88/982/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

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IEC TC 88 : WIND ENERGY GENERATION SYSTEMS			
SECRETARIAT: Denmark		SECRETARY: Mrs Christine Weibøl Bertelsen	
OF INTEREST TO THE FOLLOWING COMMITTEES:		PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.	
FUNCTIONS CONCERNED: ☐ EMC	☐ ENVIRONMENT	☐ QUALITY ASSURANCE	☐ SAFETY
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.		☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING	

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TITLE:

Amendment 1 – Wind energy generation systems – Part 1: Design requirements

PROPOSED STABILITY DATE: 2025

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES –

Part 1: Design Requirements

AMENDMENT 1

FOREWORD

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Amendment 1 to IEC 61400-1:2019 has been prepared by IEC technical committee 88: Wind energy generation systems.

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

Draft	Report on voting
XX/XX/XXXX	XX/XX/XXX

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/standardsdev/publications/.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

1 Normative references

2 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61400-1:2019 and the following 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

Add

damage equivalent load
Constant amplitude load derived from the load spectrum and a given S-N curve exponent that results in an equivalent fatigue damage

reference loads
The loads that had been utilised for detailed structural verification of the wind turbine components are called reference loads.

serviceability
ability of a structure or structural element to perform adequately for normal use under all expected actions

serviceability limit state
state which corresponds to conditions beyond which specified service requirements for a structure or structural element are no longer met

S1 - SLS characteristic load

serviceability limit state load level equal to the characteristic value of the loads from ultimate limit states classified as N (Normal)

S2 - SLS 10^{-4} frequent load case
serviceability limit state load level for frequent actions, which are exceeded for 10^{-4} of the lifetime,

S3 - SLS 10^{-2} frequent load case
serviceability limit state load level for the equivalent to frequent actions, which are exceeded for 10^{-2} of the lifetime.

3 Symbols and abbreviated terms

4.2 Abbreviated terms

Add

DEL Damage equivalent load, S_{eq}, determined from the approach that it leads to the same damage for a given reference number of load cycles, n_{eq}, as the real load spectrum under the assumption that the damage can be determined on basis of the load cycles from a linear S-N curve with a given slope, m. Let the discrete load spectrum be specified by the number of cycles n_i for the load S_i, $i = 1, 2, \ldots, n_S$. Then the equivalent load can be calculated from the equation

$$S_{eq} = \left(\frac{\sum_{i=1}^{n_S} n_i {S_i}^m}{n_{eq}}\right)^{1/m}$$

EM	Electro Magnetic
EMC	Electro Magnetic Compatibility
NTM90	Normal Turbulence Model, representative value of 90% percentile value of distribution

6.2 Wind turbine class

Replace paragraph 2 with

Class T assumes all wind model parameters to be the same and allows the combination of $V_{ref,T}$ with all turbulence categories. It does not cover all the areas prone to tropical cyclones. The evaluation of the 1-year return period storm wind speed should be done independently of the 50-year return period storm. A site assessment based on Clause 11 is needed, as a minimum assessing that V_{50} is below V_{ref} of class T ($V_{ref,T}$), and that V_1 is below the classification value.

6.3 Wind conditions

6.3.1 General

Replace paragraphs 3 and 4 with

The wind regime for load and safety considerations is divided into the normal wind conditions, which will occur frequently during normal operation of a wind turbine, and the extreme wind conditions that are defined as having a 1-year or 50-year return period.[1]

The wind conditions include a constant mean flow combined, in many cases, with either a varying deterministic gust profile or with turbulence. In all cases, an upwards inclination of the mean flow with respect to a horizontal plane of 8° shall be considered. This flow inclination angle shall be assumed to be invariant with height.

6.3.2.3 Normal turbulence model (NTM)

Replace the clause with

For the normal turbulence model, the turbulence standard deviation, σ_1, shall be defined for the standard wind turbine classes based on the Weibull distribution in equation (10) for the given hub height wind speed.

