OFFSHORE CERTIFICATION

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1. INTRODUCTION

Siting of wind turbines on land is a growing problem in northern Europe due to the fact that windy places are becoming scarce and that noise and visual impact reduce their acceptance. All these problems are taken care of when offshore siting is considered. However, offshore siting is not free from any problems and restrictions most of which were addressed in a JOULE 1 project carried out by Germanischer Lloyd and Garrad Hassan & Partners Ltd. [1]. A more in-depth study on the feasibility of offshore wind turbines in the German coastal waters was recently performed by a large group of industrial partners [2].

The revision of Part III of the JOULE project referenced in [1] lead to the publication of Germanischer Lloyd's Regulation for the Certification of Offshore Wind Energy Conversion Systems in October 1995 [3]. The Regulation was derived from Germanischer Lloyd's Rules for Offshore-Installations [4] and their Regulation for Wind Turbines [5] and reflects the experience of the society both in offshore engineering and wind energy.

2. CERTIFICATION PROCEDURE

2.1 General

According to EN 45020 certification of conformity is defined as third party activity to prove that a product or a service conforms with a standard or a normative document. Within the scope of the certification of wind energy converters (WECs) the term certification is being used for the whole range of tasks which are carried out during examination, testing, assessment and certification of WECs.

The certification is carried out in several steps which can be lumped together in the following bulleted lines:

- Design assessment (incl. specifications),
- Site assessment,
- Surveillance of fabrication,
- Surveillance of transport and installation,
- Witnessing of commissioning,
- Witnessing and assessment of prototype testing.

In addition to these tasks manufacturers have to fulfil certain requirements on quality and production procedures (e. g. ISO 9000 certification, shop and/or procedure approvals). In order to keep a certificate valid the systems have to be periodicly monitored.

Due to international requirements the subdivision into type certification and turbine certification has been introduced. Type certification comprises all actions which are relevant to the whole series of wind turbines of the same type, i. e. design assessment, quality system assessment and prototype testing assessment. The turbine certification covers the conformity assessments related to each single wind turbine, i. e. surveillance of fabrication, transport and installation, witnessing of commissioning and periodic surveillance of the turbine in service. An overview of the certification steps is given in figure 1.

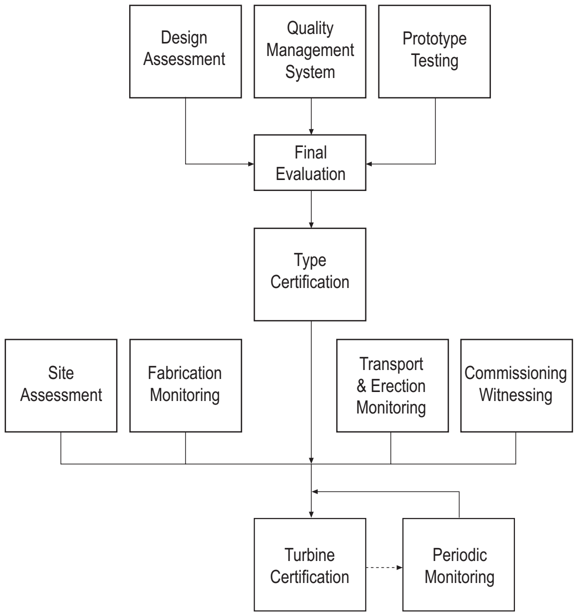

Figure 1: Steps in certification procedure

2.2 Type Certification

The most important part of the type certification is the assessment of the design documentation, which is generally carried out in two sequential steps. The first part covers all aspects of the safety and control concept as well as the load assumptions and load calculations. The load calculations for wind turbines are nowadays based on aeroelastic codes using stochastic wind fields and modal or finite element analysis techniques [6]. In the case of offshore wind turbines the loads have to contain both the aerodynamics and the fluid-structure interaction of the submersed part. The latter may have a considerable influence on the structural response for certain types of foundations and/or underwater structures.

During the second part of the design assessment all components of the system are being examined on the basis of the previously approved loads. If the dynamic analysis of the system is not part of the general load calculation it will be examined in parallel with the conformity assessment of the components. At the end of the design assessment manuals and procedures for transport, installation, start-up, commissioning, operation and maintenance are checked for suitability, completeness and compliance with the assumptions in the design documentation. A flow chart of the design assessment procedure is given in figure 2.

