

Petroleum and natural gas industries — Specific requirements for offshore structures

**Part 6: Marine operations (ISO
19901-6:2009)**

ICS 75.180.10

National foreword

This British Standard is the UK implementation of EN ISO 19901-6:2009 incorporating corrigendum December 2011.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/12, Design of offshore structures.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2010

© The British Standards Institution 2012.
Published by BSI Standards Limited 2012

ISBN 978 0 580 76996 2

Amendments/corrigenda issued since publication

Date	Comments
31 August 2012	Implementation of ISO corrigendum December 2011: Equation 15 has been updated

English Version

Petroleum and natural gas industries - Specific requirements for
offshore structures - Part 6: Marine operations (ISO 19901-
6:2009)

Industries du pétrole et du gaz naturel - Exigences
spécifiques relatives aux structures en mer - Partie 6:
Opérations marines (ISO 19901-6:2009)

Erdöl- und Erdgasindustrie - Spezielle Anforderungen für
Offshore-Anlagen - Teil 6: Mariner Betrieb (ISO 19901-
6:2009)

This European Standard was approved by CEN on 18 November 2009.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 19901-6:2009) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 19901-6:2009 has been approved by CEN as a EN ISO 19901-6:2009 without any modification.

Contents

Page

Foreword	vii
Introduction.....	ix
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Symbols and abbreviated terms	15
4.1 Symbols.....	15
4.2 Abbreviated terms	18
5 General considerations.....	20
5.1 Introduction.....	20
5.2 Jurisdiction	21
5.3 HSE plan	22
5.4 Risk management.....	22
5.5 Job safety analysis.....	23
5.6 Environmental impact study	23
5.7 Manning, qualifications, job and safety training.....	23
5.8 Incident reporting	24
5.9 Personnel tracking	24
5.10 Approval by national authorities	24
6 Organization, documentation and planning	24
6.1 Introduction.....	24
6.2 Organization and communication	24
6.3 Quality assurance and administrative procedures	26
6.4 Technical procedures	26
6.5 Technical documentation	26
6.6 Certification and documentation	29
6.7 Systems and equipment	30
7 Metocean and earthquake requirements	32
7.1 Introduction.....	32
7.2 Weather-restricted/weather-unrestricted operations	33
7.3 Metocean conditions.....	33
7.4 Metocean criteria	35
7.5 Weather windows	36
7.6 Operational duration	37
7.7 Metocean forecast	37
7.8 Earthquake	38
8 Weight control	38
8.1 Introduction.....	38
8.2 Weight control classes	38
8.3 Contingencies for class A	39
8.4 Weight and CoG constraints	39
8.5 Weight control audits	39
8.6 Dimensional control	39
9 Stability.....	39
9.1 Introduction.....	39
9.2 General requirements	39
9.3 Stability calculations.....	40

9.4	Intact stability.....	40
9.5	Damage stability	42
9.6	Single-barge transports	45
9.7	Multi-barge transports.....	45
9.8	Classed vessels	45
9.9	Self-floating structures	45
9.10	Loadout operations	47
9.11	Watertight integrity and temporary closures	48
9.12	Inclining tests.....	48
10	Ballasting operations	49
10.1	Introduction	49
10.2	Ballast system.....	50
10.3	Protection against damage and deterioration	51
10.4	Prevention of progressive flooding in damage condition	52
10.5	Control and indicating systems	52
10.6	Pumps	53
10.7	Valve arrangements.....	53
10.8	Vent systems.....	53
10.9	Air cushion system capacity	54
10.10	System testing	54
11	Loadout.....	54
11.1	Introduction	54
11.2	Categories of loadout.....	55
11.3	Structure being loaded.....	55
11.4	Site and quay.....	56
11.5	Barge	56
11.6	Link beams, skidways and skidshoes	56
11.7	Moorings.....	57
11.8	Grounded loadouts.....	57
11.9	Pumping and ballasting	58
11.10	Loadouts by trailers, SPMTs or hydraulic skidshoes	60
11.11	Propulsion system design, redundancy and back-up	60
11.12	Float-on onto submersible barges or vessels	62
11.13	Barge reinstatement and sea fastenings	63
11.14	Tugs	63
11.15	Management and organization	64
11.16	Loadout manual	64
12	Transportation.....	64
12.1	Introduction	64
12.2	General considerations	64
12.3	Towline pull required, fleet composition and towing arrangement.....	66
12.4	Tow out from dry dock	68
12.5	Inshore tow.....	70
12.6	Offshore tow.....	70
12.7	Transport by dry tow or onboard a heavy transport vessel.....	71
12.8	Transport manual.....	73
13	Temporary mooring and stationkeeping for marine operations.....	73
13.1	Introduction	73
13.2	Environmental criteria.....	74
13.3	Determination of mooring response.....	75
13.4	Sizing of mooring lines	76
13.5	Sizing of anchors	77
13.6	Sizing of attachments.....	77
13.7	Sizing of mooring line components.....	77
13.8	Clearances under extreme conditions	78
13.9	Tensioning of moorings.....	78
13.10	Other stationkeeping means	79

14	Construction and outfitting afloat	79
14.1	Introduction.....	79
14.2	Structural strength and stresses	80
14.3	Construction spread	81
14.4	Welding.....	82
15	Float-over topsides installation	82
15.1	Introduction.....	82
15.2	Environmental considerations	82
15.3	Structural considerations	82
15.4	Clearances	83
15.5	Guidance systems for topsides set-down	84
15.6	Operational aspects	85
15.7	Float-over manual.....	87
16	Pre-laid mooring including foundation	87
16.1	Introduction.....	87
16.2	Installation planning.....	88
16.3	Fluke anchor installation	90
16.4	Plate anchor installation	91
16.5	Suction anchor installation	91
16.6	Anchor pile installation.....	93
16.7	Gravity anchor installation	94
16.8	Mooring system connectors	95
16.9	Chain.....	95
16.10	Steel wire rope	96
16.11	Synthetic fibre rope.....	97
16.12	TLP tendons	98
16.13	Mooring installation manual.....	99
17	Offshore installation operations	99
17.1	Introduction.....	99
17.2	Installation site	99
17.3	Actions on and motions of floating units	99
17.4	Systems and equipment	100
17.5	Launching.....	100
17.6	Float-off	102
17.7	Upending	103
17.8	Ballasting.....	104
17.9	Lifting and lowering by external means	104
17.10	Lowering by ballasting.....	105
17.11	Precise positioning on the sea floor by active and passive means.....	106
17.12	Skirt penetration	107
17.13	Underbase grouting	108
17.14	Piling.....	109
17.15	Attachment to pre-laid mooring system	111
17.16	Connection to a tendon system	112
17.17	Offshore completion	113
17.18	Installation manual	114
18	Lifting operations	114
18.1	Introduction.....	114
18.2	Rigging geometry	115
18.3	Actions and action effects.....	115
18.4	Strengths of slings, grommets and shackles.....	124
18.5	Design verifications	132
18.6	Lift point design.....	136
18.7	Clearances	137
18.8	Bumpers and guides	139
18.9	Heave compensated lifts	141
18.10	Lifts using DP	141
18.11	Practical considerations	141

18.12	Lifting operation manual	142
19	Decommissioning and removal.....	143
19.1	Introduction	143
19.2	Removal planning	143
19.3	Preparation for removal	146
19.4	Removal	147
19.5	Transportation and disposal	149
19.6	Site clearance.....	149
Annex A	(informative) Additional information and guidance	150
A.1	General.....	150
A.2	Guidance for 6.6.2: Required or recommended documentation	150
A.3	Guidance for 11.16: Loadout manual	152
A.4	Guidance for 12.8: Transport manual.....	154
A.5	Guidance for 17.18: Installation manual.....	155
A.6	Guidance for 18.8.4: Bumper and guide loads	156
Annex B	(informative) Regional information	160
B.1	Introduction	160
B.2	Canada	160
Bibliography		164

Foreword

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

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

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

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

ISO 19901-6 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

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

- *Part 1: Metocean design and operating considerations*
- *Part 2: Seismic design procedures and criteria*
- *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 3: Topsides structure*

ISO 19901 is one of a series of International Standards for offshore structures. The full series consists of the following:

- 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* ¹⁾
- ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary* ¹⁾
- ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures* ¹⁾

1) Under preparation.

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, petrochemical 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 materials used.

It is important to recognize that structural integrity is an overall concept comprising models for describing actions, structural analysis, 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. It is necessary, therefore, to consider the implications involved in modifications in relation to the overall reliability of 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 configuration, material and techniques without hindering innovation. Sound engineering judgment is, therefore, necessary in the use of these International Standards.

This part of ISO 19901 was developed to provide requirements and guidance for the planning, engineering and safe execution of marine operations for all types of offshore structures except for drilling rigs, pipe-laying barges and diving support vessels. Marine operations for offshore structures are parts of the construction, transportation and installation phases when the structure is at risk from the marine environment. Marine operations can extend to decommissioning, redeployment, removal, etc.

This part of ISO 19901 describes the principles of and provides requirements and guidance for marine operations associated with fixed and floating offshore structures, from the point of view of planning, engineering, implementation and documentation. Alternative requirements, methods and provisions can fulfil the intention of this part of ISO 19901 and may be applied, provided it can be demonstrated that they achieve at least the same level of confidence. The overall objective of this part of ISO 19901 is to ensure that marine operations are conducted within defined and recognized safety/confidence levels, wherever they are performed. Additional standards, codes and guidelines should also be taken into account, where applicable. Special attention should be paid to national regulations governing the area in which the marine operations are performed.

