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General Specification

V112–3.0 MW 50/60 Hz

Vestas Wind Systems A/S · Alsvej 21 · 8940 Randers SV · Denmark · www.vestas.com

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Refer to section 11 General Reservations, Notes and Disclaimers, p. 31 for general reservations, notes, and disclaimers applicable to these general specifications.

1 General Description

The Vestas V112-3.0 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V112-3.0 MW turbine has a rotor diameter of 112 m and a rated output power of 3.075 MW. The turbine utilises the OptiTip® concept and a power system based on a permanent magnet 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.

2 Mechanical Design

2.1 Rotor

The V112-3.0 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
Rotational Speed Static, Rotor	12.8 rpm
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 fibre glass 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
Material	Fibre glass reinforced epoxy and carbon fibres

Blades	
Blade Connection	Steel roots inserted
Air Foils	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, automatic lubrication pump

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	
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 gearbox is a four-stage differential gearbox where the first three stages are planetary stages and the fourth stage is a helical stage.

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

Gearbox	
Type	Differential, three planetary stages + one helical stage
Gear House Material	Cast
Ratio	1:113.2
Mechanical Power	3300 kW
Lubrication System	Pressure oil lubrication
Backup Lubrication System	Oil sump filled from external gravity tank
Total Gear Oil Volume	Approximately 1170 l
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 fibre glass 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 are two-stage planetary gears with a worm drive and built-in torque limiters.

The worm drive is self locking to prevent unintentional yawing.

Yaw System	
Type	Plain bearing system with built-in friction
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yawing Speed (50 Hz)	0.5°/sec.
Yawing Speed (60 Hz)	0.6°/sec.

Table 2-11: Yaw system data.

Yaw Gear	
Type	Two-step planetary gear with worm drive
Number of Yaw Gears	8
Ratio Total (Four Planetary Stages)	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 chain hoist.

Crane	
Lifting Capacity	Maximum 990 kg
Power supply	3 x 400 V, 10 A

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, etc., are supported vertically (i.e. 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
Maximum Diameter	4.2 m (standard)/4.45 m (119 m DIBt 2)
Material	Steel

Table 2-14: Tower structure data.

2.15 Nacelle Bedplate and Cover

The nacelle cover is made of fibre glass. 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 eight 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 mounted 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 Cooler Top™ located on top of the rear end of the nacelle. The cooler top 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 I, which serves the gearbox and hydraulic systems, driven by a single electrical pump.
- The Liquid Cooling System II, which serves the generator and converter systems, driven by a single electrical pump.
- The transformer forced air cooling comprised of an electrical fan.
- The nacelle forced air cooling comprised of two electrical fans.

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 two fans located on each side of the nacelle. The airflow enters the nacelle through an air intake in the bottom of the nacelle. The fans can run at low or high speed depending on the temperature in the nacelle.

3 Electrical Design

3.1 Generator

The generator is a three-phase synchronous generator with a permanent magnet rotor that is connected to the grid through a full scale converter.

The generator housing is built with a cylindrical jacket and channels. The channels circulate cooling liquid around the generator internal stator housing.

Generator	
Type	Synchronous with permanent magnets
Rated Power [P_N]	3.3 MW
Rated Apparent Power [S_N]	3880 kVA (Cosφ = 0.85)
Frequency [f_N]	145 Hz
Voltage, Stator [U_{NS}]	3 x 710 V (@ 1450 rpm)
Number of Poles	12
Winding Type	Form with VPI (Vacuum Pressurized Impregnation)
Winding Connection	Star
Rated Efficiency (Generator only)	98%
Rated rpm/Rated Slip	1450 rpm
Overspeed Limit According to IEC (2 minutes)	2400 rpm
Vibration Level	≤ 1.8 mm/s
Generator Bearing	Hybrid/ceramic
Temperature Sensors, Stator	3 PT100 sensors placed at hot spots and 3 as back-up

Generator	
Temperature Sensors, Bearings	1 per bearing and 1 backup per bearing
Insulation Class	H (3 kV)
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 710 V dependent on generator speed.

Converter	
Rated Apparent Power [S_N]	3800 kVA
Rated Grid Voltage	650 V
Rated Generator Voltage	710 V
Rated Current	3440 A

Table 3-2: Converter data.

3.3 HV Transformer

The step-up transformer is located in a separate locked room in the nacelle with surge arresters mounted on the high-voltage side of the transformer. The transformer is a two-winding, three-phase, dry-type transformer that is self-extinguishing. The windings are delta-connected on the high-voltage side unless otherwise specified.

The low-voltage winding is star connected. The low-voltage system from the generator via the converters is a TN-S system, which means the star point is connected to earth.

The transformer is equipped with 6 PT100 temperature sensors for measuring the core and winding temperatures in the three phases.

The nacelle auxiliary power supply is supplied from a separate 650/400 V transformer located in the nacelle.

HV Transformer	
Type	Dry-type cast resin
Primary Voltage [U_N]	10-35 kV
Secondary Voltage [U_{NS}]	3 x 650 V
Rated Apparent Power [S_N]	3450 kVA
No Load Loss [P_0]	6.6 kW
Load Losses (@ 120°C) [P_n]	24.5 kW
No Load Reactive Power [Q_0]	7.5 kVAr
Full Load Reactive Power [Q_n]	275 kVAr
Vector Group	Dyn5 (options: YNyn0)
Frequency	50/60 Hz
HV-Tappings	±2 x 2.5% offload
Inrush Current	6-10 x $\hat{I}_n$ depending on type.
Short-Circuit Impedance	8% @ 650 V, 3450 kVA, 120°C
Positive Sequence Short Circuit Impedance Voltage $U_{k\ p\text{-}s1}$	7.95%
Positive Sequence Short Circuit Impedance Voltage (Resistive) $U_{kr\ p\text{-}s1}$	0.72%
Zero Sequence Short Circuit Impedance Voltage $U_{k0\ p\text{-}s1}$	7.55%
Zero Sequence Short Circuit Impedance Voltage (Resistive) $U_{kr0\ p\text{-}s1}$	0.72%
Insulation Class	F
Climate Class	C2
Environmental Class	E2
Fire Behaviour Class	F1

Table 3-3: Transformer data.