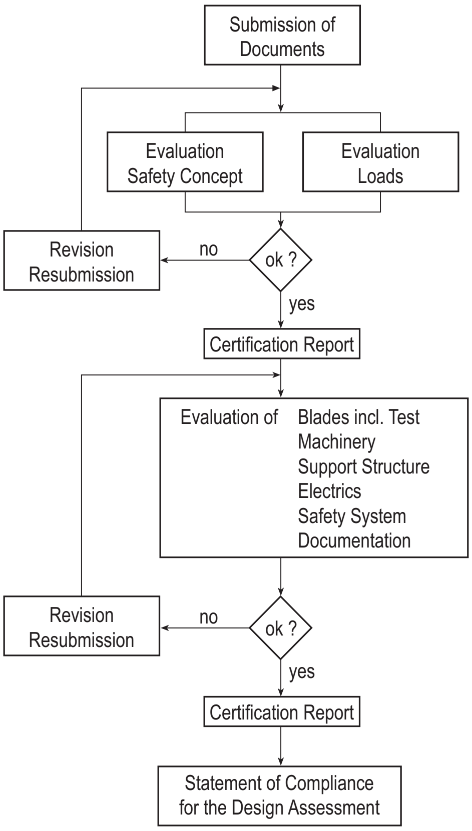

Figure 2: Design assessment procedure

The certification of quality systems according to the ISO 9000 series (since 1994 quality management systems) became a very important requirement in international trade and certification. Quality management systems cover the procedural aspects of quality only and not all aspects of the product quality. Therefore the requirements for conformity assessments of designs, work shops and special fabrication techniques remain a necessary part of the certification.

In order to validate the design calculations and to optimize control, performance and noise prototype testing is an integral part of the design and certification process. The measurements shall be based either on the recommendations of the International Energy Agency [7] or on the relevant IEC 1400 standards which are due to be published soon. For the incorporation of measurements in the certification procedure witnessing of the calibration and plausibility checks of the measurement chain are required or the measurements to be performed by independent, accredited institutions as e. g. the members of MEASNET [8].

2.3 Turbine Certification

The turbine certification is set up as complete third party assessment and surveillance of (a) specific wind turbine(s) from design assessment to commissioning and operation.

Prior to the commencement of the turbine certification the type certification shall be finished and the necessary assessments of work shops, materials and procedures shall be carried out. These assessments comprise e. g. shop approvals (welding, laminating), welders qualification tests, welding procedure and qualification tests and material certificates.

Surveillance can be subdivided in the activities performed at the manufacturers' and those carried out at the site. The extent of the surveillance at the manufacturers' depends to a large extent on the relative importance, the material used and the production process of the component produced. Production is in general monitored on a random basis. Important steps and final tests shall be witnessed.

Surveillance at the site shall be restricted to the important steps during foundation and installation work. An identification/examination of components, subassemblies, on site work and installation shall be carried out before start-up of the wind turbine.

Witnessing of the commissioning forms an integral part in the certification process as it concludes the building phase and starts the operation phase. During commissioning which is performed according to the previously approved procedures all components related to operation and safety are being inspected and/or tested.

The condition of the systems with respect to safety, maintenance and operation shall be inspected by third party every two to four years within the frame of the periodic surveillance. The time interval being dependent on several parameters, as e. g. importance of a component, condition of the overall system and the maintenance procedure.

2.4 Certificates

After completion of examinations, and of surveillance and witnessing Germanischer Lloyd issue Statements of Compliance for the relevant tasks and components/units. Certificates are being issued upon finalization of the type certification and for turbine certifications.

3. REQUIREMENTS

3.1 Principal considerations

There exists clearly a difficulty on how to apply both wind and wave loads on an offshore wind turbine without being too conservative

For fatigue analysis load spectra are to be determined which include the influences to be considered for the wind turbine plus those from waves, currents and sea-ice. If for this analysis sea state parameters are not known those from [3] can be used.

