Technical Description

Nordex N100/2500

Translation of the original sales document
This document is a translation from German. In case of doubt, the German text shall prevail.

Table of Contents

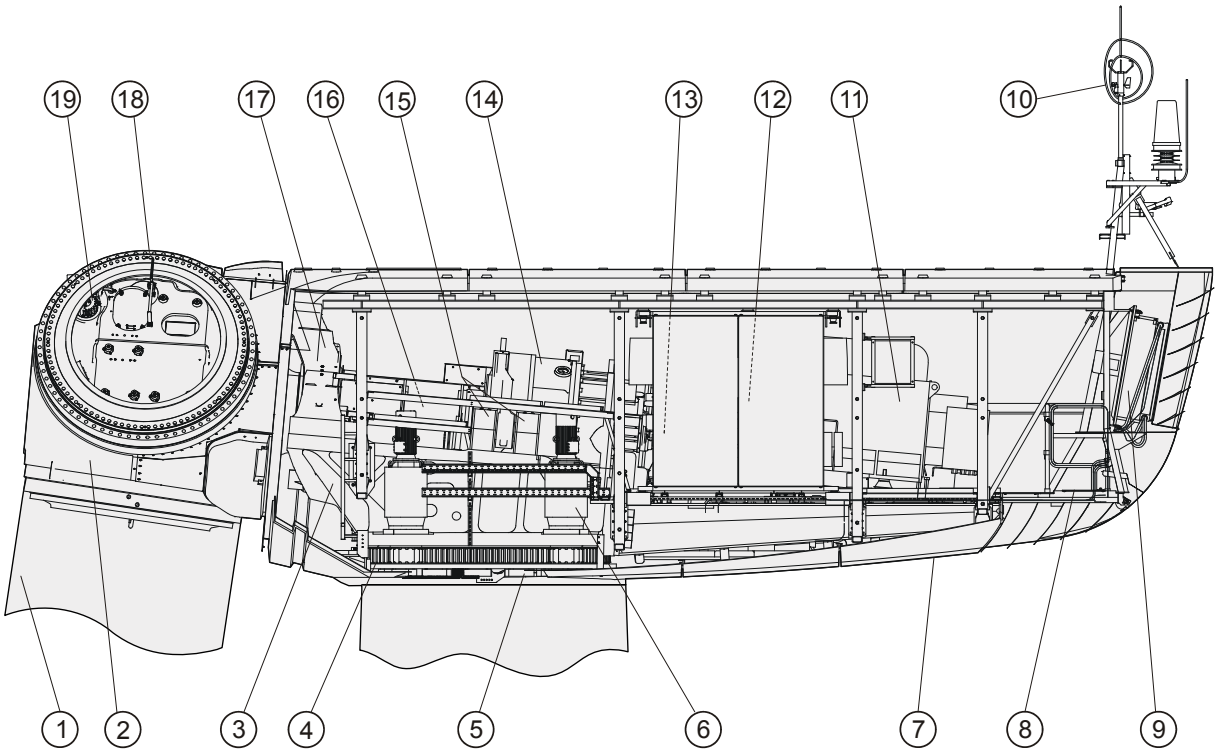
1 Design

The Nordex N100/2500 is a speed-variable wind turbine (WT) with a rotor diameter of 99.8 m and a nominal power of 2500 kW. The nacelle and rotor are designed for IEC wind class 3a. To regulate power, the blades can be pitched individually.

The wind turbine originates from the sophisticated turbine family Nordex N80, N90, N100.

Nordex is certified according to ISO 9001 quality standards. Our quality management system and thus also the production processes fulfill the requirements of ISO 9001. For all main components Nordex co-operates with a number of qualified suppliers.

