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AMENDMENT 1

AMENDEMENT 1

Wind energy generation systems –
Part 6: Tower and foundation design requirements

Systèmes de génération d'énergie éolienne –
Partie 6: Exigences en matière de conception du mât et de la fondation

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –

Part 6: Tower and foundation design requirements

AMENDMENT 1

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Amendment 1 to IEC 61400-6:2020 has been prepared by IEC technical committee TC 88: Wind energy generation systems.

The text of this Amendment is based on the following documents:

Draft	Report on voting
88/1088/FDIS	88/1096/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 Amendment 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/.

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- revised.

INTRODUCTION

Clauses and subclauses as given in this document are replacing or amending the respective clauses and subclauses of IEC 61400-6:2020. The main part of this amendment concerns updated knowledge for the design of L-flanges and modifications required due to changes to IEC 61400-1.

The previous method of fatigue assessment using the Schmidt/Neuper trilinear bolt force curve approximation has been removed as the default method from the document. It has been replaced with a physically more accurate method.

The updated methodology for fatigue assessment of L-flanges has been calibrated so that the target failure probability defined in IEC 61400-1 is achieved. Where existing flange designs are checked with the updated method, over-utilization can be found, which in some cases can show an order of magnitude higher than nominally acceptable damage.

This does not impose an immediate risk for the turbines affected, though, due to the following factors:

a) in most cases, such designs have significant conservatism in the fatigue loads assumed, e.g. due to the assumption of uni-directional wind combined with type class turbulence conditions,
b) experience shows that broken bolts are almost always found and replaced before a turbine collapses.

It is not necessary to re-assess existing flange designs using the new method. In cases where broken bolts are found in operating turbines, the affected flange should be checked with the new methodology. Based on the assessment results and the root causes analysis for the failure, further measures should be defined (e.g. shorter inspection intervals).

2 Normative references

Add the following new references to the existing list:

IEC 61400-1:2019/AMD1:2024

ISO 898-1, *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 898-2, *Fasteners – Mechanical properties of fasteners made of carbon steel and alloy steel – Part 2: Nuts with specified property classes*

ISO 898-3, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 3: Flat washers with specified property classes*

ISO 965-2, *ISO general purpose metric screw threads – Tolerances – Part 2: Limits of sizes for general purpose external and internal threads – Medium tolerance quality*

ISO 965-5, *ISO general purpose metric screw threads –Tolerances – Part 5: Limits of sizes for internal screw threads to mate with hot-dip galvanized external screw threads with maximum size of tolerance position h before galvanizing*

ISO 4759-1, *Tolerances for fasteners – Part 1: Bolts, screws, studs and nuts – Product grades A, B and C*

ISO 4759-3, *Tolerances for fasteners – Part 3: Washers for bolts, screws and nuts – Product grades A, C and F*

3 Terms and definitions

Add, after 3.42, the following new terms and definitions:

3.43
bolt assembly
fastener, nut(s), optionally washer(s), preloading method and lubrication system

EXAMPLE A stud assembly for tension-tightening can comprise a stud and one roundnut on each side, without additional washers.

3.44
design gap height
k_{design}
95 % fractile value of the log-normal distribution defined by k_{mean} and COV_{k}

Note 1 to entry: See 6.7.5.2.

3.45
unloaded gap height limit
$k_{\text{limit,unloaded}}$
allowable maximum gap height after mating of flanges, without influence of loading by dead weight of tower section(s) above the flange or preload of bolts, determined such that the calculated damage for the bolts does not exceed the allowable damage as given in 6.7.5.4

3.46
loaded gap height limit
$k_{\text{limit,loaded}}$
allowable maximum gap height after mating of flanges, and after application of for example dead weight of tower section(s) above the flange and/or partial preload of bolts, determined such that the calculated damage for the bolts does not exceed the allowable damage as given in 6.7.5.4

3.47
flatness deviation of individual flange
u_{tol}
allowable flatness deviation as defined in 6.7.3.1 for the individual flange

