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General Specification

V112-3.3/3.45 MW 50/60 Hz

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Table of contents

1 General Description 6
2 Mechanical Design 6
2.1 Rotor 6
2.2 Blades 6
2.3 Blade Bearing 7
2.4 Pitch System 7
2.5 Hub 8
2.6 Main Shaft 8
2.7 Main Bearing Housing 8
2.8 Main Bearing 8
2.9 Gearbox 8
2.10 Generator Bearings 9
2.11 High-Speed Shaft Coupling 9
2.12 Yaw System 9
2.13 Crane 10
2.14 Towers 10
2.15 Nacelle Bedplate and Cover 10
2.16 Thermal Conditioning System 11
2.16.1 Generator and Converter Cooling 11
2.16.2 Gearbox and Hydraulic Cooling 11
2.16.3 Transformer Cooling 11
2.16.4 Nacelle Cooling 11
2.16.5 Optional Air Intake Hatches 12
3 Electrical Design 12
3.1 Generator 12
3.2 Converter 12
3.3 HV Transformer 13
3.3.1 IEC 50 Hz/60 Hz version 13
3.3.2 Ecodesign - IEC 50 Hz/60 Hz version 15
3.3.3 IEEE 60Hz version 16
3.4 HV Cables 18
3.5 HV Switchgear 18
3.5.1 IEC 50/60Hz version 20
3.5.2 IEEE 60Hz version 20
3.6 AUX System 21
3.7 Wind Sensors 21
3.8 Vestas Multi Processor (VMP) Controller 21
3.9 Uninterruptible Power Supply (UPS) 22
4 Turbine Protection Systems 23
4.1 Braking Concept 23
4.2 Short Circuit Protections 23
4.3 Overspeed Protection 23
4.4 Arc Detection 24
4.5 Smoke Detection 24
4.6 Lightning Protection of Blades, Nacelle, Hub and Tower 24
4.7 EMC System 25
4.8 Earthing 25
4.9 Corrosion Protection 25
5 Safety 26
5.1 Access 26

5.2 Escape ... 26
5.3 Rooms/Working Areas ... 26
5.4 Floors, Platforms, Standing, and Working Places ... 26
5.5 Service Lift ... 26
5.6 Climbing Facilities ... 26
5.7 Moving Parts, Guards, and Blocking Devices ... 27
5.8 Lights ... 27
5.9 Emergency Stop ... 27
5.10 Power Disconnection ... 27
5.11 Fire Protection/First Aid ... 27
5.12 Warning Signs ... 27
5.13 Manuals and Warnings ... 27
6 Environment ... 28
6.1 Chemicals ... 28
7 Approvals and Design Codes ... 28
7.1 Type Approvals ... 28
7.2 Design Codes – Structural Design ... 28
8 Colours ... 29
8.1 Nacelle Colour ... 29
8.2 Tower Colour ... 29
8.3 Blade Colour ... 29
9 Operational Envelope and Performance Guidelines ... 30
9.1 Climate and Site Conditions ... 30
9.1.1 Complex Terrain ... 30
9.1.2 Altitude ... 30
9.1.3 Wind Power Plant Layout ... 31
9.2 Operational Envelope – Temperature and Wind ... 31
9.3 Operational Envelope – Grid Connection ... 32
9.4 Operational Envelope – Reactive Power Capability ... 33
9.5 Performance – Fault Ride Through ... 34
9.6 Performance – Reactive Current Contribution ... 35
9.6.1 Symmetrical Reactive Current Contribution ... 35
9.6.2 Asymmetrical Reactive Current Contribution ... 36
9.7 Performance – Multiple Voltage Dips ... 36
9.8 Performance – Active and Reactive Power Control ... 36
9.9 Performance – Voltage Control ... 37
9.10 Performance – Frequency Control ... 37
9.11 Main Contributors to Own Consumption ... 37
9.12 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height) ... 37
9.13 Noise Modes ... 38
10 Drawings ... 39
10.1 Structural Design – Illustration of Outer Dimensions ... 39
10.2 Structural Design – Side View Drawing ... 40
11 General Reservations, Notes and Disclaimers ... 40
12 Appendices ... 42
12.1 Mode 0 ... 42
12.1.1 Power Curves, Noise Mode 0 ... 42
12.1.2 Ct Values, Noise Mode 0 ... 43
12.1.3 Noise Curves, Noise Mode 0 ... 44
12.2 Mode 2 ... 45
12.2.1 Power Curves, Noise Mode 2 ... 45
12.2.2 C_t Values, Noise Mode 2 ... 46
12.2.3 Noise Curves, Noise Mode 2 ... 47
MW ... 48

12.3 Mode 3 48
12.3.1 Power Curves, Noise Mode 3 48
12.3.2 C_t Values, Noise Mode 3 49
12.3.3 Noise Curves, Noise Mode 3 50
12.4 Mode 4 51
12.4.1 Power Curves, Noise Mode 4 51
12.4.2 C_t Values, Noise Mode 4 52
12.4.3 Noise Curves, Noise Mode 4 53
12.5 Mode 5 54
12.5.1 Power Curves, Noise Mode 5 54
12.5.2 C_t Values, Noise Mode 5 55
12.5.3 Noise Curves, Noise Mode 5 56
12.6 Mode 8 57
12.6.1 Power Curves, Noise Mode 8 57
12.6.2 C_t Values, Noise Mode 8 58
12.6.3 Noise Curves, Noise Mode 8 59
12.7 3.45 MW Power Mode 60
12.7.1 Power Curves, 3.45 MW Power Mode 60
12.7.2 C_t Values, 3.45 MW Power Mode 61
12.7.3 Noise Curves, 3.45 MW Power Mode 62

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1 General Description

The Vestas V112-3.3/3.45 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V112-3.3/3.45 MW turbine has a rotor diameter of 112 m and a rated output power of 3.3/3.45 MW. The turbine utilises the OptiTip® concept and a power system based on an induction generator and full-scale converter. With these features, the wind turbine is able to operate the rotor at variable speed and thereby maintaining the power output at or near rated power even in high wind speed. At low wind speed, the OptiTip® concept and the power system work together to maximise the power output by operating at the optimal rotor speed and pitch angle.

Operating the turbine with 3.45 MW Power Mode is achieved by extended derate strategy and reduced reactive power capability compared with 3.3 MW operation.

2 Mechanical Design

2.1 Rotor

The V112-3.3/3.45 MW is equipped with a 112-metre rotor consisting of three blades and a hub. The blades are controlled by the microprocessor pitch control system OptiTip®. Based on the prevailing wind conditions, the blades are continuously positioned to optimise the pitch angle.

Rotor	
Diameter	112 m
Swept Area	9852 m^2
Speed, Dynamic Operation Range	6.2-17.7
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Blade Coning	4°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data

2.2 Blades

The blades are made of carbon and fibreglass and consist of two airfoil shells bonded to a supporting beam.

Blades	
Type Description	Airfoil shells bonded to supporting beam
Blade Length	54.65 m

Blades	
Material	Fibreglass reinforced epoxy, carbon fibres and Solid Metal Tip (SMT)
Blade Connection	Steel roots inserted
Airfoils	High-lift profile
Maximum Chord	4.0 m

Table 2-2: Blades data

2.3 Blade Bearing

The blade bearings are double-row four-point contact ball bearings.

Blade Bearing	
Lubrication	Grease

Table 2-3: Blade bearing data

2.4 Pitch System

The turbine is equipped with a pitch system for each blade and a distributor block, all located in the hub. Each pitch system is connected to the distributor block with flexible hoses. The distributor block is connected to the pipes of the hydraulic rotating transfer unit in the hub by means of three hoses (pressure line, return line and drain line).

Each pitch system consists of a hydraulic cylinder mounted to the hub and a piston rod mounted to the blade via a torque arm shaft. Valves facilitating operation of the pitch cylinder are installed on a pitch block bolted directly onto the cylinder.

Pitch System	
Type	Hydraulic
Number	1 per blade
Range	-9° to 90°

Table 2-4: Pitch system data

Hydraulic System	
Main Pump	Two redundant internal-gear oil pumps
Pressure	260 bar
Filtration	3 µm (absolute)

Table 2-5: Hydraulic system data.

2.5 Hub

The hub supports the three blades and transfers the reaction forces to the main bearing and the torque to the gearbox. The hub structure also supports blade bearings and pitch cylinder.

Hub	
Type	Cast ball shell hub
Material	Cast iron

Table 2-6: Hub data

2.6 Main Shaft

The main shaft transfers the reaction forces to the main bearing and the torque to the gearbox.

Main Shaft	
Type Description	Hollow shaft
Material	Cast iron

Table 2-7: Main shaft data

2.7 Main Bearing Housing

The main bearing housing covers the main bearing and is the first connection point for the drive train system to the bedplate.

Main Bearing Housing	
Material	Cast iron

Table 2-8: Main bearing housing data

2.8 Main Bearing

The main bearing carries all thrust loads.

Main Bearing	
Type	Double-row spherical roller bearing
Lubrication	Automatic grease lubrication

Table 2-9: Main bearing data

2.9 Gearbox

The main gear converts the low-speed rotation of the rotor to high-speed generator rotation.

The disc brake is mounted on the high-speed shaft. The gearbox lubrication system is a pressure-fed system.

Gearbox	
Type	Planetary stages + one helical stage
Gear House Material	Cast
Lubrication System	Pressure oil lubrication
Backup Lubrication System	Oil sump filled from external gravity tank
Total Gear Oil Volume	1000-1200
Oil Cleanliness Codes	ISO 4406-/15/12
Shaft Seals	Labyrinth

Table 2-10: Gearbox data

2.10 Generator Bearings

The bearings are grease lubricated and grease is supplied continuously from an automatic lubrication unit.

2.11 High-Speed Shaft Coupling

The coupling transmits the torque of the gearbox high-speed output shaft to the generator input shaft.

The coupling consists of two 4-link laminate packages and a fibreglass intermediate tube with two metal flanges. The coupling is fitted to two-armed hubs on the brake disc and the generator hub.

2.12 Yaw System

The yaw system is an active system based on a robust pre-tensioned plain yaw-bearing concept with PETP as friction material.

The yaw gears have a torque limiter.

Yaw System	
Type	Plain bearing system
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yawing Speed (50 Hz)	0.46°/sec.
Yawing Speed (60 Hz)	0.6°/sec.

Table 2-11: Yaw system data

Yaw Gear	
Type	Multiple stages geared
Ratio Total	944:1
Rotational Speed at Full Load	1.4 rpm at output shaft

Table 2-12: Yaw gear data

2.13 Crane

The nacelle houses the internal safe working load (SWL) service crane. The crane is a single system hoist.

Crane	
Lifting Capacity	Maximum 800 kg

Table 2-13: Crane data

2.14 Towers

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. The towers are designed with the majority of internal welded connections replaced by magnet supports to create a predominantly smooth-walled tower. Magnets provide load support in a horizontal direction and internals, such as platforms, ladders, and such like, are supported vertically (that is, in the gravitational direction) by a mechanical connection. The smooth tower design reduces the required steel thickness, rendering the tower lighter compared to one with all internals welded to the tower shells.

The hub heights listed include a distance from the foundation section to the ground level of approximately 0.2 m depending on the thickness of the bottom flange and a distance from the tower top flange to the centre of the hub of 2.2 m.

Towers	
Type	Cylindrical/conical tubular
Hub Heights	84 m/94 m/119 m/140 m
Hub Heights (North America)	84 m/94 m

Table 2-14: Tower structure data

2.15 Nacelle Bedplate and Cover

The nacelle cover is made of fibreglass. Hatches are positioned in the floor for lowering or hoisting equipment to the nacelle and evacuation of personnel. The roof section is equipped with wind sensors and skylights. The skylights can be opened from both inside the nacelle to access the roof and from outside to access the nacelle. Access from the tower to the nacelle is through the yaw system.

The nacelle bedplate is in two parts and consists of a cast iron front part and a girder structure rear part. The front of the nacelle bedplate is the foundation for the drive train and transmits forces from the rotor to the tower through the yaw system. The bottom surface is machined and connected to the yaw bearing and the yaw gears are bolted to the front nacelle bedplate.

The crane girders are attached to the top structure. The lower beams of the girder structure are connected at the rear end. The rear part of the bedplate

serves as the foundation for controller panels, the cooling system and transformer. The nacelle cover is installed on the nacelle bedplate.

Type Description	Material
Nacelle Cover	GRP
Bedplate Front	Cast iron
Bedplate Rear	Girder structure

Table 2-15: Nacelle bedplate and cover data

2.16 Thermal Conditioning System

The thermal conditioning system consists of a few robust components:

- The Vestas CoolerTop® located on top of the rear end of the nacelle. The CoolerTop® is a free flow cooler, thus ensuring that there are no electrical components in the thermal conditioning system located outside the nacelle.
- The Liquid Cooling System, which serves the gearbox, hydraulic systems, generator and converter is driven by an electrical pumping system.
- The transformer forced air cooling comprised of an electrical fan.

2.16.1 Generator and Converter Cooling

The generator and converter cooling systems operate in parallel. A dynamic flow valve mounted in the generator cooling circuit divides the cooling liquid flow. The cooling liquid removes heat from the generator and converter unit using a free-air flow radiator placed on the top of the nacelle. In addition to the generator, converter unit and radiator, the circulation system includes an electrical pump and a three-way thermostatic valve.

2.16.2 Gearbox and Hydraulic Cooling

The gearbox and hydraulic cooling systems are coupled in parallel. A dynamic flow valve mounted in the gearbox cooling circuit divides the cooling flow. The cooling liquid removes heat from the gearbox and the hydraulic power unit through heat exchangers and a free-air flow radiator placed on the top of the nacelle. In addition to the heat exchangers and the radiator, the circulation system includes an electrical pump and a three-way thermostatic valve.

2.16.3 Transformer Cooling

The transformer is equipped with forced-air cooling. The ventilator system consists of a central fan, located below the service floor and an air duct leading the air to locations beneath and between the high voltage and low voltage windings of the transformer.

2.16.4 Nacelle Cooling

Hot air generated by mechanical and electrical equipment is removed from the nacelle by a fan system located in the nacelle.

2.16.5 Optional Air Intake Hatches

The air intakes in the nacelle can optional be fitted with hatches which can be operated as a part of the thermal control strategy. In case of lost grid to the turbine, the hatches will automatically be closed.

3 Electrical Design

3.1 Generator

The generator is a three-phase asynchronous induction generator with cage rotor that is connected to the grid through a full-scale converter.

The generator housing allows the circulation of cooling air within the stator and rotor. The air-to-water heat exchange occurs in an external heat exchanger

Generator	
Type	Asynchronous with cage rotor
Rated Power [P_N]	3650 kW
Frequency [f_N]	0-100 Hz
Voltage, Stator [U_{NS}]	3 x 750 V (at rated speed)
Number of Poles	4/6
Winding Type	Form with VPI (Vacuum Pressurized Impregnation)
Winding Connection	Star or Delta
Rated rpm	1450-1550 rpm
Overspeed Limit Acc. to IEC (2 minutes)	2400 rpm
Generator Bearing	Hybrid/ceramic
Temperature Sensors, Stator	3 PT100 sensors placed at hot spots and 3 as back-up
Temperature Sensors, Bearings	1 per bearing
Insulation Class	F or H
Enclosure	IP54

Table 3-1: Generator data

3.2 Converter

The converter is a full-scale converter system controlling both the generator and the power quality delivered to the grid.

The converter consists of four converter units operating in parallel with a common controller.

The converter controls conversion of variable frequency power from the generator into fixed frequency AC power with desired active and reactive power levels (and other grid connection parameters) suitable for the grid. The converter

is located in the nacelle and has a grid side voltage rating of 650 V. The generator side voltage rating is up to 750 V dependent on generator speed.

Converter	
Rated Apparent Power [S_N]	4000 kVA
Rated Grid Voltage	650 V
Rated Generator Voltage	750 V
Rated generator Current	3286 A
Enclosure	IP54

Table 3-2: Converter data

3.3 HV Transformer

The step-up HV transformer is located in a separate locked room in the back of the nacelle.

The transformer is a three-phase, two-winding, dry-type transformer that is self-extinguishing. The windings are delta-connected on the high-voltage side unless otherwise specified.

The transformer comes in different versions depending on the market where it is intended to be installed.

- For 50 Hz regions the transformer is as default designed according to IEC standards. However on special request, a 60 Hz transformer based on IEC standards could also be delivered. Refer to Table 3-3.
- For turbines installed in Member States of the European Union, it is required to fulfil the Ecodesign regulation No 548/2014 set by the European Commission. Refer to Table 3-4.
- For 60 Hz regions the transformer is as default designed mainly according to IEEE standards but on areas not covered by IEEE standards, the design is also based on parts of the IEC standards. Refer to Table 3-5.

