IEC TS 61400-3-2

Edition 1.0 2019-04

TECHNICAL SPECIFICATION

colour inside

Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines

IEC TS 61400-3-2:2019-04(en)

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

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.

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

Tel.: +41 22 919 02 11
info@iec.ch
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - 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 It also gives information on projects, replaced and withdrawn publications.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
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions 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
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.

IEC Customer Service Centre - 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.

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

IEC TS 61400-3-2

Edition 1.0 2019-04

TECHNICAL SPECIFICATION

colour inside

Wind energy generation systems –
Part 3-2: Design requirements for floating offshore wind turbines

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.180

ISBN 978-2-8322-5986-3

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

CONTENTS

FOREWORD 5
INTRODUCTION 7
1 Scope 8
2 Normative references 8
3 Terms and definitions 9
4 Symbols and abbreviated terms 12
4.1 Symbols and units 12
4.2 Abbreviations 12
5 Principal elements 12
5.2 Design methods 12
5.6 Support structure markings 14
6 External conditions – definition and assessment 14
6.1 General 14
6.1.2 Wind conditions 14
6.3.3 Marine conditions 14
6.3.5 Other environmental conditions 15
7 Structural design 15
7.1 General 15
7.3 Loads 15
7.3.2 Gravitational and inertial loads 15
7.3.3 Aerodynamic loads 15
7.3.5 Hydrodynamic loads 15
7.3.6 Sea/lake ice loads 15
7.3.7 Other loads 16
7.4 Design situations and load cases 16
7.5 Load and load effect calculations 18
7.5.1 General 18
7.5.2 Relevance of hydrodynamic loads 18
7.5.3 Calculation of hydrodynamic loads 18
7.5.4 Calculation of sea/lake ice loads 19
7.5.6 Simulation requirements 19
7.5.7 Other requirements 21
7.6 Ultimate limit state analysis 21
7.6.1 General 21
7.6.3 Fatigue failure 22
7.6.6 Working stress design method 22
7.6.7 Serviceability analysis 23
8 Control system 23
9 Mechanical systems 24
10 Electrical systems 24
11 Foundation and substructure design 24
12 Assembly, installation and erection 24
12.1 General 24
12.2 General 24
12.3 Planning 25

AVA Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

12.13 Floating specific items ... 25
13 Commissioning, operation and maintenance ... 25
13.1 General ... 25
13.3 Instructions concerning commissioning ... 25
13.4 Operator's instruction manual ... 25
13.4.1 General ... 25
13.4.6 Emergency procedures plan ... 25
13.5 Maintenance manual ... 25
14 Stationkeeping systems ... 25
15 Floating stability ... 26
15.1 General ... 26
15.2 Intact static stability criteria ... 26
15.3 Alternative intact stability criteria based on dynamic-response ... 26
15.4 Damage stability criteria ... 26
16 Materials ... 27
17 Marine support systems ... 27
17.1 General ... 27
17.2 Bilge system ... 27
17.3 Ballast system ... 27
Annex A (informative) Key design parameters for a floating offshore wind turbine ... 28
A.1 Floating offshore wind turbine identifiers ... 28
A.1.1 General ... 28
A.1.2 Rotor nacelle assembly (machine) parameters ... 28
A.1.3 Support structure parameters ... 28
A.1.4 Wind conditions (based on a 10-min reference period and including wind farm wake effects where relevant) ... 29
A.1.5 Marine conditions (based on a 3-hour reference period where relevant) ... 29
A.1.6 Electrical network conditions at turbine ... 30
A.2 Other environmental conditions ... 30
A.3 Limiting conditions for transport, installation and maintenance ... 31
Annex B (informative) Shallow water hydrodynamics and breaking waves ... 32
Annex C (informative) Guidance on calculation of hydrodynamic loads ... 33
Annex D (informative) Recommendations for design of floating offshore wind turbine support structures with respect to ice loads ... 34
Annex E (informative) Floating offshore wind turbine foundation and substructure design ... 35
Annex F (informative) Statistical extrapolation of operational metocean parameters for ultimate strength analysis ... 36
Annex G (informative) Corrosion protection ... 37
Annex H (informative) Prediction of extreme wave heights during tropical cyclones ... 38
Annex I (informative) Recommendations for alignment of safety levels in tropical cyclone regions ... 39
Annex J (informative) Earthquakes ... 40
Annex K (informative) Model tests ... 41
Annex L (informative) Tsunamis ... 43
L.1 General ... 43
L.2 Numerical model of tsunami [3],[4] ... 43

