

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Wind energy generation systems –  
Part 3-1: Design requirements for fixed offshore wind turbines**

**Systèmes de génération d'énergie éolienne –  
Partie 3-1: Exigences de conception des éoliennes en mer fixes**

ITeH STANDARD PREVIEW  
(standards.iteh.ai)

IEC 61400-3-1:2019  
<https://standards.iteh.ai/catalog/standards/sist/4a2c06f-81c5-468f-b966-b104539816a5/iec-61400-3-1-2019>





## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2019 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22.000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67.000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC -

[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22.000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67.000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.



IEC 61400-3-1

Edition 1.0 2019-04

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Wind energy generation systems –  
Part 3-1: Design requirements for fixed offshore wind turbines**

**Systèmes de génération d'énergie éolienne –  
Partie 3-1: Exigences de conception des éoliennes en mer fixes**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 27.180

ISBN 978-2-8322-7609-9

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references .....	10
3 Terms and definitions .....	11
4 Symbols and abbreviated terms.....	19
4.1 Symbols and units.....	19
4.2 Abbreviations.....	20
5 Principal elements.....	21
5.1 General.....	21
5.2 Design methods.....	21
5.3 Safety classes .....	22
5.4 Quality assurance.....	22
5.5 Rotor–nacelle assembly markings.....	23
6 External conditions – definition and assessment.....	23
6.1 General.....	23
6.2 Wind turbine classes.....	24
6.3 Definition of external conditions at an offshore wind turbine site .....	24
6.3.1 General .....	24
6.3.2 Wind conditions .....	25
6.3.3 Marine conditions .....	25
6.3.4 Electrical power network conditions.....	32
6.3.5 Other environmental conditions .....	32
6.4 Assessment of external conditions at an offshore wind turbine site .....	33
6.4.1 General .....	33
6.4.2 The metocean database .....	33
6.4.3 Assessment of wind conditions .....	34
6.4.4 Assessment of marine conditions.....	36
6.4.5 Assessment of other environmental conditions .....	40
6.4.6 Assessment of electrical network conditions .....	41
6.4.7 Assessment of soil conditions.....	41
7 Structural design .....	42
7.1 General.....	42
7.2 Design methodology .....	42
7.3 Loads.....	42
7.3.1 General .....	42
7.3.2 Gravitational and inertial loads .....	42
7.3.3 Aerodynamic loads .....	43
7.3.4 Actuation loads.....	43
7.3.5 Hydrodynamic loads .....	43
7.3.6 Sea/lake ice loads .....	43
7.3.7 Other loads.....	44
7.4 Design situations and load cases.....	44
7.4.1 General .....	44
7.4.2 Power production (DLC 1.1 to 1.6).....	50

7.4.3	Power production plus occurrence of fault or loss of electrical network connection (DLC 2.1 – 2.5).....	51
7.4.4	Start up (DLC 3.1 to 3.3).....	53
7.4.5	Normal shutdown (DLC 4.1 to 4.2).....	54
7.4.6	Emergency stop (DLC 5.1).....	54
7.4.7	Parked (standstill or idling) (DLC 6.1 to 6.4).....	55
7.4.8	Parked plus fault conditions (DLC 7.1 to 7.2).....	56
7.4.9	Transport, assembly, maintenance and repair (DLC 8.1 to 8.4).....	57
7.4.10	Sea/lake ice design load cases.....	60
7.5	Load and load effect calculations.....	61
7.5.1	General.....	61
7.5.2	Relevance of hydrodynamic loads.....	61
7.5.3	Calculation of hydrodynamic loads.....	62
7.5.4	Calculation of sea/lake ice loads.....	62
7.5.5	Overall damping assessment for support structure response evaluations.....	62
7.5.6	Simulation requirements.....	64
7.5.7	Other requirements.....	65
7.6	Ultimate limit state analysis.....	66
7.6.1	Method.....	66
7.6.2	Ultimate strength analysis.....	68
7.6.3	Fatigue failure.....	68
7.6.4	Special partial safety factors.....	69
7.6.5	Assessment of cyclic loading for foundation assessment.....	69
8	Control system.....	69
9	Mechanical systems.....	70
10	Electrical system.....	70
11	Foundation and substructure design.....	70
12	Assembly, installation and erection.....	71
12.1	General.....	71
12.2	Planning.....	72
12.3	Installation conditions.....	72
12.4	Site access.....	72
12.5	Environmental conditions.....	73
12.6	Documentation.....	73
12.7	Receiving, handling and storage.....	73
12.8	Support structure systems.....	73
12.9	Assembly of offshore wind turbine.....	73
12.10	Erection of offshore wind turbine.....	74
12.11	Fasteners and attachments.....	74
12.12	Cranes, hoists and lifting equipment.....	74
13	Commissioning, operation and maintenance.....	74
13.1	General.....	74
13.2	Design requirements for safe operation, inspection and maintenance.....	75
13.3	Instructions concerning commissioning.....	76
13.3.1	General.....	76
13.3.2	Energization.....	76
13.3.3	Commissioning tests.....	76
13.3.4	Records.....	76

