Title: **IEC TS 61400-22 (First Revision of IEC WT 01)**
The new standard for Wind Turbines and Wind Farms – Onshore and Offshore

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Summary and Conclusion

Certification of wind turbines or components is state-of-the-art and a must in many places around the world. Furthermore certification to harmonised requirements is an active support of export. Therefore it is important to know the different certification processes and guidelines as well as the keystones of their development for manufacturers, banks and insurances of wind turbines and components.

This paper puts focus on IEC TS 61400-22: Conformity Testing and Certification of Wind Turbines, First Edition, 2008 (CD) and describes the outcome and latest innovations of the IEC-Maintenance Team MT 22 of the Technical Committee TC 88 for certification of wind turbines and projects on- and offshore. The results of the final meeting of MT 22 in Korea in May 2008 are covered, too. Thus it is expected that the final document will not differ from this paper.

Introduction

Certification of wind turbines has a history of almost thirty years. It has been applied differently in scope, requirements and depth only in Denmark, Germany and the Netherlands each on the basis of their own rules. These countries are still leading in the development and application of certification rules, but during recent years a number of other countries as well as many banks realised the necessity of a thorough evaluation and certification of wind turbines and their proposed installation. Among these countries are China, India, Japan, Korea, Spain and the USA.

The procedures to obtain Type and Project Certificates are described on the basis of IEC TS 61400-22: Conformity Testing and Certification of Wind Turbines, First Edition, 2008 (CD) [14] and the outcome of the final meeting of MT 22 in May 2008. Once published IEC TS 61400-22 replaces IEC WT 01 [1] without any exceptions and forms a new and trend-setting basis for certification activities to ensure safety and reliability of wind turbines and wind farms worldwide.

International standardisation efforts on wind turbine certification procedures started in 1995 within the International Electrotechnical Commission (IEC) in the Technical Committee TC 88 and resulted in the first issue of IEC WT 01 published by the Conformity Assessment Board (CAB) of the IEC in April 2001. TC 88 already started their efforts in 1988 and has so far published standards and technical specifications for the safety of wind turbines, rotor blade tests, power curve, noise and load measurements and power quality under the scope of the IEC 61400 series. Other topics are in preparation.

It was found that there are a lot of topics in preparation related to wind turbines (see www.iec.ch for details; IEC 61400 series), e. g. concerning measurements, gearboxes or offshore specifics. This led to a wider acceptance

of the IEC 61400 series and required an update of the basis for the certifications – IEC WT 01. Furthermore since the development of the first edition of IEC WT 01 in the end of the last and the beginning of this century there exist several developments in design and evaluation of wind turbines as well as revisions of standards and guidelines which needed to be covered. Therefore the Maintenance Team MT 22 started in March 2005 to review and update the existing rules and procedures with the objective of issuing a second edition. Nearly all parts of IEC WT 01 have been subject to discussions and changes. The procedures of Type and Project Certification have been updated; modules and elements have been revised and explained in more detail. The aim is still to issue a second edition of IEC WT 01 or alternatively a first edition of a standard IEC 61400-22 covering both on- and offshore wind turbines and wind farms.

Within the revision design evaluations of prototype wind turbines have been integrated including a smaller amount of documentation and evaluation in comparison to the complete design evaluation which can be done at a later stage. Furthermore opportunities for provisional Type and Project Certificates have been included.

Right now MT 22 finished the revision of IEC WT 01 which will be published as technical specification IEC TS 61400-22 including the state-of-the art in certification and the actual knowledge about turbine design.

Certification

According to the international standard ISO / IEC 17000, certification is third-party attestation related to products, processes, systems or persons, whereas attestation includes the issue of a statement, based on a decision following the review, that fulfilment of specified requirements (e.g. guidelines, codes and standards) has been demonstrated. The review itself covers verifications of the suitability, adequacy and effectiveness.

In the field of wind energy the focus lies on products like complete wind turbines or components such as rotor blades, gearboxes, generators or towers. The scope consists of the examination of structural integrity, safety and compliance with these requirements. Furthermore on- and offshore wind farms are covered as well as processes for manufacturing such as rotor blade production or welding of structures. In addition quality management (QM) system certification is part of Type Certification as explained herein and persons might be subject to certification if one thinks about training facilities or maintenance of wind turbines. To provide these services the certification body needs to be accredited based on ISO / IEC Guide 65 [15] (ISO / IEC Guide 62 in case of QM certification [17]).

