International Standard

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Specific requirements for offshore structures —

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

Exigences spécifiques relatives aux structures en mer —

Partie 7: Systèmes de maintien en position des structures en mer flottantes et des unités mobiles en mer

Reference number
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Contents

Page

Foreword ..... **vi**
Introduction ..... **vii**
1 Scope **1**
2 Normative references **2**
3 Terms, definitions, symbols and abbreviated terms **3**
3.1 Terms and definitions 3
3.2 Symbols 12
3.3 Abbreviated terms 13
4 Mooring hardware **14**
4.1 General 14
4.2 Off-vessel mooring line components 15
4.2.1 General 15
4.2.2 Anchors 15
4.2.3 Chain 15
4.2.4 Fibre rope 15
4.2.5 Steel wire rope 15
4.2.6 Connecting hardware 16
4.2.7 Buoys 16
4.2.8 Clump weights 16
4.2.9 Mooring connectors 16
4.2.10 Disconnectable turret buoy 17
4.3 On-vessel mooring line components 17
4.3.1 General 17
4.3.2 Fairleads 17
4.3.3 Bending shoes 17
4.3.4 Chain stoppers 17
4.3.5 Uni-joints 17
4.3.6 Turret 17
4.4 On-vessel tensioning equipment 18
4.5 Monitoring equipment 18
4.5.1 General 18
4.5.2 Line tension or line payout 18
4.5.3 Floating structure position and heading 19
5 Metocean and other site data **19**
5.1 General 19
5.2 Metocean data 19
5.2.1 General 19
5.2.2 Wave data 19
5.2.3 Wind data 20
5.2.4 Current data 20
5.3 Bathymetry 20
5.4 Geotechnical and geophysical data 20
5.5 Marine growth 21
5.6 Physicochemical parameters 21
5.7 Ice-related 21
6 Design and site-specific assessment of stationkeeping systems **21**
6.1 General 21
6.2 Functional requirements 21
6.3 Safety requirements 22
6.4 Planning requirements 23
6.4.1 General 23
6.4.2 Design basis 23
6.4.3 Design practices 23

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6.4.4 Installation considerations at design stage 24
6.4.5 Integrity management strategy 24
6.5 Rules and regulations 25
6.6 Independent verification for permanent systems 25
6.7 Numerical tools 25
6.8 Design situations 25
6.8.1 Limit states 25
6.8.2 Analysis cases for ultimate limit state 26
6.8.3 Analysis cases for serviceability limit state 28
6.8.4 Analysis cases for fatigue limit state 29
6.8.5 Analysis cases for abnormal and accidental limit states 30
6.8.6 Analysis cases for temporary phases 30

7 Design and site-specific assessment criteria 31
7.1 Safety factors for mooring component strength 31
7.1.1 Line tensions 31
7.1.2 Safety factors for buoyancy elements 33
7.1.3 Anchor holding capacity safety factors 33
7.2 Vessel offsets and heading 35
7.3 Requirements for clearances 35
7.3.1 General 35
7.3.2 Mooring line with seabed (thrash zone) 35
7.3.3 Mooring line with sea surface 36
7.3.4 Mooring line with hull 36
7.3.5 Mooring line with riser, umbilical, mooring line, pipeline, seabed assets and exclusion zones 36
7.3.6 Submerged turret buoy 37
7.3.7 Anchor with mooring line, pipeline, seabed assets and exclusion zones 37
7.4 Safety factors for mooring component fatigue resistance 37

8 Analysis 40
8.1 General 40
8.2 Analysis methods 41
8.3 Coupling effects 41
8.4 Environmental loads on the floating structure 42
8.4.1 General 42
8.4.2 Wave forces 42
8.4.3 Wind forces 42
8.4.4 Current forces and VIM 43
8.5 Environmental loads on mooring lines and risers 43
8.6 Mooring analysis for strength, offsets and clearances 43
8.6.1 Basic considerations 43
8.6.2 Extreme value statistics 43
8.6.3 Design values for responses to transient wind squalls 44
8.6.4 Mitigating mooring line trenching effects on AHC 44
8.7 Mooring analysis for fatigue 44
8.7.1 Basic considerations 44
8.7.2 Analysis approach 44
8.7.3 Fatigue damage calculation methods 45
8.8 Response based analysis 47

9 Dynamic positioning and thruster-assisted mooring 47
9.1 General 47
9.1.1 Dynamic positioning 47
9.1.2 Thruster assisted mooring 48
9.2 DP and TAM equipment classes 48
9.3 Available effective thrust 49
9.4 Determination of allowable thrust 49
9.5 Load sharing of TAM system 49
9.5.1 General 49

