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Edition 1.0 2019-04

TECHNICAL SPECIFICATION

colour inside

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

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WIND ENERGY GENERATION SYSTEMS –

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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*.

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- withdrawn,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.

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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.

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.

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.

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

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.

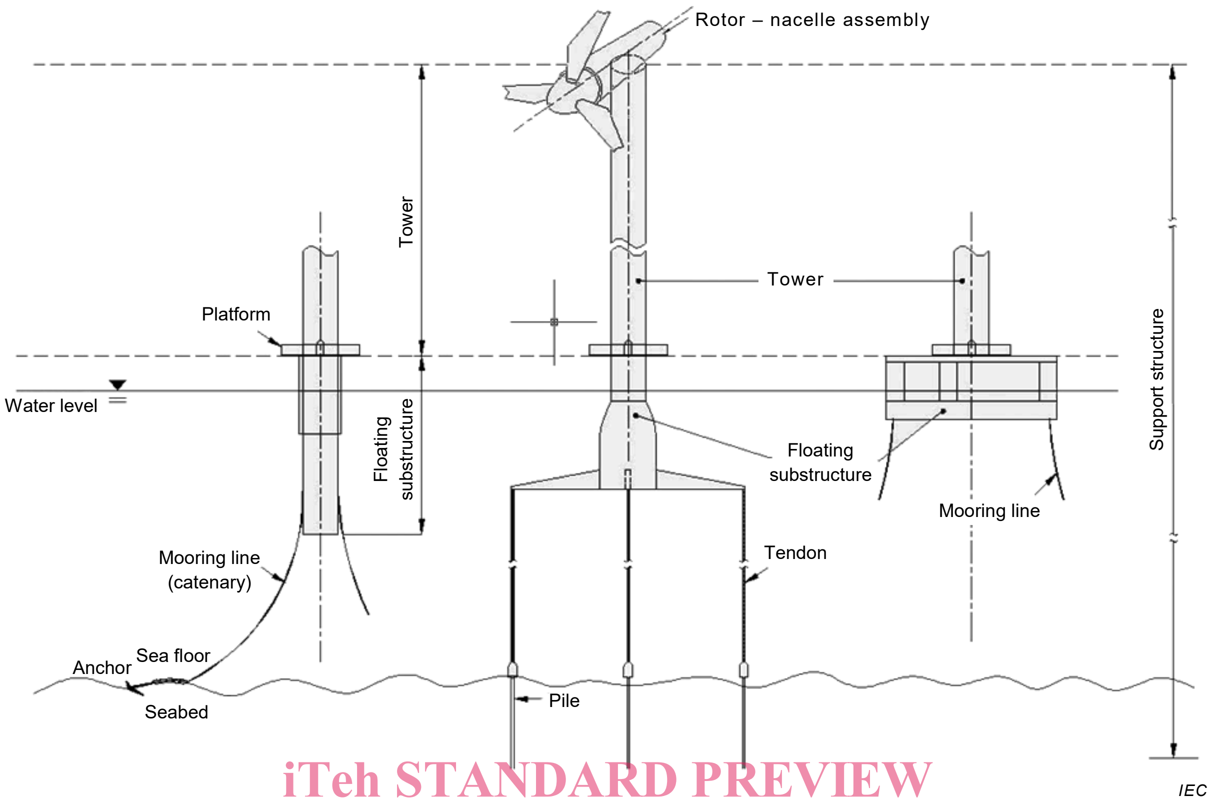
3.79
anchor
device attached to the end of the mooring line or tendon and partially or fully buried in the seabed to limit the movement of the mooring line or tendon and to transfer loads to the seabed

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.



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.

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.

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).

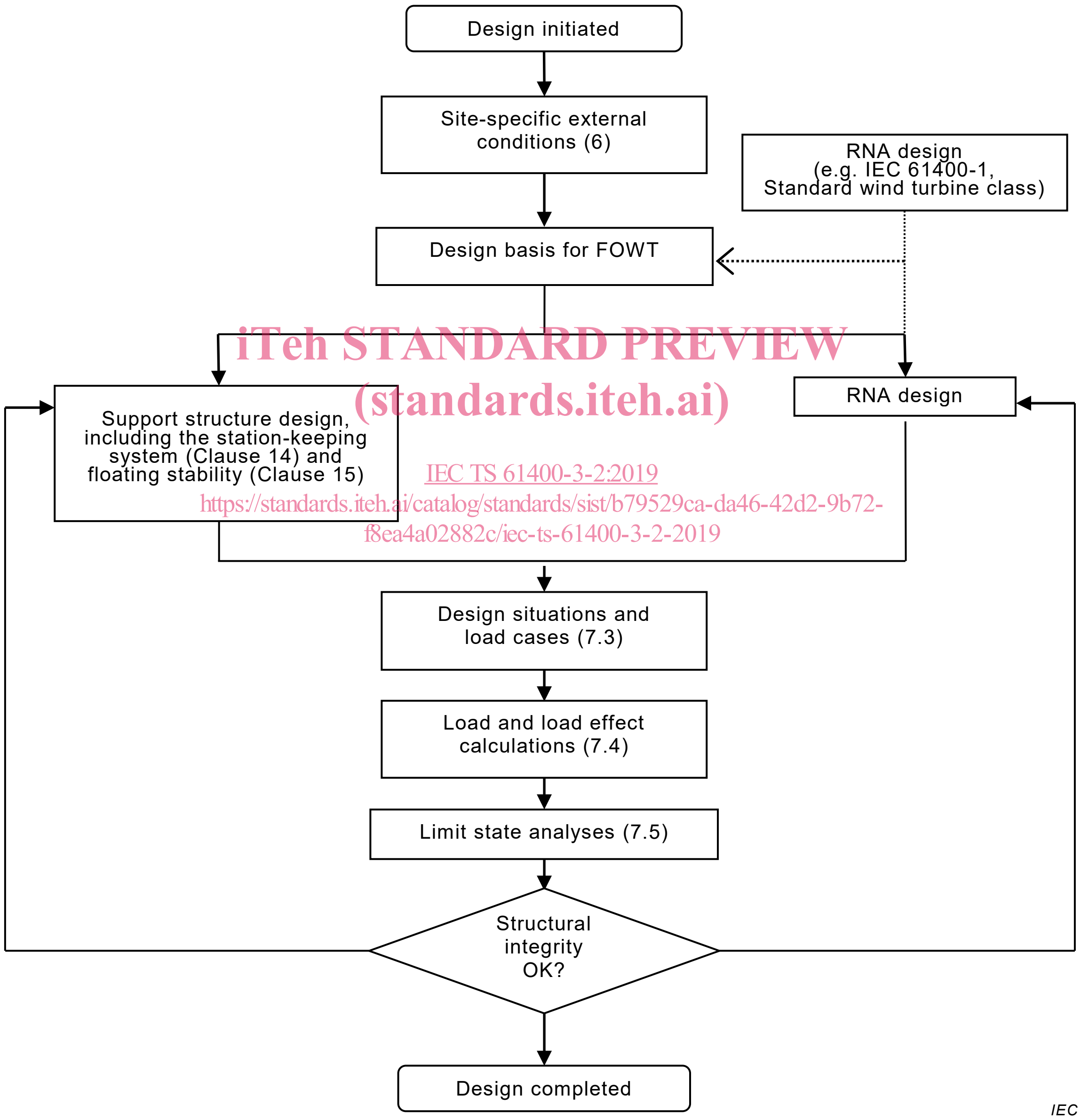


Figure 2 – Design process for a floating offshore wind turbine (FOWT)