The Weibull distribution for σ_1 shall either be applied as a distribution with scale and shape parameters as in equation (11) or by the 90% quantile value in equation (12)[2]:

$$P_W\left(\sigma_1 < \sigma_0\right) = 1 - \exp\left[-\left(\frac{\sigma_0}{C}\right)^k\right] \qquad (1)$$

[1] The return period of the extreme event is independent of the design lifetime of the turbine as the largest value for the normal failure probability is given for a single year (see Annex K)

[2] The choice of NTM model affects the level of reliability against fatigue failure. Using the Weibull distribution is more robust for inclusion of non-linear effects, but the resulting fatigue loads have no bias and therefore result in a lower reliability level in most cases compared to using the 90% quantile value.

where

$$k = 0{,}27\ V_{\text{hub}}\,(\text{s}/\text{m}) + 1{,}4$$

$$C = I_{\text{ref}}\left(0{,}75V_{\text{hub}} + 3{,}3\ \text{m}/\text{s}\right) \tag{11}$$

$$\sigma_1 = I_{\text{ref}}\left(0{,}75V_{\text{hub}} + b\right);\quad b = 5{,}6\ \text{m}/\text{s} \tag{2}$$

Values for the turbulence standard deviation σ_1 and the turbulence intensity σ_1/V_{hub} are shown in Figure 1.

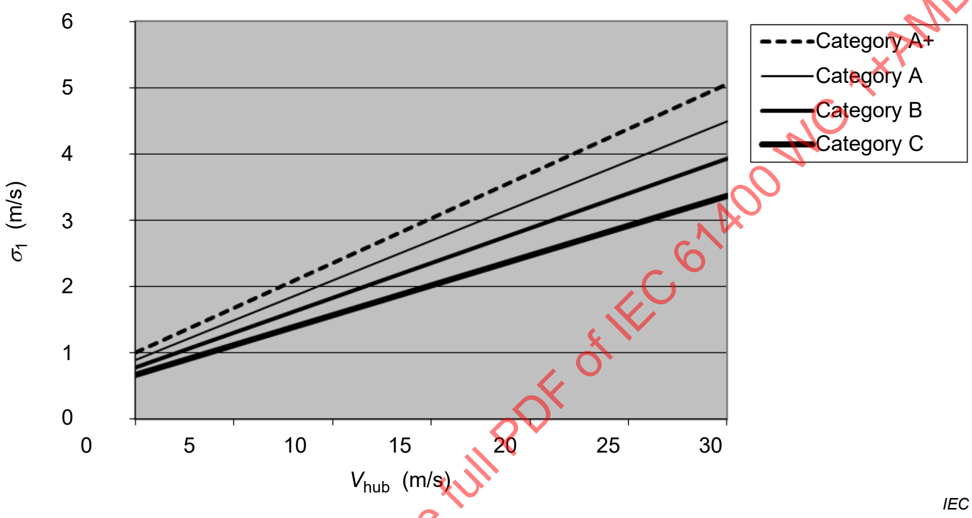

Figure 1a – Turbulence standard deviation

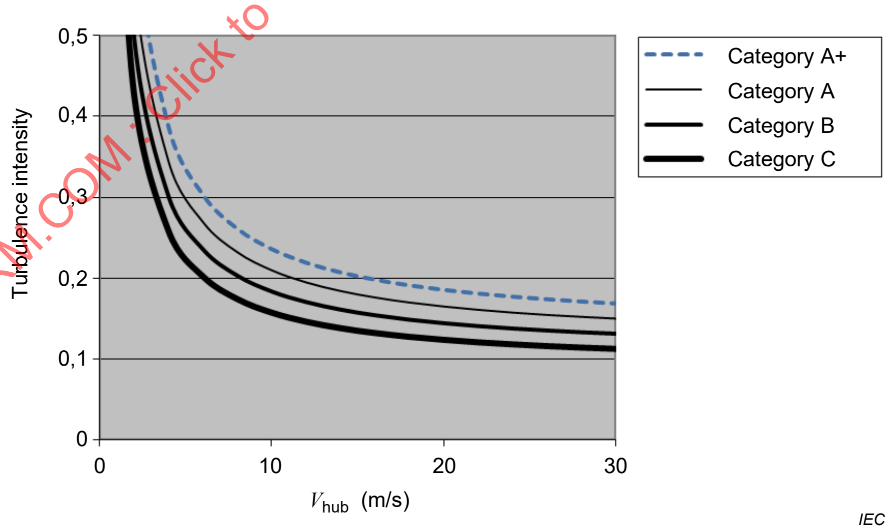

Figure 1b – Turbulence intensity

Figure 1 – Turbulence standard deviation and turbulence intensity for the normal turbulence model (NTM90 values)

Values for I_{ref} are given in Table 1.

