



Quality in the Manufacturing of Wind Turbines

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One and one adds up to more than just two! A high level of quality consciousness and the mutual cooperation of all participants is the key to success. When all participants in a project like a wind farm work as a team and take an active interest in the concerns of their partners, strategic benefits are practically inevitable.

Summary and Conclusion

This paper presents a tool for certification – the so-called IPE (Implementation of design requirements in Production and Erection) – as the practical realization of quality management. Here IPE generates added value, not only for the manufacturer and operator of the wind turbine, but also for the financiers and insurance companies. The importance of simultaneous measures to be taken during the certification process with a view to detecting weak spots in quality assurance should not be underestimated. In addition, an independent certification body then confirms that the quality-determinant measures in production have been observed and that the wind turbine meets the stringent requirements.

Introduction

Wind energy is booming worldwide. Today, approximately 17,000 wind turbines are producing reliable electricity. The individual performance of the turbines has also increased several times over the last decade. Whilst the average installed output of a unit was still about 500 kilowatts in 1995, this figure has increased to more than 1,700 kilowatts today. And this trend has surely not come to an end: if wind energy could be harvested more effectively, it would even be possible to satisfy the entire world demand for electrical power. The significance of wind energy is increasing constantly and, with it, the demands posed on the quality and reliability of the installations.

The Challenge of Series Production

Technical problems occur again and again at wind turbines. Once the wind turbine has been set up, solving these problems is very often solely the task of the operator. For this reason, it is vital to be able to trust the product as purchased. It is becoming increasingly important for the manufacturer of a turbine to preserve the confidence built up over many years, even in the case of new developments – e.g. of offshore plants. Nothing sticks in a customer's memory more than high operating and maintenance costs, even if the initial investments were very low. Everyone knows that "quality has its price".

Certification acts as a connecting link that not only offers a seal of quality for the buyer but also helps build up a process-oriented quality system for the manufacturer. Reasons for turbine manufacturers to set up quality management measures may be found, for instance, in the fact that – through the own company's size, outsourcing, globalization and the project sizes (wind farms of several hundred units) – the conditions have changed so much that the quality management (QM) increasingly has to be ensured by means of external monitoring and surveillance. This situation calls for intelligent concepts for reducing the production costs without compromising the

quality. What is more, advances in the development of multi-megawatt plants are also indispensable for offshore applications.

The objective is to ensure that the quality management measures are so implemented in the production and erection of a wind turbine that the structures and components can adequately fulfil their intended purposes during later operation within the scope of their design objective. The right course for the quality management measures is already set in the concept phase, i.e. before series manufacture of the turbine. In the design phase of the prototypes, the modifications can again exert a strong influence on the quality management measures. Assistance with regard to the necessary scope of the quality management measures can be obtained from international guidelines ([1] to [3]).

Certification

Owing to the large number of influencing factors (such as design, material, production, assembly and erection), it is clear that a higher-ranking control of all these disciplines is needed. Here certification is an eminently suitable tool. The above-mentioned measures can only be realized in the entirety of (type or project) certification.

In general, certification is subdivided into:

- (A-, B-, C-) Design Assessment
- Site-specific Design Assessment ¹
- Type Certification
- Project Certification

Whereas in the past the certification body primarily issued type certificates for which a complete assessment of the design analyses with all the necessary material and component tests (Design Assessment; Fig. 1), a quality management system, prototype surveys and the witnessing of commissioning for one of the first turbines were necessary, the required quality in production and assembly is now ensured by an IPE as part of a Type Certificate (Fig. 2). For this reason, the Type and Project Certificates are becoming more and more important, through the evaluation of all the participating disciplines.

¹ In the Site-specific Design Assessment, there is also a site-specific assessment with regard to topography, specific environmental conditions, wind conditions, earthquakes, as well as electrical and soil conditions.

