundary between ice and sea

3.27
residual current
part of the total current that is not constituted from harmonic tidal components (i.e. the tidal stream)

NOTE Residual currents are caused by a variety of physical mechanisms and comprise a large range of natural frequencies and magnitudes in different parts of the world.

3.28
return period
average period between occurrences of an event or of a particular value being exceeded

NOTE The offshore industry commonly uses a return period measured in years for environmental events. For a rare event, the return period in years is equal to the reciprocal of the annual probability of exceedance of the event.

3.29
scatter diagram
joint probability of two or more (metocean) parameters

NOTE A scatter diagram is especially used with wave parameters in the metocean context (for example in fatigue assessments). The wave scatter diagram is commonly understood to be the probability of the joint occurrence of the significant wave height (H_s) and a representative period (T_z or T_p).

3.30
sea floor
interface between the sea and the seabed

3.31
sea state
condition of the sea during a period in which its statistics remain approximately stationary

NOTE In a statistical sense the sea state does not change markedly within the period. The period during which this condition exists is often assumed to be three hours, although it depends on the particular weather situation at any given time.

3.32
seabed
materials below the sea in which a structure is founded, whether of soils such as sand, silt or clay, cemented material or of rock

3.33
seiche
oscillation of a body of water at its natural period

3.34
short-term distribution
probability distribution of a variable within a short interval of time during which conditions are assumed to be statistically stationary

NOTE The interval chosen is most often the duration of a sea state.

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3.35
significant wave height
statistical measure of the height of waves in a sea state

NOTE The significant wave height was originally defined as the mean height of the highest one-third of the zero up-crossing waves in a sea state. In most offshore data acquisition systems the significant wave height is currently taken as $4\sqrt{m_0}$, (where m_0 is the zeroth spectral moment, see **3.37 spectral moment**) or 4σ, where σ is the standard deviation of the time series of water surface elevation over the duration of the measurement, typically a period of approximately 30 min.

3.36
soliton
solitary wave or wave packet travelling on an internal density discontinuity which, as a result of the cancellation of nonlinear and dispersive effects, maintains its shape and speed over extended distances

EXAMPLE Internal tides which form on the density gradient within the water column can interact with the continental slope and form internal solitary wave packets. Offshore Northwest Australia breaking internal solitons have been noted to generate elevated seabed currents.

3.37
spectral moment
n^{th} spectral moment
integral over frequency of the spectral density function multiplied by the nth power of the frequency, either expressed in hertz (cycles per second) as $m_n(f) = \int_0^\infty f^n \; S(f) df$ or expressed in circular frequency (radians/second) as $m_n(\omega) = \int_0^\infty \omega^n S(\omega) d\omega$

NOTE 1 As $\omega = 2\,\pi f$, the relationship between the two moment expressions is: $m_n(\omega) = (2\pi)^n\, m_n(f)$.

NOTE 2 The integration extends over the entire frequency range from zero to infinity. In practice the integration is often truncated at a frequency beyond which the contribution to the integral is negligible and/or the sensor no longer responds accurately. Care should be taken when utilizing moments of order higher than 2, as for standard spectral models, the 4th moment will not converge; the value is in effect determined by the choice of truncation.

3.38
spectral peak period
period of the maximum (peak) energy density in the spectrum

NOTE In practice there is often more than one peak in a spectrum.

3.39
spectral density function
energy density function
spectrum
measure of the variance associated with a t ime-varying variable per unit frequency band and per unit directional sector

NOTE 1 Spectrum is a shorter expression for the full and formal name of spectral density function or energy density function.

NOTE 2 The spectral density function is the variance (the mean square) of the time-varying variable concerned in each frequency band and directional sector. Therefore the spectrum is in general written with two arguments: one for the frequency variable and one for a direction variable.

NOTE 3 Within this part of ISO 19901, the concept of a spectrum applies to waves, wind turbulence and action effects (responses) that are caused by waves or wind turbulence. For waves, the spectrum is a measure of the energy traversing a given space.

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3.40
squall
strong wind event characterized by a sudden onset, a duration of the order of minutes and a rather sudden decrease in speed

NOTE A squall is often accompanied by a change in wind direction, a drop in air temperature and heavy precipitation.

3.41
still water level
abstract water level typically used for the calculation of wave kinematics for global actions and wave crest elevation for minimum deck elevations

NOTE Still water level, also referred to as storm water level, is an engineering abstraction calculated by adding the effects of tides and storm surge to the water depth but excluding variations due to waves (see Figure 1). It can be above or below mean sea level.

3.42
storm surge
change in sea level (either positive or negative) that is due to meteorological (rather than tidal) forcing

3.43
sustained wind speed
time averaged wind speed with an averaging duration of 10 min or longer at a specified elevation

3.44
swell
wave that was wind-generated but has travelled out of its generation area and has no relationship with the local wind

3.45
tropical cyclone
closed atmospheric circulation around a zone of low pressure that originates over the tropical oceans

NOTE 1 The circulation is counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere.

