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. 25.

Design Codes – EMC System	
Designed according to	IEC 61400-1: 2005
Further robustness requirements according to	TPS 901785

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 1 kV a.c. – Part 1: Common rules.

8 Colour and Surface Treatment

8.1 Nacelle Colour and Surface Treatment

Surface Treatment of Vestas Nacelles	
Standard Nacelle Colours	RAL 7035 (light grey)
Gloss	According to ISO 2813

Table 8-1: Surface treatment, nacelle.

8.2 Tower Colour and Surface Treatment

Surface Treatment of Vestas Tower Sections		
	External:	**Internal:**
Tower Colour Variants	RAL 7035 (light grey)	RAL 9001 (cream white)
Gloss	50-75% UV resistant	Maximum 50%

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	< 20%

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 S**
Ambient Temperature Interval (Standard Temperature Turbine)	-30° to +50°C
Extreme Wind Speed (10 minute average)	42.5 m/s
Survival Wind Speed (3 second gust)	59.5 m/s

Table 9-1: Extreme design parameters.

Average Design Parameters	
Wind Climate	**IEC S**
Wind Speed	7.5 m/s
A-factor	8.45 m/s
Form Factor, c	2.0
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 metres above sea level as standard.

Above 1500 metres special considerations must be taken regarding e.g. 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
Ambient Temperature Interval (Low Temperature Turbine)	-30° to +40° C
Cut-in (10 minute average)	3 m/s
Cut-out (100 second exponential average)	20 m/s
Re-cut in (100 second exponential average)	18 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}	60 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	63.6 Hz	
Frequency is below [Hz] for 0.2 seconds	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 dependent on power rating as illustrated in Figure 9-1, p. 29.

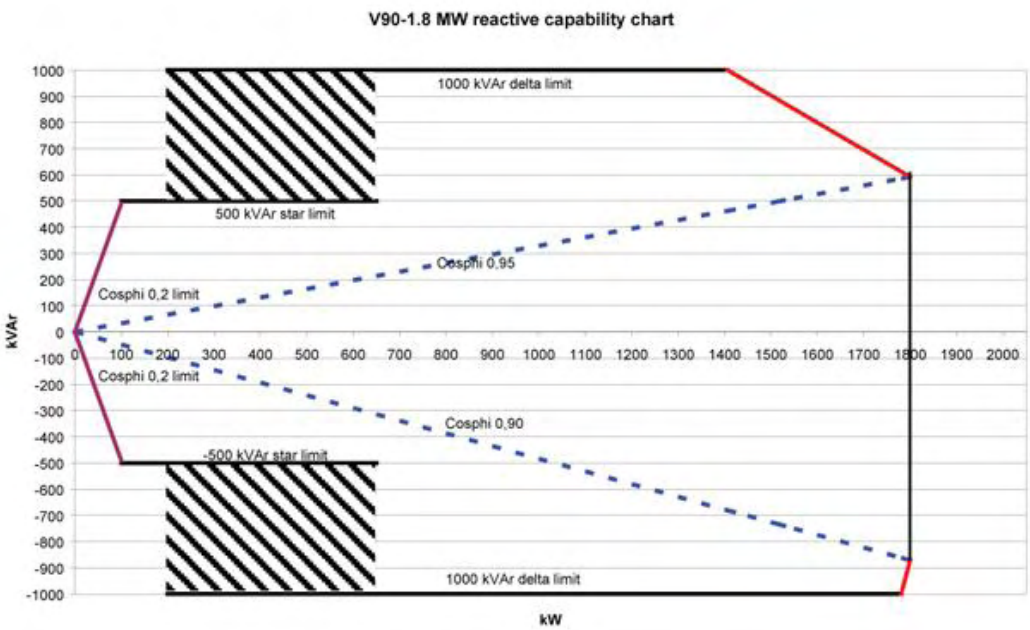

Figure 9-1: Reactive power capability.

The above chart applies at the low-voltage side of the HV transformer. The turbine maximizes active power or reactive power depending on grid voltage conditions.

