ANNEX 8

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Preamble

This technical specification describes the S95-2.1 MW wind turbine generator. The specification has to be recognised by its reference WIND TURBINE GENERATOR TECHNICAL SPECIFICATION S95-2.1 MW at Revision 02, dated 2012-02-21. The seller must not recognise this specification at any other issue or revision level unless accepted by him in writing. Each page carries its specific revision date and revision code. Chapter numbers that are not included in this specification are unassigned.

If typographical errors or conflicts exist between a customer purchase agreement and this standard specification, SUZLON Energy Ltd. reserves the right to issue a revision or a temporary revision. It is the user's responsibility to ensure to have the correct issue and revision level where applicable.
The information in this document contains general description of the technical options available which may not apply in all cases. The required technical option is therefore to be specified in the contract.

Reconciliation with purchase agreement

In the event of any conflict or discrepancy between this specification and the purchase agreement, the controlling document must be the purchase agreement.

Reconciliation with illustrations

The illustrations contained in this specification are intended to assist in understanding the text and do not form part of this specification for contractual purposes, except where otherwise stated.

Specification precedence

In the event of any conflict or discrepancy between the requirements of this specification and any other specification referred to in this specification the requirements of the text of this specification must be held to govern.

SUZLON
POWERING A GREENER TOMORROW

WIND TURBINE GENERATOR TECHNICAL SPECIFICATION

S95-2.1 MW

Project:	Standard | STV/LTV | 50 Hz
Revision Code:	PDG-CD-S-PDO-00822 [Original]
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SUZLON Energy GmbH

Kurt-Dunkelmann-Str. 5
Building 245
18057 Rostock
Germany

P +49 381 12884-0
F +49 381 12884-550
E germany-documentation@suzlon.com
I www.suzlon.com

Responsibility

Approved by
Technical Product Manager

Released by
Program Manager

Digital signature

List of changes*

Revision	Name/Date	Page	Change aspect (by buyer, manufacturer or developer)
01	B. Malcher/2011-12-07	all	New document
02	J. Mueller/2012-02-21	7	New power curve added with ct, cp values, footnote added (by developer)
		14	Converter chapter shifted into generator chapter (by developer)
		16	Mass moment of inertia blade withdrawn (by developer)

* Changes to the design of the wind turbine generator (WTG) from the standard detailed in this specification have to be made as follows:

Buyer originated changes
This specification can be revised by Specification Change Notices (SCN) which describe the changes to be made to the specification.

Manufacturer originated changes
This specification can be revised by the seller without the buyer's consent to incorporate development changes if such changes do not adversely affect price, delivery, guaranteed performance of the WTG, or the interchangeability or replaceability requirements of this specification.

Development changes
Development changes are changes considered necessary to improve the WTG, prevent delays or to ensure compliance with the purchase agreement. The seller has to notify the buyer of all changes that are made as described in this section, by giving the buyer revised pages for this specification on a periodic basis.

