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FIRST OFFSHORE WIND PROJECT OF INDIA

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Wind Turbine Testing

Wind turbine testing has always been a core element in the Type certification process, however as the wind turbine technologies have rapidly developed in recent years to meet energy demands, testing has become even more important.

Larger rotors demand advanced control and safety systems in order to operate safely and reliably. Obtaining a design conformity statement or type certificate depends on the evaluation of these systems and whether they can mitigate the alternating and extreme loads that the turbine will endure in operation.

In order to have a turbine type certified and commissioned in India, the National Institute of Wind Energy (NIWE) requires that the following tests have been conducted on a representative test wind turbine.

- **Power Performance measurements**, IEC 61400-12-1
- **Safety and Functional testing**, IEC 61400-22 appendix D
- **Yaw efficiency,** IEC 61400-13
- **Load Measurements,** IEC 61400-13
- **Type Characteristic measurements,** IEC 61400-21 (Power quality)/IEC 61400-11 (Acoustic Noise)
- **Component test**, IEC61400-23 (Blade test), Gearbox test IEC 61400-4

Data collection and post processing must be performed according to ISO 17025. If measurements and reports are prepared by an accredited company, NIWE normally assumes that the 17025 requirements have been fulfilled. NIWE will then only review conclusions and deviations outlined in the reports and evaluate these against the stated design limitations.

Power Performance Testing

The consistency of power production across wind speeds is necessary for wind power projects to offer a competitive cost of energy. The wind turbine power curve is evaluated during power performance testing in order to verify that the turbine is capable of its stated production.

Power performance testing is also an important part of the structural assessment. The power curve report is used to validate the rated wind speed level and power regulation capabilities of the controller. Large deviations might result in a redefinition of the wind turbine design load cases, which will influence the load duration distribution assumed for drive train component design.

For IEC Type approval the power curve measurements must be done in compliance with IEC 61400-12-1.

Safety and functional Testing

In this test, the different shutdown modes of the wind turbine are evaluated along with safety system redundancy. Modern turbines include advanced control and monitoring features and any failure or unexpected response needs to be properly mitigated as they might have significant impact on the structural loads.

During testing NIWE will evaluate if previous safety and functional tests are still applicable based on the test plans and control system descriptions submitted by the wind turbine manufacturer. Guidance to safety and functional test requirements is outlined in IEC 61400-22 appendix D.

Yaw Efficiency

The yaw efficiency has to be validated because yaw misalignment is a parameter in the design load case definitions. If the yaw system is deficient, this may invalidate the assumptions used in the design. Normally fatigue loads are calculated with ± 5 - 8° yaw misalignments for all wind speeds. The analysis of the yaw efficiency must validate that this is a conservative estimate with yaw efficiency data extracted from load measurements.

Loads and Dynamics

The aeroelastic computer codes used for calculating wind turbine design loads (i.e HAWC2, Bladed, Flex, Fast) are able to consider the complete structural dynamics in real time taking the complex environmental conditions and turbine control systems into account. While these computational tools are extensively validated in industry, often a considerable amount of effort is put into developing a computer model that represents the real wind turbine accurately. Often it is found necessary to calibrate the software in order to reproduce dynamics as seen on the test turbine.

The requirements for load measurement campaigns are outlined in IEC 61400-13. The main purpose is to validate the aeroelastic model used for calculating the design loads and ensure the accuracy of the design loads. The validation is based on a comparison of structural eigenmodes and a one-to-one study where environmental conditions are mirrored in the load model. The following predicted component loads are verified against the test turbine:

- Blades (Flapwise/edgewise bending and blade torsion)

- Main shaft (Bending and torsion)

- Tower top and bottom (Bending and torsion)

Additionally the turbine rotational speed, pitch regulation, power and torque have to be analyzed for validation of the controller response.

Type Characteristic Measurements (Power quality and low voltage ride through)

The Type Characteristic measurements are an optional module in the IEC Type certification. However, due to the existing electricity grid infrastructure of India it is expected that power quality and LVRT will be important elements in project certification, especially for large-scale projects. The turbines must be able to handle weak grids with frequent variations in frequency and power quality in order to properly integrate onshore/offshore wind energy and avoid technical compatibility issues.

In the Indian context, the power quality measurements should be mainly concerned with the reactive power measurements. The reactive power of the wind turbine must be recorded according to IEC 61400-21 along with its power performance. The measurement method is according to the procedure laid down in section 7.4 of IEC 61400-21.

Component Testing

Blade and gearbox testing is required as part of IEC Type certification. The blade test must be done in compliance with the technical specification IEC 61400-23. The gearbox testing is divided into a factory test anda turbine test. The requirements are outlined in IEC 61400-4. Other components that cannot be verified on a theoretical basis will also be subjected to testing.

For more information, refer the following informative links/materials:

1. IEC 61400-12-1 “Power performance measurements”

2. IEC 61400-22 “Conformity Testing and Certification of wind turbines”

3. IEC 61400-13 “Measurement of mechanical loads”

4. IEC 61400-21 “Measurement and assessment of power quality characteristics of grid connected wind turbine”

5. IEC 61400-11 “Acoustic noise measurement techniques”

6. IEC 61400-23 “Full-scale structural testing of rotor blades”

7. IEC 61400-4 “Design requirements for wind turbine gearboxes”

All IEC standards can be procured here (https://collections.iec.ch/std/catalog.nsf/collection.xsp?open&col=IEC%2061400).

ISO 17025 “General requirements for the competence of testing and calibration laboratories” can be procured here (https://www.iso.org/standard/66912.html).

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