13.3.5	Post commissioning activities .....	76
13.4	Operator's instruction manual .....	76
13.4.1	General .....	76
13.4.2	Instructions for operations and maintenance record .....	77
13.4.3	Instructions for unscheduled automatic shutdown .....	77
13.4.4	Instructions for diminished reliability .....	77
13.4.5	Work procedures plan .....	77
13.4.6	Emergency procedures plan .....	78
13.5	Maintenance manual .....	78
Annex A (informative)	Key design parameters for an offshore wind turbine .....	80
A.1	Offshore wind turbine identifiers .....	80
A.1.1	General .....	80
A.1.2	Rotor-nacelle assembly (machine) parameters .....	80
A.1.3	Support structure parameters .....	80
A.1.4	Wind conditions (based on a 10-min reference period and including wind farm wake effects where relevant) .....	80
A.1.5	Marine conditions (based on a 3-hour reference period where relevant) .....	81
A.1.6	Electrical network conditions at turbine .....	81
A.2	Other environmental conditions .....	82
A.3	Limiting conditions for transport, erection and maintenance .....	82
Annex B (informative)	Shallow water hydrodynamics and breaking waves .....	83
B.1	Selection of suitable wave theories .....	83
B.2	Modelling of irregular wave trains .....	84
B.3	Wave height distributions .....	84
B.3.1	General .....	84
B.3.2	The Goda model for maximum wave height .....	84
B.3.3	The Battjes and Groenendijk wave height distribution .....	87
B.3.4	The Forristall wave and crest height distributions .....	90
B.4	Breaking waves .....	92
B.5	Reference documents .....	95
Annex C (informative)	Guidance on calculation of hydrodynamic loads .....	96
C.1	General .....	96
C.2	Morison's equation .....	97
C.3	Diffraction .....	98
C.4	Slap and slam loading .....	99
C.5	Vortex-induced vibrations .....	102
C.5.1	General .....	102
C.5.2	Critical velocities for cross-flow motion .....	103
C.5.3	Critical velocities for in-line motion .....	104
C.6	Appurtenances .....	105
C.6.1	General .....	105
C.6.2	Alternative method for estimating hydrodynamic coefficients accounting for appurtenances and marine growth .....	105
C.7	Calculation methods .....	112
C.7.1	General .....	112
C.7.2	Explicit approach .....	113
C.7.3	Constrained wave approach .....	113
C.8	Reference documents .....	113

