DNV·GL

RECOMMENDED PRACTICE

DNVGL-RP-0440 Edition March 2016

Electromagnetic compatibility of wind turbines

DNV GL AS

FOREWORD

DNV GL recommended practices contain sound engineering practice and guidance.

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

CHANGES – CURRENT

General

This is a new document.

CONTENTS

SECTION 1 INTRODUCTION

1.1 General

This recommended practice (RP) provides principles, technical requirements and guidance for design of wind turbines and its components and systems concerning electromagnetic compatibility (EMC) and defines procedures for the EMC measurement and testing of wind turbines.

The present RP can be applied as a part of the technical basis for carrying out a DNV GL certification of the electromagnetic compatibility of wind turbines.

1.2 Objectives

The objectives of this recommended practice are to:

- ensure a constant high quality of the wind turbine and its 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
- serve as guideline for designers, suppliers, purchasers and regulators
- specify design requirements and measurement procedures for wind turbines concerning EMC and subject to DNV GL certification.

1.3 Scope and application

The recommended practice is applicable to all types of wind turbines (e.g. direct drive concepts, doubly-fed induction generators, low and high power output ratings, horizontal and vertical axis installations, with or without power converters) designed according to IEC 61400-1.

The recommended practice is applicable to the design, manufacturing, installation and testing of the wind turbines' electrical systems. This mainly refers to:

- rotating electrical machines
- power transformers
- frequency converters
- low-voltage switchgears, control gears and switchboards
- high-voltage switchgears
- lightning protection, earthing and bonding
- electrical equipment for measurement and control use
- cables, lines and accessories
- safety-related parts of the control system
- uninterruptible power systems (UPS)
- interconnection of electrical equipment
- installation of the wind turbine and its components and systems.

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 turbine during energy production or the event of faults
- keep the wind turbines' emission to the environment within tolerable levels
- avoid that disturbing sources are interfering with other sub-systems or components of the wind turbine leading to malfunction of single components or loss of control.

1.4 Definitions

1.4.1 Terminology and definitions

Table 1-1 Definitions of verbal forms

Term	*Definition*
shall	verbal form used to indicate requirements strictly to be followed in order to conform to 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	refers to third-party issue of a statement, based on a decision following review, that fulfilment of specified requirements has been demonstrated related to products, processes or systems (ISO/IEC 17000)
customer	DNV GL's contractual partner (applicant)
electromagnetic interference (EMI)	electromagnetic interference (EMI) is disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source or due to influences by electrical fields The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the circuit. These effects can range from a simple degradation of data to a total loss of data.
EMC emission	emission of electromagnetic disturbances from component / wind turbine into the environment (internal or external)
EMC immunity	immunity of component / wind turbine against electromagnetic disturbances coming from the internal or external environment
external environment	electrical system outside the wind turbine, normally the electrical grid the wind turbine is connected with
fixed installation	electrical equipment installed for permanent use at a predefined location
generic EMC standards	the 6 IEC's Generic EMC standards (see App.B) are for products operating in a particular EMC environment for which no specific EMC standards yet exist They are in effect general and somewhat simplified EMC Product standards.
internal environment	internal electrical and electronically system of the wind turbine
optional	optional services are services which are not part of the scope which is required in order to obtain statements of compliance and project certificates
power performance level	the power performance level describes the electrical power provided by the wind turbine to the connected grid It has to be defined for the radiated emission measurement.
recommendation	non-mandatory advice
verification	verification consists of evaluating and checking information to establish that an object in question meets a technical requirement or standard Multiple verification activities are performed and successfully completed to support the decision to issue a statement of compliance.
wind turbine	system which converts kinetic energy in the wind into electrical energy

1.4.2 Abbreviations and symbols

Abbreviations and symbols used in this RP.