NOTE 2 At maturity, the tropical cyclone can be one of the most intense storms in the world, with wind speeds exceeding 90 m/s and accompanied by torrential rain.

NOTE 3 In some areas, local terms for tropical cyclones are used. For example, tropical cyclones are typically referred to as hurricanes in the Gulf of Mexico and North Atlantic, while in the East Asian Sea and NW Pacific they are called typhoons. In the South Pacific and South Indian Ocean, however, they are commonly referred to as cyclones.

NOTE 4 The term cyclone is also used to refer to a tropical storm with sustained wind speeds in excess of 32 m/s (Beaufort Force 12).

3.46
tsunami
long period surface waves caused by displacement of a large volume of a body of water, normally an ocean

NOTE The vertical movement of the sea floor is often associated with fault rupture during earthquakes or with seabed mud slides.

3.47
water depth
vertical distance between the sea floor and still water level

NOTE 1 As there are several options for the still water level, there can be several water depth values. Generally, design water depth is determined to LAT or to mean sea level.

NOTE 2 The water depth used for calculating wave kinematics varies between the maximum water depth of the highest astronomical tide plus a positive storm surge, and the minimum water depth of the lowest astronomical tide less a negative

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storm surge, where applicable. The same maximum and minimum water depths are applicable to bottom-founded and floating structures, although water depth is usually a much less important parameter for floating structures. Water depth is, however, important for the design and analysis of the mooring system and risers for floating structures.

3.48
wave spectrum
measure of the amount of energy associated with the fluctuation of the sea surface elevation per unit frequency band and per unit directional sector

NOTE 1 The wave frequency spectrum (integrated over all directions) is often described by use of some parametric form such as the Pierson-Moskowitz or JONSWAP wave spectrum.

NOTE 2 The area under the wave spectrum is the zeroth spectral moment m_0, which is a measure of the total energy in the sea state; m_0 is used in contemporary definitions of the significant wave height.

3.49
wave steepness
characteristic of individual waves defined as wave height divided by wave length

NOTE 1 For periodic waves, the concept is straightforward as H / λ. For random waves, the definition is normally used with the significant wave height (H_s) and the wave length that corresponds with the mean zero crossing period (T_z) of the wave spectrum in deep water. The significant wave steepness is then defined as $H_s / \lambda_z = H_s / [(g/2\pi)\, T_z^2]$.

3.50
wind spectrum
measure of the variance associated with the fluctuating wind speed per unit frequency band

NOTE 1 The wind spectrum is an ex pression of the dynamic properties of the wind (turbulence). It reflects the fluctuations about and in the same direction as a certain mean wind speed, usually the 1 h sustained wind speed. There is hence no direction variable associated with the wind spectrum within this part of ISO 19901.

NOTE 2 As the sustained wind speed varies with elevation, the wind spectrum is a function of elevation.

4 Symbols and abbreviated terms

4.1 Symbols

$D(\theta)$	wave directional spreading function
$D(f,\theta)$	general form of the wave directional spreading function
d	water depth
$F_{coh}(f;P_1,P_2)$	coherence function between turbulence fluctuations at $P_1(x_1, y_1, z_1)$ and at $P_2(x_2, y_2, z_2)$
f	frequency in cycles per second (Hertz)
f_1	mean wave frequency of the wave spectrum ($f_1 = 1/T_1 = \omega_1 / (2\pi)$)
f_a	apparent wave frequency ($f_a = 1/T_a = \omega_a / (2\pi)$)
f_e	encounter wave frequency ($f_e = 1/T_e = \omega_e / (2\pi)$)
f_i	intrinsic wave frequency ($f_i = 1/T_i = \omega_i / (2\pi)$)
f_p	peak or modal frequency at the peak of the spectrum ($f_p = 1/T_p = \omega_p / (2\pi)$)

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f_z	average zero-crossing frequency of the water surface elevation ($f_z = 1/T_z = \omega_z/(2\pi)$)
g	acceleration due to gravity
H	height of an individual wave
H_b	breaking wave height
H_N	maximum height of an individual wave having a return period of N years. Both H_{max} and H_{mp} are also used in this context
H_s	significant wave height
$I_u(z)$	wind turbulence intensity at z m above mean sea level
k	wave number = $2\pi / \lambda$
m_n	n^{th} spectral moment (either in terms of f or ω). In particular, m_0 is the zeroth spectral moment and is equivalent to σ^2, the variance of the corresponding time series
S	spectral density function, energy density function
$S(f)$, $S(\omega)$	wave frequency spectrum
$S(f, \theta)$, $S(\omega, \theta)$	directional wave spectrum
S_{JS}	JONSWAP spectrum for a sea state
S_{PM}	Pierson-Moskowitz spectrum for a sea state
S_{OH}	Ochi-Hubble spectrum for a total sea state consisting of a combination of two sea states with a general formulation
T	wave period; also period in general
T_0	standard reference time-averaging interval for wind speed of 1 h = 3 600 s
T_a	apparent period of a periodic wave (to an observer in an earth-bound reference frame)
T_e	encounter period of a periodic wave (to an observer in a reference frame that moves with respect to earth as well as the wave; the frame is usually fixed to a moving vessel)
T_i	intrinsic period of a periodic wave (in a reference frame that is stationary with respect to the wave, i.e. with no current present)
T_p	modal or peak period of the spectrum
T_z	mean zero-crossing period of the water surface elevation in a sea state
T_1	mean period of the water surface elevation in a sea state, defined by the zero and first-order spectral moments
t	time

