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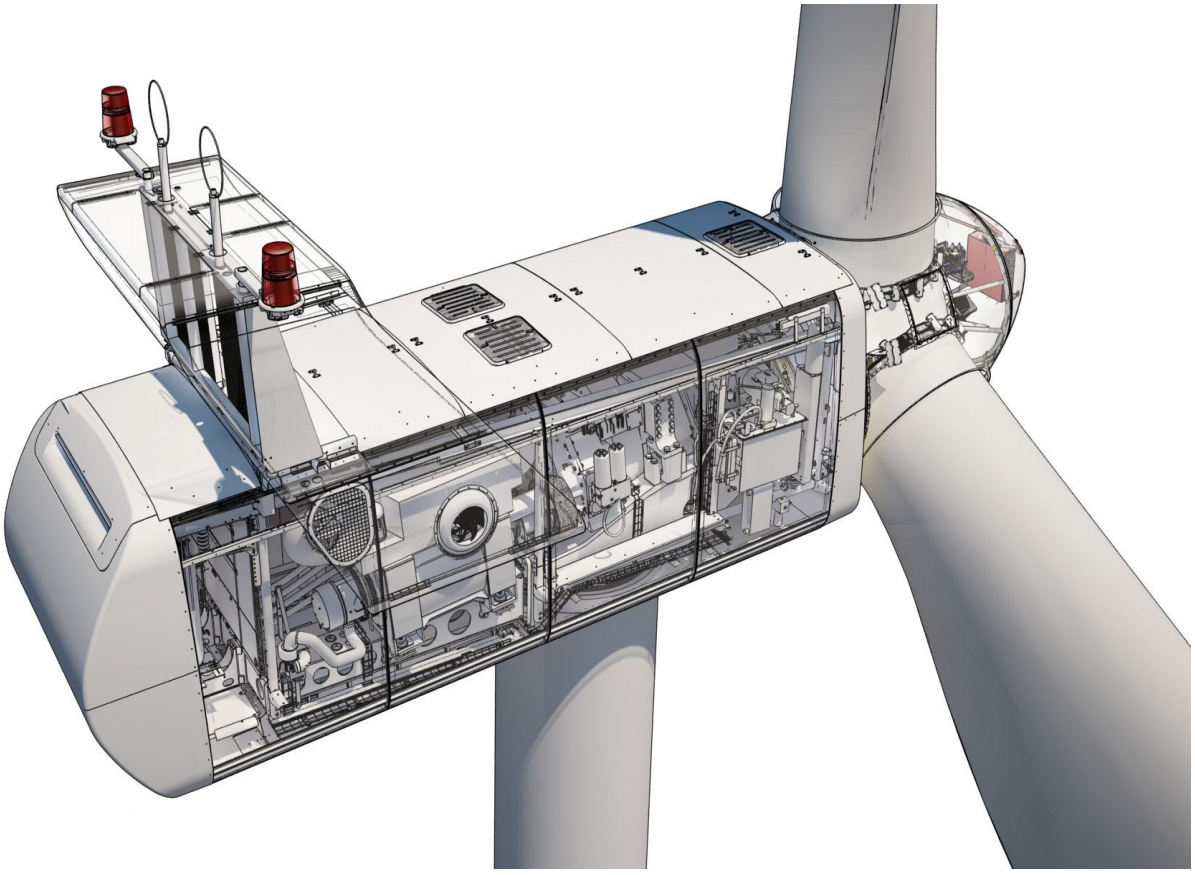
General Specification

V80-2.0 MW 50 Hz VCS



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See section 11 General Reservations, Notes and Disclaimers, p. 39 for general reservations, notes, and disclaimers applicable to these general specifications.

1 General Description

The Vestas V80-2.0 MW wind turbine is a pitch-regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V80-2.0 MW turbine has a rotor diameter of 80 m with a generator rated at 2.0 MW. The turbine utilises the OptiTip® and the OptiSpeed™ concepts. With these features, the wind turbine is able to operate the rotor at variable speed (rpm), helping to maintain the output at or near rated power.

2 Mechanical Design

2.1 Rotor

The V80-2.0 MW is equipped with an 80 metre rotor consisting of three blades and the hub. Based on the prevailing wind conditions, the blades are continuously positioned to help optimise the pitch angle.

Rotor	
Diameter	80 m
Swept Area	5027 m^2
Rotational Speed Static, Rotor	16.7 rpm
Speed, Dynamic Operation Range	10.8–19.1 rpm
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Hub Coning	2°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data

2.2 Blades

The 39 m Prepreg (PP) blades are made of epoxy and fibreglass and consist of two airfoil shells bonded to a supporting beam.

PP Blades	
Type Description	Airfoil shells bonded to supporting beam
Blade Length	39 m
Material	Fibreglass reinforced epoxy
Blade Connection	Steel roots inserted

PP Blades	
Air Foils	NACA63.xxx+FFA-W3
Largest Chord	3.372 m
Weight	6600 kg

Table 2-2: PP blades data

2.3 Blade Bearing

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

Blade Bearing	
Type	Double-row four-point contact ball bearing
Lubrication	Grease lubrication, manually re-greased

Table 2-3: Blade bearing data

2.4 Pitch System

The energy input from the wind to the turbine is adjusted by pitching the blades according to the control strategy. The pitch system also works as the primary brake system by pitching the blades out of the wind. This causes the rotor to idle.

Double-row four-point contact ball bearings are used to connect the blades to the hub. The pitch system relies on hydraulics and uses a cylinder to pitch each blade. Hydraulic power is supplied to the cylinder from the hydraulic power unit in the nacelle through the main gearbox and the main shaft via a rotating transfer.

Hydraulic accumulators inside the rotor hub ensure sufficient power to pitch the turbine in case of failure.

Pitch System	
Type	Hydraulic
Cylinder	Ø125/80–760
Number	1 piece/ blade
Range	-5º to 90º

Table 2-4: Pitch system data

Hydraulic System	
Pump Capacity	44 l/min.
Working Pressure	180-200 bar
Oil Quantity	260 l
Motor	18.5 kW

Table 2-5: Hydraulic system data

2.5 Hub

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

Hub	
Type	Cast ball shell hub
Material	Cast iron EN GJS 400-18U-LT / EN 1560

Table 2-6: Hub data

2.6 Main Shaft

Main Shaft	
Type	Forged, trumpet shaft
Material	42 CrMo4 QT / EN 10083

Table 2-7: Main shaft data

2.7 Bearing Housing

Bearing Housing	
Type	Cast foot housing with lowered centre
Material	Cast iron EN-GJS-400-18U-LT / EN 1560

Table 2-8: Bearing housing data

2.8 Main Bearings

Main Bearings	
Type	Spherical roller bearings
Lubrication	Grease lubrication, manually re-greased

Table 2-9: Main bearings data

2.9 Gearbox

The main gearbox transmits rotational torque from the rotor to the generator.

The main gearbox consists of a planetary stage combined with a two-stage parallel gearbox, torque arms, and vibration dampers.

Torque is transmitted from the high-speed shaft to the generator via a flexible composite coupling, located behind the disc brake. The disc brake is installed directly on the high-speed shaft.

Gearbox	
Type	1 planetary stage / 2 helical stages
Ratio	1:100.6 nominal
Cooling	Oil pump with oil cooler
Oil Heater	2 kW
Maximum Gear Oil Temperature	80°C
Oil Cleanliness	-/15/12 ISO 4406

Table 2-10: Gearbox data

2.10 Generator Bearings

The bearings are greased and grease is supplied continuously from an automatic lubrication unit when the nacelle temperature is above -10°C. The yearly grease flow is approximately 2400 cm³.

2.11 High-Speed Shaft Coupling

The flexible coupling transmits the torque from the gearbox high-speed output shaft to the generator input shaft. The flexible coupling is designed to compensate misalignments between gearbox and generator. The coupling consists of two composite discs and an intermediate tube with two aluminium flanges and a fibreglass tube. The coupling is fitted to three-armed hubs on the brake disc and the generator hub.

High-Speed Shaft Coupling	
Type Description	VK 420

Table 2-11: High-speed shaft coupling data

2.12 Yaw System

The yaw system is designed to keep the turbine upwind. The nacelle is installed on the yaw plate, which is bolted to the turbine tower. The yaw bearing system is a plain bearing system with built-in friction. Asynchronous yaw motors with brakes enable the nacelle to rotate on top of the tower.

The turbine controller receives information about the wind direction from the wind sensor. Automatic yawing is deactivated when the mean wind speed is below 3 m/s.

Yaw System	
Type	Plain bearing system with built-in friction
Material	Forged yaw ring heat-treated Plain bearings PETP
Yawing Speed	< 0.5˚/second

Table 2-12: Yaw system data

Yaw Gear	
Type	Non-locking combined worm gear and planetary gearbox Electrical motor brake
Motor	1.5 kW, 6 pole, asynchronous
Number of Yaw Gears	6
Ratio Total (Four Planetary Stages)	1,120 : 1
Rotational Speed at Full Load	Approximately 1 rpm at output shaft

Table 2-13: Yaw gear data

2.13 Crane

The nacelle houses the service crane. The crane is a single system chain hoist.

Crane	
Lifting Capacity	Maximum 800 kg

Table 2-14: Crane data

2.14 Tower Structure

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. Magnets provide load support in a horizontal direction for tower internals, such as platforms, ladders, and such like. Tower internals are supported vertically (that is in the gravitational direction) by a mechanical connection.

The hub heights listed include a distance from the foundation section to the ground level of approximately 0.6 m depending on the thickness of the bottom flange and a distance from the tower top flange to the centre of the hub of 1.70 m.

Tower Structure	
Type Description	Conical tubular
Hub Heights	IEC IA: 60 m/67 m/78 m IEC IIA: 60 m/67 m/80 m
Material	S355 according to EN 10024 A709 according to ASTM

Tower Structure	
Weight *	60 m IEC IA: 137 metric tonnes 67 m IEC IA: 116 metric tonnes 78 m IEC IA: 153 metric tonnes 60 m IEC IIA: 88 metric tonnes 67 m IEC IIA: 116 metric tonnes 80 m IEC IIA: 148 metric tonnes

Table 2-15: Tower structure data

NOTE * Typical values. Dependent on wind class, and can vary with site / project conditions.

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 is equipped with wind sensors and skylights which can be opened from inside the nacelle to access the roof and from outside to access the nacelle. The nacelle cover is installed on the girder structure. 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, which 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 nacelle bedplate carries the crane girders through vertical beams positioned along the side of the nacelle. Lower beams of the girder structure are connected at the rear end.

The rear part of the bedplate serves as foundation for controller panels, generator, and transformer.

Type Description	Material
Nacelle Cover	GRP
Bedplate Front	Cast iron EN-GJS-400-18U-LT / EN 1560
Bedplate Rear	Welded grid structure

Table 2-16: Nacelle bedplate and cover data

2.16 Cooling

The cooling of the main components (gearbox, hydraulic power pack, and VCS converter) in the turbine is done by a water cooling system. The generator is air cooled by nacelle air and the high-voltage (HV) transformer is cooled by mainly ambient air.

Component	Cooling Type	Internal Heating at Low Temperature
Nacelle	Forced air	Yes
Hub/Spinner	Natural air	No (Yes for low temperature (LT) turbines)
Gearbox	Water/oil	Yes
Generator	Forced air/air	No (heat source)
Slip Rings	Forced air/air	Yes
Transformer	Forced air	No (heat source)
VCS	Forced water/air	Yes
VMP Section	Forced air/air	Yes
Hydraulics	Water/oil	Yes

Table 2-17: Cooling, summary

All other heat-generating systems are also equipped with fans and/or coolers but are considered as minor contributors to nacelle thermodynamics.

2.17 Water Cooling System

The water cooling system is designed as a semi-closed system (closed system but not under pressure) with a free wind water cooler on the roof of the nacelle. This means that the heat loss from the systems (components) is transferred to the water system, and the water system is cooled by ambient air.

