



PROGETTO DI REALIZZAZIONE DI UN PARCO EOLICO

Località "Valle Castagna, Valle Cornuta, Mezzana del Cantone"
Comune di Montemilone (PZ)



B.2. Manuale d'uso e manutenzione dell'impianto

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Technical Documentation

Wind Turbine Generator Systems

3MW Platform - 50/60 Hz



Basic Information



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1 About this document

1.1 Function

This operating manual is an essential aid to ensure the successful and safe operation of the wind turbine generator system. The chapters in this operating manual contain important information which helps to operate the wind turbine generator system safely, correctly and economically. Their observance helps to avoid dangers, to reduce repair costs and outage times and to increase the reliability and service life of the WTGS. The safety information described must be complied with without fail, in order to ensure safe operation of the WTGS.

This document contains information on:

- Safety
- Technical Description and Data
- Operation
- Controller HMI User Guide
- Maintenance Log

1.2 Target Group

The operating manual must be permanently available in the WTGS and must be read and used by anybody who has been authorized to work with or in the WTGS:

- Operation, in-process fault elimination, service, disposal of operating and process materials
- Upkeep (maintenance, inspection, repair)

Personnel who have not been authorized to work with or in the WTGS may not remain in or on the WTGS during maintenance work or any other work in or on the wind turbine generator system.

There is a danger to life and limb!

The instructions of the GE Energy team must be followed without fail.

1.3 Scope of Information

This document contains all the requisite information for commissioning, operation, remote monitoring, maintenance and repair.

2 For your Safety

2.1 Authorized Personnel

The WTGS may only be assembled, operated and maintained by adequately qualified personnel, in order that it functions correctly and safely.

2.2 Environmentally-compatible Working

The WTGS is constructed in such a way that it does not have an impact on the environment. It does not emit any ecologically harmful substances.

2.3 Disposal after Decommissioning

Useless or irreparable components and consumables and process materials are disposed of in a manner harmless to the environment in accordance with the respectively valid country-specific waste disposal regulations.

3 Used Symbolology

The following designations and signs are used in the operating manual for particularly important information:



Danger

Denotes an immediate danger which will cause death or serious injuries.



Warning

Denotes a potentially hazardous situation which may result in death or serious injury if the dangerous situation is not avoided.



Caution

Denotes a potentially hazardous situation which may result in slight or minor injuries if the dangerous situation is not avoided.



Attention

Indicates a potentially hazardous situation that may result in damage to the WTGS or surrounding area if the dangerous situation is not avoided.



Note

This contains user tips and useful information. All notes should be read in the interests of proper use of the WTGS.

1. Work and/or operating steps are identified by enumeration. The numbers specify the order in which the work and/or operating steps are to be carried out!

All notices and symbols directly attached to the WTGS, such as safety signs, operating notices, rotation arrows, component identification markings, etc., must be observed without fail. They may not be removed and must be kept in a fully legible condition!

4 Proper Use

The WTGS may only be used in a technically perfect condition in line with the technical documentation. In addition, it must be used as intended, with safety in mind and with an awareness of the dangers. Any malfunctions, particularly those which could impair safety, must be reported and remedied immediately.

Proper use also includes compliance with the information in the chapters on:

- Safety
- Technical Description and Data
- Operation
- Controller HMI User Guide
- Maintenance Log

which is provided in the Operating Manual.

5 Information for the Operator

The operating manual is a constituent part of the WTGS. The operator is responsible for ensuring that the operating personnel take note of this manual.

The operator must supplement the operating manual with operating instructions based upon existing national regulations for the prevention of accidents and for environmental protection, including information on responsibilities and reporting obligations for the consideration of specific operational features, e.g. with regard to work organization, processes and deployed personnel.

In addition to the operating manual and the statutory regulations for the prevention of accidents applicable in the country of use and at the location, the commonly accepted technical rules for suitable, safe and correct working are also to be complied with.

As a general principle, the latest version of the national accident prevention regulations is to be referred to.

Further regulations may have to be complied with for special work which may only be carried out by qualified personnel. The qualified personnel are familiar with these regulations.

The operator/user may not implement any changes, extensions or modifications to the WTGS which could impair safety without the authorization of GE Energy!

Any spare parts used must meet the technical requirements specified by GE Energy.
This is always guaranteed for original spare parts.

Only deploy trained or instructed personnel. Clearly define the responsibilities of the personnel for operation, maintenance and repair.

The users must carefully read the operating manual and absorb the contents before the initial start-up of the plant. There is danger of injury if the safety precautions are not followed.

It must be ensured that a person located outside the plant can be contacted in an emergency at any time.

5.1 Orientation Training of the Maintenance Personnel (if no maintenance contract has been concluded with GE Energy)

As the operator of the WTGS, you are obliged to inform the operating and maintenance personnel about the existing legal requirements, the accident prevention regulations and the safety devices in and around the WTGS, and provide them with orientation training. The various technical qualifications of the personnel must be considered in this connection.

The operating / maintenance personnel must have understood the orientation training and it must be ensured that the orientation training is followed.

This is the only way to ensure that your personnel work with safety in mind and with an awareness of the dangers.

5.2 Briefing of the Rescue/Emergency Personnel

The operator of the wind turbine generator system is obliged to inform the local rescue services / emergency personnel about the safety regulations which are to be complied with and about the requisite rescue equipment. cf. also "Safety Information for Rescue and Emergency Personnel" in the manual in the chapter on safety.

GE Energy has no obligation to provide the requisite equipment. GE Energy gives the operator comprehensive advice about which equipment is required. Any subsequent liability claims for damages against GE Energy as a result of defective or unavailable escape equipment are excluded.

Technical Documentation Wind Turbine Generator Systems 3MW Platform - 50/60 Hz



Operating Manual

Applicable for Wind Turbine Generators from 2.5 MW to 3.8 MW



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1 Operator Qualification

Only deploy trained and instructed staff. Clearly define staff responsibilities for operation, maintenance and repair! A responsible person must be designated who must be authorized to reject third-party instructions that compromise safety.

The operator must have been instructed in all relevant existing statutory regulations, regulations for accident prevention and about available safety facilities on and around the wind turbine generator system.

The operator must understand the instructions and they must be followed without fail. This is the only way to ensure that all personnel maintain a safe and risk-free work environment.

2 Control Elements

2.1 Emergency Stop Push-Buttons

The emergency stop push buttons are located at the following positions in the plant:

Tower base

- Main control cabinet (MCC)

Nacelle

- Top box
- Below the nacelle (yaw area)

Hub

- Blade control cabinets



Note!

The emergency stop push-button should only be actuated in situations where the safety of personnel or that of the WTGS and its components is at risk.

Pressing the emergency stop push-button opens the safety chain and the WTGS rotor is brought to a standstill by means of an emergency brake.

To put the WTGS back into operation, proceed as follows:

1. Remove the malfunction or danger before putting the WTGS back into operation.
2. Unlock the emergency stop push-button.
3. Reset the error with the **Reset emergency stop circuit** key and the **Reset** key.
4. Press the start key (**Immediate start**).



Note!

Triggering the safety chain causes the rotor blades to be moved in emergency mode!

2.2 Visualization

The local visualization is realized as local web pages on the controller (ControllerHMI). A laptop needs to be connected to the wind farm LAN to run these web pages.

For remote operation the WindSCADA software shall be used.

For a detailed description of the SCADA Software functionality refer to the operating manual of the ControllerHMI and of WindSCADA.

2.3 Permanently Installed Control Elements and their Functions

2.3.1 Control Elements on the Main Control Cabinet 2.5-2.75 in the Tower Base of the WTGS

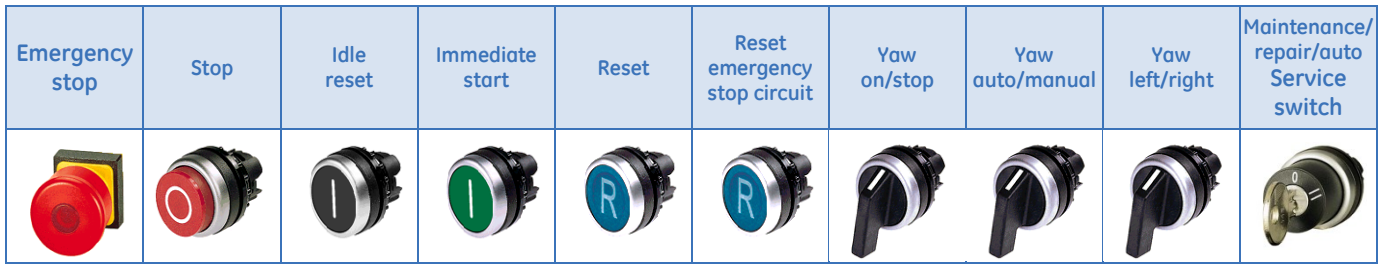


Fig. 1: Layout of control elements in the control cabinets inside the main cabinet

Designation	Control element	Function
Emergency stop 	Red mushroom button	Initiates an emergency shutdown.
Stop 	Red push-button	The wind turbine generator system is shut down and the brake is applied.
Idle reset 	Black push-button	Idling operation of wind turbine generator system. The rotor freewheels unbraked at a 89° pitch angle.
Immediate start 	Green push-button	The wind turbine generator system starts automatically if it was stopped with the Stop push-button and no faults are present.
Reset 	Blue push-button	Fault reset if wind turbine generator system has been stopped.
Reset emergency stop circuit 	Blue push-button	Resets emergency stop circuit.

Designation	Control element	Function
<p>Yaw on/stop</p> 	Two-position switch	<p>Stops the entire yaw drive when the switch is in the "Stop" position in the automatic and manual mode.</p> <p>Yaw drive remains locked until it is released once again by turning this switch.</p> <p>Plant cannot restart until the yaw is released again.</p>
<p>Yaw auto/manual</p> 	Two-position switch	Selection of automatic or manual yaw drive.
<p>Yaw left/right</p> 	Two-position switch	Activates yaw drive to move left or right if switch "Auto/Manual" is set to manual.
<p>Maintenance/ repair/auto Service switch</p>  <p>Remark: pos. I is to the left, pos. II to the right</p>	Rotary switch knob with withdrawable key that is used as rotary knob	<p>Key-operated switch, vertical: Position 0: "Operation".</p> <p>Key-operated switch: Position I: "Maintenance" Position II: "Repair"</p>

Remark: No designations have been provided on the control cabinet for the key-operated switch and the emergency stop push-button.

2.3.1.1 Description of the Service Switch

Function of the service switch

The service switch is used to allocate and record standstill times of the wind turbine generator system.

Operating Instructions and Operating Principle

Position: 0 (Operation):

No restriction of WTGS functions.

During the warranty period, use of the service switch is in general reserved for employees of GE Energy. This means that the key must remain in **"0 Operation"** position unless the person operating the switch has been authorized by the GE Energy.

Position: I (Maintenance):

The service switch must be turned to **"I Maintenance"** during:

- Outage times that GE Energy is not responsible for,
- Acceptance and function acceptance times
- Inspection times
- Regularly recurring tests
- Extraordinary repair and conversion times commissioned by the client during the warranty period. This also includes conversion and retrofitting times ordered by the owner due to further technical development of the WTGS.
- Regular maintenance (six-monthly and annual maintenance)

As soon as the switch is applied, a message is transmitted to remote monitoring. As long as the switch remains in this position, remote commands (such as remote start, remote stop, reset and other manual operations) cannot be transmitted.

The duration of this switch position is listed separately in the WTGS statistics under "maintenance time".

The WTGS can only be operated by means of the on-site control elements. No continuous operation is possible in this switch position. The WTGS automatically switches off 30 minutes after this switch has been actuated at the latest. The WTGS can be switched off earlier by actuating the "Manual stop" switch. A start is performed by resetting the WTGS ("**reset**") and afterwards starting it ("**Immediate start**"). If the switch is not in the operating position, a further automatic shutdown is carried out after another 30 minutes.

Position: II (Repair):

During the guarantee period, use of the key position "**II Repair**" is exclusively reserved for employees of GE Energy. Should somebody else detect a defect, authorization must be obtained from the responsible head of division or in exceptional cases (e.g. the head of the division is not available) from remote monitoring before actuating the repair switch.

As soon as the switch is applied, a message is transmitted to remote monitoring. As long as the switch remains in this position, it is not possible to send remote commands (such as remote start, remote stop, reset and other manual operations).

The duration of this switch position is listed separately in the WTGS statistics under repair time.

The WTGS can only be operated by means of the on-site control elements. No continuous operation is possible in this switch position. The WTGS automatically switches off 30 minutes after this switch has been actuated at the latest. The WTGS can be switched off earlier by actuating the "Manual stop" switch. A start is performed by resetting the WTGS ("**stop**") and afterwards starting it ("**Immediate start**"). If the switch is not in the position: 0 (Operation), a further automatic shutdown is carried out after 30 minutes.

On leaving the WTGS, the service switch must be returned to position "**0 Operation**" if

- maintenance has been completed or interrupted
- or
- repair work has been successfully completed.




In both cases, the prerequisite is a WTGS that is ready for operation.

Should any problems occur during start-up of the WTGS, GE Energy must be informed without delay (head of service or remote monitoring division). Afterwards, the switch must be actuated or the WTGS restarted according to their instructions.

2.3.2 Control Elements on the Top Box
(Control Cabinet in the Nacelle)

Stop	Immediate Start	Reset	Reset emergency stop circuit	
				
Yaw off/on	Yaw auto/hand	Yaw left/right	Rotor brake pump on/off	Rotor brake on/off
				
Activate rotor lock	Rotor lock off	Rotor lock on	Rotor lock bypass	Emergency stop circuit bypass
				
Generator fan on/off	Light hub off/on	Emergency stop	Optional	
			remote control device	

Fig. 2: Layout of control elements on the top box

Designation	Control Element	Function
Stop 	Red push-button	The wind turbine generator system is braked and stopped.
Immediate Start 	Green push-button	The wind turbine generator system starts automatically, if it was stopped with the Stop push-button and no faults are present.
Reset 	Blue push-button	Fault reset if wind turbine generator system has been stopped.

Designation	Control Element	Function
Reset emergency stop circuit 	Blue push-button	Resets emergency stop circuit.
Yaw on/off 	Two-position switch	Locks the yaw drive in the "off" position. Releases the automatic orientation drive in the "on" position.
Yaw auto/hand 	Two-position switch	Selects automatic or manual yaw drive.
Yaw left/right 	Two-position switch	Activates yaw drive to move left or right if switch "Auto/Manual" is set to manual.
Rotor brake pump on/off 	Two-position switch	Blocks pump in position. "Off".
Rotor brake on/off 	Two-position switch	Brake is not engaged in "Off" position. Used for positioning of rotor.
Activate rotor lock 	Rotary switch knob with withdrawable key that is used as rotary knob	Activates pump for rotor locking.
Rotor lock off 	Black push-button	The rotor lock is disengaged.

Designation	Control Element	Function
Rotor lock on 	Black push-button	The rotor lock is engaged.
Rotor lock bypass 	Rotary switch knob with withdrawable key that is used as rotary knob	Prevents activation of safety circuit when inserting the rotor lock in Pos I.
Emergency stop circuit bypass 	Black push-button	For use with the Remote Control Device for bridging the emergency stop circuit and preventing the accidental activation of the EMERGENCY-STOP function.
Generator fan on/off 	Two-position switch	Shuts off generator fans.
Light hub off/on 	Two-position switch	Switches light in hub.
Emergency stop 	Red mushroom button	Initiates an emergency shutdown.

2.3.3 Control Elements on the Blade Pitch Control Cabinets in the Hub

Emergency stop	Main switch	Battery switch
		

Fig. 3: Layout of the control elements in the control cabinet in the hub

Designation	Control element	Function
Emergency stop 	Red mushroom button	Initiates an emergency shutdown.
Manual/Auto Selector Switch 	Two-position switch	Switches between automatic and manual pitch operating mode.
Axis 1, 2, 3 Selector Switch 	Three-position switch	Selects the axis to be controlled by the EPalm handheld when in manual operating mode.
Emergency Stop Circuit Bypass 	Black push-button	Must be continuously pressed while connecting the EPalm handheld to avoid activating the Emergency-Stop function.
Harting Connector 	Harting connector plug	Port for connecting the EPalm handheld for manual control of the pitch system.
Main switch 	Two-position switch	Switches off mains voltage of axis cabinet.
Battery switch 	Two-position switch	Switches off battery supply voltage to the axis cabinet.

3 Starting-up the Wind Turbine Generator System

After elimination of a WTGS malfunction, proceed as follows to put the plant into operation again:

1. Actuate the *reset* button.
2. Actuate the *Immediate start* button.

3.1 Plant Control Procedures

3.1.1 Idling, Start-up and Production Mode

In an operational, trouble free state, the WTGS runs in the *idling* operating mode (waiting for wind), also called the *idling position*. The rotor freewheels at a 65 ° pitch angle unbraked and is used to determine the wind speed at the same time.

From a wind speed ≥ 2.5 m/s, the nacelle's orientation is adjusted via the yaw drive to ensure that the WTGS is positioned properly in the wind.

The WTGS start-up is initiated at the wind speeds shown in the **Technical Data** document. In the course of this, the blade angle is adjusted towards 0° in a speed-controlled manner. As soon as the rotor has reached operating speed, the turbine is coupled to the grid.

In addition to this, two controllers intervene in the process:

- In part-load range with wind speeds below the nominal wind speed, generator torque is controlled via the converter. This control is performed to optimize the power output according to a torque-speed characteristic. In the *Load operation* operating mode, the plant works on the grid at variable speed. Once the torque-speed characteristic has reached the nominal speed, the torque is controlled in such a way that the nominal speed is maintained. This control is used until the nominal output is reached.
- For wind speeds above the nominal wind speed, the power output is limited by controlling the rotor blade angle. In this operating range, the converter maintains the generator torque constantly at the nominal value. The generator torque is controlled in such a way that a constant nominal output is delivered. The plant initially reacts to gusts with an acceleration of the rotor. The speed is controlled in turn by adjusting the blade angle to its nominal value.

Increases of the rotor speed up to 10 % are permitted. In the *Load operation* operating state, the plant operates connected to the grid at variable speed and variable blade angle.

