



# 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 wind turbine gearboxes by RECB**





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## 1 Introduction and objective

The main objective of this operational document is to describe the evaluation method and procedure for the certification of wind turbine gearboxes.

## 2 Codes and standards

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 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

IEC 61400-4: Wind turbines – Part 4: Design requirements for wind turbine gearboxes

The RECB shall evaluate the designs of the main gearbox for compliance with the requirements of IEC 61400-1, IEC 61400-2, IEC 61400-3 and IEC 61400-4 as applicable, and the agreed additional codes and standards.

## 3 Required documentation

The following items shall be provided as a minimum for the RECB to evaluate that the gearbox design meets the requirements in the standards:

### 3.1 Documentation for Design Evaluation

- Design basis for the gearbox including general requirement specification, boundary conditions, load specifications, operational conditions. The general requirement specification shall refer to IEC 61400-4 and any additional requirements as identified in the design basis documentation, not directly covered in that standard.
- Gearbox drawings including general assembly drawings and part lists comprising all gearbox components.
- Drawings, material and manufacturing specifications for gears, housing, mounting interfaces (e.g., torque arm, shaft interfaces, reaction mounts), planet carrier, shafts, bearings and other components relevant for the specific gearbox type.
- Quality control procedures for manufacturing not covered by agreed standards.
- Gear rating calculations for static and fatigue strength.
- Face load distribution calculations for all gear meshes considering elastic deflections and tolerances.
- Scuffing calculations for all gear meshes.
- Shafts, shaft-hub connections and planet carrier strength calculations for fatigue and ultimate.
- Housing and torque arm strength calculations including bolt/pin connections for fatigue and ultimate.
- Dynamic and static bearing calculations.
- Dynamic analysis of the gearbox considering the complete drivetrain including the wind turbine rotor and generator.
- Lubrication system description and documentation for main components including filters, pumps, sensors and valves such as:
  - line diagram
  - list of main component

- a design description how the system works.
- Cooling and/or heating system description. The thermal capacity and the available cooling/heating capacity shall be documented at least in stationary condition. Stationary conditions are reached if the measured temperatures show a max. increase of 1 degree Celsius within 15 minutes testing time.
- Operation and maintenance manual
- Transport and mounting instructions
- Preliminary test programs for type testing
- Workshop prototype test specification including the description of the test rig and the detailed test program
- Workshop test report including:
  - calibration method and records
  - temperatures, pressures, oil cleanliness, etc.
  - test matrix and sequence including loads, speeds, and target operating conditions contact pattern on gears and bearings
  - pictures and observations from disassembly and inspection evaluation of the test results and design improvements as applicable
- Acceptance test specification for serial produced gearboxes
  - test load and load steps up to 100% nominal load
  - vibration and sound emission testing
  - system temperatures
  - acceptance limits

### 3.2 Documentation for Type Testing

The following items shall be provided as a minimum for the RECB to evaluate the test programs planning, method and outcomes:

- Test program for robustness test
  - Description of test objectives and approach
  - Targeted design assumptions to be validated with this testing
- Test report for robustness test
  - test rig and test set-up
  - calibration method and records
  - test sequence including loads, speeds, and target operating conditions pictures and observations from disassembly and inspection evaluation of test results and design improvements as applicable
- Test program for field test incl. description of measurements and tests to be carried out
- Test report for field test
  - calibration method and records
  - description of the test turbine and operation during the test
  - inspection protocols incl. pictures of contact patterns and oil analyses
  - test results (e.g. power, torque, temperatures, pressures, oil cleanliness, vibration levels, etc.)
  - evaluation of the test results and design improvements as applicable

### 3.3 Documentation for Manufacturing Evaluation

The following documents shall be provided in addition to the design documents, i.e. drawings and specifications, to allow the RECB to evaluate that manufacturing processes result in serial production gearboxes identical to that subject to the design evaluation and type testing. Additional production documents such as work instructions shall be made available on request during the manufacturing inspection.

- Final test program for production test
- Example test report for production test
  - Test rig and test set-up
  - Calibration method and records
  - Test sequence and loading
  - Evaluation of test results and acceptance criteria

## 4 Evaluation methods and procedures

### 4.1 General

The RECB assessment consists of documentation reviews, witness of tests and independent analyses. It is required that the documentation clearly identifies the basis for the design, i.e. codes and standards, as well as loads and relevant external conditions.