According to IEC TS 61400-22 Type Certification comprises Design Basis Evaluation, Design Evaluation, Manufacturing Evaluation, Type Testing, Foundation Design / Manufacturing Evaluation (optional), Type Characteristics Measurement (optional) and Final Evaluation. Within the Design Evaluation some items like evaluation of manufacturing plan as well as installation plan and evaluation of personnel safety are necessary for IEC TS 61400-22. The Prototype Testing includes several types of measurements as well as testing and the Manufacturing Evaluation includes an evaluation of the quality system as well as the inspection of the manufacturing.

Project Certification on basis of IEC TS 61400-22 is based on Type Certification (or at least fulfilment of its mandatory modules) and covers the aspects of Site Conditions Assessment, Design Basis Evaluation, Integrated Load Analysis, Wind Turbine Design Evaluation, Wind Turbine Manufacturing Surveillance, Support Structure Design Evaluation, Support Structure Manufacturing Surveillance, Other Installations Design Evaluation (optional), Other Installations Manufacturing Surveillance (optional), Project Characteristics Measurements (optional), Transportation and Installation Surveillance, Commissioning Surveillance, Final Evaluation and Operation and Maintenance (OM) Surveillance (optional). These individual modules are concluded with Conformity Statements.

Certificates are issued upon the successful completion of the relevant Type Certification and Project Certification.

Design Evaluation

The evaluation or assessment of the design 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 to be based on aero elastic codes using stochastic wind fields and modal or finite element analysis techniques [3]. In the case of offshore wind turbines the loads have to contain both the aero elastic behaviour of the wind turbine and the fluid-structure interaction of the submerged part. The latter may have a considerable influence on the structural response for certain types of foundations and / or underwater structures [4]. Applicable codes or standards are listed in Table 1. As the IEC standards do not cover all necessary elements of the Design Evaluation other codes as e. g. the Guideline for the Certification of Wind Turbines, Edition 2003 with Supplement 2004, [2] or the Guideline for the Certification of Offshore Wind Turbines, Edition 2005, [13] of Germanischer Lloyd are to be applied.

Figure 1: Guideline [2]

Steps of evaluation	**Codes or standards to be applied in addition to IEC TS 61400-22**
Control and Protection System	GL-Guideline [2], [13]; IEC 61400-1, Second [5] or Third [6] Edition
Loads and Load Cases (incl. Controller)	GL-Guideline [2], [13]; IEC 61400-1, Second [5] or Third [6] Edition
Rotor Blades	GL-Guideline [2], [13]; IEC TS 61400-23 [7] (for testing)
Machine and Structural Components (incl. gearbox test and test of cooling and heating system)	GL-Guideline [2], [13]; (IEC 61400-1, Third Edition [6])
Tower (and Foundation)	GL-Guideline [2], [13]
Electrical Components (incl. Lightning Protection and generator test)	GL-Guideline [2], [13]; IEC TR 61400-24 [8], IEC 60034 [19]; relevant IEC standards
Housings (Nacelle Cover and Spinner)	GL-Guideline [2], [13]
Foundation Design Requirements (optionally complete Foundation)	GL-Guideline [2], [13]
Design Control and different Processes (optionally complete Manuals)	GL-Guideline [2], [13]; IEC 61400-1, Second [5] or Third [6] Edition
Personnel Safety	GL-Guideline [2], [13]; IEC 61400-1, Second [5] or Third [6] Edition, EN 50308 [18]
Component Tests	GL-Guideline [2], [13]; IEC 61400-1, Second [5] or Third [6] Edition

Table 1: Partial Steps of the Design Evaluation

During the second part of the Design Evaluation all structures and components (e. g. machinery, tower and electrical equipment) are examined on the basis of the previously approved loads and the relevant standards and guidelines. If the dynamic analysis of the system is not part of the general load calculations it will be examined in parallel with the conformity assessment of the components. At the end of the Design Evaluation manuals and procedures for manufacturing, transport, erection, start-up, commissioning, operation and maintenance should be checked for suitability, completeness and compliance with the assumptions in the design documentation. This

evaluation can be part of the Final Evaluation, too, but is recommended to be performed within the thorough design review. In addition to this the evaluation of personnel safety is important. Rotor blade testing [7] forms an integral part of the Type Testing of the blade (see below), but might be necessary for the verification of the design already. Lightning Protection will be assessed in combination with the electrical installations. A flow chart of the Design Evaluation is shown in Figure 2.

