DNV·GL

SERVICE SPECIFICATION

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Type and component certification of wind turbines

DNV GL AS

FOREWORD

DNV GL service specifications contain procedural requirements for obtaining and retaining certificates and other conformity statements to the objects, personnel, organisations and/or operations in question.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

General

This is a new document.

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SECTION 1 INTRODUCTION

1.1 General

Lessons learned from certification projects specifically component and type certification of onshore and offshore wind turbines realised over the last years were taken into account during the development of this service specification.

The pressure on the reduction of cost of energy is high in the renewable energy sector. Focusing on reducing costs increases the risk of reducing safety, quality and reliability. Hence, the independent evaluation becomes a higher importance to ensure a state-of-the-art level of safety, quality and reliability.

Thus DNV GL's type and component certification scheme has been adapted to meet market needs and expectations.

This service specification (SE) specifies DNV GL's services for type and component certification of onshore and offshore wind turbines. It serves as a

— facilitator to identify and apply relevant technical standards
— guidance for engineers from concept to serial production
— description to meet the state-of-the-art for wind turbines, and to go beyond
— common communication platform for describing the scope and extent of activities performed for certification of a wind turbine and its components
— contractual basis for the certification of wind turbines.

This certification scheme and the IEC 61400-22 scheme are aligned with respect to the technical requirements and the certificates, however, this scheme is adjusted to reflect the actual product development sequence. For example, the test certification modules also include the test part of the final evaluation according to IEC 61400-22.

The conceptual and prototype stages of the development process are covered considering technology qualification and risk analysis.

The interface to project certification is addressed through the introduction of a new type certificate which shall be site/product specific, see [2.8].

The wind farm design lifetime is typically 20 years. The cost reduction pressure in the power sector makes it necessary to consider also increasing the design lifetime for example to 25 or 30 years. The wind farm design lifetime may be chosen and shall be taken into consideration from the project beginning through all relevant phases.

The certification services are adjusted to follow the wind turbine or component development phases from concept to serial production, see Figure 1-1.

Figure 1-1 Certification services aligned with the development process

These development phases may be supported during the wind turbine development by respective certification deliverables. The overview in Figure 1-1 provides guidance in selecting the appropriate certification deliverables.

This service specification is divided into four main sections:

Sec.1 gives an introduction to the service specification.
Sec.2 gives an overview of the certification scheme and its certification modules.
Sec.3 gives a detailed description of the certification scheme and its modules.
Sec.4 describes the final deliverables as well as the maintenance of the certificates.

Sec.1 covers type and component certification. Sec.2 to Sec.4 (as well as the appendices) focus on type certification to ease reading; component certification may be performed analogously by application of the elements and modules as listed in Sec.2 to Sec.4 (as well as appendices).

The DNV GL document system is organized according to a three-level document hierarchy, with these main features:

— Principles and procedures related to DNV GL's certification and verification services are separated from technical requirements and are presented in DNV GL service specifications (SE). Service specifications present the scope and extent of DNV GL's services.
— Technical requirements are issued as self-contained DNV GL standards (ST). Standards are issued as neutral technical standards to enable their use by national authorities, as international codes and as company or project specifications without reference to DNV GL's services.
— Associated product documents are issued as DNV GL recommended practices (RP). Recommended practices provide DNV GL's interpretation of safe engineering practice for general use by industry.

Guidance note:
The latest revision of all DNV GL documents may be found in the "rules and standards" pages on the DNV GL website www.dnvgl.com.

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1.2 Objective

This document has a dual objective: it serves as a publicly available description of DNV GL's services related to type and component certification of wind turbines and secondly it shall be referred to as a contractual document in the certification contract between the manufacturer and DNV GL.

The document specifies the obligations of the customer, usually the manufacturer, when his wind turbine or wind turbine component/system shall be certified. The document also specifies the obligations of DNV GL and the tasks carried out by DNV GL for certification.

The aim of this document is to provide a certification scheme which addresses individual needs in the various wind turbine development phases, reduce the costs over the lifetime and at the same time to not compromise the added value and quality delivered by certification. Additional certification services may be chosen to enhance the functionality, reliability and value even more. The service specification serves also to detail and clarify the certification activities and facilitate achieving compliance.

The main differentiators of the DNV GL certification scheme to other existing schemes are:

— more guidance and descriptions to facilitate application
— all wind turbine relevant topics addressed in one service specification
— all wind turbine development phases are supported by the certification scheme
— certification may be tailored by adding multiple optional services.

Depending on the specific individual interests and agreed scope the benefits by applying this service specification may be among others:

— independent approval of the wind turbine and/or component(s) to reduce the own risk in developing and designing
— building of trust in the design and construction
— reducing costs by early detection of non-conformities
— confidence in technical integrity
— confirmation of requirements as stated by project developers, investors, operators, manufacturers, governmental and non-governmental organisations
— prove by an independent body to meet the national and international acknowledged state-of-the-art and to ease market entry
— utilise statements and certificates for authorisation by governmental bodies
— prove to investors or insurer that third party approval was successfully performed
— securing sustainable energy production throughout life-cycle
— minimising technical risks
— document stepwise the maturity of the wind turbine development project
— mitigate the risks to environment and people.

1.3 Scope of application

1.3.1 General

This specification applies to type certification of wind turbines as well as for component certification. Component certification as a term used in this service specification covers e.g. major and minor components, systems, single parts or assemblies used in a wind turbine or attached to it. The mandatory certification modules comprise design, manufacturing and testing at different stages of the wind turbine development process. An overview of the certification modules is given in Sec.2 and a more detailed description is given in Sec.3.

This specification together with referred DNV GL standards and recommended practices represents a completely revised and expanded version of GL-IV-1 and GL-IV-2; both with a history of 30 years.

The services described in [1.3.2] - [1.3.11] below are optional services related to type and component certification. They may be added to component or type certification to extend the use of respective certificates by e.g. adding more options or markets.

1.3.2 Occupational health and safety

The DNV GL certification according to this service specification does not cover compliance with international or national occupational health and safety requirements. The verification of compliance with health and safety requirements such as EN 50308 and or national requirements may optionally be included in the certification scope.

Guidance note:
The compliance with European Directives including CE marking requirements is not covered by this certification scheme.

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1.3.3 Extreme temperature conditions

For site conditions including altitude outside the standard site conditions as defined in DNVGL-ST-0437, there shall be additional considerations for design and operation of wind turbines. DNVGL-RP-0363 covers the main aspects influenced by extreme temperature including air density, material properties and lubrication. It may be used to extend the normal temperature range of a component or wind turbine to very low and/or very high temperatures.

1.3.4 Condition monitoring systems

The certification of condition monitoring systems may be included in the type or component certification or it may be delivered as an independent service. The DNV GL certification service is described in the DNV GL service specification DNVGL-SE-0439.

1.3.5 Fire protection systems

The certification of fire protection system may be included as part of the type certification for a wind turbine or it may be offered as an independent service, i.e. certification of the fire protection. The service is described in detail in DNVGL-SE-0077.

1.3.6 Electromagnetic compatibility

The wind turbine control and protection system shall in general be immune against the electromagnetic emission levels within the wind turbine, see also DNVGL-ST-0438.

The certification of electromagnetic compatibility (EMC), i.e. immunity and emission may be included in the type certification of a wind turbine or delivered as a separate certification service. The DNV GL recommended practice DNVGL-RP-0440 may be used as reference.

1.3.7 Lifetime extension

Wind turbines are designed for a finite service life. Usually a design lifetime of 20, 25 or 30 years is taken as a basis for the design.

If a wind turbine or wind farm shall be operated beyond its design lifetime, the wind turbine shall be assessed with regard to its potential for lifetime extension for the specific site conditions.

Different approaches may be taken to provide the necessary verification and shall preferably utilise the existence of a Type Certificate. Further information is available in the DNVGL-SE-0263.

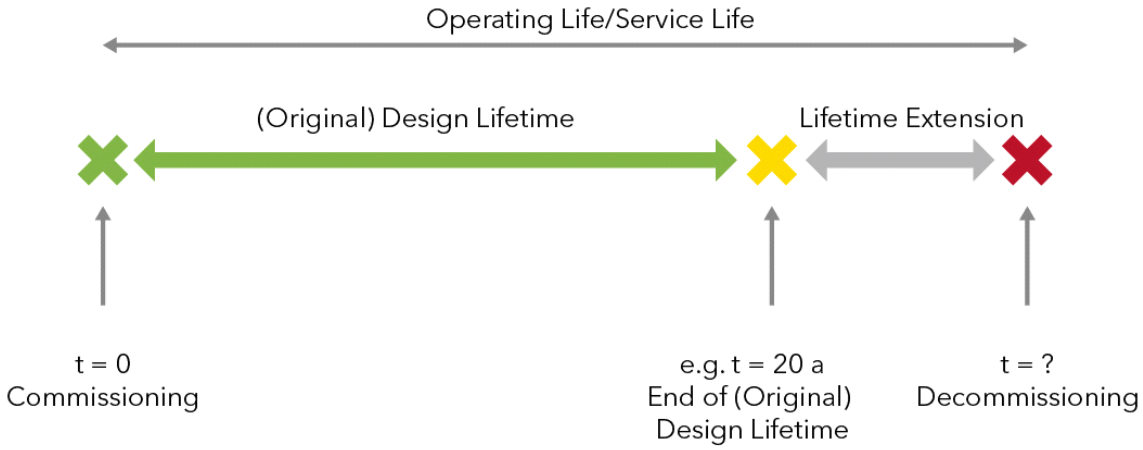

Figure 1-2 Lifetime extension

1.3.8 Grid code compliance

The certification of grid code compliance for a wind turbine shall be based on measurements of electrical characteristics including fault ride-through (FRT) as well as verification of the wind turbine model for use in grid simulations by validation against test results. The outcome shall be a type certificate for the wind turbine or an additional component or equipment certificate.

The DNV GL service for grid code compliance certification is delivered independently of the wind turbine type and component certification as described in this service specification. Further information about grid code compliance (GCC) is given in DNVGL-SE-0124.

1.3.9 Service and maintenance activities

DNV GL provides certification services for service and maintenance activities for the wind energy industry. The service is delivered independently of other services and is described in DNVGL-SE-0448.

1.3.10 Training systems

DNV GL provides certification of training system established within the renewable energy sector e.g. covering rescue training programs. The service is described in the GL Technical Note for Certification of Training Programs and Training Systems in the Renewable Energy Industry.

1.3.11 Shop approvals

The DNV GL shop approval is providing third party verification of a workshop and/or single fabrication procedure. It may be applied for manufacturing of components, repair procedures and single manufacturing procedures. Desired target is time and cost reduction during the certification process. The service is described in DNVGL-SE-0436.

1.4 Definitions

1.4.1 Terminology and definitions

Table 1-1 Definitions of verbal forms

Verbal forms	*Definition*
shall	verbal form used to indicate requirements strictly to be followed in order to conform with the document
should	verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required
may	verbal form used to indicate a course of action permissible within the limits of the document

Table 1-2 Definitions of terms

Term	*Definition*
certification	action by a certifying body, providing written assurance that adequate confidence is provided that the subject of the certification, i.e. the wind turbine, is demonstrably in conformity with a specific standard or other normative document The term designates all the activities associated with the process leading to the issue of a certificate. The scope of work is defined by the certifying body or by a regulatory body.
certification scheme	certification scheme, i.e. a sequence of phases or modules to be completed prior to the issue of a certificate
component certificate (CC)	a certificate issued by a certifying body, here DNV GL, when it has been demonstrated that a product type in question, here a wind turbine component, assembly or system, complies with the applicable regulations The component certificate shall allow the customer to manufacture certified wind turbine components or systems during the period of validity of the certificate.
component certification	certification of specific wind turbine components such as rotor blade, generator, gearbox, brake, coupling, pitch system, yaw system, nacelle frame, tower and rotor–nacelle assembly Component certification covers relevant modules of type certification with the extent depending on the component/system in question.
customer	DNV GL's contractual partner, usually the certification applicant
final certification report	final report, issued as reference document for the type or component certificate, and providing documentation of the evaluation of the elements and modules in the type or component certification The report includes a reference list of all supporting product documentation, an evaluation of whether the detailed documentation is complete and all relevant requirements are confirmed by type test results, and a review of the final product documentation.
manufacturer	the manufacturer of the wind turbine or of any wind turbine component or system in question
outstanding issue	the term outstanding issue is used to denote a deviation from standards and technical requirements specified in the certification agreement, and which needs to be completed for full compliance
prototype certificate (PT)	the prototype certificate shall allow the customer to manufacture, install and operate a prototype wind turbine during the period of validity of the certificate
rotor nacelle assembly (RNA)	the rotor nacelle assembly includes all components/systems located above the tower top flange
statement of compliance (SoC)	a statement signed by a qualified party affirming that, at the time of assessment, a product or a service meets specified requirements
statement of feasibility (SoF)	a statement signed by a qualified party affirming that, at the time of assessment, a new product under development was considered conceptually feasible and suited for further development and qualification
substructure	the structure connecting the tower with the foundation structure for an offshore wind turbine e.g. jacket structure
support structure	the support structure comprising the tower, the substructure and the foundation structure
type certificate (TC)	a certificate issued by a certifying body, here DNV GL, when it has been demonstrated that a product type in question, here a wind turbine type, complies with the applicable regulations The type certificate shall allow the customer to manufacture certified wind turbines during the period of validity of the certificate.

Table 1-2 Definitions of terms (Continued)

Term	*Definition*
type certificate – level A (TC A)	a certificate issued upon successful completion of the certification modules for level A
type certificate – level B (TC B)	a certificate issued upon successful completion of the certification modules for level B The type certificate – level B shall have outstanding issues with no safety implication during the validity period.
type certificate – site level (TC site)	a certificate issued upon successful completion of the certification modules for the site level The site specific type certificate shall list the wind turbines covered by the certificate.
verification	an evaluation or assessment to confirm that an activity, a product or a service is in accordance with specified requirements Upon confirmation according to an agreed scope of work for the verification service, DNV GL shall issue a statement of compliance or a certificate.
wind turbine	system which converts kinetic energy in the wind into electrical energy The wind turbine comprises of the rotor nacelle assembly, the tower and the electrical system including the wind turbine electrical terminals.

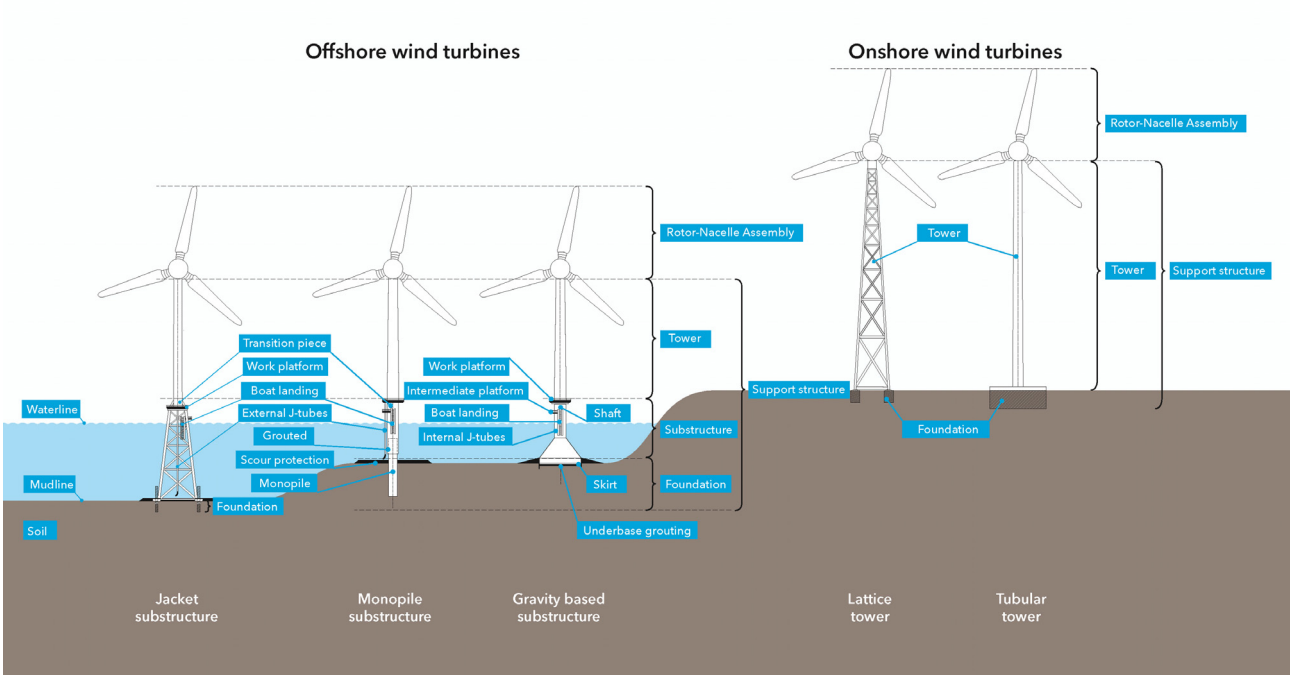

Figure 1-3 Definition of offshore and onshore wind turbines

1.4.2 Abbreviations and symbols

Abbreviations and symbols used in this service specification.

