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IECRE
OPERATIONAL DOCUMENT

IEC System for Certification to Standards relating to Equipment for use in Renewable Energy applications (IECRE System)

Conformity Assessment and Certification of Loads by RECB's

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INTERNATIONAL
ELECTROTECHNICAL
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CONTENTS

1. Introduction and objectives

The objective is the definition of the methods and procedure used for assessment of loads within the design evaluation module for type certification and as far as applicable for component certification.

For fulfilling the type certification scope a load verification by comparison of load simulations with load measurements is additionally required. This verification by comparison is scope of the type testing module and therefore not covered in this OD.

2. Codes and standards

The following referenced documents are normative for type certification of onshore, small and offshore wind turbines respectively. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61400-1, Wind turbines – Part 1: Design requirements

IEC 61400-2, Wind turbines – Part 2: Design requirements for small wind turbines

IEC 61400-3: Wind turbines – Part 3: Design requirements for offshore wind turbines

The load measurement program shall be developed considering:

IEC 61400-13: Wind turbines – Part 13: Measurement of mechanical loads

3. Documentation Requirements

Design basis report(s)

The design basis report(s) shall include information on codes and standards, wind turbine class as well as methods and calculation programs to be applied for the load analysis.
Furthermore information regarding the used turbulence model(s) and wave model(s) including their main parameters and the software used to create synthesized wind and/or wave fields shall be provided.
In case a wind turbine class S is chosen, the design parameters for describing wind turbine class S shall be part of the design basis report(s).
Other relevant information like seismic data, icing conditions or grid conditions to be considered in the design may also be included.
Design life as well as requirements for transport, installation and maintenance of the wind turbine, including locking devices and admissible wind speeds shall be specified in the design basis report(s).
Assumptions made for parameters influencing the loading but not covered by the type certificate shall be documented in the design basis reports. For onshore wind turbines, this covers at least the assumed geotechnical parameters / foundation stiffness. For offshore wind turbines additionally the assumed wave, current and tidal environmental parameters as well as wind-wave misalignment shall be included in the design basis. Furthermore, the wave kinematic and loading models and methods shall also be described. Specific parameters as marine growth, member flooding, hydrodynamic resistance of secondary structures, corrosion allowance, scour etc. may be addressed in the design basis.
The design basis report(s) shall also include definition of load cases, especially wind turbine specific cases, like special fault situations etc. as well as information on the number and set-up of load cases and choice of random seeds for stochastic wind and wave models.
Software tools and methods used for post-processing shall be described in the design basis report(s) including ultimate partial safety factors, extrapolation methods and processing of fatigue time series.

Design load documentation

The loads relevant documentation for the Design Evaluation module shall at least include the following:

- General turbine description: Overall dimensions, general drawings, wind turbine class, power curve, cut-in and cut-out wind speed, rotor speed, etc.

- Model(s) and software used to create environmental inputs shall be described. The turbulence and wave model theories used for the simulation shall be stated. The software for transferring wind and wave/current to time series in grid points for further load analysis shall include software name, version, description of mathematical models used to correctly account for coherence, turbulence and wave spectra and other parameters as wave spreading.

- The software used for the load analysis shall be described including name and version. It shall also contain a description of models used for aerodynamics (basic model, tip/hub loss model, dynamic wake model, skewed wake model, high thrust model, dynamic stall model, 3D effect model), structural dynamics, and hydrodynamics if applicable.

- Documentation including or referring drawings and specifications defining the structural system (geometry, mass, stiffness, eigenfrequencies, damping, aerodynamic properties of the rotor blade) in sufficient detail to assess the load analysis and to build an independent load calculation model. Foundation characteristics (upper and lower bound) including damping properties shall be defined. The documentation shall also include information on tolerances relevant for the load analysis such as blade geometry tolerances, blade mass distribution tolerances as well as tower inclination.

- All relevant input parameters and references allowing identifying the state of data used, including at least information regarding the braking system, mechanical and electrical efficiencies, tower head mass, mass moment of inertia of the generator, electrical and mechanical efficiencies, transmission ratio in case of geared drive trains, etc. Furthermore a load case table and reference to load case definition in the design basis, the coordinate systems used shall be included.

- Models for electromechanical components, such as the generator, pitch and yaw systems including torque limits, efficiency, friction, inertia, electrical models and structural flexibility.

- A Campbell diagram and for dynamically critical turbines (e.g. with soft-soft support structure, with blades, which are designed to change twist based on aerodynamic loading, for one- or two bladed wind turbines or in case of uncommonly high blade tip speeds) a diagram showing the wind speed dependent damping values of all modes (rotor speed and pitch angle to be chosen according to the steady-state) shall be provided.

- Information regarding vibration monitoring in case of resonance or description of methods for resonance avoidance shall be given.

- The documentation for how the vortex induced vibrations is taken into account.

- The documentation of the control system shall be provided in order to enable the certification body to carry out an independent analysis of the load assumptions and the control system algorithm and if necessary to build up an independent turbine controller model (fully or partly). It shall include the following elements:
  - Written description of the controller algorithm
  - Control system model as machine-readable code with description of input/output-interface and identification of the control system revision
  - Control system parameters
  - Turbine reactions, e.g. brake programs
  - Actuator models, e.g. hydraulic or electrical actuators

- The methods used for post-processing shall be described including partial safety factors for loads, extrapolation methods and processing of fatigue time series.