9.5 Performance – Fault Ride Through

The turbine is equipped with a reinforced converter system in order to gain better control of the generator during grid faults. The turbine control system continues to run 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. 30.

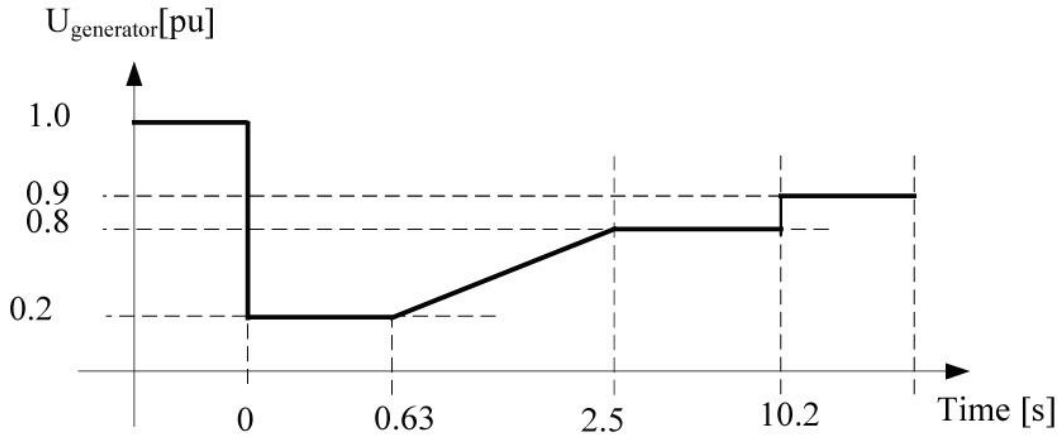

Figure 9-2: Low-voltage tolerance curve for symmetrical and asymmetrical faults.

For grid disturbances outside the protection curve in Figure 9-3, p. 30, the turbine will be disconnected from the grid.

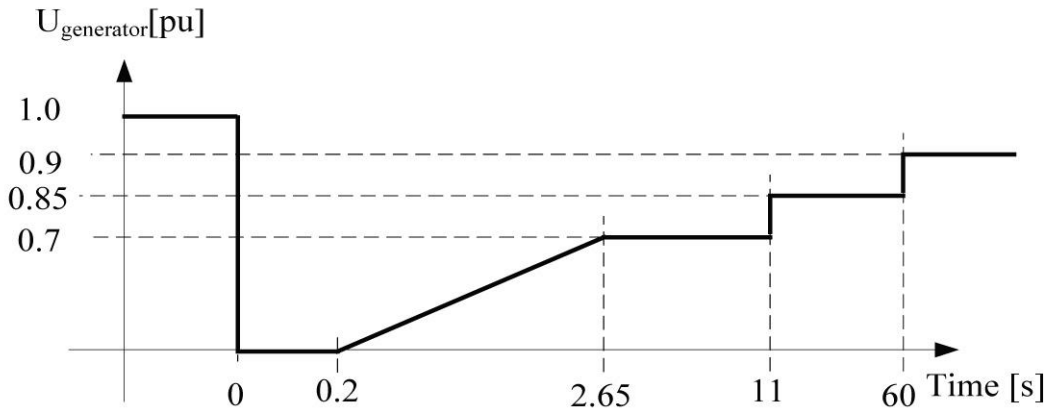

Figure 9-3: Default low-voltage protection settings for symmetrical and asymmetrical faults.

Power Recovery Time	
Power recovery to 90% of pre-fault level	Maximum 1.0 second

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 voltage measured at the point of common coupling.

The default value gives a reactive current part of 1 pu of the rated farm current at the point of common coupling. Figure 9-4, p. 31 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.