Table 1-3 Abbreviations

Abbreviation	*In full*
CC	component certificate
DAkkS	Deutsche Akkreditierungsstelle GmbH
EN	European Standard
FMEA	failure mode effect analysis
FRT	fault ride-through
FTA	fault tree analysis
GCC	grid code compliance

Table 1-3 Abbreviations (Continued)

Abbreviation	*In full*
HMI	human machine interface
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITP	inspection and test plan
LVRT	low voltage ride through
PC	project certificate
PT	prototype certificate
PT C	prototype certificate - C level
QM	quality management
RNA	rotor nacelle assembly
RP	DNV GL recommended practice
SE	DNV GL service specification
SCADA	supervisory control and data acquisition
SoC	statement of compliance
SoF	statement of feasibility
SoF D	statement of feasibility - D level
ST	DNV GL standard
TC	type certificate
TC A	type certificate - A level
TC B	type certificate - B level
TC Site	type certificate - site level

1.5 References

1.5.1 General

This document refers to relevant DNV GL service specifications, standards and recommended practices (including DNV and GL service documents) and to international codes and standards and other international publications. Unless specified otherwise in this service specification or in a certification agreement or design basis, the latest valid revision of each referenced document applies.

1.5.2 DNV GL service documents

The following DNV GL service documents are referenced in this service specification:

Table 1-4 DNV GL service documents

Document code	*Title*
DNV-RP-A203	Technology Qualification
DNVGL-RP-0363	Extreme temperature conditions for wind turbines
DNVGL-RP-0440	Electromagnetic compatibility of wind turbines
DNVGL-SE-0077	Certification of fire protection systems for wind turbines
DNVGL-SE-0124	Certification of grid code compliance
DNVGL-SE-0190	Project certification of wind power plants
DNVGL-SE-0263	Certification of lifetime extension of wind turbines
DNVGL-SE-0436	Shop approval in renewable energy
DNVGL-SE-0439	Certification of condition monitoring
DNVGL-SE-0448	Certification of service and maintenance activities in the wind energy industry (planned published in 2016)
DNVGL-ST-0076	Design of electrical installations for wind turbines
DNVGL-ST-0126	Design of wind turbine support structures
DNVGL-ST-0361	Machinery for wind turbines (planned published in 2016)
DNVGL-ST-0376	Rotor blades for wind turbines

Table 1-4 DNV GL service documents (Continued)

Document code	*Title*
DNVGL-ST-0437	Loads and site conditions for wind turbines (planned published in 2016)
DNVGL-ST-0438	Control and protection systems for wind turbines
	GL Technical Note for Certification of Training Programs and Training Systems in the Renewable Energy Industry.
GL-IV-1	Guideline for the Certification of Wind Turbines, Edition 2010
GL-IV-2	Guideline for the Certification of Offshore Wind Turbines, Edition 2012.

1.5.3 International standards and other referenced publications

The following international standards and other relevant publications are referenced in this service specification:

Table 1-5 International standards and other referenced publications

Document code	*Title*
EN 50308	Wind Turbines – Protective Measures – Requirements for Design, Operation and Maintenance
IEC 61400-11	Acoustic noise measurements techniques
IEC 61400-12-1	Power performance measurements of electricity producing wind turbines
IEC 61400-21	Measurement and assessment of power quality characteristics of grid connected wind turbines
IEC 61400-22	Conformity testing and certification of wind turbines
IEC 82079-1	Preparation of instructions for use -- Structuring, content and presentation -- Part 1: General principles and detailed requirements
ISO 9001	Quality Management Systems – Requirements
ISO 6336-5	Calculation of load capacity of spur and helical gears – Part 5: Strength and quality of materials
ISO/IEC 17020	General Criteria for the Operation of Various Types of Bodies Performing Inspection
ISO/IEC 17025	Competence of Testing and Calibration Laboratories
ISO/IEC 17065	Conformity assessment - Requirements for bodies certifying products, processes and services.

1.6 General procedures

1.6.1 Wind turbine development phases

The conceptual and prototype stages of the development process are covered considering technology qualification and risk analysis.

The interface to project certification is addressed through the introduction of a new type certificate which shall be site/product specific, see [2.8].

The certification services are adjusted to follow the wind turbine or component development phases from concept to serial production, see Figure 1-4.

Figure 1-4 Certification services aligned with the development process

These phases may be supported during the project execution by respective certification modules and services to ensure their feasibility and reliability. The overview in Table 2-1 provides guidance in selecting the relevant certification modules and services meeting the wind turbine development phase. Complementary services and phases are listed as well.

The wind turbine design lifetime is typically 20 years. The cost reduction pressure in the power sector necessitates to consider an increased design lifetime, for example to 25 or 30 years. The wind turbine design lifetime shall be selected by the applicant preferably considering the future project requirements with respect to design life time.

1.6.2 Applicant

The typical type or component certification applicant is the wind turbine or component developer or manufacturer. The applicant or customer is the direct contractual partner of DNV GL for whom DNV GL is performing the verification and certification services.

1.6.3 Certification body

DNV GL undergoes on a regular basis external audits according to ISO/IEC 17065 to prove its independency and competence by an accreditation body. Among others DNV GL is accredited and internationally acknowledged according to the following certification schemes:

- DNVGL-SE-0074:2014-12 Type and component certification of wind turbines according to IEC 61400-22
- DNVGL-SE-0190:2015-12 Project certification of wind power plants
- GL Certification scheme according to GL-IV-1, edition 2010
- GL Certification scheme according to GL-IV-2, edition 2012
- IEC Certification scheme according to IEC 61400-22
- Offshore and Onshore Wind Turbines according to the Executive Order of the Danish Ministry for Climate, Energy and Buildings No. 73 dated 2013-01-25: Bekendtgørelse om teknisk certificeringsordning for vindmøller (Executive order on the technical certification scheme for wind turbines)
- TAPS-2000: 2003-04 Provisional Type Certification Scheme for Wind Turbine Generator Systems in India
- DNVGL-SE-0073:2014-12 Project certification of wind farms according to IEC-61400-22
- BSH no. 7005, Standard Design of Offshore Wind Turbines, Federal Maritime and Hydrographic Agency (BSH), edition 2007
- Small wind turbine certification schemes: BWEA 2008-02, Renewable UK 2014-01-15, DECC UK ed.2014 (MCS), UL 6142 2012-11, AWEA 9.1: 2009.

The current accreditation certificate of DNV GL shall be provided on request. Reference lists and list of certifications are published on www.dnvgl.com.

1.6.4 Deliverables

Certification deliverables in the context of this service specification are documented by certification reports, statements of compliance, Final Certification Report and the type/component certificate, see Figure 1-5.

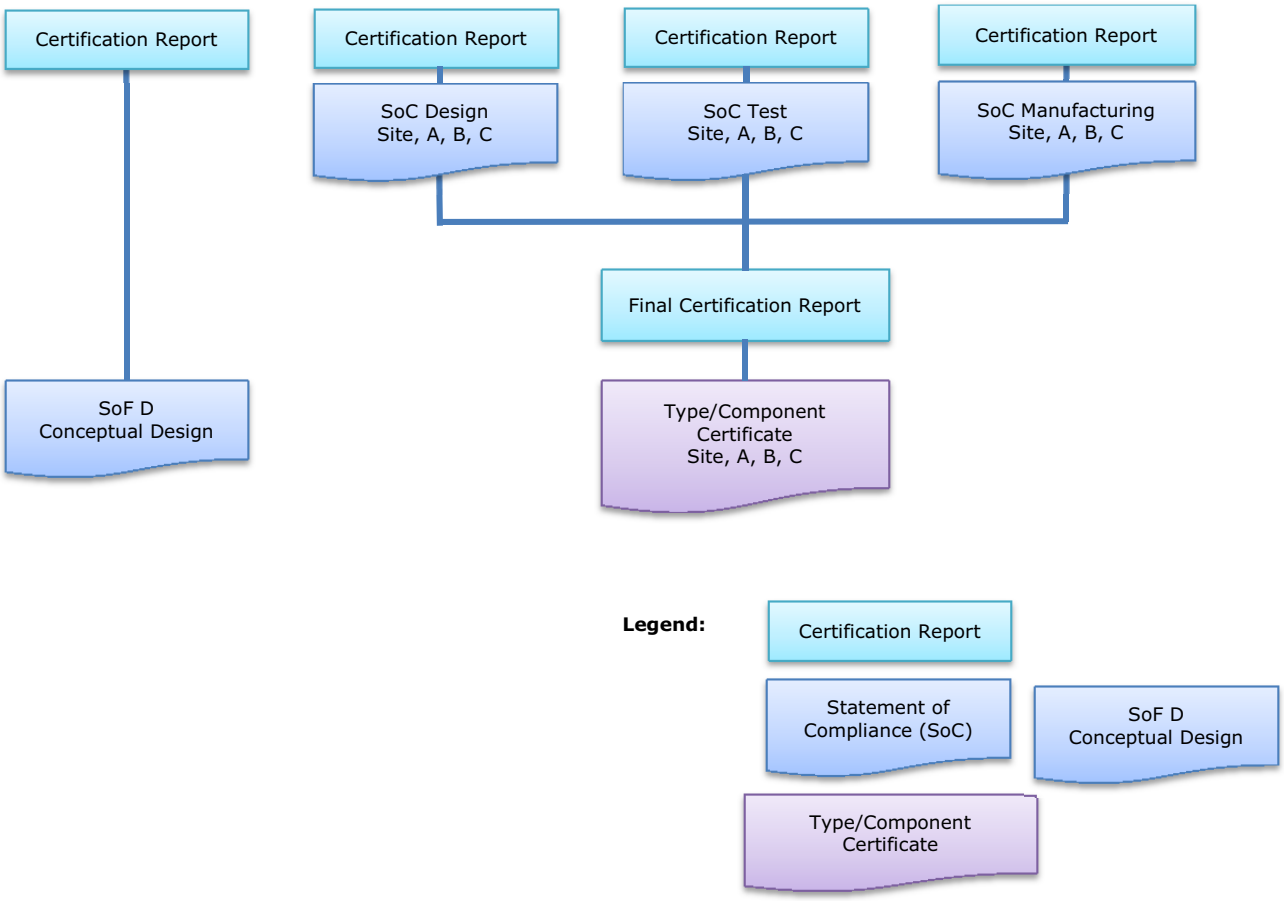

Figure 1-5 Deliverables

A type/component certificate is supported by at least the following certification documents:

— statement of compliance design
— statement of compliance manufacturing
— statement of compliance test
— final certification report.

A statement of compliance shall be issued after successful completion of each certification module. Each statement of compliance is supported by a certification report. The conceptual design phase shall be concluded by a statement of feasibility.

For the development phases and after successful completion of all the certification modules for the considered phase a type/component/prototype certificate shall be issued supported by a final certification report.

The type/component certificate is subject to maintenance during its validity period. The maintenance shall assist in keeping the certificates up to date and including modifications/improvements due to operational experience from faults/damages and general product development.

1.6.5 Customer - DNV GL interaction

The type/component certification according to this service specification provides to the customer an independent evaluation and confirms compliance of his wind turbine/component considering specific standards and needs.

This document serves also as a publicly available description of DNV GL's type/component certification services for wind power plants and it should be referred to as a contractual document in the certification

agreement between the customer and DNV GL. The document specifies the obligations of the customer in order to keep the certificates valid as well as DNV GL's service obligations to the customer.

The deliverables by DNV GL shall be agreed in detail between the customer and DNV GL as a part of the contract. In general the DNV GL certificate is issued when all of the required statements of compliance according to the type/component certification scheme have been issued.

1.6.6 Certification requirements - quality management

The customer shall operate a quality management system according to ISO 9001 covering all aspects of the development of the wind turbine or the wind turbine component.

In general test reports delivered shall be prepared by accredited testing laboratories and meet the requirements according to ISO/IEC 17025 and relevant standards. For non-accredited testing laboratories, DNV GL shall verify that the testing laboratories have the competence according IEC/ISO 17025, as applicable.

For the use of information of a component for the purpose of the type certification, DNV GL shall be given written permission by the component certificate owner.

1.6.7 Standards, codes and additional requirements

This service specification provides the key references to the technical requirements to be fulfilled for the type/component certification.

This service specification and referenced standards present the state-of-the-art in wind turbine technology. Alternative codes and standards may be applied and shall be agreed with DNV GL in the beginning of the certification project and shall be specified in detail in the design basis. The application of alternative codes and standards does not allow for a reduction of the targeted safety as described in this services specification and related technical standards. DNV GL reserves the right to ask for additional requirements to cover issues essential to the certification process and not covered by the standards in question.

In case standards are combined, caution shall be exercised and the choice of standards is subject to acceptance by DNV GL.

Guidance note:

Within a particular standard, aspects such as requirements for partial safety factors for calculations of design loads and design resistance are generally mutually balanced to give an overall acceptable safety level. In another standard with the same overall acceptable safety level, the requirements for the safety factors may have been balanced differently. Picking requirements for load factors from one standard and material factors from another may therefore easily result in unpredictable, and possibly too low or unnecessary high, safety levels.

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1.6.8 Surveillance/inspection general requirements

The customer, or an other entity having the legal responsibility for the premises where DNV GL personnel shall work, shall inform DNV GL of any safety and health hazards related to the work and/or any safety measures required for the work, prior to starting the work, or if such information is not available at that time, during the performance of the work.

Whenever DNV GL undertakes to work on site, the customer shall provide all adequate safety measures to ensure a working environment that is safe and in accordance with all relevant legislation.

If at any time during the execution of work on site a DNV GL employee judges that the work situation is unsafe then work shall be suspended until such situation has been made safe.

For surveillance/inspection during manufacturing, transportation, installation and commissioning as well as in-service, DNV GL shall report critical findings to the customer immediately after the inspection. DNV GL shall issue reports to the customer and the frequency of these shall be agreed with the customer. The reports shall describe the extent of the surveillance/inspection including findings, non-conformities and possible recommendations.

SECTION 2 SERVICE OVERVIEW

2.1 General

The objective of this section is to provide an overview of the verification activities related to type and component certification of wind turbines.

Component certification may be performed analogously by application of the elements and modules as listed in this service specification.

2.2 Assessment documents

Documentation submitted for certification shall be in English language unless otherwise agreed with DNV GL.

Each document shall have a unique and clear reference which also identifies the actual revision of the document. The documentation shall be controlled according to the quality management system of the customer. The quality procedures shall be submitted to DNV GL on request.

The documentation submitted for the certification process shall be complete and self-explanatory. The content shall meet the requirements of the agreed and applied standards.

Further information on the documentation required for certification is given in this document as well as in the referenced DNV GL service documents. Additional information shall be provided by DNV GL on request.

2.3 Deviations

Deviations from this service specification, without exception, are permitted only with the consent of DNV GL.