It is not the intent of this part of ISO 19901 to govern the design of structures, systems and components used in marine operations, beyond the principles given. Recognized codes and standards are normally accepted as the basis for the detailed design and the fabrication requirements of such components.

Annex A provides some background and some additional information to the main body of the document and it is intended that it be read in conjunction with the main body of the document.

Annex B provides regional information on the application of the document to certain specific offshore areas.

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

Part 6: Marine operations

1 Scope

This part of ISO 19901 provides requirements and guidance for the planning and engineering of marine operations, encompassing the design and analysis of the components, systems, equipment and procedures required to perform marine operations, as well as the methods or procedures developed to carry them out safely.

This part of ISO 19901 is applicable to marine operations for offshore structures including

- steel and concrete gravity base structures (GBS);
- piled steel structures and compliant towers;
- tension leg platforms (TLP);
- deep draught floaters (DDF), including spars or deep draught caisson vessels (DDCV);
- floating production semi-submersibles (FPSS);
- floating production, storage and offloading vessels (FPSO);
- other types of floating production systems (FPS);
- mobile offshore units (MOU);
- topsides and components of any of the above;
- subsea templates and similar structures;
- gravity, piled, drag embedded and suction or other anchors;
- tendon foundations;
- associated mooring systems.

This document is also applicable to modifications of existing structures, e.g. installation of additional topsides modules.

This part of ISO 19901 is not applicable to the following marine operations:

- a) construction activities, e.g. in a fabrication yard onshore, where there is no exposure to the marine environment;
- b) drilling, processing and petrochemical activities;
- c) routine marine activities during the service life of the structure;
- d) drilling from mobile offshore drilling units (MODU);

- e) installation of pipelines, flowlines, risers and umbilicals;
- f) diving.

2 Normative references

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

ISO 19900:2002, *Petroleum and natural gas industries — General requirements for offshore structures*

ISO 19901-1:2005, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations*

ISO 19901-4:2003, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 4: Geotechnical and foundation design considerations*

ISO 19901-7:2005, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

ISO 15544, *Petroleum and natural gas industries — Offshore production installations — Requirements and guidelines for emergency response*

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

IMCA M 179, *Guidance on the Use of Cable Laid Slings and Grommets*. The International Marine Contractors Association

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19900, ISO 19901-1, ISO 19901-4, ISO 19901-7 and ISO 19904-1 and the following apply.

NOTE Other terms and definitions relevant for the use of this part of 19901 are also found in ISO 19901-5^[28], ISO 19902^[29], ISO 19903^[35] and ISO 19904-1^[30].

3.1 action

external load applied to the structure (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.

NOTE An earthquake typically generates imposed accelerations.

[ISO 19900:2002, 2.1]

3.2 action effect

effect of actions on structural components

EXAMPLE Internal forces, moments, stresses, strains, rigid body motions or elastic deformations.

[ISO 19904-1:2006, 3.5]

3.3

air cushion

air pumped into underbase compartments of the structure

NOTE Normally applied in order to reduce the draught and increase the freeboard and/or to alter the structural loading.

[ISO 19903:2006, 3.10]

3.4

assembly

designed and fabricated group of bulk and equipment items that form one unit

[ISO 19901-5:2003, 3.1.1]

3.5

ballast

variable solid or fluid content in order to change the draught, stability, trim and/or heel of a structure afloat

NOTE Adapted from ISO 19901-5:2003, 3.1.2.

3.6

ballast system

system used to change the draught, stability, trim and/or heel of a structure afloat

3.7

barge

simple floating vessel, normally non-propelled, on which a structure is transported

3.8

basic variable

one of a specified set of variables representing physical quantities that characterize actions, environmental influences, geometrical quantities or material properties, including soil properties

[ISO 19900:2002, 2.5]

3.9

bending efficiency factor

factor by which the calculated breaking strength of a rope is reduced to take account of the reduction in strength caused by bending around a shackle, trunnion, padear or crane hook

3.10

bollard pull

towing or manoeuvring action that can be generated by a tug for an indefinite period of time with its propulsion system running at operational, as opposed to maximum revolutions per minute

NOTE Bollard pull is expressed in kilonewtons.

3.11

bridging document

document that aligns and co-ordinates the requirements and responses of various parties in relation to a specific aspect of a project

NOTE Commonly used to align and co-ordinate the emergency response procedures for owner and contractors.

3.12

bumper

temporary structure designed to protect structures or modules during the initial fitting stage of an installation operation

3.13

characteristic value

value assigned to a basic variable associated with a prescribed probability of not being violated by unfavourable values during some reference period

NOTE The characteristic value is the main representative value. In some design situations, a variable can have two characteristic values, an upper and a lower value.

[ISO 19900:2002, 2.7]

3.14

CoG envelope

defined constraint volume within which the centre of gravity (CoG) of an assembly or a module shall remain

NOTE Adapted from ISO 19901-5:2003, 3.1.8.

3.15

consequence factor

factor applied to critical structural components in the design of lifting operations to ensure that these components have an increased factor of safety in relation to the consequence of their failure

NOTE Consequence factors are additional safety factors, applied to critical structural components of the lifted object over and above the normal safety factors used in a WSD analysis of the lifted object. They are, accordingly, applied to lift points, their attachments to the object and components in the object supporting lift points. They are not intended for application to slings, grommets and shackles.

3.16

construction afloat

addition of material or outfitting to the structure while afloat

NOTE Adapted from ISO 19903:2006, 3.17.

3.17

crane vessel

vessel, ship or barge on which lifting equipment is mounted

NOTE For the purpose of this document, this term includes crane barges, crane ships, derrick barges, shear-leg barges and semi-submersible crane vessels.

3.18

cribbing

arrangement of timber baulks, secured to the deck of the barge or vessel, designed to support the cargo

NOTE Cribbing is generally arranged at strong points of the deck and/or cargo.

3.19

deadweight

total carrying capacity of a floating structure

NOTE 1 This includes cargo weight, deck cargo, snow and ice, marine growth, ballast water, consumables and crew onboard a floating unit.

NOTE 2 Adapted from ISO 19901-5:2003, 3.1.11.

3.20

deck mating

marine operation in which the platform topsides is floated into position and connected to the support structure

NOTE This operation is normally conducted by ballasting and deballasting of the support structure.

[ISO 19903:2006, 3.18]

3.21

decommissioning

process of shutting down a platform and removing hazardous materials at the end of its production life

[ISO 19900:2002, 2.10]

3.22

design criterion

quantitative formulation that describes the conditions that shall be fulfilled for each limit state

NOTE Adapted from ISO 19900:2002, 2.11.

3.23

design situation

set of physical conditions representing potential conditions during a certain time interval for which the design is expected to demonstrate that relevant limit states are not exceeded

NOTE Adapted from ISO 19900:2002, 2.13.

3.24

design value

value derived from the representative value for use in the design verification procedure

[ISO 19900:2002, 2.14]

3.25

determinate lift

lift where the slinging arrangement is such that the sling forces are statically determinate and not significantly affected by minor differences in sling length or elasticity

3.26

displacement

weight of the volume of water displaced by a floating structure

NOTE 1 The weight of the water displaced is the sum of the lightship weight, deadweight and mooring system load including vertical component of the mooring pre-tension and/or riser action.

NOTE 2 Adapted from ISO 19901-5:2003, 3.1.12.

3.27

dunnage

arrangement of timber on deck of a barge or vessel laid out to support the cargo

3.28

dynamic action

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

[ISO 19901-7:2005, 3.8]

3.29

dynamic amplification factor

DAF

ratio of a dynamic action effect to the corresponding static action effect

NOTE An appropriately selected dynamic amplification factor can be applied to static actions to simulate the effects of dynamic actions.

[ISO 19902:2007, 3.16]

3.30

fibre rope

rope made of various yarns and various types of construction

EXAMPLE A fibre rope can be a stranded rope consisting of three to eight strands, a parallel strand rope, a single or double-braided rope, etc.

NOTE Each combination of yarn and type of construction normally results in different properties and characteristics.

3.31

fibre rope grommet

FRG

endless loop-shaped sling made up from a single length of fibre rope

NOTE A fibre rope grommet is of similar construction to a steel wire rope grommet.

3.32

fibre rope sling

FRS

sling made from a single fibre rope, usually with spliced eye end terminations

3.33

fixed structure

structure that is bottom founded and transfers all actions on it to the seabed

[ISO 19900:2002, 2.17]

3.34

float-off

offloading an object from a submersible transport vessel or barge by means of submerging the vessel or barge deck to a depth that is sufficient to allow the object to float and be removed from the vessel/barge

3.35

float-on

loading an object onto a submersible transport vessel or barge by means of submerging the vessel or barge deck to a depth that is sufficient to allow the floating object to be manoeuvred into position over the vessel/barge

NOTE The object is then lifted from the water and onto the vessel/barge deck by deballasting the vessel/barge to its seagoing condition.

3.36

float-out

transfer of a floating structure out of a flooded dry dock

NOTE Adapted from ISO 19903:2006, 3.28.

3.37

float-over

transfer of a major assembly supported on barge(s) on to its temporary or permanent structure by means of manoeuvring the major assembly over the structure and setting it down by means of ballasting the barge(s) supporting the assembly, deballasting the structure or lowering the supports of this assembly or combination thereof

3.38

grillage

steel structure, secured to the deck of a barge or vessel, designed to support the cargo and distribute the loads between the cargo and the barge or vessel

NOTE Adapted from ISO 19901-5:2003, 3.1.19.