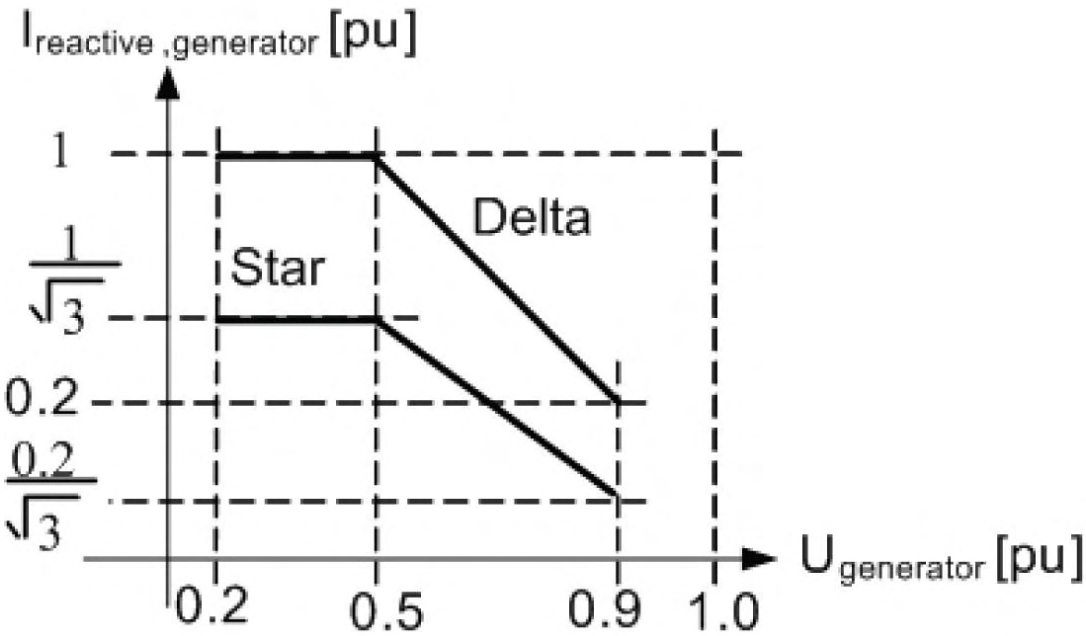

Figure 9-4: Reactive current contribution in Star and Delta drawn for 100% reactive current contribution.

9.6.2 Asymmetrical Reactive Current Contribution

Current reference values are controlled during asymmetrical faults to ensure ride through.

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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, the turbine is designed to perform at six 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
Reactive Power	2.5 pu/sec

Table 9-7: Maximum ramp rates for external control data.

To protect the turbine, active power cannot be controlled to values below the curve in Figure 9-5, p. 32.

