INTERNATIONAL STANDARD

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Second edition
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Wind turbine generator systems –

Part 1:
Safety requirements

Aérogénérateurs –

Partie 1:
Spécification de sécurité

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* See web site address on title page.

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61400-1 has been prepared by IEC technical committee 88: Wind turbine systems.

This second edition of IEC 61400-1 cancels and replaces the first edition published in 1994.

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

FDIS	Report on voting
88/98/FDIS	88/103/RVD

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

Annexes A, B and C form an integral part of this standard.

Annex D is for information only.

A bilingual version of this standard may be issued at a later date.

INTRODUCTION

This International Standard outlines minimum safety requirements for wind turbine generator systems and is not intended for use as a complete design specification or instruction manual.

Any of the requirements of this standard may be waived if it can be suitably demonstrated that the safety of the system is not compromised. Nevertheless this waiver does not apply to clause 6.

Compliance with this standard does not relieve any person, organization, or corporation from the responsibility of observing other applicable regulations.

WIND TURBINE GENERATOR SYSTEMS –

Part 1: Safety requirements

1 Scope and object

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

This standard is concerned with all subsystems of WTGS such as control and protection mechanisms, internal electrical systems, mechanical systems, support structures and the electrical interconnection equipment.

This standard applies to WTGS with a swept area equal to or larger than 40 m^2.

This standard should be used together with the appropriate IEC/ISO standards identified in clause 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 60204-1:1997, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60364 (all parts), *Electrical installations of buildings*

IEC 60721-2-1:1982, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Temperature and humidity*

IEC 61000-3-2:1998, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16 A*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test. Basic EMC publication*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test. Basic EMC publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61024-1:1990, *Protection of structures against lightning – Part 1: General principles*

IEC 61312-1:1995, *Protection against lightning electromagnetic impulse – Part 1: General principles*

ISO 2394:1986, *General principles on reliability for structures*

3 Terms and 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. The averaging time interval shall be a whole 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 cycle
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
blocking (wind turbines)
use of a mechanical pin or other device (other than the ordinary mechanical brake) to prevent movement, for instance of the rotor shaft or yaw mechanism

3.5
brake (wind turbines)
device capable of reducing the rotor speed or stopping rotation

3.6
catastrophic failure (wind turbines)
disintegration or collapse of a component or structure, that results in loss of vital function which impairs safety

3.7
characteristic value (of a material property)
value having a prescribed probability of not being attained in a hypothetical unlimited test series

3.8
complex terrain
surrounding terrain that features significant variations in topography and terrain obstacles that may cause flow distortion

3.9
control system (wind turbines)
subsystem 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

3.10
cut-in wind speed (V_{in})
lowest mean wind speed at hub-height at which the wind turbine starts to produce power (see 3.24, hub-height)

3.11
cut-out wind speed (V_{out})
highest mean wind speed at hub-height at which the wind turbine is designed to produce power (see 3.24, hub-height)

3.12
design limits
maximum or minimum values used in a design

3.13
dormant failure (also known as latent fault)
failure of a component or system which remains undetected during normal operation

3.14
downwind
in the direction of the main wind vector

3.15
electrical power network
particular installations, substations, lines or cables for the transmission and distribution of electricity

NOTE – The boundaries of the different parts of this network are defined by appropriate criteria, such as geographical situation, ownership, voltage, etc.

3.16
emergency shutdown (wind turbines)
rapid shutdown of the wind turbine triggered by a protection system or by manual intervention

3.17
environmental conditions
characteristics of the environment (altitude, temperature, humidity, etc.) which may affect the WTGS behaviour

3.18
external conditions (wind turbines)
factors affecting operation of a wind turbine, including the wind regime, the electrical network conditions, and other climatic factors (temperature, snow, ice, etc.)