6.3.3.2 Extreme wind speed model (EWM)

Replace paragraphs 1 and 2 including eqs.13 and 14 with

The EWM shall be a turbulent wind model. The wind model shall be based on the reference wind speed, V_{ref}, and a fixed turbulence standard deviation, σ_1. If the wind turbine type is designed for a T class reference wind speed, V_{ref} shall be replaced by $V_{ref,T}$ in the extreme wind speed model while keeping other parameters.

Replace footnote 3 with

3 The turbulence standard deviation for the turbulent extreme wind model is not related to the normal (NTM) or the extreme turbulence model (ETM).

7.4.1 General

Add after paragraph 5

Serviceability limit states (SLS) consider the function of the structure or one of its components under normal service conditions or the appearance of the structure.

Serviceability limit states should be verified with serviceability load levels S1, S2 or S3 as required in relevant IEC 61400 standard or technical specification.

For serviceability limit state analyses, S1 is derived from load simulations from the ultimate limit states classified as N (Normal) and for S2 and S3 the same load simulations are used as those used as basis for the fatigue limit state. The partial safety factor for loads shall be:

$$\gamma_f = 1,0 \qquad (1)$$

7.4.7 Parked (standstill or idling) (DLC 6.1 to 6.4)

Replace paragraphs 2 and 3 with

For design load cases, where the wind conditions are defined by EWM, the response shall be estimated using either a full dynamic simulation or a quasi-steady analysis with appropriate corrections for gusts and dynamic response using the formulation in ISO 4354. If slippage in the wind turbine yaw system can occur at the characteristic load, the largest possible unfavourable slippage shall be added to the mean yaw misalignment. If the wind turbine has a yaw system where yaw movement is expected in the extreme wind situations (e.g. free yaw, passive yaw or semi-free yaw), the yaw misalignment will be governed by the turbulent wind direction changes and the turbine yaw dynamic response. Also, if the wind turbine is subject to large yaw movements or change of equilibrium during a wind speed increase from normal operation to the extreme situation, this behaviour shall be included in the analysis.

In DLC 6.1, for a wind turbine with an active yaw system, a mean yaw misalignment of ±8° using the turbulent extreme wind model shall be imposed, provided restraint against slippage in the yaw system can be assured.

Delete paragraph 5: 'The partial safety factors for loads …'

Replace paragraphs 6 and 7 with

In DLC 6.3, the extreme wind with a 1-year return period shall be combined with an extreme yaw misalignment. A mean yaw misalignment of ±20° using the turbulent wind model shall be assumed.

If for the case DLC 6.2, yaw misalignment is evaluated using discrete values, the increment in yaw misalignment shall be not more than 10° in the sector of the maximum lift force on the blades.

7.6.1.3 Partial safety factor for consequences of failure and component classes

Replace paragraph 1 with

A consequence of failure factor, γ_n, is introduced to distinguish between:

a. component class 1: used for "fail-safe" components whose failure does not result in the failure of a major part of a wind turbine, for example secondary components and replaceable bearings with monitoring;

b. component class 2: used for "safe-life" components whose failures may lead to the failure of a major part of a wind turbine;

c. component class 3: used for "safe-life" components whose failure may lead to human injuries e.g. mechanical components that link actuators and brakes to main structural components for the purpose of implementing non-redundant wind turbine protection functions. Regarding blocking devices, see 7.4.9.

Add before last paragraph

For component class 3, the consequences of failure factor shall be γ_n = 1,2. If the characteristic value of the load response $F_{gravity}$ due to gravity can be calculated for the design situation in question, and gravity is an unfavourable load, the consequences of failure factor for combined loading from gravity and other sources may have the value

$$\gamma_n = 1{,}1 + 0{,}1\,\varsigma^2$$

$$\varsigma = \begin{cases} 1 - \left|\dfrac{F_{gravity}}{F_k}\right| & \text{for } |F_{\mathrm{gravity}}| \le |F_k| \\ 0 & \text{for } |F_{\mathrm{gravity}}| > |F_k| \end{cases}$$

where F_k is the characteristic load.