3.4 HV Cables

The high-voltage cable runs from the transformer in the nacelle down the tower to the 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 / 42 kV depending on the rated transformer voltage

Table 3-4: HV cables data.

3.5 HV Switchgear

The high-voltage switchgear is located in the bottom of the tower.

HV Switchgear			
Type	Gas insulated SF6		
Nominal Frequency	50/60 Hz		
Nominal Rated Voltage	10–22 kV	22.1–33 kV	33.1–35 kV
Maximum Voltage	24 kV	36 kV	40.5 kV
Maximum Short Circuit Current (1 second)	20 kA	25 kA	25 kA

Table 3-5: HV switchgear data.

3.6 AUX System

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

All 230 V consumers are supplied from a 400/230 V transformer.

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 3-6: AUX system data.

3.7 Wind Sensors

The turbine is equipped with two ultrasonic wind sensors with no movable parts. 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.

Wind Sensors	
Type	FT702LT
Principle	Acoustic Resonance
Built-In Heat	99 W

Table 3-7: Wind sensor data.

3.8 VMP (Vestas Multi Processor) 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)

The UPS is equipped with an AC/DC, DC/AC converter (double conversions) and battery cells placed in the same cabinet as the converter. During grid outage, the UPS will supply specific components with 230 V AC.

The backup time for the UPS system is proportional to the power consumption. Actual backup time may vary.

UPS	
Battery Type	Valve-Regulated Lead Acid (VRLA)
Rated Battery Voltage	2 x 8 x 12 V (192 V)
Converter Type	Double conversion
Converter Input	230 V +/-20%
Rated Output Voltage	230 Vac

UPS		
Backup Time*	Controller system	15 minutes
	Switchgear function (motor release/activation)	15 minutes
	Remote control system	15 minutes
	Internal light in tower and nacelle	1 hour (supplied by built-in batteries)
	Aviation obstruction light	1 hour
Re-charging Time	80%	Approximately 3 hours
	100%	Approximately 8 hours

Table 3-8: UPS data.

NOTE * For alternative backup times, consult Vestas.

4 Turbine Protection Systems

4.1 Braking Concept

The main brake on the turbine is aerodynamic. Braking 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. Braking of the turbine is further supported by a breaking resistor that is connected to the permanent magnet generator during shut down. This prevents loss of torque in, for example, grid loss situations.

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 push buttons.

4.2 Short Circuit Protections

Breakers	**Breaker for Auxilliary Power T4L 250A TMD 4P 690 V**	**Breaker for Converter Modules T7M1200L PR332/ P LSIG 1000 A 3P 690 V**
Breaking Capacity, I_{cu}, I_{cs}	70 kA @ 690 V	50 kA @ 690 V
Making Capacity, I_{cm}	154 kA @ 690 V	105 kA @ 690 V
L, Overload - Time Delay t_1	175–250 A K	480–1200 A 3–144 seconds
S, Short Circuit - Time Delay t_2	N/A N/A	0.72–12 kA 0.1–0.8 seconds

Breakers	**Breaker for Auxilliary Power T4L 250A TMD 4P 690 V**	**Breaker for Converter Modules T7M1200L PR332/ P LSIG 1000 A 3P 690 V**
I, Short Circuit - Instantaneous t_3	1.25–2.5 kA K	1.8–18 kA K
G, Earth Fault - Time Delay t_4	N/A N/A	240–1200 A 0.1–0.8 seconds

Table 4-1: Short circuit protection data.

The table below shows HV switchgear settings and how full load phase current on the HV switchgear depends on actual line voltage. Note: Minimum line voltage $\mathbf{U_{N,min}}$ is defined as nominal line voltage $\mathbf{U_N}$ minus allowed continuous under voltage (e.g. 10 %).

HV Switchgear Settings	
Full Load Phase Current, I_N [A]	$S_{N,transformer}$ /($U_{N,min}$ * √3)
Phase Overload Factor	1.1
Phase Multiplier Constant (Scale Factor)	0.1
Instantaneous Phase Multiplier	Minimum 8
Instantaneous Phase to Phase Time Setting	0.1 second
Ground Leak Factor	0.1
Zero Sequence Multiplier Constant	0.05
Instantaneous Zero Sequence Multiplier	2
Instantaneous Zero Sequence Time Setting	0.1 second

Table 4-2: HV switchgear settings.

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 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 over-voltage and over-current.
- 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 7.3 Design Codes – Lightning Protection, p. 22).

4.5 Earthing (Also Known as Grounding)

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.

4.6 Corrosion Protection

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

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	C3 and C4 Climate Strategy: Heating the air inside the nacelle compared to the outside air temperature lowers the relative humidity and helps ensure a controlled corrosion level.
Hub	C5	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 the bottom of the tower. 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 switch boards 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 Climbing Facilities

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

There are anchorage 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 anchorage point for the emergency descent equipment.

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

5.6 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.

5.7 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.

5.8 Emergency Stop

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

5.9 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.

5.10 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.

5.11 Warning Signs

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

5.12 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 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 Anlage 2.7/10	DIBt 2	94 m / 119 m
UL 6140 (Construction Only)	60 Hz variant only	NA

Table 7-1: Type approvals data.

7.2 Design Codes – Structural Design

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

Design Codes – Structural Design	
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

Table 7-2: Structural design codes.

7.3 Design Codes – Lightning Protection

The lightning protection system is designed according to Lightning Protection Level (LPL) I:

Design Codes – Lightning Protection	
Designed According to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non Harmonized Standard and Technically Normative Documents	IEC/TR 61400-24:2002

Table 7-3: Lightning protection 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 Blades Colour

Blades 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

Average Design Parameters	
Wind Climate	**IEC IIA**
Turbulence Intensity According to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s – 90% quantile)	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 program.