AVA Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019

L.3 Evaluation of variance of water surface elevation and current velocity [5] 45
L.4 Reference documents 46
Annex M (informative) Non-redundant stationkeeping system 47
Annex N (informative) Differing limit state methods in wind and offshore standards 48
Annex O (informative) Application of non-standard duration extreme operating gusts 50
Bibliography.....51

Figure 1 – Parts of a floating offshore wind turbine (FOWT).....11
Figure 2 – Design process for a floating offshore wind turbine (FOWT).....13
Figure L.1 – The calculated result of Equation (L.8).....45

Table 2 – FOWT specific design load cases.....17
Table 4 – Safety factor for yield stress.....23
Table N.1 – Mapping of limit states and load cases in ISO 19904-1, Table 4 and load cases from IEC TS 61400-3-2.....49

Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –

Part 3-2: Design requirements for floating 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.
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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

Technical Specification IEC TS 61400-3-2 has been prepared by IEC technical committee 88: Wind energy generation systems.

This part is to be read in conjunction with IEC 61400-1:2019, *Wind energy generation systems – Part 1: Design requirements* and IEC 61400-3-1:2019, *Wind energy generation systems – Part 3-1: Design requirements for fixed offshore wind turbines*.

AVA Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

From Clause 2 forward, this document does not replicate text from IEC 61400-1 and IEC 61400-3-1; instead, the section headings (including numbering) and text from IEC 61400-3-1 apply to this document except where noted. Exceptions include additions, deletions, or changes in requirements for FOWT relative to fixed offshore wind turbines. New clauses, subclauses, annexes, equations, tables, and terms and definitions in this document are numbered sequentially following the last corresponding number from IEC 61400-3-1.

The text of this technical specification is based on the following documents:

DTS	Report on voting
88/649/DTS	88/673/RVDTS

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

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

A list of all parts of IEC 61400 series, published under the general title *Wind energy generation systems*, can be found on the IEC website.

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.

A bilingual version of this publication may be issued at a later date.

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.

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

INTRODUCTION

This part of IEC 61400 outlines minimum design requirements for floating offshore wind turbines (FOWT) 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.

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

WIND ENERGY GENERATION SYSTEMS –

Part 3-2: Design requirements for floating offshore wind turbines

1 Scope

This part of IEC 61400, which is a technical specification, specifies additional requirements for assessment of the external conditions at a floating offshore wind turbine (FOWT) site and specifies essential design requirements to ensure the engineering integrity of FOWTs. 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 a FOWT but is also concerned with subsystems such as control and protection mechanisms, internal electrical systems and mechanical systems.

A wind turbine is considered as a FOWT if the floating substructure is subject to hydrodynamic loading and supported by buoyancy and a station-keeping system. A FOWT encompasses five principal subsystems: the RNA, the tower, the floating substructure, the station-keeping system and the on-board machinery, equipment and systems that are not part of the RNA.

The following types of floating substructures are explicitly considered within the context of this document:

a) ship-shaped structures and barges,

b) semi-submersibles (Semi),

c) spar buoys (Spar),

d) tension-leg platforms/buoys (TLP / TLB).

In addition to the structural types listed above, this document generally covers other floating platforms intended to support wind turbines. These other structures can have a great range of variability in geometry and structural forms and, therefore, can be only partly covered by the requirements of this document. In other cases, specific requirements stated in this document can be found not to apply to all or part of a structure under design. In all the above cases, conformity with this document will require that the design is based upon its underpinning principles and achieves a level of safety equivalent, or superior, to the level implicit in it.

This document is applicable to unmanned floating structures with one single horizontal axis turbine. Additional considerations might be needed for multi-turbine units on a single floating substructure, vertical-axis wind turbines, or combined wind/wave energy systems.

This document is to be used together with the appropriate IEC and ISO standards mentioned in Clause 2. In particular, this document is intended to be fully consistent with the requirements of IEC 61400-1 and IEC 61400-3-1. The safety level of the FOWT designed according to this document is to be at or exceed the level inherent in IEC 61400-1 and IEC 61400-3-1.

2 Normative references

Replacement of Clause 2 of IEC 61400-3-1:2019.