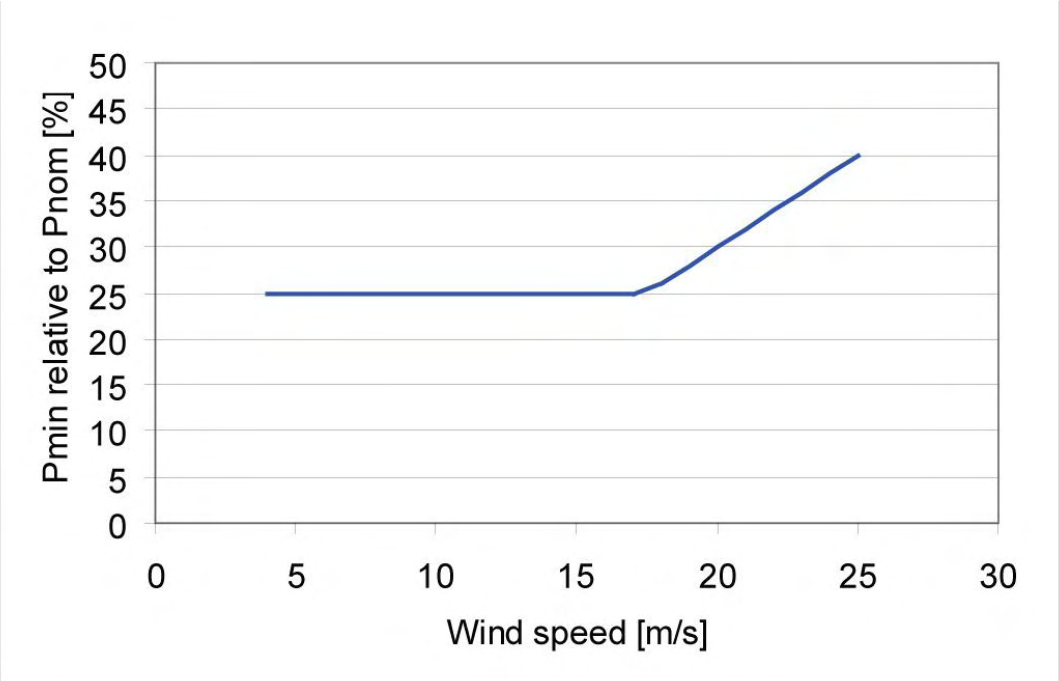

Figure 9-5: Minimum active power output related to wind speed.

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 Performance – 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)**	12 kW (Standard)
	3 x 6 kW (Low Temperature)	18 kW (Low Temperature)
Oil Pump for Gearbox Lubrication		3.5 kW
HV Transformer located in the nacelle has a no-load loss of:		3.9 kW @ grid voltage ≤ 33.0 kV 4.8 kW @ grid voltage ≥ 33.1 kV Standard IEC tolerances apply.

Table 9-8: Own consumption data.

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

See appendix sections 12.1 Mode 0, p. 37, 12.2 Mode 1, p. 42 and 12.3 Mode 2, p. 47 for power curve, C_t values and noise level.

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 of Blades	No
Leading Edge	No damage

Conditions for Power Curve, C_t Values (at Hub Height)	
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ± 2°
Grid Frequency	60 ± 0.5 Hz

Table 9-9: 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.

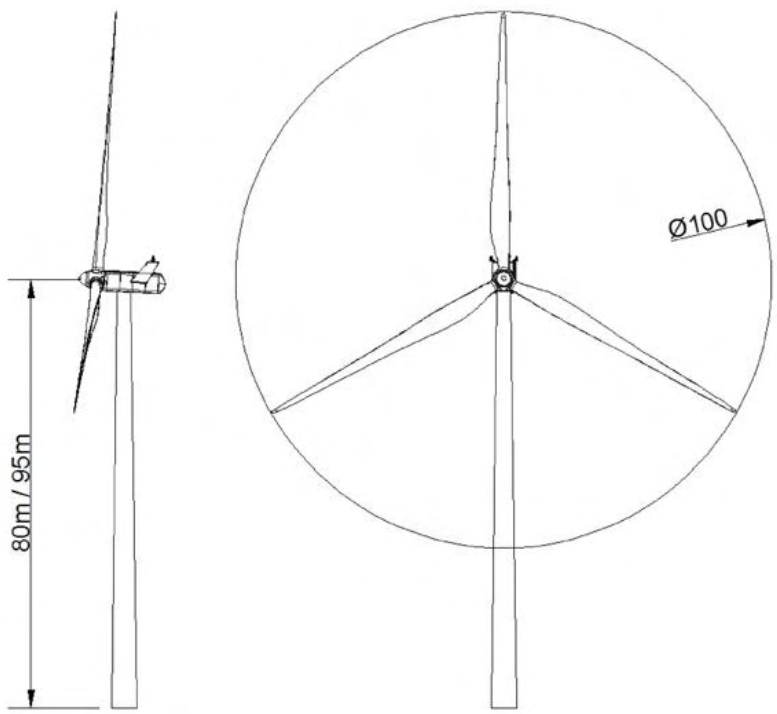

Figure 10-1: Illustration of outer dimensions: structure.