9.1.2 Altitude

The turbine is designed for use at altitudes up to 1500 m above sea level as standard.

Above 1500 m, special considerations must be taken regarding, e.g. HV installations and cooling performance. Consult Vestas for further information.

9.1.3 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing, in any case, must not be below three rotor diameters (3D).

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 Temperature Turbine)	-20° to +40°C
Cut-In (10 Minute Average)	3 m/s
Cut-Out (10 Minute Average)	25 m/s
Re-Cut In (10 Minute Average)	23 m/s

Table 9-3: Operational envelope – temperature and wind.

9.3 Operational Envelope – Grid Connection

Values are determined by the sensors and control system of the turbine.

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	650 V
Nominal Frequency	[f_N]	50/60 Hz
Maximum Steady State Voltage Jump	±2% (from turbine) ±4% (from grid)	
Maximum Frequency Gradient	±4 Hz/sec.	
Maximum Negative Sequence Voltage	3% (connection) 2% (operation)	
Minimum Short Circuit Level	15 MVA	

Table 9-4: Operational envelope – grid connection.

The generator and the converter will be disconnected if*:

Protection Settings	
Voltage Above 110% of Nominal for 60 Seconds	715 V
Voltage Above 115% of Nominal for 2 Seconds	748 V
Voltage Above 120% of Nominal for 0.08 Seconds	780 V
Voltage Above 125% of Nominal for 0.005 Seconds	812 V
Voltage Below 90% of Nominal for 60 Seconds	585 V
Voltage Below 85% of Nominal for 11 Seconds	552 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 20 times a year.

9.4 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability as illustrated in Figure 9-1, p. 26.

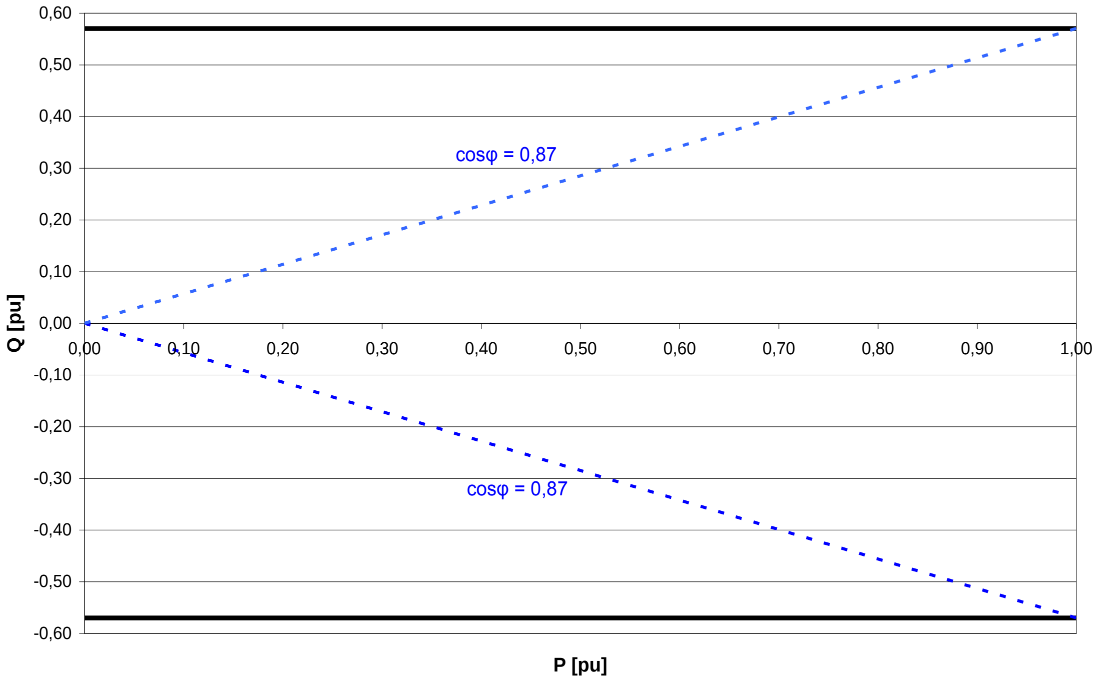

Figure 9-1: Reactive power capability

The above chart applies at the low-voltage side of the HV transformer.

Reactive power capability at full load on the high-voltage side of the HV transformer is approximately cosφ = 0.90/0.83 capacitive/inductive.

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

NOTE The reactive power capability at no-load operation may be reduced up to 50% due to cooling system capacity constraints.

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 in Figure 9-2, p. 27.

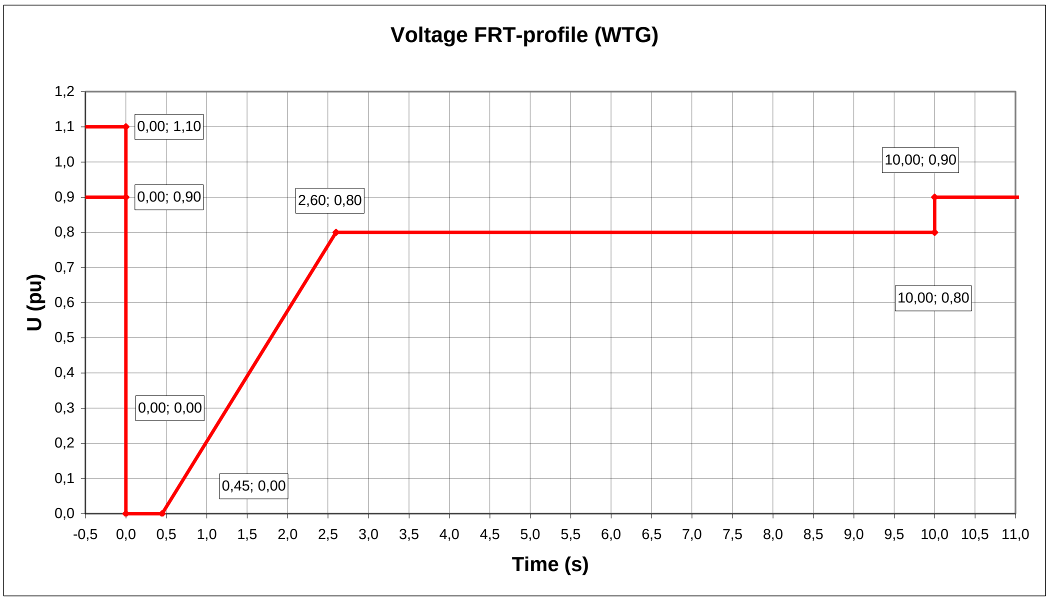

Figure 9-2: Low-voltage tolerance curve for symmetrical and asymmetrical faults.