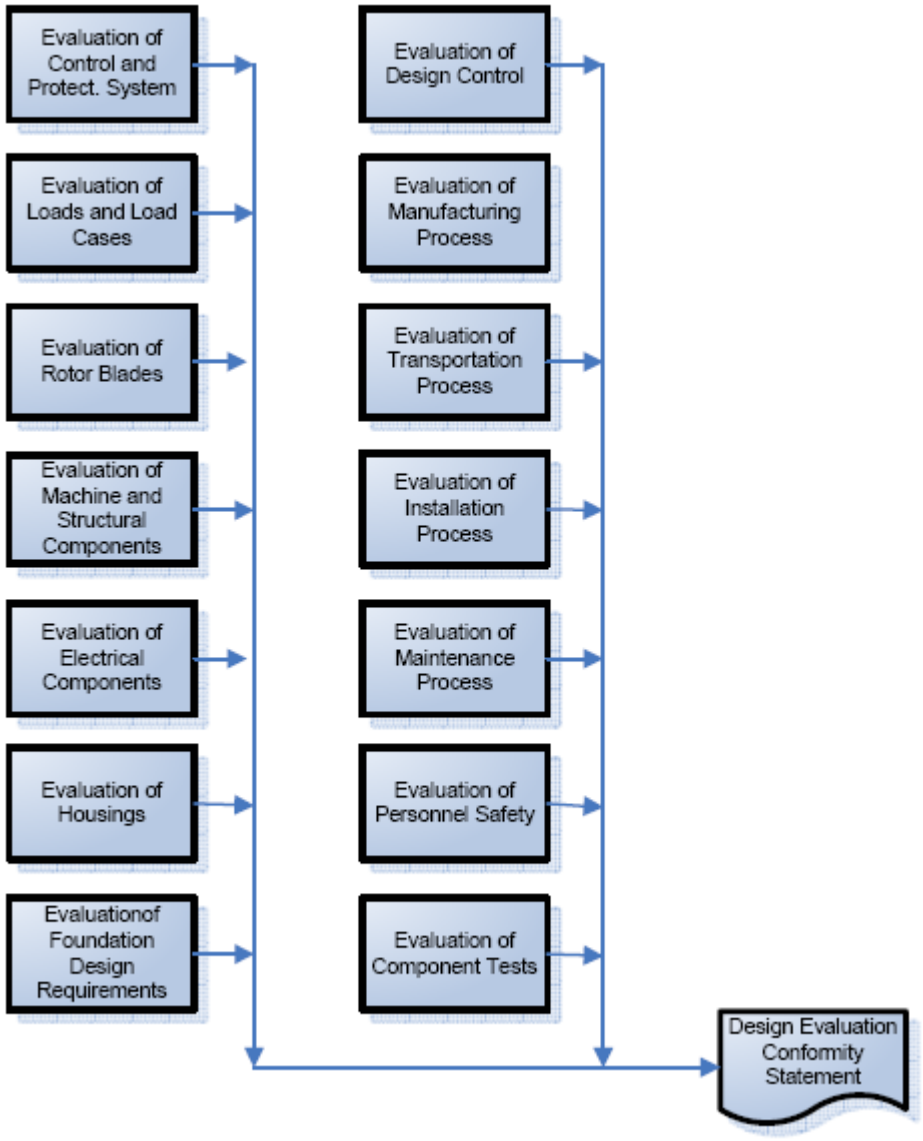

Figure 2: Elements of the Design Evaluation [14]

Type Certification

To attain the Type Certificate on basis of the IEC TS 61400-22, the following steps are necessary (Figure 3):

- Design Basis Evaluation
- Design Evaluation

- Type Testing
- Manufacturing Evaluation
- Foundation Design Evaluation (optional)
- Foundation Manufacturing Evaluation (optional)
- Type Characteristics Measurement (optional)
- Final Evaluation

