SUZLON
POWERING A GREENER TOMORROW

Technical Documentation

TECHNICAL DESCRIPTION

S9x

Project:	Prototype	
Document Number:	WD00417 [Original document]	
Document Class:	2	[3, 4 = Confidential]
Issue:	01	[2011-03-11]

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Electrical Documentation

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1 Notes on manual

This manual is part of the Technical Documentation of a SUZLON wind turbine generator (WTG).

The document is meant for authorised and qualified staff only. It has to be carefully read and understood before performing the tasks.

In this manual consistent terminology is used resulting from SUZLON terminology work in order to avoid multiple designations. Furthermore, the document contains abbreviations. When used for the first time the term is written in full notation. The abbreviation stands in brackets behind the full notation term, e.g.: wind turbine generator (WTG).

Pages, tables and figures are cross-referenced and numbered consecutively. The document contains further cross references and bookmarks intended to guide the reader to more detailed information.

Figures may come with positioning numbers explaining determined components. The positioning number appears again behind the explained component in the text as follows:

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Positioning number
Serial number
Chapter

This manual may contain special formatting to emphasise text fragments as follows:

- **bold** for e.g. instructions relating to tabs, buttons or menus in software documentation
- *italics* to emphasise reference designators
- asterisks (*) to emphasise software parameters, alarms or values

Photos and illustrations only give examples. Equipment and procedures may differ regarding the specific projects. Therefore, the content of the photos or illustrations is not to be considered as generally applicable. Contact the responsible logistic manager for project-specific information.

Dimensions and weights are given according to the "International System of Units" (SI). Project-specific these data may be completed with Anglo-American units.

If any suggestions or improvements are required please forward your comments to germany-documentation@suzlon.com.

As the SUZLON WTGs are continually improved and further developed, we reserve the right of modifications. Make sure that this document is available in the latest version according to the appropriate configuration of the WTG.

1.1 Scope

This manual is valid for the S9x WTGs (S9x = S88-2.25 MW Mark II, S95-2.1 MW, S97-2.1 MW). Please note the following variant specification giving information on the document's content.

Feature	Variant / version
Frequency	☒ 50 Hz ☒ 60 Hz

Feature	Variant / version
Temperature version	☒ Standard Temperature Version (STV) ☒ Low Temperature Version (LTV)
Tower version	☒ Tubular tower (for hub height 80 m/90 m/100 m)

1.2 Warranty

This document is based on the technical and product-specific parameters of the supplied WTG. Nevertheless, the manufacturer reserves the right to add complementary information to this document.

The manufacturer only accepts warranty and liability as they are defined in the "General Terms of Sale and Delivery".

The manufacturer does not accept any warranties or liabilities for personal injuries or damage to property, if they refer to one or several of the following causes:

The described product was

- damaged by "force majeure"
- used not as intended
- not operated according to the instructions given in the documentation
- operated after technical safeguards have been put out of service
- operated with inadmissible materials or equipment
- subject to modifications of its design, controlling and/or functionality without prior consultation of the manufacturer
- equipped with replacement parts not supplied or approved by the manufacturer
- repaired improperly.

1.3 Copyright

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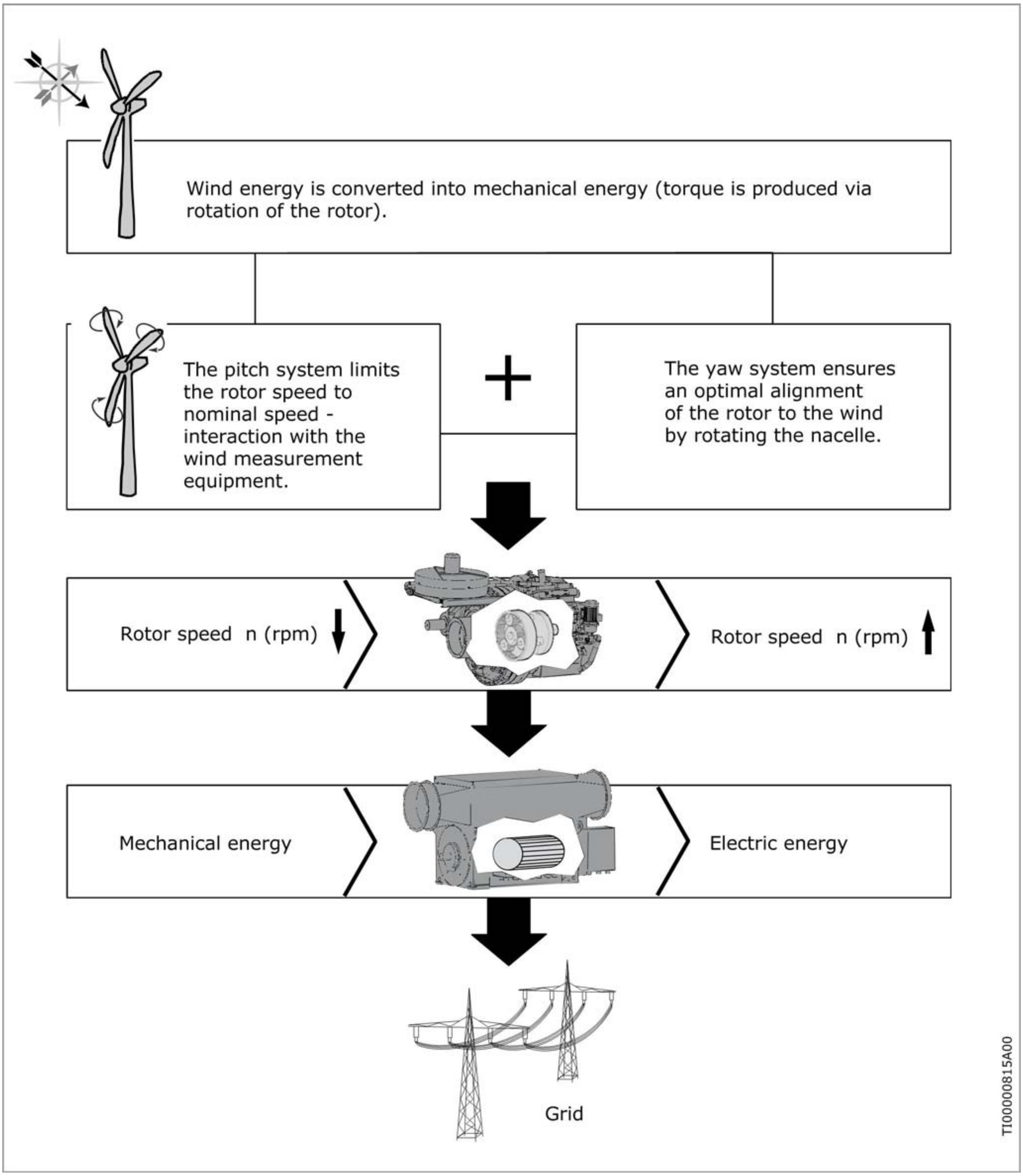
2 Operation principle

The purpose of a WTG is to convert wind energy into electric energy.



2.1 Pitch system

The pitch system regulates the rotor speed to given set points. The pitch system operates as follows: Below the nominal wind speed, the pitch angle is constant at 0° position. Once the wind speed reaches nominal speed, the pitch regulation starts to regulate the pitch angle to limit the rotor speed of the WTG to nominal speed.

Each blade has its own pitch drive system consisting of a motor with gear box, a frequency converter, a battery backup system and a forced ventilation system. The SUZLON CONTROL SYSTEM (SCS) transmits the required set points for the blade position, which is controlled for each blade separately by the respective frequency converter. The pitch drive motors are located inside the hub and equipped with an internal brake, which holds the blade position when the pitch system is not active.