For grid disturbances outside the protection curve in Figure 9-2, p. 27, 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 wind farm current at the point of common coupling. Figure 9-3 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 9-3, p. 28, the default current injection slope is 2% reactive current increase per 1% voltage decrease. The slope can be parameterized between 2 and 10 to adapt to site specific requirements.

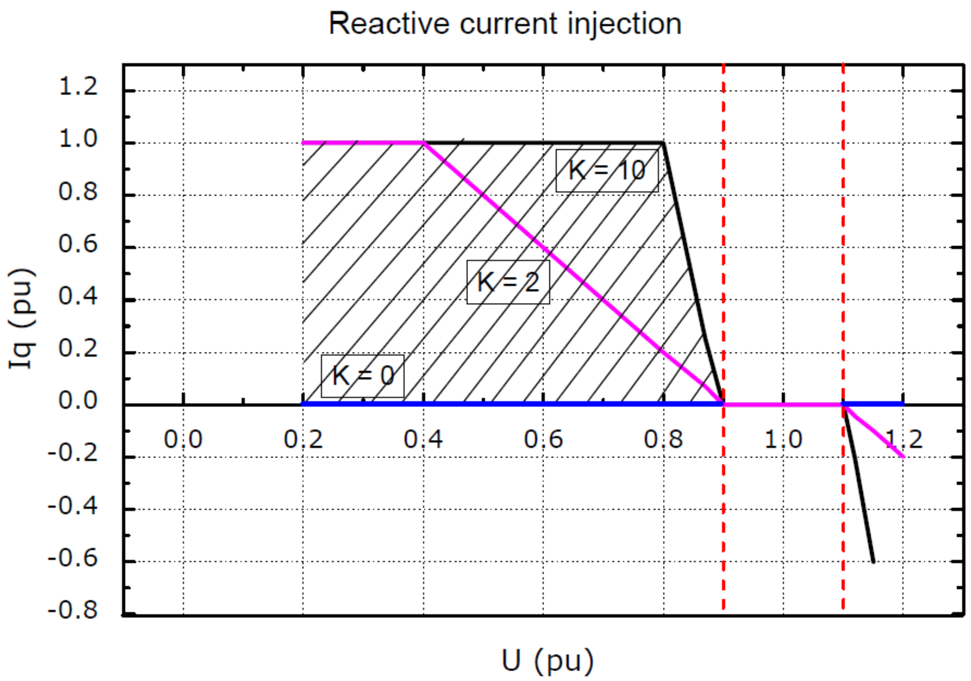

Figure 9-3: Reactive current injection.

9.6.2 Asymmetrical Reactive Current Contribution

Current reference values are controlled for each phase, and current injection follows the requirements for symmetrical current injection.

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. (300 kW/sec.)
Reactive Power	20 pu/sec. (60 MVAr/sec.)

Table 9-7: Active/Reactive Power Ramp Rates.

To protect the turbine, active power cannot be controlled to values below 20% of nominal power for any wind speed.

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).

Deadband and slope for the frequency control function are configurable.

9.11 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.):

Own Consumption	
Hydraulic Motor	2 x 15 kW (master/slave)
Yaw Motors 8 x 2.2 kW	17.6 kW
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	Maximum approximately 3 kW
HV Transformer No-load Loss	Maximum 6.6 kW

Table 9-8: Own consumption data.

9.12 Operational Envelope – Conditions for Power Curve, Noise Levels, C_t Values (at Hub Height)

Consult section 12 , p. 32 for power curves, C_t values, and noise levels.

Conditions for Power Curve, C_t Values, Noise Levels (at Hub Height)	
Wind Shear	0.00-0.30 (10 minute average)
Turbulence Intensity	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage

Conditions for Power Curve, C_t Values, Noise Levels (at Hub Height)	
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ± 2°
Grid Frequency	Nominal Frequency ± 0.5 Hz

Table 9-9: Conditions for power curve, C_t values, and noise levels.

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

To be included in future version of the document

Figure 10-1: Illustration of outer dimensions – structure.

10.2 Structural Design – Side View Drawing

To be included in future version of the document

Figure 10-2: Side-view drawing.

10.3 Structural Design – Centre of Gravity

To be included in future version of the document

Figure 10-3: Centre of gravity.

10.4 Structural Design – Tower Drawing (Example)

To be included in future version of the document

Figure 10-4: Tower design

NOTE Once the foundation is completed, the position of the tower door is fixed to ensure a safe position in relation to the electrical cabinets inside the tower.

10.5 Electrical Design – Main Wiring

To be included in future version of the document

Figure 10-5: Main wiring 50 Hz.

11 General Reservations, Notes and Disclaimers

- The general specifications described in this document apply to the current version of the V112-3.0 MW wind turbine. Updated versions of the V112-3.0 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 V112-3.0 MW wind turbine, Vestas will provide an updated general specifications applicable to the updated version.
- The 60 Hz variant will be available in the USA in Spring 2011 and in Canada in Spring 2012.
- 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

Power Curves in kW for mode 0. Conditions: 650 V on low-voltage side of high-voltage transformer and wind speed given as 10 minute average at hub height.