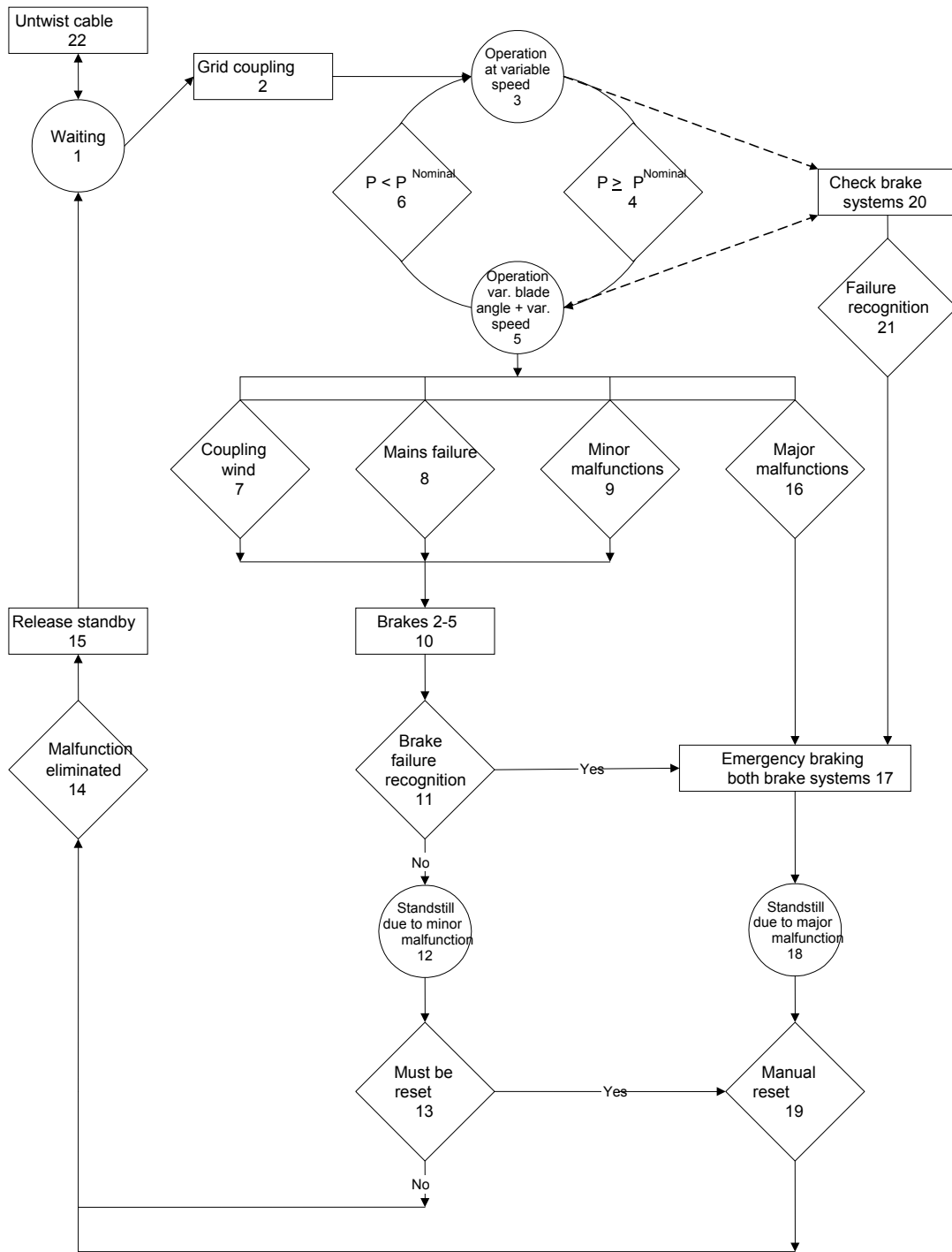


Fig. 4: Plant control procedures

3.1.2 Operational monitoring

Certain operating quantities and parameters are continually monitored by the plant control system (PCS) during operation of the WTGS.

Key features include:

- The functional readiness of blade pitch variation and control systems
- The grid quality
- The current wind speed

Operational or emergency brake procedures are triggered in the following cases:

- Exceeding or falling short of certain limits,
- Detection of errors by the PCS
- Triggering of the safety chain.

3.1.3 Operating Data

For detailed operating data, please see Technical Data document.

3.1.4 Operational Braking/Restart

Operational braking is triggered by the PCS, as soon as one of the two following events occurs:

- The cut-out wind speed is reached.
Please also read the Technical Data document.
- A malfunction is detected.
Depending on potential consequential errors, malfunctions are subdivided into six groups, to which different braking operations are allocated in turn (cf. section 3.1.7.1 Braking processes on page 21).
- The following is monitored during an operational braking process:
- whether blade pitching is carried out at the default pitching speed,
- whether a reduction in output or in speed occurs,
- whether an overspeed occurs.

In the course of this, the PLC opens the safety chain, if

- a malfunction is detected,
- the speed does not decrease consistently when the pitch angle is changed (pitching back),
- the speed exceeds 1.15 times the nominal speed.

After a malfunction of groups 2 to 7 (cf. section 3.1.7.1 Braking processes on page 21) with properly completed operational braking, the WTGS is in the *Standby with max. pitch* operating mode with braked rotor and a blade angle of 89 °.

If an error occurs, a message is transmitted via modem. If the malfunction has been resolved and if the type of malfunction permits a release, the WTGS is put into operational readiness once more after a start delay. This start delay is a fixed default in the PLC.

If the malfunction repeatedly occurs within a pre-specified period of time, the WTGS is put into the *Standby with locked start* operating mode, i.e. it is locked for a restart. The safety chain is not interrupted during this process, so that the service office is able to put the WTGS back into operation for diagnostic purposes.

If the PCS has released the WTGS for operation and if the wind speed is less than 25 m/s, the rotor blades are moved into the waiting position (idling, 65 ° pitch angle). At wind speeds between 3 m/s and 25 m/s, the WTGS is started up again and coupled to the grid.

Extreme Wind Shutdown

If the average wind speed exceeds the following values an extreme wind shutdown of the WTGS is carried out.

Cut-out wind speed	2.5-2.75
3 s average	34 m/s
30 s average	30 m/s
600 s average	25 m/s

Table 1: Shutdown wind speed

In the course of this, the WTGS moves the rotor blades in a controlled manner to 89 ° by means of an operational braking process.

3.1.5 Triggering the Safety Chain

If the safety chain is triggered, an emergency braking operation is performed, which brings the rotor to a standstill as quickly as possible, independent of the PCS. In the course of this, the rotor blades are moved to the ultimate position of 89 ° (feathering position), while the disk brake is activated simultaneously and the plant disconnected from the grid by opening the circuit breaker.

At the same time, the generator is disconnected from the grid. This is to avoid the generator torque value adding to the brake system torque value during the emergency braking operation at nominal output. This prevents both torques values from acting together to stress the rotor and gearbox.

Once the safety chain has been triggered, it is no longer possible to start the WTGS via the remote monitoring system. Before a restart is possible, the error must be reset onsite by trained staff. The yaw drive remains active, unless this system itself is defective or the safety chain has been opened through actuation of an emergency stop push-button.

3.1.6 Grid failure

In the case of a grid failure, all three pitch motors are immediately switched over to battery voltage.

All three rotor blades are moved independent of each other in the direction of the feathering position. Shortly before reaching the feathering position, the position switch (positive disconnecting break contact) on each of the blades switches off the battery voltage. The switching point has been selected in such a way that every rotor blade will come to a standstill exactly in the feathering position. At the same time, the integrated motor brakes are activated.

The electro-mechanical equipment has been selected so that this operation will work even under extremely unfavorable operating and ambient conditions. This applies in particular to the switching reaction time, the capacity (number of ampere-hours) of the battery packs and the stopping torque of the integrated motor brakes in the feathering position.

The safety chain is not interrupted by a mains failure. Except for the evaluating relay for rotor speed monitoring, all switches of the safety chain are triggered mechanically. During the mains failure, the rotor speed monitoring system is also supplied by the **UPS** (uninterruptible power supply), so that it only interrupts the safety chain in the case of over speed.

3.1.7 Brake test

During every braking operation, both the blade pitching operation and the disk brake are automatically checked for their effectiveness. In addition to this, automatic activation of the brakes for test purposes is performed at certain intervals if a braking operation has not been carried out for any reason within this period of time. The intervals have been defined in the PCS and cannot be changed by the operator of the WTGS.

The blade-pitching test and the test of the battery storage device are carried out every 168 part-load operating hours, and the disk brake test every 1400 hours.

While the plant is at a standstill, rotor blade pitching via the battery storage devices is tested. For this test, the accumulators are connected to the pitch motors as is the case when the safety chain is triggered. Both the pitching speed and the time required to attain the ultimate position are checked.

During the disk brake test, the braking time actually required at the current wind speed is compared to the specified braking time. Exceeding the maximum permissible braking time triggers the status message *Excessive secondary braking time*, resulting in the safety chain being interrupted.

In addition to this, the time between activation of the brake and the time at which the generator is motor-driven is monitored during the operational braking process (rotor blade pitching). If the specified permissible limit is exceeded in the course of this process, the error *Brake failure* is also triggered and the safety chain interrupted.

During operation of the WTGS at nominal output, the blade pitching system is constantly active (output control). In this manner, possible irregularities are detected immediately and the turbine is shut down.

3.1.7.1 Braking processes

Braking process	Aerodynamically	Electrically	Mechanically	Safety chain	Emergency stop circuit
0	Warning only, no shut-down			Applied	
1	Not applicable				
2	Speed control	Speed-dependent torque demand	The rotor brake is only applied at low speeds or to bring blades into feathering position in case of manual/remote stop or gearbox malfunctions (first soft braking process, then hard with a 10s delay)	Applied	
3	Controlled rotor blade pitching	Torque demand = 0	As 2	Applied	
4	Controlled rotor blade pitching	Speed-dependent torque demand for speeds > P3.4 + 100 rpm	As 2	Applied	
5	Uncontrolled rotor blade pitching	Speed-dependent torque demand for speeds > P3.4 + 100 rpm	As 2	Applied	
6.1	Controlled rotor blade pitching	Deceleration dependant torque demand	Immediate activation of the rotor brake with smart brake system. Brake releases after turbine stop if no remote stop has been initiated or gearbox malfunction is monitored.	Applied	
6.2	Uncontrolled rotor blade pitching	Deceleration dependant torque demand	Immediate activation of the rotor brake with smart brake system. Brake releases after turbine stop if no remote stop has been initiated or gearbox malfunction is monitored.	Released	Applied
6.3	Uncontrolled rotor blade pitching	Torque demand = 0	Immediate activation of rotor brake (hard braking process), brake releases again if no manual/remote stop or gearbox malfunctions have occurred	Released	Applied
7	At speed < 100 rpm rotor blade pitching	Torque demand = 0	Braking test: Application of the disk brake (hard braking) at P = 500kW without simultaneous blade adjustment	Applied	

Table 2: Braking processes

3.1.8 Medium Voltage Switchgear Operation

The SF6 pressure indicator should be checked every time the turbine is entered. If it is found to be below the safe operating limit, the switchgear should not be switched off. Under this circumstance, the incoming feeder shall be de-energized prior to attempting switchgear operation. The switchgear must be inspected and repaired as necessary prior to returning to service.

3.1.9 Ice Detection

Authorities may require the wind turbine not to be operated if ice is detected on the rotor blades.

In case of ice detection the turbine controller disconnects the wind turbine generator system from the grid and the rotor is brought to a standstill or rotates at a very low speed. A message is sent to the service station and the operator. The turbine does not restart until the rotor blades are detected to be free of ice or the operator has satisfied himself of the ice-free condition of the rotor blades, has acknowledged the ice alarm message and restarts the plant.

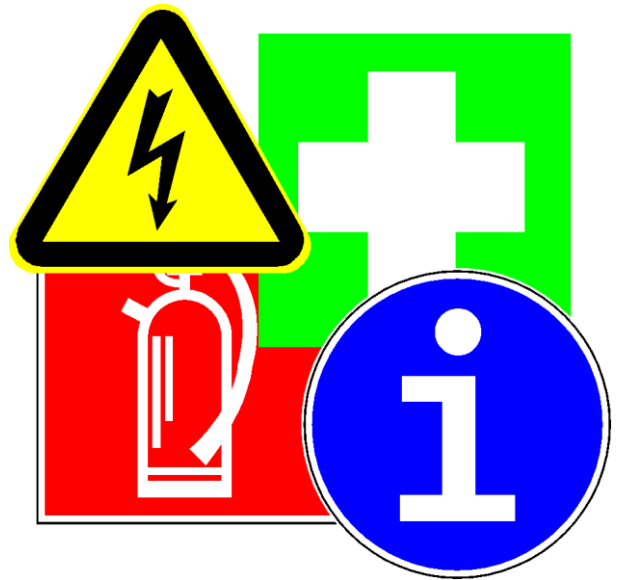
3.1.10 High Temperature / High Altitude Operation

The 3MW Platform wind turbine generator operates at high temperature and or high altitude per a control scheme where components and ambient air temperatures are monitored to ensure the wind turbine does not exceed a maximum operating temperature. If at any time, a wind turbine component temperature rises to an unacceptable level, the turbine will begin to curtail the power output to reduce overall wind turbine component temperatures. At the same time, the power output will be curtailed, a warning will be set and an energy loss counter will begin. The wind turbine components that are monitored include: main bearing, gearbox oil sump, gearbox bearings, generator bearings, generator windings, nacelle, transformer and converter control unit. If any of these units exceed the maximum derating temperature, the turbine will start to curtail power in the wind turbine generator. The intent of this control scheme is to avoid a complete shutdown of the wind turbine and prevent a 0 kW output occurrence. If the power output curtailment does not reduce the temperature, the wind turbine will trip as soon a maximum temperature event occurs.

Technical Documentation

Wind Turbine Generator Systems

3MW Platform - 50/60 Hz



Safety Manual



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1 Basic Information on the Technical Documentation for Wind Turbine Generator Systems

This Safety Manual is a constituent part of the technical documentation for wind turbine generator systems. In the case of offshore plants, the supplementary safety information for offshore plants is also to be considered.

The safety manual must be read and understood by the operating and maintenance personnel and the owner, in order to guarantee safety in and on the wind turbine generator system and to prevent accidents and personal injuries.

In addition to the safety manual, the respective specific safety information in the technical documentation, in which e.g. installation or maintenance is described, must always be read.

The basic rules of conduct for safe working in and on the WTGS are described in this Safety Manual.

Any unclear points in the technical documentation which may jeopardize the correct performance of work in or on the WTGS must first of all be clarified. Contact GE Renewable Energy for advice if necessary.

In addition to the safety manual, the local safety and accident prevention regulations must be complied with to ensure the safety of personnel.

1.1 Explanation of Abbreviations

ANSI	American National Standards Institute
BTP	Build to print
CAE	Converter AC Entry Cabinet
CBC	Converter Bridge Cabinet
CCC	Converter Control Cabinet
CDF	Converter Distortion Filter Cabinet
CHX	Converter Heat Exchanger Cabinet
CIC	Converter Inductor Cabinet
CSA	Canadian Standards Association
DFIG	Doubly-fed Induction Generator
DIN	Deutsche Industrienorm (German Industry Standard)
EHS	Environment, Health and Safety
HSS	High Speed Shaft
LSS	Low Speed Shaft

MCC	Main Control Cabinet
MCPD	Main Control & Power Distribution Cabinet
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Agency
PDP	Power Distribution Panel
PMG	Permanent Magnet Generator
PPE	Personal Protective Equipment
PPM	Pre-Assembled Power Module
TPIC	Thread Power Interface Cabinet
USV	Uninterruptible Power Supply
VDE	Verband deutscher Elektrotechniker (German Association of Electricians)
WTGS	Wind Turbine Generator System
SFT	Space Frame Tower

2 General Safety Principles

The Wind Turbine Generator System (WTGS) has been built according to the state-of-the-art and the recognized safety rules.

Hazards for the user or third parties and impairment of the wind turbine generator system and other property may nevertheless arise during the use of this facility if it is

- operated by untrained or uninstructed staff
- not used properly
- improperly maintained or serviced

The owner / operator responsible for the WTGS must ensure that

- The safety manual and the operating manual are available and are complied with
- The service conditions and technical data are complied with
- The protective devices are used
- The prescribed maintenance work is carried out
- The maintenance personnel is immediately informed or the plant immediately shut down if higher temperatures, noise, vibration, etc. compared to operation at normal rating should occur.

The operating manual contains the information required for operation of the WTGS by qualified personnel.

The warranty of the manufacturer is only provided if the currently valid operating manual is observed and complied with.



Note!

Take precautions against malfunctions and thereby prevent personal injury or death and material damage!

2.1 Personnel Groups

Different personnel groups are specified for carrying out the various tasks in and on the WTGS. Before work is started, it must be ensured that the personnel in question have the requisite qualifications to carry out the respective tasks. If necessary, suitable training or qualification measures are required, or other personnel with a suitable qualification carry out the work.

2.1.1 Qualified Persons

Work on electrical equipment and machinery may only be carried out by qualified persons who are familiar with the currently applicable safety and installation regulations. The qualified persons must be authorized to carry out the requisite tasks by the person responsible for safety in the WTGS under the health and safety regulations. A qualified person is a person who

- has appropriate training and experience
- is familiar with the currently applicable standards, regulations and accident prevention regulations and generally recognized code of practice
- has been instructed in the operating principle and service conditions of electrical and mechanical drive systems and
- can recognize and avoid dangers



Unqualified persons may not be deployed!

Note!

2.1.2 Technically Competent Persons

Technically competent persons are persons who have the requisite technical knowledge for the inspection of work equipment as a result of their professional training, their professional experience and their current professional activity.

2.1.3 Experienced Persons

An experienced person is someone who, on the basis of his technical training and experience, has gained adequate knowledge in the particular field of the equipment/device to be tested and who is acquainted with the pertinent national industrial safety legislation, the regulations for the prevention of accidents, directives and generally accepted engineering standards (DIN standards, VDE regulations, technical rules of other member states of the European Union or other contracting states of the agreement concerning the European Economic Area as well as OSHA/ANSI/NFPA/CSA standards and regulations for North America) to the extent that he is able to assess the safe working order of the equipment/device concerned.

2.1.4 Experts

Experts are persons who are familiar with the relevant industrial safety regulations, directives and generally recognized code of practice and can verify and authoritatively assess the presence of threats and dangers.

2.2 Proper Use

The Wind Turbine Generator Systems are intended solely for the generation of electrical power by means of wind energy.

Any other use or use extending beyond this is deemed to be improper. The operator / owner of the WTGS bears the sole responsibility for any damage resulting there from.

The same also applies to any unauthorized modifications made to the WTGS. As a general principle, modifications to the WTGS may be carried out only after consultation with GE Renewable Energy, in order to guarantee the safety and the correct functioning of the WTGS.

Proper use also includes compliance with the information on

- Safety
- Operation
- Service and maintenance

provided in the technical documentation of the WTGS.