3.39

grommet

endless loop-shaped sling made up from a single length of (fibre or steel wire) rope

See also **fibre rope grommet** (3.31) and **steel wire rope grommet** (3.89).

3.40

gross weight

calculated or weighed weight of the structure being lifted, including a weight contingency factor

NOTE Sometimes the gross weight is referred to as a not-to-exceed (NTE) weight.

3.41

heave compensation

system fitted to hoisting/lowering machinery on offshore construction vessels to enable the object being hoisted or lowered to maintain a constant vertical position when the vessel is oscillating in a vertical direction

3.42

hook load

sum of the rigging weight, including the DAF, and the lift weight

3.43

indeterminate lift

any lift where the sling forces are not statically determinate

3.44

launching

offloading an object into the water from a barge or other floating unit by means of sliding the object longitudinally, or less commonly, sideways along the floating unit

3.45

lift point

connection between the rigging and the structure being lifted

NOTE Lift points include padears, padeyes and trunnions.

3.46

lift weight

gross weight times the DAF

3.47

lightship weight

dry and invariable weight of a floating unit

NOTE Adapted from ISO 19901-5:2003, 3.1.27.

3.48

limit state

state beyond which the structure no longer fulfils the relevant design criteria

[ISO 19900:2002, 2.21]

3.49

link beam

connecting beam between the quay and the barge

NOTE The link beam can provide a structural connection, or can solely provide a smooth path for skidding or trailers.

3.50

load case

compatible load arrangements, sets of deformations and imperfections considered simultaneously with permanent actions and fixed variable actions for a particular design or verification

[ISO 19902:2007, 3.29]

3.51

loadout

transfer of a major assembly or a module from land onto a barge or vessel by horizontal movement or by lifting

NOTE 1 The following types of loadout operation can be distinguished:

- floating: loadout from the quay onto a floating barge;
- grounded: loadout from the quay onto a grounded barge;
- lifted: loadout performed by crane;
- skidded: loadout where the structure is skidded, using a combination of skidways, skidshoes or runners, propelled by towing engines, jacks or winches;
- trailer: loadout where the structure is wheeled onto the barge using trailers or SPMTs.

NOTE 2 Adapted from ISO 19901-5:2003, 3.1.30.

3.52

marine operation

planned and controlled vertical or horizontal movement of a structure or component thereof over, in or on water

[ISO 19903:2006, 3.36]

3.53

marine spread

fleet of vessels assembled to perform a marine operation

3.54

mating

transfer of a major assembly supported on barge(s) or vessel(s) to a temporary or permanent support structure

NOTE 1 The following types of mating operation can be distinguished:

- afloat: transfer of the barge supported major assembly to a floating structure by means of submerging the structure sufficiently to allow the assembly to be manoeuvred over it, then lifting the assembly off the barges by deballasting the structure;
- onto fixed structure: transfer of the barge supported major assembly to a fixed structure by means of manoeuvring it over the structure, then ballasting the barge supporting the assembly or lowering the supports of this assembly in order to transfer the weight of the assembly onto the structure.

NOTE 2 Adapted from ISO 19901-5:2003, 3.1.31.

3.55

minimum breaking strength

MBS

certified strength of a chain, wire rope, fibre rope or accessories

NOTE Adapted from ISO 19901-7:2005, 3.15.

3.56

mooring component

general class of component used in the mooring of floating structures

EXAMPLE Chain, steel wire rope, synthetic fibre rope, clump weight, buoy, winch/windlass or anchor.

3.57

nominal value

value assigned to a basic variable determined on a non-statistical basis, typically from acquired experience or physical conditions

[ISO 19900:2002, 2.22]

3.58

not-to-exceed weight

NTE weight

maximum acceptable weight of the structure, with an associated limiting CoG envelope

NOTE Adapted from ISO 19901-5:2003, 3.1.34.

3.59

offload

transfer of a major assembly or a module from a barge or transport vessel to land or to a self-floating condition by horizontal movement or by lifting

3.60

operational duration

planned duration of a marine operation, which includes a contingency time

3.61

owner

representative of the company or companies which own a development, who can be the operator on behalf of co-licensees

[ISO 19901-7:2005, 3.20]

3.62

padear

lift point consisting of a central member of tubular or flat plate form with horizontal trunnion, or consisting of a solid casting, around which a sling or grommet can be passed

3.63

padeye

lift point consisting essentially of a plate, reinforced by cheek plates if necessary, with a hole through which a shackle can be connected

3.64

platform

complete assembly including structure, topsides and, where applicable, foundations

[ISO 19900:2002, 2.23]

3.65

point of no return

PNR

point during an operation that represents the final opportunity to reverse, delay or abandon the operation

3.66
recognized classification society
RCS

member of the international association of classification societies (IACS), with recognized and relevant competence and experience in floating structures for marine operations, and with established rules and procedures for classification/certification of installations used in petroleum or natural gas activities

NOTE Adapted from ISO 19904-1:2006, 3.29.

3.67
representative value

value assigned to a basic variable for verification of a limit state

[ISO 19900:2002, 2.26]

3.68
reserve buoyancy

contingency buoyancy expressed in percentage of the nominal total intact buoyancy of self-floating steel structures

3.69
resistance

capacity of a structure, component or a cross-section of a component to withstand action effects without exceeding a limit state

[ISO 19904-1:2006, 3.32]

3.70
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. The return period in years is equal to the reciprocal of the annual probability of exceedance of the event.

[ISO 19901-1:2005, 3.23]

3.71
rigging

slings, shackles and other devices including spreader bars/frames used to connect the structure being lifted to the crane

3.72
rigging weight

total weight of rigging, including contingency

3.73
safe haven

sheltered location at which a tow or transport can seek refuge from inclement weather

3.74
seabed

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

NOTE 1 The seabed can be considered as the half-space below the sea floor.

NOTE 2 Adapted from ISO 19901-4:2003, 3.6.

3.75

sea fastening

temporary fastening items which keep movable items in position during transportation at sea

NOTE Adapted from ISO 19901-5:2003, 3.1.38.

3.76

sea floor

interface between the sea and the seabed

[ISO 19901-4:2003, 3.5]

3.77

semi-submersible

floating structure normally consisting of a deck structure with a number of widely spaced, large cross-section, supporting columns connected to submerged pontoons

[ISO 19904-1:2006, 3.36]

3.78

skew load factor

SKL

factor by which the load on any lift point, or pair of lift points, is multiplied to account for sling length mismatch in a statically indeterminate lift

3.79

skidshoe

bearing pad attached to the structure that engages in the skidway and carries a share of the vertical load

3.80

skidway

system of structural beams (concrete or steel) or rails, on the quay and on the barge, on which the structure is loaded out via the skidshoes

3.81

skirt

structure constructed at or below the base of a structure that extends downwards from the bottom of the foundation plate, penetrating into the seabed

NOTE 1 Skirts are used to increase the capacity of the foundation to resist vertical and horizontal loads and improve erosion resistance.

NOTE 2 Adapted from ISO 19903:2006, 3.49.

3.82

sling eye

loop at each end of a sling, either formed by a splice or by a mechanical termination

3.83

splash zone

area of a structure that is frequently wetted due to waves and tidal variations or during lift operations

NOTE 1 Refers to the wave-affected zone of the water column surrounding a structure.

NOTE 2 Adapted from ISO 19900:2002, definition 2.31.

3.84

splice

that length of sling where the rope is connected back into itself by tucking the tails of the unit ropes back through the main body of the rope(s), after forming the sling eye

3.85

spreader bar spreader frame

structure designed to resist the bending and compression forces induced by angled slings by altering the line of action of the force on a lift point into a vertical plane

NOTE The usual purpose of a spreader bar or frame is to avoid a clash between the rigging and the structure, which would result if the rigging were connected directly from the lift point to the hook.

3.86

squat effect

tendency of floating objects or vessels to undergo an increase in draught when underway

3.87

steel cable-laid sling SCLS

assembly of several (usually six) round stranded steel wire ropes (referred to as unit ropes), laid helically around a core (usually a seventh rope)

NOTE 1 The definition strictly applies to the type of steel wire rope construction. Cable-laid slings have hand-spliced eye end terminations by splicing the rope back on itself to form an eye termination.

NOTE 2 See IMCA M 179 for construction and use of cable-laid slings.

3.88

steel wire rope

rope made of various types of steel wire construction

EXAMPLE A steel wire rope can be a stranded rope consisting of six or eight strands laid helically around a core (steel core, fibre core, IWRC), a spiral rope, etc.

NOTE Each combination of material and type of construction normally results in different properties and characteristics.

3.89

steel wire rope grommet SWRG

endless loop-shaped sling made up from a single length of round stranded steel wire rope

NOTE 1 As for cable-laid slings, the steel wire rope used in a grommet is also referred to as a unit rope.

NOTE 2 A steel wire rope grommet is constructed from one continuous length of stranded wire rope and consists of a body composed of six strands around a strand core. The rope is spirally wound around the core rope in six loops. During the production of grommets a temporary rigid core is used, which is replaced by the first half loop and the last half loop of the stranded wire rope. At the start of looping, the core rope changes into an outer rope, and at the end the sixth outer rope changes back into the core rope. When removing the temporary rigid core, the ends of the stranded wire are tucked into the body core, with the tuck position diametrically opposite to the core butt position.

NOTE 3 See IMCA M 179 for construction and use of steel wire rope grommets.

3.90

steel wire rope sling SWRS

sling made from a single steel wire rope with various possible end terminations

NOTE Terminations include spliced eyes, Flemish eye with swaged steel sleeve (also known as super loop), spelter sockets, resin sockets, etc.