7.6.2.2 Partial safety factors for loads

Add to paragraph starting with 'When turbulent inflow is used …'

When the NTM is represented by a statistical distribution (equation 10 & 11) the characteristic value of the load shall correspond to the same return period as obtained using the 90% quantile value NTM90 (equation 12) except for DLC 1.1.

7.6.2.4 Partial safety factors for resistances where recognized design codes are not available

Delete footnote 17

7.6.2.5 Partial safety factors for materials where recognized design codes are available

Replace the clause with

Partial safety factors for resistance, γ_{M}, shall be applied as given in the recognized design codes, see 7.6.1.4. The partial safety factors for the consequences of failure, γ_{n}, shall be applied additionally as specified in 7.6.1.3.

7.6.3.4 Partial material factors where recognized design codes are available

Replace the clause with

Partial safety factors for resistance, γ_{M}, shall be applied as given in the recognized design codes, see 7.6.1.4. The partial safety factors for the consequences of failure, γ_{n}, shall be applied additionally as specified in 7.6.1.3. Alternatively, the provisions from section 7.6.3.3 may be used.

Add new clause 7.6.7

7.6.7 Evaluation of limit state through load comparison

As a simplified approach ultimate limit state analysis may be evaluated through a load comparison with a previously analysed design case. The reference loads shall always serve as the reference for a load comparison.

This comparison can be used to assess the suitability of an existing structural design for changed environmental conditions (as per clause 11.10) or for minor changes in turbine design (e.g..controller updates or modification in some other turbine components, e.g. tower). In case of a change of a major component the rest of the structure can be assessed based on a load comparison.

The following shall be considered as long as no component specific standards within the IEC 61400 series specifies otherwise.

For extreme loading, a comparison of contemporaneous loads is not required. All mandatory load cases shall be considered. The sign of the extreme load shall be considered when relevant.

For fatigue loading, the comparison may be based on DEL’s. The slope of the S-N curve shall be in alignment with the design analyses of each component.

The effect of mean loads shall be included if relevant.[3]

An exceedance of up to 5% in extreme loads and 3% in fatigue loads compared to the reference loads is acceptable.[4] In case of exceedances above the given tolerances, all design relevant load signals for the specific component shall be included in the comparison.

7.6.7.1 Rotor Blade

The comparison shall include a subset of blade sections and load directions representative for the design.

If there is no relevant data/information available, at least the blade sections blade root, max chord, blade mid and outer third of the blade length and blade flanges shall be considered.

7.6.7.2 Machinery structures and drive train components

For fatigue loading, equivalent loads calculated from the LDD or LRD shall be considered additionally for rotating components like gearboxes, bearings, pitch and yaw systems.

7.6.7.3 Tower and Foundation

[3] If the mean load has a substantial contribution to the fatigue damage and it is driven by the wind speed, and if the mean wind distribution differs significantly from the design conditions, then it is relevant to consider the effect. Especially bolted flange connections may be critical.

[4] The impact of these tolerances on the COV’s for loads and the probability of failure is negligible. In case of safety factor calibration according to Annex K, these tolerances need to be considered as an additional random variable on the load side, with a COV equal to the tolerance.

The comparison shall include loads extracted at representative locations of the tower sections, at least the tower top, tower bottom and if applicable at tower sections, which show a significant change in structural properties (e.g. transition sections in hybrid towers).

S3 bending moment (S3 limit state as per IEC61400-6) for concrete parts shall also be compared.

7.6.7.4 Blade deflection and tower clearance

The comparison shall include a check of the minimum tower clearance.

10.12 Electro Magnetic Compatibility (EMC)

Replace paragraph with

10.12.1 Introduction

This clause describes the design requirements for wind turbines regarding electromagnetic immunity and electromagnetic emissions with respect to Electro Magnetic Compatibility.

This includes the design phase evaluation of immunity against EM disturbances generated by EM phenomena of all occurring kind, and the reduction of EM emissions to protect radio services and in general the protection of the electromagnetic spectrum.

Furthermore, guidance is given to structure the design documentation in an organized way in Annex N.