2.3 General Information

The wind turbine generator system may only be used in a technically perfect condition in line with the technical documentation. In addition, it must be used as intended, as well as with safety in mind and with an awareness of the dangers. Any malfunctions, particularly those that could impair safety, must be reported and remedied immediately.

Anybody who has been authorized to carry out erection, commissioning, operation or maintenance work must have read and understood the complete O&M Manual, in particular the Safety Manual.

It is too late to read the manual while carrying out the work. This applies especially to personnel who are only occasionally deployed on the wind turbine generator system.

The O&M Manual must be readily available at the site of operation of the wind turbine generator system at all times. It is kept in the main cabinet of the WTGS.

The relevant regulations for the prevention of accidents (see "Information for the Operator" in "Basic information regarding the operating instructions manual") and any other generally recognized safety and industrial health regulations must also be complied with.

We cannot be held liable for any damages or accidents as a result of non-compliance with the operating instructions, the relevant regulations for the prevention of accidents and any other generally recognized safety and industrial health regulations.

Responsibilities for the different activities within the framework of operation, service and maintenance of the WTGS must be clearly defined and complied with. This is the only way to prevent mistakes, particularly in dangerous situations.

The instructions for

- Shutting down the WTGS
- Maintenance work
- Handling the rotor lock
- Confined space entry (e.g. entering the rotor hub, entering the transformer level)

must be followed during the inspection, maintenance and repair of the wind turbine generator system and the safety devices.

3 Marks, Signs and Symbols

3.1 Danger Classifications and Symbols

The following danger classifications and symbols are used in the technical documentation of the wind turbine generator systems:



Danger!

Exact description of the danger!

Indicates an imminent threatening danger resulting in death or serious injury.



Warning!

Exact description of the danger!

Indicates a potentially hazardous situation that may result in death or serious injury if the dangerous situation is not avoided.



Caution!

Exact description of the danger!

Indicates a potentially hazardous situation that may result in slight or minor injury if the dangerous situation is not avoided.



Attention!

Exact description of the danger!

Indicates a potentially hazardous situation that may result in damage to the WTGS or surrounding area if the dangerous situation is not avoided.



Note!

Notes include user tips and useful information.

The notes should be read in the interests of proper use as well as with regard to proper operation and maintenance of the WTGS.

All notices and symbols directly attached to the WTGS, such as safety signs, operating notices, rotation arrows, component identification markings, etc., must be observed without fail. They may not be removed and must be maintained in a fully legible condition.

3.2 Marks and Signs attached by GE Renewable Energy

The personnel in the WTGS must be able to check certain data at all times, in order to ensure safe operation of the WTGS. The following information must therefore be clearly visible and permanently attached:

1. Marks for identification of the device
2. Characteristic values by means of which the permissible limits for safe use are specified, e.g. permissible load, rotational speed, pressure

In addition, information about the prescribed use and about possible dangers, which could arise when handling a device, must be provided.

Safety marks could be texts, signs, signals, pictographs and colors. All texts are to be in two languages, i.e. English and the respective national language. Pictographs must be easy to understand and self-explanatory.

The signs are made of durable materials with stable colors.

The instructions on the safety signs and marks must be followed.

3.3 Signs to be attached by the Operator/Owner

The operator/owner of the WTGS is obliged to attach additional warning signs to the WTGS. These are intended to cover safety aspects which are not related to the scope of supply of the manufacturer of the WTGS.

The warning signs must state that

- It is dangerous and prohibited for unauthorized persons to enter or climb the WTGS
- It is prohibited to remain in the vicinity of the WTGS while work is being carried out outside the nacelle
- Deposits of ice which have formed on the rotor blades (depending on the location of the WTGS) could drop off (cf. Chapter 7.4.1 on page 38)

The operator/owner is responsible for seeing that any components or plant components, which he has supplied, are properly equipped with signs.

4 Information for the Operator/Owner of the Wind Turbine Generator System

The operator of the WTGS is responsible for ensuring that unauthorized persons remain outside of the WTGS. The WTGS must be kept locked to prevent this.

The wind turbine generator system may only be started up if it has been completely assembled and is in working order.

The wind turbine generator system may only be operated if all safety equipment and safety-relevant devices, e.g. detachable protective equipment, are in place and operational.

If any malfunctions occur, the wind turbine generator system must be shut down immediately and secured. Malfunctions are to be remedied without delay by trained technical personnel.

In the case of malfunctions, which are not automatically reset by the control system of the WTGS, GE Renewable Energy must be contacted before a restart is carried out, in order to confirm that the WTGS may be placed in the automatic operating mode (i.e. whether the WTGS may be restarted).

GE Renewable Energy advises the plant operator/owner to develop specific procedures for the power disconnection and energy isolation for all mechanical, electrical and hydraulic energy sources. Local and national regulations must be taken into account when developing such workplace-specific Lockout/Tagout instructions (also cf. Chapter 12 on page 74).

Follow the switch-on and shutdown procedures and take note of the visual and monitoring displays in accordance with the operating manual!

In addition to this, the operator/owner of the WTGS must comply with the following additional safety instructions (if maintenance is not carried out by GE Renewable Energy employees):

- If the WTGS is not directly connected to the public telephone system, the maintenance personnel must have a cellphone or a radio with them when ascending the tower.
- The personnel must be informed about who to contact in an emergency. (Telephone numbers of a rescue center, police, fire department...)
- The WTGS may only be entered when a second person is available to provide assistance or call for help in the case of an accident.
- Special authorization from GE Renewable Energy is required to carry out inspection and maintenance work inside a WTGS while it is in operation.
- The personnel must be instructed to keep the WTGS escape routes clear at all times when carrying out work as a part of maintenance or operation.
- In the case of work involving a fire hazard, the personnel must have a fire extinguisher (optional feature) ready at hand, in order to be able to immediately extinguish any fire which may start (cf. Chapter 11.1 on page 72).

- Personnel are not permitted to remain at a higher level in the WTGS while work involving a fire hazard is being carried out.
- Personnel instructed to carry out work in or on the WTGS must be provided with instructions and the appropriate personal protective equipment (PPE).
- If the WTGS is part of a wind farm and connected to a wind power plant, this safety manual must be supplemented in cooperation with the local power supply company, so that it also:
 - o describes the safety aspects relevant to the wind farm
 - o describes the exchange of information and names the persons who are to be contacted
 - o describes access to basic first aid facilities

5 Safety Equipment

The safety equipment serves to reduce risks and dangers. You will find further information on equipment and items, which are subject to inspection in the annex of this safety manual.

5.1 Personal Protective Equipment

Everybody must wear Personal Protective Equipment (PPE) when working on or in the WTGS to protect themselves from injury.



Danger of accident!

Never enter or climb the WTGS without the personal protective equipment. Otherwise there is danger of injury and falling.

The PPE is especially required for climbing the tower. It comprises:

- Safety harness, slider hook/wire grab fall arrestor
- Y-shape double lanyard with fall absorber
- Suspension trauma straps
- Hard hat
- Safety boots
- Gloves
- Safety glasses
- Hearing protection (if required)
- Respirator (if required)
- Fire rated clothing (as required for electrical work)

The PPE must be of an approved type, and for North America must be compliant with applicable CSA, OSHA and ANSI standards, whereas for the European Economic Area it must bear CE marks of conformity stating that it is suitable for the work and protection involved and that it is also suitable for the climatic conditions at the location of the WTGS. The extent and the equipment of the personal protective equipment may vary in some countries.

The safety harnesses and slider hooks/wire grab fall arrestors must be properly stored and must be accessible.

If several persons ascend the tower simultaneously, personal protective equipment must be available for the respective number of persons.



Note!

Check the completeness, the condition and the function of your personal protective equipment in good time before entering the WTGS. If a piece of the equipment is missing, it must be replaced before starting work.

The safety harness and the entire safety equipment must be checked before use. Damaged equipment must never be used.

The PPE must be inspected and tested by a technically competent person after any fall, or at the intervals recommended by the manufacturer at least.



Note!

Follow the manufacturer's directions for use for all component parts of the personal protective equipment!

The ladder, fall arrest system and tie-off must be inspected at the intervals recommended by the manufacturer. After a fall, the affected ladder, fall arrest system, or tie off must be inspected for damage by a technically competent person.

1. **Inspect the ladders, brackets, and clamp brackets for any bending, slipping, or twisting.**
2. **In particular, inspect the ladder rungs for rubbing marks from the fall arrest cable.**



Figure 1: Ladder champs

3. **Replace any damaged ladder sections, brackets, or hardware.**

A – Ladder bracket

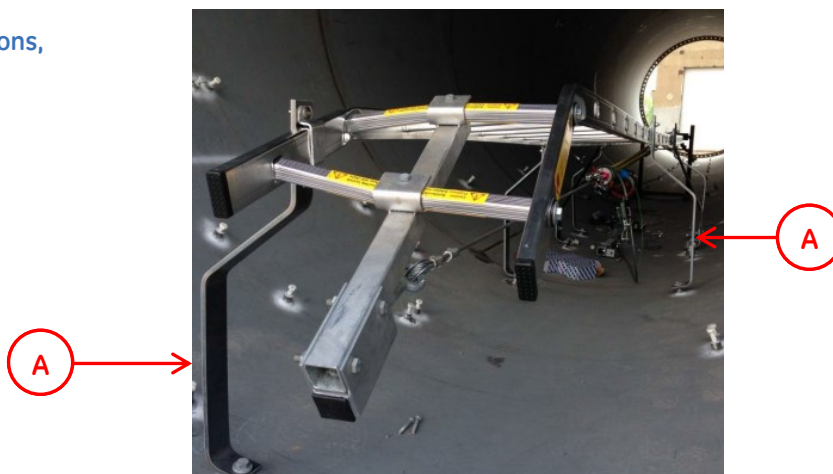


Figure 2: Ladder brackets

4. Inspect the entire fall arrest system. Any bent part, frayed cable, or spacers need to be replaced.

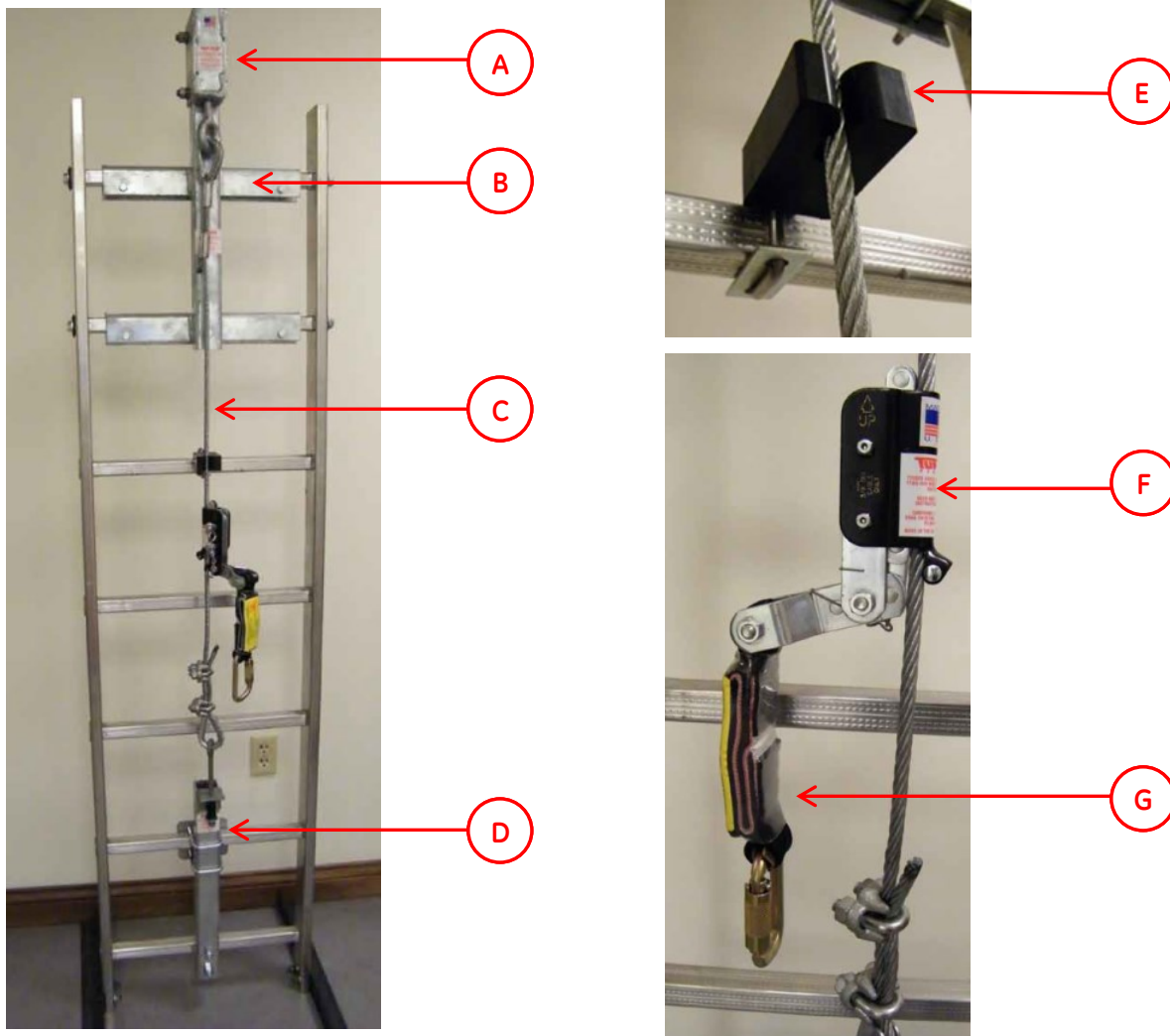


Figure 3: Fall arrest components

- A – Head end of fall arrest system
- B – Ladder rung cover connections
- C - Cable
- D – Base of fall arrest system

- E – Cable Spacer
- F – Slider
- G - Lanyard

- 5. Replace all tie off rings that have experienced a load during the fall along with attaching.

A – Bushing
 B – Tie off ring

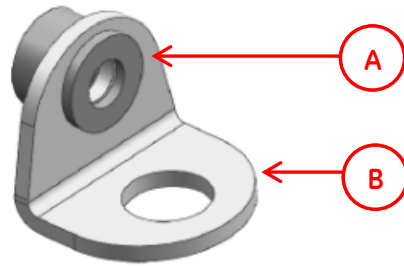


Figure 4: Tie off

- 6. Inspect and check all tie off bosses for possible weld cracking. Further, inspect the internal threads to assure that they have not been compromised and that new hardware can be threaded back in easily.

C – Welded boss



Figure 5: Welded boss

5.1.1 Safety Harness

Safety harness and the complete safety equipment

needs to be approved by EHS.

Never expose to acids/caustic chemicals. If this is unavoidable, rinse with water immediately afterwards.

Protect from sharp edges and sharp-edged objects.

Wash according to manufacturers recommendations. Afterwards dry in the shade.

Store in a well-aired place out of direct sunlight.



Attention!

The safety harness is used to protect personnel during the ascent to the nacelle of the WTGS, during the descent from the nacelle of the WTGS and, in combination with a lanyard (safety rope) and a fall arrest block, when carrying out work in areas where is a danger of falling.

The safety harnesses and the entire safety equipment must be cleaned, cared for, maintained and stored in accordance with the manufacturer's instructions.

Follow the manufacturer's instructions when putting on the safety harnesses.

5.1.2 Wire Grab Fall Arrestor

When the WTGS is provided with a wire rope fall arrest system, two wire grab fall arrestors (optional feature) should be stored together with the safety harness (optional feature).

The manufacturer's instructions for use of the wire grab fall arrestor are to be followed.

In combination with the safety harness, the wire grab fall arrestor is a safety device for ascending/descending the tower via the ladder. Should somebody slip off the ladder, the wire grab fall arrestor clamps on tightly on the safety wire rope and prevents a fall. The system consists of a wire rope, fastening elements and a travelling arrestor device. A steady straight-line ascent and descent of the ladder without the user leaning back in the harness is the best way to ensure that the wire grab fall arrestor runs freely.



Warning!

Beware of hand injuries!

A free running wire grab fall arrestor can crush your hands if you grasp the device or the safety rail.

Keep your hands on the sides of the ladder during the ascent/descent.

Using the Wire Grab Fall Arrestor

1. Insert the wire grab fall arrestor and the shock pack assembly into the D-ring (or retaining eyes) of the safety harness. Only the retaining eye at chest level is allowed to be used.
2. Push the wire grab fall arrestor into the wire rope attached to the ladder. The "up" marking intends the installation direction and NOT the travel direction.
3. Ascend and descend the ladder slowly and carefully.
4. Ensure to be in contact with the ladder on at least 3 points at all times.



Fig. 6: Usage of the wire grab fall arrestor (example)

5.1.3 Slider Hook

When the WTGS is provided with a safety rail fall arrest system, two slider hooks are stored together with the safety harness.

The manufacturer's instructions for use of the slider hook are to be followed.

In combination with the safety harness, the slider hook is a safety device for ascending/descending the tower via the ladder. Should somebody slip off the ladder, the slider hook clamps on tightly to the safety rail and prevents a fall. The system consists of a fixed guide, fastening elements, and a travelling arrestor device. A steady straight-line ascent and descent of the ladder without the user leaning back in the harness is the best way to ensure that the slider hook runs freely.



Warning!

Beware of hand injuries!

A free running slider hook can crush your hands if you grasp the device or the safety rail.

Keep your hands on the sides of the ladder during the ascent/descent.

Using the Slider Hook

1. Insert the slider hook into the retaining eyes of the safety harness. Only the retaining eye at chest level is allowed to be used.
2. Push the slider hook into the guide rail mounted on the ladder. The "up" marking intends the installation direction and NOT the travel direction.
3. Ascend and descend the ladder slowly and carefully.
4. Ensure to be in contact with the ladder on at least 3 points at all times.

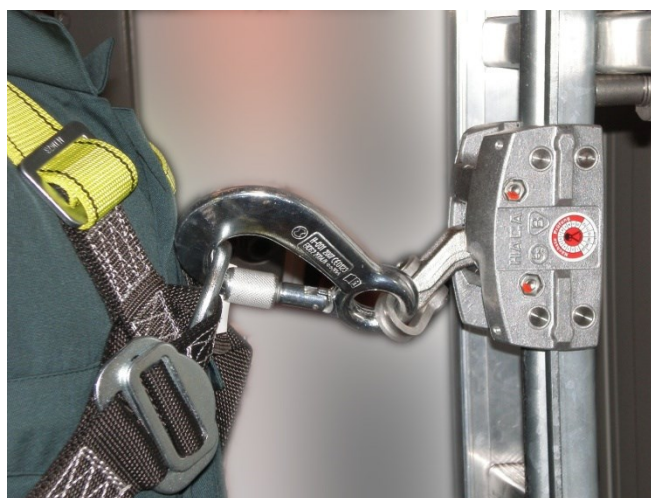


Fig. 7: Usage of the slider hook (example)

5.2 Protective Equipment for Measurements on Live Components



Danger!