Overview of the Nordex N100/2500 wind turbine



1 Rotor blade	6 Yaw drive	11 Generator	16 Rotor shaft
2 Rotor hub	7 Nacelle housing	12 Coupling	17 Rotor bearing
3 Machine frame	8 Hatch for on-board crane	13 Rotor brake	18 Pitch bearing
4 Yaw bearing	9 Heat exchanger	14 Gearbox	19 Pitch drive
5 Yaw brakes	10 Wind sensors	15 Gearbox support	

General Data	
1st Type	3-blade rotor with horizontal axis, up-wind
Power regulation	Active single blade adjustment
Nominal power	2,500 kW
Nominal power starting at wind speeds of	approx. 12.5 m/s
Speed range of rotor	9,6…14.85 rpm
Cut-in wind speed	approx. 3 m/s
Cut-out wind speed	20 m/s
Cut-back-in wind speed	18 m/s
Calculated lifetime	20 years

Climatic Design Data

The tower, nacelle, and rotor blades are certified according to national and international standards for wind turbines.

- Ambient temperature limits for standard version
  - Survival: -20 ºC…+50 ºC
  - Nominal power: -10 ºC…+40 ºC
  - Stop: -10 °C, restart at -8 °C

- The wind turbine is designed for locations at heights up to 1,000 m.

If the wind turbine is to operate at nominal power at temperatures outside the ambient temperature limits of the standard version, addition measures are required.

The ambient temperature limits for each wind turbine version are based on standard meteorological measurements taken in shade 2 m above the ground. The ambient temperature measurements which are required by the control unit are measured outside the nacelle at the height of the rotor hub.

Depending on the conditions at the site and the thermal load of individual components, a reduction in performance is possible at temperatures above the temperature limits.

At low temperatures, the wind turbine will only restart once the individual components have reached their relevant start-up temperature. The duration of this warm-up phase varies depending on the temperature of the components before the warm-up phase begins. The less the single components have cooled down, the shorter the warm-up phase. A temperature-controlled start-up procedure reduces the stress on the components during turbine start-up until the optimum operating temperature is reached.

Specific combinations of high wind speeds, high or low temperatures, high or low air density, and high or low voltage can result in a reduction in performance due to the design restraints of individual components of the wind turbine.

2 Rotor

The rotor consists of 3 blades, the hub, three pitch bearings and three pitch drives to change the pitch angle of the blades. The rotor blades are made of glass-reinforced plastic.
Each rotor blade is controlled and driven independently of the other blades. The blades are equipped with a lightning protection system including lightning receptors conduct the lightning to the rotor hub.

Rotor characteristics	
Rotor diameter	99.8 m
Swept area	7,823 m^2
Maximum tip speed	approx. 77 m/s
Specific power	320 W/m^2
Rotor tilt angle	5°
Blade cone angle	3.5°
Total weight	approx. 55 t

Rotor hub	
Material	spheroidal graphite cast iron EN-GJS-400-18U-LT
Total weight, incl. pitch system	approx. 25 t

Rotor blades	
Material	glass-reinforced plastic
Total length	48.7 m
Weight per blade	approx. 9.8 t

3 Rotor shaft

The drive train consists of the rotor shaft, the gearbox connected by a shrink disc, a coupling with overload protection and the generator.

Rotor shaft	
Material	42CrMo4 or 34CrNiMo6
Weight	approx. 10.3 t
Bearing	Spherical roller bearing
Bearing housing	spheroidal graphite cast iron EN-GJS-400-18U-LT

4 Gearbox

The gearbox is designed as a multi-stage planetary and one-stage spur gear. Alternatively a linkage with power split is also possible. The gearbox is cooled through an oil-air cooling circuit with stepped cooling capacity. The bearings and toothings are constantly pump-fed lubricated with cooled oil. The temperatures of the bearings and the oil are constantly monitored.

Gearbox	
1st type	multi-stage planetary + one-stage spur gear or linkage with power split
Nominal power	2,775 kW
Gear ratio N100/2500	50 Hz: 1 : 77.5 60 Hz: 1 : 93.2
Lubrication	pump-fed lubricated
Oil quantity including cooling circuit	approx. 450-550 l (depending on vendor)
Oil type	VG 320
Oil change	biannual check, change as required
Weight	approx. 18.5 to 20.0 t (depending on vendor)

5 Generator

The generator is a double-fed asynchronous machine. The generator is kept in its optimum temperature range by a cooling circuit.