Table 1-3 Abbreviations and symbols

Abbreviation	*In full*
AC	alternating current
DC	direct current
di/dt	rate of change of current (current change within delta of time)
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EN	European Norms
HEMP	high-altitude electromagnetic pulse
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LPS	lightning protection systems
OATS	open area test site
PLC	programmable logic controller
RP	recommended practice
SPD	surge protection device
SRP/CS	safety-related parts of the control system
UPS	uninterruptible power system

1.5 References

This document is referring to relevant international standards, guidelines and DNV GL documents. Unless otherwise specified in this RP, the latest valid revision of each referenced document applies.

Table 1-4 DNVGL documents

Reference	*Title*	*Date*	*Edition*
DNVGL-SE-0074	DNV GL service specification Type and component certification of wind turbines according to IEC 61400-22	2014-12	December 2014
DNVGL-ST-0076	Design of electrical installations for wind turbines	2015-05	May 2015

Table 1-5 IEC documents

Reference	*Title*	*Date*	*Edition*
IEC 60034-1	Rotating electrical machines - Part 1: Rating and performance (IEC 60034-1:2010, modified)	2010-02-03	12.0
IEC 60076-1	Power transformers – Part 1: General	2011-04-20	3.0
IEC 60364-4-44	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances	2007-08-14	2.0
IEC 61000-6-1	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments	2005-03-09	2.0
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments Power station and substation environment	2005-01-27	2.0
IEC 61000-6-3	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments	2006-07	2.0
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	2011-02-23	2.1
IEC 61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment	2015-08	1.0

Table 1-5 IEC documents (Continued)

Reference	*Title*	*Date*	*Edition*
IEC 61000-6-6	Electromagnetic compatibility (EMC) - Part 6-6: Generic standards - HEMP immunity for indoor equipment	2003-04-09	1.0
IEC 61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements	2012-07-10	2.0
IEC 61326-3-1	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications	2008-01	1.0
IEC 61400-1	Wind turbine generator systems – Part 1: Design requirements	2014-04-15	3.1
IEC 61400-21	Wind turbines – Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines	2008-08-13	2.0
IEC 61400-22	Wind turbines - Part 22: Conformity testing and certification	2010-05-31	1.0
IEC 61400-24	Wind turbines - Part 24: Lightning protection	2010-06-10	1.0
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules	2011-08-19	2.0
IEC 61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods	2012-03-08	2.1
IEC 62040-2	Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements	2005-10	2.0
IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications	2011-08	1.1

Table 1-6 ISO documents

Reference	*Title*	*Date*	*Edition*
ISO 2394	General principles on reliability for structures	2015-03	4
ISO 13849-1	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	2006-11-01	2.0
ISO 17000	Conformity assessment - Vocabulary and general principles	2004-11	1.0
ISO/IEC 17025	General requirements for the competence of calibration and testing laboratories	2005-05	2.0

Table 1-7 Other documents

Reference	*Title*	*Date*	*Edition*
2014/30/EU	EU directive "Harmonisation of the laws of the member states relating to electromagnetic compatibility"	2014-03-29	2014
CISPR 11	Industrial, scientific and medical equipment– Radio-frequency disturbance characteristics Limits and methods of measurement	2010-05	5.1
CISPR 16-SER	Specification for radio disturbance and immunity measuring apparatus and methods – ALL PARTS	2014-07	1.0
CISPR 16-2-3	Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements	2010-04-27	3.0

SECTION 2 WIND TURBINES - BASICS

2.1 General

Wind turbines are tall structures, defined as fixed installations according to EU directive 2014/30/EU, containing low and high power equipment inside, partly operated at high switching frequencies. With regard to perfect functioning of the crucial safety functions and the environmental impact of a wind turbine the electromagnetic compatibility (EMC) of the complete wind turbine system and of single components installed inside the wind turbine becomes more and more important.

As the common practice of EMC testing and measurement is defined mainly for equipment to be tested in calibrated and shielded testing facilities or laboratories it is a challenge to define this practice for tall outdoor structures like wind turbines.

This recommended practice is a guide providing principles and technical requirements how to adopt EMC measures in the design of wind turbines and how to perform on-site measurements of radiated emissions of wind turbines.

2.2 Wind turbine systems

During the years the electrical installations inside wind turbines became more sophisticated.