The water cooling system has three parallel cooling circuits that cool the gearbox, the hydraulic power unit, and the VCS converter.

The water cooling system is equipped with a three-way thermostatic valve. The valve is closed (total water flow bypassing the water cooler) if the temperature of the cooling water is below 35°C and fully open (total water flow led to the water cooler) if the temperature is above 43°C.

2.18 Gearbox Cooling

The gearbox cooling system consists of two oil circuits that remove the gearbox losses through two plate heat exchangers (oil coolers). The first circuit is equipped with a mechanically driven oil pump and a plate heat exchanger. The second circuit is equipped with an electrically driven oil pump and a plate heat exchanger. The water circuit of the two plate heat exchangers is coupled in serial.

Gearbox Cooling	
Gear Oil Plate Heat Exchanger 1 (Mechanically Driven Oil Pump)	
Nominal Oil Flow	50 l/min
Oil Inlet Temperature	80°C
Number of Passes	2

Gearbox Cooling	
Cooling Capacity	24.5 kW
Gear Oil Plate Heat Exchanger 2 (Electrically Driven Oil Pump)	
Nominal Oil Flow	85 l/min
Oil Inlet Temperature	80°C
Number of Passes	2
Cooling Capacity	41.5 kW
Water Circuit	
Nominal Water Flow	Approximately 150 l/min. (50% glycol)
Water Inlet Temperature	Maximum 54°C
Number of Passes	1
Heat Load	66 kW

Table 2-18: Cooling, gearbox data

2.19 Hydraulic Cooling

The hydraulic cooling system consists of a plate heat exchanger that is installed on the power pack. In the plate heat exchanger, the heat from the hydraulics is transferred to the water cooling system.

Hydraulic Cooling	
Hydraulic Oil Plate Heat Exchanger	
Nominal Oil Flow	40 l/min
Oil Inlet Temperature	66°C
Cooling Capacity	10.28 kW
Water Circuit	
Nominal Water Flow	Approximately 45 l/min (50% glycol)
Water Inlet Temperature	Maximum 54°C
Heat Load	10.28 kW

Table 2-19: Cooling, hydraulic data

2.20 VCS Converter Cooling

The converter cooling system consists of a number of switch modules which are installed on cooling plates where the cooling water is led through.

Converter Cooling	
Nominal Water Flow	Approximately 45 l/min (50% glycol)

Converter Cooling	
Water Inlet Pressure	Maximum 2.0 bar
Water Inlet Temperature	Maximum 54ºC
Cooling Capacity	10 kW

Table 2-20: Cooling, converter data

2.21 Generator Cooling

The generator cooling system consists of an air-to-air cooler installed on the top of the generator to remove the internal losses in the generator, two internal fans, and one external fan. All of the fans can run at low or high speed.

Generator Cooling	
Air Inlet Temperature: External	50°C
Nominal Air Flow: Internal	8000 m^3/h
Nominal Air Flow: External	7500 m^3/h
Cooling Capacity	60 kW

Table 2-21: Cooling, generator data

2.22 HV Transformer Cooling

The transformer is equipped with forced-air cooling. The cooling system consists of a central fan that is located under the service floor, an air distribution manifold and six hoses leading to locations beneath and between the HV and LV windings.

Transformer Cooling	
Nominal Air Flow	1920 m^3/h
Air Inlet Temperature	Maximum 40°C

Table 2-22: Cooling, transformer data

2.23 Nacelle Conditioning

The nacelle conditioning system consists of one fan and two air heaters. There are two main circuits of the nacelle conditioning system:

1. Cooling of the HV transformer
2. Heating and ventilation of the nacelle

For both systems, the airflow enters the nacelle through louver dampers in the weather shield underneath the nacelle.

The cooling of the HV transformer is described in section 2.22 HV Transformer Cooling, p. 13.

The heating and ventilation of the nacelle is done by means of two air heaters and one fan. To avoid condensation in the nacelle, the two air heaters keep the nacelle temperature +5°C above the ambient temperature. At start-up in cold conditions, the heaters will also heat the air around the gearbox.

The ventilation of the nacelle is done by means of one fan, removing hot air from the nacelle that is generated by mechanical and electrical equipment.

Nacelle Cooling	
Nominal Air Flow	1.2 m^3/s
Air Inlet Temperature	Maximum 50°C

Table 2-23: Cooling, nacelle data

Nacelle Heating	
Rated Power	2 x 6 kW

Table 2-24: Heating, nacelle data

3 Electrical Design

3.1 Generator

The generator is a three-phase asynchronous generator with wound rotor that is connected to the Vestas Converter System (VCS) via a slip-ring system. The generator is an air-to-air cooled generator with an internal and external cooling circuit. The external circuit uses air from the nacelle and expels it as exhaust out the rear end of the nacelle.

The generator has four poles, and is wound with form windings in both rotor and stator. The stator is connected in star at low power and delta at high power. The rotor is connected in star and is insulated from the shaft.

Generator	
Type Description	Asynchronous with wound rotor, slip rings, and VCS
Rated Power (PN)	2.0 MW
Rated Apparent Power	2.08 MVA (Cosφ = 0.96)
Frequency	50 Hz
Voltage, Generator	690 VAC
Voltage, Converter	480 VAC
Number of Poles	4
Winding Type (Stator/Rotor)	Random/Form
Winding Connection, Stator	Star/Delta
Rated Efficiency (Generator Only)	> 97%
Power Factor (cos)	0.96 ind – 0.98 cap

Generator	
Overspeed Limit According to IEC (2 Minutes)	2900 rpm
Vibration Level	≤ 1.8 mm/s
Weight	Approximately 8100 kg
Generator Bearing - Temperature	2 PT100 sensors
Generator Stator Windings - Temperature	3 PT100 sensors placed at hot spots and 3 as backup

Table 3-1: Generator data

3.2 HV Cables

The high-voltage cable runs from the transformer in the nacelle down the tower to the switchgear located in the bottom of the tower (switchgear is not included). 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	3x70/70 mm^2
Rated Voltage	12/20 kV (24 kV) or 20/35 kV (42 kV) depending on the transformer voltage

Table 3-2: HV cables data

3.3 Transformer

The step-up 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.

Transformer	
Type Description	Dry-type cast resin transformer.
Basic Layout	3 phase, 2 winding transformer with a tap on low voltage winding.
Applied Standards	IEC 60076-11, IEC 60076-16, Cenelec HD 637:S1.
Cooling Method	AF
Rated Power HV / LV1 / LV2	2100 / 1900 / 200 kVA
Nominal Voltage, Turbine Side LV1 / LV2	
U_m 1.1 kV	0.690 / 0.480 kV

Transformer	
Nominal Voltage, Grid Side	
U_m 12.0 kV	6.0-11.0 kV
U_m 24.0 kV	11.1-22.0 kV
U_m 36.0 kV	22.1-33.0 kV
U_m 41.5 kV	33.1-35.0 kV
Insulation Level AC / LI / LIC	
U_m 1.1 kV	3[1] / - / - kV
U_m 12.0 kV	28[1] / 75 / 75 kV
U_m 24.0 kV	50[1] / 125 / 125 kV
U_m 36.0 kV	70[1] / 170 / 170 kV
U_m 41.5 kV	80[1] / 170 / 170 kV
Off-Circuit Tap Changer	±2 x 2.5%
Frequency	50 Hz
Vector Group	Dyn5 / YNyn0
No-Load Loss[2]	4.0 kW
Load Loss @ Rated Power HV, 120°C [2]	19.0 kW
No-Load Reactive Power[3]	16 kVAr
Full Load Reactive Power [3]	220 kVAr
Positive Sequence Short-Circuit Impedance @ Rated Power LV1, 120°C[4]	
U_m 12.0-36.0 kV	7.8%
U_m 41.5 kV	9.0%
Positive Sequence Short-Circuit Resistance @ Rated Power LV1, 120°C[3]	
U_m 12.0-36.0 kV	0.8%
U_m 41.5 kV	0.9%
Zero Sequence Short-Circuit Impedance @ Rated Power LV1, 120°C[3]	
U_m 12.0-36.0 kV	7.3%
U_m 41.5 kV	8.5%

[1] @1000m. According to IEC 60076-11, AC test voltage is altitude dependent.

[2] Based on an average of measured values during qualification tests across voltages and manufacturers.

[3] Based on an average of calculated values across voltages and manufacturers.

[4] Subject to standard IEC tolerances.

Transformer	
Zero Sequence Short-Circuit Resistance @ Rated Power LV1, 120°C [3]	
U_m 12.0-36.0 kV	0.8%
U_m 41.5 kV	0.8%
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	≤ 83 dB(A)
Average Temperature Rise @ 1000m	≤ 80 K
Max Altitude[5]	2100 m
Insulation Class	155 (F)
Environmental Class	E2
Climatic Class	C2
Fire Behaviour Class	F1
Corrosion Class	C4
Weight	≤ 5500 kg
Temperature Monitoring	PT100 sensors in LV windings
Overvoltage Protection	Surge arresters on HV terminals
Temporary Earthing	3 x Ø20mm earthing ball points

Table 3-3: Transformer data

3.4 Converter

The converter controls the energy conversion in the generator. The VCS converter feeds power from the grid into the generator rotor at sub-sync speed and feeds power from the generator rotor to the grid at super-sync speed.

Converter	
Rated Slip	12%
Rated rpm	1680 rpm
Rated Rotor Power (@rated slip)	214 kW
Rated Grid Current (@ rated slip, PF = 1 and 480V)	258 A
Rated Rotor Current (@ rated slip and PF = 1)	636 A

Table 3-4: Converter data

[5] Maximum hub height altitude will depend on site location.

3.5 AUX System

The AUX system is supplied from the 690/480 V socket from the HV transformer. All motors, pumps, fans and heaters are supplied from this system.

All 230 V power sockets are supplied from a 690/230 V transformer.

Power Sockets	
Single Phase	230 V (13 A)
Three Phase	690 V (16 A)

Table 3-5: AUX system data

3.6 Wind Sensors

The turbine is equipped with two ultrasonic wind sensors with built-in heaters.

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

Table 3-6: Wind sensor data

3.7 Turbine Controller

The turbine is controlled and monitored by the System 3500 controller hardware and VMP (Vestas Multi Processor) Global controller software.

The turbine controller is based on four main processors (ground, nacelle, hub, and converter) which are interconnected by an optically based 2.5 Mbit ARCNET network.

I/O modules are connected either as rack modules in the System 3500 rack or by CAN.

The turbine control system serves the following main functions:

- Monitoring and supervision of overall operation
- Synchronizing of the generator to the grid during connection sequence in order to limit the inrush current
- Operating the wind turbine during various fault situations
- Automatic yawing of the nacelle
- OptiTip® - blade pitch control
- Noise emission control
- Monitoring of ambient conditions
- Monitoring of the grid

The turbine controller hardware is built from the following main modules:

Module	Function	Network
CT3603	Main processor. Control and monitoring (nacelle and hub)	ARCNET, CAN, Ethernet, serial
CT396	Main processor. Control, monitoring, external communication (ground)	ARCNET, CAN, Ethernet, serial
CT360	Main processor. Converter control and monitoring	ARCNET, CAN, Ethernet
CT3218	Counter/encoder module. RPM, azimuth, and wind measurement	Rack module
CT3133	24 VDC digital input module. 16 channels	Rack module
CT3153	24 VDC digital output module. 16 channels	Rack module
CT3320	Four-channel analogue input (0-10 V, 4-20 mA, PT100)	Rack module
CT6061	CAN I/O controller	CAN node
CT6221	Three-channel PT100 module	CAN I/O module
CT6050	Blade controller	CAN node
Balluff	Position transducer	CAN node
Rexroth	Proportional valve	CAN node

Table 3-7: Turbine controller hardware

3.8 Uninterruptible Power Supply (UPS)

The UPS supplies power to critical wind turbine components.