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U_c	free stream current velocity
U_{c0}	surface current speed at z = 0
U_{ref}	reference wind speed, U_{ref} = 10 m/s
$U_c(z)$	current speed at elevation z (z < 0)
$U_w(z,t)$	spatially and temporally varying wind speed at elevation z above mean sea level and at time instant t
$U_w(z)$	mean wind speed at elevation z above mean sea level averaged over a specified time interval
$U_{w,1h}(z)$	1 h sustained wind speed at elevation z above mean sea level
$U_{w,T}(z)$	sustained wind speed at elevation z above mean sea level, averaged over time interval $T < 1$ h
U_{w0}	1 h sustained wind speed at 10 m above mean sea level (the standard reference speed for sustained winds)
$u_w(z,t)$	fluctuating wind speed at elevation z around $U_w(z)$ and in the same direction as the mean wind
$V_{in\text{-}line}$	component of the current velocity in-line with the direction of wave propagation
x,y,z	coordinates of a r ight-handed orthogonal coordinate system with the xy-plane in the undisturbed still water level (for waves and currents) or mean sea level (for winds) and the z-axis positive upwards
z	vertical coordinate [measured upwards from the still water level (for waves and currents) or mean sea level (for winds)]
z_r	reference elevation for winds above the mean sea level, z_r = 10 m
z_s	stretched vertical coordinate for waves and currents (measured upwards from the still water level)
γ	shape parameter of the peak enhancement factor in the JONSWAP spectrum
η	water surface elevation above still water level as a function of time and location
θ	wave direction angle
$\bar{\theta}$	mean wave direction
θ_c	direction of the current velocity relative to the wave direction
λ	wave length or Ochi-Hubble spectrum peak enhancement factor
σ	standard deviation of the water surface elevation in a sea state
σ_a, σ_b	parameters in the peak enhancement factor of the JONSWAP spectrum

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σ_{sw}	parameter defining the width of the symmetric swell spectrum (equals the standard deviation of the Gaussian function)
ϕ	directional spreading factor
ω	angular frequency (radians per second $\omega = 2\pi f$)

4.2 Abbreviated terms

HAT highest astronomical tide

LAT lowest astronomical tide

MSL mean sea level

PSU practical salinity unit

VIV vortex-induced vibration

5 Determining the relevant metocean parameters

5.1 General

The owner or operator of an offshore installation is responsible for the selection of the environmental conditions applicable to particular design and operating situations.

The selection shall consider

— the type of structure being designed or assessed,

— the nature of the activity to be undertaken (e.g. construction, transportation, installation, drilling, production, etc.),

— the limit state considered (e.g. ultimate, fatigue, accidental),

— any additional company or regulatory requirements.

The type of metocean information that may need to be determined includes:

a) extreme and abnormal metocean parameters, which are required to develop extreme and abnormal environmental actions and/or action effects. These parameters are used to define design situation(s) and to perform design checks for ultimate limit states and accidental limit states.

b) long-term distributions of metocean parameters, in the form of cumulative conditional or marginal statistics. These parameters are used

   — to define design situation(s) and 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) long-term time series of metocean parameters for use in response based analyses

d) normal environmental conditions, which are required

   — for carrying out checks for serviceability limit states,

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— for developing actions and action effects to determine when particular operations can safely take place, and

— for planning construction activities (fabrication, transportation or installation) or field operations (e.g. drilling, production, offloading, underwater activities).

Depending on the geographical region and the offshore operations involved, other environmental conditions can be required for specific design situations or for particular operations.

5.2 Expert development of metocean criteria

Reliable estimates of (very) low probability environmental events can be made using a number of different approaches, including analysis of all data values, annual or monthly maxima, or peak-over-threshold events. Implicit in the use of each approach are assumptions about the data used, the statistical procedures applied, and the interpretation of the results.

The appropriate design parameters are also dependent on the structural form chosen, for example, different design parameters can be appropriate to fixed or floating structures.

Experts in meteorology and oceanography are needed to obtain reliable and appropriate design parameters. The experts should be involved in the analyses of the data and their interpretation into design criteria. They should be integral members of design teams, particularly when the environmental conditions and associated metocean parameters used for the design of proposed structures are based on design criteria for actions (action effects) with long return periods.

5.3 Selecting appropriate parameters for determining design actions and action effects

Environmental actions and associated action effects used in the design and assessment of offshore structures are dominated by one or more metocean parameters depending on factors including

— the structural form (e.g. fixed jacket, semisubmersible or monohull),

— the geographical location (e.g. regions where strong currents can be present),

— the exposure of individual structural elements to wind, wave or current action,

— the limit state being addressed.