3.91

strength

mechanical property of a material indicating its ability to resist actions, usually given in units of stress

[ISO 19902:2007, 3.49]

3.92

structure

organized combination of connected parts designed to withstand actions and provide adequate rigidity

[ISO 19900:2002, 2.35]

3.93

termination efficiency factor

factor by which the calculated breaking strength of a rope is reduced to take account of the reduction in strength caused by a splice or other end termination

3.94

topsides

structures and equipment placed on a supporting structure (fixed or floating) to provide some or all of a platform's functions

NOTE 1 For a ship-shaped floating structure, the deck is not part of the topsides.

NOTE 2 For a jack-up, the hull is not part of the topsides.

NOTE 3 A separate fabricated deck or module support frame is part of the topsides.

[ISO 19900:2002, 2.38]

3.95

tow

marine transportation of an object or its supporting barge by being pulled or pushed by tow vessel(s)

NOTE A tow can be defined into the following types:

- dry: marine transportation of an object with the object located clear of the water aboard a barge or other unit;
- wet: marine transportation of an object with the object floating directly in the water.

3.96

trailer

system of steerable wheels, connected to a central spine beam by hydraulic suspension that can be raised or lowered

3.97

trunnion

lift point on a structure consisting of a tubular member or cast cantilever with a stopping plate at the end, around which a sling or grommet can be passed

NOTE An upending trunnion is used to rotate a structure from horizontal to vertical, or vice versa, and the trunnion forms a bearing point around which the sling, grommet or another structure rotates.

3.98

tugger line

line between a winch and an object to control the orientation and position to prevent or reduce the motion, or to position a lifted object during an installation operation

3.99

upending

process of changing the orientation of an object in the water from the horizontal to the vertical by means of ballasting, flooding, by crane assistance or a combination of these techniques, or in air only by means of crane assistance

EXAMPLE Upending in air only by means of crane assistance, e.g. of a flare.

3.100

verification

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

3.101

watertight

capability of preventing the penetration of water into or through the structure with a water pressure head corresponding to that for which the surrounding structure is designed

[ISO 19904-1:2006, 3.50]

3.102

weather-restricted operation

marine operation that can take place safely within the limits of a favourable weather forecast

NOTE It is not necessary that the design weather criteria reflect the statistical extremes for the area and season. A suitable factor should be applied between design weather criteria and operational weather limiting criteria.

3.103

weathertight

capability of preventing the penetration of water into the structure during temporary exposure to water

NOTE A watertight closing appliance is also considered weathertight.

[ISO 19904-1:2006, 3.51]

3.104

weather-unrestricted operation

marine operation that can take place safely in any weather condition that can be encountered during a season

NOTE The statistical extremes for the area and seasons are considered in the design weather criteria.

3.105

weather window

period of time, sufficient in length to safely carry out a marine operation, for which forecast environmental conditions remain below prescribed limiting operational environmental criteria

3.106

working load limit

WLL

maximum load that can safely be applied to a rope, sling, grommet, shackle or lift point

3.107

50/50 weight estimate

value representing the median value in the probability distribution of weight estimates

[ISO 19901-5: 2003, 3.1.54]

NOTE 1 The actual weight is equally likely to be smaller or larger than the 50/50 weight estimate.

NOTE 2 The 50/50 weight estimate is used as the basis for weight budgeting.

4 Symbols and abbreviated terms

4.1 Symbols

$A_1, A_2, A_3,$	areas under or between the wind heeling moment curve and the hydrostatic righting moment curve (see Figures 2 and 3)
b	breadth, expressed in metres
B_0	total available buoyancy of the structure
B_r	reserve buoyancy, expressed in percent of B_0
d	nominal diameter of a rope, sling or leg of a grommet, expressed in millimetres
d_h	diameter of shackle pinhole, expressed in millimetres
d_p	diameter of shackle pin, expressed in millimetres
D	minimum diameter over which a sling or grommet is bent, expressed in millimetres
f_{fr}	calculated percentage friction force
f_{SF}	safety factor (in WSD method)
$f_{SF, sh}$	safety factor for a shackle (in WSD method)
$f_{SF, Y}$	safety factor for component Y (in WSD method) Y = SWRS; SCLS; FRS; SWRG or FRG
F_{dgf}	design grommet force (for a complete grommet)
$F_{dgf, 1}$	design force for one leg of a grommet
F_{dhl}	design hook load for a one-crane lift
$F_{dhl, i}$	design hook load on hook i for a two-hook lift
F_{dsf}	design sling force for a one-part sling
$F_{dsf, 2 \text{ parts}}$	design sling force for each part of a two-part sling
F_{min}	minimum value of the breaking strength of a steel wire rope, expressed in kilonewtons
F_{hl}	nominal hook load, expressed in kilonewtons
F_{rgf}	representative grommet force (for a complete grommet)
$F_{rgf, 1}$	representative force for one leg of a grommet
F_{rhl}	representative hook load for a one-hook lift by a single crane
$F_{rhl, i}$	representative hook load on hook i for a two-hook lift ($i = 1, 2$)
F_{rsf}	representative sling force for a one-part sling
$F_{rsf, 2 \text{ parts}}$	representative sling force for each part of a two-part sling
$F_{srhl, i}$	nominal hook load, F_{hl} , statically resolved between hooks $i = 1, 2$
F_{BP}	continuous static bollard pull of each tug, expressed in kilonewtons

$F_{CS,X}$	calculated strength (CRBL) of the body of component X in force terms, where X is a sling or one leg of a grommet (see 18.4.2) X = SWRS; SCLS; FRS; SWRG, 1 or FRG, 1
$F_{CS,X}$	calculated strength (CGBL) of a complete grommet of type X in force terms (see 18.4.2) X = SWRG, 2 or FRG, 2
$F_{DS,sh}$	design strength of a shackle in force terms
$F_{DS,Y}$	design strength of component Y in force terms, where Y is a sling or a grommet (in PFD method, see 18.4.6) Y = SWRS; SCLS; FRS; SWRG or FRG
F_{min}	minimum value of the breaking strength of a steel wire rope, expressed in kilonewtons
F_{PR}	minimum towline pull required, expressed in kilonewtons
$F_{RS,sh}$	representative strength of a shackle in force terms
$F_{RS,Y}$	representative strength of component Y in force terms, where Y is a sling or a grommet (see 18.4.5) Y = SWRS; SCLS; FRS; SWRG or FRG
$F_{WLL,sh}$	working load limit (WLL) of a shackle in force terms
$F_{WLL,Y}$	working load limit (WLL) of component Y in force terms, where Y is a sling or a grommet (in WSD method, see 18.4.6) Y = SWRS; SCLS; FRS; SWRG or FRG
g	acceleration of gravity, equal to 9,81 m/s ²
H_c	height of cribbing above deck, expressed in millimetres
H_{max}	maximum anticipated wave height at the site during loadout, expressed in metres
H_s	significant wave height, expressed in metres
k_{be}	bending efficiency factor
k_{CoG}	CoG factor, the value of which reflects the uncertainty in the position of the CoG when statically distributing the lift weight between the lift points
k_{DAF}	dynamic amplification factor
k_{lf}	lateral force factor
k_{sf}	CoG shift factor, the value of which reflects the uncertainty in the position of the CoG when statically distributing the total hook load between the two hooks
k_{skl}	skew load factor, the value of which reflects unequal load sharing in an indeterminate lift between slings that differ in length as a result of manufacturing tolerances
k_{te}	termination efficiency factor
k_{tf}	tilt factor, the value of which reflects the effect of uneven heights of the crane hooks and/or uneven hoisting speeds when statically distributing the total hook load between the two hooks
k_{wcf}	weight contingency factor

k_{yaw}	yaw factor, the value of which reflects the effect of yawing during lifting with two cranes when statically distributing the lift weight between the lift points
K	empirical factor for the minimum breaking strength for a given rope class and core type
l_{freebd}	effective freeboard, expressed in metres
L_{OA}	length over all, expressed in metres
$\max(a_{i,j})$	largest value of a for all i and all j
$\min(a, b)$	lower value of a and b
P_{clf}	calculated lateral force on a lift point due to known misalignment between the orientation of the lift point and the sling direction (where applicable)
P_{dlf}	design lateral force on a lift point
P_{ddf}	design force on a lift point in line with the sling direction
P_{dvf}	design vertical force on a lift point
P_{rlf}	representative lateral force on a lift point
P_{rdf}	representative force on a lift point in line with the sling direction
P_{rvf}	representative vertical force on a lift point
R_t	rope grade (tensile strength grade of the wires in the rope), expressed in newtons per square millimetre
T_{eff}	tug efficiency in the considered sea conditions, expressed in percent
W	gross weight
W_c	cargo weight, expressed in kilonewtons
W_{cw}	calculated weight
W_{lw}	nominal lift weight
$(W_{\text{rlw}})_{\text{one crane}}$	representative lift weight on a lift point for one-hook lifts by one crane
$(W_{\text{rlw}})_{\text{two cranes}}$	representative lift weight on a lift point for lifts by two cranes
W_{rw}	rigging weight
$W_{\text{rw},i}$	rigging weight associated with crane hook i ($i = 1, 2$)
W_s	weight of the sling
$W_{\text{srlw},i}$	statically resolved lift weight for crane hook i ($i = 1, 2$)
$W_{\text{srlw},j}$	statically resolved lift weight acting on lift point j
$W_{\text{srlw},i,j}$	statically resolved lift weight for crane hook i acting on lift point j
W_{ww}	weighed weight
W_0	weight of the structure in air
α	heeling angle where the maximum hydrostatic righting moment occurs, expressed in degrees
β	sum of the static wind heeling angle and the maximum roll angle, expressed in degrees