10.2 Structural Design – Side-View Drawing

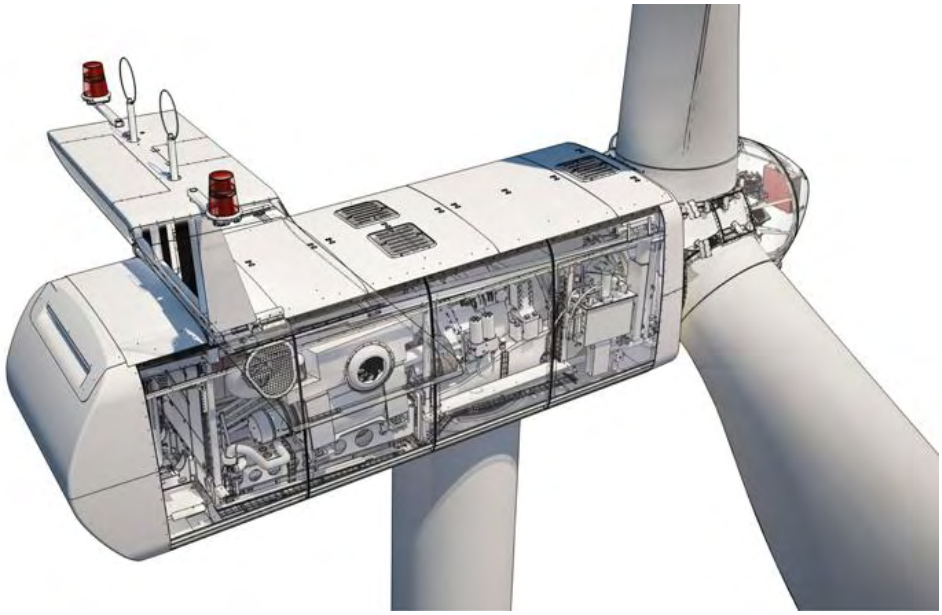

Figure 10-2: Side-view drawing.

11 General Reservations, Notes and Disclaimers

- The general specifications described in this document apply to the present design of the V100-1.8 MW wind turbine. Updated versions of the V100 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 V100-1.8 MW wind turbine, Vestas will provide updated general specifications applicable to the updated version.
- 'VCSS' turbines will not be available in the US market before Spring/Summer of 2011, and the Canadian market before Spring/Summer of 2012.
- 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 (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 Specifications', 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

Power curve, C_t values and sound power levels for noise mode 0 to 2 are defined below.

12.1 Mode 0

12.1.1 Power Curve, Noise Mode 0

Power Curve, Noise Mode 0														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**181**	136	140	144	148	152	156	160	165	169	173	177	185	189
5	**260**	198	203	209	215	220	226	232	237	243	248	254	265	271
5.5	**353**	270	278	285	293	300	308	315	323	330	338	345	360	368
6	**462**	356	365	375	385	395	404	414	424	433	443	453	472	481
6.5	**581**	443	455	468	481	493	506	518	531	544	556	569	594	606
7	**736**	563	579	595	611	626	642	658	673	689	705	720	751	767
7.5	**911**	700	720	739	758	777	796	816	835	854	873	892	930	949
8	**1108**	856	879	902	925	948	971	994	1017	1040	1063	1086	1131	1153
8.5	**1321**	1028	1055	1082	1110	1137	1163	1190	1216	1243	1269	1295	1347	1372
9	**1524**	1212	1243	1273	1304	1335	1363	1392	1421	1449	1474	1499	1547	1570
9.5	**1679**	1397	1429	1460	1491	1522	1547	1572	1597	1622	1641	1660	1695	1710
10	**1766**	1566	1591	1616	1641	1666	1682	1699	1716	1733	1744	1755	1773	1780
10.5	**1800**	1689	1705	1721	1737	1753	1762	1770	1779	1788	1792	1796	1802	1804
11	**1811**	1764	1772	1779	1786	1794	1797	1800	1803	1807	1808	1809	1812	1813
11.5	**1815**	1796	1799	1802	1805	1808	1809	1811	1812	1813	1814	1814	1815	1815
12	**1815**	1808	1810	1811	1812	1814	1814	1814	1815	1815	1815	1815	1815	1815
12.5	**1815**	1813	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Power Curve, Noise Mode 0														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

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

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12.1.2 C_t Values, Noise Mode 0,