The actual 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 online	
Rated Output Voltage	230 VAC	
Converter Input	230 V ±20%	
Backup Time*	Controller system	30 seconds
	Safety systems	35 minutes
Re-Charging Time	Typical	Approximately 2.5 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 feathering the three blades. During emergency stop, all three blades will feather simultaneously to full-end stop, thereby slowing the rotor speed.

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

4.2 Short Circuit Protections

Breakers	**Generator / Q8 ABB E2B 2000 690 V**	**Controller / Q15 ABB S3X 690 V**	**VCS-VCUS / Q7 ABB S5H 400 480 V**
Breaking Capacity I_{cu}, I_{cs}	42, 42 kA	75, 75 kA	40, 40 kA
Making Capacity I_{cm} (415V Data)	88 kA	440 kA	143 kA
Thermo Release I_{th}	2000 A	100 A	400 A

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 in order to protect against over-speed and rotating errors.

The turbine is also equipped with a VOG (Vestas Overspeed Guard), which is an independent computer module that measures the rotor rpm. In case of an overspeed situation, the VOG activates the emergency feathered position (full feathering) of the three blades.

Overspeed Protection	
VOG Sensors Type	Inductive
Trip Levels	17.8 (Rotor rpm) / 2013 (Generator rpm)

Table 4-2: Overspeed protection data

4.4 EMC System

The turbine and related equipment must fulfil the EU Electromagnetic Compatibility (EMC)-Directive with later amendments, including Council Directive 2004/108/EC of December 2004 on the approximation of the laws of the Member States relating to Electromagnetic Compatibility.

4.5 Lightning Protection System

The Lightning Protection System (LPS) consists of three main parts.

- Lightning receptors
- Down conducting system
- Earthing System

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

Table 4-3: Lightning design parameters

NOTE The Lightning Protection System is designed according to IEC standards. See section 7.7 Design Codes – Lightning Protection, p. 27.

4.6 Earthing

Separate documents describe the earthing system for each type of turbine foundation in detail.

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.

4.7 Corrosion Protection

Classification of corrosion categories for atmospheric corrosion is according to ISO 9223:1992.

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

5 Safety

The safety specifications in this safety 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, (c) conducting all appropriate safety training and education and (d) reading and understanding all safety-related manuals and instructions. See section 5.13 Manuals and Warnings, p. 24 for additional guidance.

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.

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

Escape from the service lift is by ladder.

5.3 Rooms / Working Areas

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

5.4 Platforms, Standing, and Working Places

The bottom tower section has two platforms. There is one platform at the entrance level (door level) and a platform in the top of the tower section.

Each middle tower section has one platform in the top of the tower section.

The top tower section has two platforms, a top platform and a service lift platform where the service lift stops below the top platform.

There are places to stand at various locations along the ladder.

The platforms have anti-slip surfaces.

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 or wire system) is installed through the tower.

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

There are anchor points in the tower, nacelle, 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. The anchor point is tested to 22.2 kN.

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

5.6 Moving Parts, Guards, and Blocking Devices

Moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to prevent the rotor and drive train from rotating.

It is possible to block the pitch of the cylinder with mechanical tools in the hub.

5.7 Lighting

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

There is emergency lighting in case of loss of electrical power.

5.8 Noise

When the turbine is out of operation for maintenance, the sound level in the nacelle is below 80 dB(A). In operation mode, ear protection is required.

5.9 Emergency Stop

There are emergency stops in the nacelle and in the bottom of the tower.

5.10 Power Disconnection

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

5.11 Fire Protection/First Aid

A 5 kg CO_2 fire extinguisher must be located in the nacelle at the left yaw gear. The location of the fire extinguisher, and how to use it, must be confirmed before operating the turbine.

A first aid kit must be placed by the wall at the back end of the nacelle. The location of the first aid kit, and how to use it, must be confirmed before operating the turbine.

Above the generator there must be a fire blanket which can be used to put out small fires.

5.12 Warning Signs

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

5.13 Manuals and Warnings

The Vestas 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 Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2004.

- Anti-freeze liquid 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, Certificates, and Design Codes

7.1 Type Approvals

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

Standard	Conditions	Hub Height
IEC WT-01	IEC Class IA	60 m
		67 m
		78 m
	IEC Class IIA	60 m
		67 m
		80 m
		100 m
Typenprüfung	DIBt II	100 m

Table 7-1: Type approval 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 61400-1:1999 EN 50308 ANSI/ASSE Z359.1-2007
Bedframe	IEC 61400-1:2005
Tower	IEC 61400-1:2005 Eurocode 3 DIBt: Richtlinie für Windenergieanlagen, Einwirkungen und Standsicherheitsnachweise für Turm und Gründung, 4th edition.

Table 7-2: Structural design codes

7.3 Design Codes – Mechanical Equipment

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

Design Codes – Mechanical Equipment	
Gear	Designed in accordance to rules in ISO 81400-4
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 7-3: Mechanical equipment design codes

7.4 Design Codes – Electrical Equipment

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

Design Codes – Electrical Equipment	
High-Voltage AC Circuit Breakers	IEC 60056
High-Voltage Testing Techniques	IEC 60060
Power Capacitors	IEC 60831
Insulating Bushings for AC Voltage Above 1kV	IEC 60137
Insulation Co-Ordination	BS EN 60071
AC Disconnectors and Earth Switches	BS EN 60129
Current Transformers	IEC 60185
Voltage Transformers	IEC 60186
High-Voltage Switches	IEC 60265
Disconnectors and Fuses	IEC 60269
Flame Retardant Standard for MV Cables	IEC 60332
Transformer	IEC 60076-11
Generator	IEC 60034
Specification for Sulphur Hexafluoride for Electrical Equipment	IEC 60376
Rotating Electrical Machines	IEC 34
Dimensions and Output Ratings for Rotating Electrical Machines	IEC 72 and IEC 72A
Classification of Insulation, Materials for Electrical Machinery	IEC 85
Safety of Machinery – Electrical Equipment of Machines	IEC 60204-1

Table 7-4: Electrical equipment design codes

7.5 Design Codes – I/O Network System

The distributed I/O network system has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – I/O Network System	
Salt Mist Test	IEC 60068-2-52
Damp Head, Cyclic	IEC 60068-2-30
Vibration Sinus	IEC 60068-2-6
Cold	IEC 60068-2-1
Enclosure	IEC 60529
Damp Head, Steady State	IEC 60068-2-56
Vibration Random	IEC 60068-2-64
Dry Heat	IEC 60068-2-2
Temperature Shock	IEC 60068-2-14
Free Fall	IEC 60068-2-32

Table 7-5: I/O network system design codes

7.6 Design Codes – EMC System

To fulfil EMC requirements, the design must be as recommended for lightning protection. See section 7.7 Design Codes – Lightning Protection, p. 27.

Design Codes – EMC System	
Designed According to	IEC 61400-1: 2005
Further Robustness Requirements According to	TPS 901795

Table 7-6: EMC system design codes

7.7 Design Codes – Lightning Protection

The LPS 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 7-7: Lightning protection design codes

7.8 Design Codes – Earthing

The Vestas Earthing System design is based on and complies with the following international standards and guidelines:

- IEC 62305-1 Ed. 1.0: Protection against lightning – Part 1: General principles.
- IEC 62305-3 Ed. 1.0: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- IEC 62305-4 Ed. 1.0: Protection against lightning – Part 4: Electrical and electronic systems within structures.
- IEC/TR 61400-24. First edition. 2002-07. Wind turbine generator systems - Part 24: Lightning protection.
- IEC 60364-5-54. Second edition 2002-06. Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.
- IEC 61936-1. First edition. 2002-10. Power installations exceeding 1kV a.c.- Part 1: Common rules.

8 Colour and Surface Treatment

Gloss specifications are provided according to ISO 2813:2000 at a viewing angle of 60°. Exterior coatings are UV resistant.

8.1 Nacelle Colour and Surface Treatment

Surface Treatment of Vestas Nacelles	
Standard Nacelle Colours	RAL 7035 (light grey)
Gloss	80-95 gloss units
Standard Logo	Vestas

Table 8-1: Surface treatment, nacelle

8.2 Tower Colour and Surface Treatment

Surface Treatment of Vestas Tower Section		
	External	**Internal**
Tower Colour Variants	RAL 7035 (light grey)	RAL 9001 (cream white)
Gloss	50-75 gloss units	30-50 gloss units

Table 8-2: Surface treatment, tower

8.3 Blades Colour

Blades Colour	
Blade Colour	RAL 7035 (light grey)
Tip-End Colour Variants	RAL 2009 (traffic orange), RAL 3000 (flame red), RAL 3020 (traffic red)
Gloss	≤ 30 gloss units

Table 8-3: Colours, blades

9 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and must 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.

NOTE As evaluation of climate and site conditions is complex, it is necessary to consult Vestas for every project.

9.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
Wind Climate	**IEC IA**
Ambient Temperature Interval (Standard Temperature Turbine)	-30° to +50°C
Extreme Wind Speed (10 Minute Average)	50 m/s
Survival Wind Speed (3 Second Gust)	70 m/s

Table 9-1: Extreme design parameters

Average Design Parameters	
Wind Climate	**IEC IA**
Wind Speed	10.0 m/s
A-Factor	11.28 m/s
Form Factor, c	2.0

Average Design Parameters	
Wind Climate	**IEC IA**
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.

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 for example HV installations and cooling performance. Consult Vestas for further information.

9.1.3 Wind Farm Layout

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

DISCLAIMER 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)	4 m/s
Cut-Out (100 Second Exponential Average)	25 m/s
Re-Cut In (100 Second Exponential Average)	20 m/s

Table 9-3: Operational envelope - temperature and wind

9.3 Operational Envelope – Grid Connection *

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

Operational Envelope – Grid Connection		
Nominal Phase Voltage	$U_{P, nom}$	400 V
Nominal Frequency	f_{nom}	50 Hz
Maximum Steady State Voltage Jump	± 2%	
Maximum Frequency Gradient	± 4 Hz/sec	
Maximum Negative Sequence Voltage	3%	

Table 9-4: Operational envelope - grid connection

The generator and the converter will be disconnected if:

	U_P	U_N
Voltage Above 110% of Nominal for 60 Seconds	440 V	759 V
Voltage Above 115% of Nominal for 2 Seconds	460 V	794 V
Voltage Above 120% of Nominal for 0.08 Seconds	480 V	828 V
Voltage Above 125% of Nominal for 0.005 Seconds	500 V	863 V
Voltage Below 90% of Nominal for 60 Seconds	360 V	621 V
Voltage Below 85% of Nominal for 11 Seconds	340 V	586 V
Frequency is Above [Hz] for 0.2 Seconds	53 Hz	
Frequency is Below [Hz] for 0.2 Seconds	47 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.

9.4 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability dependent on power rating as illustrated in Figure 9-1, p. 32.

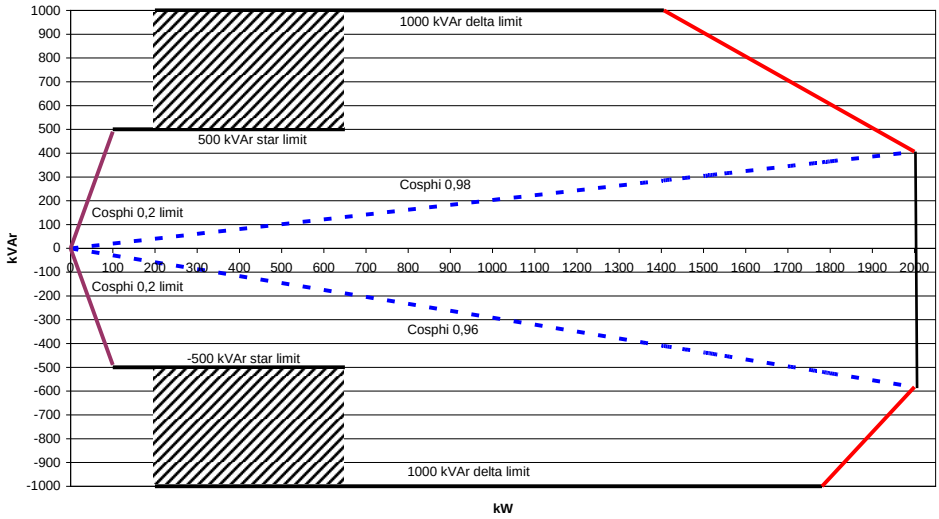

Figure 9-1: Reactive power capability

The above chart applies at the low voltage side of the HV transformer. Reactive power is produced by the rotor converter; therefore traditional capacitors are not used in the turbine.