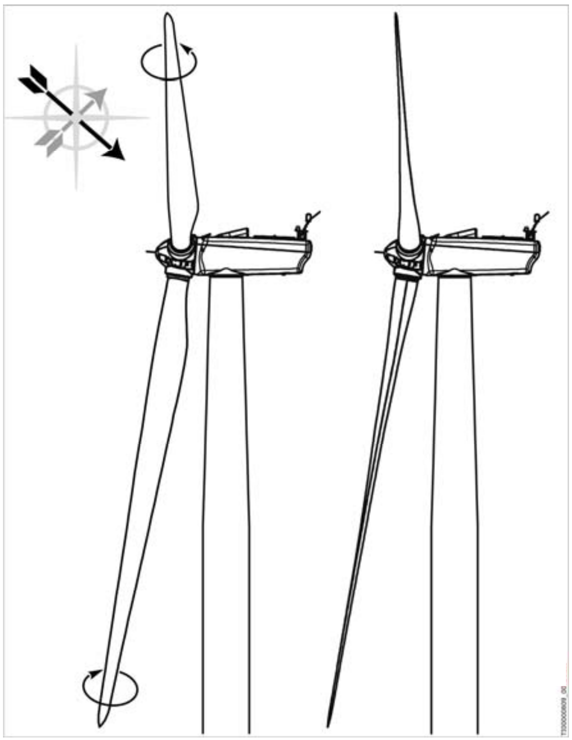


Figure 2-1: Principle of pitch system

The battery backup ensures the individual pitch drive functionality, even if grid connection is not available. In this case the WTG stops immediately and the blades pitch into feathering position using the battery boxes belonging to the battery backup system. The uninterruptible power supply (UPS) belonging to the SCS checks the status of the backup systems periodically and shuts down the WTG in case the battery charge level falls below a predefined value.

The pitch system and the battery backup systems are located inside the hub cabinet. The supply and communication cables to the nacelle are routed through the hollow main shaft. A slip ring behind the gear box transmits the electric signals from a static to a rotational condition.

The pitch system is equipped with one heater within each battery box. It heats up the battery chargers and prevents humidity inside the battery box. Heating is realised by thermostats. A temperature sensor is installed inside each battery box. The temperature sensor forces the WTG to shut down safely in case of low temperature. Each pitch drive is equipped with an absolute encoder to localise the absolute position of the blade. The pitch drive speed is measured by a resolver at all times.

2.2 Yaw system

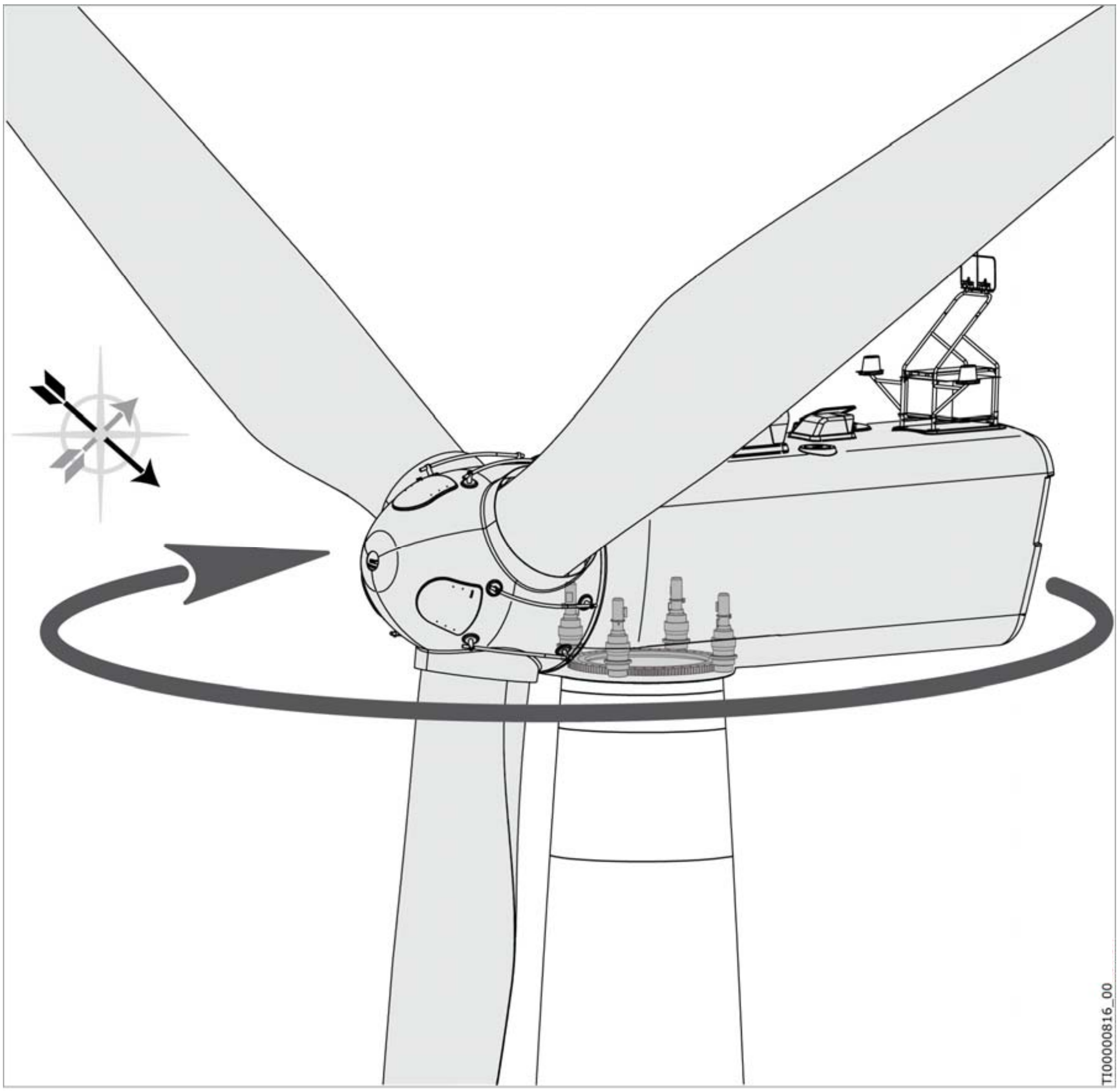


Figure 2-2: Yaw system

The nacelle is mounted to the tower with the yaw bearing.

The yaw system is used to ensure an optimal alignment of the rotor to the wind. The wind direction is measured by two wind sensors (2D ultrasonic wind sensors for LTV, wind vanes for STV) at the equipment frame on the nacelle roof. The sensors transmit the measured values to the SCS.

The yawing is performed by the four electric yaw drives, which are activated as soon as the SCS recognises a certain predefined difference between the rotor axis and the current wind direction.

The yaw angle sensor (type: proximity switch) measures the actual position of the yaw system. The sensor is located on the gear rim and counts the number of turns the nacelle performs in the given direction to avoid cable twist. If the nacelle turns more than a predefined number of times in the same direction, the WTG shuts down temporarily and starts untwisting automatically. Afterwards the WTG restarts automatically. In case the yaw angle sensor fails, the yaw twist stop switch activates the safety chain.