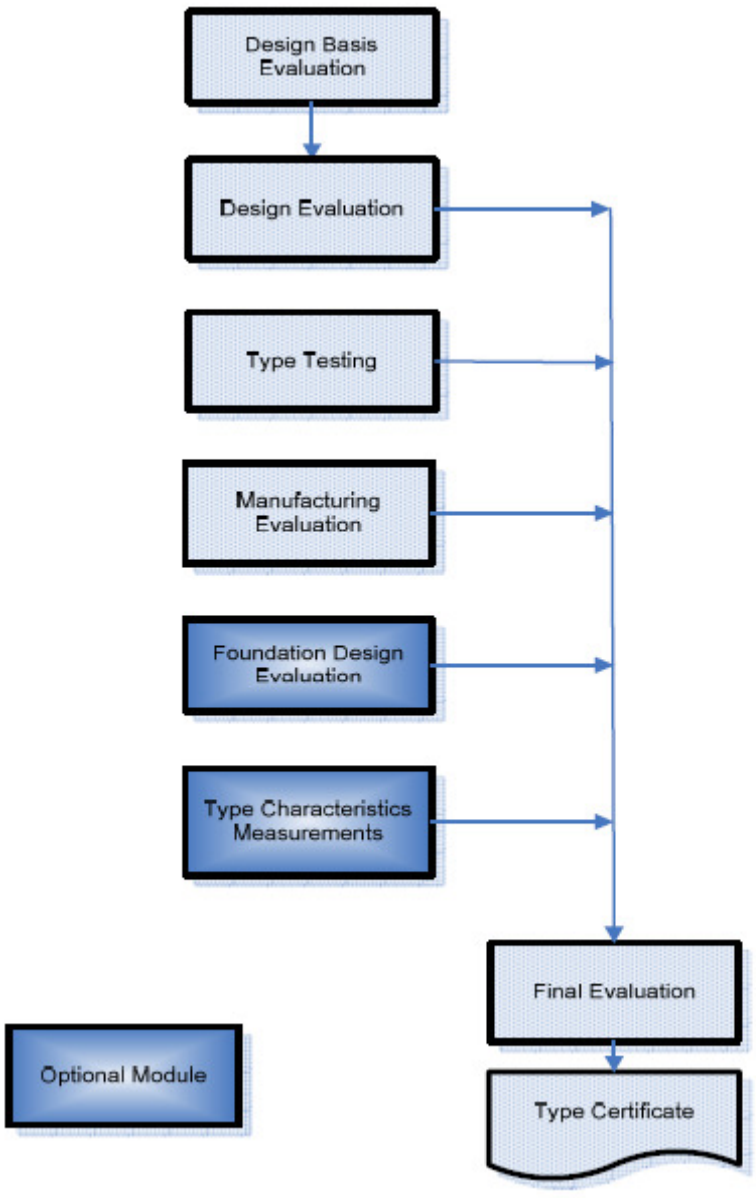

Figure 3: Modules of the Type Certification [14][1]

[1] Within Figure 3 the module „Foundation Manufacturing Evaluation“ is missing, but will be added for the final version of IEC TS 61400-22.

Conformity Statements for all of these steps as well as the Type Certificate will attest the finalisation of the certification of this type of wind turbine (Figure 4). The Type Certificate has a validity period of up to five years. During the validity period, annual reports are to be sent to the certification body containing deviating operating experience and minor modifications. A re-certification is possible to renew the certificate after five years.

Figure 4: Examples for Evaluation (Certification) Report (left),
Conformity Statement (Statement of Compliance) (middle) and Type Certificate (right)

The most important part of the Type Certification is the assessment of the design documentation, a thorough design review with respect to the requirements defined in the relevant codes and standards as presented above.

The testing of the prototype wind turbine represents the practical aspects of the Type Certification. In order to validate the design calculations, to optimise control, performance and noise behaviour and to verify the performance of the safety and control systems the Type Testing is an integral part of the design and certification process. The topics as indicated in Table 2 are to be verified by measurements which shall be based on the relevant standards mentioned. For the incorporation of measurements in the certification process the measurements shall be performed by independent institutions accredited according to ISO / IEC 17025 [16], alternatively witnessing of the calibration and plausibility checks of the measurements by the certification body or by an accredited institute are required. Furthermore the prototype of the gearbox is to be tested on an adequate test bench and on the wind turbine. All measurement results are to be evaluated and documented. The test reports will be checked for plausibility of the measurement results and compared to the assumptions in the design documentation.

Topics for Measurements	**Codes or standards to be applied in addition to IEC TS 61400-22**
Safety and Function Tests / Commissioning	GL-Guideline [2], [13]
Power Performance Measurements (Power Curve)	IEC 61400-12 [9]
Load Measurements (Actions, Loads and Stresses)	IEC TS 61400-13 [11]
Blade Tests (Static and Fatigue Test)	IEC TS 61400-23 [7]
Gearbox (Test on Turbine; Other Tests)	GL-Guideline [2], [13]

Electromagnetic Compatibility (EMC; Other Tests)	IEC 61400-1, Third Edition [6]; IEC 61000-6-1 [23], -2, [24] -4 [25]
Power Quality Tests (Electrical Characteristics; Type Characteristics Measurements; optionally)	IEC 61400-21 [12]
Low Voltage Ride Through Test (LVRT; Type Characteristics Measurements; optionally)	IEC 61400-21 [12]; GL-Technical Note [20]
Acoustic Noise Measurments (Type Characteristics Measurements; optionally)	IEC 61400-11 [10]