Annex D (informative) Recommendations for design of offshore wind turbine support structures with respect to ice loads .....	115
D.1 Introductory remarks .....	115
D.2 General.....	115
D.3 Choice of ice thickness .....	116
D.4 Load cases .....	117
D.4.1 General .....	117
D.4.2 Horizontal load from fast ice cover originating from temperature fluctuations (DLC D1) .....	117
D.4.3 Horizontal load from fast ice cover originating from water level fluctuations and arch effect (DLC D2) .....	118
D.4.4 Horizontal load from moving ice (DLC D3, D4, D7 and D8) .....	118
D.4.5 Vertical load from fast ice cover (DLC D5) .....	122
D.4.6 Pressure from ice ridges (DLC D6) .....	123
D.4.7 Dynamic loading (DLC D3, D4, D7, and D8).....	123
D.5 Requirements on stochastic simulation .....	126
D.6 Requirements on model testing .....	126
D.7 Reference documents .....	127
D.8 Databases for ice conditions .....	129
Annex E (informative) Offshore wind turbine foundation and substructure design.....	130
Annex F (informative) Statistical extrapolation of operational metocean parameters for ultimate strength analysis .....	131
F.1 General.....	131
F.2 Use of IFORM to determine 50-yr significant wave height conditional on mean wind speed.....	131
F.3 Examples of joint distributions of $T$ and $H_s$ and approximations to the environmental contour .....	133
F.4 Choice of sea state duration .....	135
F.5 Determination of the extreme individual wave height to be embedded in SSS .....	135
F.6 Reference documents .....	136
Annex G (informative) Corrosion protection .....	137
G.1 General.....	137
G.2 The marine environment .....	137
G.3 Corrosion protection considerations .....	138
G.4 Corrosion protection systems – Support structures .....	138
G.5 Corrosion protection in the rotor–nacelle assembly .....	139
G.6 Reference documents .....	140
Annex H (informative) Prediction of extreme wave heights during tropical cyclones .....	141
H.1 General.....	141
H.2 Wind field estimation for tropical cyclones.....	141
H.3 Wave estimation for tropical cyclones .....	142
H.4 Reference documents .....	142
H.5 Databases for tropical storms conditions.....	143
Annex I (informative) Recommendations for alignment of safety levels in tropical cyclone regions.....	144
I.1 General.....	144
I.2 Global robustness level criteria .....	144
I.3 Design load cases.....	145
Bibliography.....	147

Figure 1 – Parts of a fixed offshore wind turbine .....	13
Figure 2 – Design process for an offshore wind turbine .....	22
Figure 3 – Definition of water levels .....	30
Figure 4 – The two approaches to calculate the design load effect.....	67
Figure B.1 – Regular wave theory selection diagram.....	83
Figure B.2 – Comparison of wave height distribution results .....	92
Figure C.1 – Breaking wave and cylinder parameters.....	100
Figure C.2 – Oblique inflow parameters .....	101
Figure C.3 – Distribution over height of the maximum impact line force ( $\gamma = 0^\circ$ ) .....	102
Figure C.4 – Response of model and full-scale cylinder in-line and cross-flow .....	104
Figure C.5 – Geometrical definition of blocking and shielding .....	109
Figure C.6 – Influence of a fixed boundary on the drag coefficient on a circular cylinder in oscillatory supercritical flow $KC > 20$ , $Re = 10^5 - 2 \times 10^6$ .....	110
Figure C.7 – Shielding factors.....	111
Figure C.8 – Recommended value for the added mass coefficient $C_m$ of a circular cylinder; influence of a fixed boundary .....	112
Figure D.1 – Ice force coefficients for plastic limit analysis .....	121
Figure D.2 – Ice load history for frequency lock-in conditions.....	125
Figure D.3 – Time history of horizontal force component of ice load acting on a conical structure .....	125
Figure F.1 – Example of the construction of the 50-year environmental contour for a 3- hour sea state duration. ....	132
Table 1 – Conversion between extreme wind speeds of different averaging periods.....	34
Table 2 – Design load cases .....	46
Table 3 – Design load cases for sea/lake ice .....	61
Table B.1 – Constants $h_1$ and $h_2$ and normalised wave heights $h_x$ % as a function of $H_{tr}$ .....	88
Table B.2 – Breaking wave type.....	94
Table I.1 – Additional load cases for tropical cyclone affected regions .....	146

IEC STANDARD PREVIEW  
 (standards.iteh.ai)  
 IEC 61400-3-1:2019  
<https://standards.iteh.ai/catalog/standards/sist/4aa2c08f-8fc5-48bf-b968-bf04539816a5/iec-61400-3-1-2019>



## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**WIND ENERGY GENERATION SYSTEMS –****Part 3-1: Design requirements for fixed offshore wind turbines**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.  
<http://standards.iteh.ai/catalog/standards/sist/6a2c985865-42b6-4968-9a53-6c336c336c33/iec-61400-3-1-2019>
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61400-3-1 has been prepared by IEC technical committee 88: Wind energy generation systems.

