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Title : **Wind turbines - Part 2: Design requirements for small wind turbines**

Introductory note

This document has been prepared by MT 2 following accommodation of the comments received on document 88/175/CD.

ATTENTION	ATTENTION
CDV soumis en parallèle au vote (CEI) et à l'enquête (CENELEC)	**Parallel IEC CDV/CENELEC Enquiry**

1 Scope

This part of IEC 61400 deals with safety philosophy, quality assurance, and engineering integrity and specifies requirements for the safety of small wind turbines (SWTs) including design, installation, maintenance and operation under specified external conditions. Its purpose is to provide the appropriate level of protection against damage from hazards from these systems during their planned lifetime.

This standard is concerned with all subsystems of SWT such as protection mechanisms, internal electrical systems, mechanical systems, support structures, foundations and the electrical interconnection with the load.

While this standard is similar to IEC61400–1, it does simplify and make significant changes in order to be applicable to small turbines.

This standard applies to wind turbines with a rotor swept area smaller than 200 m^2, generating at a voltage below 1000 V a.c. or 1500 V d.c.

This standard should be used together with the appropriate IEC and ISO standards (see 2).

2 Normative References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of IEC 61400. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61400 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60034: *Rotating Electrical Machines*

IEC 60038: 2002, *IEC standard voltages*

IEC 60204-1: *Safety of Machinery*

IEC 60364: *Electrical installations of buildings*

IEC 60529: 1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000: *Electromagnetic compatibility (EMC)*

IEC 61400-1: 1994, *Wind turbine generator systems - Part 1: Safety requirements*

IEC 61400-12: 1998, *Wind turbine generator systems - Part 12: Wind turbine power performance testing*

IEC 61400-13: 2000, *Wind turbine generator systems – Part 13: Measurement of mechanical loads*

IEC 61400-23: 2001, *Wind turbine generator systems – Part 23: Full-scale structural testing of rotor blades*

IEC 61643: *Surge Protective Devices Connected to Low-Voltage Power Distribution Systems*

ISO 2394: 1998, *General principles on reliability for structures*

ISO 17025: 1999, *General requirements for the competence of testing and calibration laboratories*

3 Definitions

For the purpose of this International Standard, the following definitions apply:

3.1
annual average
mean value of a set of measured data of sufficient size and duration to serve as an estimate of the expected value of the quantity.
NOTE - the averaging time interval shall be an integer number of years to average out non-stationary effects such as seasonality

3.2
annual average wind speed
wind speed averaged according to the definition of annual average

3.3
auto-reclosing cycles
event with a time period, varying from approximately 0,01 s to a few seconds, during which a breaker released after a grid fault is automatically reclosed and the line is reconnected to the network

3.4
brake (for wind turbines)
device capable of reducing the rotor speed or stopping rotation

3.5
catastrophic failure (for wind turbines)
disintegration or collapse of a component or structure, that results in loss of vital function which impairs safety

3.6
characteristic value (of a material property)
value having a prescribed probability of not being attained in a hypothetical unlimited test series

3.7
control system (for wind turbines)
sub-system that receives information about the condition of the wind turbine and/or its environment and adjusts the turbine in order to maintain it within its operating limits

3.8
cut-in wind speed (V_{in})
lowest mean wind speed at hub height at which the wind turbine produces power

3.9
cut-out wind speed (V_{out})
highest mean wind speed at hub height at which the wind turbine is designed to produce power

3.10
design limits
maximum or minimum values used in a design

3.11
design situation
possible mode of wind turbine operation, e.g. power production, parking, etc.

3.12
design wind speed
wind speed used as input for the simple design equations (equal to $1{,}4V_{ave}$)

3.13
downwind
in the main wind direction

3.14
emergency shutdown (for wind turbines)
rapid shutdown of the wind turbine triggered by a protection system or by manual intervention

3.15
environmental conditions
characteristics of the environment (altitude, temperature, humidity, etc.) which may affect the turbine system behaviour

3.16
external conditions (for wind turbines)
factors affecting the operation of a wind turbine including the wind regime, other climatic factors (snow, ice, etc.), earthquake and power network conditions.