1 Technical data

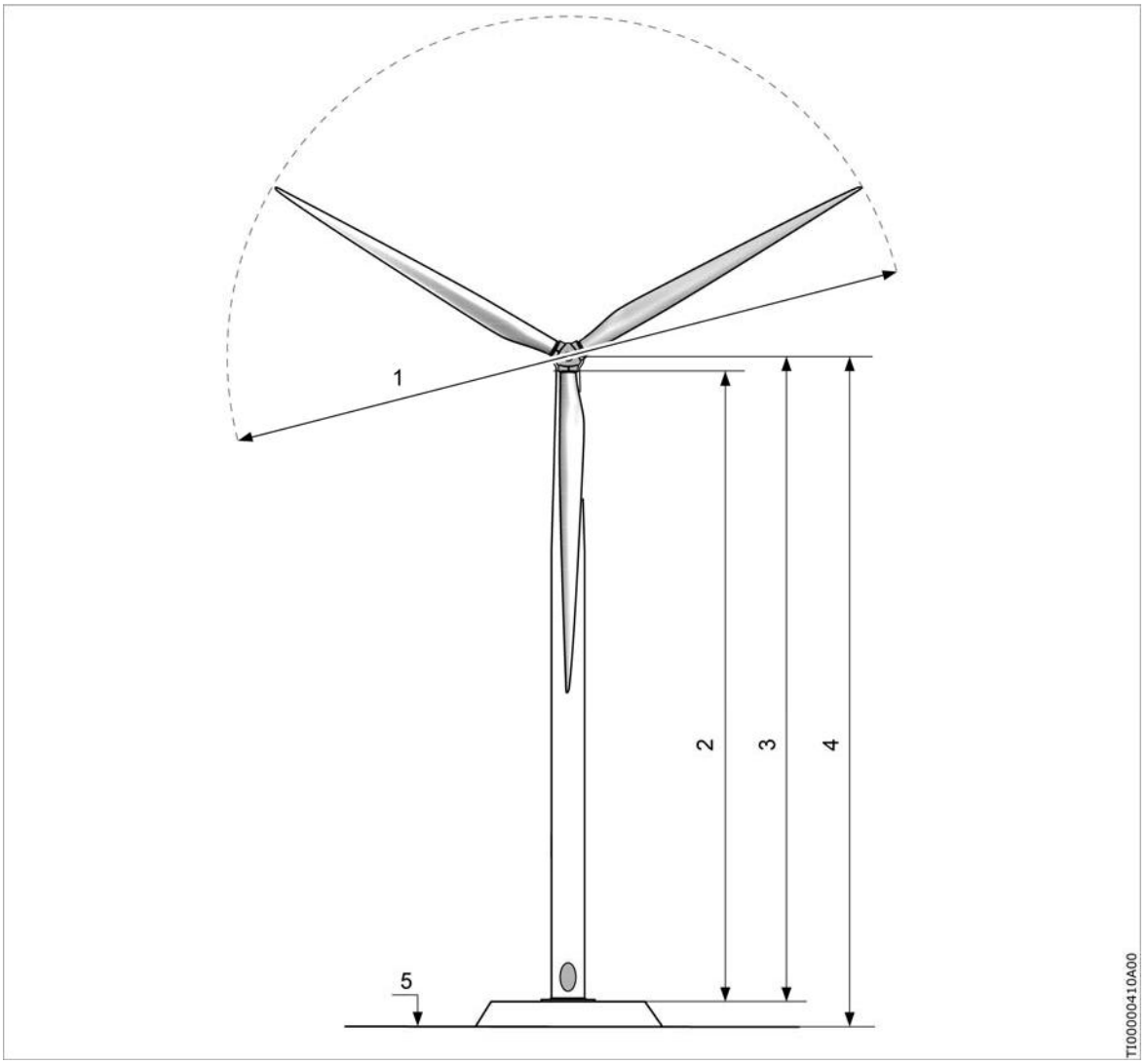
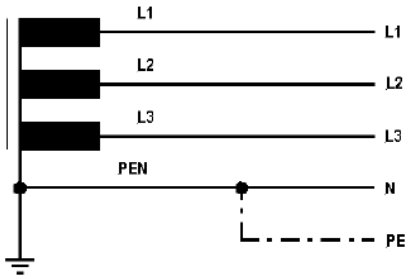


Figure 1-1: Dimensions of wind turbine generator (WTG)

1	Rotor diameter	95.0 m		
2	Tower height	77.5 m	87.6 m	96.2 m
3	Rotor height	79.0 m	89.0 m	97.7 m
4	Hub height	80.0 m	90.0 m	100.0 m
5	Ground top level			

