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Ships and marine technology — Offshore wind energy — Port and marine operations

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National foreword

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Ships and marine technology — Offshore wind energy — Port and marine operations

*Navires et technologie maritime — Énergie éolienne offshore —
Opérations portuaires et maritimes*



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Foreword

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

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

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

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

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

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*.

Introduction

The series of International Standards applicable to the offshore wind industry, ISO 29400 to ISO 29406¹⁾, constitutes a comprehensive and common basis covering port and marine operations of all offshore structures installed and maintained by the offshore wind industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for offshore wind farm components, whatever the type of structure and the nature or combination of materials used.

This International Standard presumes compliance with international (e.g. IMO), national and local rules and regulations. This International Standard does not replace the applicable rules and regulations. Adherence to this International Standard will not necessarily ensure compliance with all applicable rules and regulations.

It is important to recognize that during port and marine operations the structural integrity of the component 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 structures in offshore wind farms.

The series of International Standards applicable to offshore wind farms 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.

ISO 29400 was developed to provide comprehensive requirements and guidance for the planning, engineering and safe execution of port and marine operations for all types of components of offshore wind farms including cable-laying and -burial barges and diving support vessels but excluding floating structures.

Port operations for installation of components of offshore wind farms cover all component transport to the ports, whether by land or via inland waterways, any intermediate storage as well as preassembly activities at the ports until placing the components close to any quayside for subsequent marine operations to start.

Marine operations for offshore wind farm structures cover loadout from the quayside, offshore transportation and installation phases when the structure is at risk from the marine environment up to and including any marine logistics during offshore commissioning works. Marine operations can extend to decommissioning, redeployment, removal, etc.

ISO 29400 describes the principles of and provides requirements and guidance for port and marine operations associated with WTG, cables and topsides installed in offshore wind farms, from the point of view of planning, engineering, implementation and documentation. Alternative requirements, methods and provisions can fulfil the intention of ISO 29400 and may be applied, provided it can be demonstrated that they achieve at least the same level of assurance and reliability. The overall objective of ISO 29400 is to ensure that port and marine operations are conducted within defined and recognized safety and reliability 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 port and marine operations are performed.

It is not the intent of ISO 29400 to govern the design of structures, systems and components used in port and 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.

This International Standard is based on ISO 19901-6 while adapting it extensively to the specific requirements of the offshore wind industry.

1) Planned International Standards.

Ships and marine technology — Offshore wind energy — Port and marine operations

1 Scope

This International Standard provides comprehensive requirements and guidance for the planning and engineering of port and marine operations, encompassing all documents and works related to such port and marine operations, e.g. the design and analysis of the components, systems, equipment and procedures required to perform port and marine operations, as well as the methods or procedures developed to carry them out safely.

This International Standard is intended to be comprehensive, covering all relevant information related to port and marine operations necessary for the installation and maintenance of offshore wind farms. It is not applicable to the case of floating turbines moored to the seabed.

This International Standard is applicable to port and marine operations for offshore structures including:

- foundations made from steel and concrete gravity base structures (GBS);
- piled steel foundation structures;
- subsea templates and similar structures applied for pre-piling of foundations;
- steel towers, nacelles and blades forming part of the wind turbine generators (WTG);
- mobile offshore units (MOU): jackup vessel/self-elevating offshore unit topsides and components of any of the above for offshore substations or offshore accommodations platforms;
- array cables within the wind farms as well as export cables connecting the wind farm to the grid.

This International Standard is also applicable to modifications of existing structures, e.g. installation of additional modules or exchange of components.

This International Standard is not applicable to the following operations:

- construction activities, e.g. in a fabrication yard onshore, where there is no exposure to the marine environment;
- operational and routine activities during the service life of the windfarm related to the technical maintenance works regularly required for the components;
- diving;
- marine operations related to the operational and routine activities during the service life of the windfarm.

This International Standard presumes compliance with international, national and local rules and regulations. This International Standard does not replace the applicable rules and regulations.

2 Normative references

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

ISO 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*

ISO 19901-1, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations*²⁾

IMCA M 179, *Guidance on the Use of Cable Laid Slings and Grommets*

3 Terms and definitions

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

NOTE Other terms and definitions relevant for the use of this International Standard are also found in [10], [11] and [12].

3.1 action

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

Note 1 to entry: An imposed deformation can be caused by fabrication tolerances, settlement, temperature change or moisture variation.

Note 2 to entry: An earthquake typically generates imposed accelerations.

[SOURCE: ISO 19900:2013, 3.3]

3.2 action effect

effect of actions on structural components

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

[SOURCE: ISO 19904-1:2006, 3.5]

3.3 adverse weather

meteorological and oceanographic conditions which may affect people, equipment or facilities, to such an extent that precautionary measures must be taken to safeguard the facility to maintain a safe system of work

Note 1 to entry: Adverse weather includes, snow, ice, hail, lightning, heavy rain, high wind, low cloud base, poor visibility, severe sea states and strong currents. Weather conditions can change quickly and the effects of short-term variations such as wind gusts must be considered

3.4 air cushion

air pumped into underbase compartments of the structure

Note 1 to entry: An air cushion is normally applied in order to reduce the draught and increase the freeboard and/or to alter the structural loading.

Note 2 to entry: Adapted from ISO 19903:2006, 3.10]

3.5 array cables

all cables between WTGs and between a wind turbine generator (WTG) and the offshore substation (3.100) connecting the WTGs with the offshore substation

2) To be published.