3.3.1 IEC 50 Hz/60 Hz version

Transformer	
Type description	Dry-type cast resin transformer.
Basic layout	3 phase, 2 winding transformer.
Applied standards	IEC 60076-11, IEC 60076-16, IEC 61936-1.
Cooling method	AF
Rated power	3750 kVA
Rated voltage, turbine side	
U_m 1.1kV	0.650 kV
Rated voltage, grid side	
U_m 12.0kV	10.0-11.0 kV
U_m 24.0kV	11.1-22.0 kV
U_m 36.0kV	22.1-33.0 kV
U_m 41.5kV	33.1-36.0 kV
Insulation level AC / LI / LIC	

Transformer	
U_m 1.1kV	3[1] / - / - kV
U_m 12.0kV	28[1] / 75 / 75 kV
U_m 24.0kV	50[1] / 125 / 125 kV
U_m 36.0kV	70[1] / 170 / 170 kV
U_m 41.5kV	80[1] / 170 / 170 kV
Off-circuit tap changer	±2 x 2.5 %
Frequency	50 Hz / 60Hz
Vector group	Dyn5 / YNyn0
No-load loss [2]	5.8 kW
Load loss @ rated power HV, 120°C [2]	30.5 kW
No-load reactive power [2]	16 kVAr
Full load reactive power [2]	345 kVAr
No-load current [2]	0.5 %
Positive sequence short-circuit impedance @ rated power, 120°C [3]	9.0 %
Positive sequence short-circuit resistance@ rated power, 120°C [2]	0.8 %
Zero sequence short-circuit impedance@ rated power, 120°C [2]	8.2 %
Zero sequence short-circuit resistance@ rated power, 120°C [2]	0.7 %
Inrush peak current [2]	
Dyn5	6-9 x $\hat{I}_n$
YNyn0	8-12 x $\hat{I}_n$
Half crest time [2]	~0.7 s
Sound power level	≤ 80 dB(A)
Average temperature rise at max altitude	≤90 K
Max altitude [4]	2000 m
Insulation class	155 (F)
Environmental class	E2
Climatic class	C2
Fire behaviour class	F1
Corrosion class	C4
Weight	≤8500 kg
Temperature monitoring	PT100 sensors in LV windings and core
Overvoltage protection	Surge arresters on HV terminals
Temporary earthing	3 x Ø20 mm earthing ball points

Table 3-3: Transformer data for IEC 50 Hz/60 Hz version

NOTE

[1] @1000m. According to IEC 60076-11, AC test voltage is altitude dependent.
[2] Based on an average of calculated values across voltages and manufacturers.
[3] Subjected to standard IEC tolerances.
[4] Transformer max altitude may be adjusted to match turbine location.

3.3.2 Ecodesign - IEC 50 Hz/60 Hz version

Transformer	
Type description	Ecodesign dry-type cast resin transformer.
Basic layout	3 phase, 2 winding transformer.
Applied standards	IEC 60076-11, IEC 60076-16, IEC 61936-1, Commission Regulation No 548/2014.
Cooling method	AF
Rated power	3750 kVA
Rated voltage, turbine side	
U_m 1.1kV	0.650 kV
Rated voltage, grid side	
U_m 12.0kV	10.0-11.0 kV
U_m 24.0kV	11.1-22.0 kV
U_m 36.0kV	22.1-33.0 kV
U_m 40.5kV	33.1-36.0 kV
Insulation level AC / LI / LIC	
U_m 1.1kV	3[1] / - / - kV
U_m 12.0kV	28[1] / 75 / 75 kV
U_m 24.0kV	50[1] / 125 / 125 kV
U_m 36.0kV	70[1] / 170 / 170 kV
U_m 40.5kV	80[1] / 170 / 170 kV
Off-circuit tap changer	±2 x 2.5 %
Frequency	50 Hz / 60 Hz
Vector group	Dyn5 / YNyn0
Peak Efficiency Index (PEI) [2]	Ecodesign requirement
U_m 12.0kV	≥99.348
U_m 24.0kV	≥99.348
U_m 36.0kV	≥99.348
U_m 40.5kV	≥99.158
No-load loss [2]	
U_m 12.0kV	≤5.50 kW
U_m 24.0kV	≤5.50 kW
U_m 36.0kV	≤5.40 kW
U_m 40.5kV	≤6.00 kW
Load loss @ rated power HV, 120°C [2]	
U_m 12.0kV	≤27.70 kW
U_m 24.0kV	≤27.70 kW
U_m 36.0kV	≤28.35 kW
U_m 40.5kV	≤25.30 kW
No-load reactive power [3]	25 kVAr
Full load reactive power [3]	370 kVAr
No-load current [3]	0.5 %
Positive sequence short-circuit impedance @ rated power, 120°C [4]	9.0 %
Positive sequence short-circuit resistance@ rated power, 120°C [3]	0.8 %
Zero sequence short-circuit impedance@ rated power, 120°C [3]	8.2 %
Zero sequence short-circuit resistance@ rated power, 120°C [3]	0.7 %

Transformer	
Inrush peak current [3]	
Dyn5	6-9 x $\hat{I}_n$
YNyn0	8-12 x $\hat{I}_n$
Half crest time [3]	~ 0.7 s
Sound power level	≤ 80 dB(A)
Average temperature rise at max altitude	≤90 K
Max altitude [5]	2000 m
Insulation class	155 (F)
Environmental class	E2
Climatic class	C2
Fire behaviour class	F1
Corrosion class	C4
Weight	≤8800 kg
Temperature monitoring	PT100 sensors in LV windings and core
Overvoltage protection	Surge arresters on HV terminals
Temporary earthing	3 x Ø20 mm earthing ball points

Table 3-4: Transformer data for Ecodesign IEC 50 Hz/60 Hz version.

NOTE

[1] @1000m. According to IEC 60076-11, AC test voltage is altitude dependent.
[2] For Ecodesign transformers, PEI is the legal requirement and is calculated according to the Commission Regulation based on rated power, no-load and load losses. The listed losses are maximum values and will not simultaneously occur in a specific design as this will be incompliant with the PEI requirement.
[3] Based on an average of calculated values across voltages and manufacturers.
[4] Subjected to standard IEC tolerances.
[5] Transformer max altitude may be adjusted to match turbine location.

3.3.3 IEEE 60Hz version

Transformer	
Type description	Dry-type cast resin transformer.
Basic layout	3 phase, 2 winding transformer.
Applied standards	UL 1562, CSA C22.2 No. 47, IEEE C57.12, IEC 60076-11, IEC 60076-16, IEC 61936-1.
Cooling method	AFA
Rated power	3750 kVA
Rated voltage, turbine side	
N_{LL} 1.2 kV	0.650 kV
Rated voltage, grid side	
N_{LL} 15.0 kV	10.0-15.0 kV
N_{LL} 25.0 kV	15.1-25.0 kV
N_{LL} 34.5 kV	25.1-34.5 kV

Transformer	
Insulation level AC / LI & LIC	
N_{LL} 1.2 kV	4[1] / +10 kV
N_{LL} 15.0 kV	34[1] / +95 kV
N_{LL} 25.0 kV	50[1] / +125 kV
N_{LL} 34.5 kV	70[1] / (+150 & -170) or +170 kV
Off-circuit tap changer	±2 x 2.5 %
Frequency	60 Hz
Vector group	Dyn5 / YNyn0
No-load loss [2]	5.8 kW
Load loss @ rated power HV, 120°C [2]	30.5 kW
No-load reactive power [2]	16 kVAr
Full load reactive power [2]	345 kVAr
No-load current [2]	0.5 %
Positive sequence short-circuit impedance @ rated power, 120°C [3]	9.0 %
Positive sequence short-circuit resistance @ rated power, 120°C [2]	0.7 %
Zero sequence short-circuit impedance @ rated power, 120°C [2]	8.3 %
Zero sequence short-circuit resistance @ rated power, 120°C [2]	0.7 %
Inrush peak current [2]	
Dyn5	6-9 x $\hat{I}_n$
YNyn0	8-12 x $\hat{I}_n$
Half crest time [2]	~ 0.7 s
Sound power level	≤ 80 dB(A)
Average temperature rise at max altitude	≤ 90 K
Max altitude [4]	2000 m
Insulation class	150°C
Environmental class	E2
Climatic class	C2
Fire behaviour class	F1
Corrosion class	C4
Weight	≤ 8500 kg
Temperature monitoring	PT100 sensors in LV windings and core
Overvoltage protection	Surge arresters on HV terminals
Temporary earthing	3 x Ø20 mm earthing ball points

Table 3-5: Transformer data for IEEE 60 Hz version

NOTE

[1] @1000m. According to IEEE C57.12, AC test voltage is altitude dependent.
[2] Based on an average of calculated values across voltages and manufacturers.
[3] Subjected to standard IEEE C57.12 tolerances.
[4] Transformer max altitude may be adjusted to match turbine location..

3.4 HV Cables

The high-voltage cable runs from the transformer in the nacelle down the tower to the HV switchgear located at the bottom of the tower. The high-voltage cable is a four-core, rubber-insulated, halogen-free, high-voltage cable.

HV Cables	
High-Voltage Cable Insulation Compound	Improved ethylene-propylene (EP) based material-EPR or high modulus or hard grade ethylene-propylene rubber-HEPR
Conductor Cross Section	3 x 70 / 70 mm^2
Maximum Voltage	24 kV for 10.0-22.0 kV rated voltage 42 kV for 22.1-36.0 kV rated voltage

Table 3-6: HV cables data

3.5 HV Switchgear

A gas insulated switchgear is installed in the bottom of the tower as an integrated part of the turbine. Its controls are integrated with the turbine safety system which monitors the condition of the switchgear and high voltage safety related devices in the turbine. This ensures all protection devices are fully operational whenever high voltage components in the turbine are energised. The earthing switch of the circuit breaker contains a trapped-key interlock system with its counterpart installed on the access door to the transformer room in order to avoid unauthorized access to the transformer room during live condition.

The switchgear is available in three variants with increasing features, see Table 3-7. Beside the increase in features, the switchgear can be configured depending on the number of grid cables planned to enter the individual turbine. The design of the switchgear solution is optimized such grid cables can be connected to the switchgear even before the tower is installed and still maintain its protection toward weather conditions and internal condensation due to a gas tight packing.

The switchgear is available in an IEC version and in an IEEE version. The IEEE version is however only available in the highest voltage class. The electrical parameters of the switchgear are seen in Table 3-8 for the IEC version and in Table 3-9 for the IEEE version.

HV Switchgear			
Variant	**Basic**	**Streamline**	**Standard**
IEC standards	○	⊙	⊙
IEEE standards	⊙	○	⊙
Vacuum circuit breaker panel	⊙	⊙	⊙
Overcurrent, short-circuit and earth fault protection	⊙	⊙	⊙
Disconnector / earthing switch in circuit breaker panel	⊙	⊙	⊙
Voltage Presence Indicator System for circuit breaker	⊙	⊙	⊙
Voltage Presence Indicator System for grid cables	⊙	⊙	⊙
Double grid cable connection	⊙	⊙	⊙
Triple grid cable connection	⊙	○	○
Preconfigured relay settings	⊙	⊙	⊙
Turbine safety system integration	⊙	⊙	⊙
Redundant trip coil circuits	⊙	⊙	⊙
Trip coil supervision	⊙	⊙	⊙
Pendant remote control from outside of tower	⊙	⊙	⊙
Sequential energisation	⊙	⊙	⊙
Reclose blocking function	⊙	⊙	⊙
Heating elements	⊙	⊙	⊙
Trapped-key interlock system for circuit breaker panel	⊙	⊙	⊙
UPS power back-up for protection circuits	⊙	⊙	⊙
Motor operation of circuit breaker	⊙	⊙	⊙
Cable panel for grid cables (configurable)	○	⊙	⊙
Switch disconnector panels for grid cables – max three panels (configurable)	○	⊙	⊙
Earthing switch for grid cables	○	⊙	⊙
Internal arc classification	○	⊙	⊙
Supervision on MCB’s	○	⊙	⊙
Motor operation of switch disconnector	○	○	⊙
SCADA ready	○	○	⊙
SCADA operation of circuit breaker	○	○	⊙
SCADA operation of switch disconnector	○	○	⊙

Table 3-7: HV switchgear variants and features.

3.5.1 IEC 50/60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEC 62271-103 IEC 62271-1, 62271-100, 62271-102, 62271-200, IEC 60694
Insulation medium	SF_6
Rated voltage	
U_r 24.0kV	10.0-22.0 kV
U_r 36.0kV	22.1-33.0 kV
U_r 40.5kV	33.1-36.0 kV
Rated insulation level AC // LI Common value / across isolation distance	
U_r 24.0kV	50 / 60 // 125 / 145 kV
U_r 36.0kV	70 / 80 // 170 / 195 kV
U_r 40.5kV	85 / 90 // 185 / 215 kV
Rated frequency	50 Hz / 60 Hz
Rated normal current	630 A
Rated Short-time withstand current	
U_r 24.0kV	20 kA
U_r 36.0kV	25 kA
U_r 40.5kV	25 kA
Rated peak withstand current 50 / 60 Hz	
U_r 24.0kV	50 / 52 kA
U_r 36.0kV	62.5 / 65 kA
U_r 40.5kV	62.5 / 65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	
U_r 24.0kV	IAC A FLR 20 kA, 1 s
U_r 36.0kV	IAC A FLR 25 kA, 1 s
U_r 40.5kV	IAC A FLR 25 kA, 1 s
Connection interface	Outside cone plug-in bushings, IEC interface C1.
Loss of service continuity category	LSC2
Ingress protection	
Gas tank	IP 65
Enclosure	IP 2X
LV cabinet	IP 3X
Corrosion class	C3

Table 3-8: HV switchgear data for IEC version.

3.5.2 IEEE 60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEEE 37.20.3, IEEE C37.20.4, IEC 62271-200, ISO 12944.

HV Switchgear	
Insulation medium	SF_6
Rated voltage	
U_r 38.0kV	22.1-36.0 kV
Rated insulation level AC / LI	70 / 150 kV
Rated frequency	60 Hz
Rated normal current	600 A
Rated Short-time withstand current	25 kA
Rated peak withstand current	65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	IAC A FLR 25 kA, 1 s
Connection interface grid cables	Outside cone plug-in bushings, IEEE 386 interface type deadbreak, 600A.
Ingress protection	
Gas tank	NEMA 4X / IP 65
Enclosure	NEMA 2 / IP 2X
LV cabinet	NEMA 2 / IP 3X
Corrosion class	C3

Table 3-9: HV switchgear data for IEEE version.

3.6 AUX System

The AUX system is supplied from a separate 650/400 V transformer located in the nacelle. All motors, pumps, fans and heaters are supplied from this system.

All 230 V consumers are supplied from a 400/230 V transformer located in the tower base.

Power Sockets	
Single Phase (Nacelle and Tower Platforms)	230 V (16 A)/110 V (16 A)/ 2 x 55 V (16 A)
Three Phase (Nacelle and Tower Base)	3 x 400 V (16 A)

Table 3-10: AUX system data

3.7 Wind Sensors

The turbine is either equipped with two ultrasonic wind sensors or optional one ultrasonic wind sensor and one mechanical wind vane and anemometer. The sensors have built-in heaters to minimise interference from ice and snow. The wind sensors are redundant, and the turbine is able to operate with one sensor only.

3.8 Vestas Multi Processor (VMP) Controller

The turbine is controlled and monitored by the VMP6000 control system.

VMP6000 is a multiprocessor control system comprised of four main processors (ground, nacelle, hub and converter) interconnected by an optically based 2.5 Mbit ArcNet network.

In addition to the four main processors, the VMP6000 consists of a number of distributed I/O modules interconnected by a 500 kbit CAN network.

I/O modules are connected to CAN interface modules by a serial digital bus, CTBus.

The VMP6000 controller serves the following main functions:

- Monitoring and supervision of overall operation.
- Synchronizing of the generator to the grid during connection sequence.
- Operating the wind turbine during various fault situations.
- Automatic yawing of the nacelle.
- OptiTip® - blade pitch control.
- Reactive power control and variable speed operation.
- Noise emission control.
- Monitoring of ambient conditions.
- Monitoring of the grid.
- Monitoring of the smoke detection system.

3.9 Uninterruptible Power Supply (UPS)

During grid outage, an UPS system will ensure power supply for specific components.

The UPS system is built by 3 subsystems:

1. 230V AC UPS for all power backup to nacelle and hub control systems
2. 24V DC UPS for power backup to tower base control systems and optional SCADA Power Plant Controller.
3. 230V AC UPS for power backup to internal lights in tower and nacelle. Internal light in the hub is fed from built-in batteries in the light armature.

UPS		
Backup Time	**Standard**	**Optional**
Control System* **(230V AC and 24V DC UPS)**	15 min	Up to 400 min**
Internal Lights **(230V AC UPS)**	30 min	60 min***

UPS		
Optional SCADA Power Plant Controller **(24V DC UPS**	N/A	48 hours****

Table 3-11: UPS data

**The control system includes: the turbine controller (VMP6000), HV switchgear functions, and remote control system.*

***Requires upgrade of the 230V UPS for control system with extra batteries.*

****Requires upgrade of the 230V UPS for internal light with extra batteries.*

*****Requires upgrade of the 24V DC UPS with extra batteries.*

NOTE For alternative backup times, consult Vestas.

