IECRE OD-501-5

Edition 1.0 2017-09-12

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 Control and Protection System by RECB

IECRE OD-501-5:2017

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.
Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IECRE OD-501-5

Edition 1.0 2017-09-12

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 Control and Protection System by RECB

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE ZZ

CONTENTS

1 Acronyms

Acronym	Description
IECRE	IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications
RECB	Renewable Energy Certification Body
PL	Performance level
SRP/CS	Safety–related part of a control system
MTTFd	Mean time to dangerous failure
DC	Diagnostic coverage
DCavg	Average diagnostic coverage
CCF	Common cause failure
EMC	Electromagnetic compatibility
PL	Performance level
SIL	Safety integrity level

For further information see IECRE Publication “Acronyms, Terms and Definition”

2 Introduction and Objectives

Wind turbine operation and safety shall be governed by a control system. The control system is implementing the turbine control functions (primary layer control functions and secondary layer protection functions), including sensors, logic elements, actuators, communication networks, and power supplies. The intent of the control system is to control operation of the turbine by active and passive means and keep the operating parameters within the limits assumed in the structural design.

The control system shall keep the wind turbine in the intended operating state. The functions of the control system which ensure that a wind turbine remains within the design limits are considered as secondary layer protection functions.

This operational document describes the method and procedure for the evaluation of the design basis and the design evaluation of the control system for a wind turbine.

3 Norms 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 following standards may be used for documentation of the control system design:

IEC 60204-1: Safety of machinery – Electrical equipment of machines – Part 1: General

IEC 62061: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

ISO 13849-1: Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design requirements

ISO 13849-2: Safety of machinery – Safety-related parts of control systems – Part 2: Validation

4 Required Documentation

For the certification process it is required to submit the following information for evaluation:

- Design basis including norms and standards as well as requirement specification for the wind turbine and its control system
- Description of the wind turbine
  (Type designation, general layout and functional principles)
- Description of the control system concept and the control system
  (Structure of the control system, sequences of the start and stop procedures, behaviour of the turbine during normal operation and on detection of malfunctions, statement of trigger criteria)
- Document specifying other parameters in the operation management that influence the loads of the wind turbine
  (Cut in and cut out wind speeds, rotational speed, power temperatures etc.)
- Description of the procedure for manual intervention after the activation of any protection functions
- Document specifying software version and all the safety relevant and load relevant parameters set in the control system and their relation to the load analysis
  (Numerical values)
- Description of software logics
- Description of the sensors and (if applicable) measuring transducers of the control system
  (Type designation, setting values, time constants)
- Description of the braking systems and their behaviour
  (Structure of the braking systems, mode of operation, characteristic quantities, time constants ...)
- Calculation of the capacity of the braking systems
  (Braking moments, heat equilibrium, capacity of accumulators, dimensioning/capacity of the drives ...)
- Functional description of the locking devices
- Description of other critical systems/features relevant for the control system such as condition monitoring system, ice detection system, heating systems etc.
- Electrical and hydraulic circuit diagrams
  (At least to an extent that all hardware that performs protection functions is shown and the connection between electrical and hydraulic systems is clearly recognizable)

- Detailed description of the software used in the control system
  (software development, validation procedure and software release process)

- Fault consideration of the control system including failure mode and effects analysis required for critical complex systems. All components that take part in performing protection functions shall at least be covered by this consideration.
  (Description of all possible faults in control system, braking system, communication between devices, EMC protection, type of detection, effects and measures for limiting negative consequences. ISO 13849 or IEC 62061 may be used for this purpose)

- Documentation of the required risk reduction through protection functions when using ISO 13849 or ISO 62061 for design of the control and protection system
  (Calculations of performance levels or safety integrity levels of protection functions)

- Test plan for the safety and function tests

- Description of the control software used for load simulation.
  (Interfaces to the load analysis such as program modules for blade pitching as well as identification of critical load cases e.g. DLC 2.X)

- Description of the process that ensures that the control system (incl. software) on the wind turbine has the same behaviour as modelled in the load simulation

- Preliminary manuals, limited to relevant parts of the control system

For the certification process it is recommended to submit the following information for evaluation:

- One table that lists up all safety functions including each required performance level (PLr)

- A safety-related block diagram including possible subsystems for each safety function

- A circuit diagram (electric, hydraulic, pneumatic) showing the wiring of all Safety- Related Parts of the Control System (SRP/CS) performing the safety functions

- A list of all safety function/subsystem which lists up the performing SRP/CS including the parameters the calculation is based on (e.g. MTTFd, DC, etc.)