4 Symbols and abbreviated terms

4.1 Symbols

Add the following symbols to the existing list:

a	flange dimension (nominal distance from inside of flange to bolt circle diameter)
A	nominal area of the bolt shaft with diameter d
a^*	auxiliary value to compute bolt bending moment
a'	reduced effective flange dimension according to Tobinaga/Ishihara
A_{cf}	flange cross section area in circumferential direction
A_{S}	nominal stress area of the bolt in thread
b	weld neck thickness (normally equal to the thickness of the connected tower shell) (in 6.3.2.3 only)
b	flange dimension (nominal distance from bolt circle diameter to middle surface of connected tower shell)
$b'_{\{B,D,E\}}$	distance in between plastic hinges for failure modes B, D, E
c	flank height of the weld preparation (in 6.3.2.3 only)
c	segment width measured at the middle surface of the shell (tower wall)
C_{D}	stiffness of the compression spring (representing the compressed parts)
COV	coefficient of variation
COV_{k}	coefficient of variation of gap height
COV_{p}	coefficient of variation of preload force
C_{S}	stiffness of the tension spring (representing the bolts)
d	nominal diameter of the bolt
D	outer diameter of the tower shell
$D_{\{1,2\}}$	auxiliary values to determine coefficients for bolt force polynomial
d_{b}	diameter of the bolt hole
DFT_{sbw}	dry film thickness (DFT) of coatings applied to the flange surface beneath washers (sbw), i.e in the contact area between washers and flange
D_{w}	outside diameter of the washer
E	Young's modulus of steel
$F_{\mathrm{p,C}}^*$	preload bolt force used for modified torque method
$F_{\mathrm{p,C}}'$	preload bolt force used in the design calculations (design preload)
$F_{\mathrm{p,inst.,mean}}$	mean preload force after installation
$F_{\mathrm{p,mean}}$	design preload averaged over 5 bolts after installation
F_{S}	bolt force
$F_{\mathrm{S}}(Z)$	bolt force as a function of external force Z applied on flange segment
$F_{\mathrm{S},\{0,1,2,3\}}$	bolt forces for determination of polynomial bolt force model
$F_{\mathrm{S,min}}$	minimum (constant) bolt force for theoretically fully closed connection under compression
$F_{\mathrm{S,loss}}$	bolt force used to verify preload loss criterion

$F_S'(Z)$ slope (derivative) of bolt force curve as a function of external force Z on flange segment

$F_{t,R}$ design value of tension resistance of bolt

$F_{u,A}$ limit tension resistance for failure mode A

$F_{u,B}$ limit tension resistance for failure mode B

$F_{u,D}$ limit tension resistance for failure mode D

$F_{u,E}$ limit tension resistance for failure mode E

f_{ub} ultimate tensile strength of bolt

F_V preload

$F_{V,c}$ preload force at which edge contact occurs

f_{yb} nominal yield limit of the bolt material

$f_{Z,tot}$ total amount of settlement in the connection

f_{tot} multiplication factor used to calculate total gap stiffness

G shear modulus of steel

G_{RNA} dead weight of the RNA

G_{twr} dead weight of tower above flange connection considered

h_n flange neck height

h_{wp} distance from flange surface to weld preparation

h_{wt} distance from flange surface to weld toe

I_{cf} flange moment of inertia for a bending moment vector pointing in radial direction (bending in circumferential direction)

I_{tg} flange moment of inertia for a bending moment vector pointing in tangential direction (bending in tangential direction)

k flange gap height

$k(l)$ gap height at position l of total gap length L_{gap}

k_{design} design gap height

k_{fac} stiffness factor to calculate meridional shell stiffness

k_{fl} bending stiffness of the flange

$k_{gap,tot}$ total gap stiffness

$k_{limit,loaded}$ gap height after application of a defined load

$k_{limit,unloaded}$ gap height after mating of flanges without any load

k_{mean} mean gap height

$k_{measured}$ measured gap height

k_{seg} segment stiffness

$k_{shell,ini}$ meridional stiffness of the shell / initial shell stiffness

K shell parameter

l distance from transition radius to weld preparation (in 6.3.2.3 only)

l length of the bolt between the bolt head and the nut

$L_{30°}$ circumferential length measured at mid surface of shell over 30° sector