Danger! Electricity!

Contact can cause extremely serious injuries and even death.

Life-threatening hazard!

Access to an energized cabinet is only allowed in the following cases:

1. Visual inspection
2. Circuit breaker switching
3. Circuit metering with a Cat III 1,000 V rated meter

Special PPE is required for measurements on live components. This provides protection against electricity flowing through the body, e.g. as a result of touching live components in operation. Furthermore, it provides protection against accidental arcs caused by insulation breakdowns e.g. as a result of switching operations under load.

Refer to the National Fire Protection Association (NFPA) 70E document (GE standard) for further guidance.

5.2.1 PDP – Power Distribution Panel

Special protective equipment is mandatory for the following turbine components. There are four doors in the PDP with the following required PPE levels:

Danger Class		Door Section
Converter On-line	Converter Off-line	
NO ACCESS AREA	3	PDP-1, top left front section (supply - filter), access only with personal protective equipment 2
NO ACCESS AREA	3	PDP-2, bottom left front section (TVSS), no access under voltage.
NO ACCESS AREA	3	PDP-3, right-hand front section (incoming busbar trunking and main switch), no access under voltage
0	0	AUX.PANEL; right-hand side of the cabinet (section of the fuse 690V/400V), access only with personal protective equipment 0

Table 1: Protective equipment for the PDP

5.2.2 Converter and TPIC

As a general principle, the converter and TPIC must be completely de-energized before commencing work. The access doors to the protective motor switches are an exception to this.

Danger Class	Door Section
2	TPIC Access doors – protective motor switches, access only with personal protective equipment 2 (Gen0 Only)
0	Thread Cabinet (PMG Only)
0	Converter Master Control Cabinet (PMG Only)
0	CCC - Converter Control Cabinet (DFIG Only)
0	CDF - Converter Distortion Filter Cabinet (DFIG Only)
0	CBC - Converter Bridge Cabinet (DFIG Only)
0	CIC - Converter Inductor Cabinet (DFIG Only)
0	CAE - Converter AC Entry Cabinet (DFIG Only)
N/A	CHX - Converter Heat Exchanger Cabinet (DFIG Only) - No electrical components.

Table 2: Protective equipment for the converter and the TPIC

5.3 Hooking Points

All hooking points must be tested, certified and marked in yellow. In addition to that, they are labeled with a statement of the permissible safe working load, if they can be used for lifting purposes as well, like for example the swinging gallow in the nacelle.

These hooking points must be used in conjunction with a safety harness and a lanyard with a fall absorber for protection in areas where there is a danger of falling.

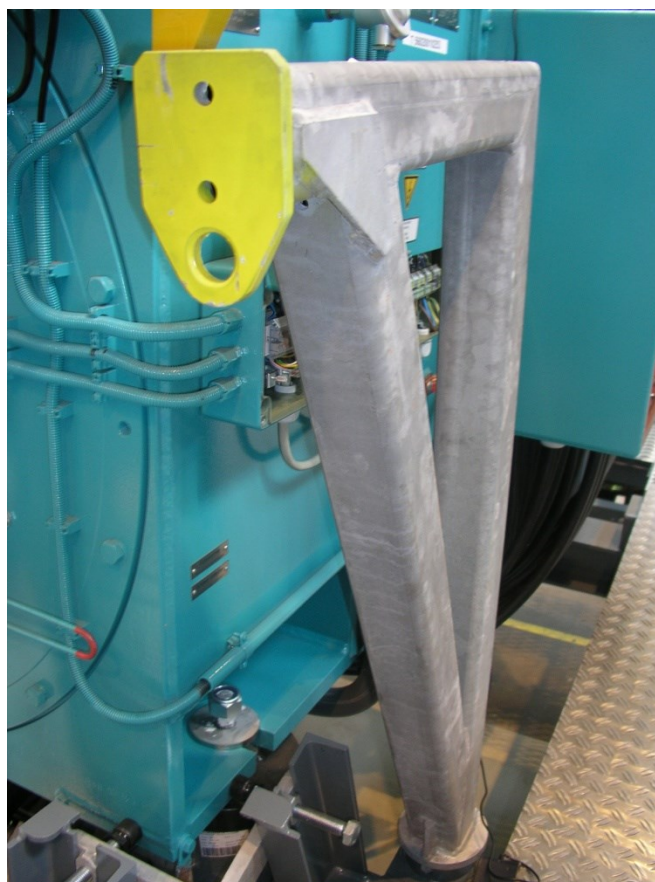


Fig. 8: Hooking point on the swinging gallows

5.4 Abseiling Device

As a rule, the WTGS is provided with an abseiling device (e.g. abseiling device AG 10 K – RK Sicherheitstechnik). The abseiling device has a rope that is long enough for the respective height of the tower of the WTGS.

The fixture for the abseiling device needs to be placed in the front of the nacelle close to the hatch.

As a result a person standing on the nacelle roof can easily reach for the equipment bag containing the abseiling device.



Fig. 9: Equipment bag

The abseiling device is used by the personnel to abseil from high workplaces. It is not a fall arresting device, instead it is used primarily for the self-evacuation of personnel in the event of an accident or fire. In case of fire, it can be used to abseil from the roof of the nacelle of the WTGS as a 2nd escape route.

As a rule, the hooking points for the abseiling device are marked in yellow and are designated with a statement of the permissible safe workload. The abseiling device is attached to the hooking point by means of a snap hook or to the roof rail by means of a sling rope and a snap hook.

Danger of accident with a defective abseiling device!

In an emergency, your life could depend on the abseiling device working properly!



Attention!

Therefore, check the integrity of the seal of the equipment bag on each visit to the nacelle.

The abseiling device is pre-assembled and is ready for use immediately after it has been removed from the equipment bag.

Carry out an additional visual inspection of the abseiling device immediately before use.



It is easy to operate the abseiling device incorrectly in emergency situations. Therefore, ensure that you know how to operate the device and are familiar with the abseiling operation. Please also read the operating manual.

This is the only way to ensure that the correct maneuvers are carried out in an emergency.

5.4.1 Abseiling from the Roof of the Nacelle

Abseiling can take place singly (shuttle system) or in pairs. The abseiling device may be loaded with a maximum of 225 kg up to a rope pitch with a length which is adequate to the relevant tower height. Abseiling takes place at a speed of 0.7 m/s. The abseiling speed is regulated by means of a centrifugal brake.

A typical abseiling operation is described in the following. The procedure described may vary depending on the abseiling device. As a general principle, always follow the instructions of the manufacturer of the respective abseiling device!

1. Make sure your safety harness is on correctly.
2. Secure yourself against falling by means of the lanyard. Attach the lanyard on the nacelle rail/ nacelle tie off points.
3. Close the roof hatch.
4. Break the lead seal on the equipment bag.
5. Remove the abseiling device from the equipment bag.

Leave the rope in the equipment bag.



Fig. 10: Abseiling device in the equipment bag

6. Attach the abseiling device to the roof rail of the nacelle by means of the sling rope and the snap hook.
7. Secure the snap hook with the clamping nut.
8. Throw down the equipment bag with the rope.
9. Check the condition and the correct functioning of the device.
10. Check the rope for loops and knots.



Fig. 11: Abseiling device



Danger!

Interruption of abseiling through loops or knots!

Loops or knots in the rope prevent abseiling, since the rope cannot run through the abseiling device if it has a knot. As a result, always check the rope carefully!

REMOVE ALL LOOPS AND KNOTS FROM THE ROPE BEFORE YOU START ABSEILING!

11. Hook the snap hook on the short end of the rope into the two textile chest rings of your safety harness.
12. Sit in front of the roof rail on the edge of the nacelle.
13. Ensure that the length of rope between the chest rings of your safety harness and the abseiling device is pulled taut.
14. Release the lanyard attached for your safety.
15. Slowly put your weight on the rope of the abseiling equipment.
After you have let go of the nacelle and the roof rail, you will abseil at a speed of 0.7 m/s.
16. After you have reached the ground, immediately release the snap hook from the chest rings of your safety harness.
17. A second person waiting on the roof can then hook in the snap hook of the end of the rope which is now at the top and abseil as described.
The rope may have to be pulled through until the snap hook arrives at the top.
18. The device must be inspected by a technically competent person after a rescue or an abseiling exercise.

5.4.2 Care and Maintenance of the Abseiling Device

The textile components of the abseiling equipment may only be cleaned by the manufacturer.

If damage to the rope, snap hook or abseiling device is discovered, the escape equipment must be withdrawn from use and inspected by the manufacturer.

Under normal service conditions, a service period of 4-6 years can be assumed for the textile ropes.

The abseiling device must be inspected by a technically competent person or by the manufacturer after a rescue or an abseiling exercise or at the intervals recommended by the manufacturer at the latest.

5.5 Fire Extinguishers (optional feature)

The WTGS can be provided with a fire extinguisher in the tower and in the nacelle.



This sign identifies the locations of the fire extinguishers.



Danger!

Danger: Electricity!

De-energize the installation before using the fire extinguisher.

After actuation of the medium-voltage circuit-breaker, keep a safe distance of at least one meter from the fire when extinguishing!

The fire extinguisher may only be used on electrical installations up to 1000V!



Note!

Ensure that you are familiar with the function and the operation of the fire extinguisher. Only thus can you act quickly and purposefully in emergency situations.

The use of fire extinguishers must be practiced. The personnel deployed in the WTGS must therefore be trained in fire fighting at regular intervals.

A technically competent person in accordance with the national regulations must regularly inspect the fire extinguishers. A record of the check with the date must be permanently affixed to the appliance in an easily visible location. The directions for use (on the fire extinguisher) must be followed before fire-fighting.

Operating principle of the optional fire extinguisher – An example

As a general principle, always follow the instructions of the manufacturer of the respective fire extinguisher.

1. Remove the safety tab (1).
2. Press down the fire-extinguishing button (2).
3. The perforating disk of the CO₂ cylinder (3) is opened and the CO₂ released for charging the tank. The appliance is ready for use.
4. The extinguishing agent, which is under pressure, flows through the riser pipe (4) to the valve armature.
5. After the fire-extinguishing button has been pressed, the extinguishing agent flows through the hose line to the spray fog nozzle (5).
6. The jet of extinguishing agent can be interrupted at any time by releasing the fire-extinguishing button.

(Contents of the fire extinguisher: 5 kg)



Fig. 12: Fire extinguisher – An example

5.6 First Aid

First aid is used for the initial treatment of an accident victim until the arrival of a doctor or until transport to a hospital, in order to avert a life-threatening situation or to prevent secondary injury.



Note!

There is a legal obligation to carry out rescue measures provided that this is possible without considerable self-endangerment.

The plant may never be entered alone, so that a second person can send an emergency call. If the interphone has a landline connection, the emergency call can be made via the interphone. An operational cellphone or radio is to be carried at all times, in order to be able to ensure rapid assistance in an emergency.

Proceed as follows in the case of an accident:

1. **Keep CALM!**
2. **In the case of serious accidents and injuries, notify a rescue center by interphone or cellphone.**
3. **Render first aid immediately.**
4. **Secure the scene of the accident.**
5. **Report all accidents (near-accidents, minor accidents, serious accidents) to your immediate supervisor. Also notify the EHS department of GE Renewable Energy.**



Attention!

Keep access to the WTGS clear!

The access roads to the plant must be kept clear at all times and be negotiable by car, in order to guarantee rapid and problem-free first aid in an emergency.

An (optional) first aid box can be located in the nacelle of the wind turbine generator system for the treatment of minor injuries. Any material removed is to be replaced immediately after use.



This sign identifies the location of the first aid box in the nacelle.

6 Safety Devices

The safety devices of the WTGS comply with the requirements of the standard DIN EN ISO 13857 'Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs'.

The unauthorized removal or the overriding (by-passing) of safety devices is a punishable offence. Any liability claim is invalid in the case of damage.

Any point, at which danger can arise, and all drive units are provided with protective covers, which can only be undone and removed by means of tools. These protective covers may only be removed by qualified staff and only for the performance of service and maintenance or repair work. The protective covers are to be refitted immediately after completion of the work.

The owner / user of the WTGS and the personnel deployed by him for operation, maintenance and repairs bear the responsibility for an accident-free work process.

6.1 Emergency Stop Pushbuttons

Any power-operated work equipment with dangerous movements must have one or - if necessary - several emergency control units for the prevention or reduction of an imminent or arisen danger, by means of which the dangerous movements can be stopped or rendered ineffective in another manner.

The emergency stop pushbuttons are not dependent on electronic logic.

Emergency stop pushbuttons (red mushroom pushbutton on a yellow base) are located on the control cabinet and, if required, on the frequency converter cabinet, the top box in the nacelle and the control cabinet(s) in the hub.



Fig. 13: Emergency stop pushbutton



Note!

The **EMERGENCY STOP** pushbutton may only be pressed in situations, in which the safety of personnel or the WTGS and its components is threatened.

Pressing the emergency stop pushbutton causes the safety chain to open, and the rotor of the WTGS is brought to a standstill via emergency braking. Initiation of the safety chain causes the rotor blades to travel to the feathering position in the [emergency] battery mode! In addition to this, the WTGS is de-energized except for the control and axis battery voltage.

6.2 Rotor Lock

The GE 3 MW Platform plants are equipped with two rotor locks. One at the low speed shaft (LSS) and a second one at the high speed shaft (HSS).

Maintenance work on the drive train during which the high speed shaft or the low speed shaft rotor lock must be engaged may only be carried out at wind speeds (10 min average value) up to

- 100/103 m rotor: 14 m/s
- 120/130/137 m rotor: 12 m/s.

The current wind speed can be read on a service laptop!

Engaging the Rotor Lock



Danger!

FOLLOW YOUR RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!
(also cf. Chapter 4)



Attention!

As a general principle, all personnel who may be affected must be notified before Lockout/Tagout devices are installed and after they have been removed.

Any employees who use the equipment or work in its vicinity must be informed without fail that the plant has been shut down and that the system-specific LOTO procedure has been applied.



Attention!

The wind turbine generator system must be in the "Manual Stop" mode!

6.2.1 Rotor Lock on the High-speed Shaft

The rotor lock on the high-speed shaft is located on the brake disk of the outgoing shaft of the gearbox. It must be engaged during all regular maintenance work on the drive train and for the physical inspection of the rotor hub.

If the turbine is unable to idle after a malfunction, the lock on the high-speed shaft must be engaged. It must be ensured that all three rotor blades are in the feathering position.

Engaging the Rotor Lock on the High-Speed Shaft

1. Manual stop and pitch blades to 85° (feathered)
2. Pull out the spring loaded locking pin of the rotor lock to enable the crank mechanism and advance the rotor lock as far as possible
3. If necessary, briefly actuate/release the "rotor brake" by the switch on the gear box, in order to disengage the brake for a short time, thereby placing the brake disk in a better position.
4. Fully engage the rotor lock until the locking pin locks home again at the lower position.

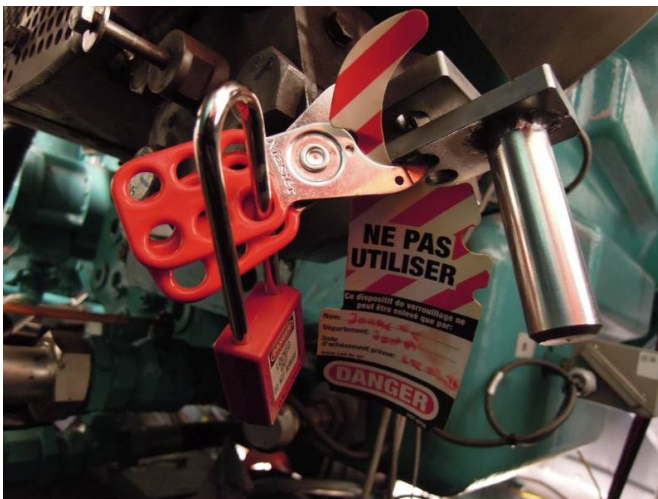


Fig. 14: Securing the HSS rotor lock with LOTO

6.2.2 Rotor Lock on the Low-Speed Shaft (LSS)

The LSS rotor lock mechanism consists of a rotor lock disk with holes attached to the main shaft flange and a lock pin attached to the bedplate upper area. Rotor and drive train motion is prevented by manually (turning the screw in the center of the rotor lock with a wrench counter-clockwise) inserting the lock pin into one of the rotor lock disk holes. The limit switch in the safety loop is opened as a result.

Engaging the Rotor Lock on the Low-speed Shaft

1. Manual stop and pitch blades to 85° (feathered).
2. After the rotor has been braked, check that the mark on the rotor lock disk can be seen at the indicator point in the flag window. Then the rotor lock cylinder is aligned with a bore hole in the rotor lock disk.

It is highly recommended that for the rotor lock alignment one person is located next to the flag window checking the position of the mark on the rotor lock disk while a second person is operating the secondary brake from the Topbox or manually on the secondary brake hydraulic.

3. Move the rotor lock pin towards the rotor lock disk by turning the screw in the center of the rotor lock with a wrench until the pin is half the way in access to the disk.

The safety chain is thereby interrupted at the limit switch in the rotor lock.

4. Operate the secondary brake. Place the switch "rotor brake pump" on the top box in the "off" position or open the responsible valve on the high speed brake hydraulic.

5. Insert the rotor lock all the way into the rotor lock disk by continuing turning the screw.

If necessary, the position of the rotor is corrected by the conical form of the bolt.

6. Operate the secondary brake. Place the switch "rotor brake pump" on the top box in the "on" position or close the responsible valve on the high speed brake hydraulic and raise brake hydraulic pressure manually.

7. Screw the M24 lock screw all the way into the cover of the lock to prevent the pin from working itself out.

The screw is flush-mounted in the catwalk board on the rotor lock.