4 Turbine Protection Systems

4.1 Braking Concept

The main brake on the turbine is aerodynamic. Stopping the turbine is done by full feathering the three blades (individually turning each blade). Each blade has a hydraulic accumulator to supply power for turning the blade.

In addition, there is a mechanical disc brake on the high-speed shaft of the gearbox with a dedicated hydraulic system. The mechanical brake is only used as a parking brake and when activating the emergency stop buttons.

4.2 Short Circuit Protections

Breakers	Breaker for Aux. Power. T4L 250A TMD 4P 690 V	Breaker for Converter Modules T7M1200L PR332/P LSIG 1000 A 3P 690 V
Breaking Capacity, Icu, Ics	70 kA@690 V	50 kA @690 V
Making Capacity, Icm	154 kA@690 V	105 kA @690 V

Table 4-1: Short circuit protection data

4.3 Overspeed Protection

The generator rpm and the main shaft rpm are registered by inductive sensors and calculated by the wind turbine controller to protect against overspeed and rotating errors.

In addition, the turbine is equipped with a safety PLC, an independent computer module that measures the rotor rpm. In case of an overspeed situation, the safety PLC activates the emergency feathered position (full feathering) of the three blades independently of the turbine controller.

Overspeed Protection	
Sensors Type	Inductive
Trip Level	17.66 (rotor rpm)/2000 (generator rpm)

Table 4-3: Overspeed protection data

4.4 Arc Detection

The turbine is equipped with an Arc Detection system including multiple optical arc detection sensors placed in the HV transformer compartment and the grid interface cabinet. The Arc Detection system is connected to the turbine safety system ensuring immediate opening of the HV switchgear if an arc is detected.

4.5 Smoke Detection

The turbine is equipped with a Smoke Detection system including multiple smoke detection sensors placed in the nacelle (above the disc brake), in the transformer compartment, in main electrical cabinets in the nacelle and above the HV switchgear in the tower base. The Smoke Detection system is connected to the turbine safety system ensuring immediate opening of the HV switchgear if smoke is detected.

4.6 Lightning Protection of Blades, Nacelle, Hub and Tower

The Lightning Protection System (LPS) helps protect the wind turbine against the physical damage caused by lightning strikes. The LPS consists of five main parts:

- Lightning receptors.
- Down conducting system (a system to conduct the lightning current down through the wind turbine to help avoid or minimise damage to the LPS itself or other parts of the wind turbine).
- Protection against overvoltage and overcurrent.
- Shielding against magnetic and electrical fields.
- Earthing system.

Lightning Protection Design Parameters			**Protection Level I**
Current Peak Value	i_{max}	[kA]	200
Impulse Charge	$Q_{impulse}$	[C]	100
Long Duration Charge	Q_{long}	[C]	200
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/µs]	200

Table 4-4: Lightning protection design parameters

NOTE The Lightning Protection System is designed according to IEC standards (see section 7 Approvals and Design Codes, p. 28).

4.7 EMC System

The turbine and related equipment fulfils the EU Electromagnetic Compatibility (EMC) legislation:

- DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.

4.8 Earthing

The Vestas Earthing System consists of a number of individual earthing electrodes interconnected as one joint earthing system.

The Vestas Earthing System includes the TN-system and the Lightning Protection System for each wind turbine. It works as an earthing system for the medium voltage distribution system within the wind farm.

The Vestas Earthing System is adapted for the different types of turbine foundations. A separate set of documents describe the earthing system in detail, depending on the type of foundation.

In terms of lightning protection of the wind turbine, Vestas has no separate requirements for a certain minimum resistance to remote earth (measured in ohms) for this system. The earthing for the lightning protection system is based on the design and construction of the Vestas Earthing System.

A primary part of the Vestas Earthing System is the main earth bonding bar placed where all cables enter the wind turbine. All earthing electrodes are connected to this main earth bonding bar. Additionally, equipotential connections are made to all cables entering or leaving the wind turbine.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements, as well as project requirements, may require additional measures.

4.9 Corrosion Protection

Classification of corrosion protection is according to ISO 12944-2.

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5-M	C3
Hub	C5-M	C3
Tower	C5-I	C3

Table 4-5: Corrosion protection data for nacelle, hub, and tower

5 Safety

The safety specifications in this section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, and (c) conducting all appropriate safety training and education.

5.1 Access

Access to the turbine from the outside is through a door located at the entrance platform approximately 3 meter above ground level. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is controlled with a lock. Unauthorised access to electrical switchboards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

5.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch, from the spinner by opening the nose cone, or from the roof of the nacelle. Rescue equipment is placed in the nacelle.

The hatch in the roof can be opened from both the inside and outside.

Escape from the service lift is by ladder.

An emergency response plan, placed in the turbine, describes evacuation and escape routes.

5.3 Rooms/Working Areas

The tower and nacelle are equipped with power sockets for electrical tools for service and maintenance of the turbine.

5.4 Floors, Platforms, Standing, and Working Places

All floors have anti-slip surfaces.

There is one floor per tower section.

Rest platforms are provided at intervals of 9 metres along the tower ladder between platforms.

Foot supports are placed in the turbine for maintenance and service purposes.

5.5 Service Lift

The turbine is delivered with a service lift installed as an option.

5.6 Climbing Facilities

A ladder with a fall arrest system (rigid rail) is installed through the tower.

There are anchor points in the tower, nacelle and hub, and on the roof for attaching fall arrest equipment (full-body harness).

Over the crane hatch there is an anchor point for the emergency descent equipment.

Anchor points are coloured yellow and are calculated and tested to 22.2 kN.

5.7 Moving Parts, Guards, and Blocking Devices

All moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

Blocking the pitch of the cylinder can be done with mechanical tools in the hub.

5.8 Lights

The turbine is equipped with lights in the tower, nacelle, transformer room, and hub.

There is emergency light in case of the loss of electrical power.

5.9 Emergency Stop

There are emergency stop buttons in the nacelle, hub and bottom of the tower.

5.10 Power Disconnection

The turbine is equipped with breakers to allow for disconnection from all power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and bottom of the tower.

5.11 Fire Protection/First Aid

A handheld 5-6 kg CO_2 fire extinguisher, first aid kit and fire blanket are required to be located in the nacelle during service and maintenance.

- A handheld 5-6 kg CO_2 fire extinguisher is required only during service and maintenance activities, unless a permanently mounted fire extinguisher located in the nacelle is mandatorily required by authorities.
- First aid kits are required only during service and maintenance activities.
- Fire blankets are required only during non-electrical hot work activities.

5.12 Warning Signs

Warning signs placed inside or on the turbine must be reviewed before operating or servicing the turbine.

5.13 Manuals and Warnings

The Vestas Corporate OH&S Manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

6 Environment

6.1 Chemicals

Chemicals used in the turbine are evaluated according to the Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2004. The following chemicals are used in the turbine:

- Anti-freeze to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

7 Approvals and Design Codes

7.1 Type Approvals

The standard turbine is type certified according to the certification standards listed below:

Certification	Wind Class	Hub Height
IEC61400-22	IEC IIA	84 m / 94 m
	IEC IIIA	119 m
DIBt 2012	WZ3, GKII, TKA	140 m
	WZ4, GKI, TKA	94 m /119 m

Table 7-1: Type approvals data

7.2 Design Codes – Structural Design

The turbine design has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes	
Nacelle and Hub	IEC 61400-1 Edition 3 EN 50308
Tower	IEC 61400-1 Edition 3 Eurocode 3
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2
Gearbox	ISO 81400-4

Design Codes	
Generator	IEC 60034
Transformer	IEC 60076-11, IEC 60076-16, CENELEC HD637 S1
Lightning Protection	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006 IEC 61400-24:2010
Rotating Electrical Machines	IEC 34
Safety of Machinery, Safety-related Parts of Control Systems	IEC 13849-1
Safety of Machinery – Electrical Equipment of Machines	IEC 60204-1

Table 7-2: Design codes

8 Colours

8.1 Nacelle Colour

Colour of Vestas Nacelles	
Standard Nacelle Colour	RAL 7035 (light grey)
Standard Logo	Vestas

Table 8-1: Colour, nacelle

8.2 Tower Colour

Colour of Vestas Tower Section		
	External:	**Internal:**
Standard Tower Colour	RAL 7035 (light grey)	RAL 9001 (cream white)

Table 8-2: Colour, tower

8.3 Blade Colour

Blade Colour	
Standard Blade Colour	RAL 7035 (light grey)
Tip-End Colour Variants	RAL 2009 (traffic orange), RAL 3020 (traffic red)
Gloss	< 30% DS/EN ISO 2813

Table 8-3: Colour, blades

9 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

9.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
Wind Climate	**IEC IIA**
Ambient Temperature Interval (Standard Temperature Turbine)	-40° to +50°C
Extreme Wind Speed (10 Minute Average)	42.5 m/s
Survival Wind Speed (3 Second Gust)	59.5 m/s

Table 9-1: Extreme design parameters

Average Design Parameters	
Wind Climate	**IEC IIA**
Wind Speed	8.5 m/s
A-Factor	9.59 m/s
Form Factor, c	2.0
Turbulence Intensity According to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s – 90% quartile)	18%
Wind Shear	0.20
Inflow Angle (vertical)	8°

Table 9-2: Average design parameters

9.1.1 Complex Terrain

Classification of complex terrain according to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex, appropriate measures are to be included in site assessment.

Positioning of each turbine must be verified via the Vestas Site Check programme.

9.1.2 Altitude

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level.

9.1.3 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

NOTE As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters, Vestas must be consulted.

9.2 Operational Envelope – Temperature and Wind

Values refer to hub height and are determined by the sensors and control system of the turbine.

Operational Envelope – Temperature and Wind	
Ambient Temperature Interval (Standard Turbine)	-20° to +45°C
Ambient Temperature Interval (Low Temperature Turbine)	-30° to +45°C
Cut-In	3 m/s
Cut-Out (10 Minute Exponential Average)	25 m/s
Re-Cut In (10 Minute Exponential Average)	23 m/s

Table 9-3: Operational envelope - temperature and wind

NOTE At ambient temperatures above +25/30°C, the turbine will maintain derated production, within the component capacity as seen in figure 9-1 and figure 9-2.

The wind turbine will stop producing power at ambient temperatures above 45°C.

For the low temperature options of the wind turbine, consult Vestas.

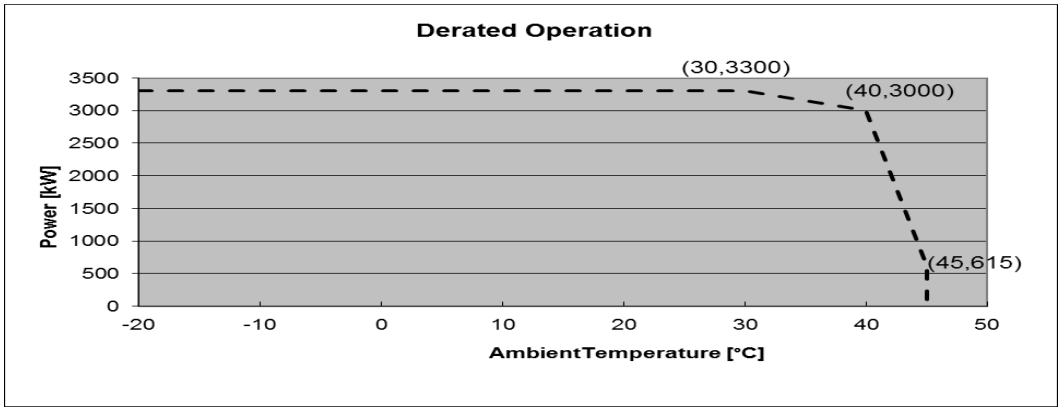

Figure 9-1: Derated Operation for 3.3 MW rating

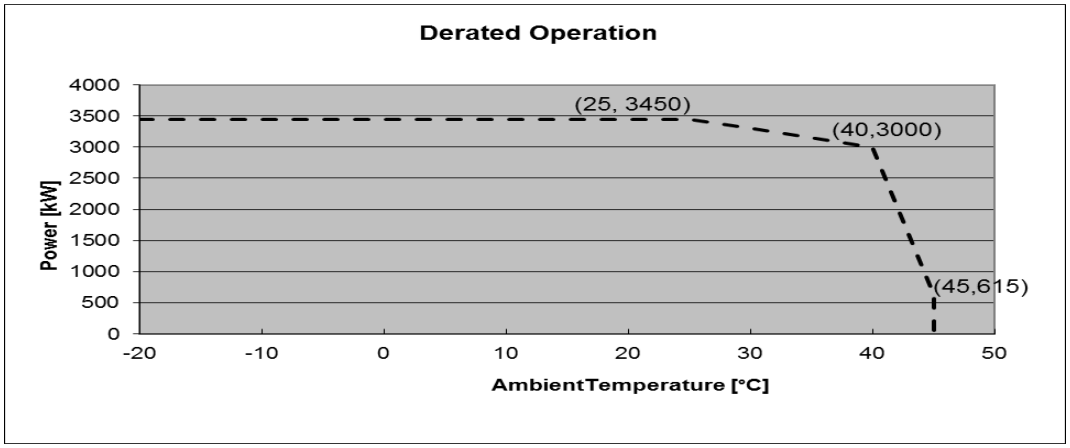

Figure 9-2: Derated Operation for 3.45 MW rating

9.3 Operational Envelope – Grid Connection

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	650 V
Nominal Frequency	[f_N]	50/60 Hz
Maximum Frequency Gradient	±4 Hz/sec.	
Maximum Negative Sequence Voltage	3% (connection) 2% (operation)	
Minimum Required Short Circuit Ratio at Turbine HV Connection	5.0	
Maximum Short Circuit Current Contribution	1.05 p.u. (continuous) 1.45 p.u. (peak)	

Table 9-4: Operational envelope – grid connection

The generator and the converter will be disconnected if*:

Protection Settings	
Voltage Above 110% of Nominal for 3600 Seconds**	715 V
Voltage Above 121% of Nominal for 2 Seconds	787 V
Voltage Above 136% of Nominal for 0.150 Seconds	884 V
Voltage Below 90% of Nominal for 60 Seconds**	585 V
Voltage Below 80% of Nominal for 10 Seconds	520 V
Frequency is Above 106% of Nominal for 0.2 Seconds	53/63.6 Hz
Frequency is Below 94% of Nominal for 0.2 Seconds	47/56.4 Hz

Table 9-5: Generator and converter disconnecting values

NOTE * Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

** The turbine may be configured for continuous operation @ +/- 13 % voltage. Reactive power capability is limited for these widened settings (See section 9.4).

9.4 Operational Envelope – Reactive Power Capability

The 3.3 MW turbine has a reactive power capability as illustrated Figure 9-3:

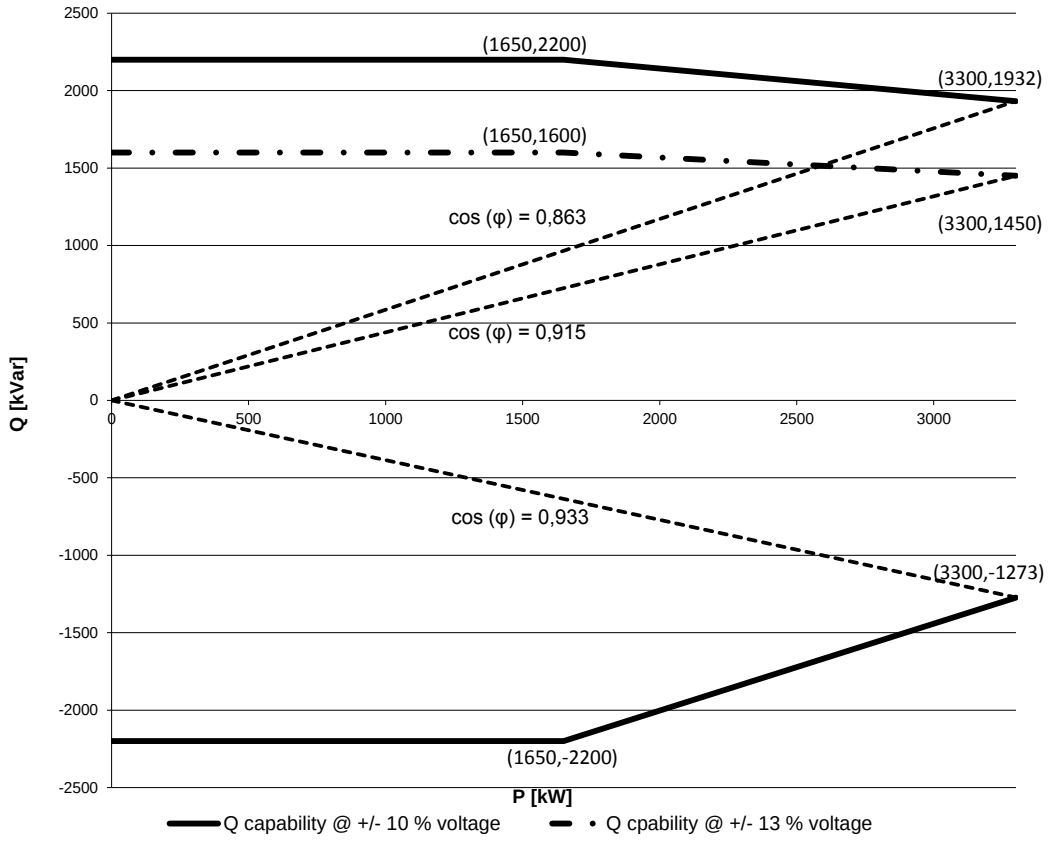

Figure 9-3: Reactive power capability

Reactive power capability at full load on high voltage side of the HV transformer is approximately: cosφ = 0.90/0.88 capacitive/inductive @ +/- 10 % voltage and 0.95/0.88 capacitive/inductive @ +/- 13 % voltage.