This documentation, EMC technical documentation, can be (re-)used as a base for final verification and validation purposes which later can be expanded if needed.

The local EMC environment is referring to the EMC environment inside the wind Turbine.

Site specific EMC environment does vary due to the different geo location(s).

The manufacturer can define the wind turbine family definitions used for the designs. When using such family grouping, the EMC properties within a family definition can vary due to design differences. This shall be documented by showing equal EMC performance of the products within the family group.

Generic definitions with regards to Electro Magnetic Compatibility:

- As a minimum, a wind park can consist of 1 turbine + infrastructure. Typically, a wind park consists of multiple wind turbines and their respective infra structure(s).
- At the highest abstraction level, a wind park can be defined as an (large) installation.
- The wind turbines used in a wind park are typically industrialized series produced large equipment which can be placed at different locations.
- Offshore wind parks are in general closed restricted area(s) meaning the number of radio systems which can be disturbed is very small or near zero, and relaxations in the emissions might be possible. (CISPR-H)

10.12.2 EMC design requirements

The wind turbine shall be designed and manufactured in such way that Electro Magnetic Compatibility is ensured. It includes all individual electrical equipment and components containing electronics which are part of the wind turbine as well as the total wind turbine. A holistic approach is required to ensure Electro Magnetic Compatibility.

The minimum basic requirements for complete turbine and its constituent components shall be IEC 61000-6-2 for immunity and IEC 61000-6-4 for emission.

To ensure compatibility of the wind turbine, the manufacturer of wind turbines shall evaluate and document the possible EMC phenomena. If needed, mitigations must be implemented. This can result in additional EMC requirements and mitigations parallel to, or on top of IEC 61000-6-2 + IEC 61000-6-4.

When using safety critical or functional safety equipment etc., additional requirements apply.

Wireless technology is advancing in the modern world. EMC and other regulatory aspects shall be evaluated when intended radiators and receivers are incorporated into the design of a wind turbine.

Possible negatively impacted communication systems due to electromagnetic emissions from the wind turbines and their occurrence shall be evaluated.

Electrical sparking is a severe source of EM emissions and possible disturbances as well a known risk factor for fire and generating the corrosive gas Ozon (O3). With regards to EMC, electrical sparking shall be reduced to the minimum, preferably avoided.

The manufacturer has the full responsibility to mitigate these EMC phenomena/effects to ensure compatibility of the wind turbine. Design and production must be aligned to ensure equal level and quality of EMC performance.

Detailed EMC documentation of the used equipment and components is required as part of the overall EMC design evaluation. An EMC Technical Documentation shall be compiled to document the design from an EMC perspective[5].

Annex N contains references regarding EMC Technical Documentation, evaluation examples and some guidance for clause 10.12.

11.3.2 Wind condition parameters

Replace paragraph 5 with

In regions prone to hurricanes[6], cyclones and typhoons, the extreme wind speed shall be evaluated by appropriate methods, for example as given in Annex J.

To be added to footnote 31

Adjustments of either the load partial safety factors or the extreme 10 min average wind speed, V_{50}, are optional and not required for compliance with this standard.

11.3.4 Data evaluation

Replace paragraph 3 with

The average value of the wind speed standard deviation $\hat{\sigma}$, i.e. the standard deviation of the longitudinal turbulence component, and its standard deviation $\hat{\sigma}_{\sigma}$ shall be determined using appropriate statistical techniques applied to measured data[7].

11.9.2 Assessment of the fatigue load suitability by reference to wind data

Replace bullet b) with

---

[5] Further EMC requirements and measurement methods are going to be described in the product standard IEC 61400-40. Example: Radiated emissions in the range of 150KHz – 30MHz, 30 MHz – 1 GHz and the according measurement methods for the different frequency ranges used. Advancements regarding in situ emission requirements and methods for high power and large equipment are ongoing in the development of ISM product family standard CISPR 37 and CISPR 11.

[6] Attention should be given to other wind flow conditions (flow downstream of elevations, low level jets, thunderstorm downburst…) that may be relevant for the turbine loads at the site but had not been considered in the design.