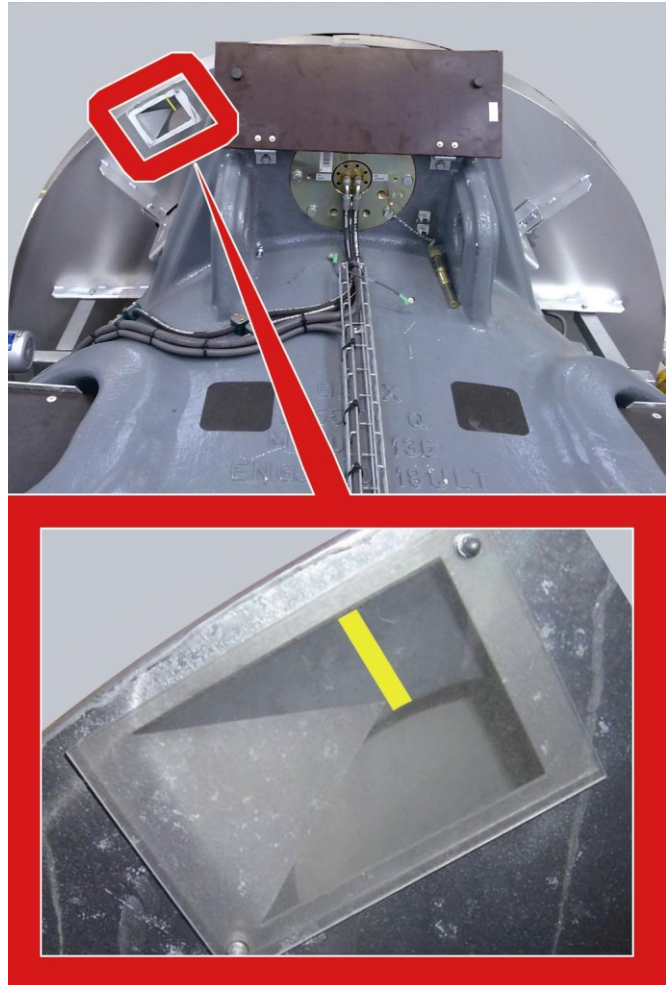


Fig. 15: Checking the alignment

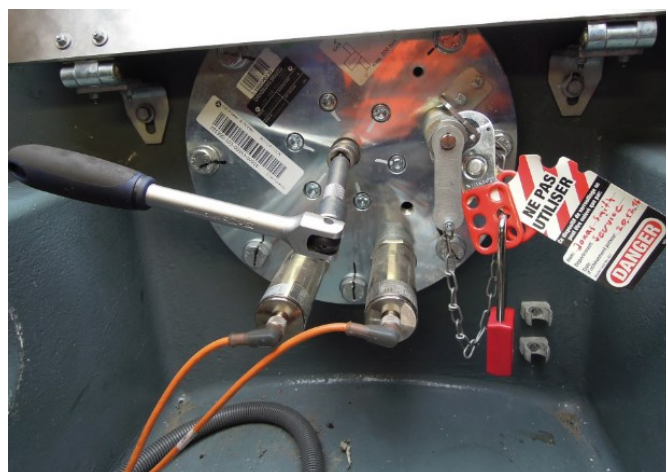


Fig. 16: Securing the LSS rotor lock with LOTO

**Achtung!****Visual check!**

The piston must be inserted all the way into the rotor lock disk, the end face of the piston must be flush with the surface on the rotor side of the rotor lock disk.

If this is not the case, the hub may not be entered.

If the wind speed unexpectedly increases, or the ambient temperature falls below -30°C , any work must stop immediately and the rotor lock must be disengaged in the reverse sequence. For detailed requirements refer to your company-specific Cold Weather Guidelines.

**Attention!****The WTGS must not get into oscillation!**

Take adequate measures to avoid oscillations by yawing the WTGS into the wind. In the event of changing wind conditions leading to oscillations of the WTGS yaw the machinehead until the oscillations stop. If this doesn't stop the oscillations, stop all activities and release the rotor lock **and** the high speed shaft brake.

**Danger!****Risk of Damage to the Wind Turbine Generator System!**

The rotor lock **and** the high speed shaft brake must always be released before leaving the turbine. Make sure that the machine is idling.

6.3 Emergency Lighting

In the case of a power failure, emergency lighting provides light in the tower and the nacelle. The emergency lighting is equipped with an independent power supply (battery), which provides voltage for the lamps for approx. 1.5 hours/90 minutes (North America) or 1 hour/60 minutes (Europe) after a power failure. The WTGS must be left immediately if the emergency lighting is activated as the result of a power failure.

7 Residual Risks

Even if all the safety requirements are complied with, a residual risk remains during operation of the wind turbine generator systems.

Anyone who works on and with the WTGS must be aware of these residual risks and follow the instructions which prevent these residual risks from resulting in accidents or damage.



Danger!

Danger of injury during ascent!

The full-body safety harness must be put on and attached to the safety rail by means of the slider hook during the ascent to the nacelle, in order to prevent the person ascending from falling. Any oil or grease deposits on the ladder must be removed immediately to prevent anyone from slipping while using the ladder.

Ensure that your footwear is clean!



Warning!

Falling objects hazard warning!

An object may be unknowingly and unintentionally dropped and hit and cause injury to somebody.

For this reason, only one person at a time may climb a section of the ladder between two platforms. The hatch covers must be closed again immediately after they have been passed through. Tools and equipment must be secured while climbing.



Danger!

Life-threatening hazard - working under suspended loads!

Never stay under suspended loads.



Danger!

Danger of falling from the nacelle!

You are exposed to strong winds when climbing out through the hatch. Attach your lanyard to the nearest hooking point from inside the nacelle. Climbing out is only allowed at wind speeds up to 15 m/s.

As a general principle, there is a falling hazard at all higher locations/workplaces.

7.1 Special Dangers – Electric Power

Note the following rules when carrying out any work on the electrical components of the plant, e.g. assembly, connection, opening of a device, maintenance:

1. DISCONNECTION
2. SECURE against re-connection
3. Ascertain safe isolation from supply
4. Ground and short-circuit
5. Cover up adjacent live components or provide them with barriers

In addition, ensure that all drives are at standstill.



Danger!

Caution! Danger from electrical voltage!

When switched on, electrical installations and machinery have live exposed conductors or rotating parts. They could therefore cause personal injury or death and material damage if the cover and the prescribed safety devices are removed, or in the event of incorrect handling and maintenance and in the case of improper use. The above stated safety regulations must therefore be complied with, particularly when removing a cover.

In addition to this, electrical energy is still present in devices with power electronics even after the supply voltage to the device has been switched off. These devices are secured against unauthorized access. After waiting an appropriate time for the device to discharge (e.g. capacitors), always check for residual voltage before starting work.

FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!

(cf. Chapter 12)

In the case of malfunctions of the energy supply of the wind turbine generator system, actuate the EMERGENCY STOP button immediately if the plant has not already been switched off by the automatic control system.

In the case of repairs, care should be taken that design features are not modified so that safety is compromised (e.g. leakage distances and sparking distances in air) and that distances are not reduced by insulation materials.

The control system and interlocking as well as the monitoring and protective functions (thermal motor protection, speed monitoring, over current, fault to ground, etc.) may not be set out of function, even during a test run.

During prolonged cold soak events where the grid remains de-energized and external ambient temperature is below -30°C , the medium voltage switchgear will be disconnected from the grid automatically. Upon re-energization of the grid, the internal turbine air surrounding the MVSG must warm up above -25°C prior to entering the turbine to reclose the MVSG. Additionally, use of the load disconnect switch panel of the switchgear must not be attempted until ambient air surrounding MVSG temperature is above -25°C .

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As a general principle, maintenance work may only be carried out by two persons, so that the second person can actuate the EMERGENCY STOP button in an emergency.

Only use insulated and approved tools.

Only use original fuses with the prescribed amperage!

7.2 Special Dangers – Hydraulic System

For maintenance work on the hydraulic system, maintenance staff must be completely acquainted with the hydraulic circuit diagram and must have been instructed about its function and the possible consequences of an operating error.

Prior to any work on the hydraulic accumulators, it must be ensured that the accumulator circuits have been depressurized. The shutdown device is clearly marked and independent of the system management.



Danger!

Danger through stored residual hydraulic energy!

FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!
(cf. Chapter 12)

7.3 Special Dangers - Noise

The A-weighted equivalent continuous sound pressure level inside the tower and the nacelle exceeds the permissible 70 dBA limit during normal operation as per European Standard EN 50308, and the permissible 85 dBA TWA per OSHA 29 CFR 1910.95. The highest sound pressure level was measured inside the nacelle.

Certain tools are prone to generate high sound pressure levels in excess of 70 dBA, such as:

- angle grinder
- pneumatic torque wrench
- air blasting pistol etc.

Any conditions requiring to raise the voice dramatically for speech, requires to wear ear protection with SNR > 25 dB (noise reduction index).

Staying in the WTGS while it is in operation is unavoidable in the case of certain maintenance and repair work. In such cases it is mandatory for personnel to wear ear protection with SNR > 25 dB to avoid accumulated permanent ear damages.



Note!

Anybody carrying out work in the tower or the nacelle when the WTGS is in operation must wear hearing protection as part of their personal protective equipment.



When obtaining ear protection make sure the packaging identifies noise reduction with a SNR value. Only certain models of foam ear protection products (to be inserted in the auditory canal) or – even better – ear muffs (covering both ears; possibly integrated in hard hat) are capable of achieving SNR > 25 dB.



Fig. 17: Foam ear protection



Fig. 18: Ear muffs (ear cups)



Fig. 19: Ear muffs integrated in hard hat

For the purpose of EN 50308 standard compliance a noise exposure assessment has been conducted on 2.5MW prototype machine at accessible working locations (Report No. 208125-01.01, performed by Koetter Consulting on April 25, 2008).

In summary per 2003/10/EC guidelines:

1. L_{Aeq} (time averaged noise level) in excess of 100 dBA could be reached inside the nacelle in the vicinity of the gearbox brake disk and high speed coupling area.
2. L_{Aeq} (time averaged noise level) in excess of 90 dBA could be reached inside the tower compartment in the vicinity of the power converter area.
3. Work in both nacelle and tower requires ear protection during wind turbine operations.

7.4 Special Dangers – Icing

7.4.1 Ice Build-up on the Rotor Blades

Ice build-up on wind turbine generator systems (WTGS) and, in particular, the shedding of ice from rotor blades can lead to problems, if wind turbine generator systems are planned in the vicinity of roads, car parks or buildings at locations with an increased risk of freezing conditions, unless suitable safety measures are taken.

If people or objects near the wind turbine generator system (within the distance **R***) could be endangered by pieces of ice thrown off during operation, GE Renewable Energy always recommends the use of ice detection.

The WTGS control system is able to detect ice by low aero performance where the actual power output of the turbine is compared to the possible output. In case of ice on the blades the power output would be lower. In icing conditions the controls system will stop the turbine.

If the blades are covered by ice asymmetrically, this can be detected by lateral tower vibration.

In case of ice detection the rotor is brought to a standstill or rotates at a very low speed. Depending on the detection a message about the icy condition is displayed on the monitor in the turbine:

- 373 Ice detected via low power (PMG and DFIG turbines)
- 375 Ice detected via tower vibrations (PMG turbines)
- 600 Ice detected via tower vibrations (DFIG turbines)

In addition, a message is sent to the remote control center/operator. The turbine does not restart until the detector is free of ice or the operator has reassured himself of the ice-free condition of the rotor blades, has acknowledged the ice alarm message and restarts the plant.

However, ice may form on the rotor blades considerably more quickly than the design of the ice detection considers. As a result, there is a residual risk for the reliable detection of ice build-up on the rotor blades.

The ice detection must be set relatively sensitively, in order to ensure that the time from when ice starts to build up on the rotor blades until the detection sends a message about the build-up of ice is as short as possible. As a consequence, a certain number of spurious trippings cannot be excluded. Loss of energy yield may occur as a result of the spurious trippings.

If an ice detector is not used, it is advisable to cordon off an area around the wind turbine generator system with the radius **R*** during freezing weather conditions, in order to ensure that individuals are not endangered by pieces of ice thrown off during operation (cf. also Section 10.1).

***R** = 1.5 x (hub height [m] + rotor diameter [m])

(Recommendation of the German Wind Energy Institute DEWI 11/1999)

7.4.2 Icy Condition of the Access Route

During the winter months, access to the plants may be very slippery due to ice or hard-packed snow. There is an increased danger of slipping.

7.4.3 Icy Condition of the Tread of the Steps outside the Nacelle

In the winter months, the tread of the steps outside the nacelle can be icy as a result of ice and hard-packed snow. There is an increased danger of slipping and falling from a height.

7.5 Exceptional Dangers – Earthquakes

In the case of a earthquake, the operator must inspect the WTGS for damage. In particular, the following turbine components must be inspected.

- Determination of the acceleration values in the tower top (PCH BOX) which arose during the earthquake.
- Contact GE Renewable Energy, in order agree on the further procedure and possible inspection schedules.

8 Safety Information for Individual Plant Components

8.1 Doors and Hatches

As a general principle, there is a falling hazard at open hatches in the WTGS. Therefore keep all hatches in the tower and in the Pre-Assembled Power Module (PPM) closed.

8.2 Pre-Assembled Power Module (PPM)

8.2.1 4-Level PPM

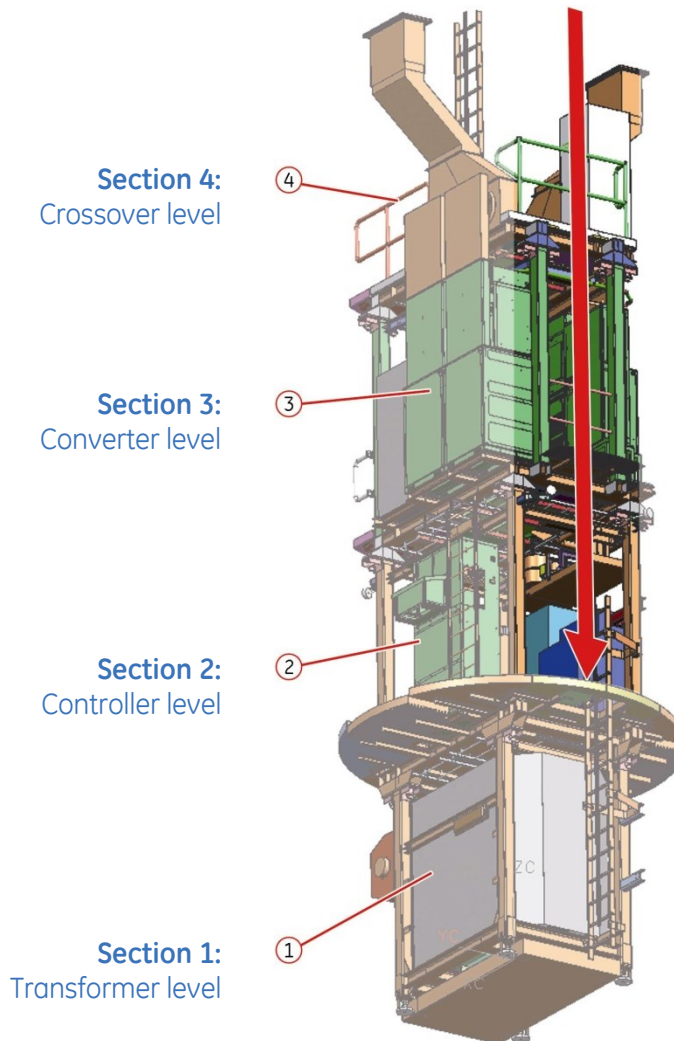


Fig. 20: 4-level PPM

When using the cable winch of the WTGS in section 4 (Crossover) do not stay in the area underneath the cable winch!



Danger!

Life-threatening hazard - working under suspended loads!

Never stay under suspended loads.

Hooking Points on the Pre-Assembled Power Module (PPM)

Several hooking points marked in signal yellow are located on each section of the PPM.

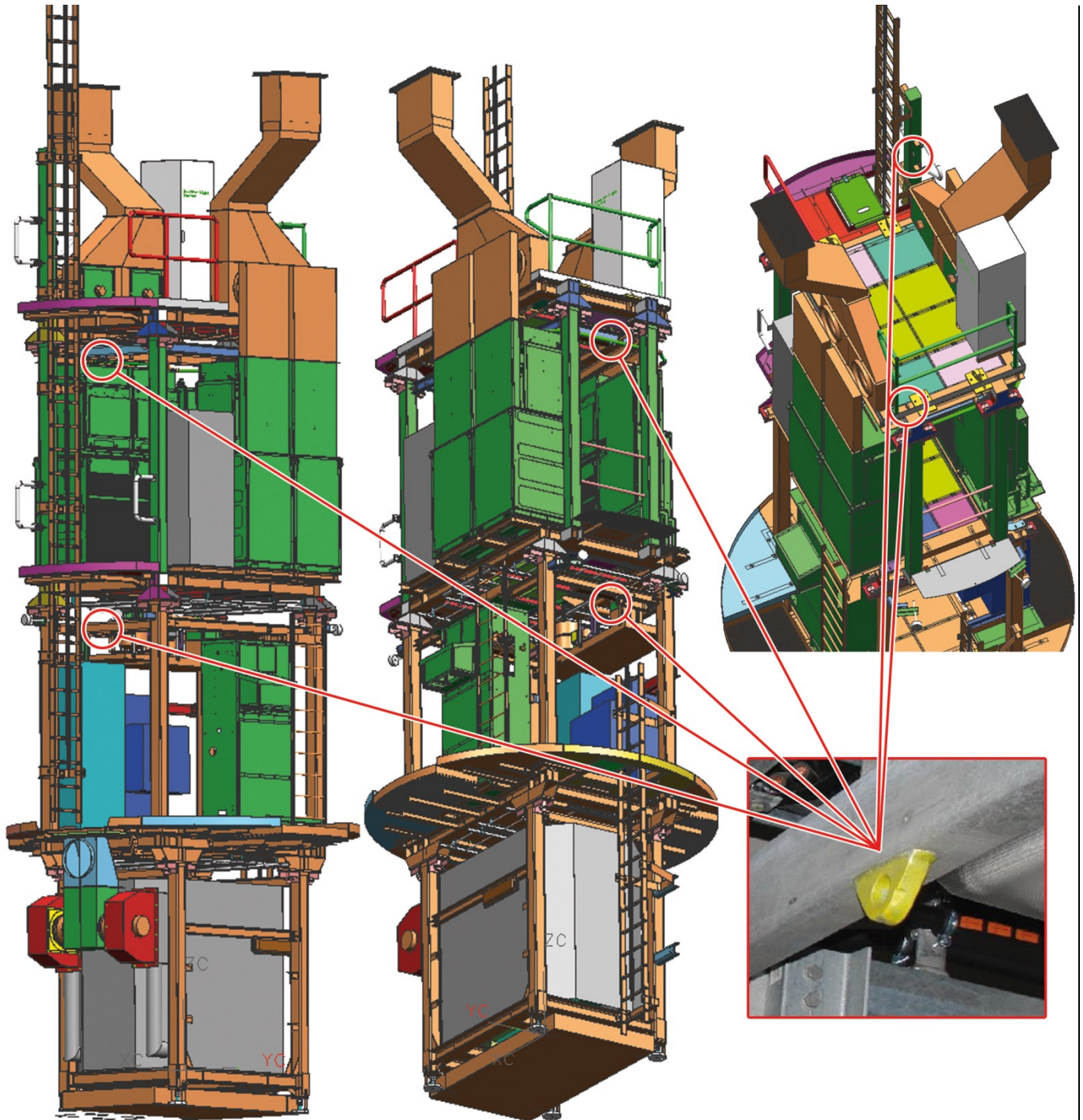


Fig. 21: Hooking points 4-level PPM

The hooking points of the respective section must be used when carrying out work which requires removal of the installed fall protection systems or safety rails.