The 3.45 MW turbine has a reactive power capability as illustrated in Figure 9-4.:

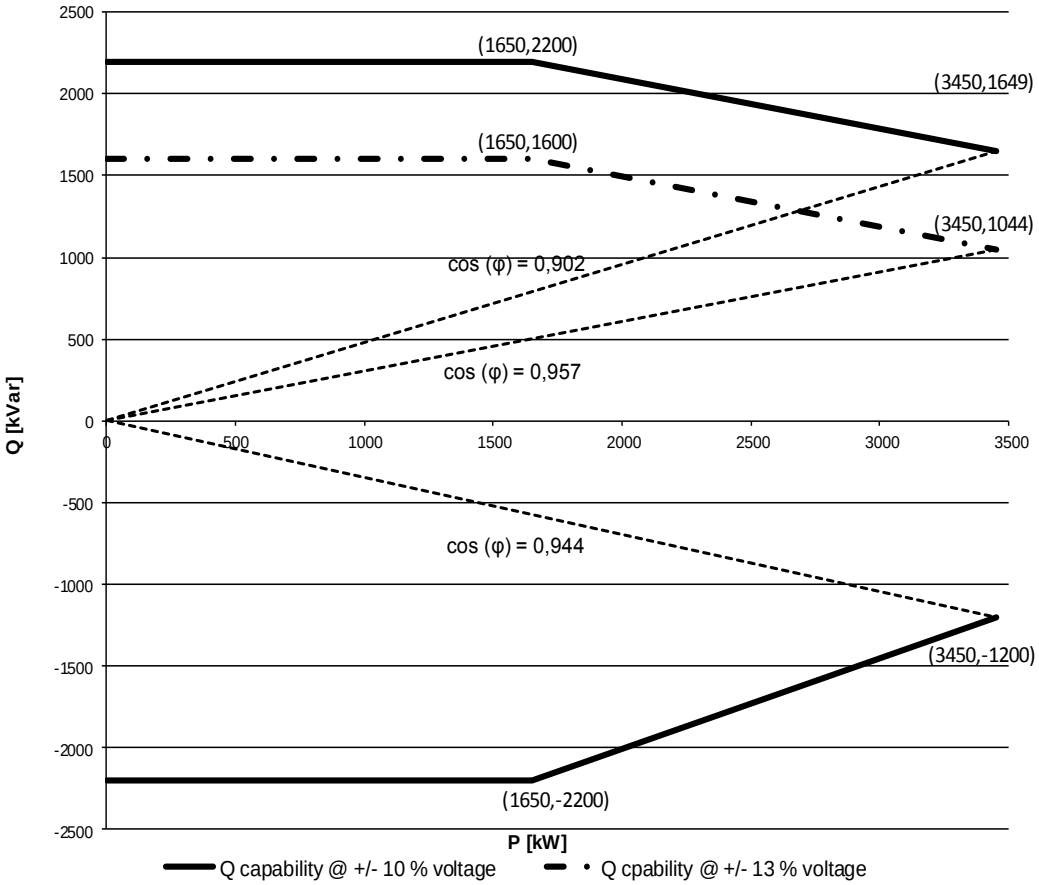

Figure 9-4: Reactive power capability for 3.45 MW rating

Reactive power capability at full load on high voltage side of the HV transformer is approximately: cosφ = 0.93/0.92 capacitive/inductive @ +/- 10 % voltage and 0.98/0.92 capacitive/inductive @ +/- 13 % voltage.

Reactive power is produced by the full-scale converter. Traditional capacitors are, therefore, not used in the turbine.

The turbine is able to maintain the reactive power capability at low wind with no active power production.

9.5 Performance – Fault Ride Through

The turbine is equipped with a full-scale converter to gain better control of the wind turbine during grid faults. The turbine control system continues to run during grid faults.

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve as illustrated:

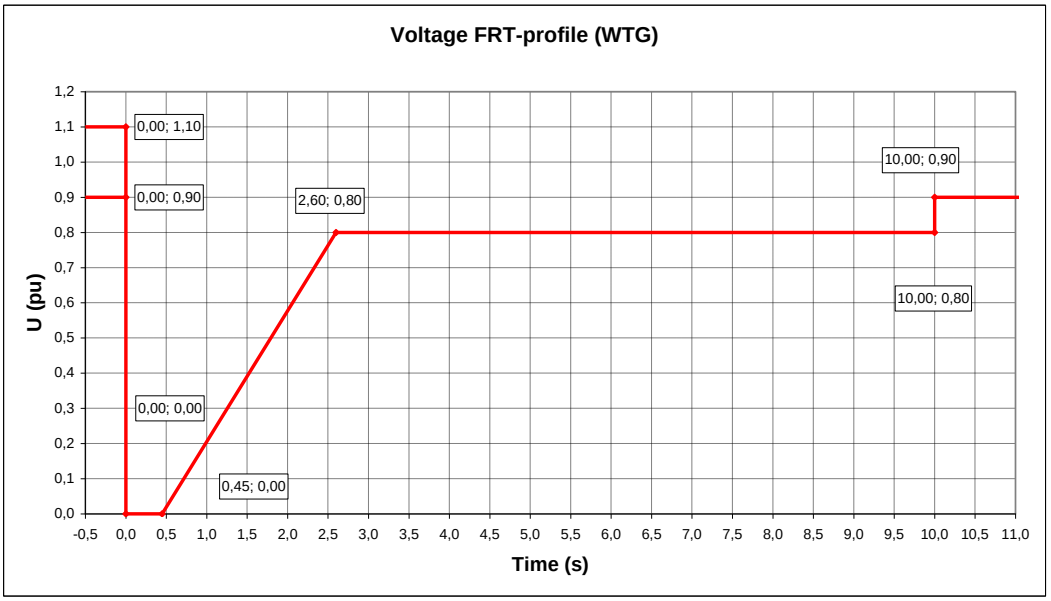

Figure 9-5: Low voltage tolerance curve for symmetrical and asymmetrical faults, where U represents voltage as measured on the grid

For grid disturbances outside the tolerance curve in Figure 9-5, the turbine will be disconnected from the grid.

Power Recovery Time	
Power Recovery to 90% of Pre-Fault Level	Maximum 0.1 seconds

Table 9-6: Power recovery time

9.6 Performance – Reactive Current Contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

9.6.1 Symmetrical Reactive Current Contribution

During symmetrical voltage dips, the wind farm will inject reactive current to support the grid voltage. The reactive current injected is a function of the measured grid voltage.

The default value gives a reactive current part of 1 pu of the rated active current at the high voltage side of the HV transformer. Figure 9-6, indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level.

As seen in Figure 9-5, the default current injection slope is 2% reactive current increase per 1% voltage decrease. The slope can be parameterized between 0 and 10 to adapt to site specific requirements.

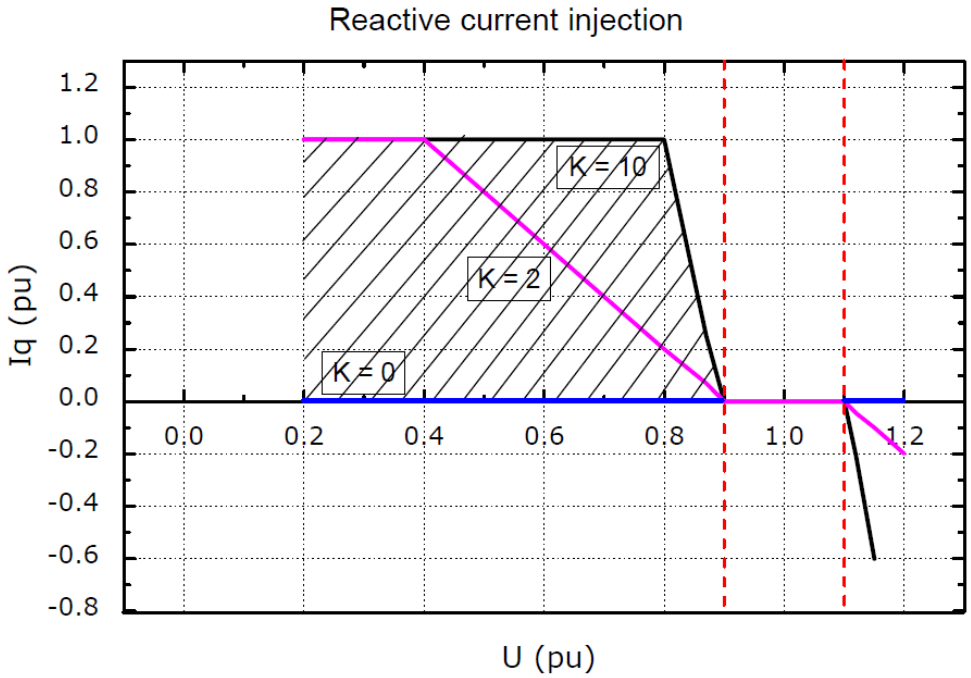

Figure 9-6: Reactive current injection

9.6.2 Asymmetrical Reactive Current Contribution

The injected current is based on the measured positive sequence voltage and the used K-factor. During asymmetrical voltage dips, the reactive current injection is limited to approximate 0.4 pu to limit the potential voltage increase on the healthy phases.

9.7 Performance – Multiple Voltage Dips

The turbine is designed to handle re-closure events and multiple voltage dips within a short period of time due to the fact that voltage dips are not evenly distributed during the year. For example, the turbine is designed to handle 10 voltage dips of duration of 200 ms, down to 20% voltage, within 30 minutes.

9.8 Performance – Active and Reactive Power Control

The turbine is designed for control of active and reactive power via the VestasOnline® SCADA system.

Maximum Ramp Rates for External Control	
Active Power	0.1 pu/sec (330 kW/sec) for max. power level change of 0.3 pu (990 kW) 0.3 pu/sec (990 kW/sec) for max. power level change of 0.1 pu (330 kW)
Reactive Power	20 pu/sec (66 MVAr/sec)

Table 9-7: Active/reactive power ramp rates

To support grid stability the turbine is capable to stay connected to the grid at active power references down to 10 % of nominal power for the turbine. For active power references below 10 % the turbine may disconnect from the grid.

9.9 Performance – Voltage Control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

9.10 Performance – Frequency Control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency).

Dead band and slope for the frequency control function are configurable.

9.11 Main Contributors to Own Consumption

The consumption of electrical power by the wind turbine is defined as the power used by the wind turbine when it is not providing energy to the grid. This is defined in the control system as Production Generator 0 (zero).The following components have the largest influence on the own consumption of the wind turbine (the average own consumption depends on the actual conditions, the climate, the wind turbine output, the cut-off hours, etc.):

Main contributors to Own Consumption	
Hydraulic Motor	2 x 15 kW (master/slave)
Yaw Motors	Maximum 18 kW in total
Water Heating	10 kW
Water Pumps	2.2 + 5.5 kW
Oil Heating	7.9 kW
Oil Pump for Gearbox Lubrication	10 kW
Controller Including Heating Elements for the Hydraulics and all Controllers	Approximately 3 kW
HV Transformer No-load Loss	See section 3.3 HV Transformer, p. 13

Table 9-8: Main contributors to own consumption data

9.12 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Consult section 12 Appendices, p. 42 for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear	0.00-0.30 (10 minute average)
Turbulence Intensity	6-12% (10 minute average)
Blades	Clean
Rain	No

Conditions for Power Curve and C_t Values (at Hub Height)	
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Frequency	Nominal Frequency ±0.5 Hz

Table 9-9: Conditions for power curve and Ct values

9.13 Noise Modes

The noise/power modes listed below are available for the V112 turbine.

Available Noise Modes for V112-3.3 MW		
Mode No.	**Maximum Noise Level**	**Standard/Option**
0	105.8 dB	Standard
	104.4 dB	Option
2	104.5 dB	Standard
	103.2 dB	Option
3	102.3 dB	Standard
	101.3 dB	Option
4	100.9 dB	Standard
	100.0 dB	Option
5	104.2 dB	Standard
	103.1 dB	Option
8	99.4 dB	Standard
	98.1 dB	Option
Available Power Modes V112		
3.45 MW	105.8 dB	Standard
	104.4 dB	Option

Table 9-10: Available noise modes

NOTE All optional noise reduced operational modes requires special blade configuration with serrated trailing edge.

The noise modes are available for the hub heights listed in table tower structure data in section 2.14 Towers, p. 10, except for noise mode 4 which is not available for hub height 119 m (DIBt).

For further details on Noise Modes, see section 12 Appendices p. 42, or contact Vestas Wind Systems A/S.

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

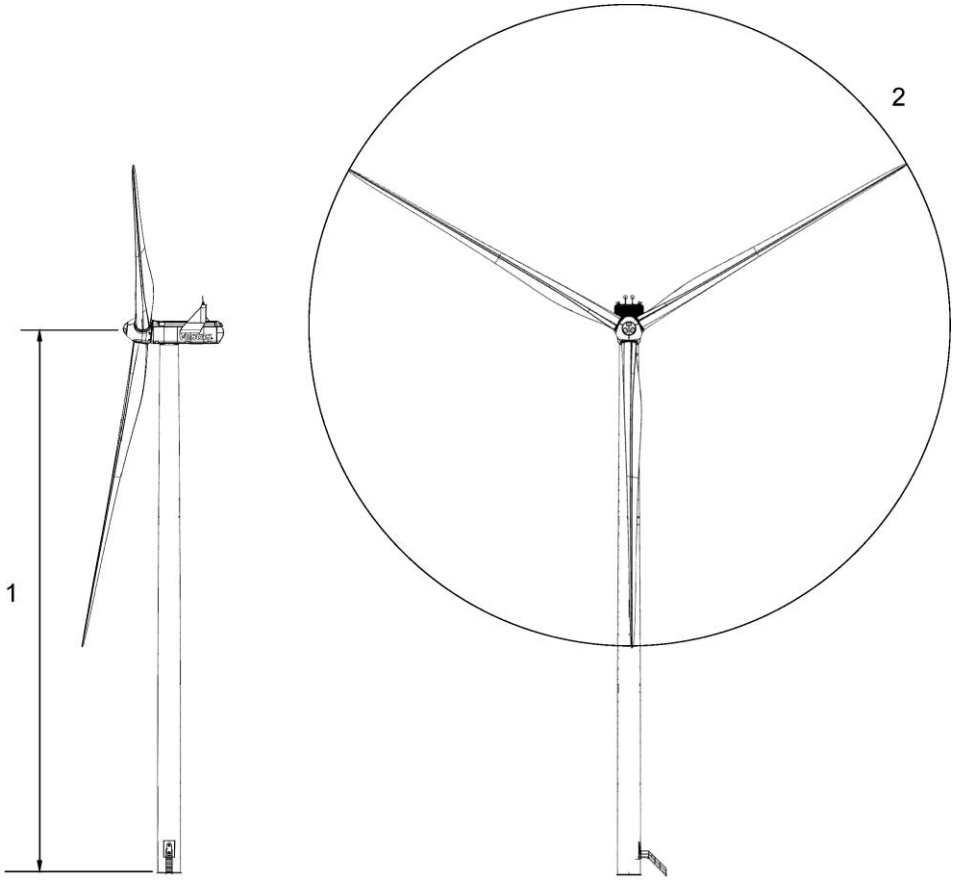

Figure 10-1: Illustration of outer dimensions – structure

1 Hub height 84/94/119/140 m

2 Diameter: 112 m

10.2 Structural Design – Side View Drawing

Figure 10-2: Side-view drawing

11 General Reservations, Notes and Disclaimers

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- The general specifications described in this document apply to the current version of the V112-3.3/3.45 MW wind turbine. Updated versions of the V112-3.3/3.45 MW wind turbine, which may be manufactured in the future, may differ from these general specifications. In the event that Vestas supplies an updated version of the V112-3.3/3.45 MW wind turbine, Vestas will provide an updated general specification applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with limited variation in frequency and voltage.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- All listed start/stop parameters (e. g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements and codes of standards.