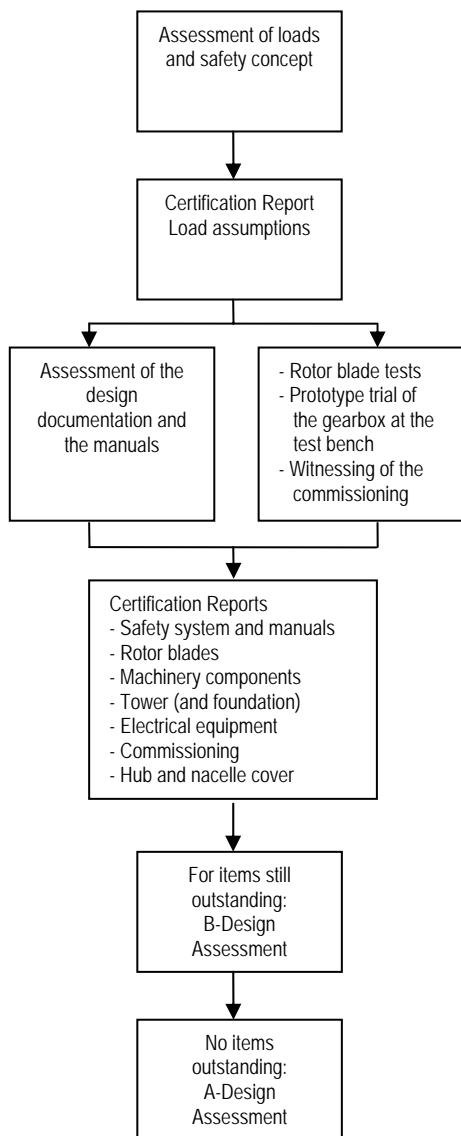


Fig. 1: Procedure for A- and B-Design Assessment [1]

Besides the design- and material-related quality evaluations in the Design Assessment, the quality management system of the manufacturer as well as the witnessing, inspections and tests of a prototype, the provisions and the implementation of the quality management measures are assessed within the scope of a Type Certification.



Fig. 2: Modules of the Type Certificate and the Project Certificate [1]

Here IPE (Implementation of design requirements in Production and Erection) of a turbine is the key to success; this is examined further in the next section. It is meaningful to extend the IPE for the Project Certification through various surveillance activities during production, transport, erection and commissioning. Further information is given in [4] and [5].

IPE as a Practical Implementation of the Quality Management

The IPE (Implementation of design requirements in Production and Erection) is the quality management tool within the (Type) Certification. The objective of IPE is to define the requirements specified in the technical documents (drawings, specifications, calculations) of the Design Assessment in a single step, and to confirm them

subsequently in the course of production and erection by means of inspections. An IPE can only be conducted with success if all participants (manufacturers, suppliers, certifiers etc.) are aware of their respective tasks and if they proceed in a coordinated manner. In this regard, special priority must be given to the planning, the aspects of which are examined in further detail below.

IPE can be subdivided into three sections:

1. Definition of the requirements (critical parts, components etc.).
2. Inspections for random testing at the beginning of production and in the case of major modifications to the design or the manufacturing process.
3. Further inspections during ongoing production of the turbine structures and components, and transition to the complete Surveillance during Production within the course of Project Certification (e.g. for special sites or wind farms).

The inspections during production cover the assessment to ensure compliance with the requirements made of

- the manufacturing companies (e.g. shop approvals for welding, laminating and bonding)
- the quality management
- the materials, and
- the production and (internal) testing.

The first and, at the same time, central step in implementing the IPE is the definition of the critical processes in manufacturing the turbine. The critical processes are defined as a result of the structural demands expressed in the Design Assessment, such as e.g. the quality grade of the materials and the production quality, and also the quality management measures agreed upon between the suppliers and the turbine manufacturers. For instance, it may be that the turbine manufacturer has chosen a special quality grade for the calculation of the tower welding seams. This requirement must be expressed in the purchasing specifications of the turbine manufacturer as well as in the (goods) incoming and outgoing checks of both partners (turbine manufacturer and supplier). According to past experience, this results in more findings for the manufacturer arising solely from the definition of the critical (from the quality assurance standpoint) parts and production processes (see 1st section of the IPE). The results are then quality management measures that are individually coordinated for that particular turbine type between the turbine and component manufacturers and also (in the Project Certification) the consideration of the site-specific aspects.