The respective hooking points of the section must be used when carrying out work on the ventilation ducts behind the converters.

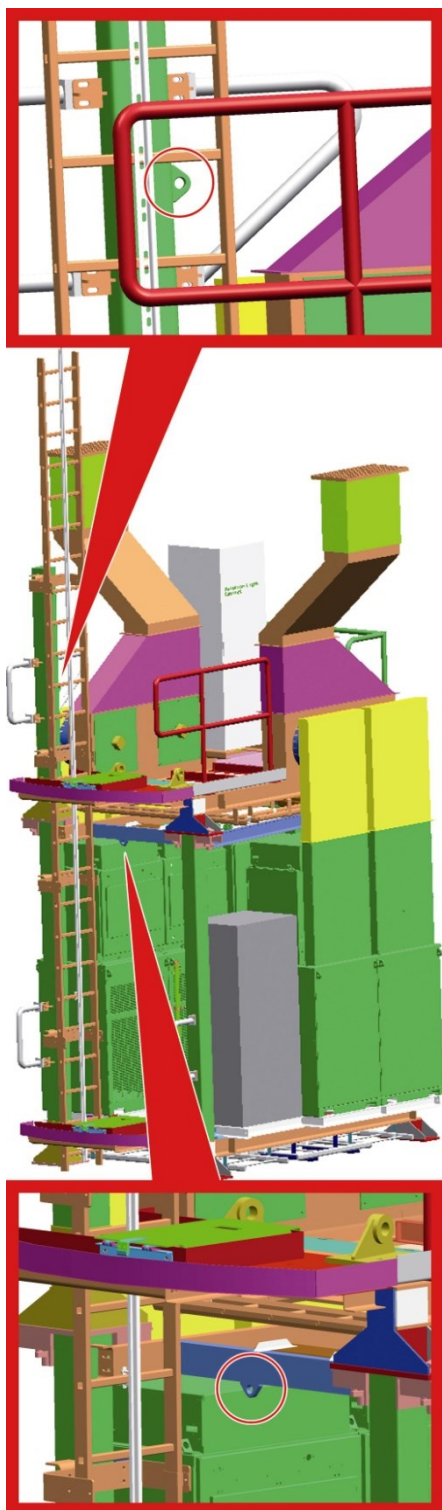


Fig. 22: Hooking points converter section

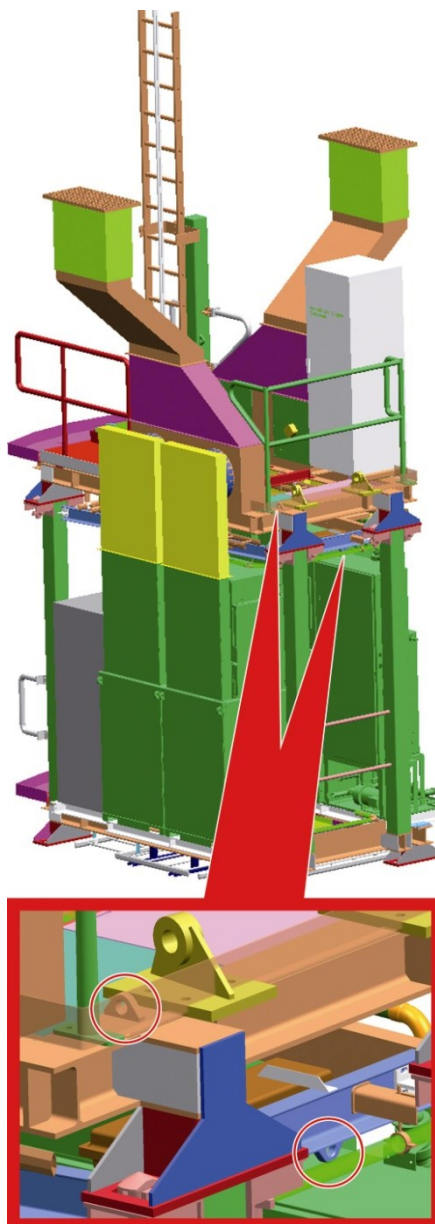
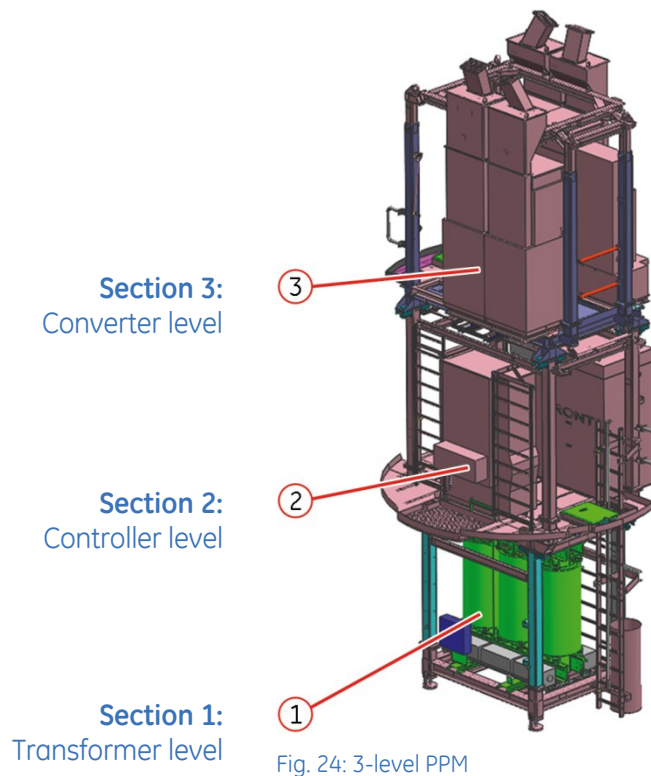


Fig. 23: Hooking points converter section

8.2.2 3-Level PPM



When using the cable winch of the WTGS in section 2 (Controller level) or 3 (Converter level) do not stay in the area underneath the cable winch!



Danger!

Life-threatening hazard - working under suspended loads!

Never stay under suspended loads.

The design of the pre-assembled power module (PPM), as well as the hybrid towers, are based on the 2-1/2 level PPM. However, the components are assembled separately and next to each other on the entry level. Thus, suspension points are not designed.

Hooking Points on the Pre-Assembled Power Module (PPM)

Several hooking points marked in signal yellow are located on each section of the PPM.

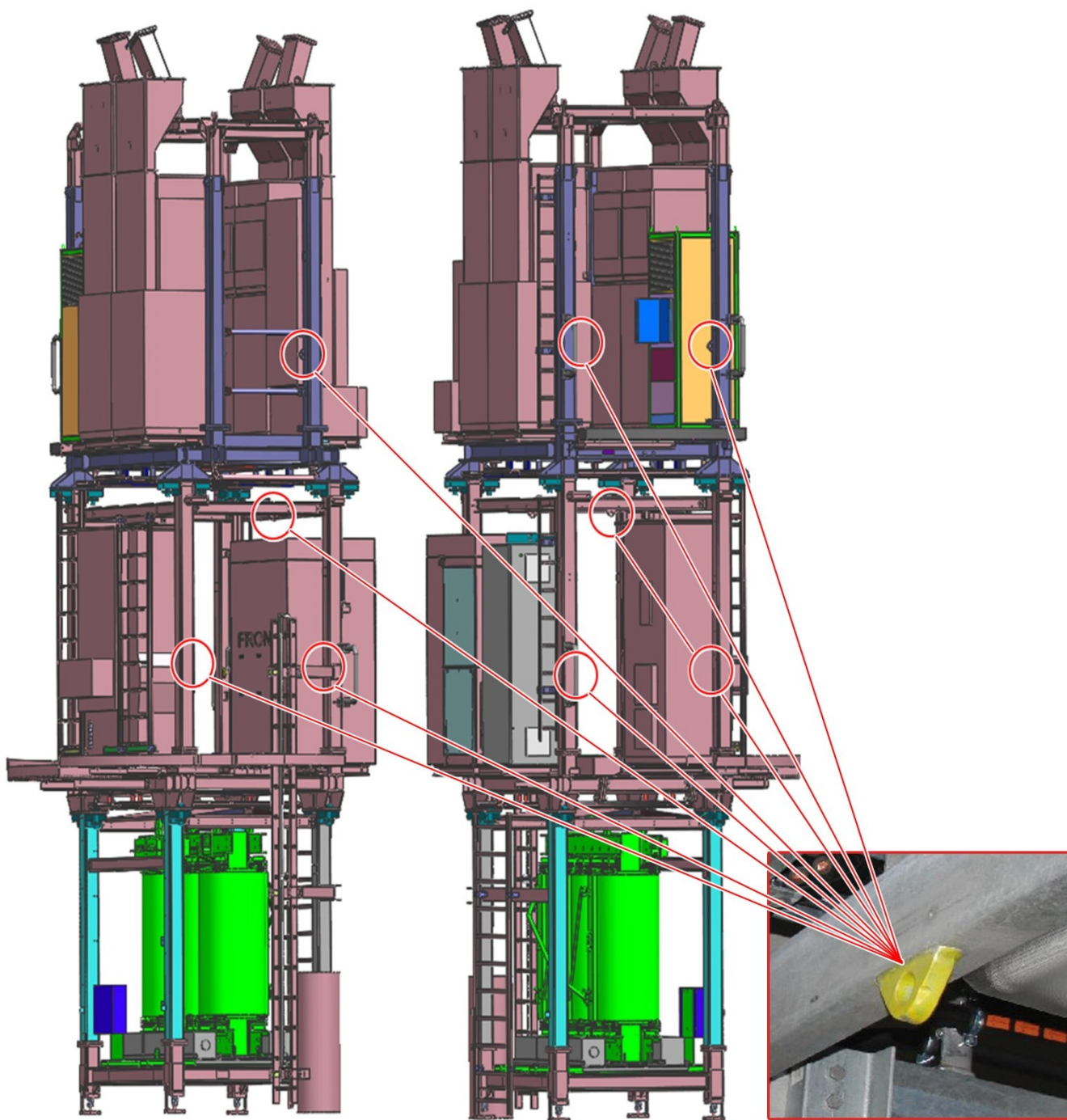


Fig. 25: Hooking points 3-level PPM

The hooking points of the respective section must be used when carrying out work which requires removal of the installed fall protection systems or safety rails.

Hatch converter level

The converter level has a hatch opening in the floor. This hatch is for use of the WTGS winch down to door level (controller level) and for support of the ventilation inside of the PPM. Therefore it should be left open and only be closed for access to the converter level.

1. Open the hatch on the converter level. To arrest the hatch in upright position, extract the railing from inside of the hatch.

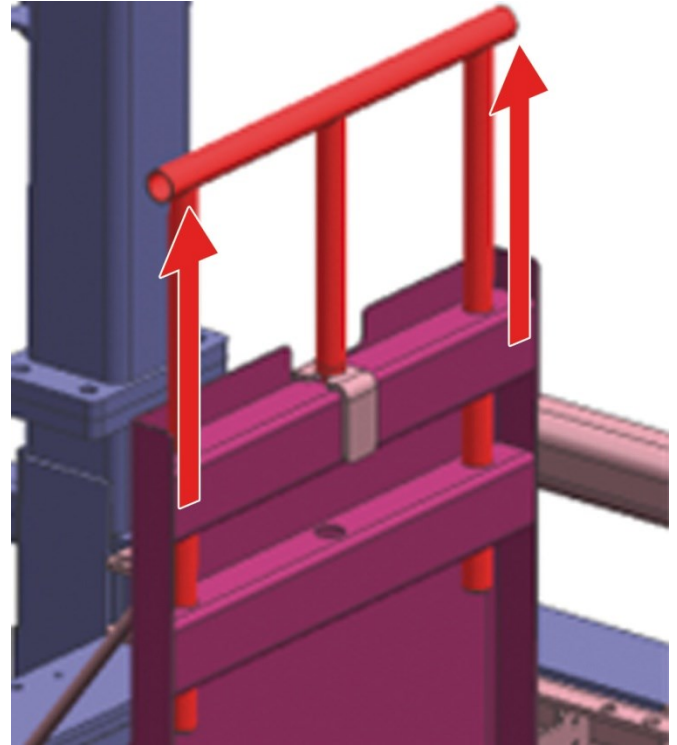


Figure 26: Hatch converter level with extracted railing

2. Lock the railing with the hatch bar.

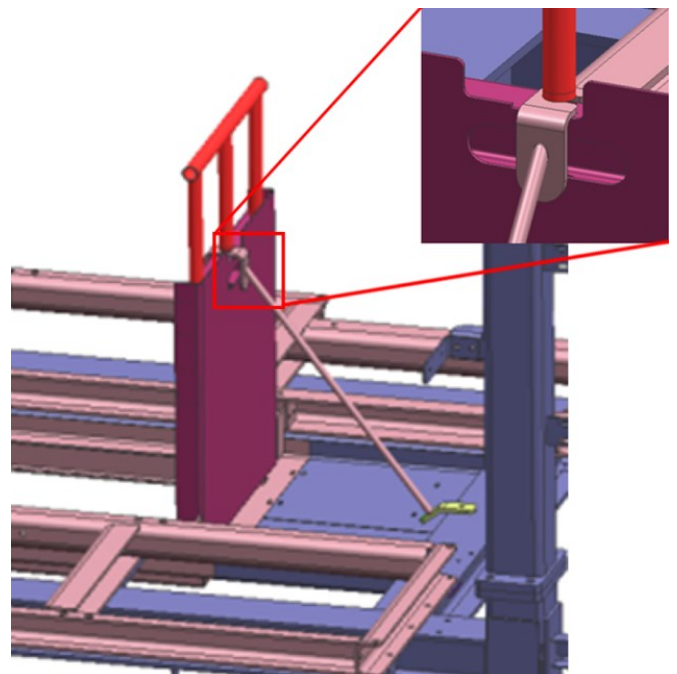


Figure 27: Locking the railing with the hatch bar

3. Bolt the hatch bar to the console.



Danger!

Danger of Falling down!

It is not allowed to stay on the inside of the converter level behind the opening when the hatch is open.

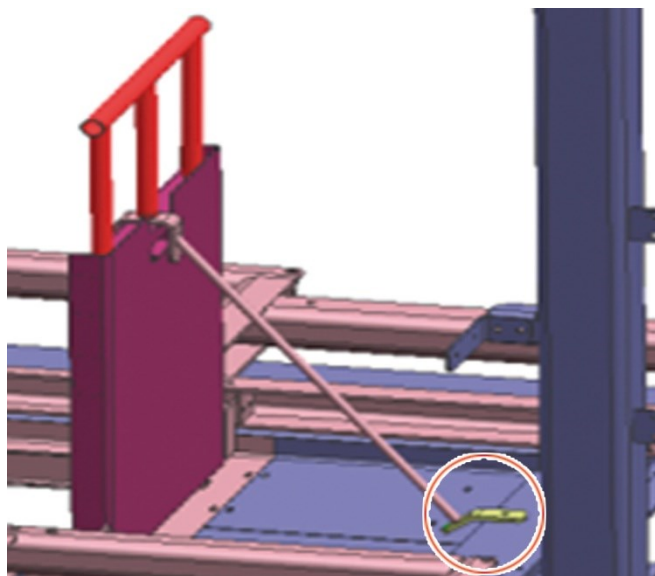


Figure 28: Bolting the hatch bar to the console

The hatch bar can be placed at the console column when not in use.

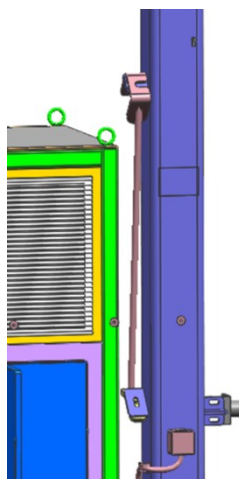


Figure 29: Hatch bar placed at the console column

8.2.3 2-1/2 Level PPM

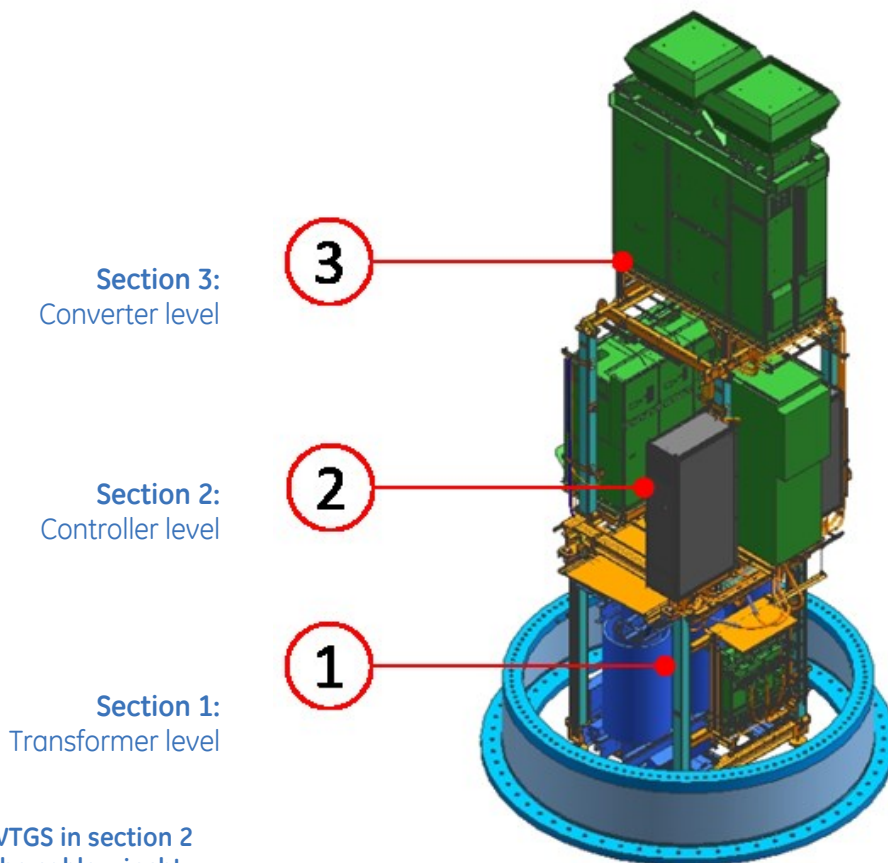


Fig. 30: 2-1/2 level PPM

When using the cable winch of the WTGS in section 2 do not stay in the area underneath the cable winch!