In individual cases the certification may involve inclusion of locally applicable regulations and codes.

The level of safety set in this service specification shall be applied, even if national or regional laws or regulations require less.

In the case of designs for which this service specification cannot be applied, DNV GL reserves the right to proceed in the spirit of the service specification.

If analysis concepts of different standards shall be applied, these should generally not be mixed.

2.4 Certification modules

The DNV GL certification scheme for wind turbines is divided into levels which account for the development stage of the wind turbine. Each level except for the D level shall include certification modules for design, test and manufacturing as shown in Table 2-1. The C level as well as the "site level" shall cover specific wind turbines whereas the A, B and D levels shall cover a type of wind turbine.

The individual certification modules depend on each other and may only be ordered in subsequent order. The levels of certification are independent of each other and may be ordered in subsequent order or individually.

Upon the successful completion of a certification module, a statement of compliance or statement of Feasibility shall be issued.

The final deliverables are listed in Table 2-1. Certificates shall be issued based on successful completion of the certification modules for design, test and manufacturing.

Table 2-1 Certification modules and deliverables

Level	*Module Design*	*Module Test*	*Module Manufacturing*	*Final Deliverable*
D	**SoF D** Statement of Feasibility Certification plan considering new technology	-	-	**SoF D** **Statement of Feasibility**
C	**SoC C-Design** Structural integrity Limited scope of evaluation of fatigue life	**SoC C-Test** Test of turbine behaviour Static blade test	**SoC C-Manufacturing** Blade manufacturing + QM certificate (blade manufacturing)	**PT C** **Prototype Certificate**
B	**SoC B-Design** *C-Design +* QM certificate - Design Outstanding issues with no safety implication during validity period allowed. *Options see "Site"-level*	**SoC B-Test** *C-Test +* Gearbox test at the test bench Other component tests e.g. from SoF D certification plan Type inspection *Options see "Site"-level*	**SoC B-Manufacturing** *C-Manufacturing +* QM certificate Gearbox manuf. + QM cert. Other critical components and processes e.g. new installation methods + QM certificate(s) *Options see "Site"-level*	**TC B** **Provisional** **Type Certificate**
A	**SoC A-Design** *B-Design +* Closing of all outstanding issues *Options see "Site"-level*	**SoC A-Test** *B-Test +* Blade fatigue test Load measurements Gearbox test at the wind turbine *Options see "Site"-level*	**SoC A-Manufacturing** *B-Manufacturing +* Hub and Nacelle Assembly, Tower *Option: Tailor inspection program for TC Site (prepare for PC/Site); see "Site"-level*	**TC A** **Type Certificate**
Site	**SoC Site-Design** *A-Design* + Site specific loads Grid connection equipment design *Options (also applicable to A and B levels):* *Foundation and/or substructure,* *Tower structure may be omitted*	**SoC Site-Test** *A-Test* *Options (also applicable to A, B and C levels):* *Noise emission* *Power performance* *Electrical characteristics Electromagnetic Compatibility*	**SoC Site-Manufacturing** *A-Manufacturing +* Inspections/audits according to inspection program. *Options (also applicable to A and B levels):* *Foundation and/or substructure,* *Tower structure may be omitted*	**TC Site** **Site Specific Type Certificate**

2.5 D level certification

D level certification is applicable for the conceptual design stage. The DNV GL certification is based on plausibility checks on the conceptual design documentation. Following a successful completion, DNV GL shall issue a Statement of Feasibility.

The D level certification is applicable for the conceptual design stage of a new wind turbine type. Hence, it is not intended to be used for the manufacturing of a wind turbine. The D level certification is usually based on a complete plausibility check of the conceptual design loads, the control and safety concepts as well as the conceptual design of the rotor blade, the safety system, the main machinery components, the electrical installations as well as of the tower.

For critical components/systems applying new technologies, a qualification programme shall be established and subject to DNV GL review. The certification plan concerning the new technologies shall be reported by DNV GL as part of the D level certification.

The Statement of Feasibility has a limited validity of 3 years in order to ensure that the certification is based on recent technology developments. Renewal shall require a new assessment with focus on the technology developments and learnings since the previous issue.

2.6 C level certification

2.6.1 General

The intention of the C level certification is to demonstrate that the wind turbine is sufficiently designed and documented for the prototype stage during the development of a new wind turbine type.

DNV GL shall carry out plausibility checks on the design documentation for the prototype. For a new blade type, the manufacturing shall be witnessed to an extent which is sufficient to get a full understanding of the manufacturing process.

Witnessing may not be required for new blade types which are using a similar manufacturing process as for a previously certified blade. However, witnessing shall normally be required for the test blade used for static test in order to verify that the test blade design and manufacturing is representative for what was assumed in the design certification module.

The results of the test of turbine behaviour as well as of the static blade test shall be assessed as part of the C level certification. Following a successful completion of each certification module, DNV GL shall issue statement of compliance and when all modules are successfully concluded, DNV GL shall issue a prototype certificate, see Table 2-1.

The assessment of the C level design is usually based on a complete plausibility check of the loads, the rotor blades, the control and protection system, the machinery components as well as of the electrical installations and the tower and foundation. National or local regulations may contain stricter requirements for certification of prototypes, e.g. A level certification for the tower and foundation.

2.6.2 Prototype certificate

The prototype certificate is valid for one specific wind turbine prototype identified by its type and address. If a wind turbine prototype is modified, e.g. with other rotor blades, a different operating mode or in other points influencing the loads, a new or revised prototype certificate shall be required.

The prototype certificate is valid for the test operation of the prototype and a maximum of 3 years.

The prototype certificate may also be issued if the test of wind turbine behaviour is outstanding or if other well defined issues are outstanding, however, the validity is limited to 1 year in these cases.

2.6.3 Design certification module - level C

The design certification of the prototype shall focus on the integrity of the wind turbine considering that the prototype test period is limited to a maximum of 3 years.

Hence, the following activities shall be included:

— load review with focus on the extreme loads
— review of control and protection system with focus on the safety system
— plausibility checks of the design of the rotor blades, the machinery components in the drive train and the tower as well as the electrical installations.

2.6.4 Test certification module - level C

The test of turbine behaviour is essential for the wind turbine prototype and is therefore part of the scope. In order to allow for commissioning and test operation of the wind turbine, the test results may be outstanding for up to 1 year provided that a detailed test program is provided.

The static blade test result of the actual blade type shall be required. For the prototype certificate, the static test of the actual blade type may be an outstanding issue provided that a similar blade type is tested and the same design and production methods have been applied; however, the validity is limited to 1 year in these cases.

2.6.5 Manufacturing certification module - level C

For the rotor blade, the manufacturing shall be witnessed to an extent which is sufficient to get a full understanding of the manufacturing process. The aim of the assessment during manufacturing is to check that the rotor blade documentation received for the C level design is representative for the blades produced for strength testing as well as for installation on the prototype.

The quality management system for the rotor blade manufacturer should be certified as complying with ISO 9001, otherwise the quality management system shall be assessed by DNV GL.

2.7 A and B level certification

2.7.1 General

The intention of the B level certification is to allow for initial production of a new wind turbine type. Hence, outstanding issues with no safety implication during the validity period are allowed.

The A level certification is intended to cover wind turbines for serial production.

The final delivery is a type certificate for the A level certification or a provisional type certificate for the B level certification.

Type certification shall confirm that the wind turbine type is designed according to a wind turbine class in conformity with the design assumptions based on this service specification and other technical requirements specified in the certification agreement and/or in the design basis and as a minimum shall include the DNV GL standards and recommended practises for wind turbines referred to in this service specification. It shall also confirm that the manufacturing process, component specifications, inspection and test procedures and corresponding documentation of the components covered by this service specification are in conformity with the design documentation.

The structural part of the tower may optionally be omitted but in this case the electrical installations which are located in the tower shall still be included. The resulting type certificate comprises certification of the complete wind turbine including design basis, design certification, type testing and manufacturing certification except for the tower design and manufacturing. The tower and foundation shall be sufficiently documented to enable type testing and load calculations for the complete wind turbine.

The A level or B level certification shall include the following modules:

— design
— test
— manufacturing.

Following the successful completion of each certification module, DNV GL shall issue statements of compliance for design, test and/or manufacturing. Upon the successful completion of all certification modules a type certificate or a provisional type certificate shall be issued. The interfaces between design, test and manufacturing are evaluated for each separate certification module.

2.7.2 Provisional type certificate

The provisional type certificate may only have outstanding issues that are not safety-relevant within the period of validity. The provisional type certificate has a validity period of 1 year. The level provisional type certificate should be replaced by a level A type certificate within the validity period.

2.7.3 Type certificate

The type certificate shall be issued if there are no outstanding items. It has a validity period of 5 years, shall be subject to annual maintenance.

For the annual maintenance, the following documents shall be submitted for verification by DNV GL:

— list of all modifications of the design of components, if applicable, documents for verification of the modifications (see Table 2-2 and Table 2-3 for examples and [4.2] for further details)
— list of all installed wind turbines of the type (at least a statement of the type with designation of the variant, serial number, hub height, location)

— list of all damages to components of the installed wind turbines (see Table 2-2 and Table 2-3 for examples and [4.2] for further details) including analyses/corrective action if applicable.

Damages and other issues should be reported as early as possible to allow proper handling of those. Furthermore, in the case the annual report is overdue by more than a month, a formal reminder will be sent to the certificate owner giving 3 weeks to rectify the situation. If no response, the certificate will be suspended/ withdrawn.

In addition to the annual maintenance, DNV GL shall carry out periodic inspections during the validity period of the certificate. The inspection frequency shall be at least once every 2½ years, to check that the wind turbines produced correspond to the type certified turbine.

Guidance note:
The periodic inspection will either be carried out in the field or in the workshop. One randomly selected type certified wind turbine or rotor nacelle assembly should be inspected in the field whereas certified components such as blades and gearboxes should be inspected in the workshop.

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Upon expiry of the validity period for a type certificate, re-certification shall be performed on request of the customer.

Table 2-2 Examples for modifications or damages to be reported

Component, system, assembly	*Detail, modification, damage*	*Documentation*
Rotor blade	Cracks in the laminate and adhesive	list of damages, root cause analysis, corrective actions
Planet carrier of main gearbox	Change of material	list of modifications, modified documentation
Bolted connection of hub/rotor shaft (multiple bolt connection)	Change in number of bolts	list of modifications, modified documentation

Table 2-3 Examples for modifications or damages not necessarily to be reported

Component, system, assembly	*Detail, modification, damage*	*Documentation*
Cover of main shaft	Change of material	-
Fixture for control cabinet	Broken once	-
Bolted connection of tower platform	Change in supplier of bolts	-

2.7.4 Design certification module - level A or B

The statement of compliance for A- or B-design includes a complete assessment of the wind turbine design documentation including review of the test programs for blade, gearbox and other critical components using new technology as well as the test programme for turbine behaviour and load measurements. The structural design of tower, foundation and/or substructure design may be included as an option.

Furthermore, the design quality control shall be covered by a certified quality management system complying with ISO 9001; otherwise the quality management system shall be assessed by DNV GL.

Following successful completion, DNV GL shall issue a statement of compliance for A- or B-design.

The statement of compliance for B-design may be issued if items are still outstanding, providing these are not directly safety-relevant.

The statement of compliance for A-design shall only be issued if there are no outstanding issues.

2.7.5 Test certification module - level A or B

For the B level certification at least the following tests shall be included:

— static blade test (covered if the C level certification is completed)
— test of turbine behaviour (covered if the C level certification is completed)
— gearbox workshop test

— other component tests
— type inspection.

In addition for the A level certification the following tests shall be included:

— blade fatigue test
— load measurements
— gearbox field test and/or durability test.

Details for tests and measurements are given in the following DNV GL standards:

— DNVGL-ST-0076 Design of electrical installations for wind turbines
— DNVGL-ST-0361 Machinery for wind turbines
— DNVGL-ST-0376 Rotor blades for wind turbines
— DNVGL-ST-0437 Loads and site conditions for wind turbines
— DNVGL-ST-0438 Control and protection systems for wind turbines.

For any other test, the standard/programme to be applied shall be agreed with DNV GL. The test or measurement programme shall be available before the test/measurement commences and should preferably be approved by DNV GL well in advance of the actual test or measurements.

Type inspection shall be carried out by DNV GL on one of the first installed wind turbines with the aim to check that the wind turbine is built according to the design documentation received for the design certification module. Further details for the type inspection are given in [3.6.2].

The tests and the type inspection shall be carried out to the largest possible extent at wind turbines located onshore. Only those parts of the tests and of the inspection which cannot be carried out on any onshore wind turbine shall be performed at wind turbines located offshore.

2.7.6 Manufacturing certification module - level A and B

2.7.6.1 General

The aim of the manufacturing certification module is to verify that the wind turbine components and systems are produced and tested according to the documentation received for the design certification modules. The evaluation shall be based on the evaluation of documentation such as drawings and specifications used in the production as well as certificates and other delivery reports from sub suppliers. The evaluation shall include at least an inspection at the nacelle and hub assembly as well as at the gearbox and blade manufacturers. The blade manufacturing may be covered through the inspection carried out for the C level.

As an option, the DNV GL inspection programme for project certification or site specific type certification may be developed as part of the A level manufacturing certification module.

2.7.6.2 Quality management

The quality management system for the wind turbine manufacturer and its sub-suppliers should be certified as complying with ISO 9001, otherwise the quality management system shall be assessed by DNV GL.

2.7.6.3 Inspection

The manufacturing certification module includes inspections on a spot check basis and shall be carried out for one wind turbine. This shall require manufacturing/assembly of at least one specimen representative for the type under certification. The inspection shall include the following:

— verification that the design specifications and design requirements are properly implemented in workshop drawings, workshop instructions, purchase specifications and installation instructions
— visual inspection of components and manufacturing processes to confirm the implementation of the design requirements
— verification of delivery documents from sub suppliers.

The focus of the inspection shall be the critical manufacturing processes.

Changes in the manufacturing processes which influence the production quality or the component properties shall be reported to DNV GL. In the event of major changes, the relevant documentation shall be submitted for renewed assessment and, if necessary, a repeated DNV GL inspection shall be made.

Guidance note:

During the validity period of a certificate changes in the manufacturing process should be reported as early as possible to allow proper handling of those; e.g. once they are defined and implemented, but latest for the annual reporting.

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2.7.6.4 Rotor blade inspection

For the rotor blade, the manufacturing shall normally be witnessed at the prototype stage (C level). The aim of the inspection is to check that the rotor blade documentation is representative for the blades produced for strength testing as well as for installation on the prototype.

2.7.6.5 Gearbox inspection

The aim of the gearbox inspection is to verify that the gearbox documentation received is representative for the gearboxes produced for workshop tests (test bench) and field/durability testing.

The verification shall be based on both inspection of the gearbox and gearbox parts at the gearbox manufacturer. The inspection shall be based on the design documentation received as well as on production records and delivery documentation from sub suppliers.

2.7.6.6 Inspection at nacelle and hub assembly

The inspection shall be supported by means of drawings, specifications and record schemes for the individual processes, structures and components.

The specifications/descriptions related to the critical manufacturing processes are reviewed by DNV GL as part of the design certification module.

The components listed below shall be verified with respect to compliance with the design documentation on a spot check basis. The check shall be based on the delivery documentation from the sub suppliers as well as visual inspection of the components in the hub and nacelle assembly workshop, i.e. visits at sub suppliers shall normally not be required.

— pitch drives
— pitch bearing
— hydraulic system(s)
— rotor hub
— rotor shaft
— main bearing
— main bearing housing
— brake
— couplings
— generator
— transformer
— converter
— electrical cabinets
— main and generator frame
— blade-pitch, rotor and yaw locks
— yaw bearing
— yaw drives
— nacelle cover and spinner
— bolted connections.

2.7.6.7 Inspection of other critical components and processes

Inspections of other critical components and critical processes may be agreed upon between the customer and DNV GL to be performed additionally. These inspections shall be carried out at the component supplier's manufacturing workshop or at a wind turbine installation site for processes related to installation and commissioning.