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9.5.2 Mean load reduction method ... 49
9.5.3 Weathervaning structures ... 50
9.5.4 System dynamic analysis ... 50
9.6 Failure mode and effects analysis ... 50
9.7 Design, test and maintenance ... 51
9.8 Operating personnel ... 51
9.9 Determination of stationkeeping capability ... 51

10 Installation, test load and as-installed survey ... 51
10.1 General ... 51
10.2 Installation considerations and storm-safe criteria ... 52
10.3 Mooring line handling and installation procedure ... 52
10.4 Test loading requirements ... 53
10.4.1 General ... 53
10.4.2 Anchor test load for permanent mooring systems ... 53
10.4.3 Anchor test load for mobile mooring systems ... 53
10.5 Installation tolerances ... 53
10.6 Traceability records ... 54
10.7 As-installed survey and establishment of as-installed capacity ... 54

11 Integrity management, survey and inspection, and monitoring ... 55
11.1 Integrity management ... 55
11.2 Surveys and inspections ... 55
11.2.1 In-service inspection program ... 55
11.2.2 As-built inspection ... 55
11.2.3 Annual survey ... 55
11.2.4 5-year survey ... 56
11.3 Conformity assessment ... 57
11.4 Monitoring ... 58
11.4.1 Position and heading monitoring ... 58
11.4.2 Line failure detection ... 58

Annex A (informative) **Additional information and guidance ... 59**

Annex B (normative) **Regional requirements and supporting information ... 140**

Bibliography ... 185

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Foreword

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

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

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

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

This third edition cancels and replaces the second edition (ISO 19901-7:2013), which has been technically revised.

The main changes are as follows:

— addition of requirements for a mooring integrity management system;

— emphasis on the definition of the operator's expectations on the performance standard;

— inclusion of fibre ropes as a standard material such as chain and steel wire ropes;

— alignment of text relating to the geotechnical design of anchors with ISO 19901-4;

— inclusion of guidance on OPB (out of plane bending) fatigue and squall design cases.

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

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

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Introduction

The International Standards on offshore structures prepared by TC 67 (i.e. ISO 19900, the ISO 19901 series, ISO 19902, ISO 19903, ISO 19904-1, the ISO 19905 series, ISO 19906) constitute a common basis covering those aspects that address design requirements and assessments of offshore structures used by the oil and gas industries worldwide. The intention in their application is to achieve reliability levels appropriate for manned and unmanned offshore structures, irrespective type of structure and the nature or combination of materials used.

It is important to recognize that structural integrity is a concept comprised of models that describe 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 design or structural system. The implications involved in modifications therefore should be considered in relation to the overall reliability of all offshore structural systems.

The International Standards on offshore structures prepared by TC 67 are intended to provide a wide breadth of choice for structural configurations, materials and techniques without hindering innovation. Informed engineering judgement is therefore necessary in the use of these International Standards.

This document was developed in response to the worldwide offshore industry's demand for a coherent and consistent definition of methodologies to analyse, design and evaluate stationkeeping systems used for floating energy production platforms (with and without storage) of various types (e.g. semi-submersibles, spar platforms, ship-shaped structures) and to assess site-specific applications of mobile offshore units (such as mobile offshore drilling units and flotels) and construction units (such as heavy lift vessels and pipelay units).

This document assumes that permanently moored hydrocarbon production systems that are equipped with stationkeeping systems as a minimum have the ability to both shut-in wells and the facility in case of emergency (e.g. emergency shut-down valves on the seabed), otherwise the consequence of mooring failure can be significantly different.

Stationkeeping is a generic term covering systems for keeping a floating structure, which is under the constant influence of external actions, either at a pre-defined location or at a pre-defined heading or both with limited excursions. Stationkeeping systems resist external actions by means of any of the following:

— mooring systems (e.g. spread mooring systems or single point mooring systems);

— dynamic positioning systems (generally consisting of thrusters)

— a combination of mooring system and thrusters (thruster assisted mooring systems).

The external actions generally consist of wind, wave, current and ice actions on the floating structure, mooring and risers.

The procedures for the design of permanent or site-specific assessment of mobile mooring systems specified in this document are based on a deterministic approach where mooring system responses (such as line tensions, vessel offsets, and anchor loads) are evaluated for a design environment defined by an annual probability of exceedance or return period. Mooring system responses are then checked against specified requirements for mooring strength, offsets and orientation, clearances, anchor capacity, fatigue resistance, etc. The minimum specified requirements are defined either in this document or by the operator if more stringent.