At maximum active and reactive power, the turbine reduces either active or reactive power, depending on which type of power has priority (for example if reactive power has priority, the active power is reduced).

9.5 Performance – Fault Ride Through

The turbine is equipped with a reinforced Vestas Converter System in order to gain better control of the generator during grid faults. The controllers and contactors have a UPS backup system in order to keep the turbine control system running during grid faults.

The pitch system is optimised to keep the turbine within normal speed conditions, and the generator speed is accelerated in order to store rotational energy and be able to resume normal power production faster after a fault and keep mechanical stress on the turbine at a minimum.

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve in Figure 9-2, p. 33.

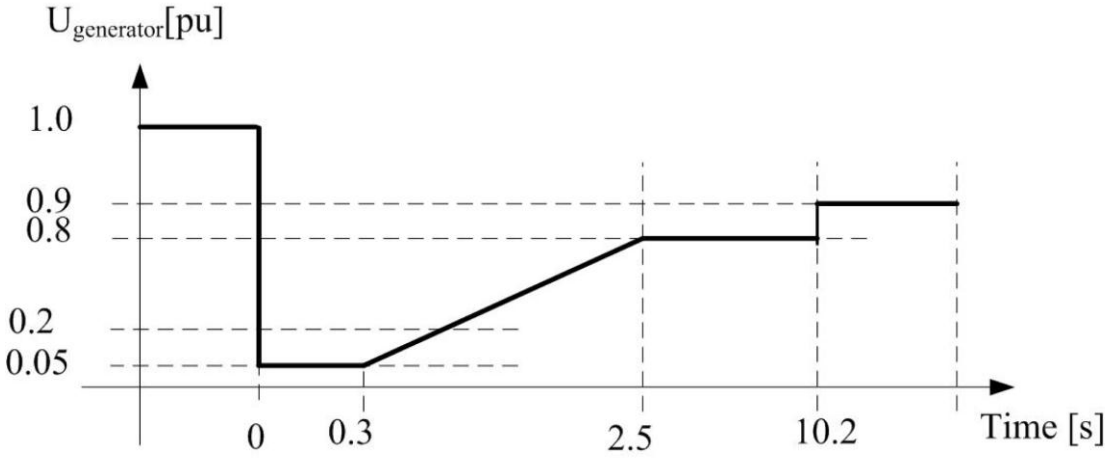

Figure 9-2: Low-voltage tolerance curve for symmetrical and asymmetrical faults

For grid disturbances outside the protection curve in Figure 9-3, p. 33, the turbine will be disconnected from the grid.

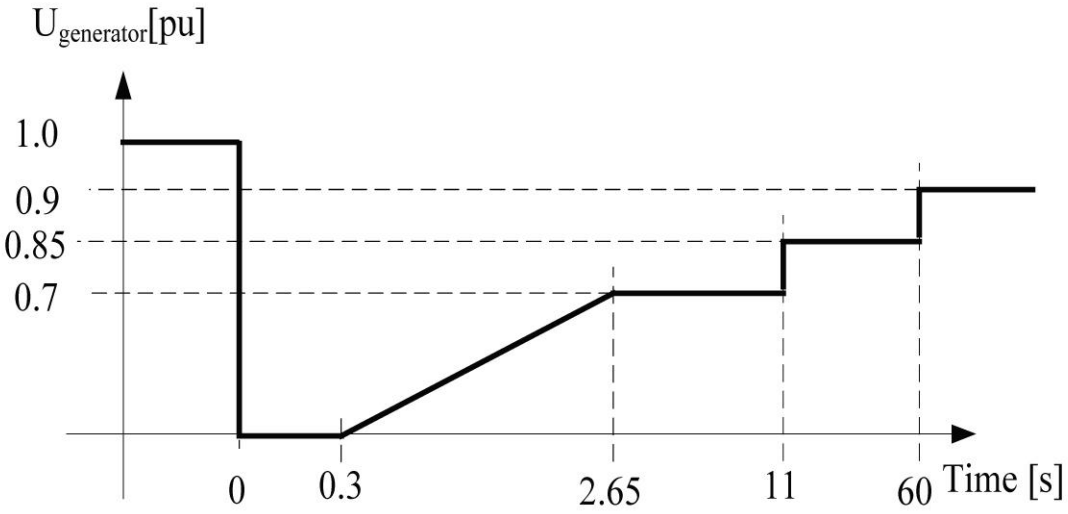

Figure 9-3: Default low-voltage protection settings for symmetrical and asymmetrical faults

Power Recovery Time	
Power Recovery to 90% of Pre-Fault Level	Maximum 1.0 second

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 voltage dips the turbine is switched from normal active and reactive power control to rotor current control. This enables the turbine to perform voltage control by supplying reactive current to the grid. The reactive current at the generator

terminals is set according to the voltage level at the generator terminals. See Figure 9-4, p. 34.

The default value gives a reactive current part of 1 pu of the rated turbine current at the generator terminals. Figure 9-4, p. 34 indicates the reactive current contribution as a function of the voltage at the generator terminals for star and delta operation. The reactive current contribution is independent from the actual wind conditions and pre-fault power level.

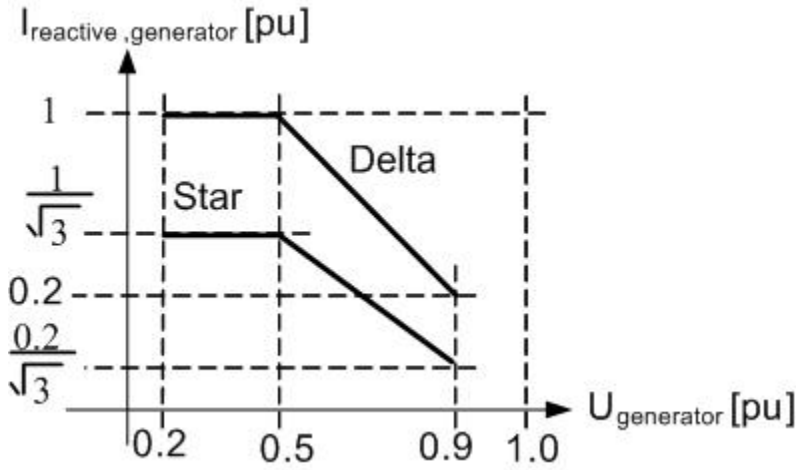

Figure 9-4: Reactive current contribution in star and delta drawn for 100% reactive current contribution

In star connection, the reactive current contribution is lowered by a factor $1/\sqrt{3}$ compared to the delta connection. Turbines may be operated in forced delta connection. This ensures full current injection by low wind.

During faults in the grid, high-voltage step (du/dt) in the grid voltage can occur, which may pause the rotor current control for up to 50 ms before the rotor current control is resumed. During these 50 ms the generator can draw a low magnetization current from the grid.

9.6.2 Asymmetrical Reactive Current Contribution

Current reference values are reduced during asymmetrical faults to ensure ride through. The current reference values are reduced from the symmetrical case with the following reduction factor on the current references:

$1-(u_{pu\_high} - u_{pu\_low})$

With 'u_{pu_high}' as the highest phase-phase or phase-ground RMS per unit voltage measured and 'u_{pu_low}' as the lowest phase-phase or phase-ground RMS per unit voltage.

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. As an example, six voltage dips of duration of 200 ms down to 20% voltage within 30 minutes will normally not lead to a problem for the turbine.

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
Reactive Power	2.5 pu/sec

To protect the turbine, active power cannot be controlled to values below the curve in Figure 9-5, p. 35.

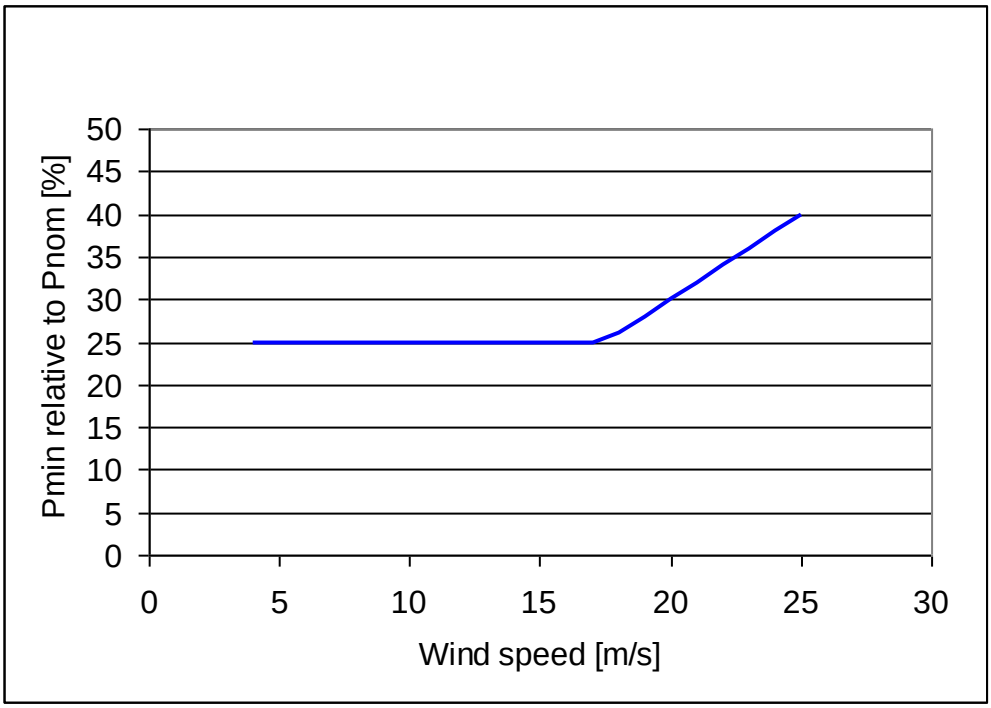

Figure 9-5: Minimum active power output dependent on wind speed

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).

Dead band 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 consumption when the wind turbine is not producing energy (generator is not

connected to the grid). This is defined in the control system as Production Generator (zero).

The following components have the largest influence on the power consumption of the wind turbine:

Own Consumption	
Hydraulic Motor	20 kW
Yaw Motors 6 x 1.75 kW	10.5 kW
Oil Heating 3 x 0.76 kW	2.3 kW
Air Heaters 2 x 6 kW (Standard) **3 x 6 kW (Low-Temperature)**	12 kW (Standard) 18 kW (Low-Temperature)
Oil Pump for Gearbox Lubrication	3.5 kW
Average of Measured No-Load Loss of the HV Transformer	4.0 kW

Table 9-6: Own consumption data

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

See section 12 Appendices, p. 40 for power curves and C_t values.

Conditions for Power Curve, 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
Ice / Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Frequency	50 ±0.5 Hz

Table 9-7: Conditions for power curve, C_t values

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

For information on hub heights, see section 2.14 Tower Structure, p. 9.