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	**23**	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	**68**	41	44	46	48	51	53	56	58	61	63	66	71	73
4	**130**	88	92	96	100	104	107	111	115	119	123	126	134	138
4.5	**206**	148	153	158	164	169	174	180	185	190	196	201	212	217
5	**301**	221	228	236	243	250	258	265	272	279	287	294	308	316
5.5	**418**	311	321	330	340	350	359	369	379	389	398	408	427	437
6	**557**	419	432	444	457	469	482	494	507	519	532	544	569	582
6.5	**720**	546	562	578	594	610	626	641	657	673	689	705	736	752
7	**912**	695	715	734	754	774	793	813	833	853	872	892	931	951
7.5	**1130**	865	889	913	938	962	986	1010	1034	1058	1082	1106	1154	1178
8	**1377**	1058	1087	1116	1145	1175	1204	1233	1262	1291	1320	1349	1406	1435
8.5	**1654**	1273	1308	1343	1377	1412	1447	1481	1516	1550	1585	1619	1688	1722
9	**1954**	1509	1549	1590	1631	1671	1712	1752	1793	1833	1873	1914	1994	2034
9.5	**2272**	1762	1809	1856	1903	1950	1997	2043	2090	2136	2181	2226	2315	2358
10	**2572**	2014	2067	2120	2173	2226	2277	2328	2379	2430	2477	2524	2611	2650
10.5	**2808**	2257	2315	2373	2430	2488	2539	2590	2642	2693	2731	2770	2835	2863
11	**2988**	2483	2544	2606	2667	2729	2773	2818	2863	2908	2934	2961	3000	3012
11.5	**3046**	2682	2738	2793	2848	2904	2931	2959	2987	3015	3025	3035	3050	3054
12	**3065**	2847	2886	2926	2965	3004	3017	3029	3041	3054	3057	3061	3067	3069
12.5	**3073**	2960	2982	3004	3026	3048	3052	3057	3062	3067	3069	3071	3073	3074
13	**3075**	3023	3033	3044	3054	3065	3067	3069	3071	3073	3074	3074	3075	3075
13.5	**3075**	3052	3057	3062	3068	3073	3073	3074	3074	3075	3075	3075	3075	3075
14	**3075**	3069	3070	3072	3073	3075	3075	3075	3075	3075	3075	3075	3075	3075
14.5	**3075**	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
15	**3075**	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
15.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

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**
22.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-1: Power curve, noise mode 0.

12.1.2 C_t Values, Noise Mode 0

C_t Values, 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	**0.913**	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913	0.913
3.5	**0.865**	0.867	0.867	0.867	0.867	0.867	0.867	0.866	0.866	0.866	0.866	0.866	0.865	0.865
4	**0.833**	0.834	0.834	0.834	0.834	0.834	0.834	0.833	0.833	0.833	0.833	0.833	0.833	0.832
4.5	**0.821**	0.823	0.823	0.823	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.821	0.821	0.821
5	**0.817**	0.820	0.820	0.820	0.819	0.819	0.819	0.819	0.818	0.818	0.818	0.818	0.817	0.817
5.5	**0.815**	0.818	0.818	0.817	0.817	0.817	0.817	0.816	0.816	0.816	0.816	0.815	0.815	0.814
6	**0.812**	0.816	0.815	0.815	0.815	0.814	0.814	0.813	0.813	0.813	0.812	0.812	0.811	0.811
6.5	**0.808**	0.813	0.812	0.812	0.811	0.811	0.811	0.810	0.810	0.809	0.809	0.808	0.807	0.807
7	**0.804**	0.810	0.810	0.809	0.808	0.808	0.807	0.807	0.806	0.806	0.805	0.805	0.803	0.803
7.5	**0.800**	0.807	0.807	0.806	0.805	0.805	0.804	0.804	0.803	0.802	0.802	0.801	0.799	0.799
8	**0.798**	0.806	0.805	0.804	0.804	0.803	0.802	0.801	0.801	0.800	0.799	0.798	0.797	0.796
8.5	**0.794**	0.803	0.802	0.801	0.801	0.800	0.799	0.798	0.797	0.796	0.796	0.795	0.793	0.792
9	**0.781**	0.791	0.790	0.789	0.789	0.788	0.787	0.786	0.785	0.784	0.783	0.782	0.780	0.779
9.5	**0.755**	0.767	0.767	0.766	0.765	0.764	0.763	0.762	0.761	0.760	0.758	0.756	0.752	0.750
10	**0.711**	0.733	0.732	0.731	0.730	0.729	0.727	0.725	0.723	0.722	0.718	0.715	0.705	0.698
10.5	**0.643**	0.691	0.690	0.688	0.686	0.685	0.681	0.676	0.672	0.668	0.660	0.651	0.633	0.623
11	**0.567**	0.646	0.643	0.640	0.638	0.635	0.627	0.619	0.611	0.603	0.591	0.579	0.554	0.541
11.5	**0.480**	0.597	0.590	0.583	0.576	0.570	0.557	0.545	0.533	0.520	0.507	0.493	0.469	0.457
12	**0.409**	0.542	0.531	0.519	0.508	0.496	0.483	0.470	0.456	0.443	0.432	0.420	0.400	0.390
12.5	**0.353**	0.481	0.468	0.454	0.441	0.428	0.416	0.404	0.393	0.381	0.372	0.362	0.345	0.338
13	**0.308**	0.421	0.408	0.395	0.383	0.370	0.361	0.351	0.341	0.332	0.324	0.316	0.301	0.295
13.5	**0.272**	0.369	0.358	0.347	0.336	0.325	0.317	0.308	0.300	0.292	0.285	0.278	0.266	0.261
14	**0.241**	0.323	0.314	0.305	0.296	0.286	0.279	0.272	0.265	0.258	0.253	0.247	0.236	0.232
14.5	**0.216**	0.286	0.278	0.270	0.263	0.255	0.249	0.243	0.237	0.231	0.226	0.221	0.211	0.207
15	**0.194**	0.255	0.248	0.242	0.235	0.228	0.223	0.217	0.212	0.207	0.203	0.198	0.190	0.186
15.5	**0.175**	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172	0.168
16	**0.159**	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156	0.153
16.5	**0.145**	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142	0.140
17	**0.133**	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130	0.128
17.5	**0.122**	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119	0.117
18	**0.112**	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	**0.103**	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102	0.100
19	**0.096**	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094	0.093
19.5	**0.089**	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088	0.086
20	**0.083**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082	0.080
20.5	**0.077**	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076	0.075
21	**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
21.5	**0.068**	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22	**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
22.5	**0.060**	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
23	**0.056**	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056	0.055
23.5	**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	0.052
24	**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
24.5	**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
25	**0.045**	0.056	0.055	0.054	0.053	0.051	0.050	0.049	0.048	0.048	0.047	0.046	0.044	0.044

Table 12-2: C_t values, noise mode 0.