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

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 61400-1:2019, *Wind energy generation systems – Part 1: Design requirements*

IEC 61400-3-1:2019, *Wind energy generation systems – Part 3-1: Design requirements for fixed offshore wind turbines*

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

ISO 19901-4:2016, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 4: Geotechnical and foundation design considerations*

ISO 19901-6:2009, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 6: Marine operations*

ISO 19901-7:2013, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

ISO 19904-1:2006, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Monohulls, semisubmersibles and spars*

ISO 19906:2010, *Petroleum and natural gas industries – Arctic offshore structures*

IMO Resolution MSC.267(85), *International Code on Intact Stability*, 2008 (2008 IS CODE)

API RP 2FPS: 2011, *Recommended Practice for Planning, Designing, and Constructing Floating Production Systems*

API RP 2T (R2015): 2010, *Recommended Practice for Planning, Designing, and Constructing Tension Leg Platforms*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply in addition to, or replacing, those stated in IEC 61400-1 and IEC 61400-3-1.

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

3.54
splash zone
external region of the FOWT support structure that is frequently wetted due to waves, tidal variations and floating substructure motions

Documents
Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

Note 1 to entry: To define upper and lower limits of the splash zone, the following parameters shall be superimposed where applicable to the specific FOWT support structure type:

- the highest still water level with a return period of 1 year increased by the crest height of a wave with height equal to the significant wave height with a return period of 1 year,
- the lowest still water level with a return period of 1 year reduced by the trough depth of a wave with height equal to the significant wave height with a return period of 1 year,
- draft variation, and
- vertical motions (heave, roll, pitch) of the floating substructure.

Note 2 to entry: While splash zone is not explicitly mentioned in this document, the definition given in this document replaces the definition found in IEC 61400-3-1, which affects the interpretation of IEC 61400-3-1 for FOWT.

3.58
support structure
part of a FOWT consisting of the tower, floating substructure, and stationkeeping system

Note 1 to entry: Refer to Figure 1.

3.79
anchor
device attached to the end of the mooring line or tendon and partially or fully buried in the seabed to limit the movement of the mooring line or tendon and to transfer loads to the seabed

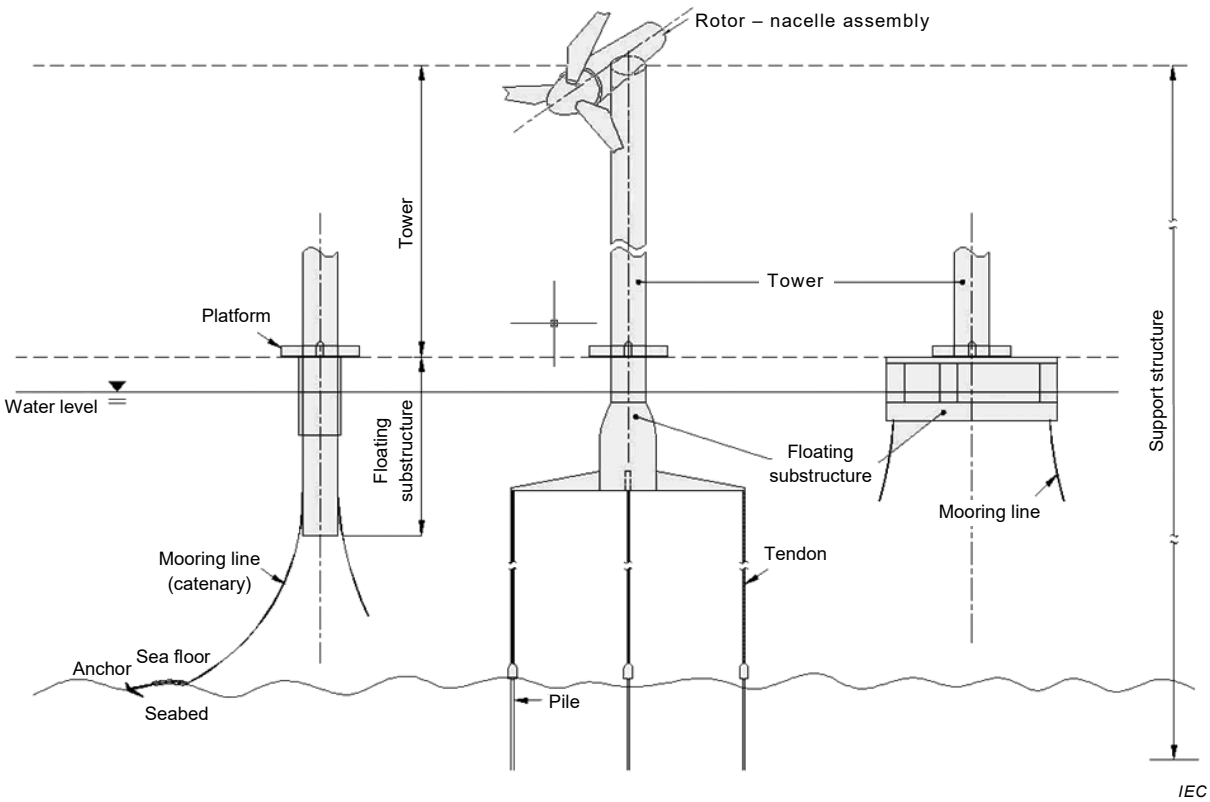
Note 1 to entry: Available options for anchoring floating structures include drag anchors, anchor piles (driven, jetted, suction, torpedo/gravity-embedded and drilled and grouted), and other anchor types such as gravity anchors and plate anchors.

