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TECHNICAL SPECIFICATION

colour inside

Wind energy generation systems – Part 31: Siting risk assessment

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Part 31: Siting risk assessment

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IEC TS 61400-31 has been prepared by subcommittee PT 61400-31: Wind energy generation systems – Part 31: Siting Risk Assessment, of IEC technical committee 88: Wind energy generation systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
88/936/DTS	88/956/RVDTS

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

A list of all parts in the IEC 61400 series, published under the general title *Wind energy generation systems*, can be found on the IEC website.

The language used for the development of this Technical Specification 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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WIND ENERGY GENERATION SYSTEMS –

Part 31: Siting risk assessment

1 Scope

This part of IEC 61400, which is a Technical Specifiation, establishes a guideline for the assessment of the risks which a wind turbine may pose to the general public.

Incidents in wind farms causing harm to the general public are very rare events. However, there are requirements to cover this topic in the permitting procedures of several countries. This document aims to facilitate a uniform scope and a uniform use of methods in wind turbine risk assessments.

This document covers harm to the general public. It does not cover occupational exposure, e.g. of personnel involved in the operation and maintenance of the turbine, since occupational risks are usually dealt with in occupational health and safety regulations. The risk of damage to structures or other objects is also not part of this document unless such damage in turn poses a risk to the public.

Harm according to this document can be direct harm or indirect harm via damage to buildings or infrastructure, e.g. gas pipelines, nuclear facilities, dykes, rail infrastructure or roads.

This document covers risk due to internal or external causes, such as technical failures, human errors, extreme wind conditions, turbine icing, lightning strikes, earthquakes, flooding, landslides or fire. However, the specific cause of an incident (e.g. an incident such as a turbine collapse) is irrelevant to the assessment of the consequences. The only relevant factor is the expected probability of occurrence for the incident considered.

In terms of transmission of the hazard to the people affected, this document describes tower collapses, shedding of the nacelle, blade failures, falling or throwing of ice pieces and fire spread.

This document does not cover risks from visual distraction and environmental risk such as noise or shadow flicker.

Wind turbines may pose a hazard to aviation through incidents such as collisions with aircrafts or disturbance of air traffic control radar. These hazards are not covered in this document. In order to mitigate the hazard of aircrafts colliding with wind turbines, aviation lights are installed on wind turbines as covered in IEC 61400-29[1][1].

Risks connected to terrorist attacks and other malicious actions are not covered by this document.

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1 Numbers in square brackets refer to the Bibliography.

This document covers only onshore wind turbines with a horizontal axis and a swept area greater than 200 m^2. Substations and other external structures are excluded. Other tall structures associated with a wind farm or wind turbine (e.g. temporary or permanent meteorological masts) also introduce risks related to their possible collapse or failure. Such structures are not covered by this document. Guidance on the risks can be inferred from the reliability classes of the tall structure as determined with reference to EN 1993 Eurocode 3: Design of steel structures [2], including the national annexes where local design requirements are specified.

As to the extent of the harm, this document is limited to the immediate, potentially lethal, physical harm. Non-lethal harm is indirectly covered as described in Clause 6.

This document describes risks during operation of the wind turbine including maintenance, idling and standstill. It does not describe risks during construction, civil works, crane operations, assembly or decommissioning.

Risks according to this document are assessed by prescriptive and/or risk-based methods.

In evaluating risk, the risk is first expressed as a localized risk. Along with the probability of people being present at the location, a risk of lethal harm per year will be used to quantify the risk of harm to people.

This document covers risk reduction measures that might be necessary to reduce risk to a tolerable level.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and symbols

For the purposes of this document, the following terms, definitions and symbols 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 Terms and definitions

3.1.1
risk
combination of the probability of occurrence of harm and the severity of that harm

[SOURCE: IEC 60050-903:2013, 903-01-07]

3.1.2
harm
physical injury or damage to persons, property, and livestock

Note 1 to entry: Harm to property and to livestock is excluded from the scope of this document.