NOTE Stationkeeping systems designed based on this deterministic approach can have differing levels of reliability.

For moored structures (vessels), system responses are calculated and compared to minimum specified requirements for:

— Ultimate limit states (ULS)**:** mooring component strength. Vessel offset, orientation, and clearance constraints. Herein the ULS includes both intact and single failure condition for stationkeeping systems.

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— Serviceability limit states (SLS): vessel offset, orientation, and clearance constraints. For mooring components this includes clearances with the vessel, risers, umbilicals, seabed, water surface, field infrastructure, exclusion zones, etc.

— Fatigue limit states (FLS) **:** cumulative mooring component fatigue damage.

— Accidental and abnormal limit state (ALS): no criteria are given for accidental or abnormal limit state which are left to operator decision or local authorities requirements.

The methodology described in this document identifies a set of coherent analysis techniques that, combined with an understanding of the site-specific metocean conditions, the characteristics of the floating structure under consideration, and other factors, can be used to determine the adequacy of the stationkeeping system to meet the functional requirements specified in this document.

Descriptions of characteristics and typical components found in these systems are given in Annex A.

Some background to, and guidance on, the use of this document is provided in 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 Annex B.

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Specific requirements for offshore structures —

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

1 Scope

This document specifies methodologies for:

a) the design, analysis and evaluation of stationkeeping systems for floating offshore structures;

b) the assessment of stationkeeping systems for site-specific applications of mobile offshore units and construction units.

Originally developed for floating structures used in the oil and gas industry, this document is now also used in the renewable energy sector. The extent of application of this document to floating structures used in other industries is at the discretion of the relevant standard entity and its users. For example, IEC 61400-3-2 for floating wind applies this document to determine stationkeeping system responses while incorporating its own load conditions, safety factors, and environmental return periods.

This document is applicable to the following types of stationkeeping systems, which are either covered directly in this document or through reference to other guidelines:

— spread mooring systems;

— single point mooring systems;

— dynamic positioning systems;

— thruster-assisted mooring systems.

This document is not applicable to:

— stationkeeping systems which do not have redundancy against failure of any single component, e.g., single anchor leg moorings (SALMs);

— stationkeeping systems which use any means other than mooring lines or thrusters such as tower soft yoke systems, or tension leg platforms (TLPs) that use tendons.

The requirements for this document address spread mooring systems and single point mooring systems with mooring lines composed of steel chain, steel wire or synthetic fibre rope.

This document is applicable to all aspects of the life cycle of mooring systems. It includes requirements relating to the selection of mooring components, mooring system configuration and performance, components design, installation, post-installation survey, and as-installed assessments as needed for mooring integrity management.

For mooring systems deployed in ice-prone environments, additional requirements in ISO 19906 apply.

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2 Normative references

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

ISO 18692-1, *Fibre ropes for offshore stationkeeping — Part 1: General specification*

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

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

ISO 19901-4, *Oil and gas industries including lower carbon energy — Specific requirements for offshore structures — Part 4: Geotechnical design considerations*

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

ISO 19901-8, *Oil and gas industries including lower carbon energy — Offshore structures — Part 8: Marine soil investigations*

ISO 19901-10, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 10: Marine geophysical investigations*

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

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

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

ISO 20438, *Ships and marine technology — Offshore mooring chains*

ISO 31000, *Risk management — Guidelines*

IMO MSC.1/Circ.1580, *Guidelines for vessels and units with dynamic positioning (DP) systems*, International Maritime Organization, 16 June 2017

IACS Unified Requirement UR W22 — *Offshore mooring chains,* International Association of Classification. Societies

API RP 2I, *In-service inspection of mooring hardware for floating structures, American Petroleum Institute*

API RP 2MIM, *Mooring Integrity Management, American Petroleum Institute*

API SPEC 9A, *Specification for wire rope, American Petroleum Institute*

ASME Section VIII, Division 1 *Boiler and Pressure Vessel Code — Rules for Construction of Pressure Vessels,* American Society of Mechanical Engineers

DNV-OS-E301:2024, *Position mooring, DNV Offshore Standard*

DNV-RP-E301:2021, *Design and installation of fluke anchors, DNV Recommended Practice*

DNV-RP-E302:2021, *Design and installation of plate anchors in clay, DNV Recommended Practice*

DNV-RP-E303:2021, *Geotechnical design and installation of suction anchors in clay, DNV Recommended Practice*

