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General Specification

V126–3.3 MW 50 Hz

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1 General Description

The Vestas V126-3.3 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V126-3.3 MW turbine has a rotor diameter of 126 m and a rated output power of 3.3 MW. The turbine utilises the OptiTip® concept and a power system based on a permanent magnet or induction generator and full-scale converter. With these features, the wind turbine is able to operate the rotor at variable speed and thereby maintaining the power output at or near rated power even in high wind speed. At low wind speed, the OptiTip® concept and the power system work together to maximise the power output by operating at the optimal rotor speed and pitch angle.

2 Mechanical Design

2.1 Rotor

The V126-3.3 MW is equipped with a 126-meter 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	126 m
Swept Area	12469 m^2
Speed, Dynamic Operation Range	5.3-16.5
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Blade Coning	4°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data

2.2 Blades

The blades are made of carbon and fibreglass and consist of two infused structural airfoil shells.

Blades	
Type Description	Infused structural airfoil shell
Blade Length	61.66 m
Material	Fibreglass reinforced epoxy and carbon fibres
Blade Connection	Steel roots inserted
Airfoils	High-lift profile

Blades	
Maximum Chord	4.0 m

Table 2-2: Blades data

2.3 Blade Bearing

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

Blade Bearing	
Lubrication	Grease

Table 2-3: Blade bearing data

2.4 Pitch System

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

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

Pitch System	
Type	Hydraulic
Number	1 per blade
Range	-9.5° to 90°

Table 2-4: Pitch system data

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

Table 2-5: Hydraulic system data

2.5 Hub

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

Hub	
Type	Cast ball shell hub
Material	Cast iron

Table 2-6: Hub data

2.6 Main Shaft

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

Main Shaft	
Type Description	Hollow shaft
Material	Cast iron

Table 2-7: Main shaft data

2.7 Main Bearing Housing

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

Main Bearing Housing	
Material	Cast iron

Table 2-8: Main bearing housing data

2.8 Main Bearing

The main bearing carries all thrust loads.

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

Table 2-9: Main bearing data

2.9 Gearbox

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

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

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

Table 2-10: Gearbox data

2.10 Generator Bearings

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

2.11 High-Speed Shaft Coupling

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

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

2.12 Yaw System

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

The yaw gears have a torque limiter.

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

Table 2-11: Yaw system data

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

Table 2-12: Yaw gear data

2.13 Crane

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

Crane	
Lifting Capacity	Maximum 800 kg

Table 2-13: Crane data

2.14 Towers

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. The towers are designed with the majority of internal welded connections replaced by magnet supports to create a predominantly smooth-walled tower. Magnets provide load support in a horizontal direction and internals, such as platforms, ladders, 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	117 m/137 m
Material	Steel or Hybrid

Table 2-14: Tower structure data

2.15 Nacelle Bedplate and Cover

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

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

The crane girders are attached to the top structure. The lower beams of the girder structure are connected at the rear end. The rear part of the bedplate serves as the foundation for controller panels, the cooling system and transformer. The nacelle cover is 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 CoolerTop® located on top of the rear end of the nacelle. The CoolerTop® is a free flow cooler, thus ensuring that there are no electrical components in the thermal conditioning system located outside the nacelle.
- The Liquid Cooling System, which serves the gearbox,hydraulic systems, generator and converter is driven by an electrical pumping system.
- The transformer forced air cooling comprised of an electrical fan.

2.16.1 Generator and Converter Cooling

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

2.16.2 Gearbox and Hydraulic Cooling

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

2.16.3 Transformer Cooling

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

2.16.4 Nacelle Cooling

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

3 Electrical Design

3.1 Generator

The generator is a three-phase synchronous generator with a permanent magnet rotor or a three phase asynchronous induction generator with cage 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	Alternative 1	Alternative 2
Type	Synchronous with permanent magnets	Asynchronous with cage rotor
Frequency [f_N]	0- 200 Hz	0-100 Hz
Voltage, Stator [U_{NS}]	3 x 710 V (at rated speed)	3 x 750 V (at rated speed)
Number of Poles	12	4/6
Winding Type	Form with VPI (Vacuum Pressurized Impregnation)	Form with VPI (Vacuum Pressurized Impregnation)
Winding Connection	Star	Star or Delta
Rated rpm	1450-1550 rpm	1450-1550 rpm
Overspeed Limit Acc. to IEC (2 minutes)	2400 rpm	2400 rpm
Generator Bearing	Hybrid/ceramic	Hybrid/ceramic
Temperature Sensors, Stator	3 PT100 sensors placed at hot spots and 3 as back-up	3 PT100 sensors placed at hot spots and 3 as back-up
Temperature Sensors, Bearings	1 per bearing	1 per bearing
Insulation Class	F or H	F or H
Enclosure	IP54	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 multiple 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 Grid Voltage	650 V