If the evaluation in the design certification module revealed special needs for components e.g. utilising new or unproven technology or for which additional testing is required, DNV GL may request inspection of the manufacturing of these components at the component suppliers. The aim of this inspection is to verify that the manufacturing process is acceptable and shall produce components of the specified quality. This includes verification that the samples for the inspections and possible testing are representative for the future serial production.

2.8 Site level certification

2.8.1 General

The site level certification is introduced to prepare for project certification of offshore and onshore wind power plants. The site level certification aims at minimising the efforts in project certification for the turbine manufacturer.

The site level certification covers the design, testing and manufacturing of site specific wind turbines. The aim is that the type of turbine with its design covers the site conditions of the project. Site specific adaptation of the wind turbine configuration shall be considered in this level of certification.

The scope of the site level certification may or may not include tower, substructure and/or foundation, i.e. the same options as for A and B level certification, see [2.7.1].

In case of site specific component design or e.g. for component certification of towers, foundations, support structures or other site specific installations this chapter may be applied, too.

2.8.2 Site specific type certificate

The type certificate for the site level covers the wind turbines listed on the site specific type certificate and shall be issued after completion of the wind turbine manufacturing based on a successful completion of all the certification modules. As the site specific type certificate is only valid for the design, testing and manufacturing of the wind turbines listed on the certificates, there shall not be any validity period on the certificate as it is valid for a specific use only.

2.8.3 Design certification module - site level

The design certification module includes an evaluation of the wind turbine design for site specific conditions as well as for project specific transport and installation loads.

Guidance note:

In the case that the final site or the final site conditions are not known, generic site conditions may be applied when deriving the site specific loads for the site level design certification module.

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The foundation and/or substructure design – if included in the scope of the certification – shall be assessed based on the specified soil conditions and manufacturing process. Additionally, changes in the design for the actual project shall also be covered.

Furthermore, the design quality control shall be covered by a certified quality management system complying with ISO 9001, otherwise the quality management system shall be assessed by DNV GL.

Upon successful completion of the design certification module, a statement of compliance for site-design shall be issued.

2.8.4 Test certification module - site level

The test certification module may in addition to the mandatory tests given in [2.7.5] for the level A certification also include e.g. noise measurements, power performance measurement as well as measurements of electrical characteristics and/or electromagnetic compatibility. The additional tests for the site level certification as compared to the level A certification are all optional. Hence, if no options are included then the certification work may be limited to verify that the certification testing given in [2.7.5] covers the site specific version of the wind turbine.

Upon successful completion of the test certification module, a statement of compliance for site-test shall be issued.

2.8.5 Manufacturing certification module - site level

The manufacturing certification module shall include inspection/audit of the actual manufacturing of the wind turbines subject to certification and manufacturing for the specific project. The inspection/audit plan shall be established by DNV GL based on the information received and experience with the actual wind turbine type and considering the quality management system. As an option, the inspection/audit plan may be approved as part of the A level type certification.

The inspection/audit shall include the review of the as built documentation for all wind turbines covered by the site level certification.

One of the first wind turbines produced shall be inspected in the assembly workshops of nacelle, hub and gearbox/generator (direct drive). Dependent on the findings, the frequency of inspections shall be determined; however, not less than every tenth assembly for each workshop shall be inspected.

Furthermore, the blade manufacturing shall be inspected. In case the tower, substructure and foundation are inside the scope of certification, the manufacturing of these components shall also be inspected with an initial inspection frequency of every fifth blade and every tenth tower/ substructure/ foundation. The frequency may decrease, however not less than every tenth blade and every twentieth tower/ substructure/ foundation. In the case of a DNV GL shop approval, inspections may not be required dependent on the scope of the shop approval.

The quality management system for the wind turbine manufacturer and its sub-suppliers should be certified as complying with ISO 9001, otherwise the quality management system shall be assessed by DNV GL.

Manufacturing of other components shall be subject to DNV GL inspection dependent on:

— quality management system for incoming goods inspection
— if critical manufacturing processes are involved
— the criticality of the component
— availability of a DNV GL shop approval.

Upon successful completion of this module a statement of compliance for site-manufacturing shall be issued listing the wind turbines serial numbers.

2.9 Component certificates

Component certificates may be issued for specific components, such as rotor blade, generator, gearbox, other electrical components, brake, coupling, pitch system, yaw system, nacelle frame, tower, foundation and rotor nacelle assembly. Component certification covers relevant modules of type certification with the extent depending on the component in question. It may be performed analogously by application of the elements and modules as listed in this service specification.

For component certification it is required that the interface including the design load envelope is clearly defined.

SECTION 3 DETAILED SERVICE DESCRIPTION

3.1 General

This section provides details of DNV GL's verification activities for each of the certification modules covered by the DNV GL type and component certification scheme for wind turbines.

For each verification activity, verification of compliance shall be made against DNV GL standards or DNV GL recommended practices. For verification activities, for which no particular standard is available, verification of compliance shall be performed against standards or other guidelines agreed between the manufacturer and DNV GL as part of the certification agreement and/or the design basis. Such standards or guidelines shall meet the intended safety level of the DNV GL service documents. The relevant parts of the GL guidelines IV-1:2010 and IV-2:2012 or DNV standards may be used until all new DNV GL standards and/or recommended practices are available.

Wind turbines intended to be certified shall be so designed, manufactured and maintained as to guarantee safe and reliable operation during their envisaged operating life. This in particular requires proof that

- the wind turbine is capable of withstanding all loads and other environmental conditions assumed to occur during manufacture and the envisaged operating life
- the wind turbine remains operable under the influence of each of the loads and other environmental conditions to be assumed in this connection.

The wind turbine shall be so designed in such way that minor causes cannot result in disproportionately heavy damage. This may for instance be achieved by

- designing the important components and systems such that failure of a part does not result in destruction of the entire installation
- ensuring that all important components and systems are capable of withstanding all foreseeable influences.

Inspection and maintenance intervals shall be planned to provide adequate assurance that no significant deterioration in the condition of the installation may arise in the interval. The design shall take into account the practicability of carrying out inspections of relevant components or systems.

Where inspection is not practicable, the component or system shall be designed and manufactured in a way that adequate durability for the entire operating life of the wind turbine is assured.

Component certification may be performed analogously by application of the elements and modules as listed in this service specification.

3.2 Design basis

The design basis shall unless otherwise agreed include the DNV GL standards listed in this service specification and in service specifications for optional/additional services if applied, see [1.3].

If relevant the design basis shall furthermore include:

- general description of the wind turbine
- main principles for the control and protection system
- environmental conditions relevant for design
- design parameters and assumptions
- design life for each load carrying structural/mechanical component
- additional codes and standards
- generic design methodologies/principles
- other requirements, e.g. related to installation and maintenance
- deviations to the applied codes and standards
- relevant recommended practices, if any.

The design basis may partly be integrated in the wind turbine design documentation. However, it is recommended that the design basis is approved by DNV GL before the detailed design phase commences.

Design basis is not defined as being a certification module and DNV GL shall report the certification of the design basis in the deliverables to the design certification module.

3.3 Design certification module for levels A, B or site

3.3.1 General

The purpose of the design certification module is to verify that the wind turbine design complies with the approved design basis. The design certification module is part of the certification scheme for all levels according to Table 2-1. The scope of the design certification module shall be limited for the C and D level certification modules.

For the A, B and site level certification module, DNV GL shall verify the design for compliance with design assumptions, standards and other requirements specified in the design basis. Following a successful completion of the verification of the design, DNV GL shall issue a statement of compliance design.

The design certification module for the A, B and site level includes the following main elements:

— control and protection system
— loads and site conditions
— rotor blades
— machinery and housings (nacelle cover and spinner)
— support structure (optional: tower and/or foundation design)
— electrical installations
— manuals (transportation, installation, commissioning, operation and maintenance).

There are DNVGL standards for each of the main elements except for the manuals which are covered by this section.

For the certification of wind turbines intended for temperatures outside the standard climatic conditions as defined in DNVGL-ST-0437, DNVGL-RP-0363 shall be applied.

Details of the verification of each of these topics are given in the following subsections. Details for the C and D level certification module are given in [3.4] and [3.5].

3.3.2 Control and protection system

DNV GL shall evaluate the documentation of the control and protection system for compliance with DNVGL-ST-0438.

For the verification of the control and protection systems as well as the test of turbine behaviour the following documentation is required:

— description of the wind turbine
— control and protection concept
— specification of the braking systems
— failure considerations
— specification of the protection functions and performance levels
— electrical and hydraulic circuit diagrams
— documentation of software
— test plan.

Detailed requirements for the certification documentation are given in DNVGL-ST-0438 App.A.

Documentation shall also be provided demonstrating that the model of the controller used in the load calculations resembles the same functionality and algorithms as that for the real wind turbine.

Advanced control features such as resonance speed avoidance, active tower damping, individual pitch control, drive train damper may require additional documentation and/or testing.

Guidance note:
In some cases workshop testing may be necessary to verify the controller software. Detailed information on this as well as further guidelines for control and protection system design and testing may be found in DNVGL-ST-0438.

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A failure analysis such as failure mode and effect analysis (FMEA) for the control and protection system shall be executed and documented by the manufacturer.

There may be additional requirements for the documentation of the control and protection system related to the marine environment and the need for remote operation/monitoring as well as back-up supply for offshore wind turbines.

3.3.3 Loads and site conditions

DNV GL shall evaluate the loads and site conditions for compliance with the standard DNVGL-ST-0437.

The site conditions shall be specified by the manufacturer as basis for the wind turbine design.

The manufacturer shall document the load analysis and also provide a summary of the loads used for design. The documentation shall include a load case description and a description of calculation models and input data such as

- parameter values relating to aerodynamics
- structural characteristics
- parameter values and software version relating to the control system.

Furthermore, the result of the load analysis shall be reported:

- description of load analysis software including post processing tools as well as version control/validation of the applied software
- description of sensors and the corresponding co-ordinate systems used by the load analysis software
- full input and output data including time series. The output data a shall generally include FFT spectra, statistics, RFC spectra, load duration distribution (LDD), Markov matrices, extreme loads, equivalent fatigue loads
- load analysis result summary for key locations and individual components such as blade, hub, shaft, gearbox, yaw system, tower, and locks.

The required load cases are defined in DNVGL-ST-0437. The design of the control and protection system shall be considered in the detailed set-up of load cases. The following design situations are covered by the load cases defined in DNVGL-ST-0437:

- power production
- power production plus occurrence of a fault (results from the failure analysis to be considered)
- start up
- normal shutdown
- emergency shutdown
- parked (standing still or idling)
- parked or fault conditions
- transport, assembly, maintenance and repair.

DNV GL shall verify the loads and the load cases. The extent of the verification shall depend on the wind turbine concept and on the size of the wind turbine e.g. small/medium stall/pitch controlled wind turbines may be verified by DNV GL using simplified well proven methods.

The load cases for "parked" or "fault conditions" should consider the control and protection system design including the conclusions from the failure analysis such as FMEA "What if approach" and failure tree analysis (FTA) "how to get approach". If the wind turbine is designed for low-voltage ride-through (LVRT) capability, this shall then be considered in the load analysis.

As part of the verification of loads and load cases, DNV GL shall carry out independent load analyses using a different analysis programme than the one used by the manufacturer. The focus of the independent analyses shall be on governing fatigue loads and selected critical extreme load cases.

The DNV GL independent load analysis may include a time domain load simulation using a special-purpose aero-elastic code.

The independent load analysis shall be used for the verification of the manufacturer's load analysis report with respect to load level and dynamic behaviour.

The DNV GL independent load analysis report may be submitted to the manufacturer as an option. This option should then be clearly specified in the certification agreement.

In case of component certification a full load and load case verification may be included or the load set is checked for plausibility and applied for the design in question. In the latter case a load comparison and – in case of higher loads - reserve calculation is necessary during type certification to integrate the component or system in a wind turbine.

3.3.4 Rotor blades

DNV GL shall evaluate the rotor blade design for compliance with DNVGL-ST-0376.

The design documentation shall comprise:

— design calculations
— drawings and specifications including layup and tolerances
— material data: Material properties shall be verified by testing at latest in connection with the final component/type certificate. If the material properties are taken very conservatively and not based on any testing, this may be acceptable for design evaluation.
— manufacturing instructions: If possible, the manufacturing instructions should be reviewed in connection with design evaluation. Otherwise the correspondence between design and manufacturing shall be checked in connection with the manufacturing evaluation.
— specifications for blade testing.

DNV GL requires that the documentation clearly identifies the basis for the design, i.e. codes and standards, as well as loads and relevant external conditions.

The DNV GL evaluation consists of documentation reviews and/or independent analyses.

For new blade designs or if the blade design documentation includes advanced analyses, such as FEM analyses of highly utilized parts, DNV GL may carry out independent analyses for verification of the design.

DNV GL shall review the handling and transportation procedures as well as the support structures in order to verify that the design envelope is not exceeded and that the blades are not damaged during transportation.

The following documentation shall be made available to DNV GL for the review of the handling and transport procedures with respect to the design:

— blade design analyses for transport and handling conditions
— drawings of different the blade transport and support devices
— specification of loads during transport including offshore transport (e.g. accelerations)
— instructions for handling and transport of blades.

3.3.5 Machinery and housings

DNV GL shall evaluate the designs of mechanical components including housings (nacelle cover and spinner) for compliance with DNVGL-ST-0361.

The design documentation relating to mechanical components normally consists of descriptions, specifications, drawings, part lists and schematics together with design calculations, which may be combined with measurement reports, test reports, FE models, drawings and part lists. DNV GL requires that the documentation clearly identifies the basis for the design, i.e. codes and standards, as well as loads and relevant external conditions.

The DNV GL evaluation consists of documentation reviews. Additionally, for mechanical components with complex or novel design details and/or an expected high utilisation DNV GL may carry out independent analyses for verification of the design. The DNV GL independent analysis report may be submitted to the manufacturer as an option. This option should then be clearly specified in the certification agreement.

For mechanical components subject to component tests, the results of the component tests may be used as full or partial documentation of the structural capacity. In this case, the test plan is subject to approval by DNV GL.

For nacelle cover and spinner, the review of the design documentation shall focus on the strength of connection points between cover/spinner and main structure/hub. Structures integrated in the nacelle cover/spinner, e.g. for crane support, hook-up points and helicopter platforms shall be reviewed as well together with the crane structure, hook-up point structure and helicopter deck structure.

3.3.6 Support structures

DNV GL shall evaluate the designs of the tower(s) and optionally of the substructure and/or the foundation for compliance with DNVGL-ST-0126.

As an option the tower structural design may be omitted from the design verification, see [2.7.1] for further details.

The design documentation relating to the tower(s) and optionally the substructure/foundation normally consists of descriptions, specifications, drawings and part lists together with design calculations and if applicable also test-reports and FE models. DNV GL requires that the documentation clearly identifies the design basis, i.e. codes and standards, calculation assumptions as well as loads and relevant external conditions.

The DNV GL assessment consists of documentation reviews. For non-standardised structural components with complex design details and/or an expected high utilisation, DNV GL may carry out independent analyses for verification of the design. The DNV GL independent analysis report may be submitted to the manufacturer as an option. This option should then be clearly specified in the certification agreement.

For structural components subject to component tests, the results of the component tests may be used as full or partial documentation of the structural capacity. In this case, the test plan is subject to approval by DNV GL.

3.3.7 Electrical installations

DNV GL shall evaluate the designs of electrical components and systems for compliance with DNVGL-ST-0076.

The design documentation related to electrical components and systems normally consists of descriptions, specifications, diagrams, schematics, drawings and part lists together with design calculations and if applicable also test reports. DNV GL requires that the documentation clearly identifies the basis for the design, i.e. codes and standards, as well as relevant external conditions.

3.3.8 Manuals

The purpose of this part of the design verification is to verify that the transport and installation manual, the commissioning manual, the operating instructions and the maintenance manual include the required information as specified in detail in App.B.

The manuals shall be in English language.