3.80
catenary mooring
mooring system where the restoring action is provided by the distributed weight of mooring lines

3.81
floating substructure
part of a FOWT support structure that floats above the sea floor, connects to the tower and station-keeping system, and consists of a buoyant structure for supporting operational loads.

Note 1 to entry: A floating substructure can also be referred to as a hull. Different floating substructure concepts are shown in Figure 1 together with the other parts of an offshore wind turbine.

Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019



From left to right: Spar, TLP, and Semi.

Figure 1 – Parts of a floating offshore wind turbine (FOWT)

3.82
mooring system
passive type of station-keeping system that typically comprises mooring lines, anchors, connectors and hardware and may include other components such as buoys, clamped weights, turrets, disconnecting system, etc.

3.83
recognized classification society
member of the International Association of Classification Societies (IACS), with recognized and relevant competence and experience in floating structures

3.84
redundancy check
design situation where a FOWT has reached a new position after one mooring line or tendon has broken and is now held in position by the remaining mooring lines or tendons

3.85
scantling
sizing of plates, girders and stiffeners of floating substructures

3.86
station-keeping system
system capable of limiting the excursions and/or accelerations of the FOWT within prescribed limits and maintaining the intended orientation

Note 1 to entry: A station-keeping system may differ from a mooring system in the case of active thrusters, tendons, etc.

Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019

3.87
taut-line mooring
mooring system where the restoring action is provided by elastic deformation of mooring lines

3.88
tendon
collection of components of a station-keeping system that forms a vertical link between the TLP-type floating substructure and the foundation on and beneath the sea floor for the purpose of providing station-keeping and floating stability to FOWTs

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply in addition to those stated in IEC 61400-1 and IEC 61400-3-1:

4.1 Symbols and units

$f_{\text{low frequency}}$	upper end of low-frequency range	[Hz]
L_k	velocity component integral scale parameter	[m]
$S.F.$	safety factor	[-]
$\sigma_{\text{allowable}}$	allowable stress	[N/mm^2 or MPa]
σ_{buckling}	allowable buckling stress	[N/mm^2 or MPa]
σ_{cr}	critical compressive buckling stress or shear buckling stress	[N/mm^2 or MPa]
σ_{y}	specified minimum yield strength	[N/mm^2 or MPa]

4.2 Abbreviations

For the purposes of this document, the following abbreviated terms apply in addition to those stated in IEC 61400-1 and IEC 61400-3-1:

FOWT	floating offshore wind turbine
IACS	international association of classification societies
IMO	international maritime organization
RCS	recognized classification society
TLB	tension-leg buoy
TLP	tension-leg platform
WSD	working stress design

5 Principal elements

5.2 Design methods

The design methodology summarized in IEC 61400-3-1:2019, Subclause 5.2, is basically able to be applied to FOWT, with the following modifications, illustrated in Figure 2.

The design of the FOWT support structure shall include the design of the station-keeping system per Clause 14 and consider floating stability per Clause 15.

Due to the additional compliance of the station-keeping system of FOWTs relative to fixed offshore wind turbines and the changed dynamic response (including couplings to the RNA), it may be less likely that an RNA initially designed as a standard wind turbine class as defined in IEC 61400-1:2019, Subclause 6.2, is suitable for use in a FOWT.

AVA Documents
Document Sharing Hub

It is necessary to demonstrate that the FOWT support structure and the site-specific offshore conditions do not compromise the RNA structural integrity. The demonstration shall comprise a comparison of loads and deflections calculated for the specific FOWT support-structure and the specific site conditions with those calculated during the initial RNA design.

The potentially increased dynamic response of FOWT relative to fixed offshore wind turbines also has implications for the design of the control and protection system (see Clause 8), mechanical systems (see Clause 9), and tower.