3 Technical overview

The WTG is devided into the main parts:

- Tower (3)
- Nacelle (2)
- Rotor (1) with blades (4)

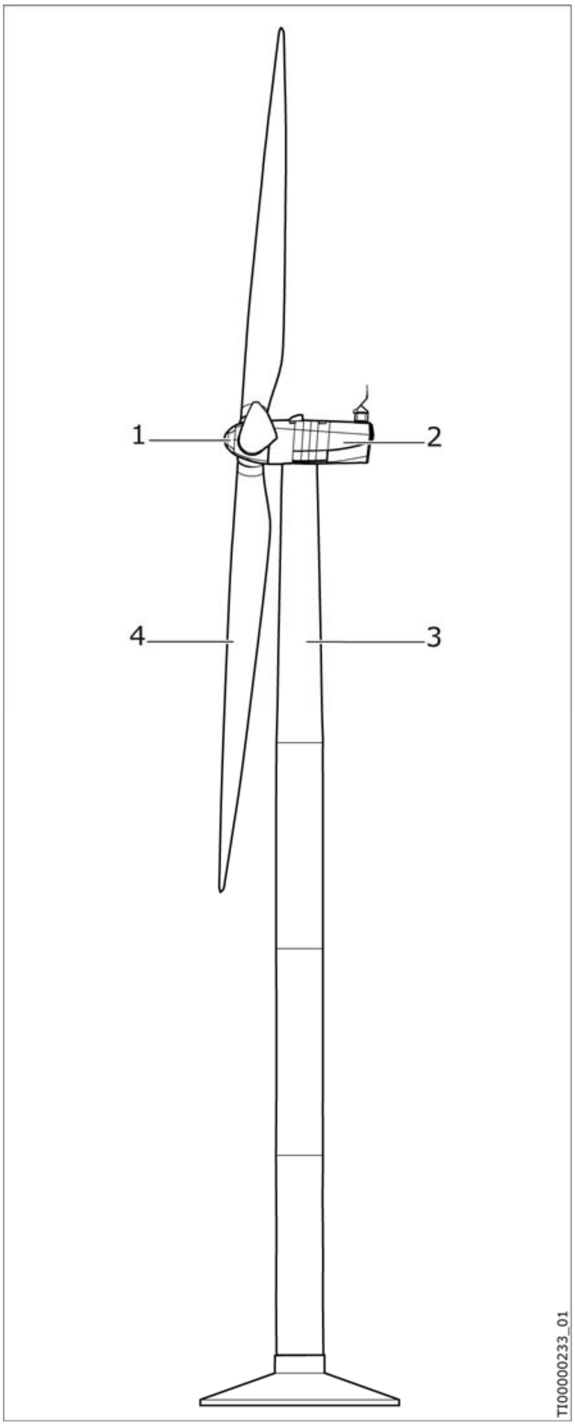


Figure 3-1: Main components of WTG

3.1 Climatic conditions (LTV only)

The low temperature version (LTV) WTG is designed for extra cold climatic conditions (see "Technical Data").

To keep the WTG in safe operating condition all significant temperatures are measured, e.g. the temperature inside and outside the WTG, pitch battery chargers or gear box oil sump.

Components are made of special resistant material to withstand extra cold climatic conditions (e.g. hub, main frame, main shaft, tower sections, brake holder, hoisting eye).

Specific determined components have been tested to perform at low temperatures. Furthermore special cable insulation as well as the speed and yaw sensors and wind measurement equipment are designed for low temperatures.

All fan heaters are powered individually by the SCS and monitored via a common feedback. Each fan heater has a thermostat, which switches on the fan heater in case the temperature is below a certain value.

3.2 Foundation and tower

The tubular steel tower consists of sections connected by means of bolted flanges. The tower is built on the foundation using anchor bolts, which are set into concrete at the foundation.

The tower can be climbed from the inside. Working platforms and a ladder with a fall protection system, optionally a lift or climbing assistent can be installed.

The bottom cabinet sections are arranged in the tower bottom . The cabinet sections are connected to the generator and the top cabinet in the nacelle via power and control cables. At the tower top the cables are routed through a cable loop. It allows the nacelle to turn several times in each direction without damaging the cables.

The power cables between WTG and grid are routed through conduits.

The tower is protected against corrosion with a special sandblasting procedure and by applying an epoxy resin coating to the tower surface.

The foundation is project-specific, depending on the ground conditions and the local rules and regulations.

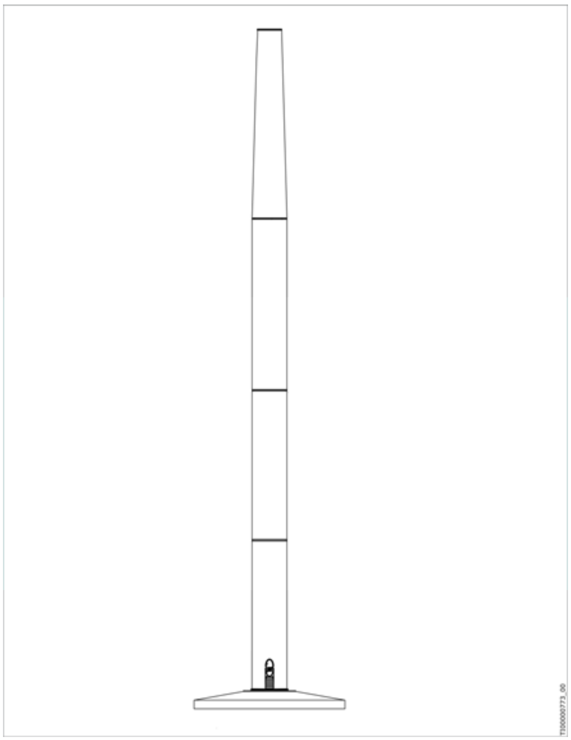


Figure 3-2: Tubular tower with 4 tower sections

3.2.1 Service lift

A service lift can be optionally installed inside the tower and is meant to carry service staff and working equipment.

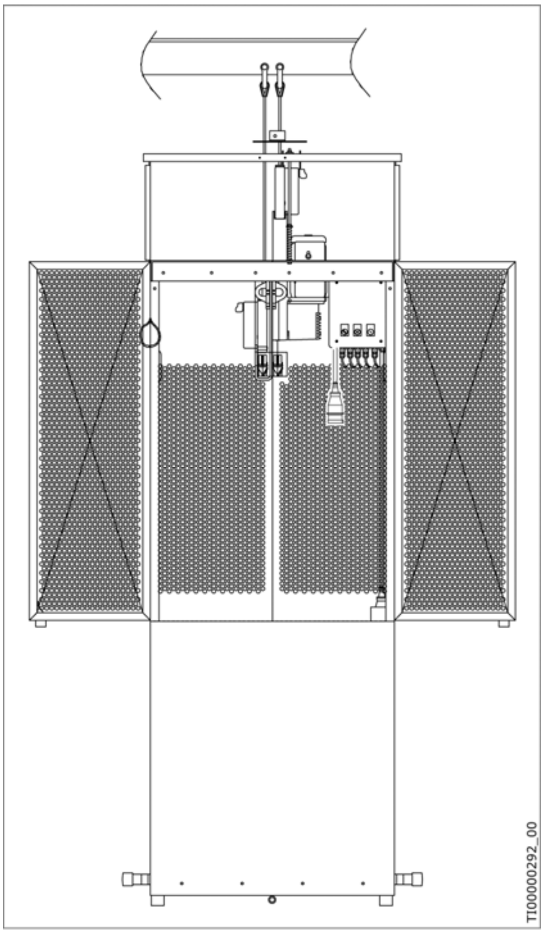


Figure 3-3: Example of service lift

3.3 Nacelle

The nacelle consists of the following main parts: main frame and girder system that carrie the drive train, as well as top cabinet and on-board hoist. The nacelle is covered by the nacelle housing and connected to the tower via the yaw assembly.