Table 2: Testing requirements on the prototype turbine and the respective standards

The evaluation of the manufacturer's QM covers the whole range of activities necessary to confirm the quality of the product. The certification of the manufacturer's QM system according to ISO 9001 (including design) covers a large portion of these requirements. In general the QM system is certified by an accredited certification body [17]. However, the link between quality management and product quality needs to be specially addressed. It shall be ensured that the requirements stipulated in the technical documentation with respect to the components are observed and implemented in production and erection. This is shown to the certification body by the manufacturers of the components and the wind turbine within the Manufacturing Evaluation. Therefore the requirements for conformity assessments of designs, work shops and special fabrication techniques remain a necessary part of the (type) certification procedure. More information on Manufacturing Evaluation can be found in [22].

Project Certification and Site Specific Design Evaluation

Project Certification is carried out for wind turbines having successfully received Type Certification and for locations for which the necessary data are available. Basically Project Certification is intended for projects covering more than one single wind turbine such as wind farms onshore as well as offshore. This certification may include all necessary installations such as measuring masts, power transmission as well as transformer stations and others. Moreover the Project Certification covers the aspects of (Figure 5):

- Type Certification (or at least fulfilment of its mandatory modules)
- Site Conditions Assessment
- Design Basis Evaluation
- Integrated Load Analysis
- Wind Turbine / RNA Design Evaluation
- Wind Turbine / RNA Manufacturing Surveillance
- Support Structure Design Evaluation
- Support Structure Manufacturing Surveillance
- Other Installations Design Evaluation (optional)
- Other Installations Manufacturing Surveillance (optional)
- Project Characteristics Measurements (optional)
- Transportation and Installation Surveillance
- Commissioning Surveillance
- Final Evaluation
- OM Surveillance (optional)