C_t values, Noise Mode 0,														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.891**	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891
4	**0.877**	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877
4.5	**0.847**	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
5	**0.820**	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820
5.5	**0.806**	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806
6	**0.802**	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802
6.5	**0.814**	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814
7	**0.807**	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807
7.5	**0.804**	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804
8	**0.795**	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.798	0.797	0.796	0.796	0.794	0.793
8.5	**0.768**	0.786	0.784	0.783	0.782	0.780	0.779	0.777	0.776	0.774	0.772	0.770	0.766	0.764
9	**0.716**	0.756	0.754	0.751	0.749	0.746	0.743	0.739	0.736	0.732	0.727	0.721	0.710	0.704
9.5	**0.636**	0.713	0.708	0.703	0.698	0.693	0.685	0.678	0.670	0.663	0.654	0.645	0.627	0.617
10	**0.545**	0.657	0.648	0.639	0.630	0.621	0.610	0.599	0.589	0.578	0.567	0.556	0.535	0.524
10.5	**0.459**	0.587	0.576	0.564	0.552	0.540	0.528	0.517	0.505	0.493	0.482	0.471	0.449	0.439
11	**0.389**	0.514	0.501	0.488	0.475	0.462	0.451	0.440	0.428	0.417	0.408	0.398	0.380	0.372
11.5	**0.333**	0.442	0.430	0.418	0.406	0.395	0.385	0.376	0.366	0.357	0.349	0.341	0.325	0.318
12	**0.288**	0.381	0.370	0.360	0.350	0.340	0.332	0.324	0.316	0.308	0.301	0.294	0.282	0.276
12.5	**0.251**	0.330	0.322	0.313	0.305	0.296	0.289	0.282	0.275	0.269	0.263	0.257	0.246	0.241
13	**0.222**	0.289	0.282	0.275	0.267	0.260	0.254	0.248	0.242	0.236	0.231	0.227	0.217	0.213
13.5	**0.197**	0.256	0.249	0.243	0.237	0.230	0.225	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.227	0.222	0.216	0.211	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169
14.5	**0.158**	0.203	0.199	0.194	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.183	0.178	0.174	0.170	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075

C_t values, Noise Mode 0,														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

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

12.1.3 Noise Curve, Noise Mode 0

Sound Power Level at Hub Height, Noise Mode 0		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002.** **Wind shear: 0.15** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**	
Hub Height	**80 m**	**95 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	93.8 4.2	93.8 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	96.0 5.6	96.4 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.9 8.4	104.4 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 9.8	105.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 11.2	105.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 12.6	105.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 13.9	105.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 15.3	105.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 16.7	105.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 18.1	105.0 18.6

Table 12-3: Noise curve, noise mode 0.

12.2 Mode 1

12.2.1 Power curve, Noise Mode 1

Power Curve, Noise Mode 1														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**180**	134	139	143	147	151	155	159	163	167	171	175	184	188
5	**256**	195	200	206	211	217	223	228	234	239	245	250	261	267
5.5	**346**	265	273	280	287	295	302	310	317	324	332	339	354	361
6	**453**	349	358	368	377	387	396	406	415	425	434	444	463	472
6.5	**576**	439	451	464	476	489	501	514	526	539	551	564	588	601
7	**728**	558	573	589	604	620	635	651	666	682	697	713	744	759
7.5	**902**	693	712	731	750	769	788	807	826	845	864	883	920	939
8	**1098**	847	870	893	916	939	961	984	1007	1030	1053	1075	1120	1143
8.5	**1312**	1019	1046	1073	1100	1127	1154	1180	1207	1234	1260	1286	1338	1364
9	**1519**	1204	1234	1265	1296	1326	1355	1384	1413	1443	1468	1494	1542	1565
9.5	**1678**	1392	1423	1455	1486	1518	1543	1569	1594	1619	1639	1658	1693	1709
10	**1766**	1562	1588	1613	1638	1664	1681	1698	1715	1732	1743	1754	1773	1780
10.5	**1799**	1687	1703	1720	1736	1753	1761	1770	1779	1788	1791	1795	1801	1803
11	**1811**	1764	1772	1779	1787	1794	1798	1801	1804	1807	1808	1810	1812	1813
11.5	**1814**	1796	1799	1802	1805	1809	1810	1811	1812	1813	1813	1814	1815	1815
12	**1815**	1809	1810	1811	1812	1813	1814	1814	1814	1815	1815	1815	1815	1815
12.5	**1815**	1813	1814	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
13	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Power Curve, Noise Mode 1														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Table 12-4: Power curve, noise mode 1