In lieu of testing described in IEC 61400-3-1, data from model-scale testing may be used to increase confidence in predicted design values and to verify structural-dynamics models and design situations (see Annex K).

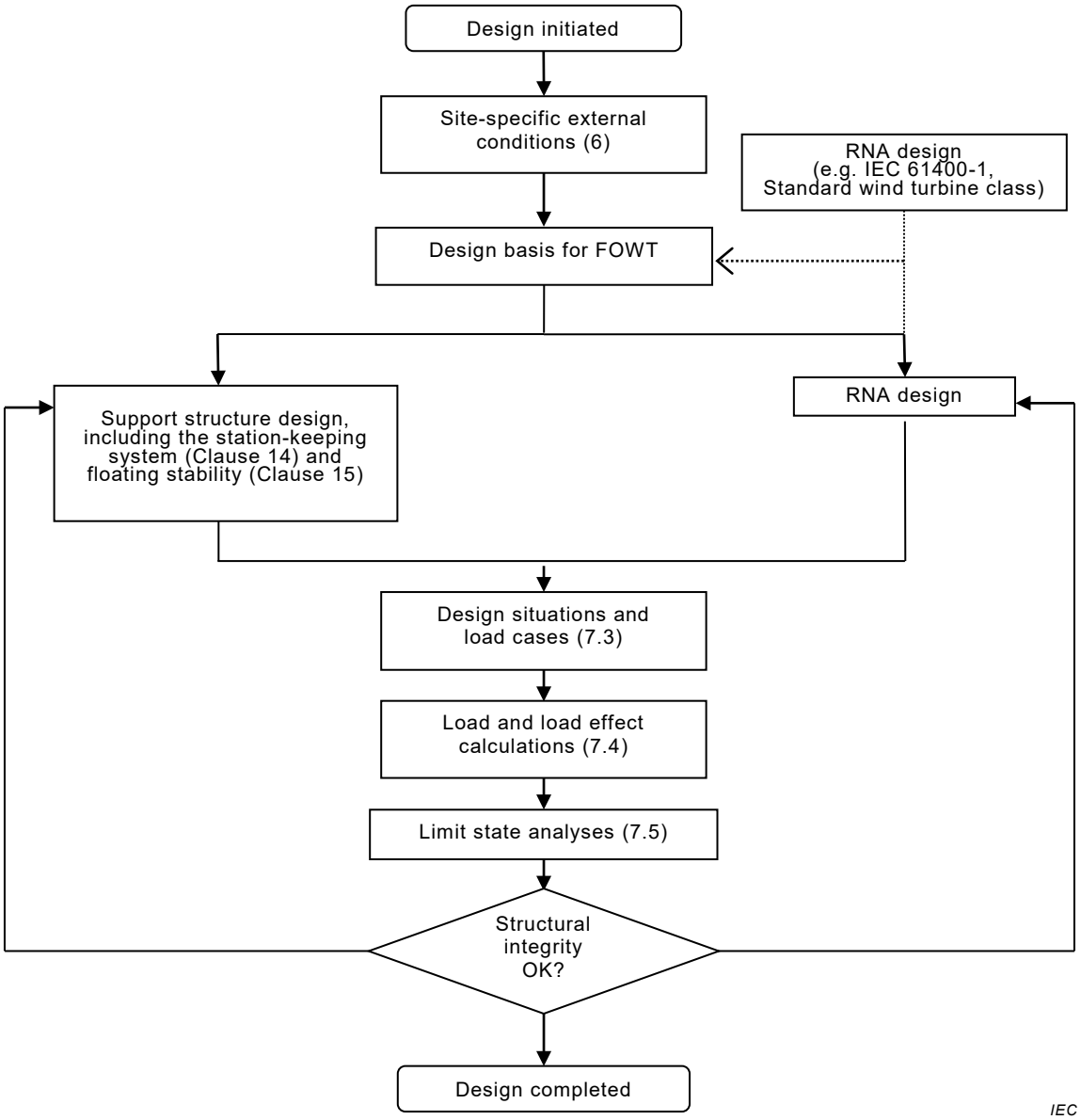


Figure 2 – Design process for a floating offshore wind turbine (FOWT)

Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019

5.6 Support structure markings

The following information, as a minimum, shall be prominently and legibly displayed on the indelibly marked FOWT support structure (including floating substructure) nameplate:

- model and serial number;
- production year;
- displacement;
- draft marking (combined load line markings for operating in sea operation);
- company and registered owner identification;
- manufacturer and country;
- owner;

6 External conditions – definition and assessment

6.1 General

6.1.1 In addition to IEC 61400-3-1, the external conditions described in this clause shall be considered in the design of a FOWT. The external conditions defined in IEC 61400-3-1:2019, Clause 6 can basically be applied, but due to the FOWT support structure being a floating system, some additional aspects regarding wind, wave and other external conditions have to be considered.