One of the reasons is the application of high-tech electronics and safety-controllers instead of older relay based functions and energy conversion concepts using power electronics. The advantage of using sophisticated electronics is that costs and space can be saved for the electrical installation inside the wind turbine.

Also the amount of measurement and monitoring functions and systems installed in wind turbines is increasing due to different advantages using programmable logic controller (PLC), even for safety functions.

Apart from the above mentioned advantages there is also some weakness of these additional systems. Due to the high energy circuits connected to the generator and the grid, disturbing voltages and currents can couple into the internal environment of the wind turbine with the fragile control circuits resulting in malfunctions or total loss of components. In the worst case the safety functions of a wind turbine can fail and lead to dangerous accidents.

On the other hand, electromagnetic emissions from wind turbines can endanger the technical external environment around wind turbines.

2.3 Disturbance sources

According to CIGRE WG C4.208 the most typical sources of disturbance that may affect the electrical installations of wind turbines are the following:

- electrical transient phenomena resulting from switching operations of circuit breakers or disconnectors in electrical high-voltage circuits
- electrical transient phenomena resulting from insulation breakdown in electrical high-voltage circuits or by spark-overs of surge arresters with metal-oxide varistor or arresters using a spark gap installed in the same circuits
- power frequency electric and magnetic fields produced by high-voltage installations
- voltage rises created by short-circuit currents in earthing systems
- power cables carrying large currents with a high rate of current rise (di/dt), caused by e.g. frequency converter, motors, transformers, etc., can induce over-voltages in cables of information technology systems, which can influence or damage information technology equipment or similar electrical equipment.

Other sources of disturbances, not specific only to electrical installations but generally present in these installations are the following:

— electrical transient phenomena resulting from lightning. These phenomena, although also present in other installations, are particularly important for electrical installations due to the presence of tall earthed structures and power lines

— electrical fast transients due to switching operations in low voltage equipment
— electrostatic discharges
— high frequency fields produced by radio transmitters, either externally or internally to the installation
— high frequency conducted and radiated disturbance from other electric or electronic equipment present in the installation
— low frequency conducted disturbances from power supplies.

SECTION 3 GENERAL CONDITIONS FOR ELECTROMAGNETIC COMPATIBILITY OF WIND TURBINES

3.1 Requirements for performance criteria

Electrical components installed in and at the wind turbine shall be designed according to the EMC requirements stated in the corresponding product standards. For components which do not have a product standard or if no EMC requirements are stated in the product standard, the generic EMC standards (see App.B) have to be applied.

The wind turbine shall be designed according to the EMC requirements for immunity and emissions stated in IEC 61400-1.

The requirements stipulated in this recommended practice are based on IEC standards. The performance criteria for EMC immunity are defined according to IEC 61000-6-2 (see App.A). The electromagnetic immunity of the main components (see [4.4]) has to be evaluated according to performance criterion A. The electromagnetic immunity of safety-related parts of the control system (see [4.4.9]) has to be evaluated according to performance criterion FS as specified in standard IEC 61326-3-1.

Guidance note:
Safety-related parts of the control system (SRP/CS) include all components and systems (electric, electronic, hydraulic or other) of the control and safety system that form part of a protection function. Protection functions are functions of the control system and / or safety system that ensure that the wind turbine remains within the design limits (e.g. limit states as defined in ISO 2394). This is achieved by ensuring that the prerequisites for load assumptions are always met with respect to the wind turbine's conditions (e.g. rotational speed, pitch, angles, etc.).

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3.2 Measurements and tests by laboratories

All tests and measurements of the complete wind turbine and its electrical components and systems shall be performed by an independent accredited laboratory. The accreditation shall cover the requirements of ISO/IEC 17025 and corresponding standards applied for test or measurement.

If the tests are performed by the manufacturer of the wind turbine or a testing laboratory without valid accreditation the tests shall be witnessed and post processing procedures evaluated by qualified experts of DNV GL.