γ_f	partial action factor (in PFD method)
$\gamma_{f,hl}$	partial action factor for hook load (in PFD method)
$\gamma_{f,lp}$	partial action factor for forces on a lift point when designing lift points and their attachment to the structure (in PFD method)
$\gamma_{f,mf}$	partial action factor for forces on a lift point when designing structural members directly supporting or framing into the lift points (in PFD method)
$\gamma_{f,m}$	partial action factor for forces on a lift point when designing other structural members (in PFD method)
$\gamma_{f,s}$	partial action factor for forces in slings, grommets and shackles (in PFD method)
γ_R	partial resistance factor (in PFD method)
$\gamma_{R,sh}$	partial resistance factor for a shackle (in PFD method)
$\gamma_{R,Y}$	partial resistance factor for component Y (in PFD method) Y = SWRS; SCLS; FRS; SWRG or FRG
ϕ_{max}	maximum dynamic heeling angle due to wind and waves, expressed in degrees
θ	angle between the sling and the horizontal plane, expressed in degrees

4.2 Abbreviated terms

CGBL	calculated grommet breaking load (see 18.4.1)
CoG	centre of gravity
COLREGS	Convention on International Regulations for Preventing Collisions at Sea, 1972, as amended
CRBL	calculated rope breaking load (see 18.4.1)
CSBL	calculated sling breaking load (see 18.4.1)
DAF	dynamic amplification factor
DDCV	deep draught caisson vessel
DDF	deep draught floater
DP	dynamic positioning
EPBD	emergency preparedness bridging document
FMEA	failure modes and effects analysis
FPS	floating production system
FPSO	floating production, storage and offloading vessel
FPSS	floating production semi-submersible
FRG	fibre rope grommet (see 18.1)
FRS	fibre rope sling (see 18.1)
GBS	gravity base structure
HAZID	hazard identification study

HSE	health, safety and environment
IACS	International Association of Classification Societies
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
IOPP	international oil pollution prevention
ISM	international safety management
ISO	International Organization for Standardization
ISPS	international ship and port facility security
IWRC	independent wire rope core
MARPOL	international convention for the prevention of pollution from ships
MBS	minimum breaking strength
MOU	mobile offshore unit
NDT	non-destructive testing
NTE	not-to-exceed
PFD	partial factor design
PMS	positioning monitoring system
PNR	point of no return
QRA	quantitative risk analysis (or assessment)
RCS	recognized classification society
ROV	remotely operated vehicle
SCLS	steel cable-laid sling (see 18.1)
SKL	skew load factor
SMC	safety management certificate
SOLAS	International Convention for the Safety of Life at Sea, 1974, as amended
SPMT	self-propelled modular transporters: a trailer system having its own integral propulsion, steering, jacking, control and power systems
SSCV	semi-submersible crane vessel
SWL	safe working load
SWRG	steel wire rope grommet (see 18.1)
SWRS	steel wire rope sling (see 18.1)
TLP	tension leg platform
UHC	ultimate holding capacity of drag anchors
ULS	ultimate limit states

WLL	working load limit (see 18.4.1)
WSD	working stress design

5 General considerations

5.1 Introduction

5.1.1 General

Marine operations for offshore installation include transient marine movements and other activities where the structure or the operation is at risk from the marine environment. Such operations can include

- loadout from shore to barge or vessel;
- launching from shore to water;
- float-out from dry docks;
- wet or dry towage and other marine transportations;
- temporary moorings and stationkeeping during construction;
- construction and outfitting afloat;
- installation by means of launching or float-off, upending, lowering by ballasting, float-over or lifting;
- installation of anchor foundations;
- installation of permanent moorings, including tendons;
- connection to permanent moorings and tendons;
- scour protection;
- decommissioning and total or partial removal of the structure.

This part of ISO 19901 gives requirements and guidance on the planning and execution of marine operations during the temporary phases of construction, transportation and installation of the various structures and their components.

General requirements and guidance on safety and emergency issues, and reference to applicable legislation are contained in 5.1.2 to 5.10. Effective management of these issues requires full knowledge of applicable regulatory requirements.

5.1.2 Safety requirements

The overall objective of the safety of marine operations is to perform all operational activities at minimum risk of accidents or incidents to personnel, environment and property. This can be met if

- the operation is designed taking into account the statistical weather extremes for the area and season;
- the operational weather conditions, chosen at values smaller than the specified limiting conditions, are forecast for a sufficiently long period to enable completion of the operation;

- the required equipment, vessels and other means are designed and checked for adequate performance with respect to their intended use;
- there is redundancy in the equipment provided to cover possible breakdown situations;
- the operations are planned, in nature and duration, such that accidental situations, breakdowns or delays have a very low probability of occurrence and are covered by detailed contingency plans;
- adequate documentation has been prepared for a safe, step-by-step execution of the operation, with clear indications of the organization and chain of command;
- the operations are conducted by competent personnel;
- safe systems of work are devised in light of a systematic risk assessment.

5.2 Jurisdiction

5.2.1 Introduction

Platform construction and marine operations are subject to approval by appropriate parties in due time before actual activities commence. Thus, national and international regulations and guidelines on personnel safety and protection of the environment are the governing requirements. It should also be noted that marine operations can involve more than one nation's area of jurisdiction and that, for barges and vessels, the jurisdiction of the flag state applies.

5.2.2 Life at sea

In order to respect life at sea, information with respect to conventions, codes and guidelines is required. The information is subdivided into separate provisions with respect to vessels on international voyages and vessels on domestic voyages, and is further subdivided to separately address mandatory instruments (i.e. conventions) and recommendatory instruments (i.e. codes and recommendations).

For vessels on international voyages, the vessel's flag state generally requires the vessel's compliance with the international conventions identified in References [1] to [7]. Such compliance is generally demonstrated by the issuance of the relevant certificate mandated by the convention.

Before selection of any vessel where the vessel's flag state is not party to the most recent protocols or amendments to the instruments referenced above, careful consideration should be exercised.

The international conventions identified in References [1] to [7] do not necessarily apply to domestic voyages. In such cases, national standards offering equivalent levels of safety should be applied.

References [8] to [18] provide recommendations that the flag state can adopt and apply as mandatory requirements, as applicable, to vessels under their jurisdiction. Where these are not adopted and applied by the flag state, national standards offering equivalent levels of safety should be applied.

5.2.3 Environment

The legislation for the protection of the environment is evolutionary and covers various purposes. It is embodied in a number of instruments of broad scope, from the law of the sea and general practices covering natural resources exploitation, protection of marine environment, pollution and dumping of waste, through to international conventions, regional conventions and national rules.

Applicable international conventions can be found in References [19] to [24].

5.3 HSE plan

A HSE plan shall be established. The objectives of the plan shall be

- to document the HSE standards, processes and procedures that apply to the work;
- to identify, assess and manage hazards and risks arising from the work, reducing them to as low as reasonably practicable;
- to ensure that safety is inherent in planning and design of the work;
- to ensure minimal impact on the environment;
- to protect the health of the workforce.

The plan shall include HSE activities during all phases of the work, from planning and design through to execution of the operation.

Selected activities are described in 5.4 to 5.10.

The use of alcohol, drugs or narcotics by personnel involved in marine operations is not permitted.

5.4 Risk management

5.4.1 Introduction

For risk management, ISO 17776 and the provisions of 5.4 and 5.5 apply.

The overall responsibility for risk management shall be clearly defined when planning marine operations.

Risk management shall be applied to the project to reduce the effects of hazards and to limit the overall risk. This objective can be achieved by addressing the following functions in turn:

- identification of potential hazards;
- assessment of risk potential;
- prevention to avoid hazards wherever possible;
- control to reduce the potential consequences of unavoidable hazards;
- measures to mitigate the consequences of an incident, should one occur.

Each marine operation, including each major system that is essential to the performance and safety of marine operations, e.g. power generation and supply systems, ballast and compressed air systems, shall be subjected to a rigorous hazard study.

Personnel and organizations involved in marine operations, as well as those involved in the design and operation of the systems, shall take part in the hazard studies.

It is recommended that consequence assessment be used to rank the probabilities and consequences of various events, to form a basis for further investigation if necessary.

5.4.2 Techniques to evaluate risks

5.4.2.1 Appropriate techniques to evaluate risks include, but are not limited to,

- design and execution: HAZID and scenario based risk assessments;
- execution implementation: job safety analyses, hazard hunts and tool box talks, which can be applied at field supervision level.

5.4.2.2 QRA techniques can be used

- to compare levels of risk between alternative proposals or between known and novel methods; and
- to enable rational choices to be made between alternatives.

5.5 Job safety analysis

Job safety analysis should be performed to detail the

- sequence of the operation;
- equipment to be used at each stage;
- hazards to be controlled;
- precautions to take and the responsibilities of persons involved.

The analysis should be performed and documented by the marine contractor as a basis for the method statement for the operation. When completed, the results of the job safety analysis should be communicated to personnel involved in the various operation activities through kick-off meetings and tool-box talks.

5.6 Environmental impact study

An environmental impact study should be carried out, where appropriate, to identify and deal with generally recognized risks to the environment (e.g. waste management, disposal at sea) or to personnel, and to population and wildlife (e.g. toxicity, explosives, radiation, noise, vibrations and other disturbances).