- This document, General Specification, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

12 Appendices

12.1 Mode 0

12.1.1 Power Curves, Noise Mode 0

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	17	19	20	23	25
3.5	**73**	44	47	50	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**209**	151	156	161	167	172	177	183	188	193	198	204	214	220
5.0	**302**	222	229	237	244	251	258	266	273	280	287	295	309	316
5.5	**415**	309	318	328	338	347	357	367	376	386	396	405	425	434
6.0	**552**	414	427	440	452	465	477	490	502	515	527	540	565	577
6.5	**714**	540	556	572	587	603	619	635	651	667	683	699	730	746
7.0	**906**	688	708	728	748	767	787	807	827	847	866	886	925	945
7.5	**1123**	857	881	905	930	954	978	1002	1027	1051	1075	1099	1147	1171
8.0	**1370**	1049	1078	1107	1137	1166	1195	1225	1254	1283	1312	1341	1399	1428
8.5	**1648**	1264	1300	1335	1370	1405	1440	1475	1509	1544	1579	1613	1682	1716
9.0	**1950**	1502	1544	1585	1626	1667	1708	1748	1789	1830	1870	1910	1990	2030
9.5	**2268**	1756	1804	1851	1898	1946	1992	2039	2085	2131	2177	2222	2313	2357
10.0	**2586**	2022	2075	2128	2181	2234	2286	2337	2389	2440	2489	2537	2631	2677
10.5	**2868**	2284	2342	2400	2459	2517	2570	2624	2677	2731	2777	2822	2907	2946
11.0	**3071**	2526	2586	2646	2706	2766	2815	2864	2913	2963	2999	3035	3098	3126
11.5	**3201**	2741	2799	2856	2914	2972	3011	3050	3090	3129	3153	3177	3217	3233
12.0	**3266**	2923	2972	3021	3071	3120	3147	3173	3200	3227	3240	3253	3273	3280
12.5	**3291**	3064	3101	3138	3175	3212	3228	3243	3258	3273	3279	3285	3293	3296
13.0	**3298**	3164	3188	3212	3236	3260	3268	3276	3284	3291	3293	3296	3298	3299
13.5	**3299**	3219	3234	3249	3263	3278	3282	3287	3291	3295	3297	3298	3299	3300
14.0	**3300**	3256	3265	3273	3282	3290	3292	3294	3296	3299	3299	3300	3300	3300
14.5	**3300**	3276	3281	3286	3291	3296	3297	3298	3299	3300	3300	3300	3300	3300
15.0	**3300**	3288	3291	3293	3296	3298	3299	3299	3299	3300	3300	3300	3300	3300
15.5	**3300**	3294	3295	3296	3298	3299	3299	3299	3300	3300	3300	3300	3300	3300
16.0	**3300**	3296	3297	3298	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
16.5	**3300**	3298	3298	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.0	**3300**	3299	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
25.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300

Table 12-1: Power curve, noise mode 0

12.1.2 Ct Values, Noise Mode 0

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.904	0.904	0.903
3.5	**0.857**	0.860	0.860	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.856
4.0	**0.828**	0.831	0.831	0.830	0.830	0.830	0.830	0.829	0.829	0.829	0.829	0.828	0.828	0.828
4.5	**0.819**	0.822	0.822	0.822	0.821	0.821	0.821	0.820	0.820	0.820	0.819	0.819	0.818	0.818
5.0	**0.814**	0.818	0.818	0.818	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.814
5.5	**0.812**	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.813	0.813	0.812	0.811
6.0	**0.807**	0.814	0.813	0.812	0.812	0.811	0.811	0.810	0.810	0.809	0.808	0.808	0.807	0.806
6.5	**0.802**	0.809	0.809	0.808	0.807	0.807	0.806	0.805	0.805	0.804	0.803	0.802	0.801	0.800
7.0	**0.795**	0.804	0.803	0.803	0.802	0.801	0.800	0.799	0.798	0.797	0.797	0.796	0.794	0.793
7.5	**0.788**	0.799	0.798	0.797	0.796	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.787	0.786
8.0	**0.781**	0.794	0.793	0.792	0.790	0.789	0.788	0.787	0.786	0.785	0.783	0.782	0.780	0.779
8.5	**0.773**	0.788	0.786	0.785	0.784	0.783	0.781	0.780	0.779	0.777	0.776	0.775	0.772	0.771
9.0	**0.763**	0.778	0.777	0.775	0.774	0.773	0.771	0.770	0.769	0.767	0.766	0.764	0.762	0.760
9.5	**0.745**	0.763	0.762	0.760	0.759	0.758	0.756	0.754	0.753	0.751	0.749	0.747	0.742	0.740
10.0	**0.711**	0.739	0.738	0.736	0.734	0.733	0.730	0.728	0.725	0.722	0.719	0.715	0.706	0.702
10.5	**0.657**	0.702	0.700	0.698	0.695	0.693	0.689	0.685	0.681	0.676	0.670	0.664	0.649	0.641
11.0	**0.587**	0.652	0.648	0.645	0.642	0.638	0.632	0.626	0.620	0.613	0.605	0.596	0.577	0.567
11.5	**0.514**	0.598	0.593	0.588	0.583	0.578	0.570	0.561	0.553	0.545	0.534	0.524	0.503	0.492
12.0	**0.445**	0.543	0.536	0.529	0.522	0.516	0.506	0.496	0.486	0.476	0.466	0.455	0.435	0.425
12.5	**0.385**	0.489	0.480	0.472	0.463	0.455	0.445	0.435	0.424	0.414	0.404	0.395	0.376	0.367
13.0	**0.335**	0.437	0.427	0.418	0.409	0.399	0.390	0.380	0.370	0.361	0.352	0.344	0.328	0.320
13.5	**0.296**	0.389	0.380	0.371	0.362	0.352	0.344	0.335	0.327	0.318	0.311	0.304	0.290	0.283
14.0	**0.263**	0.346	0.338	0.329	0.320	0.311	0.304	0.297	0.289	0.282	0.275	0.269	0.257	0.251
14.5	**0.234**	0.309	0.301	0.293	0.285	0.277	0.270	0.264	0.257	0.251	0.245	0.240	0.229	0.224
15.0	**0.209**	0.275	0.268	0.261	0.254	0.246	0.241	0.235	0.229	0.223	0.219	0.214	0.205	0.201
15.5	**0.189**	0.247	0.241	0.234	0.228	0.222	0.217	0.212	0.207	0.201	0.197	0.193	0.185	0.181
16.0	**0.171**	0.223	0.217	0.212	0.206	0.200	0.196	0.191	0.187	0.182	0.179	0.175	0.168	0.164
16.5	**0.156**	0.202	0.197	0.192	0.187	0.182	0.178	0.174	0.170	0.166	0.163	0.159	0.153	0.150
17.0	**0.142**	0.184	0.180	0.175	0.171	0.166	0.162	0.159	0.155	0.152	0.148	0.145	0.140	0.137
17.5	**0.131**	0.168	0.164	0.160	0.156	0.152	0.149	0.146	0.142	0.139	0.136	0.133	0.128	0.126
18.0	**0.120**	0.154	0.151	0.147	0.143	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.118	0.116
18.5	**0.111**	0.142	0.139	0.135	0.132	0.129	0.126	0.123	0.121	0.118	0.116	0.113	0.109	0.107
19.0	**0.102**	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.108	0.106	0.104	0.100	0.098
19.5	**0.095**	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.100	0.099	0.097	0.093	0.091
20.0	**0.088**	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.095	0.093	0.092	0.090	0.087	0.085
20.5	**0.082**	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.081	0.079
21.0	**0.077**	0.097	0.095	0.093	0.091	0.088	0.087	0.085	0.083	0.081	0.080	0.078	0.075	0.074
21.5	**0.072**	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.0	**0.068**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.066
22.5	**0.064**	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
23.0	**0.060**	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
23.5	**0.056**	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.0	**0.053**	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
24.5	**0.050**	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
25.0	**0.048**	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046

Table 12-2: C_t values, noise mode 0

12.1.3 Noise Curves, Noise Mode 0

Sound Power Level at Hub Height, Noise Mode 0		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.9	91.5
5	94.1	93.4
6	97.3	96.3
7	100.6	99.5
8	103.4	102.3
9	105.1	103.9
10	105.8	104.4
11	105.8	104.4
12	105.8	104.4
13	105.8	104.4
14	105.8	104.4
15	105.8	104.4
16	105.8	104.4
17	105.8	104.4
18	105.8	104.4
19	105.8	104.4
20	105.8	104.4

Table 12-3: Noise curves, noise mode 0

12.2 Mode 2

12.2.1 Power Curves, Noise Mode 2

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	18	19	20	23	25
3.5	**73**	44	47	50	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**209**	151	156	161	167	172	177	183	188	193	198	204	214	219
5.0	**302**	222	229	237	244	251	258	266	273	280	287	295	309	316
5.5	**415**	309	318	328	338	347	357	367	376	386	395	405	424	434
6.0	**552**	414	427	439	452	464	477	489	502	514	527	539	564	577
6.5	**713**	539	555	571	587	603	619	635	650	666	682	698	729	745
7.0	**904**	687	707	727	746	766	786	806	825	845	865	884	924	943
7.5	**1120**	855	879	903	928	952	976	1000	1024	1048	1072	1096	1144	1168
8.0	**1362**	1044	1073	1102	1131	1160	1188	1217	1246	1275	1304	1333	1390	1419
8.5	**1626**	1250	1285	1319	1353	1388	1422	1456	1490	1524	1558	1592	1660	1693
9.0	**1907**	1472	1512	1552	1592	1632	1672	1711	1751	1790	1829	1868	1945	1984
9.5	**2191**	1700	1745	1791	1836	1881	1926	1970	2015	2059	2103	2147	2235	2278
10.0	**2464**	1921	1971	2021	2071	2122	2171	2220	2270	2319	2368	2416	2511	2558
10.5	**2697**	2114	2169	2223	2277	2332	2385	2438	2492	2545	2596	2646	2744	2791
11.0	**2870**	2272	2330	2388	2445	2503	2557	2612	2667	2721	2771	2820	2912	2954
11.5	**3005**	2416	2476	2536	2595	2655	2710	2764	2818	2873	2917	2961	3040	3074
12.0	**3106**	2557	2617	2677	2737	2797	2847	2896	2946	2995	3032	3069	3131	3156
12.5	**3185**	2707	2764	2821	2879	2936	2978	3021	3063	3106	3132	3158	3201	3217
13.0	**3241**	2860	2911	2962	3013	3064	3096	3128	3160	3193	3209	3225	3250	3258
13.5	**3270**	3002	3042	3082	3121	3161	3181	3201	3220	3240	3250	3260	3275	3280
14.0	**3286**	3114	3141	3168	3195	3223	3235	3247	3259	3272	3276	3281	3288	3291
14.5	**3294**	3189	3207	3225	3243	3261	3268	3274	3281	3287	3289	3292	3295	3296
15.0	**3298**	3240	3251	3261	3272	3282	3285	3288	3292	3295	3296	3297	3298	3298
15.5	**3299**	3268	3274	3280	3286	3292	3293	3295	3296	3298	3298	3299	3299	3299
16.0	**3300**	3284	3287	3290	3293	3297	3297	3298	3299	3299	3299	3300	3300	3300
16.5	**3300**	3292	3294	3295	3297	3298	3299	3299	3299	3300	3300	3300	3300	3300
17.0	**3300**	3296	3297	3298	3299	3299	3299	3300	3300	3300	3300	3300	3300	3300
17.5	**3300**	3297	3297	3298	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300
18.0	**3300**	3298	3299	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.5	**3300**	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
25.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300

Table 12-4: Power curve, noise mode 2

12.2.2 C_t Values, Noise Mode 2

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.905	0.904	0.904	0.903
3.5	**0.856**	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.857	0.856	0.856
4.0	**0.826**	0.828	0.828	0.828	0.828	0.827	0.827	0.827	0.827	0.826	0.826	0.826	0.825	0.825
4.5	**0.811**	0.814	0.814	0.814	0.813	0.813	0.813	0.812	0.812	0.812	0.812	0.811	0.810	0.810
5.0	**0.807**	0.813	0.812	0.811	0.811	0.810	0.810	0.809	0.809	0.809	0.808	0.807	0.806	0.806
5.5	**0.804**	0.811	0.810	0.810	0.810	0.809	0.808	0.808	0.807	0.806	0.806	0.805	0.804	0.804
6.0	**0.801**	0.808	0.807	0.807	0.806	0.806	0.804	0.803	0.802	0.801	0.801	0.801	0.800	0.800
6.5	**0.794**	0.803	0.802	0.801	0.800	0.798	0.798	0.798	0.798	0.797	0.796	0.795	0.793	0.792
7.0	**0.784**	0.793	0.792	0.792	0.791	0.791	0.790	0.789	0.788	0.787	0.786	0.785	0.783	0.783
7.5	**0.775**	0.785	0.785	0.784	0.783	0.782	0.781	0.780	0.779	0.778	0.777	0.776	0.774	0.773
8.0	**0.759**	0.770	0.769	0.769	0.768	0.767	0.766	0.765	0.763	0.762	0.761	0.760	0.758	0.757
8.5	**0.739**	0.751	0.750	0.749	0.748	0.747	0.746	0.745	0.744	0.743	0.741	0.740	0.738	0.737
9.0	**0.715**	0.727	0.726	0.725	0.724	0.722	0.721	0.720	0.719	0.718	0.717	0.716	0.713	0.712
9.5	**0.684**	0.696	0.695	0.694	0.693	0.692	0.691	0.690	0.688	0.687	0.686	0.685	0.683	0.682
10.0	**0.643**	0.655	0.654	0.653	0.652	0.651	0.650	0.649	0.648	0.647	0.645	0.644	0.641	0.640
10.5	**0.588**	0.602	0.601	0.600	0.599	0.598	0.597	0.596	0.594	0.593	0.592	0.590	0.586	0.583
11.0	**0.526**	0.542	0.541	0.541	0.540	0.539	0.537	0.536	0.534	0.533	0.531	0.528	0.522	0.518
11.5	**0.466**	0.489	0.488	0.487	0.486	0.485	0.483	0.481	0.479	0.477	0.473	0.470	0.461	0.456
12.0	**0.413**	0.443	0.442	0.440	0.439	0.438	0.435	0.432	0.429	0.426	0.422	0.417	0.407	0.401
12.5	**0.367**	0.407	0.405	0.403	0.401	0.399	0.395	0.391	0.387	0.383	0.378	0.372	0.361	0.354
13.0	**0.327**	0.378	0.374	0.371	0.368	0.365	0.360	0.355	0.350	0.345	0.339	0.333	0.321	0.314
13.5	**0.292**	0.352	0.347	0.343	0.338	0.334	0.328	0.322	0.316	0.310	0.304	0.298	0.287	0.281
14.0	**0.261**	0.324	0.319	0.313	0.307	0.302	0.296	0.290	0.284	0.278	0.272	0.267	0.256	0.250
14.5	**0.234**	0.297	0.291	0.285	0.279	0.273	0.267	0.261	0.255	0.249	0.244	0.239	0.229	0.224
15.0	**0.209**	0.269	0.263	0.257	0.251	0.245	0.239	0.234	0.228	0.223	0.218	0.214	0.205	0.200
15.5	**0.189**	0.244	0.238	0.233	0.227	0.221	0.216	0.211	0.206	0.201	0.197	0.193	0.185	0.181
16.0	**0.171**	0.222	0.216	0.211	0.206	0.200	0.196	0.191	0.187	0.182	0.179	0.175	0.168	0.164
16.5	**0.156**	0.202	0.197	0.192	0.187	0.182	0.178	0.174	0.170	0.166	0.163	0.159	0.153	0.150
17.0	**0.142**	0.184	0.180	0.175	0.171	0.166	0.162	0.159	0.155	0.152	0.148	0.145	0.140	0.137
17.5	**0.131**	0.168	0.164	0.160	0.156	0.152	0.149	0.145	0.142	0.139	0.136	0.133	0.128	0.126
18.0	**0.120**	0.154	0.151	0.147	0.143	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.118	0.116
18.5	**0.111**	0.142	0.139	0.135	0.132	0.129	0.126	0.123	0.121	0.118	0.116	0.113	0.109	0.107
19.0	**0.102**	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.108	0.106	0.104	0.100	0.098
19.5	**0.095**	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.100	0.099	0.097	0.093	0.091
20.0	**0.088**	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.095	0.093	0.092	0.090	0.087	0.085
20.5	**0.082**	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.081	0.079
21.0	**0.077**	0.097	0.095	0.093	0.091	0.088	0.087	0.085	0.083	0.081	0.080	0.078	0.075	0.074
21.5	**0.072**	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.0	**0.068**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.066
22.5	**0.064**	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
23.0	**0.060**	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
23.5	**0.056**	0.071	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.0	**0.053**	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
24.5	**0.050**	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
25.0	**0.048**	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046

Table 12-5: C_t values, noise mode 2

12.2.3 Noise Curves, Noise Mode 2

Sound Power Level at Hub Height, Noise Mode 2		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.8	91.5
5	94.0	93.3
6	97.2	96.2
7	100.3	99.1
8	102.7	101.5
9	104.0	102.7
10	104.5	103.2
11	104.5	103.2
12	104.5	103.2
13	104.5	103.2
14	104.5	103.2
15	104.5	103.2
16	104.5	103.2
17	104.5	103.2
18	104.5	103.2
19	104.5	103.2
20	104.5	103.2