This bilingual version (2019-11) corresponds to the monolingual English version, published in 2019-04.

This edition cancels and replaces the first edition of IEC 61400-3 published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the first edition of IEC 61400-3:

- a) Clause 12 has been merged with Clause 6 in order to acknowledge that the design of the wind turbine support structure is generally site specific for offshore projects;

- b) The design load table has been revised to simplify the approach to waves, both for several gust cases with the Normal Sea State, and for a number of cases with the Extreme Sea State. The guidance for load calculations has been altered accordingly;
- c) For load safety factors reference is now made directly to IEC 61400-1;
- d) Clause 8 on the control system has been aligned with the latest updates in IEC 61400-1;
- e) Annex B to edition one on wave spectra has been replaced by a reference to ISO 19901-1;
- f) The annex on ice loading has been revised and updated (now Annex D);
- g) Two informative annexes concerning tropical cyclones have been introduced: Annex H on wave height assessment and Annex I on safety level;
- h) Other parts of the text have been aligned with IEC 61400-1.

This part is to be read in conjunction with IEC 61400-1, *Wind turbines – Part 1: Design requirements*<sup>1</sup>.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
88/708/FDIS	88/712/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61400 series, published under the general title *Wind energy generation systems*, can be found on the IEC website <http://www.iec.ch>.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

<sup>1</sup> Under preparation. Stage at the time of publication: IEC/RFDIS 61400-1:2018.

## INTRODUCTION

This part of IEC 61400 outlines the minimum design requirements for fixed offshore wind turbines and is not intended for use as a complete design specification or instruction manual.

Several different parties may be responsible for undertaking the various elements of the design, manufacture, assembly, installation, erection, commissioning, operation and maintenance of an offshore wind turbine and for ensuring that the requirements of this document are met. The division of responsibility between these parties is a contractual matter and is outside the scope of this document.

Any of the requirements of this document may be altered if it can be suitably demonstrated that the safety of the system is not compromised. Compliance with this document does not relieve any person, organization, or corporation from the responsibility of observing other applicable regulations.

The document is not intended to give requirements for floating offshore wind turbines. For floating installations, reference is made to IEC 61400-3-2.

## **iTeh STANDARD PREVIEW** **(standards.iteh.ai)**

[IEC 61400-3-1:2019](https://standards.iteh.ai/catalog/standards/sist/4aa2c08f-8fc5-48bf-b968-bf04539816a5/iec-61400-3-1-2019)

<https://standards.iteh.ai/catalog/standards/sist/4aa2c08f-8fc5-48bf-b968-bf04539816a5/iec-61400-3-1-2019>

## WIND ENERGY GENERATION SYSTEMS –

### Part 3-1: Design requirements for fixed offshore wind turbines

#### 1 Scope

This part of IEC 61400 specifies additional requirements for assessment of the external conditions at an offshore wind turbine site and specifies essential design requirements to ensure the engineering integrity of fixed offshore wind turbines. Its purpose is to provide an appropriate level of protection against damage from all hazards during the planned lifetime.

This document focuses on the engineering integrity of the structural components of an offshore wind turbine but is also concerned with subsystems such as control and protection mechanisms, internal electrical systems and mechanical systems.

A wind turbine shall be considered as a fixed offshore wind turbine if the support structure is subject to hydrodynamic loading and it is founded on the seabed. The design requirements specified in this document are not sufficient to ensure the engineering integrity of floating offshore wind turbines. For floating installations, reference is made to IEC 61400-3-2. In the remainder of this document, the term “offshore wind turbine” is assumed to refer to those that are fixed to the seabed.