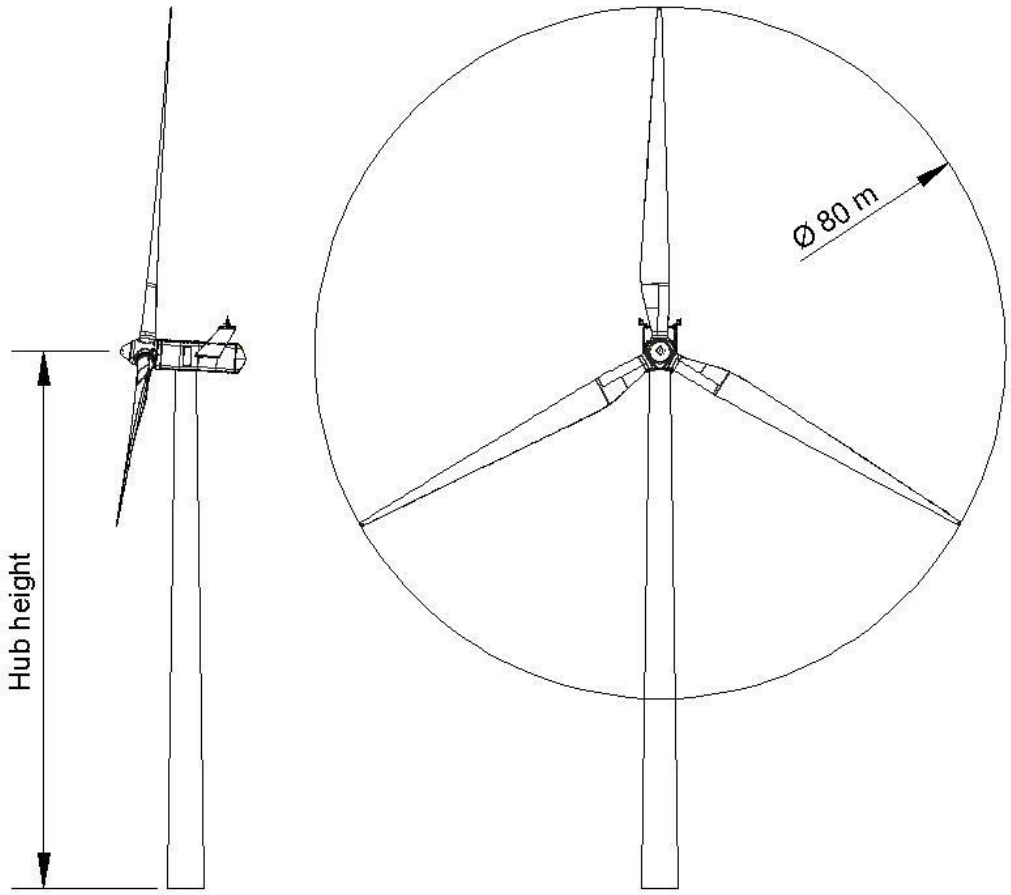

Figure 10-1: Illustration of outer dimensions–structure

1 Hub height 60/67 m, 78/80 m

2 Diameter: 80 m

10.2 Structural Design – Side-View Drawing

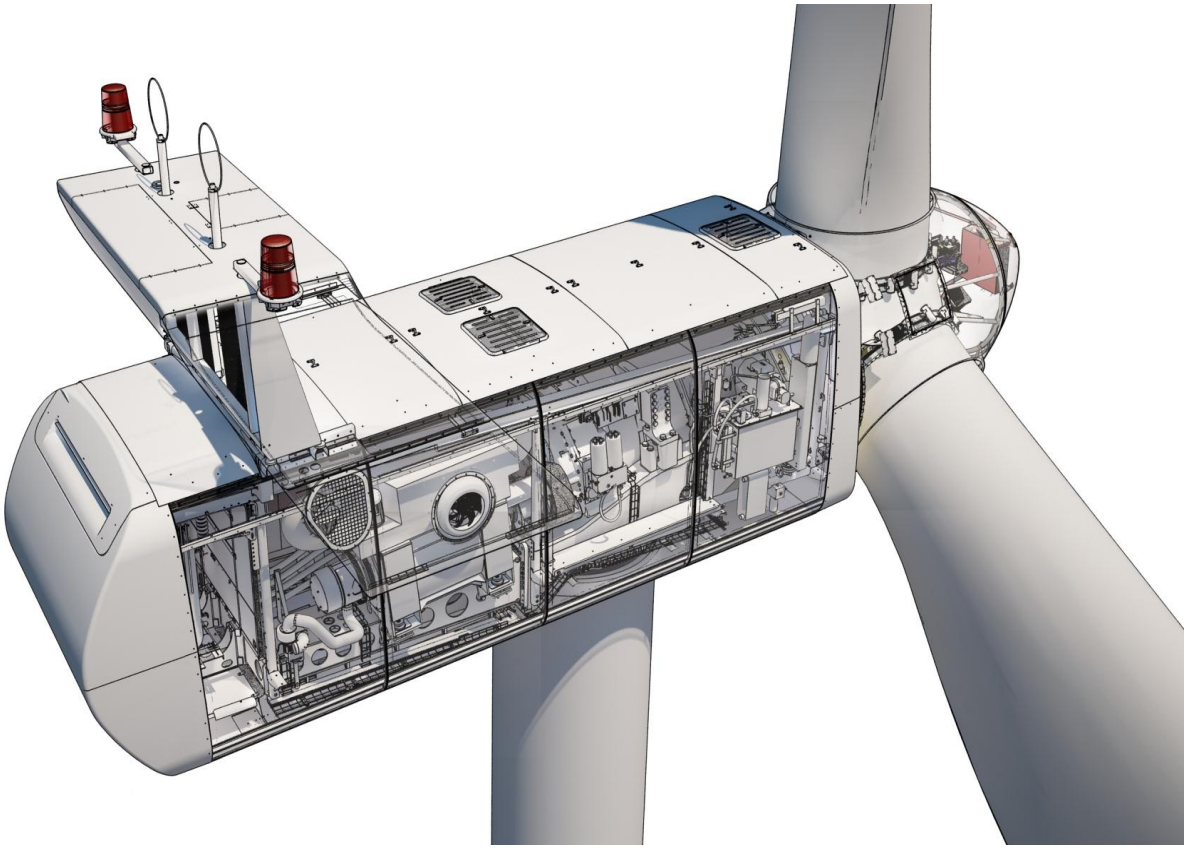

Figure 10-2: Side-view drawing

11 General Reservations, Notes and Disclaimers

- These general specifications described in this document apply to the current version of the V80-2.0 MW wind turbine. Updated versions of the V80-2.0 MW wind turbine, which may be manufactured in the future, may have general specifications that differ from these general specifications. In the event that Vestas supplies an updated version of the V80-2.0 MW wind turbine, Vestas will provide updated general specifications applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with little variation in frequency.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- The estimated power curve for the different estimated noise levels (sound power levels) is for wind speeds at 10-minute average value at hub height and perpendicular to the rotor plane.
- All listed start/stop parameters (for example 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 Specifications’, is not, 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 [kW] Star/Delta, Noise Mode 0

All of the following power curves are calculated at 690 V / 400 V on the low-voltage side of the high-voltage transformer. Wind speed at hub height, 10 minute average.

V80-2.0 MW Power Curve, Noise Mode 0												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**67**	47	50	52	54	57	59	61	64	66	68	71
4.5	**109**	81	84	88	91	94	97	101	104	107	111	114
5.0	**158**	120	125	129	134	138	143	147	152	156	161	165
5.5	**217**	167	173	179	185	191	197	202	208	214	220	226
6.0	**287**	223	231	238	246	253	261	269	276	284	291	299
6.5	**371**	289	299	309	318	328	337	347	357	366	376	385
7.0	**468**	366	378	390	402	414	426	438	450	462	474	486
7.5	**577**	450	465	480	495	510	525	540	555	570	585	599
8.0	**705**	551	569	587	605	623	641	659	678	696	714	732
8.5	**847**	663	685	707	728	750	771	793	814	836	857	879
9.0	**1000**	786	811	836	862	887	912	937	962	987	1013	1038
9.5	**1164**	916	945	974	1003	1032	1062	1091	1120	1149	1178	1207
10.0	**1330**	1048	1082	1115	1148	1181	1214	1248	1281	1314	1347	1380
10.5	**1497**	1181	1219	1256	1293	1331	1368	1405	1442	1479	1515	1551
11.0	**1656**	1311	1353	1394	1435	1476	1518	1559	1598	1637	1674	1709
11.5	**1791**	1439	1484	1530	1574	1617	1660	1703	1738	1774	1805	1833
12.0	**1889**	1562	1611	1659	1705	1744	1783	1822	1849	1875	1898	1917
12.5	**1946**	1679	1726	1773	1814	1844	1875	1905	1921	1938	1951	1962
13.0	**1976**	1783	1822	1862	1895	1914	1934	1953	1962	1971	1978	1984
13.5	**1996**	1866	1897	1928	1952	1964	1975	1987	1990	1994	1996	1998
14.0	**1999**	1926	1946	1966	1981	1986	1991	1996	1997	1998	1999	2000
14.5	**2000**	1965	1975	1985	1993	1995	1997	1999	1999	2000	2000	2000
15.0	**2000**	1981	1987	1992	1996	1997	1998	2000	2000	2000	2000	2000
15.5	**2000**	1992	1995	1997	1999	1999	1999	2000	2000	2000	2000	2000
16.0	**2000**	1997	1998	1999	2000	2000	2000	2000	2000	2000	2000	2000
16.5	**2000**	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
17.0	**2000**	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
17.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
25.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 12-1: Power curve, noise mode 0

12.1.2 C_t Values, Noise Mode 0

V80-2.0 MW Star/Delta C_t Values, Noise Mode 0												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**0.879**	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879
4.5	**0.863**	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863
5.0	**0.857**	0.856	0.857	0.857	0.857	0.857	0.857	0.857	0.857	0.857	0.857	0.857
5.5	**0.853**	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.854	0.854
6.0	**0.853**	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853
6.5	**0.852**	0.852	0.852	0.853	0.853	0.852	0.852	0.852	0.852	0.852	0.852	0.852
7.0	**0.853**	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853
7.5	**0.853**	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853
8.0	**0.848**	0.848	0.848	0.848	0.848	0.848	0.848	0.848	0.848	0.848	0.849	0.849
8.5	**0.837**	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837
9.0	**0.817**	0.817	0.817	0.817	0.817	0.817	0.817	0.817	0.817	0.817	0.817	0.817
9.5	**0.792**	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.791	0.791
10.0	**0.754**	0.756	0.756	0.756	0.756	0.756	0.756	0.755	0.755	0.754	0.754	0.752
10.5	**0.710**	0.715	0.715	0.715	0.715	0.715	0.714	0.714	0.712	0.710	0.708	0.705
11.0	**0.657**	0.672	0.672	0.672	0.671	0.669	0.668	0.666	0.663	0.659	0.654	0.648
11.5	**0.598**	0.629	0.629	0.628	0.626	0.623	0.620	0.616	0.609	0.602	0.594	0.584
12.0	**0.534**	0.587	0.586	0.584	0.581	0.574	0.567	0.560	0.550	0.539	0.528	0.516
12.5	**0.469**	0.547	0.542	0.537	0.531	0.521	0.510	0.500	0.488	0.475	0.463	0.450
13.0	**0.410**	0.505	0.496	0.488	0.478	0.466	0.453	0.440	0.428	0.416	0.404	0.393
13.5	**0.358**	0.458	0.448	0.438	0.426	0.413	0.400	0.387	0.375	0.364	0.353	0.343
14.0	**0.315**	0.414	0.401	0.388	0.376	0.364	0.352	0.340	0.330	0.320	0.310	0.302
14.5	**0.279**	0.371	0.357	0.344	0.332	0.321	0.311	0.300	0.292	0.283	0.275	0.268
15.0	**0.251**	0.330	0.319	0.307	0.297	0.287	0.278	0.269	0.262	0.255	0.248	0.241
15.5	**0.226**	0.295	0.285	0.275	0.265	0.257	0.250	0.242	0.235	0.229	0.223	0.217
16.0	**0.204**	0.265	0.256	0.247	0.239	0.232	0.225	0.218	0.213	0.207	0.202	0.196
16.5	**0.185**	0.239	0.231	0.223	0.216	0.210	0.204	0.198	0.193	0.188	0.183	0.179
17.0	**0.169**	0.217	0.210	0.203	0.197	0.191	0.186	0.180	0.176	0.171	0.167	0.163
17.5	**0.155**	0.197	0.191	0.185	0.179	0.175	0.170	0.165	0.161	0.157	0.153	0.149
18.0	**0.142**	0.181	0.175	0.170	0.165	0.160	0.156	0.151	0.148	0.144	0.140	0.137
18.5	**0.131**	0.166	0.161	0.156	0.151	0.147	0.143	0.139	0.136	0.133	0.129	0.126
19.0	**0.121**	0.153	0.149	0.144	0.140	0.136	0.133	0.129	0.126	0.123	0.120	0.117
19.5	**0.112**	0.142	0.138	0.133	0.129	0.126	0.123	0.119	0.116	0.114	0.111	0.108
20.0	**0.104**	0.131	0.127	0.124	0.120	0.117	0.114	0.111	0.108	0.106	0.103	0.101
20.5	**0.097**	0.122	0.118	0.115	0.112	0.109	0.106	0.103	0.101	0.098	0.096	0.094
21.0	**0.090**	0.114	0.110	0.107	0.104	0.101	0.099	0.096	0.094	0.092	0.089	0.087
21.5	**0.084**	0.106	0.103	0.100	0.097	0.094	0.092	0.089	0.087	0.085	0.083	0.081
22.0	**0.079**	0.099	0.096	0.093	0.091	0.088	0.086	0.084	0.082	0.080	0.078	0.076
22.5	**0.074**	0.092	0.090	0.087	0.085	0.083	0.081	0.078	0.077	0.075	0.073	0.072
23.0	**0.070**	0.087	0.084	0.082	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.067
23.5	**0.066**	0.082	0.079	0.077	0.075	0.073	0.071	0.070	0.068	0.066	0.065	0.063
24.0	**0.062**	0.077	0.075	0.073	0.071	0.069	0.067	0.065	0.064	0.063	0.061	0.060
24.5	**0.058**	0.072	0.071	0.069	0.067	0.065	0.063	0.062	0.060	0.059	0.058	0.056
25.0	**0.055**	0.068	0.067	0.065	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.053