Danger!

Life-threatening hazard - working under suspended loads!

Never stay under suspended loads.

Hooking Points on the Pre-Assembled Power Module (PPM)

A total of three Safety Hooking Points are provided in the PPM. They are marked in **signal yellow** and are located in the Controller Level, two on columns and one above the Transformer Level hatch for rescue from this level. The hooking points must be used when carrying out work which requires removal of the installed fall protection systems or safety rails.

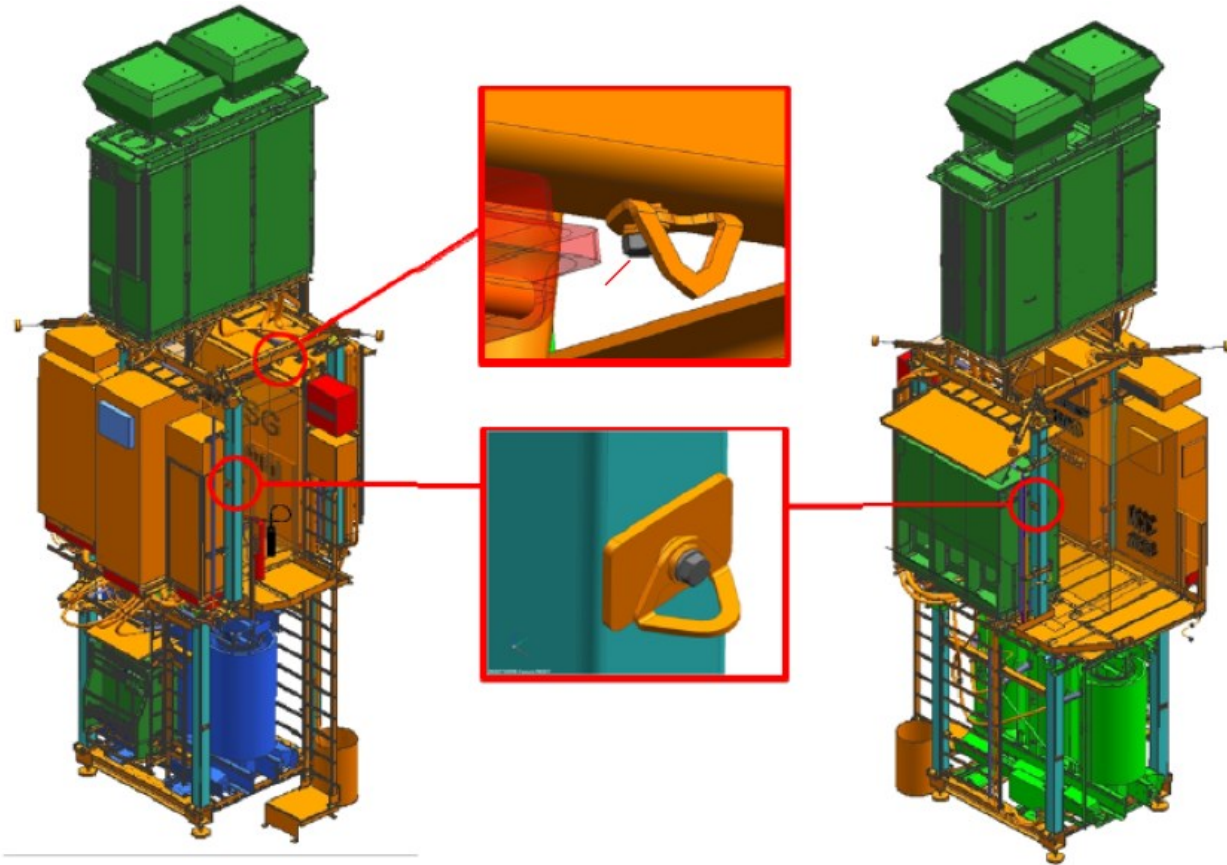


Fig. 31: 2-1/2 level PPM safety hooking point

Transformer Level Considerations

Please make sure that no object (like a cable or long tool) goes into the Transformer Level from other levels while the Medium Voltage or Auxiliary Transformers are energized.

In some PPM Configurations the Shadow Monitoring and Metering Panel Cabinets shown in Figure 35 are not installed. In this case, never attempt to climb down to the Transformer Level behind the Access Ladder, always climb down through the Hatch.

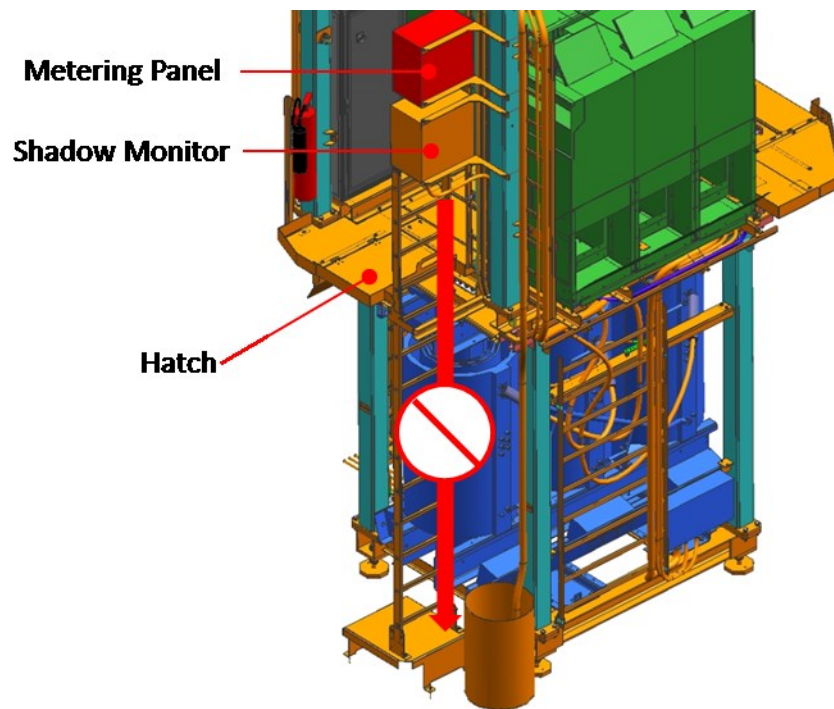


Fig. 32: Always access the transformer level through hatch

8.3 Medium-Voltage Switch Gear

In line with the national safety regulations, the medium-voltage switch gear may only be disconnected in accordance with the switching instruction by "personnel authorized to switch on and off" who have been briefed about the respective switch gear.



Danger!

FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!
(cf. Chapter 12)



Danger!

Attention! Check the work area/control cabinet before conclusion of the work!

Remove any unassembled components or tools or materials from the control cabinets. Any tools or materials left behind in the control cabinets result in unsafe working conditions for the service technicians when the wind turbine generator system is returned to operation.

Close and lock the control cabinets before the wind turbine generator system is returned to service.

8.4 Transformer

Danger! High Voltage – Life-threatening hazard!

The medium-voltage switch gear must be safety isolated before the transformer cabinet is entered. The transformer cabinet is unlocked by means of a key located in a key box inside the switchgear unit.

The transformer must be de-energized before maintenance work is carried out on the transformer or near the transformer (e.g. inspection of the anchor bolts, etc.)!



Danger!

Portable lamps need to be used for entering the transformer level.

Before energizing a dry-type transformer either initially or after any shutdown period in which the unit has cooled to ambient temperature, the transformer should be inspected for evidence of moisture and the insulation resistance should be checked. If there is evidence of moisture/condensation/ water on or around the MV transformer, or if the insulation resistance is low, the transformer cannot be energized until it is safe to do so. Suggested insulation resistance test methods include ANSI/IEEE C57.12.11.

The transformer cabinet must be locked again after completion of the work!

PLEASE OBSERVE THE RESPECTIVE LOCKOUT / TAGOUT SWITCHING INSTRUCTIONS! (cf. Chapter 12)

**Danger!****Danger to health or life when entering a confined space!**

The transformer level is considered a confined space. Review and follow the High Risk Operations Procedure HS13.1 "Confined Spaces Entry" if you need to access to this area.

The hybrid tower transformer, is protected with an enclosure and secured door against unauthorized access.

8.5 Low Voltage Main Distribution and Main Control Panel

**Danger!****FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!**

(cf. Chapter 12)

**Danger!****Caution! Danger from electrical current!**

All personnel remaining in the WTGS must be located between the person carrying out the measurements and the tower entrance during voltage measurements on the low voltage main distribution or on the low voltage main control panel.

**Danger!****Attention! Check the work area/control cabinet before conclusion of the work!**

Remove any unassembled components or tools or materials from the control cabinets. Any tools or materials left behind in the control cabinets result in unsafe working conditions for the service technicians when the wind turbine generator system is returned to operation.

Close and lock the control cabinets before the wind turbine generator system is returned to service.

**Danger!****Danger from electrical voltage!**

Before beginning any maintenance work, ensure that the main control cabinet has been disconnected from all energy sources in accordance with the currently applicable Lockout/Tagout instructions. Wear appropriate electrical PPE for entrance into energized cabinets.

**Danger!****Danger from electrical voltage!**

Be aware of the energy stored within the UPS inside the Main Control Cabinet. The UPS inside the MCC must be disconnected, in addition to disconnecting power to the MCC, to properly LOTO the MCC.

**Danger!****Check the control cabinet/work area before conclusion of work!**

Remove any unassembled components or tools or materials from the control cabinet. Any of those items left behind in the control cabinet result in unsafe working conditions for the service

technicians when the wind turbine generator system is returned to operation.

8.6 Frequency Converter (PPM)



Attention!

PLEASE OBSERVE THE RESPECTIVE LOCKOUT / TAGOUT SWITCHING INSTRUCTIONS!

(cf. Chapter 12)



Danger!

Caution! Danger from electrical current!

All personnel remaining in the WTGS must be located between the person carrying out the measurements and the tower entrance during voltage measurements on the frequency converter.



Danger!

Fire Hazard!

Ensure that you have a fire extinguisher (optional feature) with you when carrying out work on the converters/LVMD.



Attention!

Danger to personal health and environment!

The converter cooling system may contain liquids that, if released, could harm your personal health or the environment.



Danger!

Attention! Check the work area/control cabinet before conclusion of the work!

Remove any unassembled components or tools or materials from the control cabinets. Any tools or materials left behind in the control cabinets result in unsafe working conditions for the service technicians when the wind turbine generator system is returned to operation.

Close and lock the control cabinets before the wind turbine generator system is returned to service.

8.7 Nacelle



Warning!

Do not mount a working platform!

The nacelle is not designed for the lowering of a working platform!

8.8 Anemometer and Wind Vane

The anemometer and the wind vane are intensely heated in WTGs with cold weather equipment!



Attention!

Hot surface!

Disconnect the anemometer and the wind vane from the supply and allow both to cool down prior to maintenance.

Physical contact may cause burns.

8.9 Pitch Electrical Control Cabinets Inside the Hub – Axis and Battery



Danger!

Danger from electrical voltage!

Before beginning any maintenance work, ensure that the control cabinets have been disconnected from all energy sources in accordance with the currently applicable Lockout/Tagout instructions. In addition to the main circuits, take any supplementary or auxiliary circuits into account. Wear appropriate electrical PPE for entrance into energized cabinets.



Danger!

Check the control cabinet/work area before conclusion of work!

Remove any unassembled components or tools or materials from the control cabinet. Any of those items left behind in the control cabinet result in unsafe working conditions for the service technicians when the wind turbine generator system is returned to operation.



Danger!

Danger from electrical voltage!

All axis and battery cabinet doors must be securely latched in place before the system is reenergized to avoid exposure to the potentially hazardous transient voltages that are present during startup.

9 Conduct in Emergency Situations

9.1 Conduct in Case of Fire

In principle the WTGS consists of fire-resistant materials. However:



Warning!

Fire, open lights and smoking are prohibited!

If a fire does occur, however, **call the fire department immediately!**

State the following information:

- Name of the person calling
- What is on fire
- Where the fire is located (seat of the fire / location of the plant)
- Wind direction and wind strength

Note the following information in the case of fire:

- Saving lives has priority over fire-fighting
- Alarm all personnel who are in the WTGS
- Use the escape routes described in Chapter 9.2 – ensure that you are familiar with the various escape routes.
- Do not use the hoisting passenger suspension devices like elevators or climbing assists.
- Burning debris can be expected to fall down if there is a fire in the nacelle or the upper part of the tower.
- If the wind turbine generator system is still in operation, it must be stopped and a large area around the plant cordoned off.
- Close the door of the plant.

9.1.1 Fire-Fighting

Fire-fighting may only be carried out by immediately fighting an initial fire using the optional fire extinguishers available in the plant. The locations of the firefighting equipment in the tower and the nacelle are marked.

If the initial fire cannot be extinguished within a short time, abandon any further attempts to extinguish the fire and call the fire department immediately.

In addition to the direct danger from the fire, a combustion toxicity hazard and the danger of asphyxia could also arise. As a result, move in a crouched position if smoke develops and also crouch down when attempting to extinguish the fire.



Danger!

Attempts to extinguish a fire may lead to very serious burns!

Do not make any attempts to extinguish the fire, since the appropriate fire-fighting methods cannot normally be carried out without reservation (minimum clearances cannot be adhered to). Very serious burns could be the result.

9.1.2 Fire in the Tower - Person in the Nacelle

- Leave the WTGS immediately via the second escape route (cf. Chapter 9.2.2).
- Abseiling device in the nacelle - emergency exit using the abseiling device

9.1.3 Fire in the Nacelle - Person in the Nacelle

- Attempt to extinguish the fire.

If unsuccessful:

- Leave the danger area immediately via the first escape route (cf. Chapter 9.2.1).
- Do **not** use the hoisting passenger suspension device.
- Do **not** use the abseiling device.

9.1.4 Fire in the Transformer



Danger!

**Do not make any attempts to extinguish the fire – High voltage!
Conventional fire extinguishers are not suitable.**

- Leave the WTGS immediately.

In the case of transformers in the tower:

- Leave the WTGS via the second escape route (cf. Chapter 9.2.2)

In the case of transformers in the transformer station:

- Leave the WTGS via the first escape route (cf. Chapter 9.2.1).

Fire-fighting may only be carried out by trained personnel.

9.2 Escape Routes



Attention!

Keep escape routes free!

All escape and rescue routes have to be kept free from obstructions (tools, equipment, waste etc.) to enable a quick departure from the plant.

9.2.1 First Escape Route

In case of fire, leave the plant immediately. The first escape route from the nacelle is down the ladder in the tower. The descent is facilitated and made safer by resting platforms every 6 m. Do not use the hoisting passenger suspension device.

9.2.2 Second Escape Route

If the descent through the tower is no longer possible, use the second escape route. (Abseiling with the abseiling device). This either leads over the roof of the nacelle (hooking point on roof rail) or through the optional emergency descent hatch (hooking point on the swinging gallows in the nacelle).

Correct use of the abseiling device (cf. Chapter 5.4 on page 23):

- Make sure your safety harness is on correctly.
- Secure yourself against falling by means of the lanyard.



Danger!

Use of the abseiling device!

Your life could depend on the correct use of the abseiling device.

The abseiling device can also be used by two people to abseil.

Read the instructions before beginning the abseiling operation!

9.3 Information for Rescue and Emergency Personnel

The rescue services and the emergency personnel must be equipped with their own personal protective equipment (safety harness, etc.). The rescue/emergency personnel must bring with them all the equipment required for rescuing personnel from the hub, nacelle or tower.

The information stated in this safety manual must also be read by the rescue / emergency personnel.

9.4 Oil Spill – Immediate Measures

The objective of the immediate measures is to prevent or at least to contain a further uncontrolled escape of water-endangering substances and keep the areas of threatened or contaminated soil as small as possible, under consideration of safety engineering requirements.



Note!

Inform yourself about the oils used beforehand. The safety data sheets provide details of Water Hazard Classes and suitable measures for combating oil pollution.

Measures

1. Decide and act quickly, so that the amount of oil reaching the environment is kept as small as possible.
2. Prevent further discharge (closure of valves, temporary sealing of cracks and holes, e.g. by means of sealing rags, sealing bags, sealing wedges, collection in containers, pumping out, transfer, etc.)
3. Bind the discharged oil – use approved oil binding agents and oil binder mats if the oil could not be pumped out or skimmed off in time. The damage can be limited by means of collecting containers, rolled foils and a shovel.
4. Prevent the oil from getting into the soil or bodies of water.
5. Remove contaminated soil.
6. Take the contaminated oil-absorbing materials to a local specialist waste disposal company for material recovery / conversion to energy or disposal. The national regulations are to be complied with.

10 Staying in the Wind Turbine Generator System

Personnel may not stay inside the WTGS and maintenance or repair work may not be carried out in or on the WTGS under power supply. There is a danger of accident and a danger to life and limb. In order to prevent accidents, the following actions are to be carried out in the following order before and on entering the wind turbine generator system:

1. Shut down the WTGS and secure against an unauthorized return to service
2. Put on the personal protective equipment
3. Disable the power supply for the work to be carried out – carry out corresponding Lockout/Tagout instructions (cf. Chapter 12)

Staying in the WTGS while it is in operation is unavoidable in the case of certain maintenance and repair work. In such cases, particular care is called for and ear protection with SNR > 25 dB (noise reduction index) must be worn.

In addition, the following safety regulations are to be complied with without fail:

- As a general principle, no person may stay in the WTGS during a gale or a thunderstorm! If a thunderstorm comes up, the WTGS must be left immediately.
- The WTGS may only be entered when a second person is available to provide assistance or call for help in the case of an accident.
- The entrance door to the tower must be kept closed or, if the door needs to be open, it must be properly secured to prevent it from flying open and getting warped.
- Long open hair, loose clothing (e.g. flapping coats, tops with wide sleeves or trousers with wide legs) and scarves, ribbons, headscarves or jewelry may not be worn in the WTGS! There is a fundamental danger of injury as a result of getting caught, trapped or drawn in by rotating elements! Clothing must always be tailored to suit the respective work and the weather conditions.
- Switch-on and shut-down procedures in accordance with the operating manual are to be complied with for all work which concerns the operation and adjustment of the WTGS and its safety equipment.
- If any changes in the operating characteristics which are relevant to safety or any faults arise in the WTGS, it must be shut down immediately and the event reported to GE Renewable Energy or the customer (if a maintenance contract has not been concluded with GE Renewable Energy).