[SOURCE: IEC 60050-903:2013, 903-01-01, modified – addition of Note 1 to entry]

3.1.3
hazard
potential source of harm

Note 1 to entry: In English, the term "hazard" can be qualified in order to define the origin of the hazard or the nature of the expected harm (e.g. "electric shock hazard", "crushing hazard", "cutting hazard", "toxic hazard", "fire hazard", "drowning hazard").

[SOURCE: IEC 60050-903:2013, 903-01-02, modified – deletion of Notes 2 and 3 to entry]

3.1.4
risk assessment
overall process comprising a risk analysis and a risk evaluation

[SOURCE: IEC 60050-903:2013, 903-01-10]

3.1.5
quantitative risk assessment (QRA)
techniques which allow the risk associated with a particular activity to be estimated in absolute quantitative terms rather than in relative terms such as high or low

[SOURCE: ISO/TS 16901:2015, 3.24, modified – deletion of Note 1 to entry]

3.1.6
risk management
coordinated activities to direct and control an organization with regard to risk

[SOURCE: ISO 31000:2018, 3.2]

3.1.7
risk analysis
systematic use of available information to identify hazards and to estimate the risk

[SOURCE: IEC 60050-903:2013, 903-01-08]

3.1.8
risk evaluation
procedure based on the risk analysis to determine whether the tolerable risk has been achieved

[SOURCE: IEC 60050-903:2013, 903-01-09]

3.1.9
risk treatment
process of selection and implementation of measures to mitigate risk

[SOURCE: ISO 13824:2020, 3.17]

3.1.10
tolerable risk
risk which is accepted in a given context based on the current values of society

[SOURCE: IEC 60050-903:2013, 903-01-12]

3.1.11
ALARP (as low as reasonably practicable)
reducing a risk to a level that represents the point, objectively assessed, at which the time, trouble, difficulty, and cost of further reduction becomes unreasonably disproportionate to the additional risk reduction obtained

[SOURCE: ISO/TR 17177:2015]

3.1.12
safe life
prescribed service life with a declared probability of catastrophic failure

[SOURCE: IEC 60050-415:1999, 415-02-08]

3.1.13
residual risk
risk remaining after protective measures have been taken

[SOURCE: IEC 60050-903:2013, 903-01-11]

3.1.14
stakeholder
individual, group or organization that has an interest in an organization or activity

Note 1 to entry: Usually a stakeholder can affect or is affected by the organization or the activity.

[SOURCE: IEC 60050-904:2014, 904-01-10]

3.1.15
risk reduction measure
protective measure
measure intended to achieve adequate risk reduction, implemented:

- by the designer (inherent design, safeguarding and complementary protective measures, information for use) and
- by the user (organization: safe working procedures, supervision, training; permit-to-work systems; provision and use of additional safeguards; use of personal protective equipment)

[SOURCE: IEC 60050-904:2014, 903-01-17, modified – risk reduction measure has been specified as a synonym]

3.1.16
hub height
height of the centre of the wind turbine rotor above the terrain surface

[SOURCE: IEC 60050-904:2014, 415-05-06, modified – deletion of part of definition referring to vertical axis wind turbines as these are out of scope for this document]

3.1.17
hazard log
document that records or references the identified hazards, the decisions made, the adopted solutions and the status of implementation

3.1.18
prescriptive approach
method for controlling risks by prescribing rules reflecting industry experience, engineering judgement, and conservative assumptions

3.1.19
qualitative risk assessment method
method for assessing risk where experts decide on the acceptability of identified risks based subjective judgement

Note 1 to entry: The outcome of a qualitative risk assessment method is a binary result acceptable/not acceptable.

3.1.20
semi-quantitative risk assessment method
method for assessing risk that involves a categorization of the likelihood of hazardous events and a categorization of the associated consequences and the assignment of defined risk levels to each combination of these two categories

3.1.21
quantitative risk measures
standard unit used to express the degree of risk

Note 1 to entry: The risk measures used in quantitative risk assessment relate to 2 objectives:

- The protection of an individual person.
- The protection of a group of people.