- The results of the load analysis shall include at least ultimate loads and damage equivalent fatigue loads as well as other load data required for the design of the main components of the wind turbine.

- Complete load time series in electronic form including documentation of the binary data format used and any additional information needed to interpret the data (e.g. sensor file).

Load measurement program

The load measurement program according to IEC 61400-13 or IEC 61400-2 to be used for type testing of the wind turbine shall be submitted. The test program shall also consider specific issue for the actual wind turbine e.g. issues revealed during the load assessment. The result from the load measurements shall be used for verification of the load calculation model, preferable validating the important natural frequencies, load levels, fatigue loads etc. by one to one comparisons between measured and calculated values.

4. Evaluation methods and procedures

The certification body shall evaluate the documentation including design basis, load documentation and measurement program for compliance with IEC 61400-1, IEC 61400-2 or IEC 61400-3 through document review supported by independent analysis. The assessment shall include:

- Evaluation of the design basis for completeness and compliance with the selected codes and standards.

- Evaluation of suitability of design load cases with reference to the control and protection system of the wind turbine.

- Evaluation whether the applied load cases include all relevant design load cases according to the selected standard and evaluation whether the load cases are correctly assigned to design situation, abnormal/normal/transport load cases and with respect to the applied wind conditions.

- Evaluation of suitability of the simulation models used as a basis for the load analysis. The aeroelastic model shall include a sufficient level of detail of the support structure and RNA. The number of degrees of freedom, kinematic degrees of freedom, structural damping, stiffness, mass contributions, output stations/sensors and simulation time-steps shall also be considered in the evaluation.

- The implementation and consideration of aerodynamics and environmental conditions in general is a key feature to gain reliable load conditions after simulation. By means of submitted information on the software the certification body shall evaluate if a proper approach and appropriate aerodynamic properties were chosen.

- Verify by comparison that the simulation model including the control system model complies with the description of the wind turbine and the wind turbine control system. Evaluation of load analysis by comparison of design driving extreme and fatigue loads for relevant load sensors by independent comparative aero-elastic load calculation.

- Due to the non-linear flexible and dynamic behaviour of a wind turbine, it is required to perform an independent calculation in order to support the verification of the results from the manufacturer’s load simulations.

- Evaluation of basic control system behaviour by means of an independent comparative/representative controller model as part of the independent load analysis or as a separate independent analysis of the control system.

- The results from the independent load analysis shall be used to support the evaluation of the manufacturer’s load report(s) through comparison of the response i.e. loads and deflections as well as dynamic response through FFT analyses.

Independent Load Analysis (ILA)

For each turbine type (ref. CBC clarification sheet 4C) an ILA shall be performed. For minor turbine variants (e.g. different hub height) a reduced scope of ILA may be performed as long as the designer uses the same aeroelastic code as in previous load sets and as long as the overall dynamic and aeroelastic behaviour of the turbine variant is similar to a large extent.

The ILA shall preferably be performed using a different aeroelastic code than the one used by the designer. Also the pre- and post processing as well as the generation of e.g. turbulent wind fields, wave time series, hydrodynamic coefficients and other relevant data shall preferably be done using different codes than used by the designer as far as possible. The aeroelastic code used in the ILA shall be validated and respective documentation shall be available. The validation may be performed by the developer of the aeroelastic code or by the CB itself.

The aeroelastic model used in the ILA shall be independently built-up. If electronic data is used directly or automatically converted (e.g. blade data, tower data), the correctness of this data shall be verified against approved documentation.

The ILA shall cover the following aspects, which shall be compared against results obtained by the designer:

- dynamic behaviour (coupled eigenmodes, damping and decay, aeroelastic stability);
- fatigue loading (including a reduced set of operating load cases, idling load cases, stop load cases and where relevant other fatigue load cases). Comparison of fatigue load levels shall include at least 1Hz equivalent loads of individual bins and damage equivalent loads considering all fatigue load cases; and
- ultimate loading (including a reduced set of extreme turbulence load cases, error load cases, extreme wind load cases and other relevant load cases). Comparison of ultimate load level shall be done per load case as well as for the entire load level.

The ILA shall show a good agreement of the dynamic behaviour and load levels. Deviations, which exceed those to be expected due to the use of different aeroelastic tools, reduced set of load cases and reduced effort for optimization, shall be investigated and only accepted based on investigation of the cause of the deviation and if relevant an investigation of the associated risk.

5. Reporting

The evaluation report(s) issued by the RECB's shall cover the following:

1 Introduction
  1.1 Scope of evaluation
  1.2 Design basis
  1.3 Load assessment
  1.4 Independent load analysis (may be expanded in an appendix)
2 Documentation
  2.1 Reports
  2.2 Specifications
  2.3 Drawings
  2.4 Documentation for information only
3 Evaluation
  3.1 Design basis
  3.2 Load cases

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