Information on the metocean parameters appropriate to each structural form is presented in the relevant ISO publication (see Clause 2). The final choice of metocean parameters to be used to determine design actions or action effects should be carried out in consultation with structural engineers.

Where wave actions dominate, the wave condition(s) to be considered for a particular design situation can be specified through either

a) long-term statistical distributions of the oceanographic parameters describing the wave climate at the location of interest over many years;

   Where adequate data are available, the statistical distributions may reflect the joint occurrence of the oceanographic parameters. Alternatively, the distributions can be marginal distributions for separate parameters. From these long-term distributions, appropriate oceanographic design parameters shall be derived that are commensurate with the design situation involved.

b) short-term descriptions of one or a number of different design sea states, in conjunction with one or more design winds and currents;

   A design sea state shall be described by a wave spectrum together with the significant wave height, a representative frequency or period, and a mean wave direction. Where appropriate, the wave spectrum

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may be supplemented with a directional spreading function, see 8.3. A design current is specified by a surface velocity and its velocity profile over the water column, including its direction, see Clause 9.

c) one or a number of individual design waves, in conjunction with one or more design winds and currents.

A design wave shall be specified by its height and period, together with an appropriate wave theory from which the wave kinematics can be derived, as well as (an) associated direction(s), see Clause 8. A design current is specified by a surface velocity and its velocity profile over the water column including its direction, see Clause 9.

The above descriptions shall be supplemented by associated meteorological conditions that are relevant for the particular design situation considered.

The selection of the most appropriate specification a), b) or c) above depends on the data that are available for the location of interest, the type of structure concerned, the design situation involved and the limit state considered. It is entirely appropriate that a different selection is made to suit different structure types, different design situations and different limit states.

If the current is known to dominate design actions on the structure, the selection of associated wave heights and wind speeds for a given current velocity should be considered.

Where environmental actions for structural design are not dominated by wave or current conditions (but, for example, by wind or earthquakes), special consideration shall be given to the selection of the relevant metocean parameters in combination with those other events.

5.4 The metocean database

A site-specific metocean database shall be established containing information on

— significant wave heights, periods, directions and spreading,

— current speeds and directions at a number of depths throughout the water column,

— wind speeds and directions,

— sea ice, icebergs, snow and ice accretion,

— water levels, and

— other relevant metocean parameters (air and water temperatures, water salinity, etc.).

The database may either be established by site-specific measurements over a period of years or by numerical modelling (hindcasts) of historical events. If numerical simulations are used, the simulated results shall be calibrated (or verified) against appropriate measurements.

Where possible, the database should be sufficiently long to encompass all the physical processes which can be encountered during the lifetime of the structure. Where this is not possible, the metocean criteria derived directly from the database should be modified appropriately.

For more detailed advice on sea ice, icebergs, snow and ice accretion, see ISO 19906.

5.5 Storm types in a region

General information on the various types of storms which can affect the structure shall be used to supplement available data.

When determining the appropriate environmental conditions, it is important to separate storms of different types, for example, monsoons and typhoons, before performing an extreme-value analysis. Furthermore, it can be necessary to set operating limits for a particular structure for particular storm types and seasons.

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5.6 Directionality

In some locations, representative storm tracks and topographic features can provide fetch limitations on wave heights from specific directions, or tidal or general circulation currents can be in a predominant direction. For design in such situations, different wave, wind and/or current magnitudes may be used for different approach directions, provided that sufficient reliable data are available to derive them. However, the owner of the structure shall ensure that the overall reliability of the structure is not compromised by the use of such lower directional environmental conditions.

If reliable directional information is not available, conservative assumptions shall be made with respect to relative directions of winds, waves and current.

5.7 Extrapolation to extreme and abnormal conditions

Designers require metocean parameters at (very) low probabilities or recurrence rates, e.g. with a return period of 100, 1 000 or 10 000 years. Where data covering such long periods are not available, an extrapolation of existing data is necessary. Many extrapolation methods are used and there is no universally accepted method; expert advice shall be sought. In general, the longer the dataset the more accurate the extrapolation will be. In some relatively homogeneous areas, site-pooling of hindcast datasets can be used to extend the time basis for estimating return period values at a particular site, thereby reducing the uncertainty of the extrapolation. Important considerations in site-pooling are to choose sites which are far enough apart such that they provide independent realizations of the local conditions, but not to choose sites which are so far apart that true spatial variations in extremes are smoothed over. However, even with long data sets, estimates of (very) low probability parameters can still depend to a considerable degree on the extrapolation method and sampling variability. Confidence intervals may be estimated to assess the uncertainty due to sampling variability.

5.8 Metocean parameters for fatigue assessments

The fatigue limit state can govern the design of individual structural components in fixed and floating offshore structures in several parts of the world.

Fatigue is an accumulation of damage caused by the repeated application of time-varying stresses which can result from the environmental actions to which the structure is exposed.