Table 3-2: Converter data

3.3 HV 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.
Applied standards	IEC 60076-11, IEC 60076-16, Cenelec HD 637:S1.
Cooling method	AF
Rated power	3750 kVA
Nominal voltage, turbine side	
U_m 1.1kV	0.650 kV
Nominal voltage, grid side	
U_m 12.0kV	10.0-11.0 kV
U_m 24.0kV	11.1-22.0 kV
U_m 36.0kV	22.1-33.0 kV
U_m 41.5kV	33.1-35.0 kV
Insulation level AC / LI / LIC	
U_m 1.1kV	3[1] / - / - kV
U_m 12.0kV	28[1] / 75 / 75 kV
U_m 24.0kV	50[1] / 125 / 125 kV
U_m 36.0kV	70[1] / 170 / 170 kV
U_m 41.5kV	80[1] / 170 / 170 kV
Off-circuit tap changer	±2 x 2.5 %
Frequency	50 Hz
Vector group	Dyn5 / YNyn0
No-load loss [2]	5.3 kW
Load loss @ rated power HV, 120°C [2]	31.5 kW
No-load reactive power [3]	16kVAr
Full load reactive power [3]	330kVAr
Positive sequence short-circuit impedance @ rated power, 120°C [4]	8.7 %
Positive sequence short-circuit resistance@ rated power, 120°C[3]	0.7 %
Zero sequence short-circuit impedance@ rated power, 120°C[3]	8.7 %
Zero sequence short-circuit resistance@ rated power, 120°C[3]	0.7 %
Inrush peak current [3]	
Dyn5	6-9 x $\hat{I}_n$

YNyn0	8-12 x $\hat{I}_n$
Half crest time [3]	~ 0.7 s
Sound power level	≤ 80 dB(A)
Average temperature rise @ 1000m	≤80 K
Max altitude [5]	2000 m
Insulation class	155 (F)
Environmental class	E2
Climatic class	C2
Fire behaviour class	F1
Corrosion class	C4
Weight	≤8500 kg
Temperature monitoring	PT100 sensors in LV windings and core
Overvoltage protection	Surge arresters on HV terminals
Temporary earthing	3 x Ø20mm earthing ball points

Table 3-3: Transformer data

NOTE

[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] Subjected to standard IEC tolerances.
[5] Max hub height altitude will depend on site location.

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 for 10-22 kV rated voltage 42 kV for 22.1-35 kV rated 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 a separate 650/400 V transformer located in the nacelle. All motors, pumps, fans and heaters are supplied from this system.

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

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

Table 3-6: AUX system data

3.7 Wind Sensors

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

3.8 Vestas Multi Processor (VMP) Controller

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

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

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

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

The VMP6000 controller serves the following main functions:

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

3.9 Uninterruptible Power Supply (UPS)

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.

<table>
<tr><td colspan="7">UPS</td></tr>
<tr><td>Battery Type</td><td colspan="6">Valve-Regulated Lead Acid (VRLA)</td></tr>
<tr><td>Rated Battery Voltage</td><td colspan="6">2 x 8 x 12 V (192 V)</td></tr>
<tr><td>Converter Type</td><td colspan="6">Double conversion</td></tr>
<tr><td>Converter Input</td><td colspan="6">230 V +/-20%</td></tr>
<tr><td>Rated Output Voltage</td><td colspan="6">230 Vac</td></tr>
<tr><td rowspan="6">Backup Time**</td><td>Aviation Lights</td><td></td><td>0 hr.</td><td>1 hr.</td><td>8 hrs.</td><td>>8 hrs.</td></tr>
<tr><td rowspan="5">Control System*</td><td>15 min.</td><td>1 EXB</td><td>1 EXB</td><td>3 EXB</td><td>4 EXB (max. 630min.)</td></tr>
<tr><td>1 hr.</td><td>1 EXB</td><td>3 EXB</td><td>4 EXB</td><td>N.A.</td></tr>
<tr><td>2 hrs.</td><td>2 EXB</td><td>3 EXB</td><td>4 EXB</td><td>N.A.</td></tr>
<tr><td>3 hrs.</td><td>3 EXB</td><td>4 EXB</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td>>3 hrs.</td><td>4 EXB (max. 230min.)</td><td>N.A.</td><td>N.A.</td><td>N.A.</td></tr>
<tr><td rowspan="2">Re-charging Time</td><td colspan="2">80%</td><td colspan="4">Approximately 3 hours</td></tr>
<tr><td colspan="2">100%</td><td colspan="4">Approximately 8 hours</td></tr>
</table>

Table 3-7: UPS data

N.A. = desired back-up time not possible

EXB = optional extra battery pack.

**The control system includes: the turbine controller (System 6000), switchgear functions, and remote control system. Internal lights are fed by separate built-in batteries in light armatures.*

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.