3.19
extreme wind speed
highest average wind speed, averaged over *t* s, that is likely to be experienced within a specified time period of *N* years ("recurrence period": *N* years)

NOTE – In this standard recurrence periods of *N* = 50 years and *N* = 1 year and averaging time intervals of *t* = 3 s and *t* = 10 min are used. In popular language, the less precise term "survival wind speed" is often used. In this standard, however, the turbine is designed using extreme wind speeds for design load cases.

3.20
fail-safe
design property of an item which prevents its failures from resulting in critical faults

3.21
gust
temporary change in the wind speed

NOTE – A gust may be characterized by its rise-time, its magnitude and its duration.

3.22
horizontal axis wind turbine
wind turbine whose rotor axis is substantially parallel to the wind flow

3.23
hub (wind turbines)
fixture for attaching the blades or blade assembly to the rotor shaft

3.24
hub-height (wind turbines)
height of the centre of the swept area of the wind turbine rotor above the terrain surface (see 3.55, swept area)

3.25
idling (wind turbines)
condition of a wind turbine that is rotating slowly and not producing power

3.26
inertial subrange
frequency interval of the wind turbulence spectrum, where eddies – after attaining isotropy – undergo successive break-up with negligible energy dissipation

NOTE – At a typical 10 m/s wind speed, the inertial subrange is roughly from 0,02 Hz to 2 kHz.

3.27
isolated operation
stable and temporary operation of a discrete part of a power system after network splitting

3.28
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).

3.29
logarithmic wind shear law
see wind profile

3.30
maximum power (wind turbines)
highest level of net electrical power delivered by a wind turbine in normal operation

3.31
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

3.32
nacelle
housing which contains the drive-train and other elements on top of a horizontal axis wind turbine tower

3.33
network connection point (wind turbines)
cable terminals of a single wind turbine or, for a wind power station, the connection point to the electrical bus of the site power collection system

3.34
normal shutdown (wind turbines)
shutdown in which all stages are under the control of the control system

3.35
operating limits
set of conditions defined by the WTGS designer that govern the activation of the control and protection system

3.36
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

3.37
power collection system (wind turbines)
electric connection system that collects the power from one or more wind turbines. It includes all electrical equipment connected between the WTGS terminals and the network connection point

3.38
power law for wind shear
see wind profile

3.39
power output
power delivered by a device in a specific form and for a specific purpose

NOTE (wind turbines) – The electric power delivered by a WTGS.

3.40
protection system (wind turbine)
system which ensures that a WTGS remains within the design limits

3.41
rated power
quantity of power assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

NOTE (wind turbines) – Maximum continuous electrical power output which a WTGS is designed to achieve under normal operating conditions.

3.42
rated wind speed (V_r)
specified wind speed at which a wind turbine's rated power is achieved

3.43
Rayleigh distribution
probability distribution function, see 3.66 (wind speed distribution)

3.44
reference wind speed (V_{ref})
basic parameter for wind speed used for defining WTGS classes. Other design related climatic parameters are derived from the reference wind speed and other basic WTGS class parameters (see clause 6)

NOTE – A turbine designed for a WTGS 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}.

3.45
resonance
phenomenon appearing in an oscillating system, in which the period of a forced oscillation is very close to that of free oscillation

3.46
rotationally sampled wind velocity
wind velocity experienced at a fixed point of the rotating wind turbine rotor

NOTE – The turbulence spectrum of a rotationally sampled wind velocity is distinctly different from the normal turbulence spectrum. While rotating, the blade cuts through a wind flow that varies in space. Therefore, the resulting turbulence spectrum will contain sizeable amounts of variance at the frequency of rotation and harmonics of the same.

3.47
rotor speed (wind turbines)
rotational speed of a wind turbine rotor about its axis

3.48
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

3.49
safe life
prescribed service life with a declared probability of catastrophic failure

3.50
scheduled maintenance
preventive maintenance carried out in accordance with an established time schedule

3.51
serviceability limit state
limit state which corresponds with criteria governing function related normal use (ISO 2394)