3.6

assembly

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

[SOURCE: ISO 19901-5:2003, 3.1.1]

3.7

ballast

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

Note 1 to entry: Adapted from ISO 19901-5:2003, 3.1.2.

3.8

ballast system

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

3.9

barge

simple floating vessel, normally non-propelled, on which material components of an offshore wind farm, material, people and equipment are transported

3.10

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

[SOURCE: ISO 19900:2013, 3.7]

3.11

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

[SOURCE: ISO 19901-6:2009, 3.9]

3.12

blade

one of a number of structural members with aerodynamic lift surfaces assembled around the hub of a wind turbine

3.13

boat landing

part of the foundation appurtenance to be designed and used for accessing the foundation by means of a sea going vessel

3.14

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 1 to entry: Bollard pull is expressed in kilonewtons.

[SOURCE: ISO 19901-6:2009, 3.10]

3.15

bolting

work to be carried out to join two components of the wind turbine generator (WTG) or between foundation and tower by means of a bolted connection

3.16

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 1 to entry: A bridging document is commonly used to align and coordinate the emergency response procedures for owner and contractors.

[SOURCE: ISO 19901-6:2009, 3.11]

3.17

bumper

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

[SOURCE: ISO 19901-6:2009, 3.12]

3.18

cable burial

process to bury a cable into the seabed up to a defined burial depth which was either previously laid on the seabed or which is directly buried during installation by using specific equipment

3.19

cable laying

all operations related to paying out an array cable ([3.5](#)) or an export cable ([3.47](#)) from a cable lay vessel onto the seabed

Note 1 to entry: For array cables the operations between the 1st-end ([3.21](#)) and 2nd-end pull-in ([3.22](#)) if array cables are not immediately buried.

3.20

cable pull-in

all activities and equipment to be carried out and used to safely pull array cables ([3.5](#)) or export cables ([3.23](#)) through the J-tubes and/or monopiles

3.21

1st end pull-in

pulling the first end of a section of an array cable ([3.5](#)) or export cable ([3.23](#)) into the foundation of a wind turbine generator (WTG) or an offshore substation

3.22

2nd end pull-in

pulling the second end of an array cable ([3.5](#)) or export cable ([3.23](#)) into the foundation of a wind turbine generator (WTG) or an offshore substation

3.23

cable string

several sections of array cables connected in a row and feeding into the offshore substation

3.24

cable testing

tests conducted with either array cables ([3.5](#)) or export cables ([3.47](#)) and, where relevant, also the fibre optics cables in order to verify the functionality of the cables, e.g. after loadout, after cable laying and/or after cable burial and electrical connection

3.25

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 1 to entry: 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.

[SOURCE: ISO 19900:2013, 3.10]

3.26

CoG envelope

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

Note 1 to entry: Adapted from ISO 19901-5:2003, 3.1.8.

[SOURCE: ISO 19901-6:2009, 3.14]

3.27

commissioning

activities after mechanical completion including electrical testing and start-up of wind turbine generators (WTGs), offshore substations, foundations and array and export cables

3.28

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 1 to entry: 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 working stress design (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.

[SOURCE: ISO 19901-6:2009, 3.15]

3.29

construction afloat

addition of material or outfitting to the structure while afloat

Note 1 to entry: Adapted from ISO 19903:2006, 3.17.

[SOURCE: ISO 19901-6:2009, 3.16]

3.30

crane vessel

vessel, ship or barge on which lifting equipment is mounted

Note 1 to entry: For the purposes of this International Standard, this term includes jack-up vessels, crane barges, crane ships, derrick barges, shear-leg barges and semi-submersible crane vessels.

[SOURCE: ISO 19901-6:2009, 3.17]

3.31

cribbing

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

Note 1 to entry: Cribbing is generally arranged at strong points of the deck and/or cargo.

[SOURCE: ISO 19901-6:2009, 3.18]

3.32

currents

flow of water past a fixed location usually described in terms of a current speed and direction

[SOURCE: IEC 61400-3: 2009, 3.2]

3.33

deadweight

total carrying capacity of a floating structure

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

Note 2 to entry: Adapted from ISO 19901-5:2003, 3.1.11.

[SOURCE: ISO 19901-6:2009, 3.19]

3.34

deck mating

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

Note 1 to entry: This operation is normally conducted by ballasting and deballasting of the support structure.

Note 2 to entry: Adapted from: ISO 19903:2006, 3.18.

[SOURCE: ISO 19901-6:2009, 3.20]

3.35

decommissioning

process of shutting down a structure in an offshore wind farm and removing hazardous materials at the end of its production life

Note 1 to entry: Adapted from ISO 19900:2013, 3.14.

3.36

design criterion

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

Note 1 to entry: Adapted from ISO 19900:2013, 3.15.

[SOURCE: ISO 19901-6:2009, 3.22]

3.37

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 1 to entry: Adapted from ISO 19900:2013, 3.17.

[SOURCE: ISO 19901-6:2009, 3.23]

3.38

design value

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

[SOURCE: ISO 19900:2013, 3.18]

3.39

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

[SOURCE: ISO 19901-6:2009, 3.25]

3.40 **displacement**

weight of the volume of water displaced by a floating structure

Note 1 to entry: The weight of the water displaced is the sum of the lightship weight, deadweight and anchoring system load including vertical component of the mooring pre-tension.