12.1.3 Noise Curve, Noise Mode 0

Sound Power Level at Hub Height, Noise Mode 0			
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.16** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.7 4.2	94.7 4.3	94.7 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	97.3 5.6	97.5 5.7	98.1 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.9 7.0	101.2 7.2	101.9 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.3 8.4	104.5 8.6	105.1 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.0 9.8	106.5 10.0	106.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 11.2	106.5 11.4	106.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 12.7	106.5 12.9	106.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 14.1	106.5 14.3	106.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 15.5	106.5 15.7	106.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 16.9	106.5 17.2	106.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 18.3	106.5 18.6	106.5 19.3

Table 12-3: Noise curve, noise mode 0

12.2 Mode 1

12.2.1 Power Curves, Noise Mode 1

Power Curves in kW for mode 0. Conditions: 650 V on low-voltage side of high-voltage transformer and wind speed given as 10 minute average at hub height.

Power Curve, Noise Mode 1														
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	**23**	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	**68**	41	44	46	48	51	53	56	58	61	63	66	71	73
4	**130**	88	92	96	99	103	107	111	114	118	122	126	133	137
4.5	**202**	145	150	155	161	166	171	176	181	187	192	197	207	212
5	**291**	214	221	228	235	242	249	256	263	270	277	284	298	305
5.5	**404**	301	311	320	329	339	348	357	367	376	385	394	413	422
6	**540**	407	419	431	443	455	467	480	492	504	516	528	552	564
6.5	**701**	533	548	563	579	594	609	625	640	655	671	686	717	732
7	**891**	681	700	719	738	757	777	796	815	834	853	872	910	929
7.5	**1108**	850	873	897	920	944	968	991	1015	1038	1061	1085	1131	1155
8	**1354**	1042	1070	1099	1127	1156	1184	1213	1241	1270	1298	1326	1383	1411
8.5	**1630**	1257	1291	1325	1359	1393	1427	1461	1494	1528	1562	1596	1663	1697
9	**1931**	1493	1533	1573	1613	1653	1693	1733	1772	1812	1852	1891	1970	2009
9.5	**2251**	1748	1794	1840	1887	1933	1979	2025	2071	2117	2161	2206	2294	2336
10	**2554**	2002	2055	2107	2160	2212	2263	2314	2364	2415	2461	2508	2593	2632
10.5	**2794**	2248	2306	2363	2420	2477	2528	2578	2629	2680	2718	2756	2821	2849
11	**2976**	2476	2536	2596	2656	2716	2760	2804	2848	2893	2920	2948	2988	3001
11.5	**3040**	2677	2730	2784	2837	2890	2919	2948	2977	3006	3017	3028	3044	3049
12	**3063**	2839	2878	2917	2956	2995	3009	3022	3036	3050	3054	3058	3065	3067
12.5	**3072**	2950	2973	2997	3020	3043	3049	3054	3060	3066	3068	3070	3072	3073
13	**3075**	3016	3028	3040	3051	3063	3065	3068	3070	3072	3073	3074	3075	3075
13.5	**3075**	3051	3056	3061	3067	3072	3073	3074	3074	3075	3075	3075	3075	3075
14	**3075**	3068	3070	3071	3073	3075	3075	3075	3075	3075	3075	3075	3075	3075
14.5	**3075**	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
15	**3075**	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
15.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Power Curve, Noise Mode 1														
Air density [kg/m³]														
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**
23.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-4: Power curve, noise mode 1.