Table 12-6: Noise curves, noise mode 2

12.3 MW Mode 3

12.3.1 Power Curves, Noise Mode 3

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	18	19	20	23	25
3.5	**73**	44	47	50	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**209**	151	156	161	167	172	177	183	188	193	198	204	214	219
5.0	**302**	222	229	237	244	251	258	266	273	280	287	295	309	316
5.5	**415**	309	318	328	338	347	357	367	376	386	396	405	425	434
6.0	**552**	414	427	439	452	464	477	490	502	515	527	540	565	577
6.5	**714**	539	555	571	587	603	619	635	651	666	682	698	730	745
7.0	**903**	686	706	726	746	765	785	805	825	844	864	884	923	942
7.5	**1109**	847	871	895	919	943	967	990	1014	1038	1061	1085	1132	1156
8.0	**1330**	1021	1049	1078	1106	1134	1162	1190	1218	1246	1275	1303	1358	1386
8.5	**1564**	1205	1238	1271	1303	1336	1369	1401	1434	1466	1499	1531	1596	1628
9.0	**1795**	1388	1426	1463	1500	1537	1574	1611	1648	1685	1722	1758	1831	1867
9.5	**2015**	1564	1606	1647	1689	1730	1771	1812	1853	1894	1934	1974	2055	2095
10.0	**2219**	1730	1775	1820	1865	1911	1955	1999	2044	2088	2132	2175	2261	2303
10.5	**2416**	1896	1945	1994	2043	2092	2139	2186	2234	2281	2326	2371	2457	2499
11.0	**2593**	2074	2126	2178	2230	2282	2329	2376	2423	2470	2511	2552	2628	2663
11.5	**2749**	2253	2307	2361	2415	2469	2513	2558	2603	2647	2681	2715	2774	2799
12.0	**2864**	2433	2486	2538	2591	2644	2682	2720	2758	2796	2819	2841	2879	2894
12.5	**2944**	2606	2654	2701	2749	2797	2824	2851	2879	2906	2919	2932	2951	2958
13.0	**3004**	2766	2804	2842	2880	2919	2935	2952	2969	2986	2992	2998	3007	3010
13.5	**3056**	2909	2934	2959	2983	3008	3018	3027	3037	3046	3050	3053	3058	3060
14.0	**3099**	3010	3025	3042	3058	3074	3079	3084	3089	3094	3095	3097	3100	3100
14.5	**3129**	3077	3086	3096	3106	3116	3118	3121	3124	3126	3127	3128	3129	3129
15.0	**3145**	3118	3123	3129	3134	3140	3141	3142	3143	3144	3145	3145	3145	3146
15.5	**3158**	3142	3145	3148	3152	3155	3156	3156	3157	3158	3158	3158	3158	3158
16.0	**3166**	3156	3158	3160	3162	3164	3165	3165	3166	3166	3166	3166	3166	3166
16.5	**3172**	3165	3166	3168	3169	3170	3171	3171	3171	3171	3171	3171	3171	3172
17.0	**3175**	3171	3172	3172	3173	3174	3174	3174	3174	3175	3175	3175	3175	3175
17.5	**3177**	3172	3173	3174	3175	3176	3176	3176	3176	3177	3177	3177	3177	3177
18.0	**3178**	3174	3175	3176	3176	3177	3177	3177	3177	3178	3178	3178	3178	3178
18.5	**3178**	3175	3176	3176	3177	3178	3178	3178	3178	3178	3178	3178	3178	3178
19.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
19.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
20.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
20.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
21.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
21.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
22.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
22.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
23.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
23.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
24.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
24.5	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178
25.0	**3178**	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178	3178

Table 12-7: Power curve, noise mode 3

12.3.2 C_t Values, Noise Mode 3

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.904	0.904	0.903
3.5	**0.857**	0.860	0.860	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.856
4.0	**0.828**	0.830	0.830	0.830	0.829	0.829	0.829	0.829	0.828	0.828	0.828	0.828	0.827	0.827
4.5	**0.817**	0.821	0.820	0.820	0.820	0.820	0.819	0.819	0.819	0.818	0.818	0.818	0.817	0.817
5.0	**0.814**	0.818	0.818	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.813	0.813
5.5	**0.813**	0.817	0.817	0.816	0.816	0.816	0.815	0.815	0.814	0.814	0.813	0.813	0.812	0.812
6.0	**0.808**	0.814	0.813	0.813	0.812	0.812	0.811	0.811	0.810	0.809	0.809	0.808	0.807	0.807
6.5	**0.802**	0.810	0.809	0.808	0.808	0.807	0.806	0.806	0.805	0.804	0.803	0.803	0.801	0.801
7.0	**0.788**	0.796	0.796	0.795	0.794	0.793	0.793	0.792	0.791	0.790	0.789	0.789	0.787	0.786
7.5	**0.756**	0.765	0.764	0.764	0.763	0.762	0.761	0.760	0.759	0.759	0.758	0.757	0.755	0.754
8.0	**0.717**	0.726	0.726	0.725	0.724	0.723	0.722	0.721	0.721	0.720	0.719	0.718	0.716	0.715
8.5	**0.678**	0.687	0.686	0.686	0.685	0.684	0.683	0.682	0.682	0.681	0.680	0.679	0.677	0.676
9.0	**0.636**	0.645	0.644	0.643	0.643	0.642	0.641	0.640	0.639	0.639	0.638	0.637	0.635	0.634
9.5	**0.591**	0.599	0.599	0.598	0.597	0.596	0.596	0.595	0.594	0.593	0.593	0.592	0.590	0.589
10.0	**0.543**	0.551	0.550	0.550	0.549	0.548	0.548	0.547	0.546	0.546	0.545	0.544	0.542	0.541
10.5	**0.500**	0.510	0.509	0.508	0.508	0.507	0.506	0.505	0.505	0.504	0.502	0.501	0.498	0.496
11.0	**0.458**	0.477	0.476	0.475	0.475	0.474	0.472	0.470	0.468	0.467	0.464	0.461	0.454	0.450
11.5	**0.418**	0.449	0.447	0.446	0.445	0.444	0.441	0.438	0.434	0.431	0.427	0.422	0.412	0.407
12.0	**0.376**	0.423	0.420	0.418	0.416	0.414	0.409	0.404	0.400	0.395	0.389	0.383	0.370	0.363
12.5	**0.337**	0.397	0.393	0.389	0.386	0.382	0.376	0.370	0.364	0.357	0.350	0.344	0.330	0.323
13.0	**0.301**	0.370	0.365	0.360	0.354	0.349	0.342	0.335	0.328	0.322	0.315	0.308	0.294	0.288
13.5	**0.271**	0.345	0.338	0.331	0.325	0.318	0.311	0.304	0.297	0.290	0.284	0.278	0.266	0.260
14.0	**0.244**	0.316	0.309	0.302	0.295	0.288	0.281	0.275	0.268	0.262	0.256	0.250	0.239	0.234
14.5	**0.221**	0.287	0.281	0.274	0.267	0.260	0.254	0.248	0.242	0.236	0.231	0.226	0.216	0.211
15.0	**0.198**	0.259	0.253	0.246	0.240	0.234	0.228	0.223	0.217	0.212	0.207	0.203	0.194	0.190
15.5	**0.180**	0.235	0.229	0.223	0.217	0.211	0.207	0.202	0.197	0.192	0.188	0.184	0.176	0.173
16.0	**0.164**	0.213	0.208	0.202	0.197	0.192	0.187	0.183	0.179	0.175	0.171	0.167	0.160	0.157
16.5	**0.149**	0.194	0.189	0.184	0.179	0.175	0.171	0.167	0.163	0.159	0.156	0.153	0.146	0.144
17.0	**0.137**	0.177	0.173	0.168	0.164	0.160	0.156	0.153	0.149	0.146	0.143	0.140	0.134	0.131
17.5	**0.126**	0.162	0.158	0.154	0.150	0.146	0.143	0.140	0.137	0.134	0.131	0.128	0.123	0.121
18.0	**0.116**	0.149	0.145	0.141	0.138	0.134	0.131	0.129	0.126	0.123	0.120	0.118	0.113	0.111
18.5	**0.107**	0.137	0.134	0.130	0.127	0.124	0.121	0.119	0.116	0.113	0.111	0.109	0.105	0.103
19.0	**0.098**	0.126	0.123	0.120	0.117	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.096	0.095
19.5	**0.091**	0.116	0.114	0.111	0.108	0.105	0.103	0.101	0.099	0.097	0.095	0.093	0.089	0.088
20.0	**0.085**	0.108	0.105	0.103	0.100	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.083	0.082
20.5	**0.079**	0.100	0.098	0.096	0.093	0.091	0.089	0.087	0.086	0.084	0.082	0.081	0.078	0.076
21.0	**0.074**	0.094	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.073	0.071
21.5	**0.070**	0.088	0.086	0.084	0.082	0.080	0.079	0.077	0.075	0.074	0.072	0.071	0.068	0.067
22.0	**0.065**	0.082	0.081	0.079	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.067	0.064	0.063
22.5	**0.061**	0.077	0.076	0.074	0.072	0.070	0.069	0.068	0.066	0.065	0.064	0.063	0.060	0.059
23.0	**0.057**	0.072	0.071	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.056	0.055
23.5	**0.054**	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.053	0.052
24.0	**0.051**	0.064	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.050	0.049
24.5	**0.048**	0.060	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047
25.0	**0.046**	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.047	0.045	0.044

Table 12-8: C_t values, noise mode 3

12.3.3 Noise Curves, Noise Mode 3

Sound Power Level at Hub Height, Noise Mode 3		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.8	91.5
5	94.1	93.3
6	97.2	96.2
7	100.1	98.9
8	101.6	100.4
9	102.2	101.0
10	102.3	101.1
11	102.3	101.0
12	102.3	101.0
13	102.3	101.1
14	102.3	101.3
15	102.3	101.3
16	102.3	101.3
17	102.3	101.3
18	102.3	101.3
19	102.3	101.3
20	102.3	101.3

Table 12-9: Noise curves, noise mode 3

12.4 Mode 4

12.4.1 Power Curves, Noise Mode 4

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	18	19	20	23	25
3.5	**73**	44	47	50	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**207**	150	155	160	165	170	176	181	186	191	196	201	212	217
5.0	**293**	216	223	230	237	244	251	258	265	272	279	286	300	307
5.5	**401**	300	309	318	327	336	346	355	364	373	382	392	410	419
6.0	**534**	403	415	427	439	451	463	475	486	498	510	522	546	558
6.5	**693**	525	541	556	571	586	602	617	632	647	663	678	708	723
7.0	**880**	670	689	708	727	746	766	785	804	823	842	861	899	918
7.5	**1085**	830	853	877	900	923	946	969	992	1016	1039	1062	1108	1131
8.0	**1300**	998	1025	1053	1080	1108	1135	1163	1190	1218	1245	1272	1327	1354
8.5	**1508**	1162	1193	1225	1256	1288	1319	1351	1383	1414	1446	1477	1539	1570
9.0	**1700**	1314	1349	1384	1420	1456	1491	1526	1561	1596	1631	1665	1734	1769
9.5	**1879**	1457	1495	1534	1573	1612	1650	1688	1727	1765	1803	1841	1916	1954
10.0	**2044**	1590	1632	1674	1716	1758	1799	1840	1882	1923	1963	2004	2085	2125
10.5	**2201**	1718	1762	1807	1852	1897	1941	1985	2029	2073	2115	2158	2242	2283
11.0	**2350**	1851	1898	1946	1993	2040	2086	2132	2177	2223	2266	2308	2389	2428
11.5	**2496**	1994	2045	2095	2145	2195	2240	2286	2331	2376	2416	2456	2530	2564
12.0	**2630**	2160	2210	2261	2311	2362	2404	2447	2489	2532	2564	2597	2655	2679
12.5	**2744**	2340	2389	2438	2487	2536	2571	2606	2641	2676	2699	2722	2760	2775
13.0	**2821**	2509	2553	2596	2640	2683	2708	2733	2758	2784	2796	2808	2828	2835
13.5	**2863**	2655	2687	2719	2752	2784	2799	2814	2828	2843	2850	2856	2867	2871
14.0	**2893**	2751	2775	2798	2822	2845	2854	2863	2872	2882	2885	2889	2895	2896
14.5	**2910**	2816	2833	2849	2866	2882	2888	2893	2899	2904	2906	2908	2911	2912
15.0	**2920**	2857	2869	2880	2891	2903	2906	2910	2913	2916	2917	2918	2920	2920
15.5	**2926**	2885	2892	2900	2907	2915	2917	2920	2922	2924	2925	2925	2926	2926
16.0	**2929**	2901	2906	2912	2917	2923	2924	2926	2927	2929	2929	2929	2930	2930
16.5	**2932**	2913	2916	2920	2924	2928	2928	2929	2930	2931	2931	2932	2932	2932
17.0	**2933**	2920	2922	2925	2928	2930	2931	2932	2932	2933	2933	2933	2933	2933
17.5	**2934**	2921	2923	2926	2928	2935	2935	2932	2932	2933	2933	2933	2934	2934
18.0	**2934**	2924	2926	2928	2929	2935	2935	2932	2933	2934	2934	2934	2934	2934
18.5	**2934**	2926	2928	2929	2931	2935	2935	2933	2934	2934	2934	2934	2934	2934
19.0	**2934**	2930	2931	2932	2933	2935	2935	2934	2934	2934	2934	2934	2934	2934
19.5	**2934**	2931	2932	2933	2933	2935	2935	2934	2934	2934	2934	2934	2934	2934
20.0	**2935**	2932	2933	2933	2934	2935	2935	2934	2935	2935	2935	2935	2935	2935
20.5	**2935**	2934	2934	2934	2934	2935	2935	2934	2935	2935	2935	2935	2935	2935
21.0	**2935**	2934	2934	2934	2934	2935	2935	2935	2935	2935	2935	2935	2935	2935
21.5	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
22.0	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
22.5	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
23.0	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
23.5	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
24.0	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
24.5	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935
25.0	**2935**	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935	2935