This document should be used together with the appropriate IEC and ISO standards mentioned in Clause 2. In particular, this document is fully consistent with the requirements of IEC 61400-1. The safety level of the offshore wind turbine designed according to this document shall be at or exceed the level inherent in IEC 61400-1. In some clauses, where a comprehensive statement of requirements aids clarity, replication of text from IEC 61400-1 is included.

#### 2 Normative references

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

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 61400-1:2018, *Wind energy generation systems – Part 1: Design requirements*<sup>2</sup>

ISO 2394:1998, *General principles on reliability for structures*

ISO 2533:1975, *Standard Atmosphere*

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

ISO 19901-1:2015, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 1: Metocean design and operating conditions*

---

<sup>2</sup> Under preparation. Stage at the time of publication: IEC/RFDIS 61400-1:2018.

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

ISO 19902:2007, *Petroleum and natural gas industries – Fixed steel offshore structures*

ISO 19903:2006, *Petroleum and natural gas industries – Fixed concrete offshore structures*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61400-1 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1

##### **air gap**

clearance between the highest water surface that occurs during the extreme environmental conditions and the lowest exposed part not designed to withstand wave impingement

#### 3.2

##### **arch effect**

action of an arch ice (or its collapse) upon a substructure

#### 3.3

##### **arch ice**

ice build-up between substructures or between a substructure and shore that has an arch shape and eventually collapses

#### 3.4

##### **co-directional**

acting in the same direction

#### 3.5

##### **current**

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

#### 3.6

##### **diffraction**

phenomenon that describes the bending of waves around obstacles and spreading of waves past openings

#### 3.7

##### **design wave**

deterministic wave with a defined height, period and direction, used for the design of an offshore structure

Note 1 to entry: A design wave may be accompanied by a requirement for the use of a particular periodic wave theory.

#### 3.8

##### **designer**

party or parties responsible for the design of an offshore wind turbine

**3.9  
environmental conditions**

characteristics of the environment (wind, waves, sea currents, water level, sea/lake ice, marine growth, scour and overall seabed movement, etc.) which may affect the wind turbine behaviour

**3.10  
external conditions**

external factors affecting operation of an offshore wind turbine, including the environmental conditions, the electrical network conditions, and other climatic factors (temperature, snow, ice, etc.)

**3.11  
extreme significant wave height**

significant wave height of the sea state over the reference period with an annual probability of exceedance of  $1/N$  ("return period":  $N$  years), extrapolated from the extreme distribution of significant wave height at the site

**3.12  
extreme wave height**

individual wave height (generally the zero up-crossing wave height) with an annual probability of exceedance of  $1/N$  ("return period":  $N$  years)

**3.13  
fast ice cover**

rigid continuous cover of ice not in motion

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

**3.14  
fetch**

distance over which the wind blows over the sea with approximately constant wind speed and direction

IEC 61400-3-1:2019  
<https://standards.iteh.ai/catalog/standards/iec/61400-3-1-2019>  
b104539816a5/iec-61400-3-1-2019

**3.15  
fixed offshore wind turbine**

wind turbine with a sub-structure that is subject to hydrodynamic loading and is founded on the seabed

**3.16  
floating offshore wind turbine**

wind turbine with a sub-structure that is subject to hydrodynamic loading and is supported by buoyancy and a station-keeping system

**3.17  
foundation**

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

Note 1 to entry: Different foundation concepts are shown in Figure 1 together with the other parts of an offshore wind turbine support structure.