Generator	
Degree of protection	IP 54
Nominal power	2,500 kW
Nominal voltage	660 V
Frequency	50 or 60 Hz
Speed range	50 Hz: 740…1300 rpm 60 Hz: 890…1560 rpm
Poles	6
Weight	Approx. 10 t

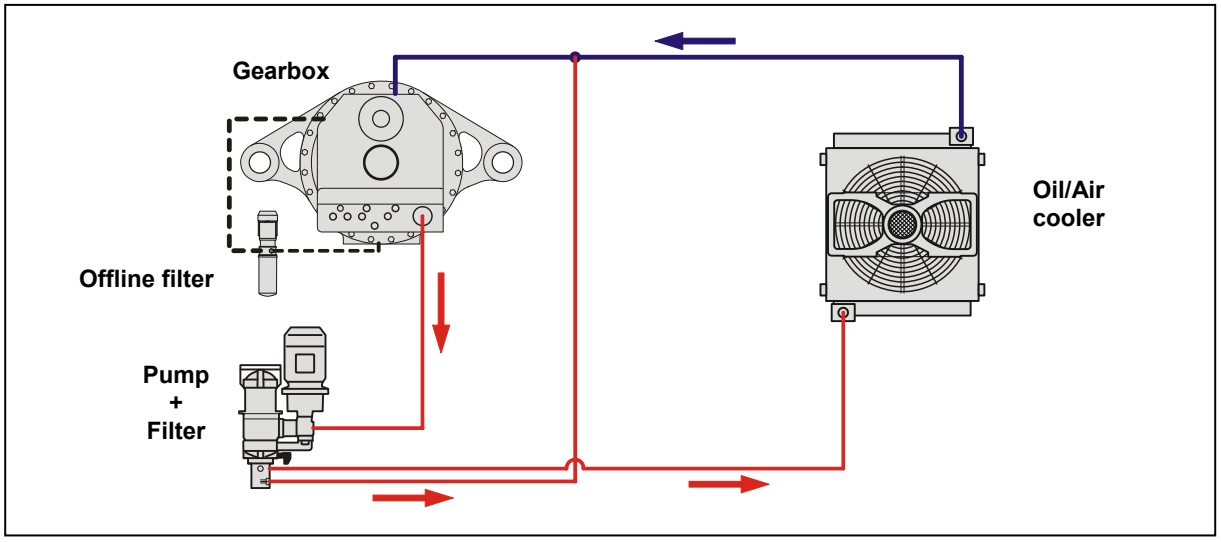
6 Cooling and filtration

The gearbox, generator and converter of the wind turbine have cooling systems which are independent from each other.
All systems are designed such that even at high ambient temperatures, optimum operating temperatures are achieved. The temperature of some gearbox bearings, the gearbox oil, the generator windings, the generator bearings and the cooling liquid (frost resistant water/glycol mixture) are monitored constantly and partially redundantly by the control system.

Gearbox cooling

The gearbox is cooled by the oil circuit in an oil/air cooler. A pump with 2 stages pushes the gearbox oil through a combined filter (coarse filter 50 µm, fine-mesh filter 10 µm) into the cooling circuit. The coarse and fine-mesh filters filter solids out of the oil. The control system monitors the level of contamination of the filter elements (differential pressure measurement).

Optionally, an additional offline filtration can be installed (super fine-mesh filter 5 µm).