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

Table 4-1: Short circuit protection data

4.3 Overspeed Protection

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

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

Overspeed Protection	
Sensors Type	Inductive
Trip Level	16.5 (rotor rpm)/1871 (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 7 Approvals and Design Codes, p. 20).

4.5 EMC System

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

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

4.6 Earthing

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

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

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

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

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

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

4.7 Corrosion Protection

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

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	Minimum C3
Hub	C5	C3
Tower	C4	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 switchboards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

5.2 Escape

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

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

Escape from the service lift is by ladder.

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

5.3 Rooms/Working Areas

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

5.4 Floors, Platforms, Standing and Working Places

All floors have anti-slip surfaces.

There is one floor per tower section.

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

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

5.5 Service Lift

The V126-3.3 MW turbine is delivered optionally with a service lift installed.

5.6 Climbing Facilities

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

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

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

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

5.7 Moving Parts, Guards and Blocking Devices

All moving parts in the nacelle are shielded.

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

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

5.8 Lights

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

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

5.9 Emergency Stop

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

5.10 Power Disconnection

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

5.11 Fire Protection/First Aid

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

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

5.12 Warning Signs

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

5.13 Manuals and Warnings

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

6 Environment

6.1 Chemicals

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

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

7 Approvals and Design Codes

7.1 Type Approvals

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

Certification	Wind Class	Hub Height
IEC61400-22	IEC IIIB	117 m

Certification	Wind Class	Hub Height
IEC61400-22	IEC IIIA	137 m
DIBt Anlage 2.7/10	DIBt II	137 m

Table 7-1: Type approvals data

7.2 Design Codes – Structural Design

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

Design Codes	
Nacelle and Hub	IEC 61400-1 Edition 3 EN 50308
Tower	IEC 61400-1 Edition 3 Eurocode 3
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2
Gearbox	ISO 81400-4
Generator	IEC 60034
Transformer	IEC 60076-11, IEC 60076-16, CENELEC HD637 S1
Lightning Protection	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006 IEC/TR 61400-24:2002
Rotating Electrical Machines	IEC 34
Safety of Machinery, Safety-related Parts of Control Systems	IEC 13849-1
Safety of Machinery – Electrical Equipment of Machines	IEC 60204-1

Table 7-2: Design codes

8 Colours

8.1 Nacelle Colour

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

Table 8-1: Colour, nacelle

8.2 Tower Colour

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

Table 8-2: Colour, tower

8.3 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 IIIA**
Ambient Temperature Interval (Standard Temperature Turbine)	-40° to +50°C
Extreme Wind Speed (10 Minute Average)	37.5 m/s
Survival Wind Speed (3 Second Gust)	52.5 m/s

Table 9-1: Extreme design parameters

Average Design Parameters	
Wind Climate	**IEC IIIA**
Nominal Power	3.3 MW
Wind Speed	7.5 m/s
A-Factor	8.46 m/s
Form Factor, c	2.0
Turbulence Intensity According to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s – 90% quartile)	18%
Wind Shear	0.20
Inflow Angle (vertical)	8°

Table 9-2: Average design parameters

9.1.1 Complex Terrain

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

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

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

9.1.2 Altitude

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

9.1.3 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing, 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 Turbine)	-20° to +45°C
Ambient Temperature Interval (Low Temperature Turbine)	-30° to +45°C
Cut-In	3 m/s
Cut-Out (10 Minute Exponential Average)	22.5m/s
Re-Cut In (10 Minute Exponential Average)	20 m/s

Table 9-3: Operational envelope – temperature and wind

NOTE At ambient temperatures above +30°C, the turbine will maintain derated production, within the component capacity as seen in figure 9-1, p24.

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

For the Low temperature options of the wind turbine, consult 'Vestas'.