Table 12-2: C_t values, noise mode 0

12.1.3 Noise Curve, Noise Mode 0

All of the following noise curves are calculated at 8 m/s, at 10 m height.

Sound Power Level at Hub Height, V80-2.0 MW, Mode 0		
Conditions for Sound Power Level	**Verification Standard: IEC 61400-11 Ed. 2** **Wind Shear: 0.16** **Max Turbulence at 10 Meter Height: 16%** **Inflow Angle (Vertical): 0 ± 2°** **Air Density: 1.225 kg/m^3**	
Hub Height	60/67 m	78/80 m
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.2 5.4	94.0 5.6
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	98.6 6.8	99.3 7.0
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.7 8.1	103.0 8.4
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.3 9.5	104.5 9.8
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 10.8	105.0 11.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 12.2	105.0 12.6
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 13.6	105.0 13.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 14.9	105.0 15.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 16.3	105.0 16.7
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 17.6	105.0 18.1

Table 12-3: Noise curve, noise mode 0

12.2 Mode 1

12.2.1 Power Curve [kW] Star/Delta, Noise Mode 1

All of the following power curves are calculated at 690 V / 400 V on the low-voltage side of the high-voltage transformer.

Wind speed at hub height, 10 minute average.

V80-2.0 MW Power Curve, Noise Mode 1												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**67**	47	50	52	54	57	59	61	64	66	68	71
4.5	**109**	81	84	88	91	94	98	101	104	107	111	114
5.0	**158**	121	125	130	134	138	143	147	152	156	161	165
5.5	**217**	167	173	179	185	191	197	203	208	214	220	226
6.0	**288**	223	231	238	246	253	261	269	276	284	291	299
6.5	**371**	289	299	309	318	328	338	347	357	366	376	386
7.0	**468**	366	378	390	402	414	426	438	450	462	474	486
7.5	**578**	450	465	480	495	510	525	540	555	570	585	600
8.0	**704**	551	569	587	605	623	641	659	677	695	713	731
8.5	**843**	661	682	704	725	747	768	790	811	832	854	875
9.0	**991**	779	804	829	854	879	904	929	954	979	1004	1029
9.5	**1148**	904	933	961	990	1019	1047	1076	1105	1134	1162	1191
10.0	**1304**	1028	1061	1093	1126	1158	1191	1223	1256	1288	1320	1353
10.5	**1460**	1152	1189	1225	1261	1297	1334	1370	1406	1442	1478	1514
11.0	**1614**	1276	1316	1356	1396	1436	1476	1516	1556	1595	1633	1670
11.5	**1756**	1404	1448	1491	1535	1578	1620	1663	1700	1737	1772	1803
12.0	**1865**	1532	1579	1626	1671	1711	1751	1791	1820	1850	1876	1898
12.5	**1933**	1656	1702	1748	1790	1822	1854	1886	1905	1924	1940	1952
13.0	**1970**	1767	1806	1846	1880	1901	1922	1943	1954	1965	1973	1979
13.5	**1994**	1856	1887	1919	1944	1957	1970	1983	1987	1991	1995	1997
14.0	**1999**	1921	1941	1962	1978	1983	1989	1995	1996	1998	1999	2000
14.5	**2000**	1963	1974	1984	1992	1994	1997	1999	1999	2000	2000	2000
15.0	**2000**	1980	1986	1992	1996	1997	1998	1999	2000	2000	2000	2000
15.5	**2000**	1992	1994	1997	1999	1999	1999	2000	2000	2000	2000	2000
16.0	**2000**	1997	1998	1999	2000	2000	2000	2000	2000	2000	2000	2000
16.5	**2000**	1998	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000
17.0	**2000**	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
17.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
25.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 12-4: Power curve, noise mode 1

12.2.2 C_t Values, Noise Mode 1

V80-2.0 MW Star/Delta C_t Values, Noise Mode 1												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**0.879**	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879
4.5	**0.862**	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862
5.0	**0.852**	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852
5.5	**0.846**	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
6.0	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
6.5	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
7.0	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
7.5	**0.838**	0.837	0.837	0.837	0.837	0.837	0.837	0.838	0.838	0.838	0.838	0.838
8.0	**0.818**	0.818	0.818	0.818	0.818	0.818	0.818	0.819	0.818	0.818	0.818	0.819
8.5	**0.794**	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794
9.0	**0.767**	0.767	0.767	0.767	0.767	0.767	0.767	0.767	0.767	0.767	0.767	0.767
9.5	**0.736**	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736
10.0	**0.698**	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698
10.5	**0.657**	0.657	0.657	0.657	0.657	0.657	0.657	0.658	0.657	0.657	0.658	0.658
11.0	**0.617**	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.617	0.617	0.616	0.615
11.5	**0.573**	0.584	0.584	0.584	0.584	0.583	0.582	0.582	0.578	0.574	0.570	0.564
12.0	**0.521**	0.554	0.554	0.553	0.552	0.547	0.543	0.539	0.532	0.525	0.516	0.507
12.5	**0.463**	0.525	0.522	0.519	0.514	0.506	0.498	0.490	0.479	0.468	0.457	0.447
13.0	**0.407**	0.492	0.485	0.478	0.469	0.458	0.447	0.436	0.424	0.413	0.402	0.391
13.5	**0.357**	0.452	0.443	0.433	0.423	0.411	0.398	0.386	0.374	0.363	0.352	0.342
14.0	**0.315**	0.411	0.399	0.387	0.375	0.363	0.351	0.339	0.330	0.320	0.310	0.302
14.5	**0.279**	0.370	0.357	0.344	0.332	0.321	0.311	0.300	0.292	0.283	0.275	0.268
15.0	**0.251**	0.330	0.319	0.307	0.297	0.287	0.278	0.269	0.262	0.255	0.248	0.241
15.5	**0.226**	0.295	0.285	0.275	0.265	0.258	0.250	0.242	0.235	0.229	0.223	0.217
16.0	**0.204**	0.265	0.256	0.247	0.239	0.232	0.225	0.218	0.213	0.207	0.202	0.197
16.5	**0.185**	0.239	0.231	0.223	0.216	0.210	0.204	0.198	0.193	0.188	0.183	0.179
17.0	**0.169**	0.217	0.210	0.203	0.197	0.191	0.186	0.180	0.176	0.171	0.167	0.163
17.5	**0.155**	0.197	0.191	0.185	0.179	0.175	0.170	0.165	0.161	0.157	0.153	0.149
18.0	**0.142**	0.181	0.175	0.170	0.165	0.160	0.156	0.151	0.148	0.144	0.140	0.137
18.5	**0.131**	0.166	0.161	0.156	0.151	0.147	0.143	0.139	0.136	0.133	0.129	0.126
19.0	**0.121**	0.153	0.149	0.144	0.140	0.136	0.133	0.129	0.126	0.123	0.120	0.117
19.5	**0.112**	0.142	0.138	0.133	0.129	0.126	0.123	0.119	0.116	0.114	0.111	0.108
20.0	**0.104**	0.131	0.127	0.124	0.120	0.117	0.114	0.111	0.108	0.106	0.103	0.101
20.5	**0.097**	0.122	0.118	0.115	0.112	0.109	0.106	0.103	0.101	0.098	0.096	0.094
21.0	**0.090**	0.114	0.110	0.107	0.104	0.101	0.099	0.096	0.094	0.092	0.089	0.087
21.5	**0.084**	0.106	0.103	0.100	0.097	0.094	0.092	0.089	0.087	0.085	0.083	0.081
22.0	**0.079**	0.099	0.096	0.093	0.091	0.088	0.086	0.084	0.082	0.080	0.078	0.076
22.5	**0.074**	0.092	0.090	0.087	0.085	0.083	0.081	0.078	0.077	0.075	0.073	0.072
23.0	**0.070**	0.087	0.084	0.082	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.067
23.5	**0.066**	0.082	0.079	0.077	0.075	0.073	0.071	0.070	0.068	0.066	0.065	0.063
24.0	**0.062**	0.077	0.075	0.073	0.071	0.069	0.067	0.065	0.064	0.063	0.061	0.060
24.5	**0.058**	0.072	0.071	0.069	0.067	0.065	0.063	0.062	0.060	0.059	0.058	0.056
25.0	**0.055**	0.068	0.067	0.065	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.053

Table 12-5: C_t values, noise mode 1

12.2.3 Noise Curve, Noise Mode 1

All of the following noise curves are calculated at 8 m/s, at 10 m height.

Sound Power Level at Hub Height, V80-2.0 MW, Mode 1		
Conditions for Sound Power Level:	**Measurement Standard: IEC 61400-11 Ed. 2** **Wind Shear: 0.16** **Max Turbulence at 10 Meter Height: 16%** **Inflow Angle (Vertical): 0 ± 2°** **Air Density: 1.225 kg/m^3**	
Hub Height	60/67 m	78/80 m
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.2 5.4	94.0 5.6
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	98.6 6.8	99.3 7.0
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.5 8.1	102.5 8.4
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.1 9.5	103.4 9.8
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.8 10.8	104.0 11.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.6 12.2	104.6 12.6
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.6 13.6	104.6 13.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.6 14.9	104.6 15.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.6 16.3	104.6 16.7
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.6 17.6	104.6 18.1

Table 12-6: Noise curve, noise mode 1

12.3 Mode 2

12.3.1 Power Curve [kW] Star/Delta, Noise Mode 2

All of the following power curves are calculated at 690 V / 400 V on the low-voltage side of the high-voltage transformer.

Wind speed at hub height, 10 minute average.