Note 2 to entry: Adapted from ISO 19901-5:2003, 3.1.12.

3.41 **dunnage**

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

[SOURCE: ISO 19901-6:2009, 3.27]

3.42 **dynamic action**

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

[SOURCE: ISO 19901-7:2013, 3.8]

3.43 **dynamic amplification factor** **DAF**

ratio of a dynamic action effect to the corresponding static action effect provided as a factor to account for the dynamic effects on a crane while lifting an object — where applicable

Note 1 to entry: An appropriately selected DAF can be applied to static actions to simulate the effects of dynamic actions.

[SOURCE: ISO 19902:2007, 3.16]

3.44 **electrical completion**

all electrical works inside a wind turbine generator (WTG) conducted after finalization of mechanical completion ([3.89](#)) in order to allow for energization of the WTG

3.45 **emergency preparedness bridging document** **EPBD**

document bridging emergency response plans of various parties working at an offshore installation site in order to achieve a mutually aligned procedure in case of emergency

3.46 **exclusive cable zones**

areas within the offshore installation site designated exclusively for the array cables of the wind farm and for the offshore installation works of the cable supplier

3.47 **export cable**

cables connecting an offshore wind farm with the shore via a cable connection between an offshore substation ([3.100](#)) and an onshore substation

3.48 **failure mode and effect analysis** **FMEA**

analysis of possible failures of any component of the safety device and determination of their consequences for the overall safety function; allowing the classification of any failure as safe, dangerous, detected or undetected with respect to the safety function

3.49

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 1 to entry: Each combination of yarn and type of construction normally results in different properties and characteristics.

[SOURCE: ISO 19901-6:2009, 3.30]

3.50

fibre rope grommet

FRG

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

Note 1 to entry: A fibre rope grommet is of similar construction to a steel wire rope grommet ([3.145](#)).

[SOURCE: ISO 19901-6:2009, 3.31]

3.51

fibre rope sling

FRS

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

[SOURCE: ISO 19901-6:2009, 3.32]

3.52

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

[SOURCE: ISO 19901-6:2009, 3.34]

3.53

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

[SOURCE: ISO 19901-6:2009, 3.35]

3.54

float-out

transfer of a floating structure out of a flooded dry dock

[SOURCE: ISO 19901-6:2009, 3.36]

3.55

float-over

transfer of a major assembly supported on barge(s) onto 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

[SOURCE: ISO 19901-6:2009, 3.37]

3.56

foundation

<offshore wind energy> part of an offshore wind turbine support structure which transfers the loads acting on the structure into the seabed

[SOURCE: IEC 61400-3: 2010; 3.11]

EXAMPLE Monopile, jacket structures or gravity based structures.

Note 1 to entry: Different foundation concepts are shown in [Figure 1](#) together with other parts of an offshore wind turbine.

Note 2 to entry: While [Figure 1](#) defines the foundation as the part below the substructure which is in the seabed, the term foundation as used in the offshore wind industry usually refers to the substructure and the foundation (terms as used in [Figure 1](#)). Thus a foundation as usually referred to in the offshore wind industry would be e.g. a monopile or a piled jacket structure. Therefore, when talking about a lift or an installation of e.g. a monopile, this ISO uses the term “foundation” instead of talking about “foundation and substructure” to be lifted.

3.57

good wind industry practice

(in connection with the operation as relevant), design and construction of the works, those practices, methods, acts, techniques and standards which are prudent and in accordance with applicable and generally accepted good practice for the works and in particular for carrying out works of a similar size and complexity as that of the works or operation of offshore wind farms of the similar size and type

3.58

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

[SOURCE: ISO 19901-6:2009, 3.38]

3.59

grommet

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

Note 1 to entry: See also fibre rope grommet ([3.50](#)) and steel wire rope grommet ([3.145](#)).

[SOURCE: ISO 19901-6:2009, 3.39]

3.60

gross weight

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

Note 1 to entry: Sometimes the gross weight is referred to as a not-to-exceed (NTE) weight.

[SOURCE: ISO 19901-6:2009, 3.40]

3.61

grouting

offshore construction process used to connect steel sections of the foundations, e.g. monopile and transitions piece or jacket and piles by using a special concrete type of mixture which is being pumped into the void between the steel structures

3.62

guard vessel

special ship attending the offshore installation site required to maintain a higher degree of readiness in order to enforce the safety zone around an offshore construction site for non-construction vessels

3.63

gust wind speed

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

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

Note 2 to entry: In practice, for design purposes, the gust wind speeds for the different durations (e.g. 3 s, 5 s, 15 s, 60 s) are derived from the wind spectrum.

[SOURCE: ISO 19901-1:2005, 3.8]

3.64

Health, Safety, Security and Environment plan

HSSE plan

plan that includes activities on health, safety, security and environment during planning, design and execution of operations

3.65

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

[SOURCE: ISO 19901-6:2009, 3.41]

3.66

hook load

sum of the rigging weight, including the dynamic amplification factor (DAF), and the nominal lift weight

Note 1 to entry: static hook load is the hook load is the gross weight or NTE weight plus the rigging weight; dynamic hook load is the static hook load times DAF; nominal hook load is maximum allowed weight (including rigging) as per crane chart.