The nacelle housing protects the internal components against various ambient conditions. Two access hatches in the nacelle housing provide ccess to the measuring instruments on the nacelle roof and the rotor.

The nacelle housing is made in sandwich construction to avoid a quick cool down. The nacelle is equipped with several fan heaters.

The temperature inside the top cabinet is controlled by temperature sensors. The cabinet heaters are connected directly to the grid and are activated via thermostats.

3.3.1 Drive train

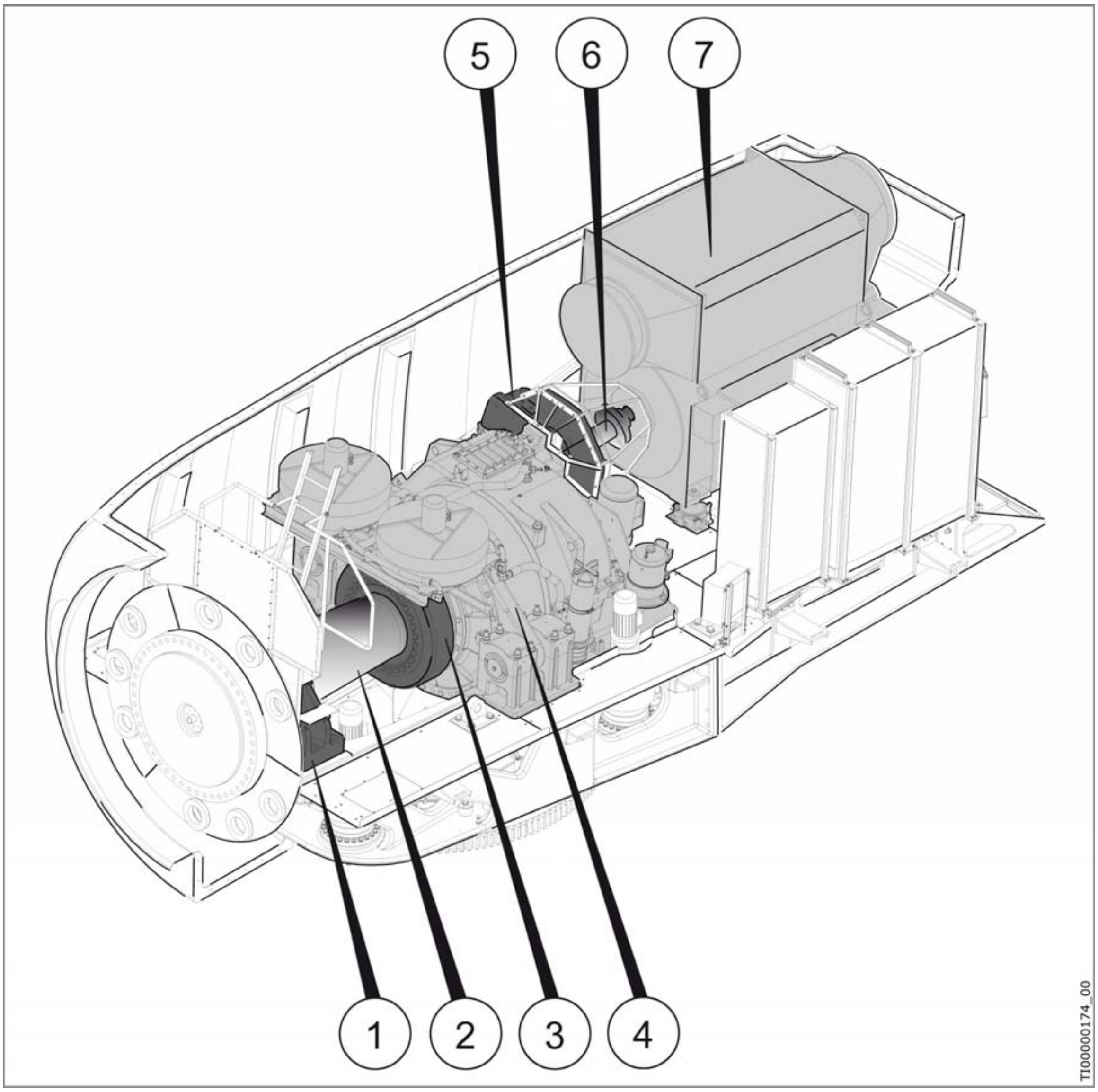


Figure 3-4: Main components of drive train

1	Main bearing	2	Main shaft
3	Shrink disc	4	Gear box
5	Mechanical brake	6	Coupling
7	Generator		

The drive train with its components transmits and transduces the rotor speed to the generator. The main components are shown in Figure 3-1.

The main shaft is supported by the main bearing on the rotor side. A shrink disc connects the main shaft to the gear box. Inside the gear box the main shaft is supported by a cylindrical roller bearing. The main shaft is hollow to reduce weight and to guide the hub cables.

In a defined temperature range, the main bearing housing of the WTG is preheated during the start procedure by a fan heater. The main bearing fan heater is directly connected to the grid. It is independent from the SCS, switched by a second thermostat for holding the temperature in the nacelle in case of a SCS failure.

Gear box

The gear box converts the low rotor speed of the main shaft into high rotational speed which is necessary for generator operation.

A mechanical oil pump supplies the gear box with oil. The oil is filtered by a micro-filter system and comprises an oil-cooling device.

The internal oil heating is equipped with heating rods. It operates when the oil sump temperature is below a defined temperature value.

External fan heaters are mounted underneath the gear box. If the oil temperature is below a defined value, the gear box is heated before it starts operating.

Generator

The WTG is equipped with a doubly-fed induction generator (DFIG) with an electronic power converter in the rotor circuit of the generator.

During operation, the stator side of the generator is permanently connected to the grid. The rotor windings are connected to the grid via slip rings and a back-to-back voltage source converter that controls both the rotor and the grid current. Thus, rotor frequency can freely differ from the grid frequency. By controlling the rotor current with the converter it is possible to adjust the active and reactive power fed to the grid from the stator and rotor.

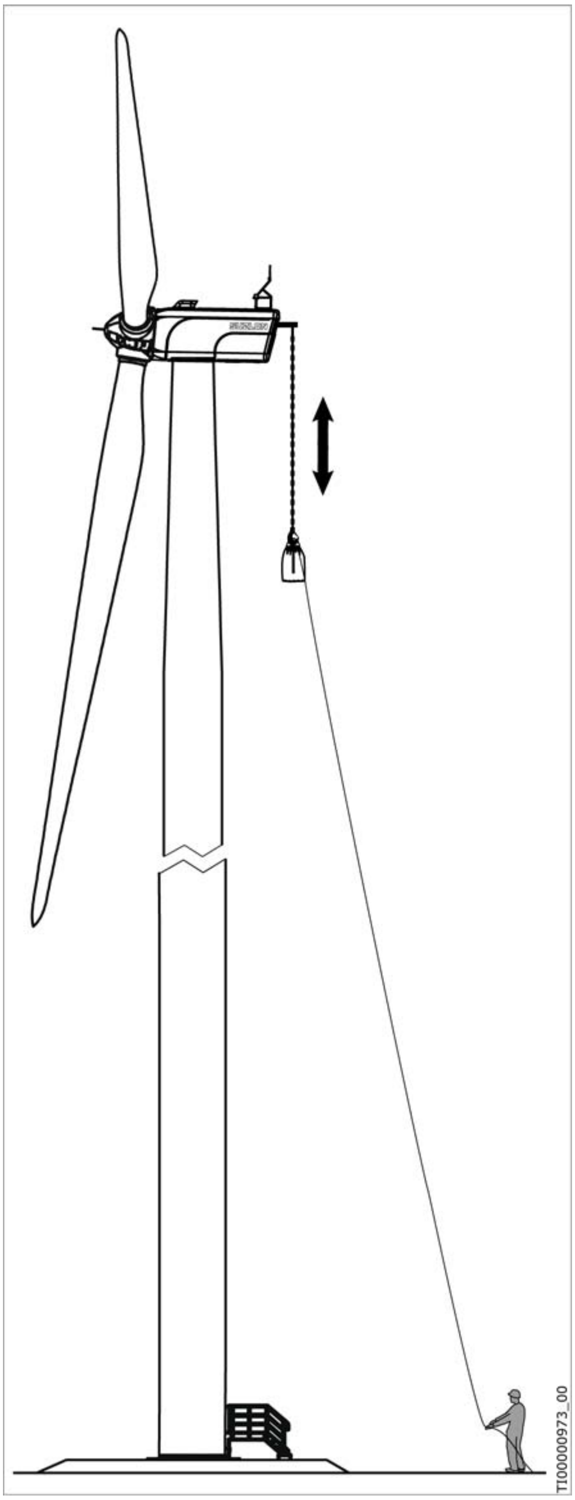
An air cooling system keeps the generator at an optimal operating temperature.