6.1.2 Wind conditions

It shall be ensured that the representation of the wind in the low-frequency range is adequate. This includes, but is not limited to, an adequate representation of power spectral density in the low-frequency range as well as adequate models for representation of gust events. In particular, this affects the extreme operating gust (EOG) as defined in IEC 61400-1:2019, Subclause 6.3.2.2.

The upper end of the low-frequency range (in Hz) is indicated by the frequency

$$f_{\text{low frequency}} = \frac{V_{\text{hub}}}{6L_{\text{k}}} \tag{23}$$

where V_{hub} is the wind speed (in m/s) at hub height averaged over 10 min and L_{k} is the velocity component integral scale parameter (in m), defined in IEC 61400-1:2019, Annex B. A turbulence model often applicable at low frequencies is described in ISO 19901-1:2015, Clause A.7.4.

Gust event durations for EOG, EDC, ECD defined in IEC 61400-1:2019-–, Subclause 6.3.2, may be inadequate for FOWT design due to possible FOWT motion natural frequencies that are considerably lower than for fixed systems and shall be evaluated, if relevant. For methods to address longer EOG periods (see Annex O).

6.3.3 Marine conditions

The loading and response of the floating substructure is typically more driven by waves than by wind; care should be taken when the combined wind and wave input to the load simulations is defined in order not to disregard important sea states.[1]

[1] For fixed offshore wind turbines, the waves are often taken dependent on the wind speed; this may be insufficient for FOWTs.

AVA Documents Document Sharing Hub

Full document details: IEC TS 61400-3-2-2019

Swells can be of importance in conjunction with low-frequency responses of FOWTs. Wind-wave misalignment cases leading to bi-directional wave loading may require specific attention for FOWTs and shall be taken into account. This may be particularly important for load cases driving tower-base fatigue.

6.3.5 Other environmental conditions

Specific attention should be paid to the assessment of the seismic analysis in the case of TLP/TLB-type floating substructures (see Annex J).

7 Structural design

7.1 General

The FOWT shall be designed in accordance with this clause. Additional requirements relevant to the design of floating substructures shall follow ISO 19904-1.

The station-keeping system shall be designed as per Clause 14.

7.3 Loads

7.3.2 Gravitational and inertial loads

IEC 61400-3-1:2019, Subclause 7.3.2 is generally applicable. Inertial loads, including gyroscopic loads, are of special importance to FOWTs due to their potentially additional compliance and increased dynamic response from aerodynamic and hydrodynamic loading.

7.3.3 Aerodynamic loads

IEC 61400-3-1:2019, Subclause 7.3.3 is generally applicable. The aerodynamic interaction between the airflow and the FOWT is of special importance due to their additional compliance and increased dynamic response. The interaction of potentially large translational and rotational motions of the floating substructure with the aerodynamic loading of the RNA and tower shall be considered, including aeroelastic effects and the associated global and local dynamic and unsteady aerodynamic effects (e.g. dynamic inflow, oblique inflow, skewed wake, unsteady airfoil aerodynamics including dynamic stall, blade-vortex interaction). Wind loads on the floating substructure shall also be considered, where relevant.

7.3.5 Hydrodynamic loads

Air gap should have a minimum value of 1,5 m. The air gap shall be determined by appropriate model tests and/or calculated using detailed global performance analyses that account for relative motions between the floating substructure and waves. When assessing the air gap requirement, consideration shall be given to the effect of wave run-up and motions of the floating substructure. The wave run-up is principally affected by the geometry of the structure, wave height, and wave steepness and is typically determined through model tests. Local wave crest elevation shall be taken into account as appropriate, refer to API RP 2FPS. As a minimum, the requirement of air gap shall be checked for the DLCs associated with extreme storms with a return period of 50 years.

Additionally, to IEC 61400-3-1, strength for wave impact load including slamming, sloshing and green water in accordance with ISO 19904-1 shall be assessed.

7.3.6 Sea/lake ice loads

Annex D of IEC 61400-3-1:2019 does not apply to FOWTs. See Annex D.

Documents
Document Sharing Hub
Full document details: IEC TS 61400-3-2-2019