Fatigue limit-state assessment of a structure requires specification of all environmental conditions that are expected to occur during the entire period of the structure's exposure, i.e. its construction phase, including transportation, and its design service life. The specification of the environment is given by the long-term distribution(s) of one or more metocean parameters. The metocean parameters relevant for the fatigue assessment depend on the type of structure and the location under consideration. The distribution(s) of the relevant parameter(s) shall be determined from the metocean database, taking due account of the requirements for the structure being considered.

When computing the cumulative fatigue damage over the life of the structure using the distribution of relevant parameters, it should be kept in mind that this is an estimate of the expected long-term fatigue damage. In such assessments, by their very nature, rare events are weighted with a low probability of occurrence. In some cases, however, it should be considered how much damage a structure may accumulate during a rare event which imposes a relatively low number of very large amplitude stress cycles. Such “low-cycle fatigue assessments” ensure that the occurrence of a single extreme or abnormal event does not consume a significant proportion of the overall fatigue life of a structural system.

For some components and types of structures, cyclic stresses due to vortex-induced vibrations (VIV) in steady currents or winds should also be considered.

Information on the metocean parameters appropriate to the fatigue assessment of certain structural forms is presented in the relevant ISO publication (see Clause 2).

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5.9 Metocean parameters for short-term activities

Transportation, installation, maintenance and removal of a structure are scheduled activities that are weather-sensitive. Operation of a structure includes regular and routine activities that are also weather-sensitive. Some of these activities are sensitive to high winds, while others are sensitive to currents, swell, wave heights, wave periods, wave directions or combinations thereof.

Examples of weather-sensitive scheduled short-term activities are

a) transportation of the structure over a relatively short distance,

b) installation of fixed steel offshore structures, including

   1) lifting, launching, upending and placement on the seabed,

   2) the period following placement but prior to and during piling, and

   3) the period following piling but prior to and during pile grouting and until grout setting,

c) installation of fixed concrete offshore structures, including

   1) placement on the seabed, and

   2) the period following placement but prior to and during any grouting and until grout setting,

d) establishment/re-establishment of a floating structure at the operating location, including the setting of mooring systems,

e) installation and foundation pre-loading for jack-ups,

f) topsides installation,

g) underwater operations, including inspection and repair, and

h) removal for decommissioning or reuse.

As well as being critical and ex pensive, these activities usually require a weather window with low environmental conditions for significant durations, e.g. sufficient to allow for all piling and pile fixing. Consequently, the accuracy of short-term forecasting can be as important as the values of the metocean parameters.

Examples of routine activities that are weather-sensitive:

— use of cranes for lifting to and from supply boats;

— use of cranes for moving items around decks;

— under-deck access;

— use of drilling derrick, particularly derrick movements;

— helicopter movements;

— personnel transfer operations by boat.

These activities generally have different weather sensitivities.

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Limiting criteria shall be established for each activity. In many cases the limitations are established by considering the safety of personnel.

It is useful in the planning of a development or the planning of a specific activity to know that the probability of the metocean parameters exceeding the criteria for particular activities is sufficiently low for sufficient time to complete these activities. The probability of sufficiently calm conditions for a given location typically varies on a seasonal basis.

Predictions of the variation in the relevant metocean parameters should be made from the metocean database. Predictions should provide either the proportion of time and the durations for which metocean parameters are expected to remain within limiting criteria, or the probability of the values of certain metocean parameters being exceeded. Seasonal variations (by month or by quarter) should be reported if these are significant. In addition, it should be considered and made clear to users of such criteria that in addition to seasonal variations in operational conditions, there can be significant year-to-year variations.

5.10 Metocean parameters for medium-term activities

Medium-term activities such as transportation of a structure or structural members, particularly when involving long exposed tows, are scheduled activities which are weather sensitive but which have durations significantly longer than the length of the available weather forecast. For such activities, certain design criteria may need to be established, such as sea-fastening load criteria.

For a transportation, the design criteria should be defined, consisting of the design wave, design wind and, if relevant, design current. Where the transportation transits through different geographical areas, the maximum wave and maximum wind may not occur in the same area, in which case it is necessary to check the extremes in each area, to establish governing load cases.

6 Water depth, tides and storm surges

6.1 General

The water depth at the site, including variations in the water depth, shall be determined where significant for the type of structure being considered.

The range of water depths at a particular site is important for the design of structures as it affects several parameters, including

— environmental actions on the structure,

— elevations of boat landings, fenders, and cellar deck on bottom-founded structures,

— riser length/stroke on floating structures, and

— mooring forces for taut or vertically moored floating structures.

For the purpose of design or assessment, the water depth can be considered to consist of a more or less stationary component, this being the water depth to a reference chart datum (e.g. LAT or MSL), and variations with time relative to this level (see Figure 1). The variations are due to the astronomical tide (see 6.2) and to the wind and atmospheric pressure, which can create storm surges (which can be positive or negative) (see 6.3). Other variations in water level can result from long-term climatic variations, sea floor subsidence or episodic events such as tsunamis. Water level variations can have a relatively minor impact in deep water, but can be considerably more important in shallow water.

It is important for the design of all structures (and in particular bottom-founded structures in shallow water) to have a good knowledge of the joint distribution of the tide, the storm surge height and the crest and trough elevations of the waves.