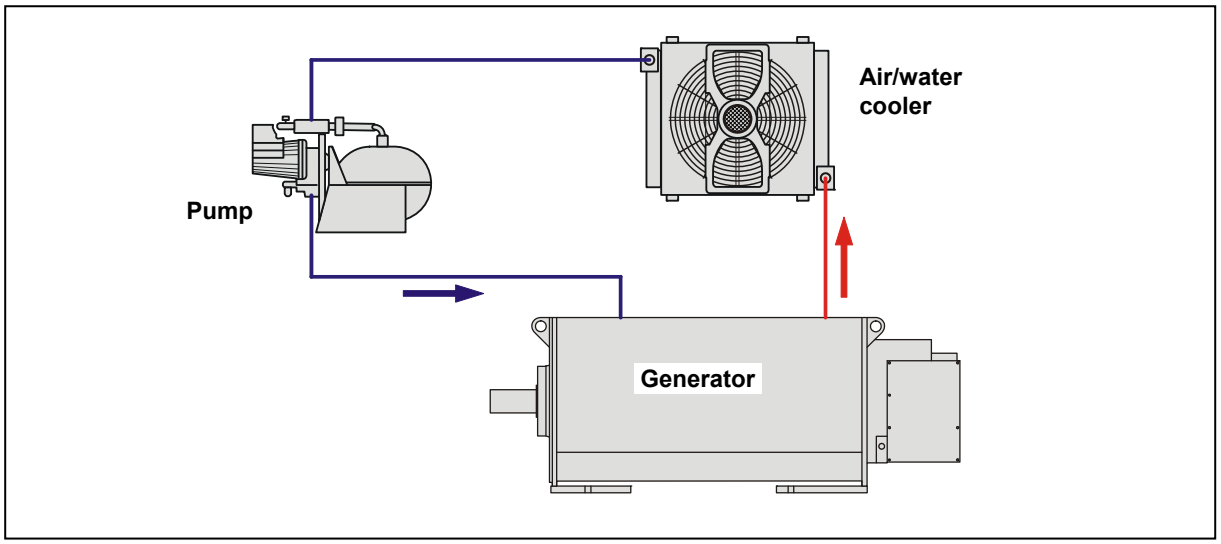


When the optimum operating temperature is not reached yet, a thermal bypass shorts the circuit and conducts the pre-heated oil back to the gearbox. As soon as the optimum operating temperature is exceeded, the active oil/air cooler starts and cools down the oil. Each cooler is additionally equipped with a fan, which is switched on or off depending on the oil temperature.

The cooled-down oil is pumped via a pipe system inside the gearbox to highly temperature-effected parts.

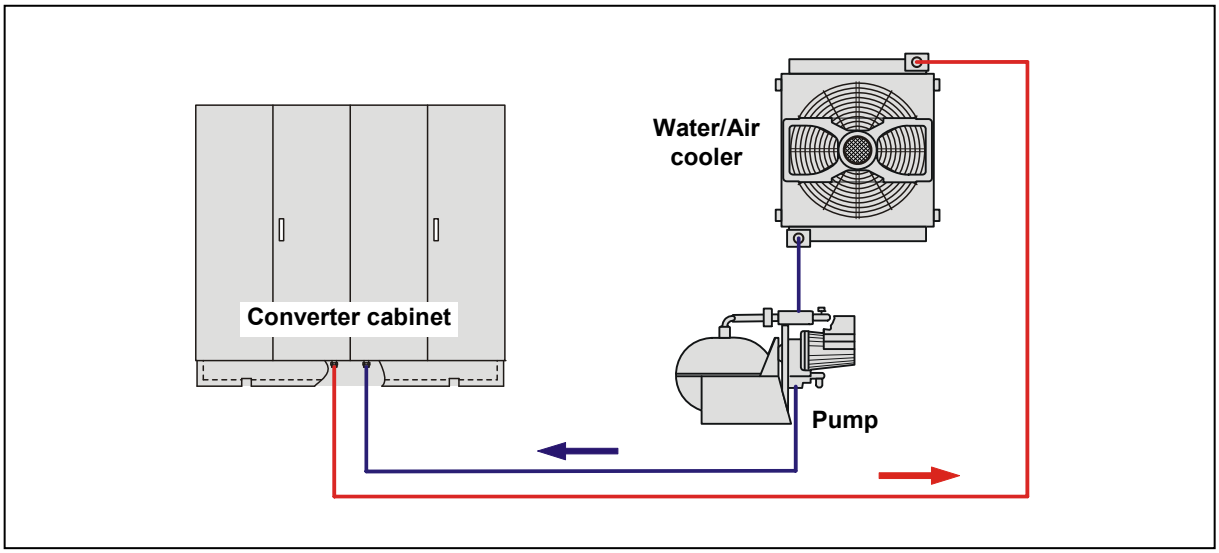
Generator cooling

The heat is led off the generator by a cooling water circuit. The heat is dissipated via an internal air cooling to the cooling water. This is conducted by a maintenance-free rotary pump to a water/air cooler. The pump starts automatically as soon as the temperature of the generator components exceeds a defined value and cools down the cooling water and thus the generator to the optimum operating temperature. The cooler is additionally equipped with a fan which is switched on or off depending on the water temperature.