[7] Linear de-trending may be applied, but unless the trend is included in the load simulation, wind statistic based on de-trended data may lead to underestimation of loads due to missing the long term trend.

a) An adequate assessment of the ambient turbulence intensity and wake effects can be performed by verifying that the wind speed standard deviation σ_1 from the normal turbulence model (NTM) used in design is greater than or equal to the effective wind speed standard deviation $\hat{\sigma}_{\text{eff}}$ (see Annex E) between the wind speeds V_{ave} and $2V_{\text{ave}}$, i.e.

$$\sigma_1 > \hat{\sigma}_{\text{eff}} \left(= I_{\text{eff}} V_{\text{hub}}\right) \qquad (3)$$

If a Weibull distribution is assumed for σ_1, then the damage equivalent wind speed standard deviation $\sigma_{1,DE}$ from the normal turbulence model (NTM) shall be used instead of σ_1, with

$$\sigma_1 = \sigma_{1,DE} = \left(\sum_{i}^{N_\sigma} p_i {\sigma_{1,i}}^m\right)^{\frac{1}{m}}$$

where

p_i is the probability of the considered turbulence bin, i

$\sigma_{1,i}$ is the wind speed standard deviation of the considered turbulence bin, i

N_σ is the number of turbulence bins

m is the Wöhler curve exponent corresponding to the material of the considered structural component

Guidance for calculating □eff can be found in Annex E. In case of complex terrain, the estimated wind speed standard deviation shall be increased in order to account for the distortion of the turbulent flow. This can be done by additional multiplication with a turbulence structure correction parameter CCT as defined in 11.2.

Replace bullet c) with

b) The site flow inclination taken as the wind energy weighted mean from all directions, shall be between –8° and +8°. Where there are no site data or calculations for the flow inclination, it shall be assumed that the flow inclination is equal to the slope, θ, for the 30° sector within a distance of $5z_{\text{hub}}$ or the $5z_{\text{hub}}$ area extended by $2z_{\text{hub}}$ downwind of the wind turbine position from the wind turbine, see 11.2.

Replace bullet e) with

a) The average site air density shall be less than the one specified in 6.4.2 for wind speeds greater than or equal to V_r. As an alternative, for an air density greater than the one specified in 6.4, it shall be demonstrated that the following condition applies:

$$\rho_{design}\, V_{ave,design}^2\, cos^2\phi_{design} \geq \rho\, V_{ave,site}^2\, cos^2\phi_{site} \qquad (4)$$

11.9.3 Assessment of the ultimate load suitability by reference to wind data

Replace bullet b) with

b) The site estimate of the extreme 10-min average wind speed V_{50} at hub height with a return period of 50 years shall be less than or equal to V_{ref} adjusted to the site specific air density and site flow inclination. If the only input basis for the site assessment is an extreme 3s average wind speed $V_{50,3s}$ at hub height, the 10-minute average V50 may be determined using equation

$$V_{50} = \frac{V_{50,3s}}{k_T}$$

where k_T= 1.28, derived from $k_T = 1 + g_v I_v$ (see ISO 4354), g_v = 2.56 and $I_v = \sigma_1/V_{hub} = 0.11$, see Equation 17.

V50 shall be modified according to Footnote 31 when the coefficient of variation of the annual maximum wind speed is larger than 15 %. For that purpose, it shall be demonstrated that the following condition applies:

$$\rho_{design} \cdot V_{ref}^2 \cdot \cos^2 \phi_{design} \geq \rho_{site} \cdot V_{50,hub}^2 \cdot \cos^2 \phi_{site} \qquad (5)$$

In case of T classification where V_1 is not defined in accordance with eq (15) and (16), in addition to the V_{50} comparison described above, design V_1 shall be evaluated against the corresponding site levels in a similar way.

11.10 Assessment of structural integrity by load calculations with reference to site-specific conditions

Replace paragraphs 1 and 2 with

The demonstration shall comprise a comparison of loads and deflections according to 7.6.7 calculated for the specific wind turbine site conditions. The calculations shall account for variations of wind conditions with mean wind direction and speed as well as for wake effects, vertical wind shear, mean wind flow angle, etc.

Replace paragraphs 7 and 8 with

Ultimate limit state analyses shall be performed if one of the criteria in 11.9.3 fails. As a minimum, turbulence (NTM and ETM) and extreme wind conditions (EWM) shall be evaluated, for which the following ultimate design load cases shall be assessed: DLC 1.1, DLC 1.3, DLC 6.1, and DLC 6.2. If the design load cases are covering the different operational events characteristic for the site of interest, no further evaluations need to be performed.