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6.2 Tides

Tidal variations are the result of the gravitational and rotational interaction between the sun, moon and earth and are regular and largely predictable; they are bounded by the highest astronomical tide (HAT) and the lowest astronomical tide (LAT) at the site.

The variations in elevation of the daily astronomical tides determine the elevations of boat landings, fenders, splash-zone treatment, conductors and risers, and the upper limits of marine growth for bottom-founded structures.

6.3 Storm surges

Storm surges are meteorologically generated. Since the generation of surges is unrelated to tides, their occurrences are randomly superimposed on tidal variations. In deep and modest water depths, tidal and storm surge elevations can be arithmetically added to good approximation. In shallow water, tide and surge can interact due to non-linear bottom friction effects. Since surges cause water level variations additional to tides, total still water levels above HAT and below LAT can occur.

6.4 Extreme water level

The extreme water level is derived through a combination of 'design crest elevation', astronomical tide and 'storm surge' referenced to either LAT or MSL.

The combination may be either a straight summation of the 'design crest elevation' and the 'still water level', or it may be developed taking into account the joint probability of occurrence of crest, tide and surge.

Extreme water level is a starting point for ascertaining the minimum height of the main deck of a bottom-founded structure. Allowance should also be made for platform settlement, reservoir subsidence and water depth uncertainty.

Structures with large diameter columns can modify the incident wave field, resulting in changes to the extreme water level (and other wave properties) estimated in the absence of wave/structure interactions. Such changes may need to be addressed as part of the design process.

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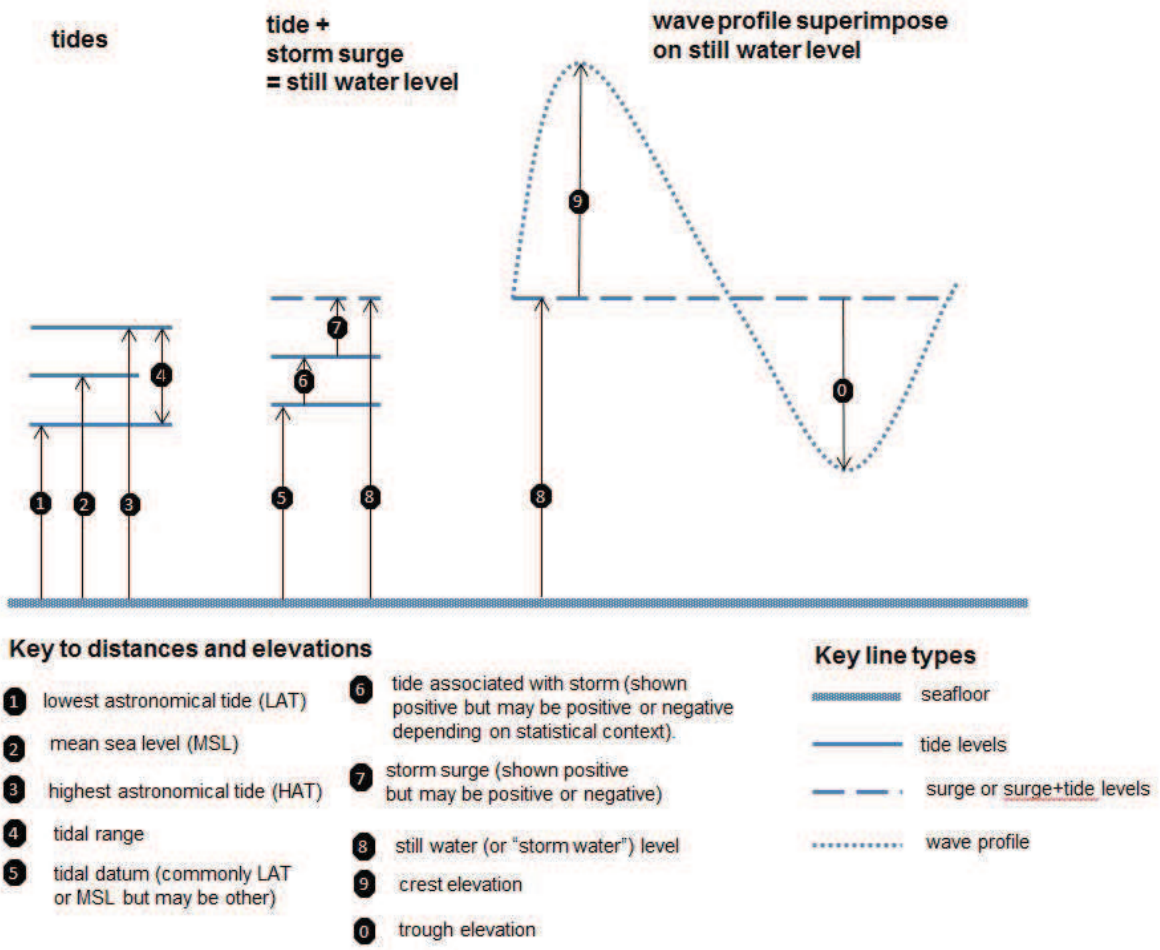