3.17
extreme wind speed
highest average wind speed, averaged over *t* seconds, that is likely to be experienced within a specified time period (recurrence period): of *T* years

NOTE - Recurrence periods of *T* = 50 years and *T* = 1 year and averaging time interval of *t* = 3 s and *t* = 10 min are used in a number of standards. In popular language the less precise term "survival wind speed" is often used. In practice, however, the wind turbine generator system is designed using the extreme wind speed for design load cases.

3.18
fail-safe
design property of an item which prevents its failures from resulting in critical faults

3.19
furling
a passive overspeed control mechanism by means of reducing the projected swept area

3.20
gust
sudden and brief increase of the wind speed over its mean value.
NOTE - A gust can be characterized by its rise-time, its amplitude and its duration.

3.21
horizontal axis wind turbine
wind turbine whose rotor axis is substantially parallel to the wind flow

3.22
hub (for wind turbines)
fixture for attaching the blades or blade assembly to the rotor shaft

3.23
hub height (for wind turbines)
height of the centre of the wind turbine rotor above the terrain surface. For a vertical axis wind turbine the hub height is the height of the equator plane

3.24
idling (for wind turbines)
condition of a wind turbine that is rotating slowly and not producing power

3.25
limit state
state of a structure and the loads acting upon it beyond which the structure no longer satisfies the design requirement (ISO 2394).

NOTE - the purpose of design calculations (i.e. the design requirement for the limit state) is to keep the probability of a limit state being reached below a certain value prescribed for the type of structure in question (ISO 2394).

3.26
load case
combination of a design situation and an external condition which results in structural loading

3.27
logarithmic wind shear law
a mathematical law which expresses wind speed variations as a logarithmic function of height above ground

3.28
mean wind speed
statistical mean of the instantaneous value of the wind speed averaged over a given time period which can vary from a few seconds to many years

3.29
nacelle
housing which contains the drive-train and other elements on top of a horizontal axis wind turbine tower

3.30
normal shutdown (for wind turbines)
shutdown in which all stages are under the control of the control system

3.31
operating limits
set of conditions defined by the SWT designer that govern the activation of the control and protection system

3.32
parked wind turbine
depending on the construction of the wind turbine, parked refers to the turbine being either in a stand-still or an idling condition

3.33
parking
situation to which a wind turbine returns after a normal shutdown

3.34
power law for wind shear
a mathematical law which expresses wind speed variations as a power law function of height above ground

3.35
power output
power delivered by a device in a specific form and for a specific purpose

NOTE (for wind turbines) - The electric power delivered by a wind turbine

3.36
protection system (wind turbine)
system which ensures that a wind turbine generator system remains within the design limits

3.37
Rayleigh distribution
a probability distribution function often used for wind speeds. The distribution depends on one adjustable parameter - the scale parameter, which controls the average wind speed

NOTE - The Rayleigh distribution is identical to a Weibull distribution (see 3.55) with shape parameter 2.

3.38
reference wind speed (V_{ref})
basic parameter for wind speed used for defining SWT classes. Other design related climatic parameters are derived from the reference wind speed and other basic SWT class parameters

NOTE - A turbine designed for a SWT class with a reference wind speed, V_{ref}, is designed to withstand climates for which the extreme 10 min average wind speed with a recurrence period of 50 years at turbine hub height is lower than or equal to V_{ref} *(see 3.17).*

3.39
resonance
phenomenon appearing in an oscillating system, in which the period of a forced oscillation is very close to that of free oscillation

3.40
rotor speed (for wind turbines)
rotational speed of a wind turbine rotor about its axis

3.41
roughness length
extrapolated height at which the mean wind speed becomes zero if the vertical wind profile is assumed to have a logarithmic variation with height

3.42
safe life
prescribed service life with a declared probability of catastrophic failure

3.43
scheduled maintenance
preventive maintenance carried out in accordance with an established time schedule

3.44
shutdown (for wind turbines)
transitional state of a wind turbine between power production and standstill or idling

3.45
standstill
condition of a wind turbine generator system that is stopped

3.46
support structure (for wind turbines)
part of a wind turbine comprising the tower and foundation

3.47
survival wind speed (deprecated)
a popular name for the maximum wind speed that a construction is designed to withstand

NOTE – This term is not used in the IEC 61400 series; the design conditions instead refer to extreme wind speed (see 3.17).