Description	Information
Wind class	IIa
WTG certification	Germanischer Lloyd (according to GL guideline 2003)
Estimated service life	20 years
Ambient temperature range – operation	STV: –10 °C to +40 °C LTV: –30 °C to +40 °C Beyond the temperature ranges stated above, a WTG may shut down if any of its core equipment moves outside its safe operating range. This is dependent on WTG load as well as on external conditions.
Ambient temperature range – general	STV: –20 °C to +50 °C LTV: –40 °C to +50 °C The WTG always has to be connected to the grid.
Ice/snow on blades	Considered in calculation of structural design
A-factor	9.59 m/s
Form factor, c	2.0
Annual average wind speed	8.5 m/s
Vertical average shear component	0.2
Extreme wind speed (10-minute average)	42.5 m/s
Survival wind speed (3-second average)	59.5 m/s
Automatic stop limit (10-minute average)	25.0 m/s
Characteristic turbulence intensity according to IEC 61400 (15.0 m/s)	18.0%
Air density	1.225 kg/m³
Altitude	1000 m above sea level
Humidity conditions	
Permissible relative ambient humidity	30 to 99%
Permissible relative humidity during operation (outside cabinet, inside WTG)	30 to 99% (no precipitation)
Permissible relative humidity during operation (inside cabinet)	20 to 80% (no precipitation)

Description	Information
Corrosion protection	
The corrosion protection applies in accordance with ISO 12944-2.	
Corrosion protection class	C4 (long)
Corrosion protection	Anti-corrosion paint
Lightning protection	
The lightning protection applies in accordance with IEC 61400-24, 62305-1, 3, 4 and DIN EN 50164-1, 2. The lightning protection system is based on the lightning protection zone concept.	
Rotor	Lightning rod
Blades	Lightning receptors on blade surface, spark gap for protection of blade bearing
Nacelle	Spark gaps, lightning rods, EMC (electromagnetic compatibility), protection mesh
Grid connection	
Find further and more detailed information in the document "Grid connection".	
TN-C-S System	
Voltage range (continous operation)	90%-110%
Current range (nominal)	~ 2000 A
	Overcurrent protection via SUZLON CONTROL SYSTEM and air circuit breaker
Frequency range (continous operation)	–6% to +5% | 47 Hz ≤ f ≤ 52.5 Hz
Voltage harmonics	Total harmonic content of the grid voltage has to be less than 3% of fundamental frequency and less than 1% for any single harmonic.
Low Voltage Ride Through (LVRT)	applicable
High Voltage Ride Through (HVRT)	applicable
Tonality	
The tonality applies according to the noise curve.	

Description	Information
Quality standard	
ISO 9001	

1.1 Operating data

Description	Information
Rated power	2.1 MW
Rotor speed	12.1 to 17.6 rpm
Power regulation	Active pitch regulated
Rated wind speed	11.0 m/s (without turbulence intensity according to GL guideline)
Cut in wind speed (30-second average)	3.5 m/s
Cut out wind speed (3-second average)	34.0 m/s
Cut out wind speed (10-minute average)	25.0 m/s
Restart wind speed (10-minute average)	23.0 m/s
Control	
Type	Programmable Logic Controller with SUZLON CONTROL SYSTEM software
Communication system	Internal: CAN-bus
	External: Ethernet, optional: MODBUS, OPC
Access	Multi-level, user authenticated

Power curve *

Annual average energy yield 9439,8 MWh/a (average wind speed of 8 m/s p.a.)