[SOURCE: ISO 19901-6:2009, 3.42]

3.67

hub

part mounted to the nacelle of a wind turbine in order to connect the blades forming the rotor assembly

3.68

indeterminate lift

any lift where the sling forces are not statically determinate

[SOURCE: ISO 19901-6:2009, 3.43]

3.69

intermediate storage

area in the staging port where the components for an offshore wind farm are temporarily stored before pre-assembly ([3.112](#)) and/or loadout onto transport vessels

3.70

jacket

foundation type of an offshore wind farm made of tubular steel members which are usually piled into the seabed

3.71

J-tube

tube being part of the foundation appurtenance designed and to be used for support and protection of the array cables (3.5) or export cable (3.47) from the seabed up to the top of the transition piece or a topside

3.72

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

[SOURCE: ISO 19901-6:2009, 3.44]

3.73

lift point

connection between the rigging and the structure being lifted

Note 1 to entry: Lift points include padears, padeyes and trunnions.

[SOURCE: ISO 19901-6:2009, 3.45]

3.74

lift weight

gross weight times the dynamic amplification factor (DAF)

[SOURCE: ISO 19901-6:2009, 3.46]

3.75

lightship weight

dry and invariable weight of a floating unit

[SOURCE: ISO 19901-6:2009, 3.47]

3.76

limit state

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

[SOURCE: ISO 19900:2013, 3.28]

3.77

link beam

connecting beam between the quay and the barge

Note 1 to entry: The link beam can provide a structural connection, or can solely provide a smooth path for skidding or trailers.

[SOURCE: ISO 19901-6:2009, 3.49]

3.78

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

[SOURCE: ISO 19902:2007, 3.29]

3.79

loadout

transfer of a foundation or, a wind turbine component, cables, a topside module of an offshore substation or any other equipment or components from land onto a barge or vessel by horizontal movement or by lifting

Note 1 to entry: 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 self-propelled modular transporters (SPMT).

Note 2 to entry: Adapted from ISO 19901-5:2003, 3.1.30.

3.80 **location**

one of many areas of an offshore construction site where a foundation with a wind turbine, an offshore substation or offshore accommodation platform will be or is located

3.81 **marine operation**

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

[SOURCE: ISO 19903:2006, 3.36]

3.82 **marine spread**

fleet of vessels assembled to perform a marine operation

[SOURCE: ISO 19901-6:2009, 3.53]

3.83 **Marine Warranty Surveyor** **MWS**

independent expert appointed by the owner on behalf of a construction-all-risk (CAR) insurance company for third party review and approval of the planning, design and execution of the loadout, offshore transport and installation

3.84 **marshalling port**

harbour chosen to perform loadout and start the offshore transport

3.85 **mating**

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

Note 1 to entry: 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 structure foundation: transfer of the barge supported major assembly to a foundation by means of manoeuvring it over the foundation, 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 to entry: Adapted from ISO 19901-5:2003, 3.1.31.

[SOURCE: ISO 19901-6:2009, 3.54]

3.86

maximum wave height

$H_{\max}$

largest of all wave crests to adjacent trough values related to a certain time and area

3.87

mean wave period

T_z

zero-crossing period of a wave

3.88

mean wind speed

average velocity of wind commonly measured by anemometer at a defined height and averaged over a certain time frame

3.89

mechanical completion

stage of the process when the WTG is firmly bolted to the foundation, before in-situ commissioning and prior to commencing power generation

EXAMPLE Connection of ladders, WTG internal cabling, software installation required.

3.90

minimum breaking strength

MBS

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

[SOURCE: ISO 19901-6:2009, 3.55]

3.91

monopile

single pile to be driven into the seabed at foundation whereupon a transition piece is to be installed

3.92

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.

[SOURCE: ISO 19901-6:2009, 3.56]

3.93

nacelle

housing which contains the drive-train and other elements on top of a horizontal axis wind turbine tower

[SOURCE: IEC 61400-3:2010, 3.34]

3.94

nominal value

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

[SOURCE: ISO 19900:2013, 3.29]

3.95

not-to-exceed weight

NTE weight

maximum acceptable weight of the structure, with an associated limiting centre of gravity (CoG) envelope

Note 1 to entry: Adapted from ISO 19901-5:2003, 3.1.34.

[SOURCE: ISO 19901-6:2009, 3.58]

3.96
offload

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

[SOURCE: ISO 19901-6:2009, 3.59]

3.97
offshore accommodation platform

fixed platform located inside an offshore wind farm used for accommodation of personnel during operational phase from which personnel embarks via helicopter, crew transfer vessel or other vessels to the wind turbine generator (WTG) for conducting service and maintenance

3.98
offshore installation site

area where the locations ([3.80](#)) of the foundations for the wind turbine generators (WTGs) and the offshore substation will be installed offshore

3.99
offshore installation vessel

vessel(s) installing the components of an offshore wind farm

EXAMPLE Foundations, transition pieces, towers, nacelles, blades, topsides

3.100
offshore substation

structure in an offshore wind farm which connects the array cables ([3.5](#)) and the export cable ([3.47](#)) and transforms the voltage level between both

3.101
offshore wind farm

offshore site generating electricity from wind energy with the components such as foundations, transition pieces, piles, towers, nacelles, hub, blades, array cables ([3.5](#)) as well as export cable ([3.47](#)) and offshore substation ([3.100](#)) and/or offshore accommodation platform where required

3.102
Offshore Transmission Owner
OFTO

entity which takes responsibility of the assets which usually link offshore generation to the onshore network based on a long-term licence

Note 1 to entry: In terms of physical assets an OFTO will normally have the ownership of (i) offshore electricity transmission infrastructure such as offshore substations, the export cable as well as the onshore cabling, (ii) any onshore substations, and (iii) the electrical equipment relating to the operation thereof.