3.48
small wind turbine (SWT)
a system of 200 m^2 rotor swept area or less that converts kinetic energy in the wind into electrical energy

3.49
swept area
projected area perpendicular to the wind direction that a rotor will describe during one complete rotation

3.50
turbulence intensity
ratio of the wind speed standard deviation to the mean wind speed, determined from the same set of measured data samples of wind speed, and taken over a specified period of time

3.51
ultimate limit state
limit states which generally correspond to maximum load carrying capacity (ISO 2394)

3.52
unscheduled maintenance
maintenance carried out, not in accordance with an established time schedule, but after reception of an indication regarding the state of an item

3.53
upwind
in the direction opposite to the main wind direction

3.54
vertical axis wind turbine
wind turbine whose rotor axis is vertical

3.55
Weibull distribution
a probability distribution function often used for wind speeds. This distribution function depends on two parameters, the shape parameter, which controls the width of the distribution and the scale parameter, which in turn controls the average wind speed. (see wind speed distribution)

3.56
wind profile - wind shear law
mathematical expression for assumed wind speed variation with height above ground.

NOTE - Commonly used profiles are the logarithmic profile (1) or the power law profile (2).

$$V(z) = V(z_r).\frac{\ln(z/z_0)}{\ln(z_r/z_0)} \qquad (1)$$

$$V(z) = V(z_r).\left(\frac{z}{z_r}\right)^{a} \qquad (2)$$

where

$V(z)$ is the wind speed at height z

z is the height above ground

z_r is a reference height above ground used for fitting the profile

z_o is the roughness length

a is the wind shear (or power law) exponent

3.57
wind speed distribution
probability distribution function, used to describe the distribution of wind speeds over an extended period of time

NOTE - Often used distribution functions are the Rayleigh, $P_R(V_o)$, and the Weibull, $P_W(V_o)$, functions.

$$P_R\{V < V_0\} = 1 - \exp\left[-p\,(V_0 / 2V_{ave})^2\right]$$
$$P_W\{V < V_0\} = 1 - \exp\left[-(V_0 / C)^k\right] \quad (3)$$

$$with\ V_{ave} = \left\{ \begin{array}{c} C\,\Gamma(1+\frac{1}{k}) \\ C\sqrt{p}/2, if\ k = 2 \end{array} \right\} \quad (4)$$

where

$P(V_0)$ is the cumulative probability function, i.e. the probability that $V<V_0$

V_0 is the wind speed (limit)

V_{ave} is the average value of V

C is the scale parameter of the Weibull function

k is the shape parameter of the Weibull function

Γ is the gamma function

Both C and k can be evaluated from real data. The Rayleigh function is identical to the Weibull function if k = 2 is chosen and C and Vave satisfy the condition stated in equation (4) for k = 2.
The distribution functions express the cumulative probability that the wind speed is lower than V_0. Thus (P(V1)-P(V2)), if evaluated between the specified limits V1 and V2, will indicate the fraction of time that the wind speed is within these limits. Differentiating the distribution functions yields the corresponding probability density functions.

3.58
wind shear
variation of wind speed across a plane perpendicular to the wind direction

3.59
wind shear exponent
also commonly known as power law exponent, see 3.56, wind profile - wind shear law

3.60
wind speed
at a specified point in space the wind speed is the speed of motion of a minute amount of air surrounding the specified point

NOTE - The wind speed is also the magnitude of the local wind velocity (vector) (see 3.61, wind velocity).

3.61
wind velocity
vector pointing in the direction of motion of a minute amount of air surrounding the point of consideration, the magnitude of the vector being equal to the speed of motion of this air "parcel" (i.e. the local wind speed)

NOTE - The vector at any point is thus the time derivative of the position vector of the air "parcel" moving through the point.

3.62
yawing
rotation of the rotor axis about a vertical axis (for horizontal axis wind turbines only)

3.63
yaw rate
the time rate of change of yaw angle, the rate of yawing

3.64
yaw misalignment
horizontal deviation of the wind turbine rotor axis from the wind direction