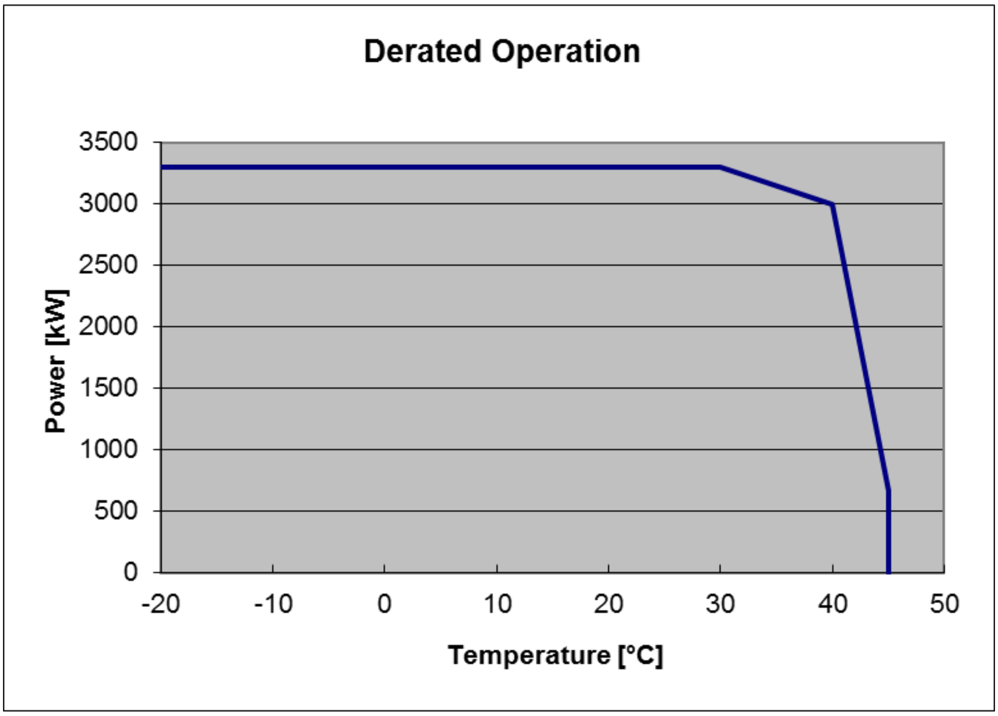

Figure 9-1: Derated Operation

9.3 Operational Envelope – Grid Connection

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	650 V
Nominal Frequency	[f_N]	50/60 Hz
Maximum 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 Required Short Circuit Ratio at Turbine HV Connection	5.0	
Maximum Short Circuit Current Contribution	1.05 p.u. (continuous) 1.45 p.u. (peak)	

Table 9-4: Operational envelope – grid connection

The generator and the converter will be disconnected if*:

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

Table 9-5: Generator and converter disconnecting values

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

9.4 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability as illustrated:

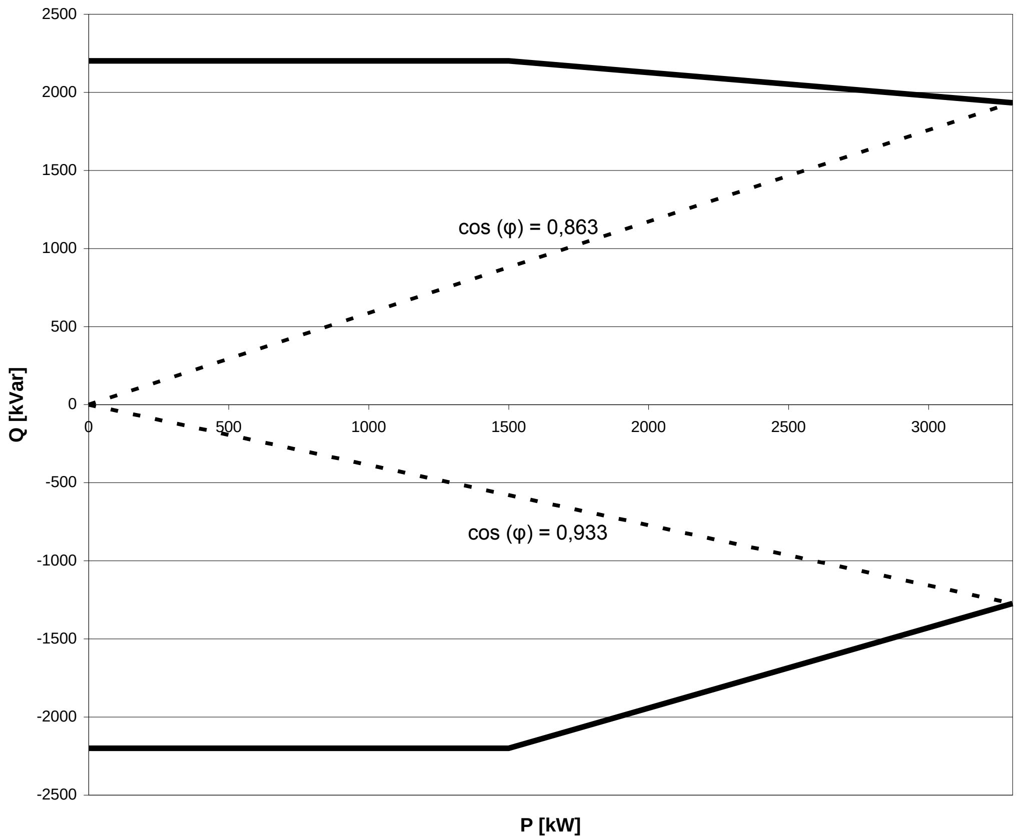

Figure 9-2: Reactive power capability

The above chart applies at the low voltage side of the HV transformer at nominal voltage ±10% and nominal frequency ±6%.