Converter cooling

The wind turbine main converter is integrated in the cabinet on the lowest platform of the tower. It is cooled both, by air and by cooling water. The pump pumps the cooling water through the internal cooling system of the main converter where heat is dissipated to the water. The heated cooling water is then passed on to the water/air cooler with integrated fan. The fan is switched on when the temperature of the converter components exceeds a defined value and dissipates the heat to the surroundings.



7 Brakes

The aerodynamic brake consists of three rotor blades which are controlled independently and redundant and which can be rotated by 90° around their own axis. A safety system monitors the pitch system. In case of unintended grid failure, the pitch is automatically connected to the emergency power supply in order to turn the blades by 90° (perpendicular to the rotation direction of the rotor).

Additionally the wind turbine is equipped with a mechanical brake system. This brake supports the braking of the rotor blades and stops the rotor. The brake power is controlled by several brake programs to avoid peak loads. After the rotor has come to a complete standstill, the brake can be locked.

Aerodynamic Brake	
1st Type	individual blade adjustment
Activation	electrical

Mechanical Brake	
1st Type	actively actuated disc brake
Location	on the high-speed shaft
Disc diameter	1,030 mm
Number of brake calipers	1
Material of brake pads	sintered metal

8 Pitch system

The pitch system moves the rotor blades in the default position from the control. The pitch system is the main brake of the wind turbine. During operation the angle of the rotor blades can vary from 0° to 90°. The pitch system operates separately for each rotor blade and consists of the electromagnetic drive with 3-phase motor, the gearbox and the drive pinion as well as the control unit with frequency converter and emergency power supply. The emergency power supply can move the rotor blades safely out of the wind in case of power outage. After that the rotor idles.

Pitch system	
Rotor blade bearing	Double row four-point contact bearing
Lubrication	Automatic lubrication unit with grease
Drive	3-phase motor incl. Spring actuated brake, Multi-stage planetary gear
Emergency power supply	Lead-acid battery

9 Hydraulic system

The hydraulic system provides the oil pressure for operation of the yaw brakes, rotor brake and nacelle roof. The hydraulic rotor lock and also the nacelle roof are lifted or closed manually.

Hydraulic system	
Hydraulic oil	VG 32
Oil quantity	approx. 20 l
Nominal power of the hydraulic pump	1.1 kW
Thermal protection	integrated PT100

10 Nacelle

The nacelle consists of the cast machine frame, a welded generator frame and a steel framework for the on-board crane. At the same time, the steel framework is the mount for the nacelle housing. The shape of the nacelle and the cooler being placed in the top section enable a natural air flow for cooling.

Nacelle	
Material of machine frame	spheroidal graphite cast iron EN-GJS-400-18U-LT
Material of generator frame and steel framework	S235JR
Material of nacelle housing	glass-reinforced plastic

11 On-board cranes

A chain hoist is installed firmly in the nacelle which is used for lifting tools, components and other work materials from the ground into the nacelle. A second, movable overhead crane is used for carrying the materials within the nacelle.

The lifting capacity of both on-board cranes is 1,000 kg.

12 Yaw system

The wind direction is continuously monitored by 2 separate sensors at hub height. Upon exceeding the permissible deviation, the nacelle is actively yawed. Yawing is effected by 4 drives. When there is no yawing operation, the yaw brakes (holding brakes) are engaged. These holding brakes are located at 2 separate places: on the one hand around the circumference on which the slewing bearing (hydraulic) is located and on the other hand on the high-speed side of the yaw drive (electric).