12.2.2 C_t Values, Noise Mode 1

C_t Values, Noise Mode 1														
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	**0.913**	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913	0.913
3.5	**0.856**	0.858	0.858	0.858	0.857	0.857	0.857	0.857	0.857	0.857	0.856	0.856	0.856	0.856
4	**0.790**	0.791	0.791	0.791	0.791	0.791	0.790	0.790	0.790	0.790	0.790	0.790	0.789	0.789
4.5	**0.742**	0.742	0.742	0.742	0.743	0.743	0.742	0.742	0.742	0.742	0.742	0.742	0.742	0.741
5	**0.720**	0.721	0.721	0.721	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.719	0.719
5.5	**0.716**	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.716	0.716	0.716	0.716	0.716	0.715
6	**0.720**	0.723	0.723	0.722	0.722	0.722	0.722	0.721	0.721	0.721	0.721	0.720	0.720	0.719
6.5	**0.725**	0.729	0.729	0.729	0.728	0.728	0.728	0.727	0.727	0.726	0.726	0.726	0.725	0.725
7	**0.732**	0.737	0.736	0.736	0.735	0.735	0.735	0.734	0.734	0.733	0.733	0.732	0.732	0.731
7.5	**0.738**	0.744	0.743	0.743	0.742	0.742	0.741	0.741	0.740	0.740	0.739	0.739	0.738	0.737
8	**0.745**	0.751	0.751	0.750	0.750	0.749	0.748	0.748	0.747	0.747	0.746	0.745	0.744	0.743
8.5	**0.749**	0.756	0.756	0.755	0.754	0.754	0.753	0.752	0.752	0.751	0.750	0.749	0.748	0.747
9	**0.746**	0.755	0.754	0.753	0.753	0.752	0.751	0.750	0.750	0.749	0.748	0.747	0.745	0.744
9.5	**0.730**	0.742	0.741	0.740	0.740	0.739	0.738	0.737	0.736	0.735	0.733	0.732	0.728	0.726
10	**0.696**	0.717	0.716	0.715	0.714	0.713	0.712	0.710	0.708	0.706	0.703	0.700	0.690	0.684
10.5	**0.634**	0.682	0.680	0.679	0.677	0.676	0.671	0.667	0.663	0.659	0.651	0.643	0.625	0.615
11	**0.562**	0.641	0.638	0.634	0.631	0.628	0.620	0.612	0.604	0.596	0.585	0.573	0.549	0.537
11.5	**0.478**	0.593	0.585	0.578	0.571	0.564	0.552	0.540	0.529	0.517	0.504	0.491	0.467	0.456
12	**0.408**	0.538	0.527	0.516	0.505	0.494	0.481	0.468	0.455	0.442	0.431	0.419	0.399	0.390
12.5	**0.353**	0.477	0.464	0.452	0.439	0.427	0.415	0.404	0.392	0.381	0.371	0.362	0.345	0.337
13	**0.308**	0.418	0.406	0.394	0.382	0.370	0.360	0.351	0.341	0.331	0.324	0.316	0.301	0.295
13.5	**0.272**	0.369	0.358	0.347	0.336	0.325	0.316	0.308	0.300	0.292	0.285	0.278	0.266	0.260
14	**0.241**	0.323	0.314	0.305	0.296	0.286	0.279	0.272	0.265	0.258	0.253	0.247	0.236	0.232
14.5	**0.216**	0.286	0.278	0.270	0.263	0.255	0.249	0.243	0.237	0.231	0.226	0.221	0.211	0.207
15	**0.194**	0.255	0.248	0.242	0.235	0.228	0.223	0.217	0.212	0.207	0.203	0.198	0.190	0.186
15.5	**0.175**	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172	0.168
16	**0.159**	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156	0.153
16.5	**0.145**	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142	0.140
17	**0.133**	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130	0.128
17.5	**0.122**	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119	0.117
18	**0.112**	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	**0.103**	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102	0.100
19	**0.096**	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094	0.093
19.5	**0.089**	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088	0.086
20	**0.083**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082	0.080
20.5	**0.077**	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076	0.075
21	**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
21.5	**0.068**	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22	**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
22.5	**0.060**	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
23	**0.056**	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056	0.055
23.5	**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	0.052
24	**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
24.5	**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
25	**0.045**	0.056	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044

Table 12-5: C_t values, noise mode 1.

12.2.3 Noise Curve, Noise Mode 1

Sound Power Level at Hub Height, Noise Mode 1			
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.16** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.3 4.2	94.3 4.3	94.4 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	96.5 5.6	96.5 5.7	97.0 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	99.8 7.0	100.2 7.2	100.8 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.2 8.4	103.5 8.6	104.3 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.0 9.8	106.5 10.0	106.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 11.2	106.5 11.4	106.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 12.7	106.5 12.9	106.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 14.1	106.5 14.3	106.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 15.5	106.5 15.7	106.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 16.9	106.5 17.2	106.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 18.3	106.5 18.6	106.5 19.3

Table 12-6: Noise curve, noise mode 1.

12.3 Mode 2

12.3.1 Power Curves, Noise Mode 2

Power Curves in kW for mode 0. Conditions: 650 V on low-voltage side of high-voltage transformer and wind speed given as 10 minute average at hub height.

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	**23**	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	**68**	41	44	46	48	51	53	56	58	61	63	66	71	73
4	**130**	88	92	96	100	104	107	111	115	119	123	126	134	138
4.5	**206**	148	153	158	164	169	174	180	185	190	196	201	212	217
5	**301**	221	228	236	243	250	257	265	272	279	286	294	308	315
5.5	**417**	311	321	330	340	350	359	369	378	388	398	407	427	436
6	**556**	419	431	444	456	469	481	494	506	518	531	543	568	581
6.5	**719**	546	561	577	593	609	625	640	656	672	688	703	735	751
7	**910**	694	714	733	753	773	792	812	832	851	871	890	929	949
7.5	**1127**	863	887	911	935	960	983	1007	1031	1055	1079	1103	1151	1174
8	**1370**	1053	1082	1111	1140	1169	1197	1226	1255	1284	1312	1341	1398	1427
8.5	**1632**	1259	1293	1327	1361	1395	1429	1463	1497	1531	1564	1598	1665	1699
9	**1905**	1474	1513	1553	1592	1632	1671	1710	1749	1788	1827	1866	1944	1983
9.5	**2180**	1692	1736	1781	1826	1871	1915	1959	2004	2048	2092	2136	2222	2265
10	**2436**	1898	1948	1998	2048	2098	2147	2196	2245	2294	2341	2389	2479	2522
10.5	**2660**	2093	2147	2201	2256	2310	2362	2415	2467	2519	2566	2613	2695	2730
11	**2845**	2278	2336	2394	2452	2510	2563	2616	2669	2722	2763	2804	2868	2890
11.5	**2952**	2453	2512	2572	2632	2691	2737	2783	2828	2874	2900	2926	2964	2975
12	**3012**	2623	2678	2733	2788	2843	2875	2908	2940	2973	2986	2999	3017	3022
12.5	**3045**	2781	2824	2868	2912	2955	2973	2991	3009	3026	3032	3038	3046	3048
13	**3060**	2910	2937	2964	2991	3019	3027	3036	3044	3053	3055	3058	3061	3061
13.5	**3069**	2982	2999	3015	3031	3048	3052	3057	3061	3065	3066	3068	3069	3069
14	**3073**	3033	3041	3049	3057	3065	3066	3068	3070	3071	3072	3072	3073	3073
14.5	**3074**	3059	3062	3065	3068	3071	3072	3072	3073	3074	3074	3074	3074	3074
15	**3075**	3069	3070	3071	3073	3074	3074	3074	3074	3075	3075	3075	3075	3075
15.5	**3075**	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

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**
23.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	**3075**	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-7: Power curve, noise mode 2.