- For reasons of clarity and comprehensibility the following evaluation results should also be listed in a table:

  a. performance level (PL) for each safety function

  b. subsystems belonging to each safety function, if existing

  c. parameters the calculated PL is based on (e.g. MTTFd, DCavg, Category)

5 Evaluation Methods and Procedures

The certification body shall evaluate the design basis and the documentation for the design of the control system.

The design basis shall be evaluated with respect to wind turbine specification, codes and standards, design methods/principles and general design parameters as well as other specific requirements for the control system.

The documentation listed in chapter 4 of this OD shall be reviewed and evaluated for compliance with the design basis. This will also include:

The documentation of the design properties of the control system shall be evaluated for compliance with the agreed requirements preferably defined in the design basis. The documentation shall include an FMEA or equivalent for critical complex systems.

The methods described in ISO 13849 or ISO 62061 shall be applied as considered in IEC 61400-1.

For emergency stop button function the method as per ISO 13850 shall be applied.

The documentation for design, functionality and if relevant the reliability of control devices/components shall be evaluated. The safety related control circuits shall be evaluated for compliance with the design basis.

The system logic and/or software used in the control system (e.g. safety logic control software or pitch converter software) shall be evaluated for compliance with the design basis and requirements identified during the design process.

Control functions/systems/components designed according to ISO 13849 shall be evaluated for compliance with the derived PL_r (required performance level) or for IEC 62061 with the derived SIL (safety integrity level).

The software quality assurance management including the management of software updates (e.g. access, software transfer and qualified personnel) shall be evaluated.

The locking, braking and other relevant system(s) shall be evaluated according to the design basis.

The fault consideration shall be evaluated for CCF (e.g. software bugs or EMC). Guidance can be taken from ISO 13849 or IEC 62061.

The preliminary manuals or equivalent documentation for the control system including error codes, actions, limits, parameters for activation, reset etc. shall be evaluated.

The test plan for the verification of the control system functions including plan for the safety and function test shall be evaluated for compliance with the design basis and considering the final design of the control system. The requirements for safety and function tests are described in the following chapter.

5.1 Requirements for safety and function tests

5.1.1 General

The purpose of the safety and function tests element of wind turbine type certification is to verify that the wind turbine under test displays the behavior predicted in the design. This chapter describes the general requirements for conducting these tests.

The certification body shall verify satisfactory demonstration of the control system functions with reference to the test plan approved in the design phase. The test plan shall at least include testing of the control functions below. In addition, the dynamic behavior of the wind turbine at rated wind speed or above shall be verified by testing if this has not been verified within the scope of the load measurements. The safety and function tests shall include functions with a single fault in the control system.

5.1.2 Definition of control functions

The control functions shall be in accordance with IEC 61400-1 and shall be defined in the design documentation. The objective of the safety and function tests is to verify the proper implementation of control functions.

5.1.3 Test plan

The plan for the safety and function tests shall include the critical functions of the control system that requires test verification, as described in the design documentation.

These critical functions shall at least include

- primary layer control functions in connection with
    - loss of grid,
    - emergency switching off,
    - turbine over speed, and
    - other critical stop situations revealed during design,
- secondary layer protection functions in connection with
    - one fault in the primary control system,
    - loss of grid, and
    - emergency switching off,
- normal operation of the turbine control functions in connection with
    - important design criteria defined in connection with the design i.e. for example pitch position for a pitch regulated turbine.