Guidance note:
DNVGL-SE-0190 states requirements on manuals for project certification. These manuals may be submitted to DNV GL in another language, if previously agreed in writing.

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3.4 Design certification module for C level

3.4.1 General

With regard to the safety system of the wind turbine, the focus of the DNV GL evaluation is to check whether the safety-relevant operating values are monitored, processed and made available to the safety system. Furthermore, the existence of sufficient redundancies in the two independent braking systems and the safety system are checked.

The blade root, hub and tower top loads shall be submitted and are checked for plausibility. This is possible if the extreme loads and fatigue loads may be compared with those of other wind turbines of similar size. If the wind turbine under certification is larger than any known wind turbine type, then the pertinent values shall be extrapolated with due consideration of the physical circumstances.

Guidance note:
A complete examination of the loads may be waived, since modifications of the control system that influence the loads are permissible for a prototype.

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The design of the rotor blades, the machinery components in the drive train and the tower as well as the electrical installations and optionally the substructure/foundation are also checked for plausibility. Experience gained in the dimensioning and design of similar turbines shall be considered, if possible.

3.4.2 Documents to be submitted

For the C level design certification module, the following documents shall be submitted; further documents may be necessary, e.g. in case of new concepts:

- name and address of the owner
- planned location of the prototype
- general description of the wind turbine including energy conversion concept (generator-converter-system)
- listing of the primary components to be utilised (e.g. main bearing, gearbox, brake, generator, converter etc.) including the manufacturer and type designations
- description of the control and safety concepts
- description of the safety system and the braking systems
- description of the electrical installations, at least inside the hub, nacelle and tower (components, rating range and single line diagram)
- concept of the lightning protection system
- results of the complete load calculations: extreme load tables and equivalents load tables. Furthermore, an analysis of the maximal rotor speed, the maximal blade deflection and a Campbell diagram for the blades shall be submitted.
- main drawings and strength calculations for the rotor blade, including structural design and blade connection
- preliminary description of the rotor blade manufacturing process
- general arrangement drawing of the nacelle
- drawings and strength calculations for hub, main shaft and main frame
- main drawings and rating calculations for the gearbox
- data sheets of the main electric components
- main drawings and strength calculations for the tower
- main drawings and strength calculations for the substructure and/or the foundation
- soil investigation report
- 10-min mean of the extreme wind speed at hub height with a recurrence period of 50 years and the mean air density for the planned location of the prototype
- test report for the arc resistance test of medium-voltage switchgear
- test program for the static blade test
- test program for the control and safety system test.

3.5 Design certification module for D level

3.5.1 General

The design certification module covers the design concept including preliminary loads, principles of the control and protection system, main dimensions as well as methods and basis for the detailed design. New technology applied for critical components shall be covered as well.

With regard to the safety system of the wind turbine, it is checked whether the safety-relevant operating values are monitored, processed and made available to the safety system. Furthermore, the existence of sufficient redundancies in the two independent braking systems and the safety system are checked.

The blade root, hub and tower top loads shall be submitted are checked for plausibility. This is possible if the extreme loads and fatigue loads may be compared with those of other wind turbines of similar size. If a wind turbine under certification, larger than any wind turbine type known, is submitted for assessment, then the pertinent values shall be extrapolated with due consideration of the physical circumstances and the design concept.

The conceptual design of the rotor blades, the main machinery components, the tower and the electrical installations and optionally the substructure/foundation shall be checked for plausibility. Experience gained in the dimensioning and design of similar turbines shall be considered, if possible.

For critical components/systems utilising new technology, DNV GL shall review risk analyses together with the corresponding technology qualification programme. Based on the documentation received, DNV GL shall amend the certification scope to the next certification levels of the certification scheme, i.e. prototype certification and provisional type certification. The technology qualification method is described in DNV-RP-A203:2013-07.

3.5.2 Documents to be submitted

For the D level design certification module, the following documents shall be submitted; further documents may be necessary, e.g. in case of new concepts and/or new technology, see also [3.5.1]:

- general description of the wind turbine including energy conversion concept (generator-converter-system)
- listing of the primary components to be utilised (e.g. main bearing, gearbox, brake, generator, converter etc.) including the manufacturers and type designations
- description of the control and safety concepts
- description of the safety system and the braking systems
- description of the electrical installations, at least inside the hub, nacelle and tower (components, rating range and single line diagram)
- concept of the lightning protection system
- results of the complete load calculations: extreme load tables and equivalents load tables. Furthermore, an analysis of the maximal rotor speed, the maximal blade deflection and a Campbell diagram shall be submitted.
- main drawings and strength calculation for the rotor blade, including structural design and blade connection
- general arrangement drawing of the nacelle
- drawings and strength calculations for hub, main shaft and main frame
- main drawings and rating calculation for the gearbox
- data sheets of the main electric components
- main drawings and strength calculations for the tower
- optional main drawings and strength calculations for the substructure and/or the foundation.

The strength calculations may be simplified and may be limited to extreme loads and simplified fatigue strength calculations.

3.6 Test certification module

3.6.1 General

The purpose of the type testing is to verify the safety and protection system, the load calculations as well as the blade and gearbox design and manufacturing.

The test certification module comprises the following elements with reference to the (lowest) level as given in Table 2-1:

— test of wind turbine behaviour – level C
— type inspection – level B
— load measurements – level A
— rotor blade tests – level C and level A
— gearbox and other component tests – level B and level A
— noise emission measurements (optional) – level B
— power performance measurements (optional) – level B
— electrical characteristic measurements (optional) – level B
— electromagnetic compatibility measurements (optional) – level B.

The elements of the type testing should be carried out by accredited laboratories. Otherwise, DNV GL shall verify that the testing is carried out fulfilling ISO/IEC 17020 or ISO/IEC 17025, as applicable. The test programme/plan shall be evaluated by DNV GL before the test starts.

The scope of the test certification module may be reduced for turbine variants or modified turbines after consultation with DNV GL, provided that the prototype test was performed in its entirety for a predecessor turbine.

The measurement points, the planned scope of the measurements, and their assessment shall be coordinated with DNV GL before installation of the measurement equipment commences. The influence of a turbine variant on the measurement result shall be assessed by DNV GL and the accredited testing laboratory which performed the measurements on the original installation.

Guidance note:
If a prototype turbine onshore is used for the prototype tests for an offshore wind turbine type, then it is advisable to select a site at the sea coast to achieve the highest possible similarity with marine atmospheric and wind conditions.

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The wind turbines at which the measurements are carried out shall conform with the design or variety of designs on which the certification is based. Compliance shall be confirmed by a declaration of the manufacturer. Any deviations in design shall be reported to DNV GL and the accredited testing laboratory before the measurement/test takes place. In a separate document discussion, reasoning and all deviations shall be listed. This document shall be submitted by the customer. If an already evaluated test report shall be used for the type certification of a variant, this test report shall be listed in the document, too. If the compliance is adequate for the corresponding test purpose, the measurement/test results may be used for the certification.

The testing laboratory performing the measurements shall record the identifications and data on the nameplates of the surveyed wind turbine and of the primary components and shall include these in the measurement report.

After the tests the following documents shall be submitted to DNV GL for evaluation:

— test report
— comparison of the test results with the design values.

3.6.2 Type inspection

The type inspection shall be carried out as part of the test certification module for the A and B levels.

The type inspection implies that the installed wind turbine is inspected for compliance with the design documentation submitted to DNV GL as part of the design certification module. The type inspection shall be visual only and shall focus on main components, systems and main connections.

The type inspection shall be carried out according to the DNV GL approved inspection plan.

3.6.3 Test of wind turbine behaviour

The test of turbine behaviour shall be concluded as part of the A, B and C level test certification module.

The test of turbine behaviour is intended to verify the parameters and characteristics used as the basis for the design of the wind turbine. The test of wind turbine behaviour shall be carried out according to DNVGL-ST-0438.

The tests shall preferably be carried out at the wind turbine fitted with instrumentation for load measurements.

The test of turbine behaviour should be carried out by a testing laboratory accredited for load measurements at wind turbines, see also [3.6.1] above.

Generally, - in terms of successor turbine types – new tests of the turbine behaviour are necessary if new load measurements are required. In the case of type variants, the scope of measurements may be reduced in consultation with DNV GL to those measurement parameters which are influenced by the design modifications.

The measurement report and the verification by the accredited testing laboratory (if applicable) and the comparison with the assumptions shall be submitted to DNV GL for evaluation.

For the certification of the control and protection systems as well as for the test of turbine behaviour the following documentation is required:

— description of the wind turbine
— control and protection concept
— specification of the braking systems
— failure considerations
— specification of the protection functions and performance levels
— electrical and hydraulic circuit diagrams
— documentation on software
— test plan, test report and comparison test results/design values of the test of turbine behaviour.

Detailed requirements for the certification documentation are given in DNVGL-ST-0438 App.A.

3.6.4 Load measurements

The load measurements and the corresponding evaluations shall be concluded as part of the A level test certification module.

Load measurements shall be carried out and reported according to a DNV GL approved test programme. DNVGL-ST-0437 shall be applied for the measurements as well as for the evaluation of the measurement results.

For non-accredited test laboratories, DNV GL shall witness the calibration. The raw data of the measurements shall be available to DNV GL for independent processing.

The results of the load measurements shall be compared with the results of the load analysis which shall be adjusted to the test turbine design and the test site conditions. The comparison report shall be submitted to DNV GL for assessment.

3.6.5 Rotor blade tests

The rotor blade static test shall be concluded for the A, B and C level test certification module. The rotor blade fatigue test shall at the latest be concluded for the A level test certification module.

New rotor blade types shall be tested according to a DNV GL approved detailed test plan. DNVGL-ST-0376 shall be applied for the rotor blade tests.

In the case of testing performed at a non-accredited testing laboratory all static tests and the pre- and post-fatigue tests shall be witnessed by DNV GL. The extent of witnessing of the fatigue tests shall be decided on a case by case basis, taking into account the experience and the quality measures of the testing laboratory, and should include witnessing/inspection of both test directions, and at least one inspection during the fatigue testing.

The test blade(s) shall be representative for the serial production blade.

The need for re-testing due to design changes of the rotor blade or the possibility to make use of a rotor blade test within a certification of variants of the blade design has to be decided on a case by case basis.

3.6.6 Gearbox and other component tests

The gearbox test is required for wind turbines with a main gearbox. Possible testing of direct drive systems or innovative drive train systems shall be covered by tailored test programmes to be agreed with DNV GL on a case by case basis.

The gearbox testing at the test bench shall be concluded as part of the B level test certification module whereas the gearbox testing at the wind turbine shall be concluded as part of the A level test certification module. Other component tests like direct drive generator testing shall be concluded at the B level test certification module.

The testing shall be carried out according to a DNV GL approved test programme. The testing of gearboxes shall be carried out and the test results shall be evaluated and reported according to DNVGL-ST-0361.

In the case of non-accredited testing laboratories, the DNV GL involvement shall be agreed on a case by case basis considering the test set-up and the type of tests included in the respective test. The agreement shall also include the DNV GL involvement during the disassembly of the gearbox.

The measurement report and the verification by the accredited testing laboratory (if applicable) shall be submitted to DNV GL for assessment.

3.6.7 Noise emission measurements (optional)

Measurements of the noise emissions may be included as an option in the test certification module.

If noise emission measurements of the wind turbine are carried out this shall to be performed in accordance with IEC 61400-11 the latest edition of which shall be applied.

Deviations from this standard shall be justified and defined in consultation with DNV GL. Furthermore, the deviations shall be listed in detail within a separate chapter in the test report.

Generally, measurements shall be agreed with DNV GL when introducing any variants of the wind turbine. However, when introducing a new rotor blade design (e.g. other aerodynamic surface), a different set point for the rotational rotor speed, a new tower design (lattice/tubular/hybrid), a new type of gearbox or major changes in the electrical installations (e.g. grid frequency), new measurements shall be carried out.

Any deviations in the design of the turbine under test from the design within the process of type certification shall be reported to DNV GL and the accredited testing laboratory before the measurement commences. Deviations from the design shall be justified and defined in consultation with DNV GL. In a separate document, discussion, reasoning and all deviations shall be listed. This document shall be submitted by the manufacturer. If an already evaluated test report shall be used for the type certification of a variant, this test report shall be listed in the document, too.

The report of the accredited testing laboratory shall be submitted to DNV GL for evaluation.

For offshore wind turbine types, the measurements may be carried out at an onshore installation of the same wind turbine type.

Guidance note:
It is very difficult, not to say impossible, to measure the noise emissions of an offshore wind turbine installation, as the measurement equipment has to be stationed around the turbine.

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3.6.8 Power performance measurements (optional)

The power performance of the wind turbine is important for the assessment of power production estimates for new projects as well as for evaluating the performance of new products. Hence, power performance measurements may be included as an option in the test certification module. The measurements should be carried out according to IEC 61400-12-1 by an accredited testing laboratory.

The measurements may be carried out at an onshore installation of the offshore wind turbine type.

3.6.9 Electrical characteristics measurements (optional)

The results from the electrical characteristics measurements are required for most projects both onshore and offshore. The results shall normally be available before connecting the wind turbines to the grid. Hence, electrical characteristics measurements may be included as an option in the test certification module.

The electrical characteristics measurements module, when included in the type certification, comprises one or more of the following elements:

— power quality tests – IEC 61400-21
— low-voltage ride-through (LVRT) tests – IEC 61400-21.

Generally, the electrical characteristics measurements shall be carried out by an accredited testing laboratory. For non-accredited test laboratories, DNV GL shall witness the measurements.

Measurement of the electrical characteristics of the wind turbine shall be carried out in accordance with IEC 61400-21.

Deviations from IEC 61400-21 shall be justified and defined in consultation with DNV GL.

In the case of type variants it shall be observed that a new measurement of the electrical characteristics is necessary as a rule, whenever the generator type, any existing power electronic device in the main power circuit, relevant parts in its controller software, or the grid frequency is changed or if a new blade design is introduced.

The changes in the controller software of electronic devices in the main power circuit shall be described and submitted for DNV GL assessment. This description shall contain the software designation, release number, implementation date, and an evaluation of the relevance concerning electrical characteristics.

Any deviations in the design of the test turbine from the design within the process of type certification shall be reported to DNV GL and the accredited testing laboratory before the measurements take place. Deviations from the design shall be justified and defined in consultation with DNV GL. In a separate document discussion, reasoning and all deviations shall be listed. This document shall be submitted by the manufacturer. If an already evaluated test report shall be used for the type certification of a variant, this test report shall be listed in the document, too.

The report of the accredited testing laboratory shall be submitted to DNV GL for evaluation.

3.6.10 Electromagnetic compatibility measurements (optional)

Wind turbines and their electrical components and systems shall be designed concerning EMC as to:

— reach a specific level of operational safety of the wind turbines during energy production or the event of faults
— keep the wind turbines' emissions to the environment within tolerable levels
— avoid that disturbing sources are interfering with other sub-systems or components of the wind turbines leading to malfunction of single components or loss of control
— ensure a constant high quality of the wind turbines and their components during energy production and an undisturbed operation in every situation by defining minimum requirements for the EMC characteristics of wind turbines (in combination with referenced standards, recommended practices, guidelines, etc.) and their influence on the environment

DNVGL-RP-0440 shall be applied to demonstrate that the electromagnetic emission level is satisfactorily and also to demonstrate that the wind turbine´s electromagnetic immunity is sufficient to avoid critical disturbances.

3.7 Manufacturing certification module

3.7.1 General

The content of the manufacturing certification module is dependent on the certification level. For the D level the manufacturing certification module is neither defined nor required. The manufacturing certification module for the C level shall include DNV GL inspection of the main manufacturing processes for one representative rotor blade being manufactured. The quality management system certificate for the blade manufacturer shall be available at this stage.

For the B level manufacturing certification module, DNV GL shall additionally carry out an inspection at the main gearbox assembly workshop for one representative gearbox. The gearbox manufacturing shall be covered by a certified quality management system. Other components, e.g. direct drive generators which may require tests as part of the DNV GL certification shall also be subject to inspection of one representative sample and should also be covered by a certified quality management system; alternatively the quality management system shall be assessed by DNV GL.