Table 12-10: Power curve, noise mode 4

12.4.2 C_t Values, Noise Mode 4

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.904	0.904	0.903
3.5	**0.857**	0.860	0.860	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.856
4.0	**0.826**	0.829	0.828	0.828	0.828	0.828	0.828	0.827	0.827	0.827	0.827	0.826	0.826	0.826
4.5	**0.788**	0.790	0.790	0.790	0.789	0.789	0.789	0.789	0.789	0.788	0.788	0.788	0.788	0.787
5.0	**0.745**	0.747	0.747	0.747	0.746	0.746	0.746	0.746	0.746	0.745	0.745	0.745	0.744	0.744
5.5	**0.739**	0.741	0.741	0.741	0.740	0.740	0.740	0.740	0.739	0.739	0.739	0.739	0.739	0.738
6.0	**0.744**	0.747	0.747	0.747	0.746	0.746	0.746	0.746	0.745	0.745	0.745	0.744	0.744	0.743
6.5	**0.748**	0.753	0.752	0.752	0.751	0.751	0.751	0.750	0.750	0.750	0.749	0.749	0.748	0.747
7.0	**0.747**	0.752	0.752	0.751	0.751	0.750	0.750	0.749	0.749	0.748	0.748	0.747	0.746	0.746
7.5	**0.732**	0.739	0.738	0.738	0.737	0.736	0.736	0.735	0.735	0.734	0.734	0.733	0.732	0.731
8.0	**0.699**	0.706	0.705	0.705	0.704	0.703	0.703	0.702	0.701	0.701	0.700	0.700	0.698	0.698
8.5	**0.650**	0.656	0.656	0.655	0.655	0.654	0.653	0.653	0.652	0.652	0.651	0.650	0.649	0.648
9.0	**0.593**	0.599	0.599	0.598	0.598	0.597	0.596	0.596	0.595	0.595	0.594	0.593	0.592	0.592
9.5	**0.539**	0.545	0.545	0.544	0.543	0.543	0.542	0.542	0.541	0.541	0.540	0.540	0.539	0.538
10.0	**0.490**	0.495	0.495	0.494	0.494	0.493	0.493	0.492	0.492	0.491	0.491	0.490	0.489	0.488
10.5	**0.445**	0.451	0.450	0.450	0.449	0.449	0.449	0.448	0.448	0.447	0.447	0.446	0.444	0.444
11.0	**0.406**	0.414	0.414	0.413	0.413	0.412	0.412	0.411	0.410	0.410	0.408	0.407	0.404	0.403
11.5	**0.372**	0.385	0.384	0.384	0.383	0.383	0.381	0.380	0.379	0.378	0.376	0.374	0.369	0.366
12.0	**0.340**	0.364	0.363	0.362	0.360	0.359	0.357	0.355	0.352	0.350	0.347	0.343	0.336	0.332
12.5	**0.311**	0.348	0.346	0.344	0.342	0.340	0.336	0.332	0.328	0.325	0.320	0.315	0.306	0.300
13.0	**0.281**	0.330	0.327	0.324	0.321	0.317	0.312	0.307	0.302	0.298	0.292	0.287	0.276	0.270
13.5	**0.253**	0.311	0.307	0.302	0.297	0.292	0.287	0.281	0.275	0.270	0.264	0.259	0.248	0.243
14.0	**0.228**	0.287	0.281	0.276	0.271	0.265	0.260	0.254	0.249	0.243	0.238	0.233	0.223	0.218
14.5	**0.205**	0.262	0.257	0.251	0.246	0.240	0.235	0.230	0.224	0.219	0.214	0.210	0.201	0.196
15.0	**0.184**	0.237	0.232	0.226	0.221	0.216	0.211	0.206	0.201	0.196	0.192	0.188	0.180	0.176
15.5	**0.167**	0.216	0.210	0.205	0.200	0.195	0.191	0.187	0.182	0.178	0.174	0.170	0.163	0.160
16.0	**0.151**	0.196	0.191	0.187	0.182	0.177	0.173	0.169	0.165	0.161	0.158	0.155	0.148	0.145
16.5	**0.138**	0.179	0.174	0.170	0.166	0.161	0.158	0.154	0.151	0.147	0.144	0.141	0.135	0.133
17.0	**0.126**	0.163	0.159	0.155	0.151	0.148	0.144	0.141	0.138	0.134	0.132	0.129	0.124	0.121
17.5	**0.116**	0.149	0.146	0.142	0.139	0.135	0.132	0.129	0.126	0.123	0.121	0.118	0.114	0.112
18.0	**0.107**	0.137	0.134	0.131	0.128	0.124	0.122	0.119	0.116	0.114	0.111	0.109	0.105	0.103
18.5	**0.099**	0.127	0.124	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.101	0.097	0.095
19.0	**0.091**	0.116	0.114	0.111	0.108	0.105	0.103	0.101	0.099	0.096	0.094	0.093	0.089	0.087
19.5	**0.084**	0.108	0.105	0.103	0.100	0.098	0.096	0.093	0.091	0.089	0.088	0.086	0.083	0.081
20.0	**0.078**	0.100	0.098	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.081	0.080	0.077	0.075
20.5	**0.073**	0.093	0.091	0.089	0.087	0.084	0.083	0.081	0.079	0.077	0.076	0.074	0.072	0.070
21.0	**0.068**	0.087	0.085	0.083	0.081	0.079	0.077	0.075	0.074	0.072	0.071	0.070	0.067	0.066
21.5	**0.064**	0.082	0.080	0.078	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.066	0.063	0.062
22.0	**0.060**	0.076	0.075	0.073	0.071	0.069	0.068	0.067	0.065	0.064	0.063	0.061	0.059	0.058
22.5	**0.057**	0.072	0.070	0.068	0.067	0.065	0.064	0.063	0.061	0.060	0.059	0.058	0.056	0.055
23.0	**0.053**	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.051
23.5	**0.050**	0.063	0.062	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.048
24.0	**0.047**	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.046	0.046
24.5	**0.045**	0.056	0.055	0.054	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043
25.0	**0.042**	0.053	0.052	0.051	0.049	0.048	0.047	0.046	0.045	0.045	0.044	0.043	0.041	0.041

Table 12-11: C_t values, noise mode 4

12.4.3 Noise Curves, Noise Mode 4

Sound Power Level at Hub Height, Noise Mode 4		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.7	91.4
5	92.5	91.9
6	95.1	94.1
7	98.2	96.9
8	100.2	98.9
9	100.7	99.5
10	100.7	99.5
11	100.7	99.6
12	100.8	99.7
13	100.9	99.9
14	100.9	100.0
15	100.9	100.0
16	100.9	100.0
17	100.9	100.0
18	100.9	100.0
19	100.9	100.0
20	100.9	100.0

Table 12-12: Noise curves, noise mode 4

12.5 Mode 5

12.5.1 Power Curves, Noise Mode 5

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	18	19	20	23	25
3.5	**73**	44	47	50	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**209**	151	156	161	167	172	177	183	188	193	198	204	214	220
5.0	**302**	222	229	237	244	251	258	266	273	280	287	295	309	316
5.5	**415**	309	318	328	338	347	357	367	376	386	396	405	425	434
6.0	**552**	414	427	439	452	465	477	490	502	515	527	540	565	577
6.5	**714**	539	555	571	587	603	619	635	650	666	682	698	730	745
7.0	**903**	686	706	726	745	765	785	805	824	844	864	884	923	942
7.5	**1112**	849	873	897	921	945	969	993	1017	1041	1065	1089	1136	1160
8.0	**1340**	1027	1055	1084	1112	1141	1169	1198	1226	1255	1283	1312	1368	1396
8.5	**1576**	1212	1246	1279	1312	1345	1378	1411	1444	1478	1510	1543	1609	1641
9.0	**1817**	1403	1441	1479	1517	1555	1593	1630	1668	1706	1743	1780	1854	1890
9.5	**2060**	1598	1641	1683	1726	1768	1810	1852	1894	1936	1978	2019	2101	2142
10.0	**2310**	1799	1846	1893	1940	1987	2034	2080	2126	2172	2218	2264	2354	2398
10.5	**2562**	2007	2059	2110	2162	2214	2264	2315	2366	2416	2465	2513	2607	2653
11.0	**2798**	2226	2282	2338	2394	2450	2502	2554	2607	2659	2705	2752	2839	2879
11.5	**3004**	2456	2513	2571	2629	2686	2736	2786	2835	2885	2925	2964	3035	3066
12.0	**3154**	2687	2741	2796	2851	2906	2947	2989	3030	3072	3099	3126	3171	3190
12.5	**3239**	2896	2943	2989	3036	3082	3111	3139	3167	3195	3210	3224	3247	3255
13.0	**3278**	3066	3099	3133	3166	3199	3215	3230	3246	3262	3267	3273	3281	3283
13.5	**3288**	3173	3192	3211	3230	3249	3256	3264	3271	3279	3282	3285	3289	3291
14.0	**3295**	3236	3246	3257	3267	3278	3281	3285	3288	3292	3293	3294	3296	3296
14.5	**3298**	3269	3275	3280	3286	3291	3293	3294	3296	3298	3298	3298	3298	3298
15.0	**3300**	3287	3289	3292	3295	3298	3298	3299	3299	3300	3300	3300	3300	3300
15.5	**3300**	3294	3295	3296	3298	3299	3299	3299	3300	3300	3300	3300	3300	3300
16.0	**3300**	3296	3297	3298	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
16.5	**3300**	3298	3298	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.0	**3300**	3299	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
23.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
24.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
25.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300

Table 12-13: Power curve, noise mode 5

12.5.2 C_t Values, Noise Mode 5

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.904	0.904	0.903
3.5	**0.857**	0.860	0.860	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.856
4.0	**0.828**	0.831	0.831	0.830	0.830	0.830	0.830	0.829	0.829	0.829	0.829	0.828	0.828	0.828
4.5	**0.819**	0.822	0.822	0.822	0.821	0.821	0.821	0.820	0.820	0.820	0.819	0.819	0.818	0.818
5.0	**0.814**	0.818	0.818	0.818	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.814
5.5	**0.812**	0.817	0.816	0.816	0.816	0.815	0.815	0.814	0.814	0.814	0.813	0.813	0.812	0.811
6.0	**0.807**	0.813	0.812	0.812	0.811	0.811	0.810	0.810	0.809	0.809	0.808	0.807	0.806	0.806
6.5	**0.802**	0.809	0.809	0.808	0.807	0.807	0.806	0.805	0.804	0.804	0.803	0.802	0.801	0.800
7.0	**0.794**	0.802	0.801	0.801	0.800	0.799	0.799	0.798	0.797	0.796	0.795	0.795	0.793	0.792
7.5	**0.778**	0.786	0.785	0.785	0.784	0.783	0.782	0.782	0.781	0.780	0.779	0.778	0.777	0.776
8.0	**0.748**	0.757	0.756	0.756	0.755	0.754	0.753	0.752	0.752	0.751	0.750	0.749	0.748	0.747
8.5	**0.708**	0.716	0.715	0.715	0.714	0.713	0.712	0.712	0.711	0.710	0.709	0.709	0.707	0.706
9.0	**0.664**	0.672	0.671	0.671	0.670	0.669	0.669	0.668	0.667	0.666	0.665	0.665	0.663	0.662
9.5	**0.622**	0.630	0.629	0.628	0.628	0.627	0.626	0.626	0.625	0.624	0.623	0.622	0.621	0.620
10.0	**0.581**	0.589	0.589	0.588	0.587	0.587	0.586	0.585	0.584	0.583	0.583	0.582	0.580	0.579
10.5	**0.543**	0.553	0.552	0.551	0.550	0.550	0.549	0.548	0.547	0.546	0.545	0.544	0.541	0.539
11.0	**0.504**	0.521	0.520	0.519	0.519	0.518	0.516	0.514	0.513	0.511	0.509	0.506	0.500	0.496
11.5	**0.464**	0.495	0.494	0.492	0.490	0.489	0.486	0.483	0.480	0.477	0.472	0.468	0.458	0.453
12.0	**0.421**	0.471	0.468	0.465	0.462	0.459	0.454	0.449	0.444	0.440	0.433	0.427	0.413	0.406
12.5	**0.375**	0.445	0.440	0.435	0.430	0.425	0.418	0.412	0.405	0.398	0.391	0.383	0.368	0.360
13.0	**0.332**	0.415	0.408	0.401	0.394	0.387	0.379	0.371	0.363	0.355	0.348	0.340	0.325	0.318
13.5	**0.295**	0.380	0.371	0.363	0.355	0.347	0.339	0.331	0.323	0.316	0.309	0.302	0.288	0.282
14.0	**0.262**	0.343	0.334	0.326	0.318	0.309	0.302	0.295	0.288	0.281	0.274	0.268	0.256	0.251
14.5	**0.234**	0.307	0.300	0.292	0.284	0.276	0.270	0.263	0.257	0.250	0.245	0.239	0.229	0.224
15.0	**0.209**	0.275	0.268	0.261	0.253	0.246	0.241	0.235	0.229	0.223	0.219	0.214	0.205	0.201
15.5	**0.189**	0.247	0.241	0.234	0.228	0.222	0.217	0.212	0.207	0.201	0.197	0.193	0.185	0.181
16.0	**0.171**	0.223	0.217	0.212	0.206	0.200	0.196	0.191	0.187	0.182	0.179	0.175	0.168	0.164
16.5	**0.156**	0.202	0.197	0.192	0.187	0.182	0.178	0.174	0.170	0.166	0.163	0.159	0.153	0.150
17.0	**0.142**	0.184	0.180	0.175	0.171	0.166	0.162	0.159	0.155	0.152	0.148	0.145	0.140	0.137
17.5	**0.131**	0.168	0.164	0.160	0.156	0.152	0.149	0.146	0.142	0.139	0.136	0.133	0.128	0.126
18.0	**0.120**	0.155	0.151	0.147	0.143	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.118	0.116
18.5	**0.111**	0.142	0.139	0.136	0.132	0.129	0.126	0.123	0.121	0.118	0.116	0.113	0.109	0.107
19.0	**0.102**	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.108	0.106	0.104	0.100	0.098
19.5	**0.095**	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.100	0.099	0.097	0.093	0.091
20.0	**0.088**	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.095	0.093	0.092	0.090	0.087	0.085
20.5	**0.082**	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.081	0.079
21.0	**0.077**	0.097	0.095	0.093	0.091	0.088	0.087	0.085	0.083	0.081	0.080	0.078	0.075	0.074
21.5	**0.072**	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.0	**0.068**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22.5	**0.064**	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
23.0	**0.060**	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
23.5	**0.056**	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.0	**0.053**	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
24.5	**0.050**	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
25.0	**0.048**	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046

Table 12-14: C_t values, noise mode 5

12.5.3 Noise Curves, Noise Mode 5

Sound Power Level at Hub Height, Noise Mode 5		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.9	91.5
5	94.1	93.4
6	97.3	96.3
7	99.9	98.8
8	101.3	100.0
9	102.0	100.7
10	102.8	101.5
11	103.7	102.5
12	104.2	103.1
13	104.2	103.1
14	104.2	103.1
15	104.2	103.1
16	104.2	103.1
17	104.2	103.1
18	104.2	103.1
19	104.2	103.1
20	104.2	103.1

Table 12-15: Noise curves, noise mode 5

12.6 Mode 8

12.6.1 Power Curves, Noise Mode 8

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**23**	9	10	11	12	13	15	16	18	19	21	22	25	27
3.5	**74**	46	48	51	54	56	59	61	64	67	69	72	77	79
4.0	**135**	94	98	101	105	109	113	116	120	124	128	132	139	143
4.5	**207**	150	155	161	166	171	176	181	187	192	197	202	213	218
5.0	**294**	217	224	231	238	245	252	259	266	273	280	287	301	308
5.5	**403**	301	310	320	329	338	347	357	366	375	384	393	412	421
6.0	**536**	404	417	429	441	453	465	477	489	501	513	525	548	560
6.5	**694**	527	542	557	573	588	603	618	634	649	664	679	710	725
7.0	**876**	668	687	706	725	744	762	781	800	819	838	857	895	914
7.5	**1067**	817	840	862	885	908	931	954	976	999	1022	1044	1090	1112
8.0	**1257**	966	992	1019	1045	1072	1098	1125	1151	1178	1204	1230	1283	1309
8.5	**1434**	1104	1135	1165	1195	1225	1255	1285	1315	1345	1374	1404	1463	1493
9.0	**1592**	1229	1262	1295	1329	1362	1395	1428	1461	1494	1526	1559	1624	1657
9.5	**1734**	1341	1377	1413	1449	1485	1521	1556	1592	1628	1663	1698	1769	1804
10.0	**1861**	1443	1481	1519	1558	1596	1634	1672	1710	1748	1786	1824	1898	1935
10.5	**1977**	1538	1578	1619	1659	1700	1740	1780	1820	1860	1899	1938	2015	2052
11.0	**2081**	1627	1670	1713	1755	1798	1840	1881	1923	1964	2003	2042	2117	2154
11.5	**2176**	1715	1760	1804	1849	1894	1936	1978	2020	2062	2100	2138	2209	2242
12.0	**2254**	1799	1845	1891	1937	1982	2024	2066	2107	2149	2184	2219	2282	2310
12.5	**2315**	1880	1926	1972	2018	2065	2105	2145	2185	2224	2255	2285	2337	2359
13.0	**2359**	1958	2004	2050	2096	2142	2178	2215	2251	2288	2311	2335	2376	2393
13.5	**2389**	2032	2076	2120	2165	2210	2240	2271	2302	2332	2351	2370	2401	2414
14.0	**2412**	2103	2144	2185	2226	2267	2292	2318	2343	2369	2383	2397	2420	2429
14.5	**2426**	2168	2204	2240	2276	2313	2333	2354	2374	2394	2405	2416	2433	2439
15.0	**2434**	2215	2247	2279	2311	2342	2359	2376	2392	2409	2417	2426	2439	2444
15.5	**2441**	2260	2287	2314	2341	2369	2382	2396	2409	2423	2429	2435	2444	2448
16.0	**2445**	2297	2320	2343	2366	2389	2399	2410	2421	2431	2436	2441	2448	2451
16.5	**2449**	2329	2348	2367	2386	2405	2413	2422	2430	2438	2442	2445	2451	2453
17.0	**2452**	2357	2372	2388	2403	2418	2425	2431	2437	2444	2446	2449	2453	2454
17.5	**2451**	2376	2388	2400	2412	2424	2429	2434	2440	2445	2447	2449	2452	2454
18.0	**2453**	2394	2403	2413	2423	2432	2436	2440	2444	2448	2450	2451	2454	2455
18.5	**2454**	2408	2416	2423	2431	2439	2442	2445	2448	2450	2452	2453	2455	2456
19.0	**2457**	2421	2427	2433	2439	2445	2447	2450	2452	2454	2455	2456	2457	2458
19.5	**2458**	2429	2434	2439	2444	2448	2450	2452	2454	2456	2457	2457	2458	2458
20.0	**2458**	2436	2440	2444	2448	2452	2453	2454	2455	2457	2457	2457	2458	2458
20.5	**2458**	2441	2444	2447	2450	2454	2455	2455	2456	2457	2457	2458	2458	2458
21.0	**2458**	2444	2447	2450	2452	2455	2456	2456	2457	2458	2458	2458	2458	2458
21.5	**2457**	2442	2445	2448	2450	2453	2454	2455	2455	2456	2457	2457	2458	2458
22.0	**2458**	2446	2448	2450	2452	2454	2455	2455	2456	2457	2457	2457	2458	2458
22.5	**2458**	2449	2450	2452	2454	2455	2456	2456	2457	2457	2457	2457	2458	2458
23.0	**2458**	2450	2452	2453	2455	2456	2457	2457	2457	2458	2458	2458	2458	2458
23.5	**2458**	2452	2453	2454	2456	2457	2457	2457	2458	2458	2458	2458	2458	2458
24.0	**2458**	2454	2454	2455	2456	2457	2457	2457	2458	2458	2458	2458	2458	2458
24.5	**2458**	2455	2456	2456	2457	2457	2457	2458	2458	2458	2458	2458	2458	2458
25.0	**2458**	2456	2456	2456	2457	2457	2457	2458	2458	2458	2458	2458	2458	2458