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

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

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

9.5 Performance – Fault Ride-Through

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

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

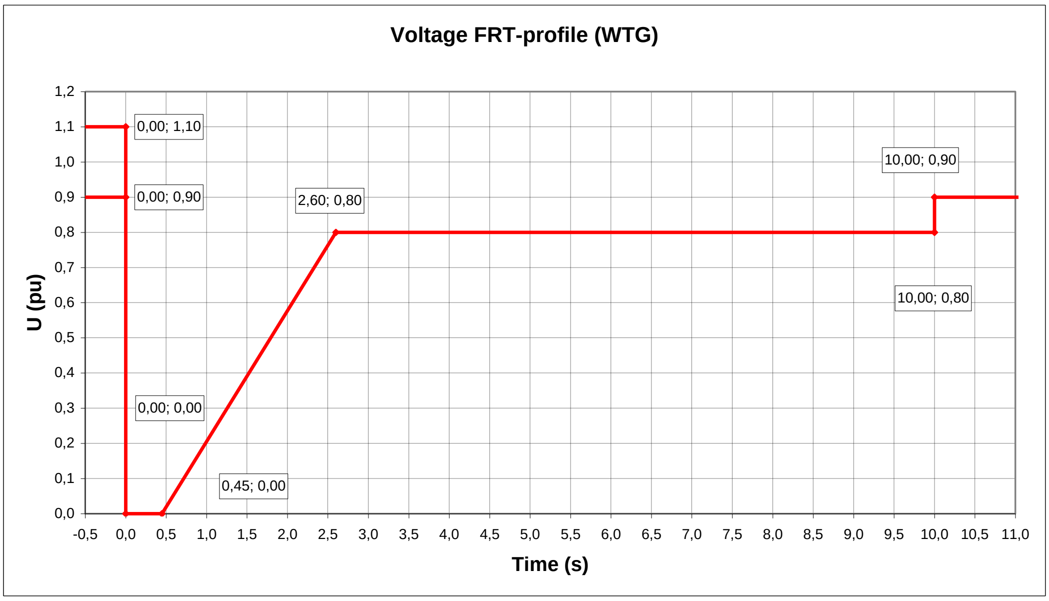

Figure 9-3: Low voltage tolerance curve for symmetrical and asymmetrical faults, where U represents voltage as measured on the grid

For grid disturbances outside the protection curve in Figure 9-3, 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 active current at the high voltage side of the HV transformer. Figure 9-4, p. 28 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 9-4, p. 28, the default current injection slope is 2% reactive current increase per 1% voltage decrease. The slope can be parameterized between 0 and 10 to adapt to site specific requirements.

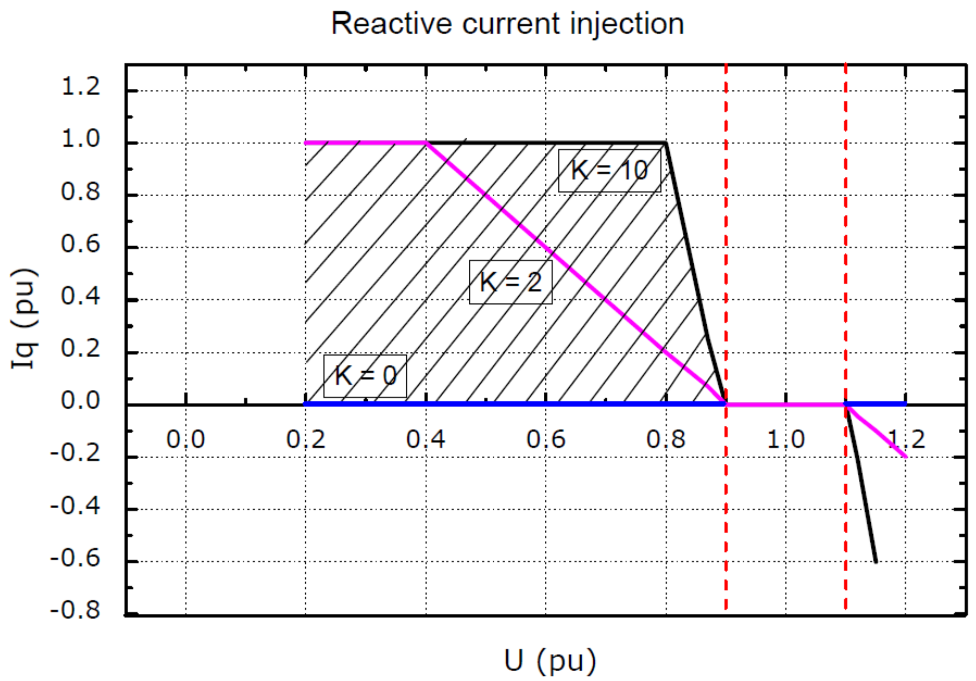

Figure 9-4: Reactive current injection

9.6.2 Asymmetrical Reactive Current Contribution

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

9.7 Performance – Multiple Voltage Dips

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

9.8 Performance – Active and Reactive Power Control

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

Maximum Ramp Rates for External Control	
Active Power	0.1 pu/sec (330 kW/sec)
Reactive Power	20 pu/sec (66 MVAr/sec)