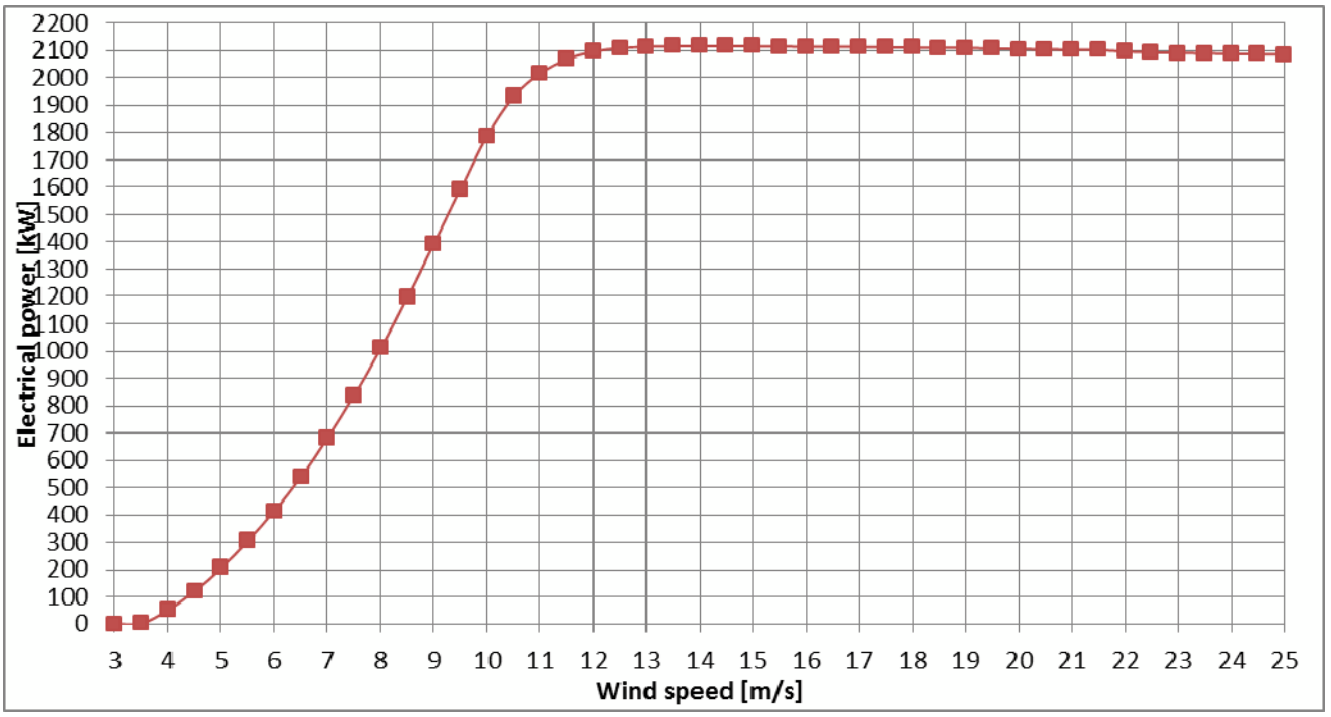


Figure 1-2: Power curve
The released power curve is created according to IEC 61400-12 guidelines. The actual power curve on specific sites varies due to site-specific conditions.

Wind speed v_{Hub} [m/s]	Electrical power [kW]	Energy yield [MWh/a]	Cp [-]	Ct [-]
3,00	0,0		0,0000	0,0000
3,50	2,6	0,8	0,0139	0,9568
4,00	52,3	16,7	0,1881	0,9275
4,50	122,5	42,1	0,3097	0,8986
5,00	206,4	74,8	0,3803	0,8754
5,50	304,0	114,5	0,4209	0,8515
6,00	414,9	160,2	0,4425	0,8387
6,50	539,5	210,8	0,4525	0,8399
7,00	683,1	267,1	0,4587	0,8409
7,50	839,2	325,0	0,4582	0,8354
8,00	1010,0	383,5	0,4544	0,8151
8,50	1197,1	441,6	0,4490	0,7815
9,00	1393,2	494,8	0,4402	0,7430