Table 12-16: Power curve, noise mode 8

12.6.2 C_t Values, Noise Mode 8

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.900**	0.904	0.903	0.903	0.903	0.902	0.902	0.902	0.901	0.901	0.901	0.900	0.900	0.899
3.5	**0.852**	0.855	0.855	0.855	0.854	0.854	0.854	0.854	0.853	0.853	0.853	0.852	0.852	0.852
4.0	**0.823**	0.825	0.825	0.825	0.825	0.824	0.824	0.824	0.824	0.824	0.823	0.823	0.823	0.822
4.5	**0.784**	0.786	0.785	0.785	0.785	0.785	0.785	0.785	0.784	0.784	0.784	0.784	0.783	0.783
5.0	**0.743**	0.745	0.745	0.745	0.745	0.744	0.744	0.744	0.744	0.743	0.743	0.743	0.743	0.742
5.5	**0.739**	0.741	0.741	0.740	0.740	0.740	0.740	0.740	0.739	0.739	0.739	0.739	0.738	0.738
6.0	**0.743**	0.747	0.746	0.746	0.746	0.746	0.745	0.745	0.745	0.744	0.744	0.744	0.743	0.743
6.5	**0.744**	0.748	0.748	0.748	0.747	0.747	0.747	0.746	0.746	0.745	0.745	0.745	0.744	0.743
7.0	**0.733**	0.738	0.737	0.737	0.737	0.736	0.736	0.735	0.735	0.734	0.734	0.733	0.732	0.732
7.5	**0.705**	0.710	0.710	0.709	0.709	0.708	0.708	0.707	0.707	0.706	0.706	0.705	0.704	0.704
8.0	**0.660**	0.666	0.665	0.665	0.664	0.664	0.663	0.663	0.662	0.662	0.661	0.661	0.660	0.659
8.5	**0.605**	0.610	0.609	0.609	0.608	0.608	0.607	0.607	0.607	0.606	0.606	0.605	0.604	0.604
9.0	**0.546**	0.550	0.550	0.549	0.549	0.549	0.548	0.548	0.547	0.547	0.546	0.546	0.545	0.545
9.5	**0.491**	0.495	0.494	0.494	0.494	0.493	0.493	0.492	0.492	0.492	0.491	0.491	0.490	0.490
10.0	**0.440**	0.444	0.444	0.443	0.443	0.443	0.443	0.442	0.442	0.441	0.441	0.441	0.440	0.440
10.5	**0.396**	0.400	0.400	0.399	0.399	0.399	0.398	0.398	0.398	0.398	0.397	0.397	0.396	0.395
11.0	**0.357**	0.362	0.362	0.361	0.361	0.361	0.360	0.360	0.360	0.359	0.359	0.358	0.356	0.355
11.5	**0.323**	0.329	0.329	0.329	0.329	0.328	0.328	0.327	0.327	0.326	0.325	0.324	0.321	0.319
12.0	**0.291**	0.301	0.301	0.300	0.300	0.300	0.299	0.298	0.297	0.296	0.294	0.292	0.288	0.285
12.5	**0.261**	0.276	0.276	0.275	0.275	0.274	0.273	0.271	0.270	0.269	0.266	0.264	0.258	0.255
13.0	**0.235**	0.254	0.253	0.253	0.252	0.251	0.249	0.248	0.246	0.244	0.241	0.238	0.231	0.228
13.5	**0.212**	0.235	0.234	0.233	0.232	0.231	0.228	0.226	0.224	0.221	0.218	0.215	0.208	0.205
14.0	**0.191**	0.218	0.216	0.214	0.213	0.211	0.209	0.206	0.203	0.200	0.197	0.194	0.187	0.184
14.5	**0.172**	0.201	0.199	0.197	0.195	0.193	0.190	0.187	0.184	0.182	0.178	0.175	0.169	0.166
15.0	**0.155**	0.184	0.182	0.180	0.177	0.175	0.172	0.169	0.166	0.164	0.161	0.158	0.152	0.149
15.5	**0.140**	0.170	0.167	0.165	0.162	0.160	0.157	0.154	0.152	0.149	0.146	0.143	0.138	0.135
16.0	**0.128**	0.156	0.154	0.151	0.149	0.146	0.144	0.141	0.138	0.136	0.133	0.130	0.125	0.123
16.5	**0.117**	0.144	0.142	0.139	0.137	0.134	0.132	0.129	0.126	0.124	0.121	0.119	0.114	0.112
17.0	**0.107**	0.133	0.131	0.128	0.126	0.123	0.121	0.118	0.116	0.114	0.111	0.109	0.105	0.103
17.5	**0.098**	0.123	0.121	0.118	0.116	0.113	0.111	0.109	0.107	0.104	0.102	0.100	0.096	0.094
18.0	**0.090**	0.114	0.112	0.109	0.107	0.105	0.103	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18.5	**0.083**	0.106	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.082	0.080
19.0	**0.077**	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.075	0.074
19.5	**0.071**	0.091	0.089	0.087	0.085	0.083	0.081	0.079	0.078	0.076	0.074	0.073	0.070	0.069
20.0	**0.066**	0.085	0.083	0.081	0.079	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.065	0.064
20.5	**0.062**	0.079	0.077	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.061	0.060
21.0	**0.058**	0.074	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.061	0.060	0.059	0.057	0.056
21.5	**0.054**	0.069	0.068	0.066	0.065	0.063	0.062	0.060	0.059	0.058	0.057	0.056	0.053	0.052
22.0	**0.051**	0.065	0.063	0.062	0.060	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.050	0.049
22.5	**0.048**	0.061	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.047	0.046
23.0	**0.045**	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.044	0.043
23.5	**0.042**	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.041	0.041
24.0	**0.040**	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.041	0.039	0.038
24.5	**0.038**	0.048	0.046	0.045	0.044	0.043	0.042	0.042	0.041	0.040	0.039	0.038	0.037	0.036
25.0	**0.036**	0.045	0.044	0.043	0.042	0.041	0.040	0.039	0.038	0.038	0.037	0.036	0.035	0.034

Table 12-17: C_t values, noise mode 8

12.6.3 Noise Curves, Noise Mode 8

Sound Power Level at Hub Height, Noise Mode 8		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.2	91.0
4	91.6	91.3
5	92.5	91.9
6	95.1	94.1
7	97.8	96.6
8	99.2	97.8
9	99.4	98.1
10	99.4	98.1
11	99.4	98.1
12	99.4	98.1
13	99.4	98.1
14	99.4	98.1
15	99.4	98.1
16	99.4	98.1
17	99.4	98.1
18	99.4	98.1
19	99.4	98.1
20	99.4	98.1

Table 12-18: Noise curves, noise mode 8

12.7 3.45 MW Power Mode

12.7.1 Power Curves, 3.45 MW Power Mode

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**22**	8	9	10	11	12	14	15	16	18	19	20	23	25
3.5	**73**	44	47	49	52	55	57	60	62	65	68	70	75	78
4.0	**134**	93	97	100	104	108	112	116	119	123	127	131	138	142
4.5	**209**	151	156	161	167	172	177	182	188	193	198	204	214	220
5.0	**302**	222	229	237	244	251	258	266	273	280	287	295	309	316
5.5	**415**	309	318	328	338	347	357	367	376	386	396	405	425	434
6.0	**552**	414	427	439	452	465	477	490	502	515	527	540	565	577
6.5	**714**	540	556	572	587	603	619	635	651	667	683	699	730	746
7.0	**906**	688	708	728	748	768	787	807	827	847	866	886	926	945
7.5	**1123**	857	881	905	930	954	978	1002	1027	1051	1075	1099	1147	1171
8.0	**1371**	1049	1078	1108	1137	1166	1196	1225	1254	1284	1313	1342	1400	1429
8.5	**1648**	1265	1300	1335	1370	1405	1440	1475	1509	1544	1579	1613	1682	1716
9.0	**1950**	1503	1544	1585	1626	1667	1708	1749	1789	1830	1870	1910	1990	2030
9.5	**2268**	1757	1804	1851	1898	1946	1992	2039	2085	2132	2177	2223	2313	2357
10.0	**2586**	2022	2075	2128	2182	2235	2286	2338	2389	2440	2489	2537	2632	2678
10.5	**2878**	2284	2342	2401	2459	2517	2571	2625	2679	2733	2781	2830	2921	2963
11.0	**3107**	2526	2588	2649	2711	2773	2825	2877	2930	2982	3024	3066	3141	3174
11.5	**3273**	2745	2806	2867	2928	2989	3036	3084	3131	3178	3210	3241	3296	3319
12.0	**3374**	2934	2991	3049	3106	3164	3200	3237	3274	3311	3332	3353	3386	3399
12.5	**3422**	3092	3141	3190	3238	3287	3312	3337	3362	3387	3399	3410	3428	3434
13.0	**3441**	3217	3254	3290	3327	3364	3379	3394	3409	3425	3430	3436	3443	3446
13.5	**3445**	3302	3326	3351	3375	3400	3409	3418	3427	3436	3439	3442	3447	3448
14.0	**3449**	3358	3375	3391	3408	3425	3429	3434	3439	3444	3446	3447	3449	3450
14.5	**3450**	3396	3406	3417	3427	3437	3440	3443	3445	3448	3449	3449	3450	3450
15.0	**3450**	3419	3425	3431	3437	3444	3445	3446	3448	3449	3449	3450	3450	3450
15.5	**3450**	3431	3435	3439	3443	3447	3448	3448	3449	3450	3450	3450	3450	3450
16.0	**3450**	3439	3441	3443	3446	3448	3449	3449	3449	3450	3450	3450	3450	3450
16.5	**3450**	3443	3445	3446	3448	3449	3449	3449	3450	3450	3450	3450	3450	3450
17.0	**3450**	3445	3446	3447	3448	3449	3449	3450	3450	3450	3450	3450	3450	3450
17.5	**3450**	3445	3446	3447	3448	3449	3449	3449	3450	3450	3450	3450	3450	3450
18.0	**3450**	3446	3447	3448	3449	3449	3450	3450	3450	3450	3450	3450	3450	3450
18.5	**3450**	3448	3448	3449	3449	3450	3450	3450	3450	3450	3450	3450	3450	3450
19.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
19.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
20.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
20.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
21.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
21.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
22.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
22.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
23.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
23.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
24.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
24.5	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450
25.0	**3450**	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450	3450

Table 12-19: Power curves, 3.45 MW Power Mode

12.7.2 C_t Values, 3.45 MW Power Mode

Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.904**	0.908	0.908	0.907	0.907	0.907	0.906	0.906	0.906	0.905	0.905	0.904	0.904	0.903
3.5	**0.857**	0.860	0.860	0.860	0.859	0.859	0.859	0.858	0.858	0.858	0.858	0.857	0.857	0.856
4.0	**0.828**	0.831	0.831	0.830	0.830	0.830	0.830	0.829	0.829	0.829	0.829	0.828	0.828	0.828
4.5	**0.819**	0.822	0.822	0.822	0.821	0.821	0.821	0.820	0.820	0.820	0.819	0.819	0.818	0.818
5.0	**0.814**	0.818	0.818	0.818	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.814
5.5	**0.812**	0.817	0.817	0.816	0.816	0.815	0.815	0.815	0.814	0.814	0.813	0.813	0.812	0.811
6.0	**0.807**	0.814	0.813	0.813	0.812	0.811	0.811	0.810	0.810	0.809	0.808	0.808	0.807	0.806
6.5	**0.802**	0.809	0.809	0.808	0.807	0.807	0.806	0.805	0.805	0.804	0.803	0.802	0.801	0.800
7.0	**0.795**	0.804	0.803	0.803	0.802	0.801	0.800	0.799	0.798	0.797	0.797	0.796	0.794	0.793
7.5	**0.788**	0.799	0.798	0.797	0.796	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.787	0.786
8.0	**0.781**	0.794	0.793	0.792	0.790	0.789	0.788	0.787	0.786	0.785	0.783	0.782	0.780	0.779
8.5	**0.773**	0.788	0.786	0.785	0.784	0.783	0.781	0.780	0.779	0.777	0.776	0.775	0.772	0.771
9.0	**0.763**	0.778	0.777	0.775	0.774	0.773	0.771	0.770	0.769	0.767	0.766	0.764	0.762	0.760
9.5	**0.745**	0.763	0.762	0.760	0.759	0.758	0.756	0.754	0.753	0.751	0.749	0.747	0.742	0.740
10.0	**0.711**	0.739	0.738	0.736	0.734	0.733	0.730	0.727	0.725	0.722	0.718	0.715	0.706	0.702
10.5	**0.660**	0.702	0.700	0.697	0.695	0.693	0.689	0.685	0.681	0.677	0.671	0.666	0.653	0.646
11.0	**0.596**	0.652	0.649	0.646	0.643	0.640	0.635	0.629	0.624	0.619	0.611	0.604	0.587	0.578
11.5	**0.529**	0.599	0.595	0.591	0.587	0.583	0.576	0.569	0.563	0.556	0.547	0.538	0.519	0.509
12.0	**0.464**	0.546	0.541	0.536	0.530	0.525	0.517	0.509	0.501	0.492	0.483	0.473	0.454	0.444
12.5	**0.404**	0.495	0.488	0.482	0.475	0.469	0.460	0.451	0.442	0.432	0.423	0.414	0.395	0.386
13.0	**0.353**	0.446	0.439	0.431	0.423	0.415	0.406	0.397	0.388	0.379	0.370	0.361	0.345	0.337
13.5	**0.312**	0.402	0.393	0.385	0.377	0.368	0.360	0.351	0.343	0.334	0.327	0.319	0.305	0.298
14.0	**0.276**	0.359	0.351	0.343	0.335	0.326	0.319	0.311	0.303	0.296	0.289	0.282	0.270	0.264
14.5	**0.246**	0.322	0.314	0.306	0.299	0.291	0.284	0.277	0.270	0.263	0.257	0.252	0.241	0.235
15.0	**0.219**	0.287	0.280	0.273	0.266	0.259	0.253	0.247	0.241	0.234	0.229	0.224	0.215	0.210
15.5	**0.198**	0.259	0.252	0.246	0.239	0.233	0.227	0.222	0.217	0.211	0.207	0.202	0.194	0.190
16.0	**0.179**	0.234	0.228	0.222	0.216	0.210	0.205	0.201	0.196	0.191	0.187	0.183	0.176	0.172
16.5	**0.163**	0.212	0.207	0.201	0.196	0.191	0.187	0.182	0.178	0.174	0.170	0.167	0.160	0.157
17.0	**0.149**	0.193	0.188	0.183	0.179	0.174	0.170	0.166	0.162	0.159	0.155	0.152	0.146	0.143
17.5	**0.137**	0.176	0.172	0.168	0.163	0.159	0.156	0.152	0.149	0.145	0.142	0.139	0.134	0.131
18.0	**0.126**	0.162	0.158	0.154	0.150	0.146	0.143	0.140	0.137	0.134	0.131	0.128	0.123	0.121
18.5	**0.116**	0.149	0.145	0.142	0.138	0.135	0.132	0.129	0.126	0.123	0.121	0.118	0.114	0.112
19.0	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.109	0.105	0.103
19.5	**0.099**	0.126	0.123	0.120	0.117	0.114	0.112	0.110	0.107	0.105	0.103	0.101	0.097	0.095
20.0	**0.092**	0.117	0.114	0.112	0.109	0.106	0.104	0.102	0.100	0.097	0.096	0.094	0.090	0.089
20.5	**0.086**	0.109	0.106	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.084	0.083
21.0	**0.080**	0.102	0.099	0.097	0.095	0.092	0.090	0.088	0.087	0.085	0.083	0.082	0.079	0.077
21.5	**0.075**	0.096	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.074	0.073
22.0	**0.071**	0.089	0.087	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.073	0.072	0.069	0.068
22.5	**0.066**	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.068	0.065	0.064
23.0	**0.062**	0.078	0.077	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060
23.5	**0.059**	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057
24.0	**0.055**	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057	0.056	0.054	0.053
24.5	**0.052**	0.065	0.064	0.063	0.061	0.060	0.059	0.058	0.056	0.055	0.054	0.053	0.051	0.051
25.0	**0.049**	0.062	0.061	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048

Table 12-20: C_t values, 3.45 MW Power Mode

12.7.3 Noise Curves, 3.45 MW Power Mode

Sound Power Level at Hub Height, 3.45 MW Power Mode		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] (Blades without optional serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] (Blades with optional serrated trailing edge)**
3	91.3	91.1
4	91.9	91.5
5	94.2	93.4
6	97.3	96.3
7	100.6	99.5
8	103.4	102.3
9	105.8	104.4
10	105.8	104.4
11	105.8	104.4
12	105.8	104.4
13	105.8	104.4
14	105.8	104.4
15	105.8	104.4
16	105.8	104.4
17	105.8	104.4
18	105.8	104.4
19	105.8	104.4
20	105.8	104.4

Table 12-21: Noise curves, 3.45 MW Power Mode