MTS, *DP operations guidance*, *Marine Technology Society*

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3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
action
external load applied to the *structure* (3.1.59) (direct action) or an imposed deformation or acceleration (indirect action)

EXAMPLE An imposed deformation can be caused by fabrication tolerances, settlement, temperature change or moisture variation. An imposed acceleration can be caused by an earthquake

[SOURCE: ISO 19900:2019, 3.3]

3.1.2
action effect
result of *actions* (3.1.1) on a *structural component* (3.1.57) (e.g. internal force, moment, stress, strain) or on the *structure* (3.1.59) (e.g. deflection, rotation)

[SOURCE: ISO 19900:2019, 3.4]

3.1.3
active stationkeeping system
stationkeeping system (3.1.55) that makes use of *dynamic positioning* (3.1.15), thruster assistance, line length or pretension adjustments, planned changes in vessel draught, winching (kedging) off location, or disconnection, as opposed to a *passive mooring system* (3.1.34)

3.1.4
catenary mooring system
mooring system (3.1.30) where the restoring *action* (3.1.1) is provided by both distributed weight and strain deformation of *mooring lines* (3.1.29)

3.1.5
close proximity
when any part of another surface facility lies within a contour described by the set of offsets coinciding with each *mooring line* (3.1.29) reaching 100 % *minimum break strength* (3.1.24) in the intact or *redundancy* (3.1.37) check condition, whichever is larger

3.1.6
clump weight
heavy component typically used in shallow water where the restoring of a chain-only *catenary mooring system* (3.1.4) is not sufficient to meet the specified offsets

Note 1 to entry: These components are generally fastened to a large diameter chain segment.

Note 2 to entry: This segment is usually around the touch down zone or on the seabed.

3.1.7
common mode failure
failures of similar components on different *mooring lines* (3.1.29) resulting from the same direct cause, where these failures are not consequences of each other

Note 1 to entry: The potential for common mode failures reduces the effectiveness of system *redundancy* (3.1.37).

Note 2 to entry: It is generally accepted that the failures occur simultaneously or within a short time of each other.

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3.1.8
cyclic action
repetitive environmental *action* (3.1.1) that can cause cumulative damage of the *structure* (3.1.59), *structural component* (3.1.57), or *resistance* (3.1.39) of materials including soils

Note 1 to entry: cyclic action causes no significant acceleration of the structure or structural members.

3.1.9
damaged condition
state of the *stationkeeping system* (3.1.55) with a weakened or missing *mooring line* (3.1.29) or a failure of the thruster system or a combination of both

Note 1 to entry: A missing line can have either failed or been weakened by external damage (e.g., cut in synthetic ropes or corroded chain) or been removed for *maintenance* (3.1.23) or inspection.

Note 2 to entry: A total or partial loss of a buoyancy or weight element is also a damaged condition.

Note 3 to entry: For thruster assisted *mooring systems* (3.1.30), the damaged condition includes the most critical case with one leg damaged or the single worst failure of the integrated thruster control system as identified by the *failure mode* (3.1.18) and effect analysis.

3.1.10
degradation mechanism
time-based physical or chemical mechanism or process resulting in reduced functionality or capacity

EXAMPLE Corrosion, wear, fatigue.

3.1.11
design criteria
quantitative formulations that describe the conditions to be fulfilled for each *design situation* (3.1.13)

3.1.12
design service life
design life
planned period for which a *structure* (3.1.59) is used for its intended purpose with anticipated *maintenance* (3.1.23), but without substantial repair being necessary

3.1.13
design situation
design condition
set of physical conditions for which the *structure* (3.1.59) or its components are verified

EXAMPLE A defined combination of one environmental condition, one vessel loading condition, one water depth, *riser* (3.1.41) configuration, intact or one-line missing

[SOURCE: ISO 19900:2019, 3.16, modified — The preferred term has been changed from "design/assessment situation" to "design situation"; the admitted term "design condition" has been added; EXAMPLE has been added.]

3.1.14
dynamic action
external *action* (3.1.1) that induces acceleration of a *structural component* (3.1.57), normally specified by a spectrum and associated parameters for wind and waves or by time series of wind speed and direction for *squalls* (3.1.54)

3.1.15
dynamic positioning
DP
stationkeeping technique consisting primarily of a system of automatically controlled on-board thrusters, which generate appropriate thrust vectors to counter the mean and slowly varying induced *actions* (3.1.1)

[SOURCE: ISO 19904-1:2019, 3.17, modified — "automatically controlled" has been added.]

