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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Wind energy generation systems –
Part 8: Design of wind turbine structural components

Systèmes de génération d'énergie éolienne –
Partie 8: Conception des composants structurels des éoliennes

IEC 61400-8:2024-07(en-fr)

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WIND ENERGY GENERATION SYSTEMS –

Part 8: Design of wind turbine structural components

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

Draft	Report on voting
88/1010/FDIS	88/1023/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

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INTRODUCTION

This part of the IEC 61400 series outlines the minimum requirements for the design of wind turbine nacelle-based structures and is not intended for use as a complete design specification or instruction manual.

Several different groups can be responsible for undertaking the various elements of the design, manufacture, assembly, installation and maintenance of a wind turbine nacelle and for ensuring that the requirements of this document are met. The division of responsibilities between these parties is a contractual matter and is outside the scope of this document.

The requirements stated in this document may be altered if it can be sufficiently demonstrated that the structural integrity of the system is not compromised.

The specific scope of the document is provided in Clause 1. For cases out of the scope of this document, reference should be made to relevant IEC/ISO standards.

WIND ENERGY GENERATION SYSTEMS –

Part 8: Design of wind turbine structural components

1 Scope

This part of IEC 61400 outlines the minimum requirements for the design of wind turbine nacelle-based structures and is not intended for use as a complete design specification or instruction manual. This document focuses on the structural integrity of the structural components constituted within and in the vicinity of the nacelle, including the hub, mainframe, main shaft, associated structures of direct-drives, gearbox structures, yaw structural connection, nacelle enclosure. It also addresses connections of the structural components to control and protection mechanisms, as well as structural connections of electrical units and other mechanical systems. This document focuses primarily on ferrous material-based nacelle structures but can apply to other materials also as appropriate. The design of bolted and welded joints in the nacelle structures is included, as well as cast and forged components. Material testing requirements to use in the design process for nacelle structures are specified. While the structural connections of the gearbox and the main shaft are in the scope, the design of the gears and bearings are not included.

The safety level of the wind turbine designed according to this document shall be at or exceed the level inherent in IEC 61400-1:2019. Probabilistic methods to calibrate partial safety factors and for use in the design process are provided.

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

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

IEC TS 61400-3-2:2019, *Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines*

IEC 61400-5:2020, *Wind energy generation systems – Part 5: Wind turbine blades*

IEC 61400-6:2020, *Wind energy generation systems − Part 6: Tower and foundation design requirements*

IEC 61400-13:2015, *Wind turbines – Part 13: Measurement of mechanical loads*

ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*

ISO 148-1:2016, *Metallic materials – Charpy pendulum impact test – Part 1: Test method*

ISO 945-1:2019, *Microstructure of cast irons – Part 1: Graphite classification by visual analysis*

ISO 1083:2018, *Spheroidal graphite cast irons – Classification*

ISO 1099:2017, *Metallic materials – Fatigue testing – Axial force-controlled method*

ISO 1143:2021, *Metallic materials – Rotating bar bending fatigue testing*

ISO 2394:2015, *General principles on reliability for structures*

ISO 3800:1993, *Threaded fasteners – Axial load fatigue testing – Test methods and evaluation of results*

ISO 6892-1:2019, *Metallic materials – Tensile testing – Part 1: Method of test at room temperature*

ISO 7500-1:2018, *Metallic materials – Calibration and verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Calibration and verification of the force-measuring system*

ISO 12107:2012, *Metallic materials – Fatigue testing – Statistical planning and analysis of data*

ISO 12108:2018, *Metallic materials – Fatigue testing – Fatigue crack growth method*

ISO 12135:2021, *Metallic materials – Unified method of test for the determination of quasistatic fracture toughness*

ISO/TR 14345:2012, *Fatigue − Fatigue testing of welded components − Guidance*

ISO 16269-6:2014, *Statistical interpretation of data − Part 6: Determination of statistical tolerance intervals*

ASTM-E466-21:2021, *Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials*

BS 7910:2013, *Guide to methods for assessing the acceptability of flaws in metallic structures*

CEN/TS 16415:2013, *Personal fall protection equipment – Anchor devices – Recommendations for anchor devices for use by more than one person simultaneously*

EN 1090-2:2018, *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*

EN 1090-3:2019, *Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures*

EN 1369:2012*, Founding – Magnetic particle testing*

EN 1369:1996, *Founding – Magnetic particle inspection*

EN 1371-1:2011, *Founding – Liquid penetrant testing – Part 1: Sand, gravity die and low pressure die castings*

EN 1371-1:1997, *Founding – Liquid penetrant inspection – Part 1: Sand, gravity die and low pressure die castings*