Normal and extreme loads are being derived from superpositions of normal and extreme wind loads and a „reduced“ wave loading or extreme wave loading and a „reduced“ wind gust loading. The reduced wave loading is associated with 2/3 of the extreme wave height which is equal to 1.86 times the significant wave height. The reduced wind gust loading is associated with the 1 min mean wind speed (see [3]). An overview on how wind and waves are combined in the load cases is given in the following

- Load cases N, E, S, M
  + reduced wave loads
- Basic state N
  + extreme 1-year wave
- Basic state E
  + extreme wave
  or + 50 year sea-ice
  or + 50 year wave
- Basic states S,M
  + extreme wave

where: N normal, E extreme, S special, M transport and installation.

3.2 Special Features of Offshore Wind Turbines

The environment of offshore wind turbines requires certain differences in the design of these turbines. It is generally accepted that offshore wind turbines need not be designed for the same safety class as onshore turbines because the aspects of public safety can be treated differently, i. e. lower safety margins in the design. There are no people living in the neighbourhood of offshore wind farms therefore noise and visual impact are less important, too.

Much more emphasis must be put on reliability, extended remote control and longer maintenance periods. Whenever a fault occurs in an onshore turbine which cannot be reset by remote control a service team can be at the site within hours. However, if this happens at an offshore location and weather conditions do not allow immediate access the turbine may remain in the faulty conditions for a long period, e. g. if the access is restricted due to ice. Remote control of offshore wind turbines should go beyond the generally accepted scope and should allow the operator to remotely try to reset and operate the turbine in case of faults which would need manual intervention on onshore units. In order to avoid the access problems as much as possible maintenance intervals should be longer and remote control should allow a wide range of supervision, inspection and control.

Very important design modifications for offshore siting are proper corrosion protection including the interior of the nacelle, lifting gear, boat landing and special access. To reduce the cost of cables it can be necessary to install transformers at every unit, if necessary inside the nacelle.

In addition a risk analysis shall be prepared to evaluate the probability of ship collision.

4. REGULATIONS

Building permits of offshore wind turbines depend on a large number of different institutions involved. This is not only due to the different technical fields but also due to the impact from the marine environment (navigation, national parks, pipelines, cables, defence areas, etc.). Many European countries have appointed one authority to coordinate the necessary involvement of the relevant organisations. In most countries this appointment is also different depending on the distance to the shore, i. e. local, inside 12-miles or outside.

In Europe the technical design of windturbines shall be based on the relevant European Directives, the applicability of which are described in [9]. Special importance for wind turbines is within the Machinery and the Construction Product Directives. However, the Low Voltage and Electromagnetic Compatibility Directives need to be fulfilled, too. All of these Directives are general purpose documents which ask for harmonised standards and requirements.

A European set of building codes are the Eurocodes 1, 2, 3 which are published as ENV 1991, 1992, 1993. The Eurocodes are based on the method of analysing limit states according to ISO 2394 and do require the use of partial safety factors. Eurocode 1 defines loads, Eurocode 2 contains requirements for concrete structures and Eurocode 3 those for steel structures.

In addition to the existing IEC-standards, the European Directives, Eurocodes and a number of national codes Germanischer Lloyd's Regulation for the Certification of Offshore Wind Energy Converser System [3] gives guidance on the special design requirements for offshore wind turbines as well as detailed rules for design and analysis of offshore structures and wind turbine components.

International codes and regulations such as MARPOL and IMO are to be fulfilled.

5. CONCLUSION

The design of offshore wind turbine foundations can be based on the long term experience gained in projects of the oil and gas industry. However, it has to be pointed out that for existing offshore structures wind is generally not one of the dimensioning load components. The structural design of the offshore wind turbine has to take into account both wind loads and the structural response of the foundation which may result from waves, currents or ice.

Offshore wind turbines are designed for unmanned operation, although it is anticipated to control turbines in wind farms remotely from operation control rooms which are permanently manned.

Before using wind turbines at offshore locations they shall be thoroughly tested and the availability been proven.

Extended remote control is one of the design modifications for offshore wind turbines. Others are corrosion protection against marine atmosphere, boat or helicopter landing facilities and lifting gear for components.

Design rules for offshore wind turbines have been derived from codes for wind turbines and those for offshore structures. Although there is considerable experience for both of those structures their combination revealed new load combinations which need to be considered in the design, construction and operation of offshore wind farms.

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