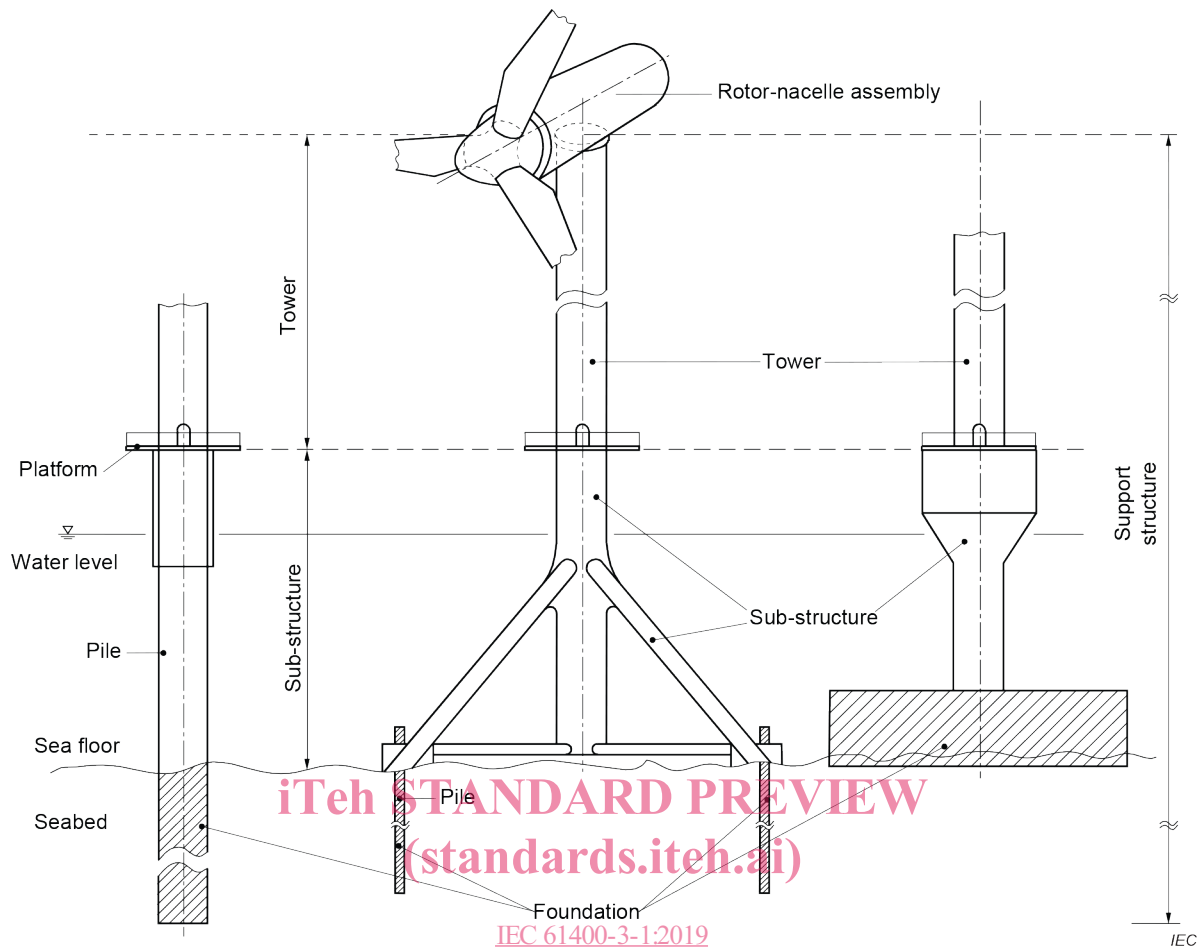


Figure 1 – Parts of a fixed offshore wind turbine

### 3.18 highest astronomical tide

highest still water level that can be expected to occur under any combination of astronomical conditions and under average meteorological conditions

Note 1 to entry: Storm surges, which are meteorologically generated and essentially irregular, are superimposed on the tidal variations, so that a total still water level above highest astronomical tide may occur.

### 3.19 hindcasting

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

### 3.20 hub height

height of the centre of the swept area of the wind turbine rotor above the mean sea level

### 3.21 hummocked ice

crushed ice and ice floes piled up into ridges when large ice floes meet with each other or with a rigid obstacle, for example an offshore wind turbine support structure

### 3.22 ice floe

sheet of ice in size from metres to several kilometres, not rigidly frozen to a shore, still or in motion