The certification body shall verify satisfactory demonstration of the control system, focused on the items above.

Further to these tests, it can be relevant in accordance to the design documentation to include one or more of the following situations:

- emergency shutdown during operation with no additional faults;
- operating vibration levels and excessive vibration protection;
- over speed protection at rated wind speed or above;
- start-up and shutdown above rated wind speed;
- yaw control (including cable twist);
- testing the situations described above in the first three bullets for wind speeds above rated power.

The basis for this testing is the design documentations and simulation. The test report may include simulation of the tested event; including the actual conditions (i.e. wind speed, turbulence, wind shear etc.). Each test shall be described in the test plan. In many cases, several component failure modes or critical events will lead to similar behavior of the control system and may be covered by a single test.

For each test, the test plan shall detail the physical quantities to be measured, the instrumentation and data acquisition system and the calibration and operational settings for the control system, any required special actuators, solenoids, or electrical switches if necessary, and all external condition requirements associated with the test.

Procedures for conducting each test, including appropriate safety measures, shall be described in the test plan. Also, as part of the test plan, the operating body shall identify the criteria for acceptable wind turbine system behavior (including dynamic behavior). This will typically be found in

the design documentation. These criteria shall be subject to approval by the certification body and the applicant.

The certification body shall further verify that the descriptions given in the test plan are adequate for successful implementation of the test.

5.1.4 On-site test activities

The test shall be carried out in accordance with the approved test plan. Any modifications to the test plan, which are found to be necessary during the test, shall be documented and subject to approval.

5.1.5 Analysis and reporting

A test report shall be prepared. The test reports shall conform to the requirements of ISO/IEC 17025 and relevant standards used to define the test requirements. In addition, test reports shall include a description of:

- the wind turbine or component, with identification by means of serial number (and control system software revision number(s), where applicable);
- any differences between the wind turbine or component under test with the corresponding part included in the certification; and
- any significant unexpected behavior.

The data analysis shall also minimally include time series plots of each critical physical quantity measured and either a table of computed values of statistical measures of the data variability (including maximum and minimum values) or suitable statistical graphs such as histograms, exceedance curves or power spectral densities. The analysis shall include identification of the critical overall system natural frequencies displayed in the data. The reported information shall establish that the purpose of the test has been fulfilled and that the agreed acceptance criteria have been met.

6 Reporting

The evaluation report shall cover the following:

1 Introduction

  1.1 Short description of the scope of the certification activity

  1.2 Design basis

  1.3 Design evaluation

2 Documentation

  2.1 Reports

  2.2 Specifications, data sheets

  2.3 Drawings, schematics, flow charts

  2.4 Documentation for information only

  2.5 Test plan

3 Design basis evaluation

4 Design evaluation

Reference to customer documents on the following issues:

4.1 General description including modes of operation (principles, methods, environment…)

4.2 Fault analysis (FMEA, ISO 13849…)

4.3 Devices/components (sensors, actuators, hydraulic valves, emergency stop, controllers…)

4.4 Software and system logics (algorithms, flow charts, quality management, settings)

4.5 Locking, braking and other systems (condition monitoring, heating, ice detection…)

4.6 Test plan (safety and function test, workshop tests, etc.)

4.7 Preliminary manuals (set point lists, remote control, error codes…)

5 Conditions and assumptions

5.1 Assumptions and input to load evaluation (DLC 2.X, parameters relevant to define the design envelope, advanced systems influencing design loads…)

5.2 Assumptions and input to the final manuals (maintenance/test interval for safety related control functions, condition monitoring, commissioning requirements…)

6 Conclusion (including possible outstanding issues)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
info@iec.ch
www.iec.ch

IEC SYSTEM FOR CERTIFICATION TO STANDARDS RELATING TO EQUIPMENT FOR USE IN RENEWABLE ENERGY APPLICATIONS (IECRE SYSTEM)

IECRE Secretariat c/o IEC
3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
secretariat@iecre.org
www.iecre.org