Annex B provides definitions of the aforementioned ultimate and fatigue load cases for site-specific conditions. In case of wind turbines located at sites subjected to cold climate conditions, earthquakes, wake effects or LVRT exceeding the design conditions, the corresponding relevant load cases DLC1.6, DLC1.7, DLC1.8, DLC2.5, DLC6.5, DLC6.6 or DLC6.7 in Table B.1 should be considered. Other design situations 2), 3), 4), 5), 7) and 8) in Table B.1 only need to be considered when the control system behaviour and transport, assembly, maintenance and repair procedures are site-dependent.

For turbines designed with standard classes in Clause 6 the load cases using ECD, EDC, EOG and EWS do not need to be considered in the site assessment.

For Class S designs, the load cases using ECD, EDC, EOG and EWS do not need to be considered in the site assessment if those load cases were considered for the design with air density, wind shear and flow angle values of the standard classes in clause 6, and the value of σ_1 for the gusts used in these design load cases was equal or larger to the value of σ_1 for the ambient NTM (non-wake conditions) used for the design[8].

Annex B

B.1 General

Replace paragraph 6 with

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[8] If ECD, EDC, EOG and EWS are to be considered in the site assessment, they may be considered with the standard class values in clause 6 of air density, wind shear and flow angle, and site specific representative ambient turbulence if no further information of gusts at the site is available.

As stated in 11.10 for site suitability assessment, site suitability assessment as a minimum turbulence (NTM and ETM) and extreme wind conditions (EWM) shall be evaluated, for which the following ultimate design load cases shall be assessed: DLC 1.1, DLC 1.3, DLC 6.1, and DLC 6.2. If the design load cases are covering the different operational events characteristic for the site of interest, no further evaluations need to be performed. In case of wind turbines located at sites subjected to cold climate conditions, earthquakes, wake effects or LVRT exceeding the design conditions, the corresponding relevant load cases DLC1.6, DLC1.7, DLC1.8, DLC2.5, DLC6.5, DLC6.6 or DLC6.7 in Table B.1 should also be considered in the assessment.

Other design situations 2), 3), 4), 5), 7) and 8) in Table B.1 only need to be considered when the control system behaviour and transport, assembly, maintenance and repair procedures are site-dependent.

Load cases using ECD, EDC, EOG and EWS in Table B.1 are only relevant for design purposes of Class-S wind turbines.

B.2 Power production (DLC 1.1 to 1.9)

In table B.1reference to footnote 25 in the abbreviation $_{ETMs}$ with reference to footnote 32.

Replace paragraph 5 with

In DLC 1.6, the assessment of loads resulting from the ambient site-specific ETM_s model in combination with an inter-turbine wake condition shall be assessed. The combined probability of ambient turbulence and waked turbulence shall have a return period of at least 50 years. The inter-turbine spacing S shall cover the worst loading conditions between a minimum spacing S_{min} (to be defined by the manufacturer) and S = 20D, where D is the turbine rotor diameter.

Alternatively, wake effects may be considered in the evaluation of DLC 1.1 in which case DLC 1.6 may be omitted.

Annex E

Add the following below formula E.3 and the list of variables:

Consistent with 6.3.2.3, the effective wind speed standard deviation might alternatively be calculated using the site-specific Weibull distribution of the ambient turbulence. In that case the representative turbulence in equation (E.3), $\hat{\sigma}_c$, should be calculated from the following formula,

$$\hat{\sigma}_c = \left(\sum_{i}^{N_\sigma} p_i {\sigma_i}^m \right)^{\frac{1}{m}} \quad \text{(E.XX)}$$

where

p_i is the probability of the considered turbulence bin, i

σ_i is the wind speed standard deviation of the considered turbulence bin, i

N_σ is the number of turbulence bins

If the representative turbulence, $\hat{\sigma}_c$, is calculated from equation (E.XX) then, the corresponding effective turbulence, I_{eff}, found from equation (E.3) must not be used for load calculations, it may only be used for comparison of damage equivalent turbulence intensities.