Wind speed v_{Hub} [m/s]	Electrical power [kW]	Energy yield [MWh/a]	Cp [-]	Ct [-]
9,50	1592,4	539,9	0,4278	0,7030
10,00	1787,7	574,0	0,4118	0,6618
10,50	1931,2	582,4	0,3843	0,6076
11,00	2016,3	566,9	0,3489	0,5352
11,50	2068,3	538,0	0,3132	0,4631
12,00	2096,4	500,9	0,2794	0,4005
12,50	2109,2	459,5	0,2487	0,3474
13,00	2114,0	417,1	0,2216	0,3031
13,50	2116,5	375,5	0,1982	0,2668
14,00	2116,2	335,4	0,1776	0,2368
14,50	2116,0	297,5	0,1599	0,2115
15,00	2115,8	262,2	0,1444	0,1901
15,50	2115,0	229,5	0,1308	0,1717
16,00	2114,5	199,6	0,1189	0,1558
16,50	2114,2	172,5	0,1084	0,1419
17,00	2113,8	148,1	0,0991	0,1298
17,50	2112,2	126,4	0,0908	0,1190
18,00	2111,2	107,1	0,0834	0,1096
18,50	2110,5	90,3	0,0768	0,1012
19,00	2109,8	75,6	0,0709	0,0936
19,50	2107,3	62,9	0,0655	0,0869
20,00	2105,5	52,0	0,0606	0,0808
20,50	2104,4	42,8	0,0563	0,0753
21,00	2103,2	34,9	0,0523	0,0703
21,50	2102,0	28,4	0,0487	0,0658
22,00	2096,4	22,9	0,0453	0,0616
22,50	2092,8	18,3	0,0423	0,0579
23,00	2091,2	14,6	0,0396	0,0545
23,50	2089,7	11,6	0,0371	0,0513
24,00	2088,2	9,2	0,0348	0,0485
24,50	2086,6	7,2	0,0327	0,0458

Wind speed v_{Hub} [m/s]	Electrical power [kW]	Energy yield [MWh/a]	Cp [-]	Ct [-]
25,00	2084,9	5,6	0,0307	0,0434

1.2 Tower

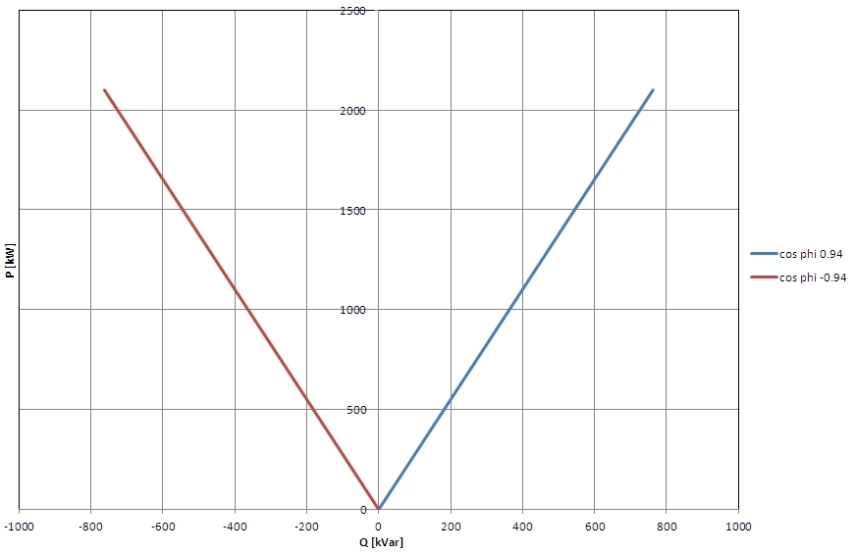
Description	Information		
Material	Welded steel plate according to EN 10025		
Colour	RAL 9003		
Internals	Ladder, platforms, anchorage points, cabling, lights, emergency light, climbing assistance (optional), service lift (optional)		
Foundation	Project-specific		
Tower height	**77.5 m**	**87.6 m**	**96.2 m**
Top end diameter	3.02 m	3.02 m	3.02 m
Bottom end diameter	4.30 m	4.55 m	4.30 m

1.3 Nacelle

Description	Information
Colour	RAL 9003, RAL 5021
Main frame	
Type	Cast frame
Material	EN-GJS-350-22U-LT
Main shaft	
Type	Forged shaft and flange
Material	42CrMo4/42CrMoS4
Main bearing	
Bearing type	Spherical roller bearing
Housing type	Cast housing, flanged feet
Housing material	EN-GJS-350-22U-LT