The generator includes an anti-condensation heater which is activated while starting the generator. Heating idling means to heat up the generator by means of free wheeling with a defined speed. This is controlled by the pitch angle of the blades. The generator slip ring is equipped with an internal thermostat which controls the slip ring temperature and activates the slip ring heater if required.

The generator bearings are equipped with a time-controlled automatic lubrication system.

3.3.2 On-board hoist

The on-board hoist is located inside the nacelle to carry items into and out of the nacelle through a hatch. The on-board hoist is driven by an electric motor and mounted on a slide rail. The slide rail is fixed to the nacelle housing underneath the roof.



3.4 Rotor

The rotor consists of:

- hub
- nose cone (covers the hub)
- three blades

A double-row ball bearing connects each blade to the hub. The hub transmits the rotor speed via the drive train to the generator.

The pitch system rotates the blades (see Chapter 2.1).

4 Hydraulic system

The hydraulic power unit provides the oil pressure that is required to actuate the mechanical brake and the rotor lock. It can be operated with the operation box or the hydraulic hand pump.

4.1 Mechanical brake

The mechanical brake is located on the high speed shaft between gear box and coupling. The brake is applied by hydraulic pressure (active brake). The brake pads are pressing against the brake disc, thus braking the high speed shaft (HSS).

The mechanical brake is only used to stop the WTG when it has already been slowed down by the aerodynamic brake. The mechanical brake operates at a very low rotor speed. It is only used as a parking brake to apply the rotor lock or in case of an emergency.

4.2 Rotor lock

The rotor lock stops the rotation of the rotor and the drive train mechanically. To stop the rotation, the rotor lock pin moves into a defined hole in the rotor lock disc.

The rotor lock is applied e.g. during service and maintenance work. It provides additional personal safety when working inside the hub and on the nacelle/rotor roof.

The rotor lock disc is mounted on the main shaft inside the nacelle. The rotor lock pin is located underneath the main bearing and is operated by the hydraulic power unit. It is only allowed to apply the rotor lock under certain circumstances (see "Operation").

A sensor (rotor lock proximity sensor) detects the status of the rotor lock. Only in case the rotor lock is not applied the WTG is able to start.

5 Cooling systems

Several cooling systems exist in the WTG for e.g.:

- gear box
- generator
- cabinets

The components to be cooled are monitored by sensors which process the information to the SCS.

Gear box

The gear box (see Chapter 3.3.1) is cooled via the oil flow that is passed through the gear box oil cooler. A thermal choke shuts off the oil circulation during start-up until the minimum operating temperature of the oil has been reached. An oil pump carries the oil directly to the relevant gear box components.

Generator

Two separate air cooling circuits cool the generator.

Air ducts feed the inner closed cooling air circuit to provide all moving parts with cool air. A heat exchanger, a part of the stator housing, transfers the heated air to the outer cooling circuit.

The air intake of the outer cooling circuit is located at the drive end side. One axial-flow bladed fan, located at the drive end side, takes the air in, carries it through the axially placed cooling tubes and discharges it at the generator air duct.

Cabinets

The cabinets are cooled by a fans.

The fans take cool air through filters into the cabinets. Warm air escapes the cabinets via filtered outlets. Thermostats and humidistat activate fans and heaters if the temperature/humidity inside the cabinets reaches a certain limit.

6 Lubrication systems

Lubrication system ensure permanent and essential operation of moving parts of the WTG due to a sufficient oil or lubrication supply for determined components. Two types of lubrication systems are installed inside the WTG:

Closed lubrication system

Closed lubrication systems, e.g. special roller bearings, contain lubricant for the whole service life of a WTG. Those systems do not have to be refilled.

Open lubrication system

Open systems supply the components with grease at all times using grease tanks. Such systems are used e.g. for the pitch system (gear rim) and have to be refilled at determined intervals.

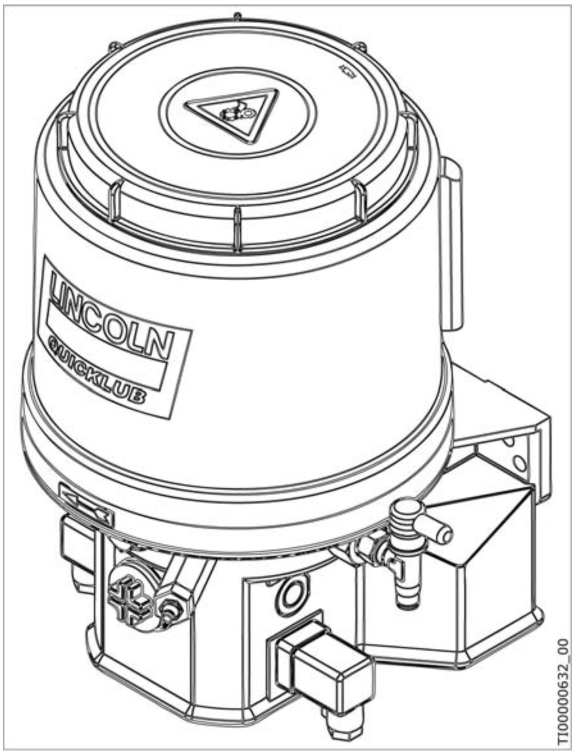


Figure 6-1: Grease tank for open lubrication system

Automatic lubrication system (ALS)

ALS generally comprise a controller or timer, a pump and reservoir, metering valves and fittings as well as supply and feed lines. It delivers a controlled amount of lubricant to multiple, specific locations on the WTG (e.g. generator bearings) while it is operating at specific times from a central location.

7 Grid connection

The WTG is connected to the grid by means of the generator. A transformer is used to transform medium voltage to high voltage and minimises electric losses.

When the WTG starts up the blades turn to a determined blade angle depending on the wind speed, thus accelerating the rotor. When the generator speed has reached synchronous speed, the WTG is connected to the grid.

7.1 Compensation

The electric power required by the WTG to produce electric energy is active power but each asynchronous electric generator needs a certain amount of reactive power. Reactive power is additional load on the electric supply system, e.g. the cables. Capacitor banks in the bottom cabinet compensate the reactive power that is constantly measured during operation. Capacitors switch on and off depending whether additional capacity is needed or not.