12.3.2 C_t Values, Noise Mode 2

C_t Values, Noise Mode 2													
Air density [kg/m³]													
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**
3	**0.913**	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913
3.5	**0.865**	0.867	0.867	0.867	0.867	0.866	0.866	0.866	0.866	0.866	0.866	0.865	0.865
4	**0.826**	0.827	0.827	0.827	0.827	0.827	0.827	0.827	0.826	0.826	0.826	0.826	0.826
4.5	**0.808**	0.810	0.810	0.810	0.810	0.809	0.809	0.809	0.809	0.809	0.808	0.808	0.808
5	**0.802**	0.805	0.804	0.804	0.804	0.804	0.803	0.803	0.803	0.803	0.802	0.802	0.802
5.5	**0.798**	0.800	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.798	0.798	0.798	0.797
6	**0.795**	0.799	0.798	0.798	0.798	0.797	0.797	0.797	0.796	0.796	0.796	0.795	0.795
6.5	**0.792**	0.797	0.796	0.796	0.795	0.795	0.794	0.794	0.794	0.793	0.793	0.792	0.791
7	**0.789**	0.794	0.794	0.793	0.793	0.792	0.792	0.791	0.791	0.790	0.790	0.789	0.788
7.5	**0.782**	0.789	0.789	0.788	0.787	0.787	0.786	0.786	0.785	0.784	0.784	0.783	0.782
8	**0.771**	0.779	0.778	0.777	0.777	0.776	0.775	0.775	0.774	0.773	0.773	0.772	0.770
8.5	**0.751**	0.758	0.758	0.757	0.756	0.756	0.755	0.754	0.754	0.753	0.752	0.751	0.750
9	**0.719**	0.727	0.726	0.725	0.725	0.724	0.723	0.722	0.722	0.721	0.720	0.720	0.718
9.5	**0.678**	0.685	0.685	0.684	0.683	0.683	0.682	0.681	0.681	0.680	0.679	0.678	0.676
10	**0.629**	0.638	0.637	0.637	0.636	0.636	0.635	0.634	0.633	0.633	0.631	0.630	0.627
10.5	**0.575**	0.588	0.588	0.587	0.587	0.586	0.585	0.584	0.583	0.582	0.580	0.577	0.570
11	**0.517**	0.541	0.541	0.540	0.539	0.538	0.536	0.535	0.533	0.531	0.526	0.522	0.509
11.5	**0.455**	0.497	0.496	0.495	0.494	0.492	0.489	0.485	0.481	0.477	0.470	0.462	0.446
12	**0.398**	0.459	0.456	0.453	0.450	0.448	0.441	0.435	0.429	0.423	0.414	0.406	0.389
12.5	**0.348**	0.423	0.418	0.413	0.409	0.404	0.396	0.388	0.380	0.372	0.364	0.356	0.341
13	**0.306**	0.388	0.381	0.374	0.367	0.360	0.352	0.344	0.336	0.328	0.320	0.313	0.299
13.5	**0.271**	0.350	0.343	0.335	0.327	0.320	0.312	0.305	0.298	0.290	0.284	0.277	0.265
14	**0.241**	0.315	0.308	0.300	0.292	0.285	0.278	0.271	0.265	0.258	0.252	0.247	0.236
14.5	**0.216**	0.283	0.276	0.269	0.261	0.254	0.248	0.242	0.236	0.230	0.226	0.221	0.211
15	**0.194**	0.254	0.247	0.241	0.234	0.228	0.223	0.217	0.212	0.207	0.202	0.198	0.190
15.5	**0.175**	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172
16	**0.159**	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156
16.5	**0.145**	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142
17	**0.133**	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130
17.5	**0.122**	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119
18	**0.112**	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110
18.5	**0.103**	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102
19	**0.096**	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094
19.5	**0.089**	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088
20	**0.083**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082
20.5	**0.077**	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076
21	**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
21.5	**0.068**	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067
22	**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
22.5	**0.060**	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059
23	**0.056**	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056
23.5	**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
24	**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
24.5	**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
25	**0.045**	0.056	0.055	0.054	0.053	0.051	0.050	0.049	0.048	0.048	0.047	0.046	0.044

Wind speed [m/s]	**1.275**
3	0.913
3.5	0.865
4	0.825
4.5	0.808
5	0.802
5.5	0.797
6	0.794
6.5	0.791
7	0.787
7.5	0.781
8	0.770
8.5	0.749
9	0.717
9.5	0.675
10	0.624
10.5	0.565
11	0.501
11.5	0.438
12	0.381
12.5	0.333
13	0.293
13.5	0.260
14	0.231
14.5	0.207
15	0.186
15.5	0.168
16	0.153
16.5	0.140
17	0.128
17.5	0.117
18	0.108
18.5	0.100
19	0.093
19.5	0.086
20	0.080
20.5	0.075
21	0.070
21.5	0.066
22	0.062
22.5	0.058
23	0.055
23.5	0.052
24	0.049
24.5	0.046
25	0.044

Table 12-8: C_t values, noise mode 2.

12.3.3 Noise Curve, Noise Mode 2

Sound Power Level at Hub Height, Noise Mode 2			
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.16** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.7 4.2	94.7 4.3	94.7 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	97.3 5.6	97.5 5.7	98.1 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.9 7.0	101.2 7.2	101.9 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 8.4	104.5 8.6	104.5 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 9.8	104.5 10.0	104.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 11.2	104.5 11.4	104.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 12.7	104.5 12.9	104.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 14.1	104.5 14.3	104.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 15.5	104.5 15.7	104.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 16.9	104.5 17.2	104.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 18.3	104.5 18.6	104.5 19.3

Table 12-9: Noise curve, noise mode 2.