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3.1.16
end-of-life break strength
ELBS
break strength of a *mooring component* (3.1.28) at the end of the *design service life* (3.1.12) that accounts for the reduction of *minimum break strength* (3.1.24) due to degradation during service

3.1.17
expected value
first-order statistical moment of the probability density function for the considered variable that, in the case of a time-dependent parameter, can be associated with a specific reference period

3.1.18
failure mode
manifestation of loss of functionality of a *mooring component* (3.1.28) and manner by which a failure is observed

3.1.19
fitness-for-service assessment
engineering evaluations to demonstrate that a *structure* (3.1.59) or a *structural component* (3.1.57) which deviates from its design basis fulfills defined *structural integrity* (3.1.58) and performance requirements

Note 1 to entry: Deviations can include deterioration or damage, life extension, and other changes and modifications to the structure or to the design basis.

[SOURCE: ISO 19900:2019, 3.23, modified —"is fit-for-service" has been replaced by "fulfills defined structural integrity and performance requirements".]

3.1.20
floating structure
floating facility
floating unit
ship
vessel
structure (3.1.59) where the full weight is supported by buoyancy

Note 1 to entry: The full weight includes lightship weight, *mooring system* (3.1.30) pre-tension, *riser* (3.1.41) pre-tension, operating weight, etc.

Note 2 to entry: this definition encompasses any structure using permanent or *mobile mooring systems* (3.1.25). Sometimes shortened to structure.

[SOURCE: ISO 19900:2019, 3.25, modified — The abbreviated terms have been added; notes 1 and 2 to entry have been added.]

3.1.21
integrated thruster control system
ITCS
complete propulsion system consisting of thrusters, and control, power generation and distribution systems

3.1.22
limit state
state beyond which the *structure* (3.1.59) or *structural component* (3.1.57) no longer satisfies the *design criteria* (3.1.11)

[SOURCE: ISO 19900:2019, 3.31]

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3.1.23
maintenance
combination of all technical, administrative and managerial tasks during the life of a facility, intended to retain it in, or restore it to, a state in which it can perform the required function

[SOURCE: ISO 50007:2017, 3.21, modified — "actions" has been replaced by "tasks"; "asset" has been replaced by "facility".]

3.1.24
minimum break strength
MBS
minimum break load
MBL
break test load
BTL
catalogue break strength
CBS
hardware component's certified break strength meeting requirements of an industry standard

3.1.25
mobile mooring system
mooring system (3.1.30), generally retrievable, intended for deployment at a specific location for a short-term operation, such as those for *mobile offshore units* (3.1.27)

Note 1 to entry: Some components of a mobile mooring system can be irretrievable and thus are designed following the requirements for a *permanent mooring system* (3.1.35).

Note 2 to entry: Mobile mooring systems that cannot follow the nominal inspection schedule are categorised as permanent mooring systems.

3.1.26
mobile offshore drilling unit
MODU
mobile offshore unit (3.1.27) capable of engaging in drilling and well intervention operations for exploration or exploitation of subseafloor energy related fluid and gas resources

3.1.27
mobile offshore unit
MOU
offshore *structure* (3.1.59) intended to be frequently relocated to perform a particular function

EXAMPLE Pipelaying vessel or barge, offshore construction structure, accommodation structure (flotel), service structure, or *mobile offshore drilling units* (3.1.26).

Note 1 to entry: Those units can be either in operating condition (when intended operation is ongoing), in standby condition (when intended operation is temporarily stopped) or in survival condition (when intended operation is stopped and unit is not adjacent to another unit).

[SOURCE: ISO 19904-1:2019, 3.33, modified — In the definition, "offshore" and "frequently" have been added; EXAMPLE and note 1 to entry have been added.]

3.1.28
mooring component
component used in the mooring of *floating structures* (3.1.20)

EXAMPLE Chain, steel wire rope, synthetic fibre rope, connector, *clump weight* (3.1.6), buoy, winch, windlass, fairlead or anchor.

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3.1.29
mooring line
mooring leg
anchor leg
assembly of connected *mooring components* (3.1.28), including the anchor up to and including the weld (or bolted joint) connecting the on-vessel mooring equipment to the *floating structure* (3.1.20)

3.1.30
mooring system
stationkeeping system (3.1.55) consisting of one or more *mooring lines* (3.1.29), including their associated on-vessel mooring equipment

3.1.31
natural frequency
frequency at which a mechanical oscillator has its maximum response when subjected to a white noise excitation

3.1.32
natural period
period at which a mechanical oscillator has its maximum response when subjected to a white noise excitation

3.1.33
operator
representative of the company or companies leasing the site

Note 1 to entry: The operator is normally the energy company acting on behalf of co-licensees.