For the A level manufacturing certification module, DNV GL shall additionally carry out inspections at the assembly workshops for the hub and nacelle assemblies for one representative wind turbine. This shall include check of incoming goods inspection but does not include visits at the sub-suppliers other than as stated above for B and C level manufacturing module, i.e. gearbox and for other components that require test.

For the A level manufacturing certification module, DNV GL shall also carry out an inspection of the tower manufacturing for one representative wind turbine tower covered by a certified quality management system.

The site level manufacturing certification module shall include inspections of the manufacturing of the wind turbines to be certified including identified components. The frequency of the inspections shall be established based on the initial inspection.

If requested by the manufacturer, DNV GL shall issue a shop approval, provided the approval conditions are fulfilled. The shop approval shall be taken into account when determining the inspection extent and frequency in connection with the site level manufacturing certification module, see also [3.7.3].

3.7.2 Quality management system

The quality management system for the wind turbine manufacturer as well as for the component manufacturers subjected to DNV GL inspection shall meet the requirements of ISO 9001, whereby ISO 9000 defines fundamentals and vocabulary. Alternatively the quality management system shall be assessed by DNV GL.

For the manufacturers of products who do not pursue their own development activities, the exclusion of "design and development" of ISO 9001 is permissible.

Guidance note:

The validity of the certificate is maintained by means of regular audits. These audits are carried out at set intervals in time (e.g. once a year and, if necessary, more often). The certification is generally valid for three years. It commences with the date of the certificate. On completion of the re-certification (usually comprising the execution of a renewal audit), a certificate may be issued which again is valid for three years. The validity of the certificate necessitates that all the conditions under which it was granted are still being met and no serious shortcomings have arisen in the quality management system.

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3.7.3 Shop approval

DNV GL recommends performing a shop approval at wind turbine component suppliers. This may include various workshops for example those for rotor blades, rotor blade repairs, steel support structures, foundations, grouting material as well as mechanical and electrical components.

The shop approval confirms that a workshop operates with approved production facilities, working procedures and qualified staff. DNV GL assesses the ability to manufacture wind turbine components in compliance with international standards and guidelines or acknowledged methods.

The DNV GL shop approval is independent of component, type- or project certification and always specific for the respective workshop. It consists of the two elements "general document review" and "on-site inspection". The document review includes evaluation of the general quality documentation, e.g. specifications for manufacturing purposes. Furthermore, a validity check of equipment being used, abilities as well as skills of staff, is covered by the shop approval. Within the on-site inspection the evaluation of the workshop and related manufacturing and quality processes is included.

During A, B and C level manufacturing certification for component and type certification the general document review may be omitted if a workshop holds a shop approval. However, the scope of specific document reviews shall be agreed with DNV GL. For A, B and C level certification a design specific audit shall be carried out as part of the manufacturing certification module. If a workshop holds a shop approval the scope of audit shall be reduced in agreement with DNV GL.

During site level manufacturing certification the general document review and initial audit may be omitted if a workshop holds a shop approval. However, the scope of specific document review shall be agreed with DNV GL. The scope of regular inspections shall be reduced in agreement with DNV GL.

The DNV GL service specification for shop approval services DNVGL-SE-0436 offers guidance for wind turbine component supplier.

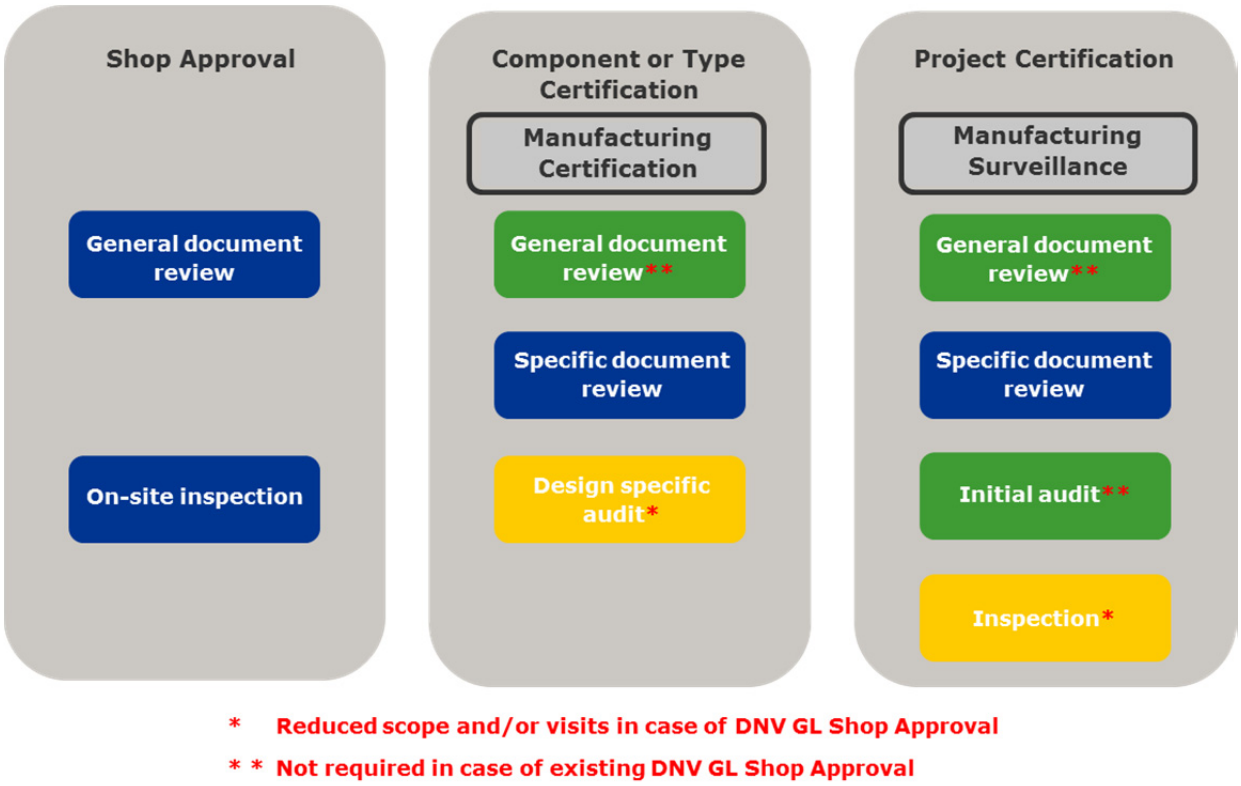

Figure 3-1 Benefit and interaction concept of DNV GL shop approval between different certification levels

3.7.4 Rotor blade manufacturing

3.7.4.1 Manufacturing certification module for A, B or C levels

The manufacturing inspection of one representative blade shall be carried out in the rotor blade manufacturing workshop and may be combined with the selection of a representative blade for testing. The following documentation shall be made available for DNV GL during the inspection, see also DNVGL-ST-0376:

- production plan
- work instructions
- drawings
- quality procedures and quality control sheets
- list of materials
- ISO 9001 certificate.

The manufacturing inspections shall comprise the following:

- verification that the design specifications are properly implemented in workshop drawings, workshop instructions, purchase specifications and installation instructions
- random inspections of the manufacturer's workshop
- random reviews of the material certificates
- random checks on the effectiveness of the procedures for the acceptance of purchased components
- random checks of the fabrication processes.

The random checks shall focus on the critical manufacturing processes. The assessment requires manufacturing of at least one rotor blade representative of the type under certification.

3.7.4.2 Manufacturing certification module for site level

Within the site level manufacturing certification module DNV GL shall conduct manufacturing surveillance for the rotor blades and blade root bolts/bushings in order to verify compliance with the approved design and with the intended quality. The inspections shall be conducted at the manufacturer's premises for production and shall focus on:

- quality control and qualification of raw materials
- compliance of components with the approved design
- compliance with quality plan requirements
- visual inspection of on-going jobs
- visual inspection of finished blades before shipping
- handling
- repair
- transport.

An initial audit shall be performed for the first rotor blade subject to certification. The initial audit shall cover the following:

- check compliance with requirements to lamination workshops
- agree on the inspection plan
- compliance of serial production with approved design.

The extent/depth of the inspections and the number of inspections to be carried out for each production facility as part of the manufacturing certification shall be evaluated by DNV GL based on the outcome of the initial audit as well as on DNV GL's experience with the manufacturer as well as the presence of a DNV GL shop approval. Inspection frequencies in general are given in [2.8.5].

Manufacturing inspections are scheduled based on the agreed inspection plan. The inspection plan is based on the outcome of the initial audit as well as any areas highlighted in a report as part of the component certification review. Should there be any findings from an inspection, then these shall be raised in the

inspection reports and at the discretion of the inspector, a subsequent inspection may be arranged to verify the closure of the findings. This process shall continue until full confidence is reached by the inspector that the products covered by the site level manufacturing certification module have the required quality and that the manufacturing site is capable of reproducing the approved design.

The manufacturing documentation according to DNVGL-ST-0376 shall be made available to DNV GL:

- type certificate/site level design certification and the blade reports referenced therein
- inspection and test plan (ITP). The ITP shall be provided as a table including the following information:
  - all relevant production steps and the corresponding production documents, e.g. drawings, instructions, checklists and specifications
  - the responsible person for each production step
  - DNV GL the inspection scope for each production step shall be defined in agreement with DNV GL, e.g. witnessing, hold point, review of documentation or testing
- the following documents shall be provided in the same revision that shall be used in production for this project
  - all documents referenced in the ITP
  - general arrangement drawings and specifications
  - manufacturing drawings, specifications and work instructions
  - inspection check sheets, NDT reports, and measurements reports
  - list of materials
- if the documentation used for the current project differs from the documents referenced in the type certificate/statements of compliance/certification reports modifications have to be listed and explained
- ISO 9001 certificate.

As an alternative to the ISO 9001 certificate, the following documents shall be provided

- quality management handbook/manual
- quality management procedures
- quality management work instructions
- qualification matrix of workshop employees.

DNV GL shall have full access to the relevant manufacturing, storage, testing and assembly sites. The possibility for photo documentation of findings shall be ensured.

The inspections shall be based on relevant standards together with design documentation of the design evaluation, such as documentation of:

- critical items
- test programs
- approved design documentation.

The as built documentation for each blade covered by the manufacturing certification shall be available and DNV GL shall review the as-built documentation on a spot check basis for the rotor blades covered by the site level certification module.

3.7.5 Gearbox manufacturing

3.7.5.1 Manufacturing certification module for A and B levels

The manufacturing inspection of one representative gearbox shall be carried out in the gearbox manufacturing workshop and if possible be carried out in connection with the witnessing/visit during gearbox testing. The quality control records including material certificates and inspection reports for the gearbox shall be available to DNV GL and should comprise all gears, shafts and housings/torque arm as well as non-standard bearings. The gears shall be inspected to check compliance with the appropriate requirements of ISO 6336-5. Other selected gearbox parts shall also be checked for compliance with the requirements in the design documentation and the quality control procedures.

3.7.5.2 Manufacturing certification module for site level

The frequency of the inspection shall be established based on the initial inspection and/or the results of the A or B level certification inspection. Requirements for inspection frequencies are given in [2.8.5].

The DNV GL shop approval shall also be taken into account when determining the inspection extent/depth and frequency in connection with the site level manufacturing certification module.

The as built documentation including manufacturing, quality control and test documentation shall be available for all gearboxes covered by the manufacturing certification module. DNV GL shall carry out spot checks with focus on gears, shafts and critical housing parts as well as on the records of work shop testing.

The frequency of inspections/audits shall be each 5^{th} gearbox for the initial phase and up to each 20^{th} in the case of a well implemented quality control system combined with a DNV GL shop approval.

The inspections shall be carried out with the same scope as for the B level manufacturing certification module.

3.7.6 Hub and Nacelle assembly

3.7.6.1 Manufacturing certification module for A level

The manufacturing inspection of one representative hub and nacelle assembly shall be carried out in the workshop(s). The following documentation for the assembly work as well as for the sub-supplier's work shall be made available for DNV GL during the inspection:

- production/manufacturing plan
- work instructions and quality control procedures
- work shop drawings and purchase specifications
- quality control records
- material certificates and test reports
- ISO 9001 certificate.

As an alternative to the ISO 9001 certificate, the following documents shall be provided

- quality management handbook/manual
- quality management procedures
- quality management work instructions
- qualification matrix of workshop employees.

The manufacturing inspections shall comprise the following:

- verification that the design specifications are properly implemented in workshop drawings, workshop instructions, purchase specifications and installation instructions
- random inspections of the manufacturer's workshop
- random review of the material certificates
- random checks on the effectiveness of procedures for the acceptance of purchased components
- random checks of the critical fabrication processes.

The random checks shall focus on the critical manufacturing processes.

Selected components shall be verified with respect to compliance with the design documentation on a spot check basis. [2.7.6.6] lists these components and the details of the spot checks.

3.7.6.2 Manufacturing certification module for site level

The surveillance of the assembly of hub and nacelle shall be completed in the workshop. The initial manufacturing surveillance at the assembly workshop(s) shall be carried out for one of the first hubs and nacelle assemblies respectively. The extent and frequency of the surveillances at the assembly workshop shall be determined depending on the results of the initial inspection. The manufacturing surveillance shall focus on:

- compliance with quality plan requirements

— visual inspection of units under assembly
— visual inspection of the electrical installation
— documentation review (components certificates, production worksheets and final documentation).

The following components which are parts of the nacelle and hub assembly shall be considered for surveillance in connection with the site level manufacturing certification module. The list of components and processes to be inspected shall be evaluated considering the wind turbine specific design, e.g. direct drive, gearbox design. If the results of a manufacturing process may be inspected sufficiently at the assembly workshop, inspection at the sub-suppliers is not necessary, e.g. machined areas for a cast or welded component may be inspected during incoming goods inspection at the assembly workshop. Therefore the list below should be adjusted and agreed at the beginning of the project.

— rotor hub
— rotor shaft and axle journal
— main bearing
— main bearing housing(s)
— generator
— transformer
— frequency converter
— high-voltage switchgear
— generator structure (direct drive only)
— main and generator frame.

The manufacturing surveillance for these components shall be carried out for the first manufactured components to be covered by the certification. The extent of surveillance shall be based on a documentation review at the manufacturers' premises, covering the following items:

— compliance with quality plan requirements
— visual inspection of on-going jobs and finished products in order to check compliance with documented manufacturing procedures
— test documentation review
— final documentation review.

Requirements on the frequency of these inspections are given in [2.8.5].

3.7.7 Tower manufacturing

3.7.7.1 General

When the tower structure is included in the scope of certification, evaluation of manufacturing of standard conical/tubular steel towers shall be required for the site and A level manufacturing certification modules.

For other types of towers, such as concrete or lattice towers there shall be requirements for inspection in connection with the A, B and site level manufacturing certification module. This is also the case for the substructure and foundation if inside the scope of certification. [3.7.8] includes general information for other critical components and may also be applied for towers, foundations and substructures.

3.7.7.2 Manufacturing certification module for site, A and B levels

Manufacturing surveillance/inspection shall be carried out for towers and for the substructure/foundation when included in the scope of certification.

For the A and B level manufacturing certification modules, the manufacturing inspection of one representative tower or substructure/foundation shall be carried out in the workshop(s).

For the site level manufacturing certification module, manufacturing surveillance, the extent and frequency of surveillance at the workshop(s) shall be determined depending on the results of the initial inspection.

The manufacturing surveillance/inspection for standard conical or tubular steel towers shall only be required for the site and A level manufacturing certification modules. The surveillance/inspection of these standard towers at the manufacturer's workshop shall be focused, (for surveillance, inspections on a random basis), on:

— compliance with quality plan requirements
— incoming goods inspection
— welding procedures specification and welding procedures qualification
— welders' qualification
— construction drawings (shop drawings) versus reviewed drawings (design drawings)
— visual inspection of on-going jobs
— repair work
— witnessing of non-destructive testing and its documentation
— coating
— visual inspection of finished sections before shipping
— documentation review
— ISO 9001 certificate.