Table 9-7: Active/reactive power ramp rates

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

9.9 Performance – Voltage Control

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

9.10 Performance – Frequency Control

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

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

9.11 Main Contributors to Own Consumption

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

Main contributors to Own Consumption	
Hydraulic Motor	2 x 15 kW (master/slave)
Yaw Motors	Maximum 18 kW in total
Water Heating	10 kW
Water Pumps	2.2 + 5.5 kW
Oil Heating	7.9 kW
Oil Pump for Gearbox Lubrication	10 kW
Controller Including Heating Elements for the Hydraulics and all Controllers	Approximately 3 kW
HV Transformer No-load Loss	See section 3.3 HV Transformer, p. 12

Table 9-8: Main contributors to own consumption data

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

See section 12 Appendices, p. 34 for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear	0.00-0.30 (10 minute average)
Turbulence Intensity	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1

Conditions for Power Curve and C_t Values (at Hub Height)	
Inflow Angle (Vertical)	0 ±2°
Grid Frequency	Nominal Frequency ±0.5 Hz

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

9.13 Noise Modes

The noise modes listed in table 9-10 below are available for the V126-3.3 MW turbine.

Available Noise Modes for V126-3.3 MW		
Mode No.	**Mode Name**	**Maximum Noise Level**
0	Optimised Power	107.5 dB
2	Max. 106.5 dB	106.5 dB
3	Max. 104.5 dB	104.5 dB
4	Max. 102.5 dB	102.5 dB
5	Max. 101.0 dB	101.0 dB
	DK Noise Mode	105.5 dB

Table 9-6: Available noise modes

The noise modes are available for the hub heights listed in table tower structure data in section 2.14 Towers, p. 9.

For further details on Noise Modes, see section 12 Appendices, p34, or contact Vestas Wind Systems A/S

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

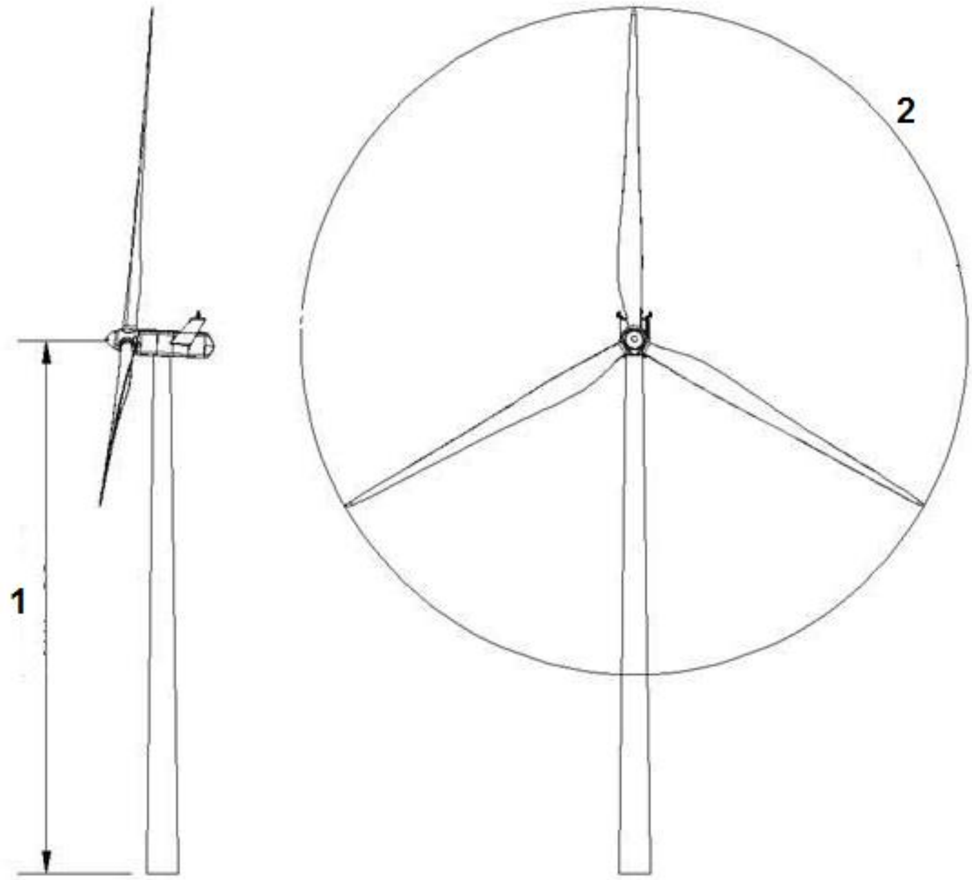

Figure 10-1: Illustration of outer dimensions – structure.

1 Hub height 117/137 m **2** Diameter: 126 m

10.2 Structural Design – Side View Drawing

Figure 10-2: Side-view drawing.