V80-2.0 MW Power Curve, Noise Mode 2												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**67**	47	50	52	54	57	59	61	64	66	68	71
4.5	**109**	81	84	88	91	94	98	101	104	107	111	114
5.0	**158**	121	125	130	134	138	143	147	152	156	161	165
5.5	**217**	167	173	179	185	191	197	203	208	214	220	226
6.0	**288**	223	231	238	246	253	261	269	276	284	291	299
6.5	**371**	289	299	309	318	328	337	347	357	366	376	386
7.0	**468**	366	378	390	402	414	426	438	450	462	474	486
7.5	**577**	449	464	479	494	509	524	539	554	569	584	599
8.0	**701**	548	566	584	602	620	638	656	674	692	710	728
8.5	**835**	654	675	697	718	739	760	782	803	824	845	866
9.0	**973**	764	789	813	838	862	887	911	936	960	985	1009
9.5	**1114**	877	905	933	961	989	1017	1045	1072	1100	1128	1156
10.0	**1251**	986	1017	1049	1080	1111	1142	1174	1205	1236	1267	1298
10.5	**1386**	1093	1128	1162	1197	1231	1266	1300	1334	1369	1403	1437
11.0	**1518**	1198	1236	1274	1311	1349	1386	1424	1461	1499	1536	1573
11.5	**1644**	1301	1341	1382	1423	1463	1504	1544	1584	1624	1663	1701
12.0	**1761**	1401	1445	1489	1532	1575	1618	1661	1701	1741	1778	1812
12.5	**1855**	1506	1552	1598	1643	1685	1727	1770	1804	1838	1867	1893
13.0	**1922**	1619	1664	1709	1751	1786	1822	1858	1883	1909	1930	1946
13.5	**1969**	1723	1763	1803	1839	1868	1896	1925	1943	1960	1973	1982
14.0	**1989**	1820	1852	1883	1911	1930	1949	1969	1977	1985	1990	1994
14.5	**1997**	1898	1920	1942	1960	1969	1979	1988	1991	1995	1997	1998
15.0	**1998**	1942	1955	1967	1977	1983	1988	1994	1995	1997	1998	1999
15.5	**2000**	1972	1979	1985	1991	1993	1995	1998	1998	1999	2000	2000
16.0	**2000**	1988	1991	1994	1997	1998	1998	1999	2000	2000	2000	2000
16.5	**2000**	1995	1996	1998	1999	1999	1999	2000	2000	2000	2000	2000
17.0	**2000**	1998	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000
17.5	**2000**	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
25.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 12-7: Power curve, noise mode 2

12.3.2 C_t Values, Noise Mode 2

V80-2.0 MW Star/Delta C_t Values, Noise Mode 2												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**0.879**	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879
4.5	**0.862**	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862
5.0	**0.852**	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852
5.5	**0.846**	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
6.0	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
6.5	**0.843**	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843
7.0	**0.840**	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840
7.5	**0.832**	0.831	0.831	0.831	0.831	0.831	0.831	0.832	0.832	0.832	0.832	0.832
8.0	**0.813**	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813
8.5	**0.783**	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783
9.0	**0.743**	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743
9.5	**0.699**	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
10.0	**0.650**	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
10.5	**0.604**	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604	0.604
11.0	**0.560**	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560
11.5	**0.518**	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.518	0.518	0.517
12.0	**0.478**	0.481	0.481	0.481	0.481	0.481	0.481	0.480	0.479	0.478	0.476	0.473
12.5	**0.435**	0.449	0.448	0.448	0.447	0.446	0.445	0.444	0.440	0.436	0.432	0.426
13.0	**0.392**	0.422	0.421	0.419	0.417	0.413	0.410	0.406	0.400	0.395	0.388	0.381
13.5	**0.351**	0.394	0.391	0.388	0.383	0.378	0.373	0.368	0.361	0.354	0.347	0.339
14.0	**0.312**	0.370	0.365	0.359	0.353	0.346	0.339	0.332	0.324	0.316	0.308	0.301
14.5	**0.278**	0.345	0.337	0.330	0.322	0.314	0.306	0.298	0.290	0.282	0.275	0.268
15.0	**0.251**	0.317	0.308	0.300	0.291	0.284	0.276	0.268	0.261	0.254	0.247	0.241
15.5	**0.226**	0.289	0.280	0.272	0.263	0.256	0.249	0.241	0.235	0.229	0.223	0.217
16.0	**0.204**	0.263	0.254	0.246	0.238	0.232	0.225	0.218	0.213	0.207	0.202	0.197
16.5	**0.185**	0.238	0.231	0.223	0.216	0.210	0.204	0.198	0.193	0.188	0.183	0.179
17.0	**0.169**	0.217	0.210	0.203	0.197	0.191	0.186	0.180	0.176	0.171	0.167	0.163
17.5	**0.155**	0.197	0.191	0.185	0.179	0.175	0.170	0.165	0.161	0.157	0.153	0.149
18.0	**0.142**	0.181	0.175	0.170	0.165	0.160	0.156	0.151	0.148	0.144	0.140	0.137
18.5	**0.131**	0.166	0.161	0.156	0.151	0.147	0.143	0.139	0.136	0.133	0.129	0.126
19.0	**0.121**	0.153	0.149	0.144	0.140	0.136	0.133	0.129	0.126	0.123	0.120	0.117
19.5	**0.112**	0.142	0.138	0.133	0.129	0.126	0.123	0.119	0.116	0.114	0.111	0.108
20.0	**0.104**	0.131	0.127	0.124	0.120	0.117	0.114	0.111	0.108	0.106	0.103	0.101
20.5	**0.097**	0.122	0.118	0.115	0.112	0.109	0.106	0.103	0.101	0.098	0.096	0.094
21.0	**0.090**	0.114	0.110	0.107	0.104	0.101	0.099	0.096	0.094	0.092	0.089	0.087
21.5	**0.084**	0.106	0.103	0.100	0.097	0.094	0.092	0.089	0.087	0.085	0.083	0.081
22.0	**0.079**	0.099	0.096	0.093	0.091	0.088	0.086	0.084	0.082	0.080	0.078	0.076
22.5	**0.074**	0.092	0.090	0.087	0.085	0.083	0.081	0.078	0.077	0.075	0.073	0.072
23.0	**0.070**	0.087	0.084	0.082	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.067
23.5	**0.066**	0.082	0.079	0.077	0.075	0.073	0.071	0.070	0.068	0.066	0.065	0.063
24.0	**0.062**	0.077	0.075	0.073	0.071	0.069	0.067	0.065	0.064	0.063	0.061	0.060
24.5	**0.058**	0.072	0.071	0.069	0.067	0.065	0.063	0.062	0.060	0.059	0.058	0.056
25.0	**0.055**	0.068	0.067	0.065	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.053

Table 12-8: C_t values, noise mode 2

12.3.3 Noise Curve, Noise Mode 2

All of the following noise curves are calculated at 8 m/s, at 10 m height.

Sound Power Level at Hub Height, V80-2.0 MW, Mode 2		
Conditions for Sound Power Level:	**Measurement Standard: IEC 61400-11 Ed. 2** **Wind Shear: 0.16** **Max Turbulence at 10 Meter Height: 16%** **Inflow Angle (Vertical): 0 ± 2°** **Air Density: 1.225 kg/m^3**	
Hub Height	60/67 m	78/80 m
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.2 5.4	94.0 5.6
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	98.6 6.8	99.3 7.0
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	101.6 8.1	101.7 8.4
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.0 9.5	102.0 9.8
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.3 10.8	102.4 11.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.1 12.2	103.3 12.6
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.4 13.6	103.3 13.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.8 14.9	104.0 15.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 16.3	104.1 16.7
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 17.6	104.1 18.1

Table 12-9: Noise curve, noise mode 2

12.4 Mode 3

12.4.1 Power Curve [kW] Star/Delta, Noise Mode 3

All of the following power curves are calculated at 690 V / 400 V on the low-voltage side of the high-voltage transformer.

Wind speed at hub height, 10 minute average.

V80-2.0 MW Power Curve, Noise Mode 3												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**67**	47	50	52	54	57	59	61	64	66	68	71
4.5	**109**	81	84	88	91	94	98	101	104	107	111	114
5.0	**158**	121	125	130	134	138	143	147	152	156	161	165
5.5	**217**	167	173	179	185	191	197	203	208	214	220	226
6.0	**288**	223	231	238	246	253	261	269	276	284	291	299
6.5	**371**	289	299	309	318	328	338	347	357	366	376	385
7.0	**468**	366	378	390	402	414	426	438	450	462	474	485
7.5	**576**	449	464	479	494	509	524	539	553	568	583	598
8.0	**698**	546	564	582	600	618	636	654	672	690	707	725
8.5	**829**	650	671	692	713	734	755	776	798	819	840	861
9.0	**963**	756	781	805	829	854	878	902	926	951	975	999
9.5	**1099**	865	892	920	947	975	1003	1030	1058	1085	1112	1140
10.0	**1230**	969	1000	1030	1061	1092	1122	1153	1184	1214	1245	1276
10.5	**1358**	1071	1105	1139	1173	1207	1240	1274	1308	1341	1375	1408
11.0	**1484**	1172	1209	1246	1283	1319	1356	1393	1429	1466	1502	1539
11.5	**1607**	1272	1312	1351	1391	1431	1470	1510	1549	1588	1626	1664
12.0	**1726**	1371	1414	1457	1500	1542	1584	1627	1666	1706	1743	1778
12.5	**1826**	1478	1524	1569	1613	1655	1698	1740	1774	1809	1840	1867
13.0	**1902**	1595	1640	1685	1726	1763	1799	1835	1862	1888	1910	1928
13.5	**1956**	1704	1744	1784	1821	1850	1879	1908	1927	1946	1961	1972
14.0	**1983**	1807	1839	1871	1899	1919	1939	1960	1969	1978	1985	1989
14.5	**1995**	1890	1913	1935	1954	1964	1974	1985	1989	1993	1995	1996
15.0	**1997**	1938	1951	1964	1975	1980	1986	1992	1994	1996	1997	1998
15.5	**1999**	1970	1977	1984	1990	1992	1995	1997	1998	1999	1999	2000
16.0	**2000**	1988	1991	1994	1996	1997	1998	1999	1999	2000	2000	2000
16.5	**2000**	1994	1996	1997	1998	1999	1999	2000	2000	2000	2000	2000
17.0	**2000**	1998	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000
17.5	**2000**	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
18.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
25.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 12-10: Power curve, noise mode 3