Note 2 to entry: The operator can be termed the owner or the duty holder.

Note 3 to entry: The operator is the entity responsible for the definition of the design basis for the *stationkeeping system* (3.1.55).

EXAMPLE The operator owns the development while the MODU is owned by the drilling contractor.

[SOURCE: ISO 19900:2019, 3.35, modified — In note 1 to entry, "oil company" has been replaced by "energy company"; note 3 to entry and EXAMPLE have been added]

3.1.34
passive mooring system
mooring system (3.1.30) that responds to changes in *floating structure* (3.1.20) draught, trim, and environmental actions without any intervention or adjustment of the *mooring lines* (3.1.29), and does not use thrusters

3.1.35
permanent mooring system
mooring system (3.1.30) normally used to moor *floating structures* (3.1.20) deployed for long-term operations, such as those for a floating production system

3.1.36
recognized classification society
RCS
member of the International Association of Classification Societies (IACS), with established rules and procedures for classification and certification of *floating structures* (3.1.20) used in energy activities, located at a specific site, for an extended period of time

3.1.37
redundancy
ability of the *structure* (3.1.59) to find alternative load paths following structural failure of one or more components, thus limiting the consequences of such failures

[SOURCE: ISO 19902:2020, 3.38, modified — Note 1 to entry has been removed.]

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3.1.38
representative
assigned to a basic variable for *limit state* (3.1.22)*verification* (3.1.66) in a *design situation* (3.1.13)

EXAMPLE Representative strength or representative excursions are typical variables used in limit state verifications.

3.1.39
resistance
ability of a *structure* (3.1.59), or a *structural component* (3.1.57), to withstand *action effects* (3.1.2)

[SOURCE: ISO 19900:2019, 3.41]

3.1.40
return period
average period between occurrences of an event being exceeded

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

Note 2 to entry: For the purpose of this definition, events include both discrete hazardous events as well as exceedances of a threshold value of a relevant variable.

[SOURCE: ISO 19900:2019, 3.42, modified — The words "being exceeded" have been added.]

3.1.41
riser
piping connecting the process facilities or drilling equipment on the *floating structure* (3.1.20) with the subsea facilities or pipelines, or with a reservoir

Note 1 to entry: Possible functions include drilling and well intervention, production, injection, subsea systems control and export of produced fluids.

Note 2 to entry: Risers are meant to include a single (drilling) riser, multiple risers or umbilicals.

[SOURCE: ISO 19904-1:2019, 3.44, modified — Note 2 to entry has been added.]

3.1.42
risk assessment
overall process of risk identification, risk analysis and risk evaluation

[SOURCE: ISO 31073:2022, 3.3.8]

3.1.43
robustness
ability of a *structure* (3.1.59) to withstand hazardous events without being damaged to an extent disproportionate to the cause

[SOURCE: ISO 19900:2019, 3.44]

3.1.44
safety factor
value of the design *resistance* (3.1.39) divided by the total design *action* (3.1.1)

EXAMPLE For the assessment of *mooring line* (3.1.29) strength, the safety factor is the representative strength divided by the characteristic load. For fatigue assessment, the safety factor is 1 divided by the representative cumulative fatigue damage during the *design service life* (3.1.12).

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3.1.45
sea state
condition of the sea during a period in which its statistics remain approximately stationary

Note 1 to entry: In a statistical sense the sea state does not change markedly within the period. The period during which the condition exists is often assumed to be three hours, although it depends on the particular weather situation at any given time.

[SOURCE: ISO 19901-1:2015, 3.31]

3.1.46
semi-submersible
floating structure (3.1.20) normally consisting of a deck *structure* (3.1.59) with, typically, three or more widely spaced, large cross-section, supporting columns connected to submerged pontoons

Note 1 to entry: Pontoon/column geometry is usually chosen to reduce global motions in a broad range of wave frequencies.

[SOURCE: ISO 19904-1:2019, 3.46]

3.1.47
serviceability
ability of a *structure* (3.1.59) or *structural component* (3.1.57) to perform adequately for a normal use under all expected actions

[SOURCE: ISO 2394:2015, 2.1.32, modified — The words "structural member" have been replaced by "structural component".]