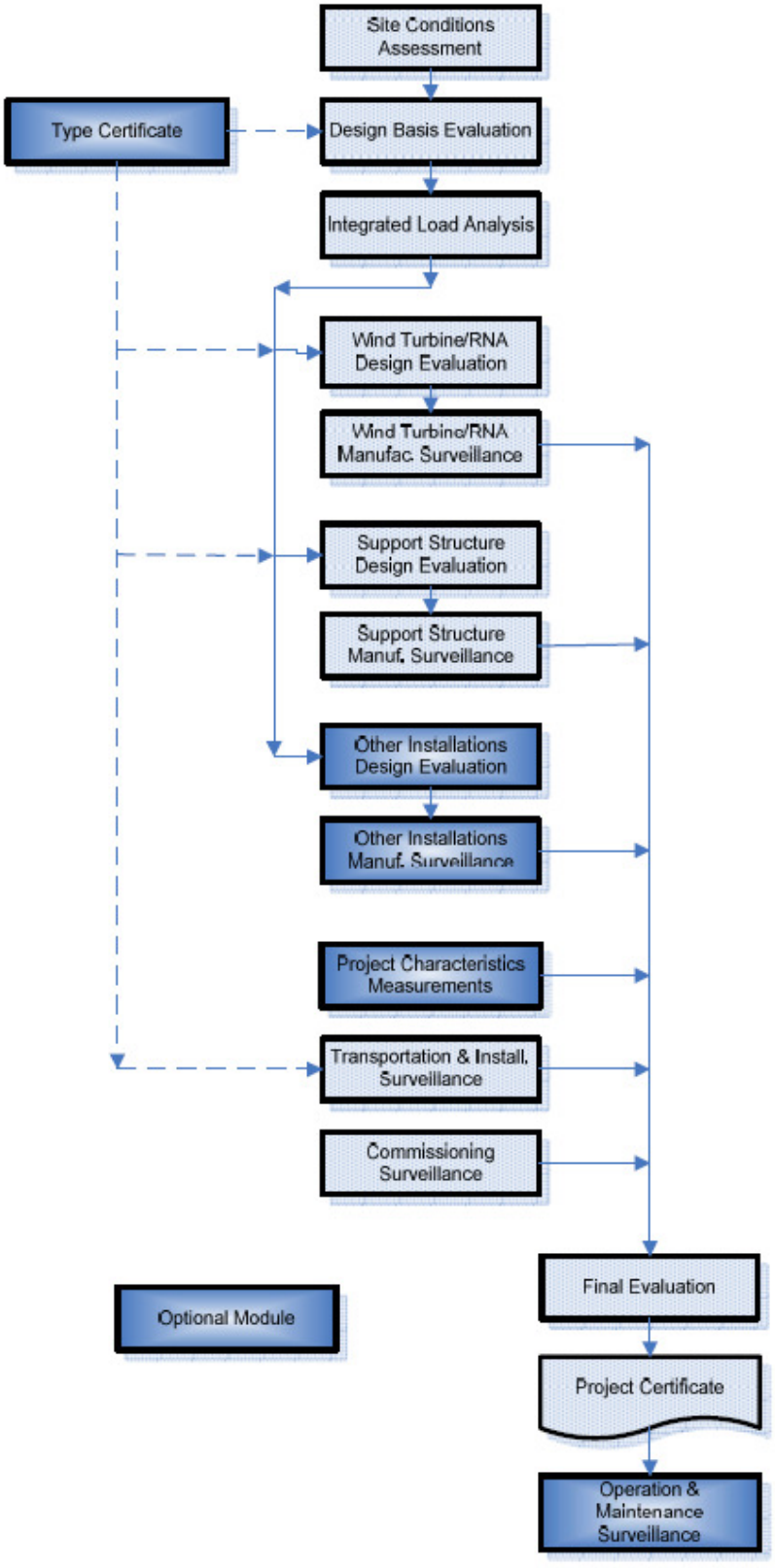

Figure 5: Modules of the Project Certification [14]

Following completion, the Project Certificate is issued by the certification body. It does not expire as long as the Operation and Maintenance Surveillance (OM Surveillance) is carried out at regular intervals (every 2.5 years). Major modifications, conversions or repairs not approved by the certification body affect the validity of the certificate.

Site Assessment can be carried out on the basis of the GL-Guidelines [2], [13]. For the selected sites wind (and wave) conditions, other environmental conditions (hot / cold climate, earthquake, corrosion, etc.), electrical network conditions and soil conditions shall be evaluated by measurement or derived from theoretical or other data (e.g. in case of earthquake from standards). More information on Site Conditions Assessment (and Design Basis Evaluation) is provided in [22].

After evaluation of the Site Assessment, the conditions resulting will be checked against those used within the general Design Evaluation as part of the Type Certification. In case the conditions at the site are stronger, additional calculations or modifications of the turbine design are to be carried out to demonstrate the integrity of the design to be suitable for the site in question. The general Design Evaluation can then be enhanced to a Site Specific Design Evaluation which includes the Support Structure Design Evaluation as well. If a Type Certificate is not present, the Wind Turbine / Rotor-Nacelle-Assembly (RNA) Design Evaluation and the Support Structure Design Evaluation are done including all mandatory elements of Type Certification, but on a basis referring to the site in question only.

The surveillance of installation at the site of erection shall be restricted to the important steps during support structure and erection work. An identification and inspection of component manufacturing, transportation, on site work and installation shall be carried out before start-up of the wind turbine. Commissioning witnessing forms an integral part of the certification process between the building phase and 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 should be inspected by third party at regular intervals of at least 2.5 years within the scope of the optional Operation and Maintenance Surveillance.

The Certification Body

Germanischer Lloyd Industrial Services GmbH, Business Segment Wind Energy (GL) is an internationally operating certification body for wind turbines and leads the world in this field. GL carries out examinations, certifications and expertises and is actively involved in the development of national and international standards (e.g. TC 88). GL offers the complete range of services for certifying wind energy products and projects. Certification of wind turbines is carried out on the basis of the GL Guideline for the Certification of Wind Turbines (Edition 2003 with Supplement 2004) [2] and the GL Guideline for the Certification of Offshore Wind Turbines (Edition 2005) [13]. Furthermore, GL is accredited to carry out certification in accordance with all relevant standards in the field of wind energy.

Conclusion

The rapid growth of the wind energy industry and the growing size of wind turbines itself enforce financing banks and insurance companies as well as authorities to require reliability and safety assessments of these projects. The assessments are carried out within the certification of the individual turbines or the projects such as wind farms, onshore and offshore. Within the framework of the certification of wind turbines, reliability, safety, strength and fatigue are evaluated in order to guarantee safe operation for building authorities, financing institutions, manufacturers and operators as well as insurance companies. The work of Maintenance Team MT 22 leads to a first edition of IEC TS 61400-22 covering all aspects of state-of-the-art certification procedures and forming a basis for certification schemes worldwide.

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