Figure 1 — Water depth, tides and storm surges

7 Wind

7.1 General

Wind speed and direction vary in space and time. Normally, wind speed time-series data at a site are only available at a single elevation. It is unusual to have multiple measurements on the tens to hundreds of metres horizontal-length scales relevant to offshore structures. Furthermore, time series are often only available at time scales much longer (e.g. 10 min to 3 h) than the natural response periods of most structures. On length scales typical of even the largest offshore structures, the mean and standard deviation of the wind speed, averaged over durations of the order of an hour, do not vary horizontally, but they do change with elevation (wind profile). For averaging durations shorter than 1 h, there will be periods with higher mean speeds and increased spatial variation. As such, typical practice is to specify wind criteria at a clearly specified averaging interval and reference elevation. The most commonly used reference elevation is 10 m above mean sea level. Wind profile factors, gust factors, auto- or coherence spectra appropriate to the local wind regime may then be applied in conjunction with the reference winds to appropriately account for fine-scale spatial and temporal effects.

Wind speeds are classified as either

— sustained wind speeds, or

— gust wind speeds.

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The elevation and averaging interval of any wind speed or gust should always be reported.

Extreme gusts occur due to a variety of phenomena. These include squalls, thunderstorms, downbursts, tornados, water spouts, all of which are relatively short-lived. The ratio of maximum gust wind speed to hourly mean wind speed at any one location in these examples can be large.

However, gusts also occur during periods of high hourly mean wind speed due simply to turbulence, but in this case the ratio of maximum gust wind speed to hourly mean wind speed over the sea is typically less than about 1,5.

Wind conditions shall be determined by proper analysis of wind data. Guidance on collecting wind data is given in A.7.1.

To determine appropriate design situations for offshore structures with regard to wind, the extreme, abnormal and normal wind conditions shall be specified in accordance with the type of structure and the nature of the structure's response. Wind turbulence in gusts has three-dimensional spatial scales related to their duration. For example, 3 s gusts are coherent over shorter distances and therefore affect smaller components of a structure than 15 s gusts. For structures (structural components) that are subject to appreciable dynamic response, it can be necessary to take the time variation of actions caused by wind into account.

Further guidance is provided below, while procedures for determining actions and action effects caused by wind for different types of structure shall be in accordance with the relevant ISO publication cited below (see also Clause 2):

— ISO 19901-3 for topside structures

— ISO 19902 for fixed steel offshore structures;

— ISO 19903 for fixed concrete offshore structures;

— ISO 19904-1 for monohulls, semi-submersibles and spars associated with floating offshore structures;

— ISO 19905-1 for jack-ups associated with site-specific assessment of mobile offshore units;

— ISO 19906 for arctic offshore structures.

7.2 Wind actions and action effects

Wind acts on the topsides and that portion of the structure that is above the water, as well as upon any equipment, deck houses, bridges, flare-booms and derricks that are located on the topsides. As the wind speed varies with elevation, the height of the component shall be taken into account. A vertical wind profile that can be used is discussed in 7.3 and provided in A.7.3.

For the design of offshore structures that respond globally in a nearly static fashion, global actions caused by wind are generally much less important than those caused by waves and currents. However, for the local response of certain parts or of individual components of these structures, the action effects caused by wind can be significant. Global actions on structures shall be determined using a time-averaged design speed in the form of a sustained wind speed. For the design of individual structural components, a time-averaged wind speed can also be adequate, but the averaging duration shall be reduced to allow for the smaller turbulence scale that can affect individual components. Local actions on individual components shall therefore be determined using a gust wind speed. Guidance on the selection of appropriate averaging times is given in A.7.2.

For the design of offshore structures (or structural components) that are subject to appreciable dynamic response, the time and spatial variation of the wind speed needs to be accounted for. A dynamic analysis of a structure (or structural components) is generally necessary when the wind field contains energy at frequencies near the natural frequencies of the structure (structural components). Such analyses require detailed knowledge of the wind turbulence intensity, the wind frequency spectrum and its spatial coherence (see 7.4).

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A special case of dynamic response is the VIV of relatively slender structures subjected to steady winds in which alternate vortex shedding excites components. Components of fixed steel offshore structures can be exposed to VIV during construction and transportation. Flare structures and telecommunication towers can also be susceptible to VIV throughout their lives.

Wind should be considered in detail for compliant bottom-founded structures and floating structures.

7.3 Wind profile and time-averaged wind speed

The vertical profile of the mean wind speed in storms is usually expressed by a logarithmic function. Adjustments to the wind profile at a particular location or under certain conditions may be made when appropriate measured data from an offshore location are available (i.e. measured data for the kind of event used in design).