SECTION 4 DESIGN REQUIREMENTS CONCERNING ELECTROMAGNETIC COMPATIBILITY CONCEPT

4.1 General

During the operation of electrical devices electromagnetic interactions between devices occur. Such devices work as an emitter (sender) on other devices which are influenced by them (receiver).

EMC of a complete system (e.g. wind turbine) including its components according to the generic EMC standards (see App.B) shall be ensured by the manufacturer (e.g. for design, manufacturing, installation) and the user of the wind turbine (e.g. for operation, maintenance, service).

Electrical devices and systems are electromagnetically compatible when they are not disturbed by other devices and systems on the one hand and when they do not disturb other devices or systems on the other hand. No malfunctioning of electrical devices and systems shall occur due to electromagnetic interactions.

The complete wind turbine shall be designed and installed ensuring that all relevant EMC measures according to the relevant standards are taken into account. This shall be valid not only for each part and single component of the turbine, but also for the entire system.

4.2 Measures to reduce electromagnetic interference

In IEC 60364-4-44:2011, chapter 444 measures against electromagnetic influences are stated

and can be useful for the development of an EMC compliant electrical system. For wind turbines the following requirements have to be considered for applicability and documented:

- Metal sheaths of cables shall be bonded at both ends to the common bonding network. Exception is made to short high voltage cables for which a specific analysis of the free end shield voltage shall be made. This has to be documented in the corresponding circuit diagrams and earthing and bonding plans.
- Inductive loops should be avoided by selection of separate routes for power, signal and data circuits wiring (e.g. in cabinets, switchgears, etc.).
- Power and signal cables shall be kept separate and should, wherever practical, cross each other at right angles. This has to be stated in the design documentation.
- The use of signal and data cables shall be done according to the EMC requirements and, if applicable, additionally to further manufacturer's instructions of the electrical devices (e.g. controls, safety devices, etc.). For example signal and data cables shall have shields. This has to be stated in the design documentation for EMC relevant installations.
- Equipotential bonding connections should have an impedance as low as possible:
  - by being as short as possible
  - by having a cross-section shape that results in low inductive reactance and impedance per metre of route, e.g. a bonding braid with a width to thickness ratio of five to one. This has to be stated in the earthing and bonding plans of the wind turbine
  - where a lightning protection system is installed power and signal cables shall be separated from the down conductors of lightning protection systems (LPS) by either a minimum distance or by use of screening. The minimum distance shall be determined by the designer of the LPS in accordance with IEC 61400-24.
- Metallic sheaths or shields of power and signal cables should be bonded in accordance with the requirements for lightning protection given in IEC 61400-24.

Based on these measures against electromagnetic interference (EMI) the manufacturer shall design the wind turbine taking these measures into account. Implementation shall be documented by means of circuit diagrams and corresponding description of lightning protection.

4.3 Circuit diagrams

The connection of the cable shielding shall be defined and shall be made clearly visible in the circuit diagrams. If filters and capacitors are installed due to EMC purposes this has to be implemented in the circuit diagram, too.

Furthermore, the type and installation position of surge protection devices (SPD) shall be contained.

4.4 Components

4.4.1 General

The electromagnetic immunity of the electrical components has to be confirmed in the corresponding component documentation.

The electromagnetic emissions of the electrical components shall not be higher than the limits of the corresponding product standard. This has to be stated in the corresponding component documentation.

The following minimum requirements have to be fulfilled for the electrical installations of the wind turbine and its main electrical components.

4.4.2 Rotating electrical machines

Rotating electrical machines shall fulfil the requirements according to IEC 60034-1:2010 subclause 13 (electromagnetic compatibility). Immunity tests are not required there, emission type tests shall be carried out in accordance with CISPR 11 and CISPR 16 (series) as applicable.

Fulfilment of the requirements shall be stated in the generator documentation.

4.4.3 Frequency converter

Frequency converter (main power converter and converter for motor control) shall be designed in accordance with the electromagnetic immunity requirements and requirements for electromagnetic emissions. The relevant EMC requirements are given in IEC 61800-3.

The manufacturer of the frequency converter shall evaluate the results proving that the EMC requirements are fulfilled based on measurements, calculations and / or simulations. This shall be stated in the documentation by the manufacturer of the frequency converter.