5.7 Manning, qualifications, job and safety training

Personnel shall be appropriately qualified, trained and assessed for the work they are expected to undertake so as to ensure that they can undertake that work competently. All personnel should also have adequate knowledge of the English language. Supervisors should possess a thorough knowledge of the entire operation under their control and have prior experience with similar operations. Other key personnel should have knowledge and experience within their area of responsibility.

Qualification requirements for job categories critical to safe operations shall be specified. See Reference [25] for regulations on safe manning. Before commencement of an operation, personnel involved should be briefed by the supervisors regarding responsibilities, communication, work procedures and safety, as well as given a step-by-step run-through of the operation.

Job-specific training should be carried out and should cover the following topics:

- general and specific site regulations;
- legal obligations;
- instructions regarding the operation in question and any associated activities;
- instructions regarding the use of the plant and equipment.

Computer simulations, model tests and simulator training of the operation can give valuable information for the personnel carrying out the operation.

Personnel should receive safety training in accordance with the requirements of applicable national and international conventions, codes and guidelines. The training should include general safety requirements, emergency training and drills as appropriate to the job requirements and locations in which work is to be performed.

Fire and evacuation alarms should be periodically tested, and drills should be carried out periodically, or as required by safety legislation. Where more than one manned platform or vessel is affected by the construction activities, consideration should be given to joint emergency drills.

Finally, an up-to-date list with information of next of kin should be maintained.

5.8 Incident reporting

During marine operations, incident reporting depends on the contract requirements and governmental regulations and can include

- periodic reports;
- incident, accident and near-miss accident reports;
- pollution or substantial threat of pollution reports.

5.9 Personnel tracking

A suitable security and tracking system should be in use to

- record the presence of personnel on the installation and supporting vessels;
- track their whereabouts;
- restrict access to certain areas to authorized personnel only, if required.

5.10 Approval by national authorities

National authorities can decide to survey and approve the operations, or parts thereof.

6 Organization, documentation and planning

6.1 Introduction

The organization, documentation and planning that shall be set up for the performance of marine operations are outlined in 6.2 to 6.7. The degree of documentation shall suit the complexity and risks involved in the operation.

6.2 Organization and communication

6.2.1 Project organization

An appropriate organization shall be set up, illustrating how the marine operations integrate with the rest of the project. Key responsibilities shall be clearly defined. The responsibilities and reporting lines shown on the organization chart shall include

- owner's organization and project management for the project;
- contractor's project management for the project;

- engineering design;
- procurement;
- construction;
- marine operations;
- HSE;
- project controls;
- quality;
- interface management.

6.2.2 Operational organization

Separate organization charts shall be drawn up for each marine operation, showing the reporting line into the project organization. The details of the organization charts and their overall setup should be consistent with the size or complexity of the project and should be limited to the parties actually involved. Each operational organization chart should indicate, as appropriate, the functional links among the following entities:

- owner's representative;
- overall project management;
- operational management;
- towing vessels;
- mooring systems and marine spread;
- ballast system operation;
- weather forecasting;
- support services;
- advisory panel providing expertise as required;
- HSE;
- statutory, regulatory and approving bodies.

In each case, the responsibilities and duties of each function should be clearly defined and published to minimize uncertainties and overlapping responsibilities.

Where transfer of responsibility is involved, the hand-over period from one organization to another (e.g. fabrication to marine operations, or onshore to offshore) should be identified.

During ongoing marine operations, the selection of site team members shall be limited to those persons with defined roles during the operation. Any organizational changes that are part of an emergency response should be clearly identified. Back-up services, including emergency services, contingency assistance and technical advisory services, shall be identified and appropriately located.

Communication systems, including radio channels, telephone, telefax, e-mail and out-of-hours numbers, shall be identified.

Personnel changes that occur during the course of an operation as a result of shift changes should be identified. Every effort should be made to avoid changes of personnel during critical stages of the operation.

Key personnel participating in a marine operation shall communicate in one language.

NOTE For preparation of appropriate operational manuals, see 6.5.2.

6.3 Quality assurance and administrative procedures

An acceptable quality management system shall be in place and all activities shall be managed through it. A system such as the ISO 9000 series ^[26], or any other equally acceptable system, may be used.

Operators of vessels shall have a management system in compliance with the ISM Code ^[9], verified by valid ISM certificates; see 6.6.2.

6.4 Technical procedures

Technical procedures shall be set up to control the design and engineering related to marine activities.

These procedures shall define the use of applicable technical standards and ensure agreement and uniformity on matters such as

- the use of international and national standards;
- the use of certifying authority/regulatory body standards;
- project criteria;
- design premises;
- metocean criteria;
- calculation procedures;
- response forecasting.

Design premises are defined as the fundamental principles and philosophy upon which the outline and detailed design of a marine operation are based; design premises include, among others, design criteria, methods of analysis and a description of software used.

Marine operations involving complex procedures that are not proven by past experience shall require analysis and/or the performance of simulations and/or model tests in order to demonstrate the adequacy of the planned procedures. Such analyses, simulations or model tests shall be used primarily to investigate the anticipated motions and the stability of the structure during any critical phases of marine operations.

6.5 Technical documentation

6.5.1 Document numbering system

The document numbering system used for marine operations should normally follow and comply with the overall numbering system already in place for the project. As an alternative, a specific document numbering system and document register may be used.

Marine operations documents shall be clearly identified by number, revision and date, type of document, discipline involved and review status.

6.5.2 Marine operations documents

6.5.2.1 Documents relating to marine operations should be grouped into levels according to their status, for example

- design basis and criteria documents;
- marine operations procedures documents;
- supporting documents, including definitions of actions, structural and naval architectural calculations, systems operational manuals, equipment specifications and decommissioning reports.

Procedure documents that are intended for use as an active tool during marine operations should include a section that clearly shows their reference to higher and lower level documents and should list interrelated documents.

Documents listed in a marine operations procedures document should be available and accessible on board or on-site close to the operation for reference by anyone that is involved.

6.5.2.2 Elements that are considered essential and that should be included in, or referred to by, a marine operations document are the following:

- introduction;
- reference documents;
- outline execution plan;
- organigram and lines of command;
- job descriptions for key personnel;
- safety plan, including a description of safety equipment, the location and signalization of safety routes, and requirements for personnel training;
- information on authorities and permits, including notification requirements;
- contractual approvals and hand-over;
- environmental criteria, including design and operational criteria;
- operational bar chart, showing the anticipated duration of each activity, interrelated activities, key decision points and hold points;
- preparations, surveys and outline check lists;
- specific step-by-step instructions for each phase of the operation, including sequence, timing and resources;
- contingency plans;
- results of related calculations, e.g. environmental actions, moorings, ballast, stability, bollard pull;
- appendices listing more detailed information, such as drawings, calculations, equipment specifications, site information, dimensional control, operational monitoring and control systems, logging of operational control parameters, communication systems, ROV procedures, check lists;
- EPBD.

6.5.3 Operational schedule

A detailed activity schedule should be established showing how the marine operation is planned. The schedule should be presented as an operational bar chart, showing the duration of each activity, interrelated activities, key decision points and hold points.

For weather-restricted activities, the duration shall be set equal to the planned duration plus estimated contingency time. Risk analysis should be used as an assisting tool to establish realistic contingency times.

6.5.4 Contingency philosophy

Marine operations shall include contingency and back-up plans.

Where there are limits on an operation, the operation shall either be completed within the limits or aborted. In the latter case, the vessel(s) should be able to return to a safe condition or safe haven within the available time, even if a breakdown occurs to any system or equipment.

To be able to meet such requirements, essential systems, parts of systems or equipment should have redundancy systems, back-up systems or back-up system alternatives.

Back-up systems may be an integrated part of the primary system when feasible.

For systems consisting of several units, back-up or redundancy may be provided by having a sufficient number of spare units available on-site. The time required for the transfer of operations to back-up or redundancy systems should be assessed.

Spare parts and key service personnel should be available on-site or on stand-by. If key parts and service personnel are on stand-by, then the time taken to mobilize them to the site should be assessed in order to check the effectiveness of the contingency arrangements.

6.5.5 Contingency planning and emergency procedures

For emergency procedures and response, ISO 15544 and the provisions of 6.5.5 and 6.5.6 apply.

Contingency and emergency planning shall form part of the general operational procedures. Plans shall be developed for foreseeable emergencies that can be identified by a risk assessment, which can include

- occurrence of severe weather or sea states in excess of allowable metocean criteria;
- planned precautionary action in the event of forecast severe weather;
- structural or stability parameters approaching pre-set limits;
- failure of ballast or compressed air system;
- failure of equipment, such as lift system;
- loss of communication;
- loss of vessel or barge control;
- loss of electrical power;
- fire;
- collision;
- pollution;

- leakage;
- structural failure;
- mooring line failure;
- man overboard;
- personnel accidents or medical emergencies;
- medical evacuation from remote locations;
- grounding;
- unexpected water depth limitations or sea floor hazards;
- piracy, mutiny, terrorism, or other unauthorized intervention.

Emergency procedures for all phases of marine operations should be prepared to cover foreseeable hazards, including those due to adverse weather conditions, human errors, technical failures and associated changes on the configuration of the operations underway.

The procedures should include details on alarm signals, reporting, communication, organization and required equipment, for instance personnel rescue means and fire-fighting equipment.

The project operational organization shall be prepared to manage, as contingency measures, any changes to an agreed procedure arising from an emergency situation not previously identified in hazard studies. The management of such an unforeseen situation shall support any decision made by means of adequate risk and safety assessment tools as described in 5.4 and 5.5.