Note 2 to entry: OFTO differs from owner ([3.106](#)).

3.103
offshore transport

offshore transportation of the components of an offshore wind farm from designated marshalling port or another fabrication yard to the offshore installation site

3.104
offshore type certificate

type certificate for rotor and nacelle assembly in accordance with WT-01 & 61400-1 ed.3 or any other offshore-specific type certificate for other components of an offshore wind farm, such as cranes

3.105
operational duration

planned duration of a port and marine operation, excluding a contingency period

Note 1 to entry: See also weather window ([3.168](#)).

[SOURCE: [57](#)]

3.106

owner

representative of the company or companies which own an offshore wind farm project

EXAMPLE An owner can be wind farm lease and permit holder, developer, employer of contractors which manufacture and install the components of an offshore wind farm and potential operator of the offshore wind farm.

Note 1 to entry: "Owner" differs from "OFTO" ([3.102](#)).

3.107

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

[SOURCE: ISO 19901-6:2009, 3.62]

3.108

padeye

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

[SOURCE: ISO 19901-6:2009, 3.63]

3.109

permit to access

permit issued by the construction management of an offshore wind farm during construction on a daily basis to an offshore installation vessel ([3.99](#)) to allow entry into the safety zone of an offshore installation site in order to conduct its designated works agreed by the construction management

3.110

platform

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

[SOURCE: ISO 19901-6:2009, 3.64]

3.111

point of no return

PNR

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

[SOURCE: ISO 19901-6:2009, 3.65]

3.112

pre-assembly

all stages of the process for the assembly of the wind turbine generator (WTG) components at the staging port including works and parts of the WTG or other required components in order to commence loadout of pre-assembled WTG component

3.113

pre-piling

all activities in relation to installing piles in the seabed where upon a jacket or a similar deep foundation is going to be installed

3.114

recognized organisation

RO

organisation that has been assessed by a flag State, and found to comply with Part 2 of the Code for Recognized Organizations (RO Code) MSC.349(92) and MEPC.237(65)

Note 1 to entry: Adapted from MSC.349(92).

3.115

remote-operated vehicle

ROV

underwater vehicle operated remotely from a surface vessel or installation

[SOURCE: ISO 14723:2009, 4.32]

3.116

representative value

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

[SOURCE: ISO 19900:2013, 3.38]

3.117

reserve buoyancy

contingency buoyancy expressed in percentage of the nominal total intact buoyancy of barges or vessels

[SOURCE: ISO 19901-6:2009, 3.68]

3.118

resistance

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

[SOURCE: ISO 19904-1:2006, 3.32]

3.119

return period

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

Note 1 to entry: 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.

[SOURCE: ISO 19901-1:2005, 3.23]

3.120

rigging

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

[SOURCE: ISO 19901-6:2009, 3.71]

3.121

rigging weight

total weight of rigging, including contingency

[SOURCE: ISO 19901-6:2009, 3.72]

3.122

rotor-nacelle assembly

part of an offshore wind turbine carried by the support structure

Note 1 to entry: See [Figure 1](#) for information.

[SOURCE: IEC 61400-3:2010; [3.35](#)]

3.123

safe haven

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

[SOURCE: ISO 19901-6:2009, 3.73]

3.124

scour protection

materials to place on the seabed to prevent scour from developing around the foundation where the foundation penetrates into the seabed

3.125

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 to entry: The seabed can be considered as the half-space below the sea floor.

Note 2 to entry: Adapted from ISO 19901-4:2003, 3.6.

[SOURCE: ISO 19901-6:2009, 3.74]

3.126

sea fastening

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

Note 1 to entry: Adapted from ISO 19901-5:2003, 3.1.38.

[SOURCE: ISO 19901-6:2009, 3.75]

3.127

sea floor

interface between the sea and the seabed

[SOURCE: ISO 19901-4:2003, 3.5]

3.128

Search And Rescue

SAR

operation to retrieve persons in distress, provide for their initial medical or other needs and deliver them to a place of safety

3.129

section of array cable

length of array cable ([3.5](#)) of a specific cable type between two foundations or a foundation and an offshore substation or between a foundation and an onshore substation

3.130

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

[SOURCE: ISO 19904-1:2006, 3.36]

3.131

significant wave height

H_s

mean wave height (crest to trough) of the one-third highest waves

3.132

site chart

updated map of the offshore installation site showing important information of e.g. all planned locations ([3.80](#)), allowable jack-up positions, jack-up footprints, as as-built/as-laid information, safety zone, positions of all other equipment temporarily anchored in the offshore installation site such as measurement equipment, cardinal buoys, to allow the bridges of all offshore installation vessels and other offshore spreads working in the offshore installation site to have the same information

3.133

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

[SOURCE: ISO 19901-6:2009, 3.78]

3.134

skidshoe

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

[SOURCE: ISO 19901-6:2009, 3.79]

3.135

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

[SOURCE: ISO 19901-6:2009, 3.80]

3.136

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

[SOURCE: ISO 19901-6:2009, 3.81]

3.137

sling eye

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

[SOURCE: ISO 19901-6:2009, 3.82]

3.138

special purpose vessel

mechanically self-propelled vessel which by reason of its function might carry more than 12 special personnel

Note 1 to entry: A special purpose vessel fulfils various roles on offshore wind farms include rock dumping vessel, fall pipe vessel, Unexploded Ordnance (UXO) survey, explosive ordnance disposal, and deployment and operation of bubble curtains for noise mitigation measures.