3.1.22
individual risk
risk measure for an individual person calculated for the (usually hypothetical) person with the highest exposure to the hazard

Note 1 to entry: This is an equity-based measure, which starts with the premise that all individuals have unconditional rights to certain levels of protection. This leads to standards, applicable to all, held to be usually acceptable in normal life, or which refer to some other premise held to establish an expectation of protection. In practice, this often converts into fixing a limit to represent the maximum level of risk to which an individual may be exposed. If the risk estimate derived from the risk assessment is above the limit and further control measures cannot be introduced to reduce the risk, the risk is held to be unacceptable whatever the benefits.

The measure is defined for a hypothetical most-critical individual, who is exposed to the risk. This hypothetical person describes an individual, who is in some fixed relation to the hazard and for whom it is assumed, that he/she is most exposed to it. In this way his/her characteristics (time of exposure, place, etc.) make the risk to which she/he is subjected over-arching for each possible realistic individual exposure. By using this approach, it will be guaranteed that each individual person will be protected according to an acceptance framework.

For individual risk, the unit of risk is the loss of life per year.

3.1.23
IRPA (individual risk per annum)
probability that a specific or hypothetical individual will be killed due to exposure to the hazards or activities during one year

Note 1 to entry: To be able to determine this value, quantitative knowledge is needed about the use of the hazardous area by individuals. In the population that uses the area, a hypothetical individual is defined such that the associated risk is conservative for all individuals in the exposed group. This selected hypothetical person is called the critical individual. When the critical individual is defined as a person who is permanently localized at a given point his IRPA equals the LIRA-value at this location. This can thus be written as

$$\text{IRPA [fatalities yr}^{-1}\text{]} = \text{LIRA [fatalities yr}^{-1}\text{]} \cdot \text{probability of occupancy [-]}.$$

3.1.24
LIRA (localized individual risk per annum)
probability that an average unprotected person, permanently present at a specified location, is killed during one year due to a hazardous event

Note 1 to entry: This value is independent of any specific individual and is defined locally. This probability is defined for the locality in which the exposure is present. Since this value is determined for a specific location, it is possible to draw contours of equal LIRA-values (LIRA-contours) on a map. These LIRA contours are expressed in units of [fatalities yr^{-1} m^{-2}].

3.1.25
societal risk
collective risk measure for a group of people exposed to the hazard

Note 1 to entry: Societal risk reflects the society's point of view. In this perspective, very unlikely hazards with widespread consequence become important. For societal risk, the unit of risk is the loss of life per year. Societal risk is generally expressed by f-N curves

3.1.26
domino effect
cumulative effect produced when one primary undesired event sequentially or simultaneously triggers one or more secondary undesired events in nearby installations

Note 1 to entry: The domino effect can lead to overall consequences that are much more severe than the consequences of the initial incident. Due to the domino effect, the overall risk of close-by installations can be greater than the combined risk of each of the installations individually. The word domino in this context refers to the triggering of secondary incidents, not to a long chain of subsequent events.

3.1.27
f-N curve
relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards

Note 1 to entry: An f-N curve plots the annual frequency f of events which cause at least N fatalities against the number N on log-log scales.

3.1.28
ice throw
ice detaching from the rotor with an initial velocity

Note 1 to entry: The motion of the rotor blade of an operating wind turbine will impart a significant initial velocity to ice pieces shedding from the blade surface. This initial velocity affects the ice pieces' trajectory and their impact position on the ground.

3.1.29
ice fall
ice detaching from a turbine with no or very little initial velocity

Note 1 to entry: Ice shedding from the rotor blades of a stopped or idling wind turbine will have no or little initial velocity. The ice pieces' trajectories thus result solely from gravity and wind drift.

3.1.30
effect distance
maximum distance around a wind turbine at which a certain hazard originating from the wind turbine can be expected to have a relevant effect

3.1.31
tip height
hub height plus half of the rotor diameter

3.2 Symbols used in this document

R_{m}	Minimum endogenous mortality (MEM) rate	[yr^{-1}]
R_i	Maximum allowable additional mortality rate for hazard i	[yr^{-1}]
β	Policy factor for voluntariness and direct benefit	[-]
f	Cumulative frequency of N or more fatalities in an f-N plot	[yr^{-1}]
N	Number of fatalities in an f-N plot	[-]
a	Risk version factor; slope in an f-N plot	[-]
k	Constant factor in a f-N plot	[yr^{-1}]