7.4 Wind spectra

If a structure (or a structural component) is subject to appreciable dynamic response due to wind action, the temporal and spatial variations of the wind speed shall be considered. Turbulent wind may be viewed as an evolving field of vortices being swept past the structure. Additional turbulence is generated by the structure itself. The most accurate wind actions are derived from physical testing in a boundary-layer wind tunnel, or by using computational fluid dynamics. Useable results can be obtained from a time series of wind velocity generated by adding spectral frequency components (mathematically as described below for waves) to the mean wind speed. In the absence of three-dimensional wind modelling, only the speed fluctuations in the mean wind direction can be described. An appropriate form of the frequency spectrum for wind speeds in the mean direction is given in A.7.4. The spatial variation of the wind speed in the mean direction between two points in space is expressed by means of a coherence function (see A.7.4).

The concept of a wind spectrum is only applicable to stationary wind conditions. As squalls are transient (non-stationary), the temporal and spatial variations of the wind speed in a squall cannot be described by a wind spectrum. Analysis of actions and action effects caused by squalls requires the specification of a time series of wind velocity, which captures the transient squall peak.

8 Waves

8.1 General

Surface waves are generally very important for the design of offshore and coastal structures. Facility design requires the specification of the operational wave statistics and extreme return-period wave conditions comprising spectral and/or deterministic wave height and period parameters, direction of wave propagation and the spread of the directions.

Ocean waves are irregular in shape, vary in height, length and speed of propagation, and travel in many directions. In general, small waves in deep water may be regarded as the linear superimposition of many small individual sinusoidal components, each of which is a periodic wave with its own amplitude, frequency and direction of propagation; with linear waves the components have random phase relationships with respect to each other. Linear superposition of waves may be described as a wave spectrum defining the amplitude of waves for frequencies and directions.

For larger waves, generally occurring at low probabilities (long return periods), waves are not linear. Interactions of wave components of differing frequencies and directions change the shape of the waves, an effect being that higher wave crests occur compared to those estimated using linear wave assumptions. In intermediate and shallow water depths, the non-linearity of the waves increases and becomes very important.

Waves may be described as either

— a sea state, defined by either the frequency-direction wave spectrum or the frequency spectrum (see 8.3) or

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— an individual wave, defined by wave height (or crest height), period and water depth (this wave is also called a deterministic or single wave) (see 8.4).

In a sea state, the wave energy can be distinguished into two broad classes: wind-seas and swells. Wind-seas are generated by the local wind, while swells consist of wind-driven waves that have travelled out of the generation area, and have no relationship with the local wind.

The range of wave conditions that can occur at the site of the structure shall be specified. For operational conditions, details of the occurrence and joint occurrence of wave heights, periods, directions, spectral shape and spreading of waves shall be specified. For extreme conditions, the return-period values of waves shall be specified. Associated values and ranges of wave periods and water depths shall also be specified.

It can be required to partition the wave energy spectrum into swell and wind sea components.

In determining the operational and extreme wave conditions, the physical processes which lead to the wave forms at the site shall be considered. In this respect, non-linear effects can be significant (e.g. breaking).

The response of a structure to waves depends on, among other things, its dynamic response characteristics. Structures with significant dynamic response (i.e natural periods around the wave frequencies or their second-order components) require wave energy spectra or time series of the surface elevation for their analysis. These may be specified in a number of ways; a common approach is to use a sea state defined by a standard wave frequency spectrum, with a given significant wave height, a representative frequency/period, a mean wave direction and, sometimes, a directional spreading function. It is important to define the range of wave conditions which can be experienced at the facility site.

For structures that only respond in a quasi-static mode, it can be sufficient to use individual periodic waves. The most important wave parameters required to describe a single, periodic design wave are its height, crest elevation above still water level, period and direction of travel. The wave kinematics properties can then be estimated using the local still water depth. The distribution of individual waves in a given sea state can be estimated from statistical wave parameters, such as the significant wave height and the mean zero-crossing period.

In some applications, periodic or regular waves may be used as an adequate abstraction of a real sea for design purposes. Periodic waves are also the building blocks for the linear random wave model. Where closer agreement to real waves is required, fully non-linear wave models are available for use, but require careful calibration for application to design conditions to ensure consistent structural reliability levels are achieved.

It is often desirable to specify the duration associated with sea states. Traditionally, 3 h durations are often specified. However, durations actually depend on the particular weather situation and how the criteria will be applied to design. In differing parts of the world, significant wave heights near the peak of a storm can be nearly constant over durations that could either be significantly shorter or significantly longer than 3 h. Furthermore, if the intention of specifying a duration is to design to a response at a given N-year target return period level, then the duration necessary to achieve this response shall be carefully considered. The N-year response is not necessarily achieved during the peak of the N-year sea state. The most rigorous way to ensure that the N-year response is achieved is through a response-based design approach.

8.2 Wave actions and action effects

Wave conditions shall be specified in an appropriate way for the type of structure under consideration, for extreme, abnormal and normal conditions.

The linear spectral model for waves is presented in 8.3. Regular periodic wave models are presented in 8.4. The height of the highest wave crests in extreme and abnormal metocean conditions can be of special significance, see 8.7.

Procedures for determining actions and action effects caused by waves for different types of structure shall be in accordance with the relevant ISO publication cited below (see also Clause 2):

— ISO 19902 for fixed steel offshore structures;

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