11 General Reservations, Notes and Disclaimers

-
- The general specifications described in this document apply to the current version of the V126-3.3 MW wind turbine. Updated versions of the V126-3.3 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 V126-3.3 MW wind turbine, Vestas will provide an updated general specification applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with limited variation in frequency and voltage.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- All listed start/stop parameters (e. g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements and codes of standards.
- This document, General Specification, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

12 Appendices

12.1 Mode 0, "Optimised Power"

12.1.1 Power Curves, Noise Mode 0, "Optimised Power"

	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**
3.0	**36**	18	19	21	23	24	26	28	29	31	33	35	38	40
3.5	**99**	65	68	71	74	77	81	84	87	90	93	96	102	105
4.0	**177**	126	131	135	140	145	149	154	158	163	168	172	181	186
4.5	**274**	201	208	214	221	227	234	241	247	254	260	267	280	287
5.0	**393**	293	302	312	320	329	339	348	357	366	375	384	402	411
5.5	**537**	405	417	429	441	453	465	477	489	501	513	525	549	561
6.0	**712**	540	555	571	587	602	618	634	649	665	681	696	728	743
6.5	**919**	700	720	740	759	779	799	819	839	859	879	899	938	958
7.0	**1161**	888	913	938	963	988	1013	1037	1062	1087	1112	1136	1186	1210
7.5	**1436**	1103	1134	1164	1194	1225	1255	1286	1316	1346	1376	1406	1466	1496
8.0	**1747**	1348	1385	1422	1458	1495	1531	1567	1604	1640	1676	1711	1782	1818
8.5	**2082**	1623	1666	1708	1751	1794	1835	1877	1918	1960	2001	2041	2122	2162
9.0	**2421**	1915	1963	2010	2058	2106	2151	2197	2243	2289	2332	2376	2463	2505
9.5	**2741**	2210	2261	2313	2364	2416	2464	2512	2560	2608	2652	2697	2782	2823
10.0	**3011**	2500	2553	2607	2660	2714	2760	2806	2852	2898	2936	2973	3041	3072
10.5	**3185**	2770	2820	2870	2920	2971	3006	3042	3077	3113	3137	3161	3202	3219
11.0	**3267**	2979	3019	3059	3098	3138	3161	3184	3207	3231	3243	3255	3274	3281
11.5	**3293**	3136	3161	3187	3213	3238	3249	3260	3270	3281	3285	3289	3294	3296
12.0	**3298**	3226	3239	3252	3266	3279	3283	3287	3291	3295	3296	3297	3299	3300
12.5	**3300**	3269	3275	3281	3287	3293	3294	3296	3297	3299	3299	3300	3300	3300
13.0	**3300**	3287	3290	3293	3295	3298	3298	3299	3299	3300	3300	3300	3300	3300
13.5	**3300**	3292	3294	3296	3297	3299	3299	3300	3300	3300	3300	3300	3300	3300
14.0	**3300**	3297	3298	3298	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300
14.5	**3300**	3299	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
15.0	**3300**	3299	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
15.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
16.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
16.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
17.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
18.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
19.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
20.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
21.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.0	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
22.5	**3300**	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300

