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oSIST prEN IEC 61400-8:2022

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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

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SECRETARIAT: Denmark	SECRETARY: Mrs Christine Weibøl Bertelsen
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT	☐ QUALITY ASSURANCE ☐ SAFETY
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TITLE:

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS

Part 8: Design of Wind Turbine Structural Components

FOREWORD

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International Standard IEC 61400-8 has been prepared by IEC technical committee 88: Wind energy generation systems.

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/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.

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withdrawn,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.

The National Committees are requested to note that for this document the stability date is 20XX..

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

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 may 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 standard are met. The division of responsibility between these parties is a contractual matter and is outside the scope of this standard.

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

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

WIND ENERGY GENERATION SYSTEMS –

Part 8: Design of Wind Turbine Structural Components

1 Scope

The IEC 61400-8 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 standard focuses on the engineering 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 covering and other structural connections to subsystems of control and protection mechanisms, electrical units and mechanical systems. The standard 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. Structures or components outside of the nacelle, such as the tower, foundations or blades are not in the scope of this standard. Further, the standard does not address non-structural components or systems such as hydraulics or electrical units. While the structural connections of the gearbox and the main shaft, are in scope, the design of the gears and bearings are not included.

This standard shall be used together with the appropriate standards mentioned in Section 2. In particular, this standard is consistent with the requirements of IEC 61400-1 Ed.4. The safety level of the wind turbine designed according to this standard shall be at or exceed the level inherent in IEC 61400-1 Ed.4. 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.

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

BS 7919:2013. Guide to methods for assessing the acceptability of flaws in metallic structures

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

IEC 61400-1 *Design Requirements*, Ed. 4, 2019

IEC 61400-3, Wind turbines – Part 3: Design requirements for offshore wind turbines, Ed. 2, 2019

IEC 61400-4 *Design requirements for wind turbine gearboxes* Ed. 2, in process

IEC 61400-5 Wind Energy Generation systems – part 5: Wind turbine blades, 2020

IEC 61400-6 *Tower and Foundation Design requirements* Ed. 1, 2019

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

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

ISO 898-1:2013 Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread

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

ISO 1143:2010 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 12107 Fatigue Testing – Statistical Planning and Analysis of Data, 2012

ISO 16269 – 6:2014 Statistical interpretation of data, Determination of Statistical Tolerance Levels

ISO 12108: 2018 Metallic materials -- Fatigue testing -- Fatigue crack growth method

ISO 14345: 2012 Fatigue Testing of welded components

EN 12680-3:2011, Ultrasonic examination. Spheroidal graphite cast iron castings

EN 13445-3 "Unified pressure vessels", Part-3, Design, 2014

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 12135:2016 Metallic materials – Unified method of test for the determination of quasistatic fracture toughness

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

EN 1011-4/A1:2004 Welding - Recommendations for welding of metallic materials - Part 4: Arc welding of aluminium and aluminium alloys

EN 1090-1 + A1:2012 Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components

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 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 50308:2004 Wind turbines. Protective measures. Requirements for design, operation and maintenance

Eurocode 3: 2010. Design of steel structures – Part 1-9: Fatigue

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

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

VDMA 23901, Components and Systems for Wind Turbines in Cold Environments, Verband Deutscher Maschinen- und Anlagenbau e.V., 2016

VDMA 23902, 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., 2014

VDI 2230 Blatt 1:2015-11Systematic calculation of highly stressed bolted joints - Joints with one cylindrical bolt

VDI 2230 Part 2: 2014-12- Systematic calculation of high duty bolted joints –Joints with several cylindrical bolts

DIN50100: Load controlled fatigue testing – Execution and evaluation of cyclic tests at constant load amplitudes on metallic specimens and components

3 Definitions

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

Basquin equation

Power law representation of S-N curves

3.2

component capacity

The maximum loading (e.g. stress) the component can withstand / static strength criterium

3.3

component loading

The loading (e.g. stress) acting on the component

3.4

component tests

Full scale tests or sample tests that sufficiently represent the component

3.5

damage equivalent load

The load which when repeated a certain number of cycles causes the same amount of damage as the original combination of several loads and cycles.

3.6

defect model

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

3.7

design limits

Maximum or minimum values of a parameter as used in design

3.8

design life

Minimum intended life of the structure used in the design process that structure shall survive

3.9

design load

The mechanical loads whether dynamic or static that the structure shall withstand in its lifetime

3.10

failure assessment diagram (FAD)

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

3.11

fail-safe

design property of a structure or system which prevents its failure from resulting in critical consequences

3.12

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. Notch factors may need to be considered

3.13

impact Energy

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

3.14

limit state

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

3.15

local Stresses

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

3.16

mode I / failure mode I

Crack opening mode I (in tensile direction) in accordance with FKM-guideline or BS 7910

3.17

Paris-Erdogan equation

An equation used to compute the cyclic crack growth behaviour

3.18

primary structures

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

3.20

S-N curve

Relation between the number of stress cycles a material can undergo before failure.

3.21

safe-life

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

3.22

secondary Structures

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

3.33

structural model

A model oriented to the shape and dimensions of the defect surrounding structure

4 Symbols and abbreviations

CAPEX Capital Expenditure
COV Coefficient of Variation
OPEX Operational Expenditure
EPFM Elastic Plastic Fracture Mechanics
FAD Failure Assessment Diagram
FE Finite Element
FEA Finite Element Analysis
LEFM Linear Elastic Fracture Mechanics
LRF Load and Resistance Factor
LRF_f Load Reserve Factor against fatigue load
LRF_u Load Reserve Factor against ultimate load
LSE Limit State Equation
PSF Partial Safety Factor
RNA Rotor Nacelle Assembly
S/N Stress- Cycle Curve for fatigue of materials

a	Depth of surface cracks, half depth of embedded cracks / continuous embedded cracks	mm
a_0	Initial crack length	mm
a_{crit}	Critical crack length / limiting crack depth	mm
a_{end}	Calculated crack length after calculated lifetime	mm
A	Elongation at fracture	%
c	Half crack length of surface and embedded cracks	mm
C	Constant value in crack growth law, e.g. Paris Erdogan equation	
da/dN	Crack growth rate per load cycle	mm/loadcycle
D	Accumulated damage	-
E	Modulus of elasticity (Young's modulus)	MPa
h	Location of the crack in the depth direction	mm
L_r	FAD parameter, ratio of applied load to plastic limit load	-
J	J-Integral	kJ/m^2, N/mm
K	Stress intensity factor	$Mpa.m^{0.5}$
K_C	Fracture toughness	$Mpa.m^{0.5}$
K_I	Stress intensity factor for crack opening mode I (tensile mode)	$Mpa.m^{0.5}$
K_{IC}	Fracture toughness for crack opening mode I (tensile mode)	$Mpa.m^{0.5}$
K_r	FAD parameter, ratio of applied SIF to fracture toughness K_{mat}	$Mpa.m^{0.5}$