Yaw bearing	
Type	ball bearing
Material	42CrMo4
Weight	approx. 2.3 t

Yaw drive	
Motor	asynchronous motor
Gearbox	4-stage planetary gear
Number of drives	4
Lubrication	oil, ISO VG 620
Yaw rate	approx. 0.5 °/s

Yaw brake	
1. 1st Type	disc brake with hydraulic brake calipers
Material of brake pads	organic
Number of brake calipers	14
2. 1st Type	electrical spring-actuated brake on every motor

13 Tower and foundation

The Nordex N100/2500 is erected for different hub heights on tubular steel towers or hybrid towers.

Rotor hub height		100 m MTR	140 m (MT)
Classes		DIBt 2 IEC 3a	DIBt 2 IEC 3a
Number of tower sections		5	3 + adapter
Weight with interiors	[t], approx.	296.7	141.0*

* the tubular steel tower incl. adapter only

The service lift, the ladder, fall protection, resting and working platforms are located inside the tower.

Corrosion protection of the tubular steel tower is achieved by a coating system of the tower surface according to ISO 12944.

The foundation depends on the ground conditions at the intended site.

Tubular steel tower	
Material	S355
Corrosion protection	multi-layer epoxy resin coating
Tower base connection	anchor cage cast in concrete foundation

14 Grid connection

The wind turbine is connected to the grid by means of an IGBT converter based on the principle of the double-fed asynchronous generator. By changing the appropriate parameter in the IGBT converter, the power factor correction can be adjusted to a value of 0.95 inductive to 0.95 capacitive under specific circumstances. With this system, the starting current ratio for grid connection can be limited to a value of about 1.

The wind turbine can be equipped with an extended grid connection package, see separate document “Electrical Properties”.

15 Control and safety system

The wind turbine is controlled by the Nordex Control 2 software, which continuously analyses the data from all connected sensors and generates the control signals for the wind turbine.

The wind turbine runs with 2 measuring instruments for capturing wind data. One instrument is used for controlling the wind turbine; the second instrument monitors the first one. In case one instrument fails, the second is used for further system control.

On a control screen of each PC, both inside the wind turbine and from remote, all operational data can be monitored and checked and a number of functions, such as starting, stopping and yawing can be controlled.

In addition, the wind turbine is equipped with a remote monitoring system. The data and signal transfer only requires an ISDN connection and the "Internet Explorer".

The wind turbine is equipped with an uninterruptible power supply (UPS). In case of a grid failure, the UPS together with the batteries of the pitch system ensure a safe shut down of the wind turbine. The UPS ensures the operation of the WT controls (including data storage) and external communication until the wind turbine is shut down (period of approx. 10 minutes). This guarantees the continuous monitoring of the wind turbines status and further data transfer of the controls can be downloaded for later analysis until the wind turbine is shut down.

Controller		
1st Type	Hardware	Remote Field Controller/PLC Nordex Control 2
	Software	
Automatic restart:		
- After grid failure		yes
- After cut-out wind		yes

16 Lightning protection

During the development of the Nordex N100/2500, the utmost attention has been devoted to lightning protection. For all components, a most reliable protection has been achieved. The lightning and overvoltage protection of the wind turbine is based on the lightning protection zone concept and meets the DIN EN 62305 standard. A detailed description can be found in the document “Lightning and overvoltage protection”.

17 Operation control

The main task of the operation control (computer + NC 2 software) is to ensure an automatic and safe operation of the wind turbine in all situations by monitoring and constantly keeping the parameters within the set range as stored in the control computer of the wind turbine. Each sensor is queried every 40 ms. The parameters are provided by Nordex and are adapted to the respective site. The objective is a safe and automatic operation of the wind turbine in all situations.

When the wind speed is lower than the cut-in wind speed, the wind turbine remains at a standstill (energy save modus), i.e. only the computer remains in operation capturing (weather) data. All other systems are switched on only if required and thus do not consume energy. Exceptions are the safety related functions, e.g. the brake system (hydraulic pump). The rotor is idling.

When the cut-in wind speed is reached, the wind turbine will change to the mode 'Ready for operation'. Now all systems are tested and the nacelle aligns to the wind direction. If the wind increases, the rotor accelerates. When a certain speed is reached, the generator is connected to the grid and the wind turbine starts producing electricity.