As an alternative to the ISO 9001 certificate, the following documents shall be provided

— quality management handbook /manual
— quality management procedures
— quality management work instructions
— qualification matrix of workshop employees.

For other types of towers, such as concrete, lattice or hybrid towers as well as for foundations and substructures, a detailed manufacturing surveillance programmes shall be tailor made for each specific project and included in the site, A and B level manufacturing certification modules.

3.7.8 Manufacturing of other critical components

3.7.8.1 Manufacturing certification module for A and B level

For critical components or those where additional testing is required, inspection at the component supplier may be requested by DNV GL. The inspection shall focus on the manufacturing process related to the critical issues identified in the certification modules for design and test. This includes verification that the sample for testing is representative for the future serial production.

The manufacturing inspection of one representative component shall be carried out in the workshop(s). The following documentation shall be made available to DNV GL during, preferably before the inspection:

— production/manufacturing plan
— work instructions and quality control procedures
— work shop drawings and purchase specifications
— quality control records
— material certificates and test reports
— ISO 9001 certificate.

As an alternative to the ISO 9001 certificate, the following documents shall be provided

— quality management handbook /manual
— quality management procedures
— quality management work instructions
— qualification matrix of workshop employees.

The manufacturing inspections shall comprise the following:

- verification that the design specifications are properly implemented in workshop drawings, workshop instructions, purchase specifications and installation instructions
- random inspections of the manufacturer's workshop
- random reviews of the material certificates and quality control records
- random checks on the effectiveness of procedures for the acceptance of purchased components
- random checks of the fabrication processes
- random checks of tests results for acceptance testing.

The random checks shall focus on the critical manufacturing processes.

3.7.8.2 Manufacturing certification module for site level

The initial manufacturing surveillance at the assembly workshop(s) for other critical components shall be carried out for one of the first component to be covered by the manufacturing certification. The extent and frequency of surveillance shall be determined depending on the results of the initial inspection. The manufacturing surveillance shall focus on:

- compliance with quality plan requirements
- visual inspection of the manufacturing process
- critical items identified in the design assessment
- documentation review (components certificates, production worksheets and final documentation).

SECTION 4 CERTIFICATES AND STATEMENTS

4.1 General

Upon the successful completion of a certification module, a statement of compliance shall be issued together with a certification report. The certification report shall conclude on the work carried out for the certification module and contain a reference list of all supporting documentation.

The certificate and the final certification report shall be issued based on the statements for design, test and manufacturing for the selected certification level. The final certification report shall include the final conclusion for the certification including the integration of the statements.

The type certificate may also refer to one or more component certificates. Component certificates issued by another certification body may only be included if agreed with DNV GL on beforehand, see [4.3].

All issued and valid certificates shall be listed on the DNV GL internet site.

4.2 Modifications and recertification

Modifications of a wind turbine for which a type or prototype certificate has been issued are permitted with respect to the validity of the certificate only if they do not change or affect the principal characteristics at all, or if they change or affect the principal characteristics within the extent specified in the applicable design code or standard. The same applies in case of components or systems subject to component certification.

The following changes will normally require new testing for the relevant test certification module elements:

- a change in rotor diameter by more than 2%
- a change in rotor rotational speed by more than 2%
- a different design of the safety system
- a different way of limiting the power output
- modified blade profiles
- modifications which lead to a significant increase in the load spectrum
- increase of the power output by more than 5%
- major changes of the wind turbine design.

However, all changes within or outside the criteria in the above list requires an updated type certificate stating the values of the changed parameters.

Major changes may lead to recertification if required by the applicable standard or if deemed necessary by DNV GL.

Guidance note:
Examples of major design changes, see also Table 2-2 Examples for modifications or damages to be reported:

- change in number or quality of bolts
- change in geometry, e.g. hub geometry
- change in type and quality of material
- change in sub-supplier of e.g. bearing(s), gearbox or hydraulic unit.

Example of minor design changes, see also Table 2-3:

- additional drilled holes in non-loaded areas of the housing
- change of standard parts (screws, springs etc.)
- new corrosion protection according to specification
- exchange of anemometer
- exchange of catalogue parts (circuit breakers, resistors, fittings, hoses, etc.).

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

DNV GL may require recertification if additional requirements for maintenance of the certificate are set by national authorities or by the applicable design code or standard during the validity period of the certificate.

Upon failure to conform to the conditions of the certificate e.g. design changes, the customer shall be requested by DNV GL to correct the non-conforming situation within a specified time frame.

If no satisfactory corrective action is taken, the certificate in question shall be withdrawn and the accreditation authority, under whose authority the certificate was issued, shall be informed accordingly. Certification documents issued by DNV GL shall upon withdrawal or suspension be returned to DNV GL.

Major revision to a referenced standard as well as other new industry learning during the validity period of a certificate shall be evaluated by DNV GL. If such a revision or learning is judged to have implications for the integrity and safety of the certified wind turbine or component, it shall have to be modified and/or re-evaluated in order to retain its certificate. Transition periods and guidance for implementation of new revisions shall be established by DNV GL for each individual case.

4.3 Integration of component certificates

Component certificates may be issued for major components, e.g. blade or gearbox in order to facilitate an efficient integration in the type certification of several different wind turbine types. The component certification shall follow the same procedure as the type certification including certification modules for design, test and manufacturing and may be issued for the Site, A and B levels.

Component certificates issued according to this service specification by DNV GL or other accredited certification bodies may after a successful evaluation be integrated in a type certificate. To support this evaluation, the customer shall document that the component certificate and its defined interfaces complies with the wind turbine design basis, load assumptions and other requirements relevant for integration of the component.

The use of component certificates shall be specified in the type certification contract. When integrating component certificates from other certification bodies, the following shall be reviewed or if necessary covered in a clarification meeting:

— scope of work falls within the accredited scope of the other certification body
— quality and completeness of the technical reporting:
— component certificate including the final certification report
— statements of compliance (design, test, manufacturing) including certification reports
— quality management system certificate(s)
— technical documents required for the integration of the component such as interface description, load envelope, conditions/provisions, assumptions, limitations and outstanding issues.

The validity of the type certificate shall not exceed the validity of the integrated component certificate.

DNV GL shall not take any responsibility for the component certification work carried out by the other certification body.

4.4 Customer obligations

The customer shall take appropriate actions according to the requirements of the ISO 9001 certification scheme with respect to complaints and any deficiencies that affect compliance with the requirements for the certificate. The customer shall keep records of all complaints relating to the compliance of the wind turbine, component or system with the standards and requirements used for the certificate. These records as well as documentation for actions taken shall be available to DNV GL and to the certification body which has certified the customer's quality system. Reports of these records and actions taken as well as reports of minor modifications to the design shall be submitted to DNV GL, at least once per year, see [2.7.3].

Proposals for major modifications to the design, to procedures, and to specifications and other documents shall be reported without delay together with all documentation affected by the modification in order for the certificate to be maintained and extended.

Surveys of randomly chosen specimens of each type of turbine/component shall be carried out during the validity period of the certificate for the purpose of verification of the manufacturer's design procedures, their maintenance and implementations in relation to the design procedures and the design parameters initially approved by DNV GL (see also [2.7.3]). The customer shall provide access to the turbine/component chosen for inspection.

Once any safety-related accident or failure of the installed certified turbines or components comes to the customer's knowledge, the customer shall report this accident or failure to DNV GL. Such major accidents or failures may result in a request by DNV GL for information on the accident and the causes as well as corrective actions to be taken by the customer in order to maintain the type/component certificate. Based on an evaluation of the accident or failure and, if relevant, an evaluation of the corrective actions, DNV GL shall decide if the type/component certificate shall be suspended until a satisfactory corrective action is implemented. A suspension implies that wind turbines or components may not be advertised, sold, manufactured or installed with reference to the suspended type certificate. The type certificate may be suspended up to a maximum of one year provided that a plan for corrective action by the customer is agreed with DNV GL.

If no satisfactory corrective action is taken, the type or component certificate in question shall be withdrawn and the accreditation authority, under whose authority the certificate was issued, shall be informed accordingly. Certification documents issued by DNV GL shall upon withdrawal or suspension be returned to DNV GL.

4.5 Rules for the use of the certificate

The DNV GL certification deliverables such as certificates, statements and reports shall be provided when the certification project is successfully concluded. The aim of the certification deliverables is to provide all the stakeholder's with a transparent proof of the certification result. examples of a type certificate and a statement of compliance is included in [A.2].

The certification services described in this service specification are delivered as accredited services in compliance with ISO/IEC 17065. ISO/IEC 17065 contains requirements to both competence and impartiality of the certification body in connection with the delivery of conformity assessment services.

ISO/IEC 17065 also includes requirements to the certificate/statement holder as follows:

— The type certificate/statement of compliance shall not be used in such a manner as to bring DNV GL into disrepute. Furthermore, misleading or unauthorized statements regarding the type certificate are not allowed.
— The DNV GL issued certification documents such as certificates, statements, inspection reports and final evaluation reports shall only be provided to others in their entirety.
— Any claims regarding the certificate shall be promoted with reference to a specific item in the scope for the certification.

Wind turbines and components may also carry a certification mark stating the certificate covering the product, see [A.1].

APPENDIX A CERTIFICATION MARK AND SAMPLE CERTIFICATE

A.1 Certification mark

DNV and GL have merged to form DNV GL. DNV GL is accredited for type and component certification of wind turbines according to this service specification.

The certification mark as shown in [A.1] may be attached to type or component certified products. The certification mark shall not be used in such a way that it may mislead or give the impression that other products than the certified products are covered by the certificate. If the certification mark is used in brochures, letters and other printed material, a distinct reference to the certified product shall be stated.

The certification mark shall be approved and provided by DNV GL before use.

Figure A-1

A.2 Sample certificate and statement of compliance

A sample type certificate is shown in Figure A-2 and a sample statement of compliance for A-design is shown in Figure A-3.

DNV·GL

TYPE CERTIFICATE

Certificate No.:	Issued:	Valid until:
TCA-DNVGL-SE-0441-[ID with 5 digits]-[rev.]	[YYYY]-[MM]-[DD]	[YYYY]-[MM]-[DD]

Issued for:

<Wind Turbine Type>

Specified in Annex 1

Issued to:

<Wind Turbine Manufacturer>

< Address line >
< Address line >

According to:

DNVGL-SE-0441:2016 Type and component certification of wind turbines

Based on the documents:

AD-DNVGL-SE-0441-[ID with 5 digits]-[rev.]	Statement of Compliance, A-Design, dated yyyy-mm-dd
AT-DNVGL-SE-0441-[ID with 5 digits]-[rev.]	Statement of Compliance, A-Test, dated yyyy-mm-dd
AM-DNVGL-SE-0441-[ID with 5 digits]-[rev.]	Statement of Compliance, A-Manufacturing, dated yyyy-mm-dd
CCA-DNVGL-SE-0441-[ID with 5 digits]-[rev.]	Component Certificate, dated yyyy-mm-dd
FCR-TC-DNVGL-SE-0441-[ID]-[rev.]	Final Certification Report, dated yyyy-mm-dd

Changes of the system design, the production and erection or the manufacturer's quality system are to be approved by DNV GL.

Place, yyyy-mm-dd

For DNV GL Renewables Certification

[Name of SLL for "Cert. decision"]
[Function]

DAkkS Deutsche Akkreditierungsstelle D-ZE-11053-01-00

By DAkkS according DIN EN IEC/ISO 17065 accredited Certification Body for products. The accreditation is valid for the fields of certification listed in the certificate.

Place, yyyy-mm-dd

For DNV GL Renewables Certification

[Name of PM "doing it"]
[Function]

The accredited certification body is Germanischer Lloyd Industrial Services GmbH, Brooktorkai 18, 20457 Hamburg.
DNV GL Renewables Certification is the trading name of DNV GL's certification business in the renewable energy industry.

Figure A-2 Sample Type Certificate

DNV·GL

STATEMENT OF COMPLIANCE

Statement No.:
AD-DNVGL-SE-0441-[ID]-[rev.]

Issued:
[YYYY]-[MM]-[DD]

Issued for:

A-Design

of

<Wind Turbine Type>

Specified in Annex 1

Issued to:

<Wind Turbine Manufacturer>

< Address line >
< Address line >

According to:

DNVGL-SE-0441:2016 Type and component certification of Wind Turbines

Based on the document:
CR-AD-DNVGL-SE-0441-[ID]-[rev.] Certification Report, dated yyyy-mm-dd

Changes of the system design are to be approved by DNV GL.

Place, yyyy-mm-dd

For DNV GL Renewables Certification

[Name of SLL for "Cert. decision"]
[Function]

DAkkS Deutsche Akkreditierungsstelle D-ZE-11053-01-00

By DAkkS according DIN EN IEC/ISO 17065 accredited Certification Body for products. The accreditation is valid for the fields of certification listed in the certificate.

Place, yyyy-mm-dd

For DNV GL Renewables Certification

[Name of PM "doing it"]
[Function]

The accredited certification body is Germanischer Lloyd Industrial Services GmbH, Brooktorkai 18, 20457 Hamburg.
DNV GL Renewables Certification is the trading name of DNV GL's certification business in the renewable energy industry.

Figure A-3 Sample statement of compliance A-design

APPENDIX B MANUALS

B.1 General

The purpose of this appendix is to define the requirements for the transport and installation manual, the commissioning manual, the operating instructions and the maintenance manual.

The manuals shall be in English language.

B.2 Transport and installation manual

B.2.1 General

The objective of the transport and installation manual is to provide information for the transport and installation activities and procedures to all parties involved, including the wind turbine designer and certification body.

The format and level of detail of the transport and installation manual shall be such that the resulting loads and risks may be evaluated and that the qualified technical personnel performing the required tasks are able to understand the instructions.

The manual for land/sea transport and installation shall describe all working steps that have to be performed during transport to the installation location, positioning, assembly and erection of the onshore/offshore wind turbine.

The form sheets for the recording of transport and installation shall be used to document the execution of the individual working steps during the transport and installation process. A blank form sheet of the transport and installation report shall be included in the transport and installation manual.

Notes regarding safety and regulations for the prevention of accidents shall be so arranged in the text that they appear before the operating action in question. They shall be highlighted as being safety and accident-prevention notes.

IEC 82079-1:2012, especially sections 5.8.1 and 5.8.2, should also be considered when preparing the transport and installation manual.

The manual shall contain the following information as a minimum:

- identification of the type of wind turbine:
  - manufacturer, supplier, importer
  - designation, type and, if applicable, type variant
  - type of rotor blade
  - rated power
  - rotor diameter
  - hub height(s)
- identification of the installation site
- prerequisites for the land/sea transportation and installation
- sequence of the land/sea transport and installation
- warnings and measures against hazardous situations
- blank form sheets for the recording.

The transport and installation manual may contain documents and information which vary from site to site (e.g. water depth, vessels, buoys, lights, routes). The variable information should be given with upper and lower limiting values in the documents and should be given as example for the type certification process. Finalized documents with site-specific information shall be part of the documentation for the project certification or the site specific type certificate.

B.2.2 Prerequisites for land/sea transport and installation

All prerequisites for the execution of the work shall be stated, e.g. requirements for the weather conditions (limiting wind speeds, temperatures, rainfall, precipitation, wave height, water level and current speed), requirements for site access and working area or adequate curing of the foundation or any grouted connections.

The precise designations and dimensions of all wind turbine components to be assembled and installed shall be specified, together with all data needed for installation such as weights, lifting points etc.

Special tools or equipment necessary for the installation shall be specified with due consideration of the loads and weights during installation. Requirements for these tools or equipment, e.g. testing or regular inspections, shall be specified.

The maximum admissible delay between installation of the substructure and installation of the rest of the support structure and the maximum admissible delay until mounting of the rotor and nacelle assembly shall be stated.

Requirements for the vehicles/vessels (tug power, navigation equipment etc.) and other equipment needed (floating cranes etc.) shall be stated.