The assessment of the documents and the inspections on site are independently done by the certification body. The inspection is the heart, and also the logical consequence, of the quality management measures that have been put into place. It leads to commercial added value, both for the turbine manufacturer and for the operator. This is achieved in that inspections are used to bridge the gap between the "theoretical" assurance of the design requirements and the assessment of the "practical" implementation in production and erection.

The purchaser or operator of the turbine receives his added value through the certified expert assessment of all production processes, which frequently remain hidden and can seldom be tracked down to this level of detail, even in the course of his project planning.

Scope of the Quality Management Measures

The scope of the inspections during production and erection is independent of the level of excellence exhibited by the quality management measures. For this reason, it must be decided in individual cases whether a component

(e.g. a hub casting) can be inspected in the manufacturer's works (foundry) or in the course of the incoming inspection at the plant manufacturer (turbine manufacturer). If, for example, the turbine manufacturer requires a work's test certificate from the hub manufacturer which contains all the parameters relevant for the later function of the component of the plant (e.g. properties of the material, dimensions, shape and positional tolerances), the IPE must be carried out at the hub manufacturer. If the turbine manufacturer performs such an examination within the scope of the incoming inspection and if this is documented, the IPE at the turbine manufacturer may be sufficient. In exceptional cases, an IPE inspection both at the hub manufacturer and the plant manufacturer may become necessary. Similarly, it is of course only possible to conduct an examination of the foundation structure on site.

The results of the IPE inspections of the areas:

- rotor blades
- hub
- shaft
- main, pitch and yaw bearing (pitch and yaw drives)
- main bearing casing and/or torque restraining arm
- gearbox (production and prototype trial on a test bench and at the turbine)
- locking devices and mechanical brakes
- generator, transformer
- machine frame and generator frame
- tower
- foundation (on site; see above)
- bolted connections
- assembly of hub and nacelle

are compiled in a so-called "Statement of Compliance for the Implementation of design requirements in Production and Erection", or just "Statement of Compliance" (Fig. 4).

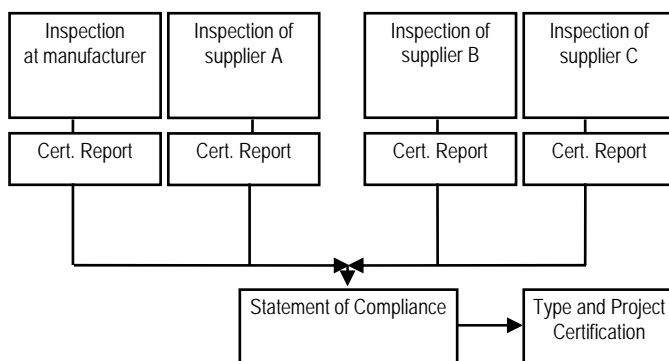


Fig. 4: The result of the IPE

Individual Certification Reports on the IPE inspections are generally valid for 3 years and have an effect on the Statement of Compliance and the Type Certificate. Individual IPE inspections may be applied to other turbines of a manufacturer (providing synergy effects), provided that certain prerequisites are met. The inspections within the scope of IPE can also be taken into account for the surveillances of production, transport and erection that are required within the scope of a Project Certificate.

In summary, the IPE may be characterized by the following guiding principles:

- IPE is the practical bridging of the gap between certification and QM, and hence also serves to implement the requirements of ISO 9001:2000.
- IPE serves to reduce the workload and to prevent/detect errors (risk minimization through use of the "four eyes are better than two" principle) and is thus a form of active product optimization.
- IPE serves as a sales argument and for increasing the level of customer satisfaction, and is therefore a seal of quality for that particular wind turbine type.
- IPE yields additional information for the designer, through the independent inspections and Certification Reports.
- IPE provides greater reliability in the interaction with financiers and insurance companies.

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