Table 12-1: Power curve, noise mode 0

12.1.2 C_t Values, Noise Mode 0, "Optimised Power"

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3.0	**0.949**	0.951	0.952	0.952	0.952	0.952	0.952	0.951	0.951	0.950	0.950	0.949	0.948	0.947
3.5	**0.930**	0.936	0.936	0.935	0.935	0.934	0.933	0.933	0.932	0.932	0.931	0.931	0.929	0.929
4.0	**0.910**	0.916	0.915	0.915	0.914	0.914	0.913	0.912	0.912	0.911	0.911	0.910	0.909	0.909
4.5	**0.878**	0.883	0.883	0.882	0.882	0.881	0.881	0.880	0.880	0.879	0.879	0.879	0.878	0.877
5.0	**0.861**	0.868	0.867	0.867	0.866	0.865	0.865	0.864	0.864	0.863	0.862	0.862	0.861	0.860
5.5	**0.855**	0.864	0.863	0.862	0.861	0.861	0.860	0.859	0.858	0.858	0.857	0.856	0.854	0.854
6.0	**0.847**	0.857	0.856	0.855	0.854	0.853	0.852	0.851	0.850	0.850	0.849	0.848	0.846	0.845
6.5	**0.838**	0.851	0.849	0.848	0.847	0.846	0.845	0.844	0.843	0.842	0.840	0.839	0.837	0.836
7.0	**0.828**	0.843	0.842	0.840	0.839	0.838	0.836	0.835	0.834	0.832	0.831	0.830	0.827	0.825
7.5	**0.818**	0.835	0.834	0.832	0.831	0.829	0.828	0.826	0.824	0.823	0.821	0.820	0.816	0.815
8.0	**0.805**	0.826	0.824	0.822	0.820	0.819	0.817	0.815	0.813	0.811	0.809	0.807	0.802	0.800
8.5	**0.774**	0.808	0.806	0.803	0.800	0.797	0.794	0.791	0.787	0.784	0.781	0.777	0.770	0.767
9.0	**0.724**	0.774	0.769	0.765	0.761	0.757	0.752	0.747	0.743	0.738	0.734	0.729	0.719	0.714
9.5	**0.667**	0.727	0.722	0.717	0.711	0.706	0.701	0.695	0.690	0.684	0.678	0.673	0.661	0.654
10.0	**0.602**	0.674	0.669	0.663	0.658	0.652	0.645	0.639	0.632	0.625	0.618	0.610	0.594	0.586
10.5	**0.530**	0.621	0.615	0.608	0.601	0.594	0.585	0.577	0.568	0.559	0.549	0.540	0.520	0.510
11.0	**0.456**	0.561	0.552	0.544	0.535	0.527	0.517	0.507	0.497	0.487	0.477	0.466	0.446	0.437
11.5	**0.390**	0.501	0.491	0.481	0.470	0.460	0.450	0.439	0.429	0.419	0.409	0.399	0.381	0.373
12.0	**0.336**	0.441	0.430	0.420	0.409	0.399	0.389	0.380	0.370	0.360	0.352	0.344	0.329	0.322
12.5	**0.293**	0.385	0.375	0.366	0.356	0.346	0.338	0.330	0.321	0.313	0.306	0.299	0.287	0.280
13.0	**0.257**	0.337	0.329	0.320	0.312	0.303	0.296	0.289	0.282	0.275	0.269	0.263	0.252	0.247
13.5	**0.229**	0.299	0.291	0.284	0.276	0.269	0.263	0.257	0.250	0.244	0.239	0.234	0.225	0.220
14.0	**0.204**	0.265	0.259	0.252	0.245	0.239	0.234	0.228	0.223	0.218	0.213	0.209	0.200	0.196
14.5	**0.183**	0.237	0.231	0.225	0.219	0.214	0.209	0.204	0.200	0.195	0.191	0.187	0.180	0.176
15.0	**0.164**	0.212	0.206	0.201	0.196	0.191	0.187	0.183	0.179	0.175	0.171	0.168	0.161	0.158
15.5	**0.149**	0.191	0.186	0.182	0.177	0.173	0.169	0.166	0.162	0.158	0.155	0.152	0.146	0.143
16.0	**0.135**	0.173	0.169	0.165	0.161	0.157	0.154	0.150	0.147	0.144	0.141	0.138	0.133	0.131
16.5	**0.124**	0.158	0.154	0.150	0.147	0.143	0.140	0.137	0.134	0.131	0.129	0.126	0.121	0.119
17.0	**0.113**	0.144	0.141	0.137	0.134	0.131	0.128	0.126	0.123	0.120	0.118	0.116	0.111	0.109
17.5	**0.104**	0.132	0.129	0.126	0.123	0.120	0.118	0.115	0.113	0.110	0.108	0.106	0.102	0.101
18.0	**0.096**	0.121	0.119	0.116	0.113	0.111	0.108	0.106	0.104	0.102	0.100	0.098	0.095	0.093
18.5	**0.089**	0.112	0.110	0.107	0.105	0.102	0.100	0.098	0.096	0.094	0.092	0.091	0.087	0.086
19.0	**0.082**	0.103	0.101	0.099	0.096	0.094	0.092	0.090	0.089	0.087	0.085	0.084	0.081	0.079
19.5	**0.076**	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.081	0.079	0.078	0.075	0.074
20.0	**0.071**	0.089	0.087	0.085	0.083	0.081	0.080	0.078	0.077	0.075	0.074	0.072	0.070	0.069
20.5	**0.066**	0.083	0.081	0.079	0.078	0.076	0.074	0.073	0.072	0.070	0.069	0.068	0.065	0.064
21.0	**0.062**	0.077	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.066	0.064	0.063	0.061	0.060
21.5	**0.059**	0.073	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.060	0.058	0.057
22.0	**0.055**	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.056	0.054	0.053
22.5	**0.052**	0.064	0.063	0.062	0.060	0.059	0.058	0.057	0.056	0.055	0.054	0.053	0.051	0.050

Table 12-2: C_t values, noise mode 0

12.1.3 Noise Curves, Noise Mode 0, "Optimised Power"

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	**117 m**	**137 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	95.8 4.4	96.0 4.6
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	99.4 5.9	99.8 6.1
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.4 7.4	103.9 7.6
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 8.9	107.5 9.1
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 10.4	107.5 10.6
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 11.9	107.5 12.2
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 13.3	107.5 137
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 14.8	107.5 15.2
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 16.3	107.5 16.7
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 17.8	107.5 18.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	107.5 19.3	107.5 19.8

Table 12-3: Noise curves, noise mode 0