3.1.48
significant value
statistical measure of a zero-mean random variable equal to the mean of the one third highest extrema during a specific time period

Note 1 to entry: The significant value has the same dimensional properties as the variable being examined.

3.1.49
single point mooring
multiple-line *mooring system* (3.1.30) that allows the *floating structure* (3.1.20) to which it is connected to vary its heading (weathervane)

EXAMPLE One example of a single point mooring is a turret mooring system where *mooring lines* (3.1.29) are attached to a turret, which includes bearings to allow the *structure* (3.1.59) to rotate.

3.1.50
ship-shaped structure
monohull *floating structure* (3.1.20) having a geometry similar to ocean-going ships

3.1.51
spar platform
SPAR
deep-draught, small water-plane area *floating structure* (3.1.20)

3.1.52
splash zone
zone in which part of a *structure* (3.1.59) is intermittently exposed to air and immersed in the sea

Note 1 to entry: Herein the relevant structural parts are *mooring lines* (3.1.29), fairleads and thrusters.

[SOURCE: ISO 19900:2019, 3.48, modified — "zone in which" has been added; note 1 to entry has been added.]

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3.1.53
spread mooring
mooring system (3.1.30) consisting of multiple *mooring lines* (3.1.29) terminated at different locations on a *floating structure* (3.1.20), and extending outwards, providing an almost constant heading

3.1.54
squall
strong wind event characterized by a sudden onset, a duration of the order of minutes and a rather sudden decrease in speed

Note 1 to entry: A squall is often accompanied by a change in wind direction, a drop in air temperature and heavy precipitation.

Note 2 to entry: The World Meteorological Organization classification of a squall requires the wind speed to increase by at least 8 m/s and attain a top speed of at least 11 m/s, lasting at least one minute in duration.

[SOURCE: ISO 19901-1:2015, 3.40]

3.1.55
stationkeeping system
system capable of limiting the excursions of a *floating structure* (3.1.20) within prescribed limits

3.1.56
storm safe condition
condition of a *floating structure* (3.1.20) during installation when the minimum number of *mooring lines* (3.1.29) are hooked up to meet an intact condition *design situation* (3.1.13) associated with a site- and seasonal-specific *return period* (3.1.40) “storm” event

Note 1 to entry: The design situation has tension limits including *safety factors* (3.1.44) while maintaining appropriate clearances with infrastructure during the “storm” event.

3.1.57
structural component
discrete part of a *structure* (3.1.59)

[SOURCE: ISO 19900:2019, 3.49, modified — Note 1 to entry and EXAMPLE have been removed.]

3.1.58
structural integrity
ability of a *structure* (3.1.59) or a *structural component* (3.1.57) to maintain performance throughout the *design service life* (3.1.12), with respect to structural safety, *robustness* (3.1.43), *serviceability* (3.1.47), and durability

[SOURCE: ISO 19900:2019, 3.50, modified — The words "total service life" have been replaced by "design service life".]

3.1.59
structure
combination of physically connected *structural components* (3.1.57)

[SOURCE: ISO 19900:2019, 3.53]

3.1.60
swell
wave that was wind-generated but has travelled out of its generation area and has no relationship with the local wind

[SOURCE: ISO 19901-1:2015, 3.44]

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3.1.61
taut line mooring system
mooring system (3.1.30) where the restoring *action* (3.1.1) is provided by elastic deformation of *mooring lines* (3.1.29)

Note 1 to entry: The angle of taut line mooring system at the mudline is typically non-zero, even in equilibrium condition.

Note 2 to entry: Mooring system restoring forces are due to forces from both catenary and strain deformations of the mooring lines.

3.1.62
thruster-assisted mooring
TAM
stationkeeping system (3.1.55) consisting of *mooring lines* (3.1.29) and thrusters

Note 1 to entry: The thruster system can be manually controlled or automatically controlled.

Note 2 to entry: The automatic thruster system needs to be able to automatically provide needed thrust force and moment to counter the environment loads.

3.1.63
touchdown point
location on a *mooring line* (3.1.29) where the line transitions from contacting the seabed to being in the water column

Note 1 to entry: The touchdown point can change as the draught and horizontal offset of the *floating structure* (3.1.20) change.

3.1.64
thrash zone
touchdown zone
range of all *touchdown points* (3.1.63) within defined operating conditions

EXAMPLE The extent of the touchdown zone can be specified based on 100 years *return period* (3.1.40) environmental conditions along with minimum and maximum *floating structure* (3.1.20) draughts and resulting offsets.