12.4.2 C_t Values, Noise Mode 3

V80-2.0 MW Star/Delta C_t Values, Noise Mode 3												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**0.879**	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879
4.5	**0.862**	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862
5.0	**0.852**	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852
5.5	**0.846**	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
6.0	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
6.5	**0.842**	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842
7.0	**0.836**	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836
7.5	**0.824**	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.824	0.824	0.824
8.0	**0.800**	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
8.5	**0.767**	0.766	0.766	0.766	0.767	0.767	0.767	0.767	0.767	0.767	0.767	0.767
9.0	**0.724**	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724
9.5	**0.680**	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680
10.0	**0.631**	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631
10.5	**0.585**	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585
11.0	**0.543**	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543
11.5	**0.503**	0.504	0.504	0.504	0.504	0.504	0.503	0.503	0.503	0.503	0.503	0.502
12.0	**0.465**	0.468	0.468	0.468	0.468	0.468	0.468	0.467	0.466	0.466	0.464	0.461
12.5	**0.426**	0.438	0.438	0.438	0.437	0.436	0.435	0.434	0.431	0.428	0.424	0.419
13.0	**0.387**	0.415	0.413	0.412	0.409	0.406	0.403	0.400	0.394	0.389	0.383	0.377
13.5	**0.348**	0.389	0.386	0.383	0.379	0.374	0.369	0.364	0.357	0.351	0.344	0.337
14.0	**0.311**	0.367	0.362	0.356	0.350	0.344	0.337	0.330	0.323	0.315	0.307	0.300
14.5	**0.278**	0.343	0.336	0.328	0.321	0.313	0.305	0.297	0.290	0.282	0.274	0.267
15.0	**0.250**	0.316	0.308	0.299	0.291	0.283	0.275	0.268	0.261	0.254	0.247	0.241
15.5	**0.225**	0.288	0.280	0.271	0.263	0.256	0.249	0.241	0.235	0.229	0.223	0.217
16.0	**0.204**	0.262	0.254	0.246	0.238	0.232	0.225	0.218	0.212	0.207	0.202	0.196
16.5	**0.185**	0.238	0.231	0.223	0.216	0.210	0.204	0.198	0.193	0.188	0.183	0.179
17.0	**0.169**	0.217	0.210	0.203	0.197	0.191	0.186	0.180	0.176	0.171	0.167	0.163
17.5	**0.155**	0.197	0.191	0.185	0.179	0.175	0.170	0.165	0.161	0.157	0.153	0.149
18.0	**0.142**	0.181	0.175	0.170	0.165	0.160	0.156	0.151	0.148	0.144	0.140	0.137
18.5	**0.131**	0.166	0.161	0.156	0.151	0.147	0.143	0.139	0.136	0.133	0.129	0.126
19.0	**0.121**	0.153	0.149	0.144	0.140	0.136	0.133	0.129	0.126	0.123	0.120	0.117
19.5	**0.112**	0.142	0.138	0.133	0.129	0.126	0.123	0.119	0.116	0.114	0.111	0.108
20.0	**0.104**	0.131	0.127	0.124	0.120	0.117	0.114	0.111	0.108	0.106	0.103	0.101
20.5	**0.097**	0.122	0.118	0.115	0.112	0.109	0.106	0.103	0.101	0.098	0.096	0.094
21.0	**0.090**	0.114	0.110	0.107	0.104	0.101	0.099	0.096	0.094	0.092	0.089	0.087
21.5	**0.084**	0.106	0.103	0.100	0.097	0.094	0.092	0.089	0.087	0.085	0.083	0.081
22.0	**0.079**	0.099	0.096	0.093	0.091	0.088	0.086	0.084	0.082	0.080	0.078	0.076
22.5	**0.074**	0.092	0.090	0.087	0.085	0.083	0.081	0.078	0.077	0.075	0.073	0.072
23.0	**0.070**	0.087	0.084	0.082	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.067
23.5	**0.066**	0.082	0.079	0.077	0.075	0.073	0.071	0.070	0.068	0.066	0.065	0.063
24.0	**0.062**	0.077	0.075	0.073	0.071	0.069	0.067	0.065	0.064	0.063	0.061	0.060
24.5	**0.058**	0.072	0.071	0.069	0.067	0.065	0.063	0.062	0.060	0.059	0.058	0.056
25.0	**0.055**	0.068	0.067	0.065	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.053

Table 12-11: C_t values, noise mode 3

12.4.3 Noise Curve, Noise Mode 3

All of the following noise curves are calculated at 8 m/s, at 10 m height.

Sound Power Level at Hub Height, V80-2.0 MW, Mode 3		
Conditions for Sound Power Level:	**Measurement Standard: IEC 61400-11 Ed. 2** **Wind Shear: 0.16** **Max Turbulence at 10 Meter Height: 16%** **Inflow Angle (Vertical): 0 ± 2°** **Air Density: 1.225 kg/m^3**	
Hub Height	60/67 m	78/80 m
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.2 5.4	94.0 5.6
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	98.6 6.8	99.3 7.0
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	101.0 8.1	101.3 8.4
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	101.5 9.5	101.5 9.8
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	101.8 10.8	101.8 11.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.5 12.2	102.8 12.6
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.2 13.6	103.3 13.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.8 14.9	104.0 15.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 16.3	104.1 16.7
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 17.6	104.1 18.1

Table 12-12: Noise curve, noise mode 3

12.5 Mode 4

12.5.1 Power Curve [kW] Star/Delta, Noise Mode 4

All of the following power curves are calculated at 690 V / 400 V on the low-voltage side of the high-voltage transformer.

Wind speed at hub height, 10 minute average.

V80-2.0 MW Power Curve, Noise Mode 4												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**67**	47	50	52	54	57	59	61	64	66	68	71
4.5	**109**	81	84	88	91	94	98	101	104	107	111	114
5.0	**158**	121	125	130	134	138	143	147	152	156	161	165
5.5	**217**	167	173	179	185	191	197	203	208	214	220	226
6.0	**288**	223	231	238	246	253	261	269	276	284	291	299
6.5	**371**	289	299	309	318	328	337	347	357	366	376	385
7.0	**467**	365	377	389	401	413	425	437	449	461	473	485
7.5	**573**	446	461	476	491	506	521	536	551	565	580	595
8.0	**691**	540	558	576	593	611	629	646	664	682	699	717
8.5	**813**	638	658	679	700	720	741	762	782	803	824	844
9.0	**936**	736	759	783	807	830	854	878	901	925	948	972
9.5	**1060**	834	861	888	914	941	967	994	1021	1047	1074	1100
10.0	**1178**	928	957	987	1016	1046	1075	1105	1134	1164	1193	1222
10.5	**1294**	1020	1053	1085	1117	1149	1181	1214	1246	1278	1310	1342
11.0	**1408**	1112	1147	1182	1217	1252	1287	1321	1356	1391	1426	1460
11.5	**1521**	1202	1240	1278	1315	1353	1390	1428	1465	1502	1539	1575
12.0	**1626**	1289	1329	1369	1409	1449	1489	1529	1568	1607	1644	1680
12.5	**1721**	1371	1414	1457	1499	1541	1583	1625	1663	1701	1737	1770
13.0	**1805**	1455	1500	1545	1589	1632	1674	1717	1752	1787	1819	1846
13.5	**1879**	1551	1597	1642	1685	1724	1763	1802	1832	1863	1889	1910
14.0	**1929**	1644	1687	1731	1771	1805	1839	1873	1896	1918	1936	1950
14.5	**1965**	1737	1776	1815	1850	1876	1902	1929	1943	1958	1969	1976
15.0	**1980**	1828	1858	1887	1912	1928	1944	1961	1968	1976	1982	1987
15.5	**1992**	1893	1913	1934	1951	1961	1971	1981	1985	1990	1993	1994
16.0	**1997**	1940	1953	1966	1977	1982	1987	1992	1994	1996	1997	1998
16.5	**1999**	1970	1977	1984	1990	1992	1995	1997	1998	1999	1999	1999
17.0	**2000**	1986	1989	1993	1996	1997	1998	1999	1999	2000	2000	2000
17.5	**2000**	1995	1996	1998	1999	1999	1999	2000	2000	2000	2000	2000
18.0	**2000**	1998	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000
18.5	**2000**	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
19.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
20.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
21.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
22.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
23.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
24.5	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
25.0	**2000**	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 12-13: Power curve, noise mode 4

12.5.2 C_t Values, Noise Mode 4

V80-2.0 MW Star/Delta C_t Values, Noise Mode 4												
Air density [kg/m^3]												
Wind speed [m/s]	**1.225**	**0.97**	**1**	**1.03**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
4.0	**0.879**	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.879
4.5	**0.862**	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862	0.862
5.0	**0.852**	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852
5.5	**0.846**	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
6.0	**0.844**	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844	0.844
6.5	**0.840**	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840
7.0	**0.826**	0.826	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.826	0.826
7.5	**0.802**	0.801	0.801	0.801	0.801	0.802	0.802	0.802	0.802	0.802	0.802	0.802
8.0	**0.769**	0.768	0.768	0.768	0.768	0.769	0.769	0.769	0.769	0.769	0.769	0.769
8.5	**0.729**	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729	0.729
9.0	**0.684**	0.683	0.683	0.684	0.684	0.684	0.684	0.684	0.684	0.684	0.684	0.684
9.5	**0.638**	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638
10.0	**0.591**	0.590	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591
10.5	**0.547**	0.546	0.546	0.546	0.546	0.546	0.546	0.546	0.547	0.547	0.547	0.547
11.0	**0.506**	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506	0.506
11.5	**0.468**	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.468	0.468	0.468
12.0	**0.432**	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.432	0.432	0.430
12.5	**0.397**	0.401	0.401	0.401	0.400	0.400	0.400	0.400	0.399	0.397	0.396	0.393
13.0	**0.363**	0.371	0.371	0.371	0.371	0.370	0.370	0.369	0.367	0.364	0.361	0.357
13.5	**0.331**	0.347	0.347	0.346	0.345	0.343	0.341	0.339	0.336	0.333	0.329	0.324
14.0	**0.301**	0.326	0.325	0.323	0.321	0.318	0.315	0.313	0.308	0.303	0.298	0.292
14.5	**0.273**	0.308	0.305	0.302	0.299	0.295	0.291	0.287	0.281	0.276	0.270	0.264
15.0	**0.248**	0.292	0.288	0.283	0.279	0.273	0.268	0.262	0.256	0.251	0.245	0.239
15.5	**0.224**	0.273	0.267	0.262	0.256	0.250	0.245	0.239	0.233	0.227	0.222	0.216
16.0	**0.204**	0.253	0.247	0.241	0.235	0.229	0.223	0.217	0.212	0.206	0.201	0.196
16.5	**0.185**	0.234	0.227	0.221	0.215	0.209	0.203	0.198	0.193	0.188	0.183	0.178
17.0	**0.169**	0.215	0.208	0.202	0.196	0.191	0.186	0.180	0.176	0.171	0.167	0.163
17.5	**0.155**	0.197	0.191	0.185	0.179	0.174	0.170	0.165	0.161	0.157	0.153	0.149
18.0	**0.142**	0.181	0.175	0.170	0.165	0.160	0.156	0.151	0.148	0.144	0.140	0.137
18.5	**0.131**	0.166	0.161	0.156	0.151	0.147	0.143	0.139	0.136	0.133	0.129	0.126
19.0	**0.121**	0.153	0.149	0.144	0.140	0.136	0.133	0.129	0.126	0.123	0.120	0.117
19.5	**0.112**	0.142	0.138	0.133	0.129	0.126	0.123	0.119	0.116	0.114	0.111	0.108
20.0	**0.104**	0.131	0.127	0.124	0.120	0.117	0.114	0.111	0.108	0.105	0.103	0.101
20.5	**0.097**	0.122	0.118	0.115	0.112	0.109	0.106	0.103	0.101	0.098	0.096	0.094
21.0	**0.090**	0.114	0.110	0.107	0.104	0.101	0.099	0.096	0.094	0.092	0.089	0.087
21.5	**0.084**	0.106	0.103	0.100	0.097	0.094	0.092	0.089	0.087	0.085	0.083	0.081
22.0	**0.079**	0.099	0.096	0.093	0.091	0.088	0.086	0.084	0.082	0.080	0.078	0.076
22.5	**0.074**	0.092	0.090	0.087	0.085	0.083	0.081	0.078	0.077	0.075	0.073	0.072
23.0	**0.070**	0.087	0.084	0.082	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.067
23.5	**0.066**	0.082	0.079	0.077	0.075	0.073	0.071	0.070	0.068	0.066	0.065	0.063
24.0	**0.062**	0.077	0.075	0.073	0.071	0.069	0.067	0.065	0.064	0.063	0.061	0.060
24.5	**0.058**	0.072	0.071	0.069	0.067	0.065	0.063	0.062	0.060	0.059	0.058	0.056
25.0	**0.055**	0.068	0.067	0.065	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.053

Table 12-14: Ct values, noise mode 4

12.5.3 Noise Curve, Noise Mode 4

All of the following noise curves are calculated at 8 m/s, at 10 m height.

Sound Power Level at Hub Height, V80-2.0 MW, Mode 4		
Conditions for Sound Power Level:	**Measurement Standard: IEC 61400-11 Ed. 2** **Wind Shear: 0.16** **Max Turbulence at 10 Meter Height: 16%** **Inflow Angle (Vertical): 0 ± 2°** **Air Density: 1.225 kg/m^3**	
Hub Height	60/67 m	78/80 m
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.2 5.4	94.0 5.6
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	98.6 6.8	99.3 7.0
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.2 8.1	100.2 8.4
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.4 9.5	100.4 9.8
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.7 10.8	100.7 11.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	101.4 12.2	101.7 12.6
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.2 13.6	102.4 13.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.6 14.9	103.8 15.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 16.3	104.1 16.7
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	104.1 17.6	104.1 18.1

Table 12-15: Noise curve, noise mode 4