EN 1993-1-8:2007, *Eurocode 3: Design of steel structures – Part 1-8: Design of joints*

EN 1993-1-9:2007, *Eurocode 3: Design of steel structures – Part 1-9: Fatigue*

EN 1993-1-10:2007, *Eurocode 3: Design of steel structures – Part 1-10: Material toughness and through-thickness properties*

EN 1999-1-1:2008, *Eurocode 9: Design of aluminium structures – Part 1-1: General structural rule*

EN 1999-1-3:2007, *Eurocode 9: Design of aluminium structures – Part 1-3: Structures susceptible to fatigue*

EN 12680-3:2011, *Ultrasonic examination – Part 3: Spheroidal graphite cast iron castings*

EN 50308:2004, *Wind turbines − Protective measures − Requirements for design, operation and maintenance*

DIN 50100:2016, *Load controlled fatigue testing – Execution and evaluation of cyclic tests at constant load amplitudes on metallic specimens and components*

FKM Guideline, *Fracture Mechanics Proof of Strength for Engineering Components, 2018 (FKM – RBM-04-18)*

IIW-Doc. 2259-152259-15, *Hobbacher A., Recommendations for fatigue design of welded joints and components, International Institute of Welding, 2014*

IIW-Doc. XIII-2240r2-08/XV-1289r2-08, *Fricke W., Guideline for the Fatigue Assessment by Notch Stress Analysis for Welded Structures, 2010*

VDI 2230-1:2015, *Systematic calculation of highly stressed bolted joints – Joints with one cylindrical bolt*

VDI 2230-2:2014, *Systematic calculation of high duty bolted joints – Joints with several cylindrical bolts*

VDMA 23902:2014, *Guideline for fracture mechanical strength assessment of planet carriers made of nodular cast iron EN-GJS-700-2 for wind turbine gear boxes, Verband Deutscher Maschinen- und Anlagenbau e.V.*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms and definitions 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 Terms and definitions

3.1.1
basquin equation
power law representation of S-N curves

3.1.2
component capacity
maximum static stress the component can withstand

3.1.3
damage equivalent load
equivalent constant range load
load which when repeated a certain number of cycles, causes the same amount of damage as the original combination of several loads and cycles

3.1.4
defect model
model which is used to substitute the geometrical dimensions of an idealized defect type

3.1.5
design life
minimum intended life of the structure, as used in the design process that the structure shall survive under fatigue

3.1.6
design load
mechanical loads whether dynamic or static that the structure shall withstand in its design life

3.1.7
failure assessment diagram
FAD
diagram which is used to check if there is any risk of brittle failure of plastic collapse while performing a fracture mechanic strength assessment

3.1.8
fail-safe
design property of a structure or system which prevents its failure

3.1.9
global stresses
stresses in terms of nominal stresses which are applicable for simple continuous structures (e.g. beams, shells, plates), where the stress can be derived out of sectional forces by analytical methods

Note 1 to entry: Notch factors may need to be considered.

3.1.10
impact energy
energy absorbed/required to break a V-notched test sample on pendulum impact testing machine

3.1.11
limit state
state of a structure beyond which it no longer satisfies the design requirements

3.1.12
local stresses
local stress analysis points at specific regions of a global structure (e.g. at radii, notches) with consideration of the notch shape

3.1.13
mode I
failure mode I
crack opening mode (in tensile direction) in accordance with FKM Guideline of fracture mechanics or BS 7910

3.1.14
Paris-Erdogan equation
equation used to compute the cyclic crack growth behaviour

3.1.15
primary structures
structures which are in the main force flow of the nacelle structure (e.g. the planet carrier of the gearbox)

3.1.16
S-N curve
relation between the number of stress cycles a material can undergo before failure

3.1.17
safe-life
design life period of a system after which it should be removed from service

3.1.18
secondary structures
structures which are not in the main force flow of the nacelle structure (e.g. the housing of the gearbox)

3.1.19
structural model
model oriented to the shape and dimensions of the defect surrounding structure

3.2 Symbols and abbreviated terms

COV	coefficient of variation
EPFM	elastic plastic fracture mechanics
FAD	failure assessment diagram
FE	finite element
FEA	finite element analysis
LEFM	linear elastic fracture mechanics
LRF_{f}	load reserve factor against fatigue load
LRF_{u}	load reserve factor against ultimate load
LRF_{full}	load reserve factor with the full detailed model
$LRF_{simplified}$	load reserve factor with the simplified model
LSE	limit state equation
PSF	partial safety factor
$M_{\delta mf}$	mean value of δmf
RNA	rotor nacelle assembly (herein used without inclusion of blades)
S/N	stress cycle curve for fatigue of materials