12.2.2 C_t values, Noise Mode 1

C_t values, Noise Mode 1														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.890**	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890
4	**0.863**	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863
4.5	**0.809**	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809
5	**0.764**	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764
5.5	**0.741**	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741
6	**0.733**	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
6.5	**0.766**	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766
7	**0.755**	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755
7.5	**0.750**	0.749	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
8	**0.748**	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.748	0.748	0.748	0.747
8.5	**0.735**	0.745	0.744	0.744	0.743	0.742	0.741	0.741	0.740	0.739	0.738	0.737	0.734	0.733
9	**0.699**	0.729	0.727	0.726	0.724	0.722	0.720	0.717	0.715	0.712	0.708	0.703	0.694	0.689
9.5	**0.631**	0.699	0.695	0.691	0.687	0.683	0.676	0.669	0.663	0.656	0.648	0.639	0.622	0.613
10	**0.544**	0.652	0.643	0.634	0.626	0.617	0.607	0.597	0.586	0.576	0.565	0.555	0.533	0.522
10.5	**0.458**	0.585	0.574	0.562	0.551	0.539	0.527	0.516	0.504	0.492	0.481	0.470	0.448	0.438
11	**0.388**	0.514	0.501	0.488	0.475	0.462	0.451	0.440	0.428	0.417	0.408	0.398	0.380	0.371
11.5	**0.333**	0.442	0.430	0.418	0.406	0.395	0.385	0.376	0.366	0.356	0.349	0.341	0.325	0.318
12	**0.288**	0.381	0.370	0.360	0.350	0.340	0.332	0.324	0.316	0.308	0.301	0.294	0.282	0.276
12.5	**0.251**	0.331	0.322	0.313	0.305	0.296	0.289	0.282	0.275	0.269	0.263	0.257	0.246	0.241
13	**0.222**	0.289	0.282	0.275	0.267	0.260	0.254	0.248	0.242	0.236	0.231	0.227	0.217	0.213
13.5	**0.197**	0.256	0.249	0.243	0.237	0.230	0.225	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.227	0.222	0.216	0.211	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169
14.5	**0.158**	0.203	0.199	0.194	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.183	0.178	0.174	0.170	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075

C_t values, Noise Mode 1														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

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

12.2.3 Noise Curve, Noise Mode 1

Sound Power Level at Hub Height, Noise Mode 1		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.15** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**	
Hub Height	**80 m**	**95 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	93.7 4.2	93.7 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	95.3 5.6	95.7 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	99.1 7.0	99.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	102.9 8.4	103.4 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 9.8	105.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 11.2	105.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 12.6	105.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 13.9	105.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 15.3	105.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 16.7	105.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	105.0 18.1	105.0 18.6