Description	Information		
Heating	STV: no fan heater	LTV: one fan heater, power: 9 kW	
Lubrication	Automatic lubrication system		
	Tank capacity: 8 l		
Gearbox			
Type	1 planetary stage, 2 helical stages		
Housing material	Cast		
Gearbox mount material	EN-GJS-350-22U-LT/EN-JS 1019		
Shaft seals	Maintenance-free labyrinth seals		
Cooling	Forced oil cooling lubrication system		
Mechanical power	2.250 MW		
Heating	STV: no fan heater	LTV: two fan heaters, power: 9 kW each	
Gear ratio	1:98.8 (±0.5)		
Gear ratio of each stage	1. stage: 5.68	2. stage: 3.86	3. stage: 4.50
Gearbox – electric oil pump			
Voltage (phase to phase)	3 × 690 V		
Oil capacity	410 l		
Mechanical brake			
Type	Hydraulic disc brake, activated by hydraulic pressure (active brake)		
Brake disc	Steel		
	Mounted on high speed shaft (HSS)		
Hydraulic power unit			
Voltage (phase to phase)	3 × 400 V		
Power	1.5 kW		

Description	Information	
Maximum hydraulic pressure	Hydraulic brake: 115 bar	
	Rotor lock system: 700 bar	
Oil capacity	0.0045 m³ (4.5 litres)	
Heating	STV: no fan heater	LTV: one fan heater, power: 9 kW
Coupling		
Type	Flexible coupling	
Yaw system – yaw bearing		
Type	Friction bearing with gear rim	
Yaw system – yaw drives		
Type	Electric asynchronous motor, electric motor brake (spring-applied), 5-stage planetary gear box with output pinion	
Quantity	4	
Yaw speed	22.0 °/min	
Voltage (phase to phase)	3 × 690 V	
Rated output power	3.0 kW per drive	
Generator		
Type	Asynchronous 3-phase induction generator with slip rings operated with rotor circuit inverter system (DFIG)	
Rated frequency	50 Hz (+5%/–6%)	
Number of poles/synchronous speed	4/1500 rpm	
Speed at rated power	rotor short-circuited: 1511 rpm	
Operation speed range	1200 to 1800 rpm	
Rated generator speed	1568 rpm	
Efficiency	96.8%	
Max. rotor slip	±20.0%	
Power factor (compensated)	0.94 lagging to 0.94 leading	

Description	Information	
Cooling	IC6A1A6 (as per IEC 60034-6), air-cooled; forced air-air cooled	
Winding connection of stator/rotor	Delta (Δ)/Star (Y)	
Rated power	2.1 MW	
Apparent power	2.265 MVA	
Locked rotor voltage	rotor short-circuited: 3300 V	
Rated voltage - rotor	DFIG operation: 220 V	
Rated voltage - stator	690 V/±15%	
Rated current - rotor	rotor short-circuited: 385 A	DFIG operation: 390 A
Rated current - stator	rotor short-circuited: 1895 A	DFIG operation: 1785 A
No-load current	rotor short-circuited: 340 A	
Starting current	rotor short-circuited: 12317.5 A	
Starting current (full load)	rotor short-circuited: 6.5 A	
Maximum current to grid connection (stator current)	DFIG operation: 2150 A	
Reactive power absorbed without load	rotor short-circuited: 405 kVAr	
Reactive power absorbed at rated power	rotor short-circuited: 890 kVAr	
Sub-synchronous speed for DFIG	1205 to 1500 rpm	
Reactive power curve as a function of active power		