[SOURCE: See [37] in Bibliography]

3.139

splash zone

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

Note 1 to entry: Refers to the wave-affected zone of the water column surrounding a structure.

[SOURCE: ISO 19901-6:2009, 3.83]

3.140

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

[SOURCE: ISO 19901-6:2009, 3.84]

3.141

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 1 to entry: 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.

[SOURCE: ISO 19901-6:2009, 3.85]

3.142

squat effect

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

[SOURCE: ISO 19901-6:2009, 3.86]

3.143

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 to entry: 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 to entry: See IMCA M 179 for construction and use of cable-laid slings.

[SOURCE: ISO 19901-6:2009, 3.87]

3.144

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 1 to entry: Each combination of material and type of construction normally results in different properties and characteristics.

[SOURCE: ISO 19901-6:2009, 3.88]

3.145

Steel Wire Rope Grommet

SWRG

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

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

Note 2 to entry: A SWRG 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 to entry: See IMCA M 179 for construction and use of SWRG.

[SOURCE: ISO 19901-6:2009, 3.89]

3.146

**Steel Wire Rope Sling
SWRS**

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

Note 1 to entry: Terminations include spliced eyes, Flemish eye with swaged steel sleeve (also known as super loop), spelter sockets, resin sockets, etc.

[SOURCE: ISO 19901-6:2009, 3.90]

3.147

strength

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

[SOURCE: ISO 19902:2007, 3.49]

3.148

structure

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

[SOURCE: ISO 19900:2013, 3.49]

3.149

sub-structure

part of an offshore wind turbine support structure which extends upwards from the seabed and connects the foundation to the tower

Note 1 to entry: See [Figure 1](#).

[SOURCE: IEC 61400-3: 2010; 3.46]

3.150

support structure

part of an offshore wind turbine consisting of the tower, sub-structure and foundation

Note 1 to entry: See [Figure 1](#).

[SOURCE: IEC 61400-3:2010; 3.47]

3.151

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

[SOURCE: ISO 19901-6:2009, 3.93]

3.152

third party

person or body that is recognized as being independent of the parties involved, as concerns the issue in question

3.153

topsides

structures and equipment placed on a supporting foundation such as a tower including nacelle, hub and blades as well as topside for offshore substations or offshore accommodation platforms

Note 1 to entry: For a jack-up, the hull is not part of the topsides.

Note 2 to entry: A separate fabricated deck or module support frame is part of the topsides.

Note 3 to entry: Adapted from ISO 19900:2013, 3.52.

3.154

tow

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

Note 1 to entry: 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.

[SOURCE: ISO 19901-6:2009, 3.95]

3.155

tower

tower constituting the part of a support structure for the wind turbine generator (WTG) between the top flange of the foundation and the bottom flange of the nacelle connecting the sub-structure to the rotor-nacelle assembly

Note 1 to entry: See [Figure 1](#).

[SOURCE: IEC 61400-3]

3.156

trailer

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

[SOURCE: ISO 19901-6:2009, 3.96]

3.157

transport frames

steel structure to support, if required, the onshore transport of the wind turbine generator (WTG) components which will be joined onto the corresponding steel structure at the vessel (i.e. bolting frames or twistlocks) for sea-fastening

3.158

transition piece

part of the foundation connecting the foundation support structure to the wind turbine generator (WTG) tower

3.159

tripod

three-legged offshore foundation, normally fixed by piles to the seabed

3.160

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 1 to entry: 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.

[SOURCE: ISO 19901-6:2009, 3.97]

3.161

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

[SOURCE: ISO 19901-6:2009, 3.98]

3.162

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.

[SOURCE: ISO 19901-6:2009, 3.99]

3.163

verification

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

[SOURCE: ISO 19901-6:2009, 3.100]

3.164

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

[SOURCE: ISO 19901-6:2009, 3.101]

3.165

weather-restricted operation

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

Note 1 to entry: 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.

[SOURCE: ISO 19901-6:2009, 3.102]

3.166

weathertight

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

Note 1 to entry: A watertight closing appliance is also considered weathertight.

[SOURCE: ISO 19901-6:2009, 3.103]

3.167

weather-unrestricted operation

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

Note 1 to entry: The statistical extremes for the area and seasons are considered in the design weather criteria.

[SOURCE: ISO 19901-6:2009, 3.104]

3.168

weather window

operational duration [\[3.105\]](#) including a contingency period determined with due allowance for the nature and criticality of the individual operations (safe to safe) and for which forecast environmental conditions remain below prescribed operational limits

3.169

50/50 weight estimate

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

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

Note 2 to entry: The 50/50 weight estimate is used as the basis for weight budgeting.