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

12.3 Mode 2

12.3.1 Power Curve, Noise Mode 2

Power Curve, Noise Mode 2														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**181**	136	140	144	148	152	156	160	165	169	173	177	185	189
5	**260**	198	203	209	215	220	226	231	237	243	248	254	265	271
5.5	**353**	270	278	285	293	300	308	315	323	330	338	345	360	367
6	**462**	355	365	375	384	394	404	413	423	433	442	452	471	481
6.5	**581**	443	455	468	480	493	506	518	531	543	556	568	594	606
7	**735**	563	579	594	610	626	642	657	673	688	704	720	751	766
7.5	**908**	697	717	736	755	774	793	812	831	851	870	889	926	945
8	**1090**	840	863	886	909	932	954	977	999	1022	1045	1067	1113	1135
8.5	**1271**	981	1008	1034	1061	1087	1113	1140	1166	1192	1218	1244	1297	1323
9	**1437**	1112	1142	1172	1201	1231	1261	1290	1320	1349	1379	1408	1465	1494
9.5	**1580**	1227	1260	1293	1325	1358	1390	1423	1455	1487	1518	1549	1607	1634
10	**1689**	1331	1367	1402	1437	1473	1506	1540	1573	1607	1634	1661	1709	1729
10.5	**1757**	1425	1462	1499	1536	1573	1604	1635	1666	1697	1717	1737	1768	1780
11	**1792**	1512	1549	1585	1622	1659	1683	1708	1732	1757	1768	1780	1797	1802
11.5	**1805**	1592	1624	1657	1690	1722	1738	1755	1771	1787	1793	1799	1808	1811
12	**1811**	1666	1691	1715	1740	1764	1774	1783	1792	1802	1805	1808	1812	1813
12.5	**1813**	1726	1742	1757	1773	1789	1794	1799	1804	1809	1810	1812	1814	1814
13	**1814**	1765	1774	1784	1793	1802	1805	1807	1810	1812	1813	1814	1815	1815
13.5	**1815**	1786	1791	1797	1803	1808	1810	1811	1813	1814	1815	1815	1815	1815
14	**1815**	1802	1805	1808	1811	1813	1814	1814	1814	1815	1815	1815	1815	1815
14.5	**1815**	1812	1812	1813	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1813	1813	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1814	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Power Curve, Noise Mode 2														
Air density kg/m^3														
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

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

12.3.2 C_t values, Noise Mode 2

C_t values, Noise Mode 2,														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.891**	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891
4	**0.877**	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877
4.5	**0.847**	0.847	0.847	0.847	0.847	0.846	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
5	**0.818**	0.818	0.818	0.818	0.818	0.817	0.818	0.818	0.818	0.818	0.818	0.818	0.818	0.818
5.5	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
6	**0.796**	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796
6.5	**0.811**	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811
7	**0.800**	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
7.5	**0.783**	0.783	0.783	0.783	0.783	0.782	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783
8	**0.747**	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747
8.5	**0.695**	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695
9	**0.634**	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634
9.5	**0.569**	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.569	0.567	0.565
10	**0.505**	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.512	0.512	0.509	0.507	0.500	0.496
10.5	**0.441**	0.462	0.462	0.462	0.462	0.462	0.460	0.458	0.456	0.454	0.450	0.445	0.435	0.428
11	**0.381**	0.417	0.416	0.415	0.415	0.414	0.410	0.407	0.403	0.400	0.394	0.388	0.375	0.368
11.5	**0.330**	0.377	0.375	0.373	0.371	0.369	0.364	0.359	0.354	0.349	0.342	0.336	0.323	0.317
12	**0.287**	0.342	0.339	0.335	0.331	0.328	0.322	0.316	0.311	0.305	0.299	0.293	0.281	0.275
12.5	**0.251**	0.310	0.305	0.300	0.295	0.290	0.285	0.279	0.273	0.267	0.262	0.257	0.246	0.241
13	**0.222**	0.279	0.274	0.268	0.263	0.258	0.252	0.247	0.241	0.236	0.231	0.226	0.217	0.213
13.5	**0.197**	0.250	0.245	0.240	0.235	0.229	0.224	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.225	0.220	0.215	0.210	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169
14.5	**0.158**	0.203	0.198	0.193	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.182	0.178	0.174	0.169	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075

C_t values, Noise Mode 2,														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1.0**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

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

12.3.3 Noise Curve, Noise Mode 2

Sound Power Level at Hub Height, Noise Mode 2		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2. 2002** **Wind shear: 0.15** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**	
Hub Height	**80 m**	**95 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	93.8 4.2	93.8 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	96.0 5.6	96.4 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 8.4	103.0 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 9.8	103.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 11.2	103.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 12.6	103.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 13.9	103.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 15.3	103.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 16.7	103.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.0 18.1	103.0 18.6

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