7.2 Medium voltage (MV) cabinet and transformer

The MV cabinet and transformer are located outside the WTG and are within the responsibility of the owner.

The transformer transforms electric energy from one voltage level to another, e.g. from the grid to the WTG or vice versa.

8 Lightning and surge protection

The lightning protection in WTGs is designed according to IEC TR 61400-24. The standard specifies a full protection against direct lightning strikes and the effects of lightning strikes. The lightning protection is designed according to the highest existing lightning protection level I (LPL I) .

The lightning protection of the WTG consists of four main parts:

- Exterior lightning protection
- Interior lightning protection
- Equipotential bonding system
- Earthing system

8.1 Lightning protection zones (LPZ)

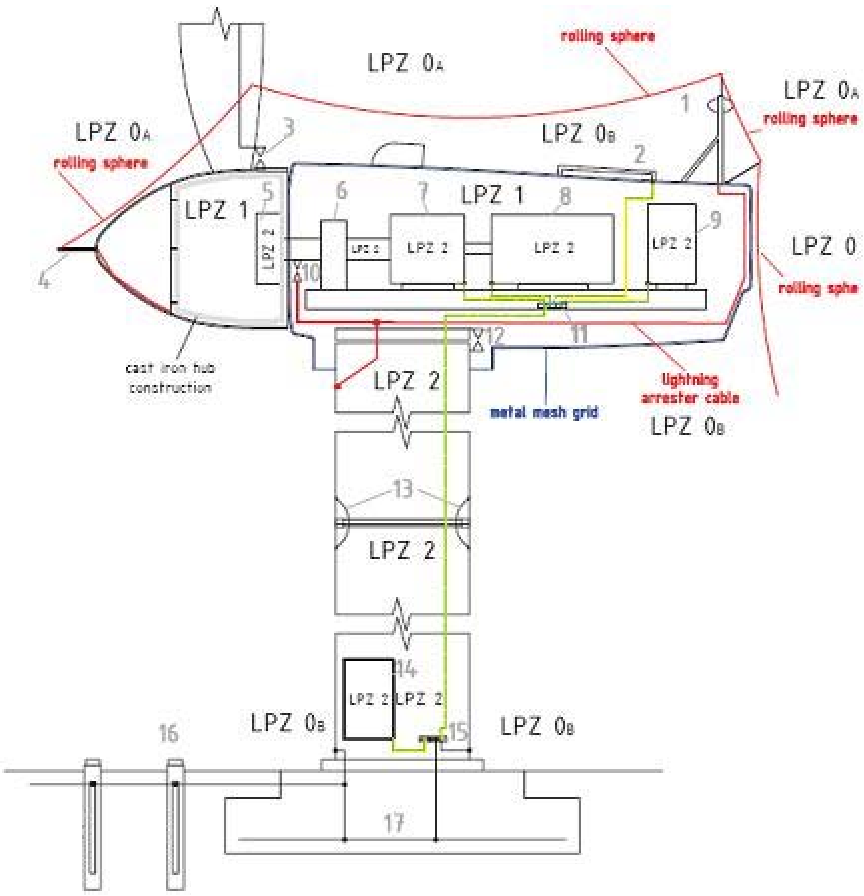


Figure 8-1: Overview lightning protection zones (LPZ)

1 Equipment frame with lightning rod
2 Handrail
3 Spark gap (blade bearing – hub)
4 Lightning rod
5 Hub cabinet
6 Main bearing
7 Gear box
8 Generator
9 Top cabinet
10 Spark gap (rotor – main bearing)
11 Equipotential busbar nacelle
12 Spark gap (yaw bearing – main frame)
13 Earthing strap
14 Bottom cabinet
15 Equipotential busbar tower
16 Earthing bolt
17 Earthing of foundation

8.1.1 Rolling sphere simulation

The lightning protection system and hence the LPZs are designed in accordance with the rolling sphere simulation on the geometry of the WTG.

The rolling sphere simulation is used to locate and dimension the lightning rods to allow the highest level of lightning protection against the nacelle.

During simulation the rolling sphere with a radius of 20 m is running across the geometry of the WTG. To ensure LPZ 1 (inside WTG) and LPZ 0_B (outside WTG) the rolling sphere is not allowed to contact a part of the nacelle or the hub but only the lightning rods.

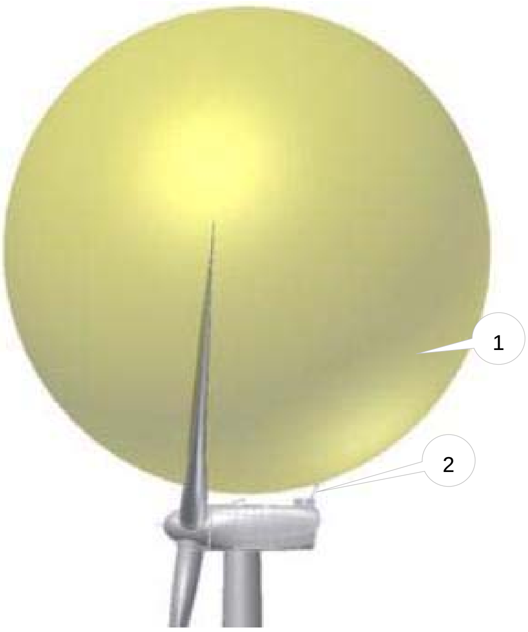


Figure 8-2: Rolling sphere model

1 Rolling sphere

2 Lightning rod at equipment frame

8.1.2 Lighning protection

Lighning protection is realised at different locations by

- ligning rods
- spark gaps
- earthing straps

The hub is made of cast iron. All electric components have the required distance to the nose cone, which is equipped with a lightning rod. The hub complies with the requirements for a Faraday cage.

The blades are equipped with a lightning arrester. The lightning is guided from the arresters to the hub and via spark gaps to the main shaft. The main shaft conducts the lightning to the earthed tower via earthing straps.

The nacelle housing is provided with a mesh of galvanised steel. The meshes are interconnected to each other in order to build a Faraday cage. The meshes are attached to the tower using earthing straps. The equipment frame on top of the nacelle is equipped with a lightning rod.

The blade bearings and the drive train are protected against lightning current by means of spark gaps.

1 Spark gap plate
2 Rotor lock disc

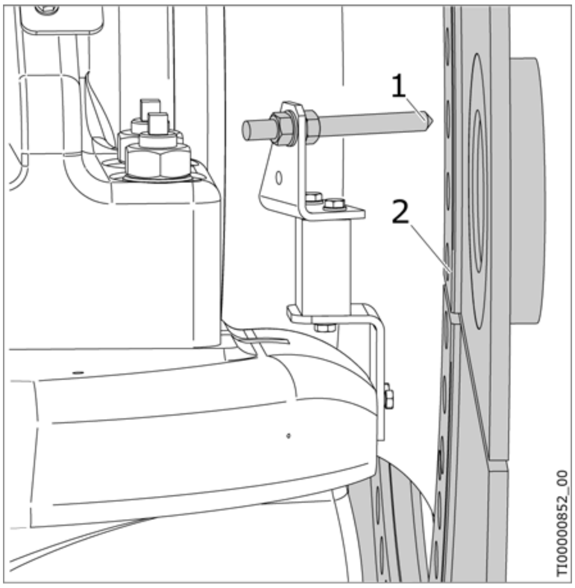


Figure 8-3: Spark gap between rotor lock disc (2) and spark gap plate (1)

The lightning is bled off via lightning rods and spark gaps to the tower and earthed via earthing straps mounted at the tower shell.