Based on the test results concerning EMC, the manufacturer of the frequency converter shall define and document corresponding measures that have to be observed during assembly or installation. At a minimum the shielding of connecting cables shall be defined in detail. This has to be shown in the product documentation.

If the frequency converter is defined acc. to IEC 61800-3 as category C4 an EMC plan with the necessary information according to annex E of IEC 61800-3:2012 shall be established.

4.4.4 Low-voltage switchgear, controlgear and switchboards (voltages of up to 1000 VAC or 1500 VDC)

Low-voltage switchgears, controlgears and switchboards shall be designed and tested according to IEC 61439-1:2011, subclause 9.4. The EMC tests have to be documented including information on test conditions and the test setup. Also the installation requirements in the wind turbine have to be defined and documented.

4.4.5 Power transformer

Power transformers are to be considered as passive elements with respect to EMI and EMC. They cause no electromagnetic disturbances and their performance is not affected by such (see IEC 60076-1:2011 subclause 11).

4.4.6 High-voltage switchgear

For high-voltage switchgears EMC shall be considered for auxiliary and control circuits. Reference is made to IEC 62271-1:2011 subclause 5.18 (for design) and subclause 6.9 (for testing).

EMC tests (emission tests and immunity tests) are mandatory type tests for auxiliary and control circuits of high-voltage switchgears if they include electronic equipment or components. The test results shall be stated in corresponding EMC type test reports.

If the measurement of electromagnetic compatibility on site (after installation in wind turbine) is necessary, reference is made to IEC 62271-1:2011 Annex J.

4.4.7 Lightning protection

Measures of the lightning protection system of the wind turbine are also applicable for EMC. The requirements for the lightning protection design are given in section 10 of DNVGL ST-0076 and in standard IEC 61400-24.

4.4.8 Electrical equipment for measurement and control and its accessories

Electrical equipment for measurement and control use and its accessories shall be designed and tested according to IEC 61326-1. Compliance with the requirements given in IEC 61326-1 shall be stated in the component documentation.

4.4.9 Safety-related parts of the control system

For components being safety-related part of the control system (see [3.1]) all EMC requirements shall be fulfilled according to IEC 61326-3-1. Especially for functional safety EMC of the SRP/CS is relevant, therefore the immunity requirements are to be studied carefully and have to be fulfilled.

Safety-related parts shall be tested regarding immunity and fulfil the performance criterion FS as defined in IEC 61326-3-1.

Corresponding documentation and test reports shall be included in the component documentation.

4.4.10 Uninterruptible power systems

Uninterruptible power systems shall be designed and tested according to IEC 62040-2. Compliance with the requirements given in IEC 62040-2 shall be stated in the component documentation.

SECTION 5 TYPE TESTING

5.1 General

Measurements shall be performed at least at one sample wind turbine. This tested turbine shall be of a design that is sufficiently in compliance to the design of the wind turbine type under evaluation.

The test scope shall be the measurement of the conducted and radiated electromagnetic emissions of the wind turbine.

It may happen that the measurements of the radiated and conducted emissions of the wind turbine under test do not fulfil the requirements due to unfavourable environmental influences. In this case a statement of the measurement laboratory shall be provided including description of the present environmental conditions/influences during measurement period.

In that case a wind turbine with the same design installed on another location may be used for new measurements.

5.2 Radiated emissions

5.2.1 Test plan

Before the measurements are started a test plan shall be created. The test plan shall at least contain measurements required according to this recommended practice. The sequence of the measurements shall be described in detail.

With the test plan the EMC most critical operation modes/cases (e.g. power performance level, operation mode, load changes, etc.) shall be defined by the manufacturer and reasons shall be given for this definition.

With the test plan the calculation factors used if the distance is larger than 30 m shall be given (see [5.2.5]).

5.2.2 Measurement procedure

The measurement of the radiated emissions of a wind turbine shall be done in general according to CISPR 11 and CISPR 16-2-3. The limits for the emissions are stated in the CISPR 11. For definition of the test setup the CISPR 16-2-3:2010 chapter 7.5 “Measurements of equipment in situ” shall be used.