A listing including quantities of all equipment and material necessary for the installation shall be given, e.g. grouting material, bolts, mooring and fastening equipment, special tools.

The required qualifications for the technical personnel shall be defined.

The intended route(s) and duration of sea transport shall be stated.

B.2.3 Sequence of land/sea transport and installation

All working steps taken during transport and installation shall be described. Auxiliary equipment and resources shall be specified exactly (e.g. lubricants, grouting materials, oil for filling up the gearbox).

The transport and installation manual shall refer to drawings, specifications or instructions necessary for the land/sea transport and installation of the wind turbine:

— the work instructions for making the bolted connections needed during installation shall be included in the manual
— all necessary tests and checks shall be listed
— procedures for energizing electrical equipment shall be provided.

Guidance note:
For situations of grid unavailability the installation of temporary power equipment, e.g. external diesel generator set, should be provided.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

B.2.4 Warnings and measures against hazardous situations

Hazardous situations which may arise from deviations from the planned working sequence shall be described and countermeasures and/or contingency plans shall be specified. Such situations may include: lightning, snow, icing, visibility, extreme temperatures, very high winds, waves or currents during installation, prolonged periods of the substructure and/or the support structure standing without rotor nacelle assembly at critical wind speeds and/or wave frequencies.

Hazardous situations which may arise due to unintended motion or rotation shall be named, and countermeasures shall be specified to avoid this.

Safety and accident-prevention measures that are necessary before or during installation, e.g. use of personal protective equipment, guards or locking devices, shall be specified.

For personnel entering any enclosed working space, such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

Emergency procedures and rescue operations shall be described.

B.2.5 Transport and installation records

The records shall document the execution of all checks and working steps of the land/sea transport and onshore/offshore installation process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording measurement values and test results.

All adjustment settings and set values as well as the expected measurement results shall be specified.

The transport and installation record may consist of several sub-records (e.g. for different assemblies or phases of work).

The following fields shall be provided as a minimum:

- type identification of the wind turbine
- serial number, operator and installation site of the wind turbine
- name of the person carrying out the corresponding working step
- weather conditions, if the weather is able to influence the quality of work (e.g. temperature, rain, snow, range of sight, lighting, average wind speed, gust wind speed, wave height and tidal condition)
- reports of the execution of all working steps
- reports of the execution of all tests and checks
- extra space for possible remarks or items outstanding
- date and signature of the person(s) responsible and/or carrying out the work.

B.3 Commissioning manual

B.3.1 General

The commissioning manual describes all working steps that shall be performed during commissioning in order to ensure safe functioning of the wind turbine.

The commissioning manual applies for one type of wind turbine and, if applicable, for its variants.

The commissioning records shall document the execution of the individual working steps during the commissioning process. A blank form sheet of the commissioning records shall be included in the commissioning manual.

The format and level of detail of the commissioning manual shall be such that qualified technical commissioning personnel performing the required tasks are able to understand the instructions.

IEC 82079-1:2012, especially section 5.8.3, should also be considered when preparing the commissioning instructions.

The commissioning manual shall contain the following information as a minimum:

- type identification of the wind turbine
    - manufacturer, supplier, importer
    - designation, type and, if applicable, type variant
    - rotor diameter, hub height
    - type of rotor blade
    - rated power
- checks required before the start of commissioning
- working steps of the commissioning process
- checks required to conclude the commissioning
- warnings against hazardous situations
- blank form sheets for the commissioning record.

B.3.2 Checks before commissioning

All checks required before the start of commissioning shall be listed. The following statements shall be provided as a minimum and the task listed shall be completed:

- commissioning of the auxiliary systems and subsequent external equipment needed for operation of the wind turbine (e.g. transformer, grid connection station)
- any trial runs of individual components which may be necessary in the factory or on site
- filling up of all operating media (e.g. lubricants, coolants, hydraulic fluid, nitrogen in pressure tanks)
- any acceptance tests needed according to governmental regulations (e.g. for pressure vessels, lifts).

The required qualifications for the technical commissioning personnel shall be defined.

All working steps needed for commissioning shall be described. For the commissioning of individual assemblies (e.g. yaw system), reference may be made to subordinate commissioning manuals for such assemblies.

All prerequisites for the proper execution of commissioning, e.g. lowest/highest wind speed, wave heights and necessary outside temperatures, shall be specified.

Tests of all functions of the protection systems and the braking systems shall be described. The switching values to be set and the criteria to be met shall be specified. The following tests shall be performed as a minimum and it shall be checked that all tests complies with expected behaviour and messages in the wind turbine controller log system:

- function of all emergency stop pushbuttons
- function of all sensors and switches which also act on the protection system (e.g. overspeed test)
- measurement of the essential parameters of the braking systems, e.g. speed of blade pitching, hydraulic pressure of the mechanical brake(s)
- response of all necessary functions after activation of the protection system (e.g. braking systems, generator disconnection)
- test to verify that the functions responding to the activation of the protection system are independent of the control system
- grid loss
- testing of all limiting values and parameters that have been set for the protection system.

All tests regarding the functions of the control system of the wind turbine shall be described. The switching values to be set and criteria to be met shall be specified. The following tests shall be performed as a minimum:

- automatic start-up
- shut-downs applying all braking procedures individually
- plausibility check of the yaw system
- plausibility check of the measured values
- comparison of the limiting values and parameters which were set with the prescribed values as documented.

Furthermore, the following working steps shall be described:

- registration of the data on the rating plates of the primary components
- possible settings to be made in the control system on the basis of the measurement results (e.g. natural frequency of the support structure).

B.3.3 Checks to conclude commissioning

All checks required to conclude commissioning shall be listed. The following statements shall be provided as a minimum:

- visual inspections (e.g. rotor blades, corrosion protection, tightness of hydraulic system)
- checking of the required notices and warning plates.

B.3.4 Warnings against hazardous situations

Hazardous situations which may arise during commissioning shall be named and countermeasures shall be specified. Such situations may include: grid loss, lightning, icing or very high winds or waves during commissioning.

Hazardous situations which may arise due to unintended motion or rotation shall be listed, and countermeasures shall be specified to avoid this.

Safety and accident-prevention measures which are necessary before or during commissioning, e.g. use of personal protective equipment, guards or locking devices shall be specified.

For personnel entering any enclosed working space, such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

Emergency procedures and rescue operations shall be described.

B.3.5 Commissioning records

The commissioning records shall document the execution of all checks and working steps of the commissioning process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording the measured values and test results.

All adjustment settings and set values as well as the expected measurement results shall be specified.

The commissioning records may consist of several sub-reports (e.g. for primary components, for familiarization of the operating personnel).

The following information shall be provided as a minimum:

- type identification of the wind turbine
- serial number, operator and installation site of the wind turbine
- manufacturer, type and serial number from the rating plates of the primary components, at least of the rotor blades, gearbox, generator and tower
- controller software version
- persons present during commissioning
- weather conditions on the day of commissioning, if the weather shall influence the quality of the work/ tests
- confirmation that all checks required before the start of commissioning have been completed
- report on the execution of all working steps of the commissioning
- confirmation that all checks required to conclude commissioning have been completed
- extra space for possible remarks, items outstanding or parts replaced
- date and signature of the person(s) responsible and/or carrying out the work.

B.4 Operating manual

B.4.1 General

The operating manual is intended to provide the operator or his representative with the knowledge necessary for proper operation of the wind turbine.

The operating manual applies for one type of wind turbine and, if applicable, for its variants.

The format and level of detail of the operating manual shall be such that qualified personnel with technical training are able to understand the instructions.

IEC 82079-1:2012, especially section 5.9, should also be considered when preparing the operating manual.

The operating manual shall contain the following information as a minimum:

- type identification of the wind turbine:
    - manufacturer, supplier, importer

  - designation, type and, if applicable, type variant
  - rotor diameter, hub height
  - rated power
- notes for operators
- warnings against hazardous situations
- help with fault-finding
- operating records.

B.4.2 Notes for operators

At least the following information shall be provided:

- general description of the operation concept
- description of the functions and operational modes of all the operating and indicating elements (switches, pushbuttons, lamps, measuring instruments)
- description of starting and stopping procedures
- description of emergency shut-down
- explanation of fault messages (insofar as these are issued)
- description of all work procedures required for the operation of the wind turbine (e.g. necessary communication)
- emergency procedure plans, e.g. action required in the event of over-speed, ice formation, lightning storms, earthquakes, brake failure, rotor imbalance, loose fasteners or fire at the wind turbine
- explanation of malfunctions and how to clear them
- description of components and functions that need to be taken into/out of service on a seasonal basis or for other reasons
- description of measures to be taken if the wind turbine is taken out of operation for a longer period, e.g. because of a damaged grid connection. These measures could be e.g. lockage of the blade pitch system and/or rotor, or installing a backup power supply. Measures to avoid stand still damages to e.g. bearings and gears shall also be described.
- description of measures to be taken if the wind turbine is taken into operation after a longer period of standstill. The measures could be e.g. opening of locks and/or drying/heating of components that need to be dry when re-powered. The measures may also include inspections for stand still damages.

DNV GL provides certification services for operation (service and maintenance) activities for the wind energy industry. The service is delivered independently from other services and is described in DNV GL-SE-0448.

B.4.3 Warnings against hazardous situations

Hazardous situations which may arise when operating the wind turbine on site shall be named and countermeasures shall be specified. Such situations may include fire, lightning, ice formation, and very high wind speed or waves.

Hazardous situations which may arise due to unintended motion or rotation shall be listed and countermeasures (e.g. emergency procedure plans) shall be specified to avoid this.

Safety and accident-prevention measures, e.g. use of personal protective equipment, guards or locking devices shall be specified.

Emergency procedures and rescue operations shall be described.

B.4.4 Malfunctions

Without carrying out any repairs, the operator should be capable of recognizing the cause of a malfunction and – insofar as it cannot be cleared simply by an operating action – of providing the qualified technical maintenance personnel with useful advance information.

The operator should be able to judge whether a fault may develop into a hazardous situation.

B.4.5 Operating records

Operating records shall be kept and shall include the following:

— type identification of the wind turbine
— serial number, operator and installation site of the wind turbine
— operating hours
— shut-down hours
— date and time of fault
— nature of fault
— date and time of maintenance or repair activity
— nature of maintenance or repair activity.

Guidance note:
If this information is filed digitally based on an automated process it should be described how to access this information, e.g. via HMI or SCADA.

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B.5 Maintenance manual

B.5.1 General

The maintenance manual describes all working steps that have to be performed during maintenance in order to ensure safe functioning of the wind turbine; this includes supervising actions, reconditioning, repairing, adjusting and cleaning.

The maintenance manual applies for one type of wind turbine and, if applicable, for its variants.

The maintenance records documents the execution of the individual working steps during the maintenance process. A blank form sheet of the maintenance record shall be included in the maintenance manual.

The maintenance shall be carried out by qualified technical maintenance personnel.

The format and level of detail of the maintenance manual shall be such that qualified technical maintenance personnel performing the required tasks are able to understand the instructions.

IEC 82079-1:2012, especially section 5.10 shall be observed for the preparation of the maintenance manual.

The maintenance manual shall contain the following information as a minimum:

— type identification of the wind turbine
    — manufacturer, supplier, importer
    — designation, type and, if applicable, type variant
    — rotor diameter, hub height
    — type of rotor blade
    — rated power
— prerequisites for maintenance
— working steps of the maintenance
— warnings against hazardous situations
— maintenance plan
— blank form sheet for the maintenance record.

B.5.2 Prerequisites for maintenance

All prerequisites for the execution of the maintenance work shall be stated, e.g. requirements for the weather conditions such as wind, waves and temperatures.

Special tools or lifting devices necessary for the maintenance shall be specified.

All tools, spare parts and auxiliary materials that have to be stored permanently in the wind turbine shall be listed. The intervals for regular checks for completeness of these parts shall be specified.

Technical documentation of the wind turbine and their subsystems including e.g. wiring diagrams, hydraulic schemes or lubrication charts shall be accessible.

The required qualifications for the technical maintenance personnel shall be defined in the maintenance manual.

DNV GL provides certification services for service and maintenance activities for the wind energy industry. The service is delivered independently from other services and is described in DNV GL-SE-0448.

B.5.3 Working steps for maintenance

All working steps needed for maintenance or inspections shall be described according to the listing in the following. The descriptions may be supplemented by appropriate pictorial representations. The objectives of the individual maintenance operations (oil levels, brake settings, oil pressures, etc.) shall be indicated clearly.

- the frequency of the scheduled maintenance (e.g. half-yearly, yearly or five-yearly) shall be specified
- a set of work instructions for the inspection of bolted connections shall be included in the maintenance manual
- a detailed listing and description of the necessary tests for the safety protection system (e.g. over-speed test, emergency shut-down functions, measurement of the nitrogen content in hydraulic accumulators) shall be included in the maintenance manual. The required frequency of these tests shall be indicated (e.g. annually). The completion of the tests shall be recorded in the maintenance record.
- a detailed listing and description of the necessary inspection and tests of the lightning protection system shall be included in the maintenance manual. The required frequency of these inspections and tests shall be indicated (e.g. annually).
- if applicable, the investigations of technical experts and authorized persons, as required by the relevant national regulations (e.g. for lifts, fire-extinguishing systems and pressure vessels) and conditions of the building permits, shall be included in the maintenance manual, and columns/sections shall be provided in the maintenance report for the confirmation that these investigations have been carried out.
- all components and auxiliary materials of the wind turbine that have to be exchanged according to schedule during the operating life (e.g. hydraulic hoses, brake pads, slip-rings, gear oil) shall be listed. The intervals or criteria for the exchange shall be specified.
- an instruction to at least yearly take samples of the oil from the main gearbox and analyse these samples (including measurement of the cleanliness) shall be included in the maintenance manual
- information shall be given about the quality and quantity of spare parts and auxiliary materials to be used, e.g. lubricants (spare parts list).

Additionally the following applies for offshore wind turbines:

- A description of all inspections and other tasks to be carried out for the outside lighting and emergency shelter equipment as well as rescue at sea equipment and possible backup power supply units shall be included in the maintenance manual if applicable.
- A detailed listing and description of the necessary inspections to be done at the scour protection system at the foundation shall be included in the maintenance manual. Actions and corrective measures to be taken in case of damages or inadmissible wear shall be stated.
- A description of all inspections and tasks to be carried out at the corrosion protection system (both coating and cathodic protection systems, as applicable) shall be included in the maintenance manual.

B.5.4 Warnings against hazardous situations

Hazardous situations which may arise during maintenance shall be listed and countermeasures shall be specified. Such situations may include fire, lightning, icing and very high winds.

Hazardous situations which may arise due to unintended motion or rotation shall be listed and countermeasures shall be specified to avoid this.

Safety and accident-prevention measures that are necessary before or during maintenance, e.g. use of personal protective equipment, guards or locking devices shall be specified.

For personnel entering any enclosed working space such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

Emergency procedures and rescue operations shall be described.

B.5.5 Maintenance plan

The maintenance plan shall present all required maintenance tasks and shall state the appropriate time sequence.

If the maintenance and inspection work is scheduled by using a database, a printout of the scheduled maintenance work shall be provided from this database.

Guidance note:
If maintenance work is scheduled in regular intervals (e.g. quarterly, annually), it is helpful to compile a list of all working steps applicable in one interval.

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B.5.6 Maintenance records

The maintenance records shall document the execution of all checks and working steps of the maintenance process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording measured values and test results.

All adjustment settings and set values as well as the expected measurement results shall be specified.

The maintenance report may consist of several sub-reports (e.g. for primary components such as rotor blades or tower).

The following fields shall be provided as a minimum:

— type identification of the wind turbine
— serial number, operator and installation site of the wind turbine
— persons present during maintenance
— weather conditions on the day of maintenance
— operating hours
— shut-down hours
— report on the execution of all working steps of the maintenance
— confirmation that all checks required to conclude maintenance have been completed
— parts replaced
— extra space for possible remarks or items outstanding
— date and signature of the person(s) responsible.

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