Description	Information			
Load in % of rated active power	25	50	75	100
Power factor without compensation	0.74	0.88	0.91	0.92
Power factor with compensation	Variable 0.94 cap. 1 – 0.94 ind.			
Stator resistance (R_s)	starting and operation: 0.0065 per unit			
Rotor resistance (R_r)	starting: 0.0083 per unit		operation: 0.0074 per unit	
Stator reactance (X_s)	starting: 0.0851 per unit		operation: 0.0972 per unit	
Rotor reactance (X_r)	starting: 0.0686 per unit		operation: 0.1049 per unit	
Magnetising reactance (X_m)	starting: 1.8672 per unit		operation: 5.572 per unit	
Magnetising reactance (R_{fe})	131 Ω			
Generator rotor type	Wound rotor, bar winding			
Damping ratio	1128 Nm/rpm			
Mass moment of inertia	Approx. 195 kgm²			
Protection class	IP 54 (slip ring IP 23)			
Thermal classification	Class H			
Lubrication	Automatic lubrication system			
	Tank capacity: 1 l			
Converter section				
Technology	IGBT			
Operation range of converter/generator: slip range	±20%			
Nominal slip	Depends on power curve			
Protection class	IP 54			
Cooling	Liquid			
Temperature range of coolant inlet	25 °C to 60 °C (operation)			
Maximum flow of coolant	Approx. 120 l/min with approx. 1 bar pressure drop			

Description	Information
Maximum IGBT power loss in form of heat during continous operation	18 kW
Rated current	Line side converter: 500 A, machine side converter: 435 A
Rated voltage	Line side converter: 690 V, machine side converter: 690 V
Voltage range	Line side converter: 690 V/±10%, machine side converter: 0 to 760 V
Rated frequency	Line side converter: 50 Hz, machine side converter: 10 Hz
Switching frequency	Line side converter: 4500 Hz, machine side converter: 2250 Hz (≥1.2 Hz), 1125 Hz (<1.2 Hz)
Frequency variation capability	–6% to +5%

1.4 Rotor

Description	Information
Rotor cone angle	5°
Rotor speed at rated power	15.83 rpm
Tip speed at rated power	78.7 m/s
Main shaft tilt angle	5°
Power regulation	DFIG inverter system
Rotor orientation	Upwind
Colour (rotor with blades)	RAL 9003
Hub	
Type	Cast spherical hub
Material	EN-GJS-350-22U-LT
Mass moment of inertia	n/a
Blades	
Type	SUZLON SB46
Quantity	3

Description	Information
Length	46.3
Material	Glass-fibre reinforced plastic (GRP)/Epoxy
Mass moment of inertia	n/a
Type of aerodynamic brake	Pitch/full blade
Profiles	Risoe B
Pitch system	
Type	Electric asynchronous motor with forced ventilation unit, electric motor brake (spring-applied), 3-stage planetary gear box with output pinion, frequency converter and batteries
Pitch angle range (operating range)	0 to 90°
Pitch system – blade bearing	
Type	Double row ball slewing bearing
Lubrication	Blade bearing/teeth: automatic lubrication system
	Tank capacity: blade bearing: 8 l, teeth: 4 l
Pitch system – pitch drives	
Type	Electric asynchronous motor with forced ventilation unit, electric motor brake (spring-applied), 3-stage planetary gear box with output pinion
Quantity	3 (1 per blade)
Pitch speed	0 to 8 °/s
Emergency pitch speed	8 °/s
Rated output power	7.5 kW per drive
Pitch system – pitch batteries	
Quantity	1 battery box per blade
Service life	2 to 4 years
Rated voltage per battery	12 V
Rated capacity (20 hour rate)	7.2 Ah
Heater	Each battery box equipped with 4 heaters (120 W each) and 2 fans

Description	Information
Thermal insulation	Thermal insulation tiles

1.5 Transformer

The scope of supply of the transformer is agreed by contract. If the transformer is supplied by the customer the below values are to be referenced as recommendations.

Description	Information	
Type	Oil filled transformer	
Winding connection	Delta (Δ)/Star (Y)	
Vector group	Dyn5/Dyn11 (grid-dependent)	
Rated apparent power	2500 kVA	
Tapping	At HV ±5% in 2.5% steps	India: At HV ±6% in 3.0% steps
Reactance	6%	India: 6.25%
No-load losses	~ 2550 W	
Full load losses	~ 22500 W	
Total losses	~ 25000 W	
Rated winding ratio	(XX) kV/0.69 kV	
	Voltage level at line side depends on supply voltage level.	