### 4.2 Design Basis (Design Specification) Evaluation

For type certification of a wind turbine a design specification will define the basis for the gearbox design and shall include the relevant requirements from the wind turbine design basis. However, for a component certification of a gearbox, a design basis will be required. The design basis or design specification shall identify all requirements, assumptions and methodologies, which are essential for the design of gearboxes intended for use in wind turbines. The purpose of the evaluation is to determine if the design basis or design specification is properly documented and sufficient for a safe design of the wind turbine type.

The RECB shall check and document the interfaces and the load assumptions (RFC, LDD, Extreme loads).

The design documentation shall be assessed regarding completeness and adequacy for the following aspects:

- Drivetrain concept (integrated drivetrain, 3- or 4-point suspension, etc.)
- Type and arrangement of brakes, couplings and gear support/mounting
- Gearbox design concept (functional description including gear arrangements)
- Operation requirements and conditions
- Normal and extreme environmental conditions
- Main technical data (e.g. nominal speed, ratio, nominal torque, etc.)
- Applied codes and standards if deviating from ISO 61400-4
- Concept of drivetrain analysis (scope of verification)
- Description of the cooling and lubrication system
- Supplementary equipment
- Load duration distribution (LDD, LRD)
- Extreme loads including reverse torque
- Time series for fatigue calculations

### **4.3 Design Evaluation**

The purpose of design evaluation is to assess that the gearbox is designed and documented in conformity with the design basis including design assumptions, specific standards and related technical requirements with respect to the rating calculations (e.g. for gears, bearings, structural elements, etc.). This also includes analytical verifications and documentation on gearbox elements relevant for proper function and reliable design such as lubrication and cooling system.

#### **4.3.1 Strength Evaluation**

The design reports subject to design evaluation shall include details on load assumptions, material properties, modelling, input data, boundary conditions, etc.

The evaluation of the gearbox strength shall comprise a review of the design documentation listed in section 3 for compliance with the design basis and also using the results from the RECBs independent analyses and parallel calculations as follows:

- For complex torque- and load-transmitting gearbox structures the RECB shall carry out independent finite element analyses for verification of the design. This will include but is not limited to planet carrier and torque arm.
- Independent rating calculations shall be carried out for all meshes using validated software.
- The design evaluation shall also include an evaluation of face load distribution through workshop test results, design calculation and independent calculations.
- Furthermore, parallel calculations for all bearing locations shall be carried out in order to evaluate the bearing calculations. Such calculations may be simplified and does not have to include all advanced features such as contact stress distribution.

The gear rating calculations shall also be assessed considering the result of the workshop test according to 4.3.4.

#### **4.3.2 Drive train analysis**

The applied calculation model shall be assessed including stiffness, mass, inertia for all relevant drivetrain components. The result of the analysis shall be assessed i.e. the resulting Campbell Diagram as well as estimated effects from possible resonances. The workshop test according to 4.3.4 should be used to assess the model used for drivetrain analysis.

#### **4.3.3 Lubrication system**

The lubrication systems shall be assessed based on the design basis requirements and the documentation listed in section 3. The assessment of the lubrication system should especially address the temperatures during each relevant operational mode. This shall include assessment of cooling and/or heating systems as well as addressing the need for additional workshop testing related to high or low temperature operation.

#### **4.3.4 Workshop prototype tests**

The results of workshop prototype tests shall be used as full or partial documentation of the structural capacity of the gearbox. The workshop prototype test plan is subject to approval by the RECB.

The testing and the disassembly should be witnessed by the RECB and observations from the test shall be dealt with as described in IEC 61400-4. Alternative arrangements are possible in specific cases if agreed with the RECB on beforehand. The test report shall be assessed and possible improvements to the design shall be evaluated.

In the case of ambient temperatures outside the standard wind turbine classes defined in IEC 61400-1, these temperatures shall be considered for the design, manufacturing and testing.



#### **4.3.5 Testing during serial production**

The assessment of the acceptance tests for serial produced gearbox shall be regarded as an important part during the design evaluation of a wind turbine. The implementation of the specified requirements should be part of the manufacturing evaluation. This includes the inspection of the test rig and the evaluation of test protocols and results. In this connection, calibration methods and certificates may be part of the evaluation as well.

#### **4.3.6 Type test program**

The test programs for robustness test and field test shall be assessed. The type test program will focus on validating the design through testing in the wind turbine as well as a robustness test according to IEC 61400-4.

The type test program may in some cases also include parts for the workshop prototype test. This shall be stated clearly in the RECB's design evaluation report.

