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2005-08

Wind turbines –

Part 1:
Design requirements

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES –

Part 1: Design requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 turbines.

This third edition cancels and replaces the second edition published in 1999. It constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– the title has been changed to "Design requirements" in order to reflect that the standard presents safety requirements rather than requirements for safety or protection of personnel;
– wind turbine class designations have been adjusted and now refer to reference wind speed and expected value of turbulence intensities only;
– turbulence models have been expanded and include an extreme turbulence model;
– gust models have been adjusted and simplified;

– design load cases have been rearranged and amended;
– the inclusion of turbulence simulations in the load calculations is emphasised and a scheme for extreme load extrapolation has been specified;
– the partial safety factors for loads have been adjusted and simplified;
– the partial safety factors for materials have been amended and specified in terms of material types and component classes;
– the requirements for the control and protection system have been amended and clarified in terms of functional characteristics;
– a new clause on assessment of structural and electrical compatibility has been introduced with detailed requirements for assessment, including information on complex terrain, earthquakes and wind farm wake effects.

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

FDIS	Report on voting
88/228/FDIS	88/232/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61400 consists of the following parts under the general title *Wind turbine generator systems:*

Part 1: Design requirements
Part 2: Design requirements for small wind turbines
Part 11: Acoustic noise measurement techniques
Part 12: Wind turbine power performance testing
Part 13: Measurement of mechanical loads
Part 14: Declaration of apparent sound power level and tonality values
Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
Part 23: Full-scale structural testing of rotor blades
Part 24: Lightning protection

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

This part of IEC 61400 outlines minimum design requirements for wind turbines and is not intended for use as a complete design specification or instruction manual.

Any of the requirements of this standard may be altered if it can be suitably demonstrated that the safety of the system is not compromised. This provision, however, does not apply to the classification and the associated definitions of external conditions in Clause 6.Compliance with this standard does not relieve any person, organization, or corporation from the responsibility of observing other applicable regulations.

The standard is not intended to give requirements for wind turbines installed offshore, in particular for the support structure. A future document dealing with offshore installations is under consideration.

WIND TURBINES –

Part 1: Design requirements

1 Scope

This part of IEC 61400 specifies essential design requirements to ensure the engineering integrity of wind turbines. Its purpose is to provide an appropriate level of protection against damage from all hazards during the planned lifetime.

This standard is concerned with all subsystems of wind turbines such as control and protection mechanisms, internal electrical systems, mechanical systems and support structures.

This standard applies to wind turbines of all sizes. For small wind turbines IEC 61400-2 may be applied.

This standard should be used together with the appropriate IEC and ISO standards mentioned in Clause 2.

2 Normative references

The following referenced documents are indispensable for the application 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 60204-1:1997, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60204-11:2000, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

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 61000-6-1:1997, *Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 1: Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-2:1999, *Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 2: Immunity for industrial environments 15*

IEC 61000-6-4:1997, *Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 4: Emission standard for industrial environments*

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 principle*

IEC 61400-21:2001, *Wind turbine generator systems – Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines*

IEC 61400-24: 2002, *Wind turbine generator systems – Part 24: Lightning protection*

ISO 76:1987, *Rolling bearings – Static load ratings*

ISO 281:1990, *Rolling bearings – Dynamic load ratings and rating life*

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

ISO 2533:1975, *Standard Atmosphere*

ISO 4354:1997, *Wind actions on structures*

ISO 6336 (all parts), *Calculation of load capacity of spur and helical gears*

ISO 9001:2000, *Quality management systems – Requirements*

3 Terms and definitions

For the purposes of this document, the following terms and 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 should be a whole number of years to average out non-stationary effects such as seasonality

3.2
annual average wind speed
V_{ave}
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) that cannot be released accidentally 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

NOTE The brake may operate on, for example, aerodynamic, mechanical or electrical principles.

3.6
characteristic value
value having a prescribed probability of not being attained (i.e. an exceedance probability of less than or equal to a prescribed amount)

3.7
complex terrain
surrounding terrain that features significant variations in topography and terrain obstacles that may cause flow distortion

3.8
control functions (wind turbines)
functions of the control and protection system that based on information about the condition of the wind turbine and/or its environment, adjust the turbine in order to maintain it within its operating limits

3.9
cut-in wind speed
V_{in}
lowest wind speed at hub height at which the wind turbine starts to produce power in the case of steady wind without turbulence

3.10
cut-out wind speed
V_{out}
highest wind speed at hub height at which the wind turbine is designed to produce power in the case of steady wind without turbulence

3.11
design limits
maximum or minimum values used in a design

3.12
dormant failure
failure of a component or system which remains undetected during normal operation

3.13
downwind
in the direction of the main wind vector

3.14
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.

3.15
emergency shutdown (wind turbines)
rapid shutdown of the wind turbine triggered by a protection function or by manual intervention

3.16
environmental conditions
characteristics of the environment (wind, altitude, temperature, humidity, etc.) which may affect the wind turbine behaviour

3.17
external conditions (wind turbines)
factors affecting operation of a wind turbine, including the environmental conditions (temperature, snow, ice, etc.) and the electrical network conditions

3.18
extreme wind speed
value of the highest wind speed, averaged over t s, with an annual probability of exceedance of $1/N$ ("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.

3.19
fail-safe
design property of an item which prevents its failures from resulting in critical faults

3.20
gust
temporary change in the wind speed

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

3.21
horizontal axis wind turbine
wind turbine whose rotor axis is substantially horizontal

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

3.23
hub height (wind turbines)
z_{hub}
height of the centre of the swept area of the wind turbine rotor above the terrain surface. (see 3.51, swept area)

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

3.25
inertial sub-range
frequency interval of the 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 sub-range is roughly from 0, 2 Hz to 1 kHz.

3.26
limit state
state of a structure and the loads acting upon it, beyond which the structure no longer satisfies the design requirement

[ISO 2394, modified]

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 (see ISO 2394).

3.27
logarithmic wind shear law
see 3.62

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
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

3.31
network loss
loss of network for period exceeding any ride through provision in the turbine control system

3.32
normal shutdown (wind turbines)
shutdown in which all stages are under the control of the control system

3.33
operating limits
set of conditions defined by the wind turbine designer that govern the activation of the control and protection system

3.34
parked wind turbine
depending on the design of the wind turbine, parked refers to the turbine being either in a standstill or an idling condition

3.35
power collection system (wind turbines)
electric system that collects the power from one or more wind turbines. It includes all electrical equipment connected between the wind turbine terminals and the network connection point

3.36
power law for wind shear
see 3.62

3.37
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 wind turbine

3.38
protection functions (wind turbine)
functions of the control and protection system which ensure that a wind turbine remains within the design limits