1 Earthing strap
2 Connection earthing strap – tower shell

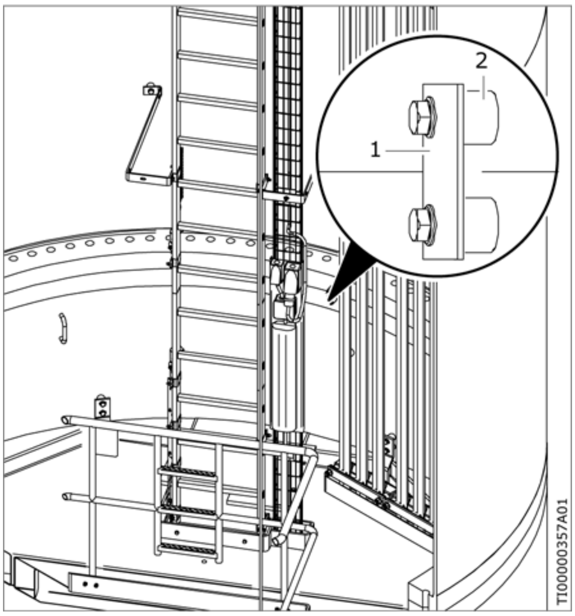


Figure 8-4: Earthing between tower sections

8.2 Equipotential bonding system

The task of the equipotential bonding system is the potential equalisation of all metal system components like housings, handrails, ladders and cabinets. The potential equalisation avoids the generation of dangerous voltages that endanger people and technical systems.

The equipotential bonding system connects all metal components of the WTG. As a result, the electric potential of all components is the same. In case of contacting two components, staff is not exposed to danger caused by high voltage.

8.3 Surge protection device (SPD)

The lightning protection of the WTG includes surge current and surge voltage arresters, also called surge protection devices (SPDs). SPDs protect the electric systems against indirect effects of lightning strikes.

8.4 Subterranean earthing system (optional)

The subterranean earthing system connects the WTG with the transformer and all components outside the WTG. The subterranean earthing system has to avoid potential differences between the WTG and the transformer in case of lightning strike. It is connected to the PAS busbar in the bottom of the WTG.

9 Condition Monitoring System (CMS) (optional)

The intention of the CMS is to prevent damage and loss of components. It forecasts damage and allows a minimum time for maintenance works. Additionally, it is possible to analyse damage, increase the reliability and mean time between failures (MTBF).

CMS is a basic diagnostic system. It measures vibration at drive train components and automatically detects relevant changes. In CMS surveillance centre experts can diagnose damage and prepare instructions for operating staff. The analysis of damage causes can help to develop possibilities of damage prevention.

The CMS acts as follows:

- Measurement of vibration on drive train (main bearing, gear box, generator)
- Communication to controller
- Communication to CMS surveillance centre (remote control)

10 SUZLON CONTROL SYSTEM (SCS)

The SCS is a WTG and wind farm controlling and monitoring system.

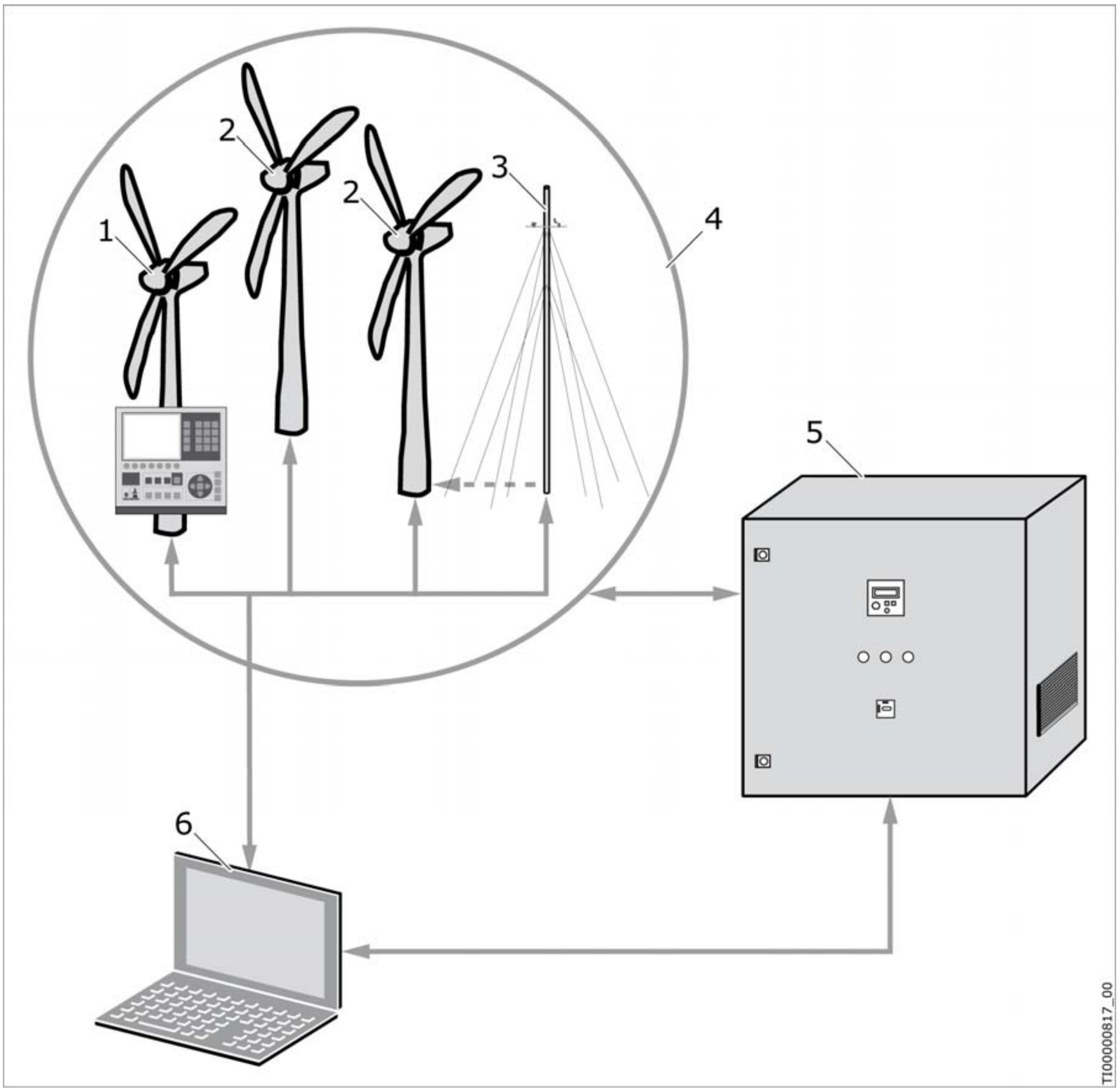


Figure 10-1: Interaction of the components of the SCS

1	WTG with SERVICE TERMINAL (SC-TERMINAL) and SC-TURBINE	4	Wind farm
2	WTG with SUZLON CONTROL-TURBINE (SC-TURBINE)	5	SUZLON CONTROL-POWER PLANT CONTROLLER (SC-PPC)
3	SUZLON CONTROL-METSTATION	6	SUZLON CONTROL-COMMANDER (SC-C)

10.1 SUZLON CONTROL-TURBINE (SC-TURBINE)

SC-TURBINE is the control system of a single WTG. It ensures safe and stable operation and power production of the WTG via different sensors and measurements (e.g. electrical grid data, wind speed and direction, rotor speed, yaw and blade angle and component temperatures). A flash memory stores statistical and operational data.