6.5.6 Emergency preparedness bridging document

Procedures issued by parties involved in a marine operation should be compatible with each other, and gathered in an emergency preparedness bridging document (EPBD).

In the event of an emergency situation, the EPBD should define who is the on-scene commander and his role, and the interfaces between the various parties involved.

The EPBD should also include a flow chart outlining the responsibility for notifying a maritime rescue co-ordination centre and, if necessary, onshore base organizations, the owner and public relations.

The extent of any onshore support required depends on the nature and scale of the emergency situation. Should onshore support be required, the EPBD should define which emergency response organization among the involved parties takes primacy in the organization of the onshore support.

6.6 Certification and documentation

6.6.1 General

Statutory obligations for documentation and certification requirements for any particular structure, vessel or operation shall be determined in advance. For each document required, the issuing authority and the applicable rules shall be identified.

A project assurance plan should be established, defining the minimum requirements for vessel certification and for the reports from inspection and maintenance condition surveys.

A complete and updated list of certificates and documents that it is required to carry on board ships is given in Reference [27]. A review of the required and recommended documents is given in 6.6.2 and in A.2.

The certification, documentation and all correspondence should be in English. Where the original certification, documentation or correspondence is not in English, a reliable translation into English or another agreed working language should be provided.

6.6.2 Required or recommended documentation

Table 1 lists the documentation that is either required or recommended for transportation of various types of vessels and floating structures.

For marine operations in general, at least some, if not all, of the documentation listed in Table 1 is mandatory for compliance with international legislation. Specialist advice should be obtained regarding required documentation.

Vessels involved in the performance of marine operations should be in possession of a certificate of compliance with the ISM Code^[9], demonstrating that the company owning the vessel(s) has developed and put into effect a vessel safety management system in line therewith.

In addition, vessels carrying crew and passengers should carry an international ship security certificate indicating that they comply with the requirements of the ISPS Code.

6.7 Systems and equipment

6.7.1 General

Operational systems and equipment should be tested and commissioned prior to the operation.

Vessels, systems and equipment required for installation operations should be in good condition with appropriate certification (see also Table 1), and fit for the purpose for which they are intended. They should have the capability and capacity to operate effectively under the environment and actions for which the operation is designed. They should be used in accordance with manufacturer's instructions and procedures. Where possible, they should be designed to be fail-safe and should possess an adequate level of reliability and redundancy.

6.7.2 Marine vessels

Marine vessels and their equipment should be inspected prior to the operation to confirm their suitability and validity of certification, as applicable for the type of vessel and voyage planned; see 6.6.

Vessel stability should be in accordance with Clause 9 throughout all stages of the operation, unless it can be shown that reduced stability requirements can be accepted. For example, during phases of deck mating, taking account of the reduced environmental conditions and the partial restraints of the structure to the vessel, reduced stability criteria may be considered.

Table 1 — Required or recommended documentation for the transportation of various types of vessels and floating structures ^{[27],[36]}

Document ^a		Cargo vessel	Offshore construction vessel/supply/tug	All towage (manned)	Barge towage (unmanned)	FPSO towage (unmanned)	Other towage (unmanned)
Required documents							
1	Certificate of registry	✓	✓	✓	—	—	—
2	Certificate of class (hull)	✓	✓	✓	✓	✓	—
3	Certificate of class (machinery)	✓	✓	✓	✓	—	—

Table 1 (continued)

Document ^a		Cargo vessel	Offshore construction vessel/ supply/tug	All towage (manned)	Barge towage (unmanned)	FPSO towage (unmanned)	Other towage (unmanned)
4	International tonnage certificate	✓	✓	✓	✓	—	—
5	Cargo ship safety construction certificate	✓	✓	✓	—	—	—
6	Cargo ship safety equipment certificate	✓	✓	✓	—	—	—
7	Certificates for navigation lights and shapes	—	—	—	✓	✓	✓
8	Load line certificate	✓	✓	✓	✓	—	—
9	Load line exemption	—	—	—	✓	✓	✓
10	MARPOL and IOPP ^b certificate	✓	✓	✓	—	—	—
11	Safety management certificate (SMC)	✓	✓	✓	—	—	—
12	Customs clearance	✓	✓	✓	✓	✓	✓
13	De-rat certificate, or exemption	✓	✓	✓	—	—	—
14	Safety radio certificate	✓	✓	✓	—	—	—
15	Stability booklet	✓	✓	✓	✓	✓	✓
16	ISPS certificate	✓	✓	✓	✓	✓	✓
17	Bollard pull certificate	—	✓	—	—	—	—
18	Certificates for bridle, tow wires, pennants, stretchers and shackles	—	✓	✓	✓	✓	✓
19	Suez or Panama Canal documentation (if relevant)	✓	✓	✓	✓	✓	✓
20	Certificates for life saving appliances	✓	✓	✓	—	—	—
21	Minimum safe manning document	✓	✓	✓	—	—	—
22	Muster list	✓	✓	✓	—	—	—
Recommended documents, where applicable							
23	Medicine certificate	✓	✓	✓	—	—	—
24	POB list	✓	✓	✓	—	—	—
25	Installation certificate for gas welding equipment	✓	✓	✓	✓	✓	✓
26	Lift certificate	✓	✓	✓	✓	✓	✓
27	Certificate for transportation of dangerous cargoes/chemicals, etc.	✓	✓	✓	✓	✓	✓

Table 1 (continued)

Document ^a		Cargo vessel	Offshore construction vessel/supply/tug	All towage (manned)	Barge towage (unmanned)	FPSO towage (unmanned)	Other towage (unmanned)
28	Damage control plans and booklets	✓	✓	✓	✓	✓	✓
29	Certificate of class (DP systems if applicable)	—	✓	—	—	—	—
30	Certificate of class (propulsion systems)	—	✓	—	—	—	—
31	Certificate of class (safety construction)	—	✓	—	—	—	—
32	Certificate of class (safety equipment)	—	✓	—	—	—	—
^a See A.2 for guidance.							
^b Not required for unmanned towages unless fitted with machinery.							
NOTE 1 Smaller vessels (cargo vessels and offshore construction vessels, including supply vessels and tugs) can be exempt from some certification requirements.							
NOTE 2 Some documents are not required for inland voyages or inland towages.							

7 Metocean and earthquake requirements

7.1 Introduction

It can be impractical and/or uneconomical to plan to perform marine operations in extreme environmental conditions. Consequently, marine operations are generally weather-sensitive, requiring weather windows of minimum duration with specified limits on the metocean parameters during which the marine operations can be performed. Setting the limits too high can lead to unacceptable risk, whereas setting the limits too low can lead to excessive waiting times.

Metocean parameters limiting environmental conditions shall comply with ISO 19901-1. With regards to marine operations, reference shall be made specifically to ISO 19901-1:2005, 5.9, which deals with metocean parameters for short-term activities.

Metocean criteria for marine operations shall provide a realistic evaluation of the sensitivity of a marine operation to meteorological and oceanographic conditions. These criteria are a major step to ensuring the safe execution of a marine operation. The metocean criteria shall be obtained by establishing limiting criteria for the metocean parameters by which the meteorological and oceanographic conditions are characterized. The response characteristics of particular installation vessels to specific aspects of the metocean environment shall be considered when establishing these limiting criteria.

A set of limiting metocean criteria that is dependent on the type and duration of the operation shall be established. Such criteria shall include, but not be limited to,

- wind magnitude and direction,
- wave height and period,
- current magnitude and direction,
- swell magnitude and direction.

Operations can be defined as weather-restricted or weather-unrestricted; see 7.2.

The risk of subjecting a marine operation to an extreme event exceeding the defined metocean criteria varies with location, and regard should be paid to local codes of practice. The meteorological conditions that are specific to particular geographical areas (such as arctic, temperate, tropical and equatorial areas) should be considered. Oceanographic conditions that are swell-dominated or swell-protected and have significant currents due to tide, ocean circulation and local rivers should also be considered.

Appropriate weather policies shall be established and documented to secure a good prospect of personnel survival in the event of evacuation, escape and rescue.

Some consideration to earthquakes is given in 7.8.

7.2 Weather-restricted/weather-unrestricted operations

7.2.1 Weather-restricted operations

A weather-restricted operation is a marine operation that can be completed within the limits of a favourable weather forecast. The reliability of weather forecasts is such that weather-restricted operations should generally be completed within 72 h.

7.2.2 Weather-unrestricted operations

Weather-unrestricted operations can safely take place in any weather condition that can be encountered during a season. The weather condition(s) shall reflect the statistical extremes for the area and season concerned.

7.3 Metocean conditions

7.3.1 Wind

Wind conditions shall be considered in the planning and engineering of marine operations. For the description of the wind parameters, reference is made to ISO 19901-1.

7.3.2 Wave and swell conditions

Wave conditions shall be considered in the planning and engineering of marine operations. For the description of the wave and swell parameters, reference is made to ISO 19901-1.

If swell has a noticeable effect on the operation, the response of the vessel to combined wind-driven seas and swell should be evaluated. In shallow water, lateral surge motions due to shoaling swell and second order wave drift actions should be considered.

For operations involving phases that are sensitive to large or extreme wave heights, such as temporary on-bottom stability, the maximum wave height and associated period should be used.

For precise operations that are sensitive to small fluctuations of the sea level, even under calm sea state conditions, the occurrence of long period, small amplitude swell on the site should be checked.

Attention should also be paid to particular site conditions that are prone to current acting against the waves, which can amplify wave steepness.