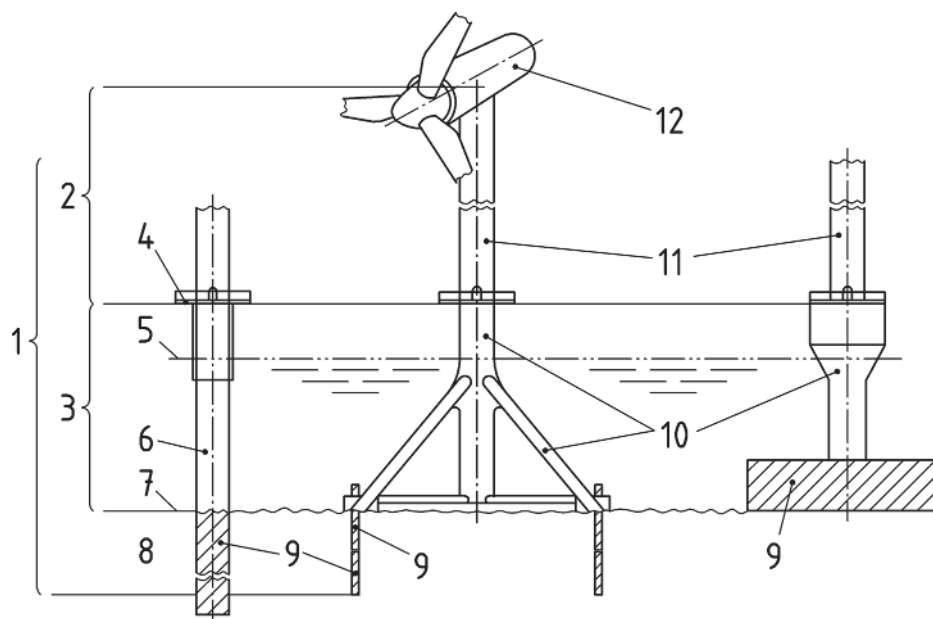
[SOURCE: ISO 19901-5:2003, 3.1.54]

3.170**wind turbine generator — offshore wind turbine generator
WTG**

wind turbine generator forming part of the permanent works, including the tower, local turbine control and monitoring system and electrical system down to and including the switchgear at the base of the wind turbine tower onto which the high voltage sea cable is to be connected

Note 1 to entry: To avoid misinterpretation, the high voltage sea cable is not part of the WTG.

Note 2 to entry: See [Figure 1](#) depicting all parts of an offshore wind turbine.

**Key**

1 support structure	5 water level	9 foundation
2 tower	6 pile	10 sub-structure
3 sub-structure	7 sea floor	11 tower
4 platform	8 seabed	12 rotor-nacelle assembly

Figure 1 — Parts of an offshore wind turbine

[SOURCE: IEC 61400-3:2009, Figure 1]

3.171**working load limit
WLL**

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

[SOURCE: ISO 19901-6:2009, 3.106]

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 4](#) and [5](#))

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 19.6.2) 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 19.6.2) 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 19.6.6) 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 topline 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 19.6.5) 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 19.6.6) 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
$(W_{rlw})_{one\ crane}$	representative lift weight on a lift point for one-hook lifts by one crane
$(W_{rlw})_{two\ cranes}$	representative lift weight on a lift point for lifts by two cranes
W_{rw}	rigging weight
$W_{rw,i}$	rigging weight associated with crane hook i ($i = 1, 2$)
W_s	weight of the sling
$W_{srlw,i}$	statically resolved lift weight for crane hook i ($i = 1, 2$)
$W_{srlw,j}$	statically resolved lift weight acting on lift point j
$W_{srlw,i,j}$	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

ASD/WSD	Allowable Stress Design/Working Stress Design
CMS	Condition Monitoring System
CPT	Cone Penetration Test
EPBD	Emergency preparedness bridging document
EPIRB	Emergency Position Indicating Radio Beacon
GBS	Gravity Base Structure
HAZID	HAZard IDentification study
LRFD	Load and Resistance Factor Design
MOU	Mobile Offshore Unit
NDT	Non-Destructive Test
OWF	Offshore Wind Farm
PMS	Positioning Monitoring System
SCADA	Supervisory Control And Data Acquisition system for the WTGs
SPMT	Self Propelled Modular Transporters
QRA	Quantified Risk Analysis

5 General considerations

5.1 Introduction

5.1.1 General

There are two categories of “port facility” when installing offshore wind farms:

- almost all WTG components, foundations, topsides and cabling are manufactured in facilities adjacent to a loadout quay, and this constitutes the “manufacturer’s port”;

- most often the components are transported to a “marshalling port”, from where they are loaded out onto the installation vessel and taken to the offshore wind farm, but sometimes they are transferred directly from the manufactures to the OWF on board the installation vessel.

In terms of activities at ports there are also two distinct types:

- between the former two types of facility there are vessel operations associated with “transportation” which can be characterized as “Project Cargo Logistics”;
- operations when components leave the marshalling port are associated with “installation” which is a “construction” activity.

Port operations include activities at the staging port in order to prepare the components for loadout as well as any preparations of the port areas for the construction. Such operations can include:

- pre-assembly of components;
- temporary storage;
- positioning components at the quayside for loadout;
- set-up of offices for construction;
- implementation of port security measures;
- offload of components from barge or vessel to shore;
- soil preparation and levelling at the quayside (where required).

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 anchoring and station keeping during construction;
- installation by means of launching or float-off, upending, lowering by ballasting, float-over or lifting;
- cable installation;
- unexploded ordnance survey;
- refuelling offshore substations and temporary generators used on WTG before full energization (if required);
- provisioning of vessels and structures in the offshore wind farm;
- paint repair works;
- scour protection;
- decommissioning and total or partial removal of the structure.

ISO 29400 gives requirements and guidance on the planning and execution of port and marine operations during the temporary phases of port operations, loadout, 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.