During operation, the nacelle follows the wind direction. The nacelle is capable of turning by 360° several times. But if the setpoint is exceeded the wind turbine shuts down and the nacelle turns back automatically, i.e. the tower cables are untwisted. Afterwards the wind turbine starts again.

Once the cut-out wind speed is exceeded, the wind turbine shuts down, i.e. the blades turn by approx. 90° into feathering position. The rotor slows down and idles until the wind decreases below the cut-in wind speed.

Sensors are installed in all systems and many components of the wind turbine. They report the current state to the controls. There are setpoints (parameters) given for each measuring point. They must be kept. If the value deviates from the setpoint, the control reacts respectively.

Upon exceeding a certain temperature limit, at first e.g. the pump of the cooling circuit is switched on. If the temperature falls below the setpoint again, the pump is switched off. If another setpoint is exceeded, a warning message is sent to the Nordex remote monitoring.

The remote monitoring is online 24 h a day, 7 days a week and they can decide what to do by processing all current data of the wind turbine. If the temperature falls again below a temperature limit value, the warning message disappears. When exceeding a third temperature limit value, the wind turbine is switched off immediately. This third value is selected such that any damage to the wind turbine can be prevented.
All in all, six parameters belong to one temperature measuring point, three high and three low temperature limit values.

When exceeding certain parameters regarding the safe operation, the wind turbine is switched off immediately, e.g. values above cut-out wind speed or pressure drop at the hydraulic system. A soft braking procedure is triggered in case of external disturbances, e.g. too high wind speed or grid failure. In case of safety critical disturbances an emergency-stop is triggered to ensure that the rotor slows down as fast as possible.

Using this data, the control computer calculates the 3 second average value in each case. These values are then used to create a 30 second average value and in turn a 10 minute average value. These values are used to control the wind turbine. In the case of the wind speed, the control system applies the 10 minute average value, because otherwise the wind turbine would shut down too early or too frequently due to the turbulences of the wind. To prevent damage caused by short but strong gusts, which become lost in average value, the 3 second average value is also taken into account. Consequently, the wind turbine is shut down when the 10 minute average value exceeds 20 m/s or when the 3 second average value exceeds 26 m/s. This gives the wind turbine comprehensive protection against storms.

For safety reasons, a certain delay must be kept after every shut down before the wind turbine starts again.

18 General reservations and Options

Deviation from the conditions specified above may have an adverse impact on the operation of the wind turbine. In particular, a performance reduction may occur.

The rotor bearing, the tooth system of the 3 pitch bearings, the yaw bearing and the 2 generator bearings are lubricated via 4 individual automatic lubrication units. This ensures sufficient and continuous lubrication and enables easy maintenance.

At very low temperatures, after e.g. a grid failure, some turbine components require a certain time for preheating.

Should icing occur on the rotor blades, the wind turbine must be stopped. An ice warning system can be delivered as an option.

Option **Ice warning system**

Ice detection can automatically be effected via the wind turbines ice warning system. The system is designed to detect the formation of ice, to stop the WT and to prevent ice projection. For further information refer to the document “Measures against ice formation”.

Option **Transformer in the tower**

In the standard design, the transformer is located in a separate transformer substation. As an option, the transformer can also be installed in the tower. This way, the additional compact transformer substation outside the tower is no longer required. The transformer can be replaced through the tower door, if necessary.

Option **Condition Monitoring System (CMS)**

The CMS serves the monitoring of vibration characteristics of the wind turbine drive train. It works continuously and fully automatically. The CMS uses the measurement values to calculate e.g. 10 minute values, maximum or average values which are then saved together with the operational data and analyzed. A software enables the visualization and evaluation (diagnosis) of data. If limit values are exceeded they are automatically recognized and reported via the Internet. The CMS meets the minimum requirements stipulated by the insurance provider. For further information refer to the document “Condition Monitoring System”.

Option **Obstacle lights**

Regardless of country and site-specific requirements each wind turbine can be provided with the corresponding wind turbine flight warning equipment. It comprises color-markings on the rotor blades and/or obstacle lights. For further information refer to the documents “Obstacle lights” and “Standard color-marking”.

In connection with the continuous development and improvement of our products, we reserve the right to make technical changes without prior notice.