The SC-TURBINE software runs on a controller and ensures safe and high performance of the WTG.

SC-TURBINE can be monitored and controlled with the SERVICE TERMINAL or SC-C directly at the WTG. In close interaction with SC-C it is possible to communicate with the WTG and to create reports and logs of stored WTG data or the whole wind farm.

10.2 SUZLON CONTROL-COMMANDER (SC-C)

SC-C is designed as a user interface to WTGs. It manages access for customers, service staff and other persons according to defined access levels to all wind farm devices, such as WTGs, meteorological masts and also to SC-PPC. At the same time it collects, stores and distributes all required data. SC-C is required to see the WTG status, carry out simple operations like start, stop, reset and to create reports. SC-C is the gate to SC-TURBINE and SC-PPC.

SC-C can be installed on any kind of operating system. The laptop/PC has to comply with defined requirements.

10.3 SERVICE TERMINAL (SC-TERMINAL) (optional)

SC-TERMINAL is used to operate a single WTG.

10.3.1 SC-TERMINAL - fixed

The fixed SC-TERMINAL is included in a cabinet door of the bottom cabinet. It consists of processor, monitor and key pad.

10.3.2 SC-TERMINAL - portable

A portable and compatible SC-TERMINAL can be connected to a WTG. The SC-TERMINAL consists of processor, monitor and key pad in a single box and can be plugged to every WTG.

10.4 SUZLON CONTROL-POWER PLANT CONTROLLER (SC-PPC, optional)

The SC-POWER PLANT CONTROLLER (SC-PPC) is designed to control a complete wind farm according to specific requirements. The wind farm is controlled as a power plant. It is possible to e.g. reduce the power output of the wind farm which is in certain cases necessary to meet the requirements of the power utilities or to stop individual WTGs to avoid shadow flicker effects at particular areas.

The software runs on a controller in close interaction with SC-TURBINE. Visualisation and remote control of SC-PPC is possible via SC-C.

10.5 SUZLON CONTROL-METSTATION (SC-METSTATION) (optional)

The SC-METSTATION provides a detailed and correct representation of actual weather conditions of a wind farm. Additional forecasts and calculations are possible.

The measured data is used for:

- Production forecast
- Free wind speed
- Wind direction
- Production loss calculation
- Air density calculation
- Turbulence intensity

The SC-METSTATION is located inside the wind farm it belongs to. It is equipped with anemometers and wind vanes that are installed at hub height. The maximum number of wind measurement equipment can be extended to four anemometers and four wind vanes.

11 Lighting

11.1 Tower

Tower lights are mounted inside the tower at certain intervals next to the tower ladder.

All tower lights can be switched on and off by a single toggle switch located at the entrance of the WTG.

The tower lights have a battery backup to ensure safe working conditions in case of emergency.

11.2 Nacelle

Four overhead lights are located inside the nacelle. Toggle switches are located at the right side (view to the rotor) of the nacelle inside.

11.3 Hub

The hub light is located above the hub entry, inside the hub body. The corresponding switch is fixed right next to the light.

1 Toggle switch for the hub cabinet light

2 Hub cabinet light

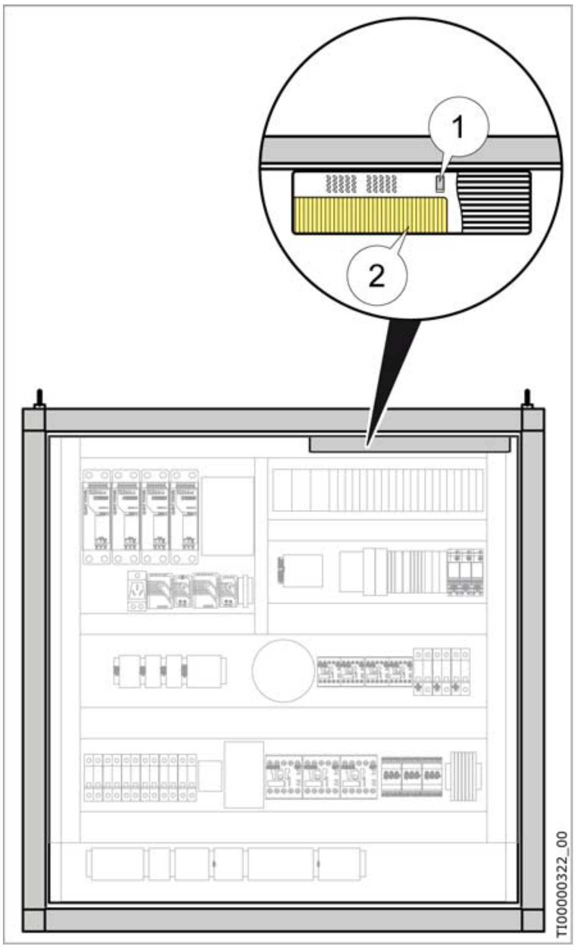


Figure 11-1: Cabinet light

11.4 Aviation light (optional)

Aviation lights can be fitted on top of the nacelle at the equipment frame. The aviation lights have to be realised according to the national requirements.

Blinding can be avoided by covering the aviation lights but allowing the lights to be visible for e.g. pilots.

12 Sensors

All sensors are connected to the SCS. If default settings are exceeded, the WTG or the respective component reacts as defined by the SCS.

Table 12-1: Sensor overview

Sensor type	Description / use
Thermostats and humidistat	Temperature and humidity sensors observe the temperatures and humidity at several components inside and outside the WTG. In case the defined settings are exceeded fans and heaters turn on or off, alarms are triggered and/or the safety chain of the WTG opens. (Use: e.g. gear box, generator, cabinets, nacelle inside and outside).
Vibration sensor	Mechanical and electric vibration sensors detect dynamic unbalances. In case the defined settings are exceeded, the safety chain opens. (Use: e.g. at main bearing, gear box mounts).
Oil/grease sensor	Several sensors observe the function of the automatic lubrication system and the filling level of the grease and/or oil tanks at different observation points. These sensors pass the information to the SCS. (Use: e.g. yaw system, pitch system, gear box, generator).
2D ultrasonic wind sensor (LTV only)	The wind measurement equipment is mounted on top of the nacelle roof and measures the wind direction and the wind speed. It consists of two 2D ultrasonic wind sensors. The sensors are surrounded by a protection cage to protect them against electromagnetic fields. The sensors are equipped with integrated heaters. The SCS works with one of the sensors to receive a wind speed value. It permanently tests the plausibility of the sensors and chooses the higest wind speed. The wind direction is averaged between the two wind sensors. (Use: pitch system 2.1, yaw system 2.2)
Anemometer and wind vanes (STV only)	The wind measurement equipment is mounted on top of the nacelle roof and measures the wind direction and the wind speed. It consists of two anemometers and 2 wind vanes. The sensors are surrounded by a protection cage to protect them against electromagnetic fields. The SCS works with one of the anemometers to receive a wind speed value. It permanently tests the plausibility of the sensors and chooses the higest wind speed. The wind direction is averaged between the two wind vanes. (Use: pitch system 2.1, yaw system 2.2)
Speed sensor	Proximity sensors and counter modules observe the speed at rotating WTG components. The measured values are used to optimise the WTG output and to to react in case of overspeed. (Use: main shaft, high speed shaft)

Sensor type	Description / use
Angle sensor	Angle sensors detect the position of the belonging component and pass the position to the SCS. The user is able to move the component to a required position (e.g. for maintenance works). (Use: pitch system 2.1, yaw system 2.2)
North position sensor	The sensor makes out the position of the nacelle with regards to north.