Guidance note:
The results of EMC measurements are depending on environmental influences. That is the reason why the generic EMC standards require a calibrated and well defined test area for EMC measurements (OATS, fully anechoic chamber, etc.). A tall structure like a wind turbine cannot be measured in such defined environment.

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This recommended practice defines a way to measure wind turbines in situ. Due to environmental conditions the emissions of single wind turbines can deviate from the results obtained by the in situ measurement of one turbine for certification. Therefore site specific measurements may be necessary in addition. These can also be done according to this RP.

5.2.3 Measurement positions around the wind turbine

The position of the antenna can be seen in Figure 5-1. At minimum 4 points in an interval of 90° around the wind turbine shall be taken. The indicator for the definition of the measurement points shall be the nacelle (e.g. point 1 is towards the hub, point 2 is towards the right side of nacelle, etc.).

The antenna shall be directed towards the nacelle. In certain cases (e.g. concrete tower if radiation through the tower can be expected, frequency converter in the tower bottom) the measurements shall also be done with measurement points defined in the direction of the tower bottom (see Figure 5-2).

If the main source of the radiated emissions is expected to be located e.g. in the middle of the tower, additional measurements with measurement points defined in the direction of the main source shall be performed also.

All measurements shall be done with antenna in horizontal and vertical position.

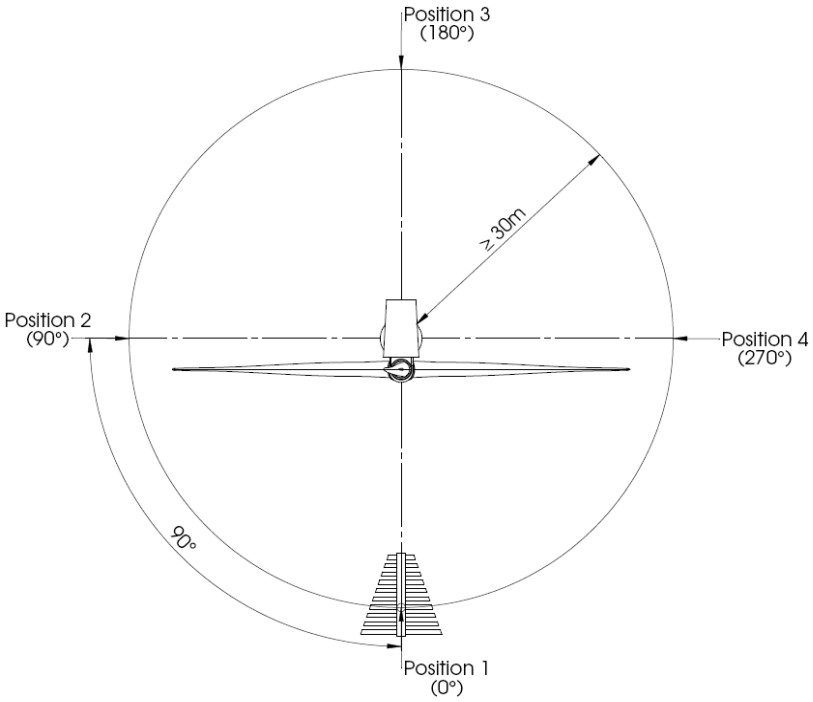

Figure 5-1 Measurement of radiated emissions: antenna positions around the wind turbine