7.3.3 Current

7.3.3.1 Current conditions shall be considered in the planning and engineering of marine operations. For the description of the current parameters, reference is made to ISO 19901-1.

For marine operations, data and forecasts should be provided for current speed and direction including, as appropriate, current profiles from the surface to the sea floor.

7.3.3.2 Current can be divided into six different components:

- wind-generated current, which is typically a surface current in the direction of the wind;
- ocean currents (for example the Gulf Stream), which can have homogenous flow down to several hundred metres;
- tidal current, which can also be felt down to a considerable depth below the surface although the velocities normally decrease with depth;
- freshwater outflow (river generated), which is typically a surface current;
- local current phenomena, such as loop (inertial), soliton (internal) and topographical currents;
- bottom currents.

7.3.3.3 To be able to forecast current with the required reliability, the following is normally necessary:

- for sites where tidal current dominates, measurement during at least one complete lunar cycle during the same season of the year as the actual planned operation;
- for sites where the complexity of the bathymetry (topographical current) can generate unstable flow, real-time current measurements with devices that record the current velocity and direction, with readouts at various depths; an example is the shedding of current stream around land obstacles that can introduce macro vortices in the main current flow.

7.3.4 Other metocean factors

Other factors and combinations of factors that can be critical and shall be considered include

- combinations of wind, wave and current;
- water level, including tide and surge;
- restricted visibility;
- sea ice, icebergs, snow and ice accretion on topsides and structure, exceptionally low temperatures;
- tropical cyclones, dust storms and wind squalls;
- water density and salinity;
- precipitation;
- air temperature;
- water temperature.

Additional guidance and recommendations for operations in ice-affected waters for certain geographic areas can be found in Annex B.

7.3.5 Temperature

The occurrence of extreme high and low environmental temperatures shall be considered for their effect on equipment, operations and personnel. Very low or high temperature can adversely affect hydraulic, pneumatic, ballasting and mechanical systems. Changes in operational fluids can be required and auxiliary heating or cooling systems can be necessary. Personnel activities can be affected by temperature.

7.3.6 Marine growth

The effect of marine growth on corrosion, weight, effective diameter and surface roughness shall be considered.

7.4 Metocean criteria

7.4.1 Design and operational criteria

For each specific phase of a marine operation, the design and operational metocean criteria shall be defined as follows.

- The design criteria are that set of values for the metocean parameters (wind, wave, current, water level, visibility, water density, water salinity, water temperature, marine growth and icing), for which design calculations are carried out, and against which the structure and/or operation is checked.
- For the design metocean parameters, the directionality of waves, wind and current shall be considered.
- For weather-unrestricted operations, the operational metocean criteria are the same as the design criteria, although lower values can be set for practical reasons.
- For weather-restricted operations, the operational metocean criteria are that set of values for the metocean parameters (wind, wave, current, water level, visibility, water density, water salinity, water temperature, marine growth and icing), which are not exceeded at the start of the operation and which are forecast not to be exceeded for the duration of the operation, allowing for contingencies.

7.4.2 Return periods

Metocean criteria for marine operations depend on the planned duration of the operation including contingency. Generally, operations with a planned duration of up to three days may be considered as weather-restricted operations for which a specific weather window may be defined, while operations with a planned duration of more than three days should be considered as weather-unrestricted operations. Return periods of the metocean parameters for weather-unrestricted operations may be estimated as a multiple of the operational duration; a minimum 10 times the duration of the operation may be used.

In areas with consistent weather patterns, the duration of a weather-restricted operation may be extended beyond three days, if such an extension can be justified by appropriate documentation.

The choice of return periods should be based on the consequence of failure of the operation. The regional hazard curve of the sea state should also be considered. As general guidance, the periods in Table 2, which are based on North Sea weather conditions, may be applied. Return periods can depend on location.

Table 2 — General guidance for return periods of metocean parameters for weather-unrestricted operations (based on North Sea conditions)

Duration of the operation	Return periods of metocean parameters
Up to 3 days	Specific weather window to be defined
3 days to 1 week	1 year, seasonal
1 week to 1 month	10 year, seasonal
1 month to 1 year	100 year, seasonal
More than 1 year	100 year, all year

7.4.3 Response-based analysis

For critical, long-duration marine activities, or operations in complex offshore environments where wind, sea, swell and currents are all significant, an analysis of the vessel responses should be conducted. Through numerical simulations, statistical estimates of the vessel or component behaviour can be directly characterized. This technique is especially important when more than a single directional parameter can dictate the response and, therefore, the sensitivity of the operation.

7.4.4 Probability distributions of sea state parameters

In order to understand the relationship of sea state parameters, such as the significant wave height and peak period, the uni- and bi-variable distributions should be examined. This includes the joint frequency distributions of significant wave height and period, and wind speed, wave height and current speed versus direction. For those parameters that dictate operability, weather windows should be computed.

7.5 Weather windows

7.5.1 Weather-restricted operations

Weather-restricted operations shall be planned using reliable time history data that indicate not only the probability of not exceeding the limiting criteria but also the persistence of such conditions for the season considered.

In mature areas like the North Sea, this information is normally available, but in other areas it does not always exist or can be difficult to obtain. In some cases, limitations in the availability of data can be compensated for, achieving the same level of confidence, by applying statistical extrapolation methods. The quality of data available can influence the assessment of overall risk.

Consideration shall be given to applying a reduction factor to the limiting criteria in order to account for remaining uncertainties. The reduction factor should be determined as a function of the duration of the operation, the number of data sources and the quality of the available data.

Weather windows should be developed based on thresholds of the key sensitive parameters of the operation. For example, based on known limiting thresholds for wind and wave, the duration statistics for favourable conditions should be computed.

7.5.2 Impact on design

During the design stage of the marine operation, the following shall be considered:

- measures to make the operation more efficient and provide more margin on the weather window;
- redesign of the operation to tolerate higher metocean parameters (higher waves, current and wind conditions);
- possible contingency situations, and back-up and stand-by measures;
- possible delays to previous activities, which can push the operation into an unfavourable season.

7.5.3 Margins on weather

A margin shall be added to the design weather criteria, if these are based on statistical maxima. The margin accounts for inaccuracies in the calculation model and the probability of exceeding the maxima. For precise operations, a margin of 20% on critical parameters is recommended. For other operations, it is a matter of judgement.

7.6 Operational duration

7.6.1 Time schedule

7.6.1.1 For defining the weather window required for a time-critical marine operation, the scheduled plan of the operational duration shall be as realistic as possible.

The window duration shall have necessary margins for

- inaccuracy in operational schedule;
- technical or operational delays;
- uncertainty in the environmental statistics;
- accuracy of the metocean forecast.

7.6.1.2 The forecast window duration shall be in excess of the total critical operational schedule. This should be evaluated against a background of the planned operation and the consequences of exceedance. As a guideline, the following points should be considered:

- extra allowance for operations with vulnerable or critical equipment;
- reduced allowance for operations with a time schedule based on previous similar operations;
- extra allowance for operations in geographical areas and/or seasons where conditions are difficult to predict.

7.6.2 Point of no return

Weather-restricted operations shall be divided into a series of phases where the operation can be aborted and brought to a safe condition within the remainder of the existing weather window. The weather window in which conditions remain below operational criteria shall be of sufficient duration to reach a safe condition before proceeding beyond the point of no return (PNR).

The reliability of the weather window is crucial for the critical period during an operation between any PNR and the structure reaching a safe situation.

7.7 Metocean forecast

7.7.1 General

Forecasts shall be obtained before and during marine operations. The forecast shall be issued at suitable regular intervals dependent on the operation, with the intervals not exceeding 12 h.

For complex and/or long weather-restricted operations, forecaster(s) with local experience shall preferably be present on-site to check the local situation and provide regular weather briefing based on forecasts from two independent sources. This applies to major marine operations such as

- float-over topsides;
- float-out;
- GBS tow out;
- offshore installation and lifting;
- sensitive barge towing.

7.7.2 Forecast parameters

The forecast should cover short- and medium-term and outlook periods, and should include

- synopsis, barometric pressure, temperature;
- wind direction and speed, where the speed should be given for 10 m and 50 m heights above sea level; the wind speed should indicate 1 min and 1 h means and also indicate wind gusts;
- waves and swell, including significant and maximum height, direction and period;
- loop currents and wind squalls;
- visibility, rain, snow, sleet, icing and sea ice;
- confidence level of the forecast.

7.7.3 On-site monitoring

Where operations are sensitive to local (near-site or on-site) environmental conditions or to changes in these, real-time measurement, as well as regular forecast, both prior to start and during operations, shall be considered.

7.8 Earthquake

Possible effects of earthquakes (not metocean effects as tsunamis) on structures during marine operations, if applicable, should be taken into account.

8 Weight control

8.1 Introduction

Weight control should be performed by means of a well defined procedural system, such as that described in ISO 19901-5^[28].

Weight control procedures shall be in operation throughout construction and outfitting when afloat. In the weight control documentation, SI units should be used.

8.2 Weight control classes

In relation to weight control classes, ISO 19901-5^[28] states that

- “Class A weight control shall apply if the project is weight or CoG sensitive for lifting and marine operations or during marine operations (with the addition of temporaries), or has many contractors with which to interface. Projects can also require this high definition if risk gives cause for concern.”
- “Class B weight control shall apply to projects where the focus on weight and CoG is less critical for lifting and marine operations than for projects where Class A is applicable.”
- “Class C weight control shall apply to projects where the requirements for weight and CoG data are not critical.”