General disclaimer to technical requirements on stability, crane and towline stated in these rules: If special purpose vessels are used, they shall follow IMO rules in respect to these requirements. It should also be noted that marine operations in coastal waters can involve more than one nation's area of jurisdiction and that, for barges and ships, while the flag state jurisdiction is primary, additional requirements may be imposed by the coastal or port state.

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 not exceeding the specified operational limits, are forecasted 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.

Special precautions must be adhered to during any jacking operations. Location specific assessment and procedures must be provided by each of the respective offshore installation vessels for each jacking location in a vessel approach plan and reviewed by the marine warranty surveyor before any jacking operations take place. Marine coordination of the owner will issue a site chart to be used by all offshore installation vessels in planning their vessel movements. The approval of the vessel approach plan by the marine warranty surveyor (MWS) is a precondition for obtaining permit to access the location in question.

Each of the respective offshore installation vessels must take full account of the exact locations where vessels have previously jacked and the positions of proposed and/or installed subsea cables.

In case of anchoring, the respective offshore installation vessel must provide detailed anchor plans taking full account of project plan, sub-sea cables etc. for approval by the MWS and the marine coordination of the owner. Actual anchor positions shall be documented by the offshore installation vessel when deployed and again when recovered. Each of the respective offshore installation vessel safety zones must take into account anchor positions.

5.2 Jurisdiction

5.2.1 Introduction

Installation of offshore wind farms and related port 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, while the flag state jurisdiction is primary, additional requirements may be imposed by the coastal or port state.

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 recommended 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 and mandatory codes identified in References [20] to [26], [35] and [40]. 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 [20] to [26] do not apply to domestic voyages. In such cases, national standards offering equivalent levels of safety should be applied.

References [31], [34], [36] to [38], and [41] to [44] 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 [32] to [36].

5.3 HSSE plan

A Health, Safety, Security and Environment (HSSE) plan shall be established. The objectives of the plan shall be:

- to document the HSSE 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;
- to ensure the security of the work site, particularly the port facilities including components and access procedures.

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

Selected issues to be taken up in the HSSE plan 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.

It is good industry practice that no major activity is carried out on a site without an approved method statement. The risk assessment process shall be part of that approval procedure. The risk assessment itself shall be part of any method statement. A mandatory interface shall be defined to ensure that there is extensive and adequate communications with all parties involved including the party responsible for the engineering and design related to installation issues as well as the party responsible for the method statements. As a consequence all design phase documents related to the installation shall be cross referenced in the method statements.

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

Personnel and organisations involved in port and 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

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, safety campaigns and drills, hazard hunts and tool box talks, which can be applied at field supervision level.

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 port contractor as well as the marine contractor for their respective field of work 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 resulting in officially issued permit-to-work documents.

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, hazardous materials transports) or to personnel, and to population and wildlife (e.g. toxicity, explosives, 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. Communication should be agreed to be conducted in a language commonly shared by all key personnel. Supervisors shall possess a thorough knowledge of the entire operation under their control and have prior experience with similar operations. Other key personnel shall have knowledge and experience within their area of responsibility.

Qualification requirements for job categories critical to safe operations shall be specified. Special care and training shall be given to all repetitive offshore operations such as installation of foundations, cable laying and burial, WTG-tower installation as well as nacelle and blade installation. See Reference [46] for regulations on safe manning. Before commencement of an operation, personnel involved shall 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 in form of tool-box talks.

Job-specific training shall 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 components of the offshore wind farm and equipment used for marine operations.

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.

An up-to-date list with information of next of kin should be maintained.

5.8 Incident reporting

During port and marine operations, incident reporting depends on the contract requirements and governmental regulations and is preferable provided with daily progress reports. It can include:

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

Specific requirements on incident reporting, investigation and loss adjusting could apply in case of incidents related to the construction-all-risk insurance (where in place).

5.9 Personnel tracking

A suitable security and tracking system corresponding to the requirements as stated in the HSSE plan where allowed by government regulations/legislation should be in use to:

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

Recording for each individual shall include information such as name, address, telephone number, NOK information, date and expiry of training and health certificates, records of site inductions etc. including facilities to register PPE with inspection intervals;

Each person shall receive his/her personal identification (ID) card which shall always be carried when on the site. Whenever a person is scheduled to go offshore, the database will be checked by construction management to investigate if all training, inductions etc. are in place for the person and fits the task to be performed; The ID card may be used for electronic tracking of personnel movement by presenting the card to a terminal on the vessels when a vessel or installation is boarded or left. In this case the ID and location is automatically recorded in the people tracking system. If the electronic system is not used the system will be kept up to date semi manually by the owner's construction management based on e-mail and voice communication.

Special attention shall be given to the fact that during offshore installation of offshore wind farm multiple installation and commissioning works are likely to take place at various locations simultaneously, e.g. commissioning of foundations, array cables, and mechanical and electrical completion of WTG as well as contractual taking-over between owner's contractors and owners. Due to these works, high traffic via crew transfer vessels, accommodation vessels or helicopters is likely to take place during the construction phase requiring an effective personnel tracking system.

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 port and 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 to govern how the port and 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;
- manufacturing;
- port operations;
- marine operations;
- HSSE management;
- project controls;
- quality management;
- interface management;
- document management.

6.2.2 Operational organization

Separate organization charts shall be drawn up for each port and 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;
- port management;
- towing vessels;
- mooring and anchoring systems;
- marine spread;
- ballast system operation;
- weather forecasting;
- support services;
- marine warranty services;
- certification services;