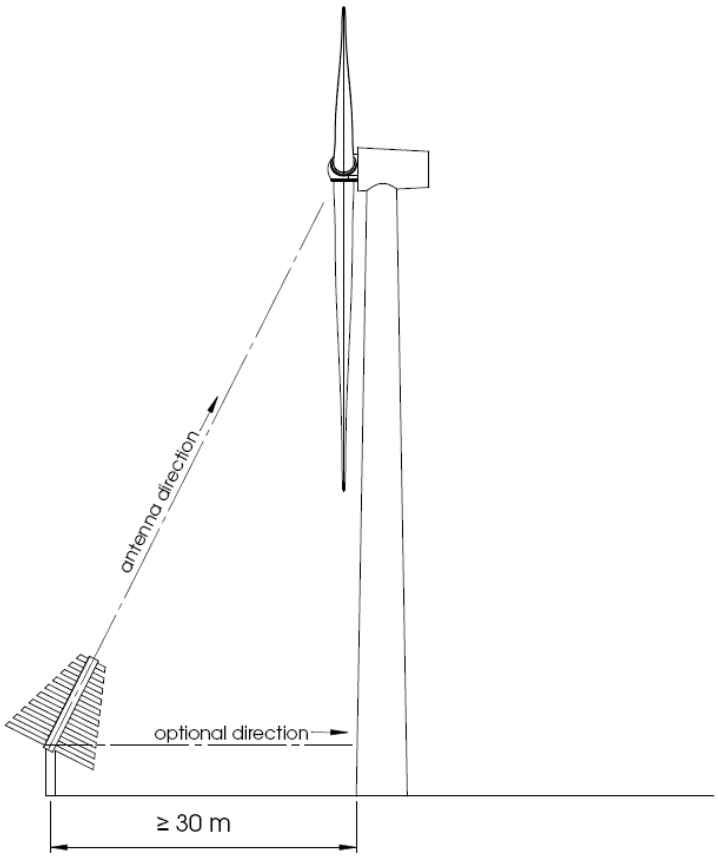

Figure 5-2 Measurement of radiated emissions: antenna direction

5.2.4 Power performance levels during measurement

The measurements shall be done at least at three different power performance levels which are:

— stand by
— full power (rated power)
— worst case, if worst case is the same as full power another power performance level has to be used (e.g. 50% of rated power).

Additionally it might also be worthwhile to perform measurements with disconnected wind turbine for indication of the surrounding emissions in the environment (e.g. radiated by neighbouring wind turbines).

5.2.5 Distance between antenna and wind turbine

The distance between antenna and wind turbine shall not be less than 30 m, higher distances are allowed. If the antenna is more than 30 m away from the wind turbine the calculation factors for the limits mentioned in CISPR 11 shall be used. Documentation shall be given in the test plan.

Guidance note:
In areas with high environmental noise additional measurements with a distance of 10 m between antenna and wind turbine might be beneficial to detect the influence of the wind turbine against the environment.

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5.3 Conducted emissions measurement

For conducted emissions of the main power interface of a wind turbine the measurement of electrical characteristics according to IEC 61400-21:2008 has to be performed and the measurement results have to be included in a corresponding report.

Guidance note:
The measurement method described in IEC 61400-21:2008 is only valid for a frequency range up to 9 kHz. Conducted emissions might be much higher (up to MHz).

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APPENDIX A DEFINITION OF PERFORMANCE CRITERIA ACCORDING TO IEC 61000-6-2:2005 CHAPTER 4

The variety and the diversity of the apparatus within the scope of this standard make it difficult to define precise criteria for the evaluation of the immunity test results.

If, as a result of the application of the tests defined in this standard, the apparatus becomes dangerous or unsafe, the apparatus shall be deemed to have failed the test.

Performance Criterion A: The apparatus continues to operate as intended during and after the test. No degradation of performance is observed below the performance level specified by the manufacturer.

Performance Criterion B: The apparatus continues to operate as intended after the test. During the test, degradation of performance is however allowed. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, these may be derived from the production description and documentation or what the user may reasonably expect.

Performance Criterion C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

APPENDIX B GENERIC EMC STANDARDS ACCORDING TO IEC

Reference	Title
	Residential, commercial, light industrial environment
IEC 61000-6-3	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments
IEC 61000-6-1	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments
	Industrial environment
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
	Power station and substation environment
IEC 61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment
	Indoor equipment
IEC 61000-6-6	Electromagnetic compatibility (EMC) - Part 6-6: Generic standards - HEMP immunity for indoor equipment

DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16 000 professionals are dedicated to helping our customers make the world safer, smarter and greener.