3.1.65
tropical cyclone
tropical revolving storm
TRS
closed atmospheric circulation around a zone of low pressure that originates over the tropical oceans

Note 1 to entry: The circulation is counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere.

Note 2 to entry: 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 to entry: 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 to entry: The term cyclone is also used to refer to a tropical storm with sustained wind speeds exceeding 32 m/s (Beaufort Force 12).

[SOURCE: ISO 19901-1:2015, 3.45, modified — The admitted terms "tropical revolving storm" and "TRS" have been added.]

3.1.66
verification
examination made to confirm that an activity, product or service is in accordance with specified requirements

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3.1.67
virtual mass and inertia
effective mass and inertia
sum of mass and added hydrodynamic mass or inertia and added hydrodynamic inertia

3.1.68
weathervaning
process by which a *floating structure* (3.1.20) passively varies its heading in response to time-varying environmental *actions* (3.1.1)

3.2 Symbols

a	non-dimensional ratio of the motion amplitude
C	coefficient (non-dimensional unless otherwise specified)
D	annual fatigue damage, or fatigue damage ratio
d	diameter of the mooring line or component, in metres (m)
f	frequency, in hertz (Hz)
K	fatigue constant (non-dimensional unless otherwise specified)
L	design service life, in years
m	inverse slope of T-N or S-N fatigue curves
N	total number of (permissible) cycles
n	number of cycles per annum, in (-/year)
P	probability of occurrence
Q	mean load ratio
R	ratio of tension range to reference breaking strength
S	strength, in newtons (N); or stress range, in megapascals (MPa)
s	standard deviation
T	tension force, in newtons (N); or non-dimensional tension ratio
t	time, period or duration, in seconds (s)
v	velocity, in metres per second (m/s)
z	elevation, in metres
γ	safety factor
σ	stress, in megapascals (MPa)
μ	mean

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3.3 Abbreviated terms

AHC	anchor holding capacity
AJP	annual joint probability of occurrence
ALARP	as low as reasonably practical
ALS	Accidental (and abnormal) limit state
CALM	catenary anchor leg mooring
CFD	computational fluid dynamics
CVI	close visual inspection
FEA	finite element analysis
F-GVI	focussed visual inspection
FLS	fatigue limit state
FMEA	failure modes and effects analysis
FPS	floating production system
FPSO	floating production, storage and offloading structure
FSO	floating storage and offloading structure
GoM	Gulf of Mexico
GVI	general visual inspection
HAZID	hazard identification
HMPE	high modulus polyethylene
IACS	International Association of Classification Societies
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
IPB	in plane bending
MIM	mooring integrity management
MPI	magnetic particle inspection
MPM	most probable maximum
OD	operator defined
OPB	out of plane bending
ORQ	oil rig quality
PWC	preferential weld corrosion
QI	quantitative inspections

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RAO response amplitude operator

RBA response based analysis

RBI risk based inspection

ROV remotely operated vehicle

RRP required, recommended or permitted

SALM single anchor leg mooring

SCF stress concentration factor

SIM structural integrity management

SLS serviceability limit state

ULS ultimate limit state

UTM universal transverse mercator

VIM vortex-induced motion

4 Mooring hardware

4.1 General

Understanding of the peculiarities of mooring components is key to the correct design of a stationkeeping system.

The function of mooring components is to connect a floating structure to the seabed (see ISO 19904-1:2019, Clause 18). Mooring components are all connected items from and including the anchor up to and including the weld or bolted joint connecting the on-vessel mooring equipment to the floating structure. This assembly constitutes a mooring line.

Typical mooring components include:

a) off-vessel mooring line components – anchor, chain, fibre rope, steel wire rope, connecting hardware, buoys, clump weights and weight chain;

b) on-vessel mooring line components - fairleads, bending shoes, padeyes;

c) on-vessel tensioning equipment.

Disconnectable permanent mooring systems usually include a disconnectable (turret) buoy which provides the stationkeeping function and supports the risers and mooring lines.

Manufacturing of mooring hardware shall be subject to an operator approved quality plan, and RCS approval when classed.

The scope of the quality plan shall include manufacturing process control, inspection and testing.

The quality plan shall address the failure modes identified by a mooring integrity risk review. The mooring integrity risk review should occur during the design phase.

Reviews of the manufacturing tolerances (during the design stage) and physical fit-up tests (after manufacture and in advance of installation spread mobilisation) shall be undertaken for all components to verify they can be connected as described in the installation procedure.

The design and arrangement of components shall be consistent with the mooring line and anchor installation philosophy.

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