#### **4.3.7 Manuals**

The operation and maintenance manual shall be checked for compliance with the design basis as well as issues and limitations/conditions from the design e.g. oil parameters such as cleanliness and viscosity. The operation and maintenance manual shall then include maintenance and inspection intervals including change of oil and oil filters. The operation and maintenance manual shall also be assessed with respect to operating temperature limitations.

For new gearbox concepts/types, the preliminary manuals are sufficient for the design evaluation certification module. In such cases the final evaluation certification module shall include the assessment of the final gearbox manuals.

#### **4.3.8 Prototype certification**

The design evaluation of the gearbox in connection with a prototype certification of a wind turbine can be reduced considering 3 years design life as well as considering the limited requirements for design documentation:

- Ultimate strength and fatigue strength considering 3 years design life for all main load-carrying gearbox components such as planet carriers, torque arm. Other mechanical elements (e.g. gears, bearings, shafts, etc.) will only be considered if critical for the integrity of the wind turbine drive train.
- Aspects relevant for the integrity of the wind turbine drive train considering a service life of 3 years (e.g. lubrication and cooling system, operation and maintenance requirements, etc.).

### **4.4 Type Testing**

The purpose of type testing is to validate the gearbox design through practical testing according to the requirements defined in IEC 61400-4 as well as in the test specifications.

#### **4.4.1 Robustness test**

The robustness test shall be carried out as required in IEC 61400-4 and should include as realistic loading as possible. The disassembly should be witnessed by the RECB and observations from the test shall be dealt with as described in IEC 61400-4. The test report shall be assessed and possible improvements to the design shall be evaluated.

#### **4.4.2 Field Test**

The requirements regarding the test of the gearbox in the wind turbine shall be agreed between wind turbine manufacturer and gearbox manufacturer and shall be assessed by the RECB. At least the preliminary test program should be developed as part of the design phase.

Witnessing of the gearbox field test by the certification body is not necessary if the measurements and inspections are carried out either by an RETL or until RETLs are approved a test laboratory accredited according to ISO/IEC 17025.

Significant changes in the drivetrain, a significant increase of the nominal torque or considerable modifications to the design of the gearbox may require a new field test. The extent of measurements during a new field test shall be agreed with the RECB.

The report from the field test shall be assessed by the RECB for compliance with the design including lubrication system performance (temperatures, pressures, oil cleanliness), vibration levels, contact patterns, etc.

#### **4.5 Manufacturing Evaluation**

The purpose of manufacturing evaluation is to assess if a specific gearbox is manufactured in conformity with the design documentation verified during the design evaluation. The manufacturing evaluation presupposes that the manufacturer of the gearbox operates a quality system. It requires manufacturing of at least one representative specimen of the type under certification. For further details, see OD 501.

#### **4.6 Final Evaluation**

The final evaluation module may include the evaluation of the type testing and manufacturing evaluation as well as assessment of the final manuals. For further details, see OD 501.

For component certification, the final evaluation will be carried out for the gearbox only.

For type certification, the final evaluation will cover the whole wind turbine and if applicable also the incorporation of component certificates covering for example gearbox, blades and tower.

Component certificates shall clearly state interfaces, load assumptions, operating conditions and limitation for incorporating the gearbox in a wind turbine.

### **5 Reporting**

The reporting template in OD-550-x shall be used for the reporting from the design evaluation of wind turbine gearboxes. Any non-resolved deviations to the procedures and standards shall be highlighted in the conclusion of this report. For further requirements to reporting and handling of non-conformities, see the draft Rules of Procedures document WE-OMC/007/DC 2015-03-2.

The following items shall be part of the Evaluation Report:

1. Documentation
  - 1.1 Design basis documents (specifications, descriptions, etc.)
  - 1.2 Design reports
  - 1.3 Load assumptions
  - 1.4 Drawings
  - 1.5 Specifications and manuals
  - 1.6 Documents for information
2. Design basis (standards, specifications, conditions, loads, etc.)
3. Design evaluation
  - 3.1 Application in wind turbines (interfaces, conditions, etc.)
  - 3.2 Lubrication, heating and cooling system
  - 3.3 Mechanical components (gears, bearings, shafts, etc.)
  - 3.4 Gearbox structures (housing, torque-arm, etc.)

- 3.5 Dynamic drive train analysis
- 3.6 Gearbox testing
  - 3.6.1 Test programs (prototype, robustness and field)
  - 3.6.1 Prototype test results
- 4. Type testing
  - 4.1 Final test programs
  - 4.2 Robustness test results
  - 4.3 Field test results
- 5. Manufacturing evaluation
- 6. Final evaluation
- 7. Conclusion

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