10.1 Approaching and Entering a Frosted Wind Turbine Generator System

Before parking near the turbine, stop approx. 350 m from the turbine and check the rotor blades for ice by means of binoculars and the sound of the rotation of the blades. If the turbine is running and ice is present on the rotor blades, call for a remote stop.

Once the blades have come to a complete standstill, verify that none of the blades is located over the entrance door of the turbine. If this is the case, call for a remote traverse of the yaw drive in any direction, so that the rotor is positioned on the opposite side of the door of the turbine. As soon as the rotor is correctly positioned, call for a remote stop of the yaw drive and ask for confirmation of this operation.

Once the above conditions have been complied with, park your vehicle at a safe distance from the WTGS (at least 100 m). Watch out for falling ice as you approach the tower. If the wind is blowing against the opposite side of the door (or into the rotor at this point), you must proceed with extreme caution, since falling ice could be blown in your direction.



Warning!

Danger of slipping as a result of icy conditions!

There is danger of slipping as a result of the frozen ground and ice on the foundation and the stairs.

Sprinkle de-icing salt or sand over the foundation.

Use the handrail when going up the stairs.

Leave the immediate vicinity of the WTG after completing your work. Watch out for falling ice. Get into your vehicle. Do not call for a remote re-activation of the yaw drive and restart of the turbine until you are approximately 350 m away from the WTG.

10.2 Shut-down of the Wind Turbine Generator System

Before starting any service work, the wind turbine generator system must be deactivated. Proceed as follows:

1. Inform the remote monitoring division (before entering the plant)
2. Inform the operator / customer (before entering the plant)
3. For Standard Bachmann units only (without web pages): Deactivate the remote monitoring program:
 - Telephone list
Deactivate the checkbox in the menu "Configuration" / "Call list"/ and confirm.
 - PC
Deactivate the checkbox in the menu "Configuration" / "PC" /.
 - SMS
Deactivate the checkbox in the menu "Configuration" / "SMS" /.
 - Cityruf paging service
Deactivate the checkbox in the menu "Configuration" / "Cityruf" /.
 - Fax
Deactivate the checkbox in the menu "Configuration" / "Fax" /.

NOTE: Line 3 not applicable to WTG without a Turbine PC

4. Set the key-operated switch to "Repair/Maintenance".
5. Press the "Stop" button to shut-down the plant manually.



Danger!

Danger of accident!

The WTGS must remain shut down as long as personnel are in the plant. Before it is returned to service by authorized personnel, check without fail that nobody is in the plant. Otherwise the danger of an accident arises!

10.3 Climbing the Tower

- Only persons who are physically fit and capable of coping with the ascent may climb the WTGS.
- The WTGS must be shut down and secured against unauthorized start-up before the tower is ascended. The WTGS must remain shut down as long as anybody is climbing the tower or is on the tower platform.
- The entrance door to the tower must be kept locked, in order to inhibit access to unauthorized persons.
- In order to avoid accidents caused by falling objects, nobody may stay under the ladder while somebody is ascending the tower. Even a small screwdriver can cause very serious injuries if it drops from a great height.



Danger!

Danger through falling objects!

Falling objects can cause very serious injuries irrespective of their size and weight!

Tools and equipment must be secured while climbing. Never stay in the vicinity of the ladder while somebody is ascending or descending. The ladder may only be used by one person at a time. Only after this person has reached an intermediate platform and has closed the tower hatch or has reached the ground in the tower base and stepped back from the ladder, may the next person approach the ladder.

- The safety harness must always be put on correctly before ascending the tower.
- Always check the safety harness and the entire safety equipment prior to use. Damaged PPE may never be used.
- Safety boots and a hardhat must be worn when ascending the tower. Gloves must be worn while climbing.
- The maximum possible fall path must be kept to a minimum by means of rope-shortening devices or similar.
- Only use marked hooking points with an adequate load-bearing capacity.
- The tower may only be ascended by means of the ladder installed inside the tower or the hoisting passenger suspension devices / service platform which may be installed. (Follow the operating instructions of the manufacturer).
- In case of the wire rope fall arrest system, the wire grab arrester must run freely on the rope while ascending and descending the tower. Never touch the wire grab arrester while climbing/descending. Otherwise there is a danger of injury!
- In case of the rail-slider hook fall arrest system, the slider hook must run freely in the rail while ascending and descending the tower. Never touch the slider hook while climbing/descending. Otherwise there is a danger of injury!

- Both hands must be kept free during the ascent or descent. Tools, lubricants and other material may only be transported in a suitable bag. Permanent "3-point contact" with the ladder is only guaranteed by this means.
- Greater care needs to be exercised when climbing the ladder in wet conditions or if the tower is covered in ice.
- Only unhook the lanyard after you have reached the tower platform and the access hatch has been closed.
- Ensure that you are always protected by at least one lanyard with a fall arrest block.
- The rest platforms in the tower are fitted with hatches that must be kept closed at all times. The platform hatches must therefore be opened on reaching a platform and closed again immediately after crossing to the next section of the tower.

10.4 Deactivation of the Yaw Drive

Yaw stop switches are located in the tower base, below the nacelle and on the top box in the nacelle. The yaw drive and the automatic nacelle adjustment are disabled in the "Off" switch position, so that the nacelle is technically prevented from moving if there is a change in wind direction.

10.5 Entering the Nacelle

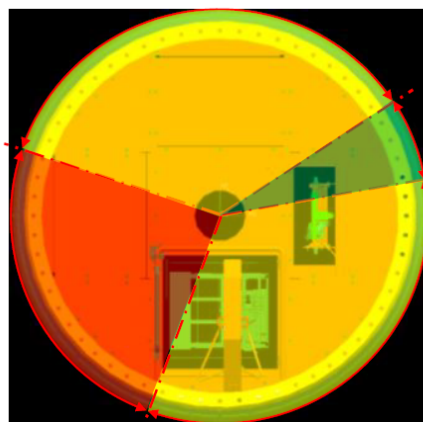
Before entering the nacelle, the machine head have to be turned into a direction where at minimum one ladder can be accessed safely. The appropriate angles are shown in the sketches below:

Nacelle Entrance Ladder

Nacelle Yaw Positions with Nacelle Entrance Ladder Conflicts

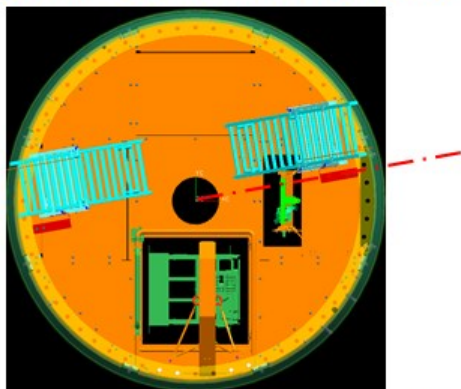
• **Summary:**

- ~88° arc with both ladders blocked ■
- 123.5° + 125° arcs with one ladder accessible ■
- ~23.5° arc with both ladders accessible ■

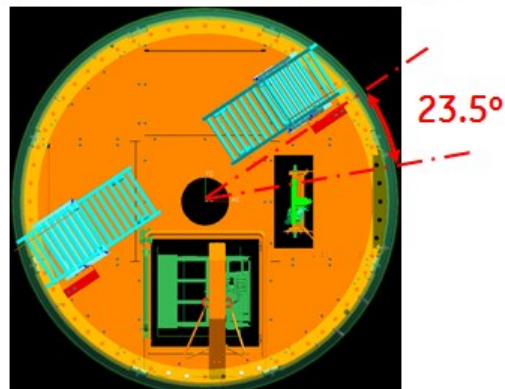


Reference mark indicates right side of nacelle, as seen facing upwind (upwind is 90° CCW of the reference mark)

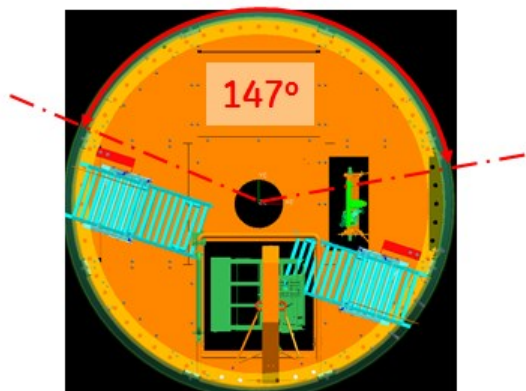
Start point – both ladders accessible



End point – both ladders accessible
Start point – one ladder accessible



End point – one ladder accessible
Start point – no ladder accessible



End point – no ladder accessible
Start point – one ladder accessible

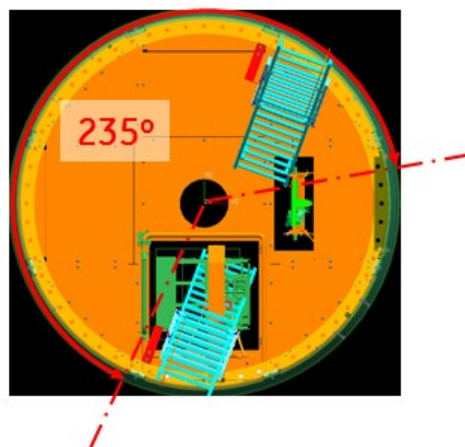


Fig. 33: Nacelle Entrance Ladder

After the ladders are in a safe position as shown above the yaw stop switch on the uppermost tower platform must be placed in the "Off" position before crossing from the tower to the nacelle. The yaw drive and the automatic nacelle adjustment are thereby disabled.

Depending on the position of the nacelle, the available simple ladder is hooked into one of the holders to prevent the ladder from slipping. Some of the WTGS are provided with a permanently installed extension ladder.

When working in the nacelle or in the hub in half-light or darkness always carry a flashlight.

Hooking points are available in the vicinity of every platform.

10.6 Nacelle Walkway and Working Platforms

All platforms in the nacelle enclosure are rated for distributed loads of 300 kg/m² or a point load of 150 kg on a 200 mm x 200 mm area of any given panel. Note that the point load limit includes personnel weight, PPE and any additional load carried. Do not overload the platforms!

10.7 Walking on the Roof of the Nacelle



Falling Hazard! Warning: strong wind currents!

Before climbing out of the nacelle enclosure through the roof hatch above the gearbox, the lanyard must be hooked on to the nearest hooking point on the nacelle.



Danger!

The roof rail is to be selected as a hooking point for all other work on the roof of the nacelle.

For the BTP nacelle, the roof rail has been properly designed and tested to support 2 people, however the individual hooking points are for 1 person only.



Danger!

Falling Hazard!

Do not overload the roof of the nacelle enclosure! It is rated for max. 300 kg/m² or 150 kg on 200 mm x 200 mm. A maximum of two persons at a time may stay on the nacelle roof.

Only one person at a time may be tied off to each of the hooking points on the nacelle roof or to the roof rail respectively.

The roof of the nacelle may only be walked on to enter the rotor hub and for carrying out work on the wind vane, the anemometer or the obstruction lights. Only trained or oriented personnel are permitted to work on the roof of the nacelle. Work on the roof of the nacelle is only allowed up to maximum wind speeds of 15 m/s.

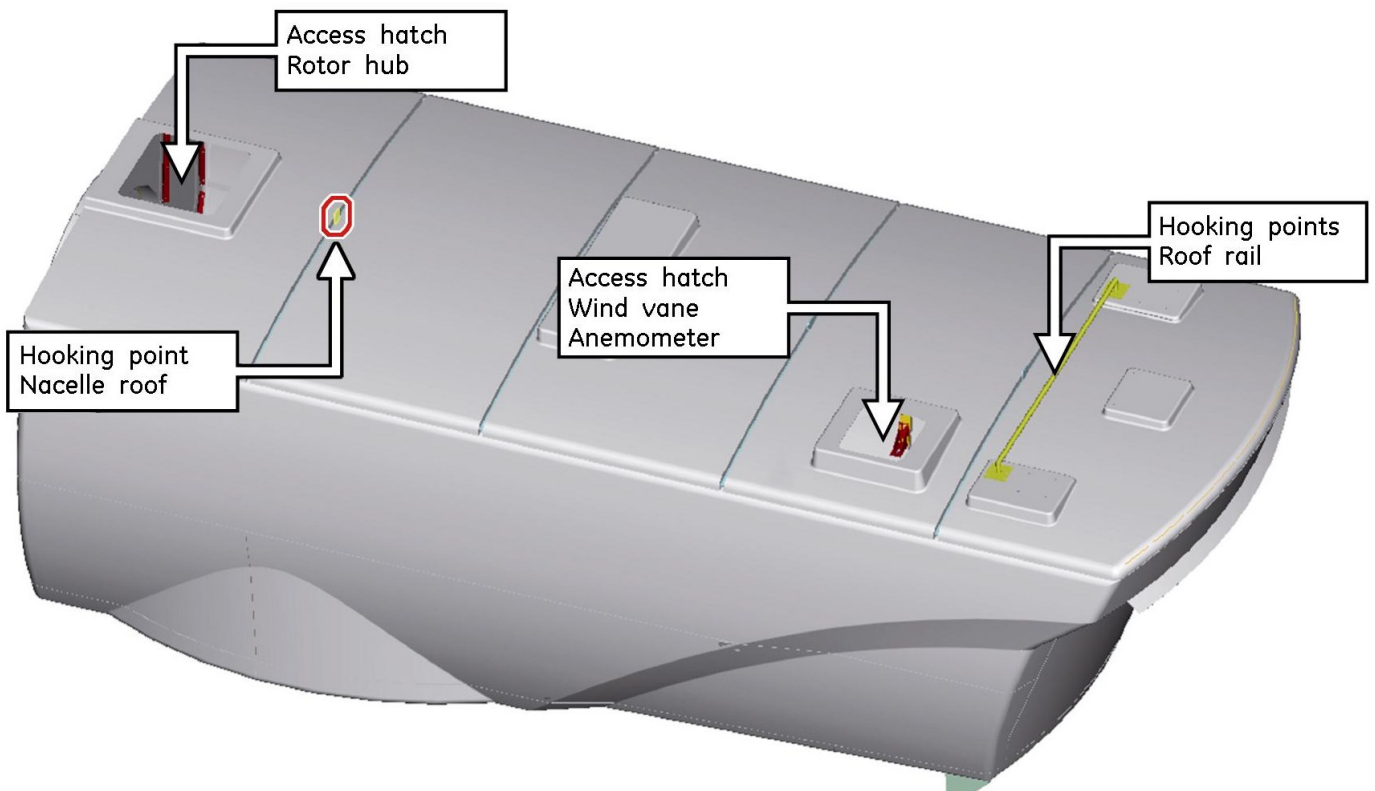


Fig. 34: Modular nacelle enclosure

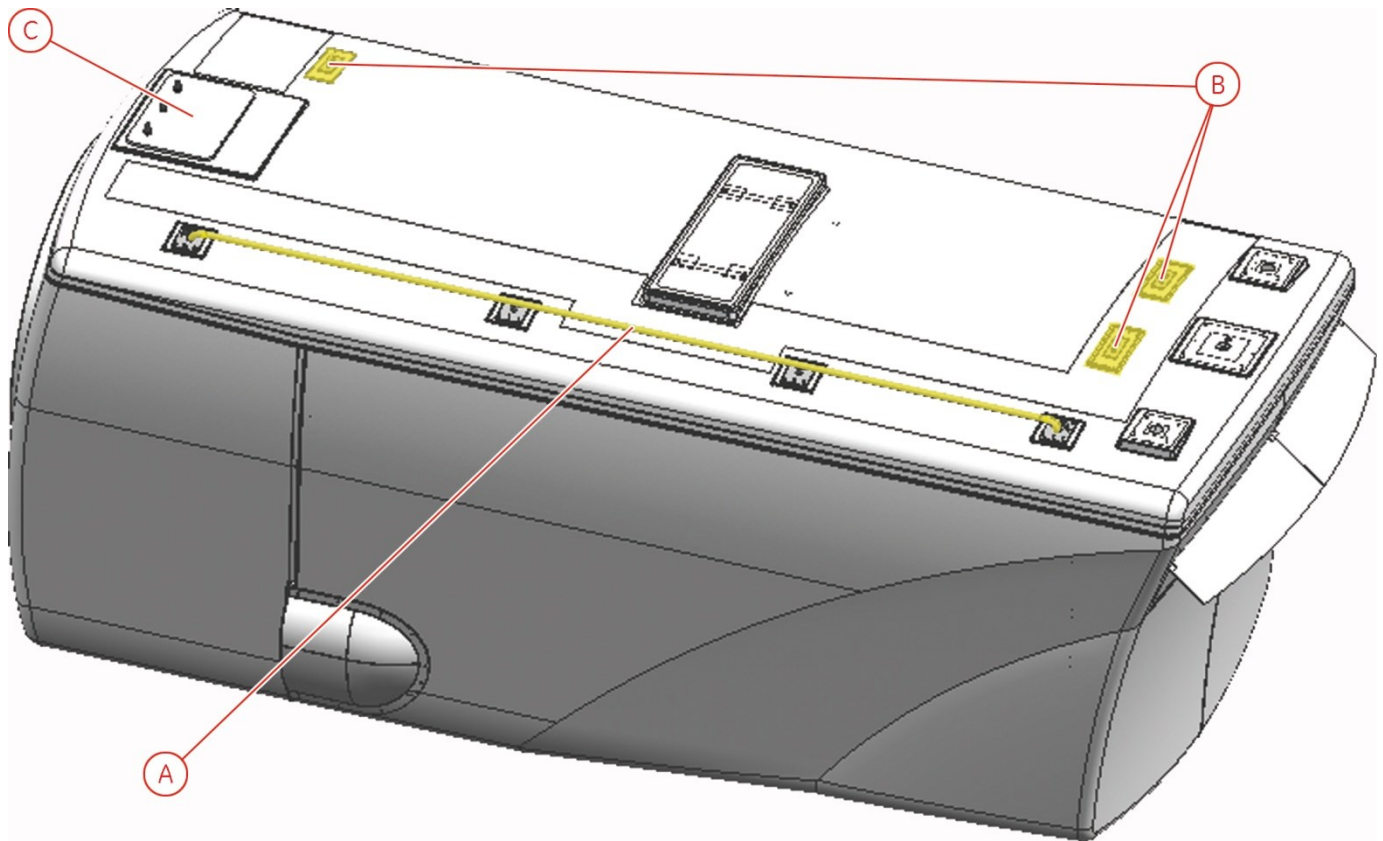


Fig. 35: BTP nacelle enclosure

- A – safety anchoring rail
- B – hooking points nacelle roof
- C – access hatch near rotor hub

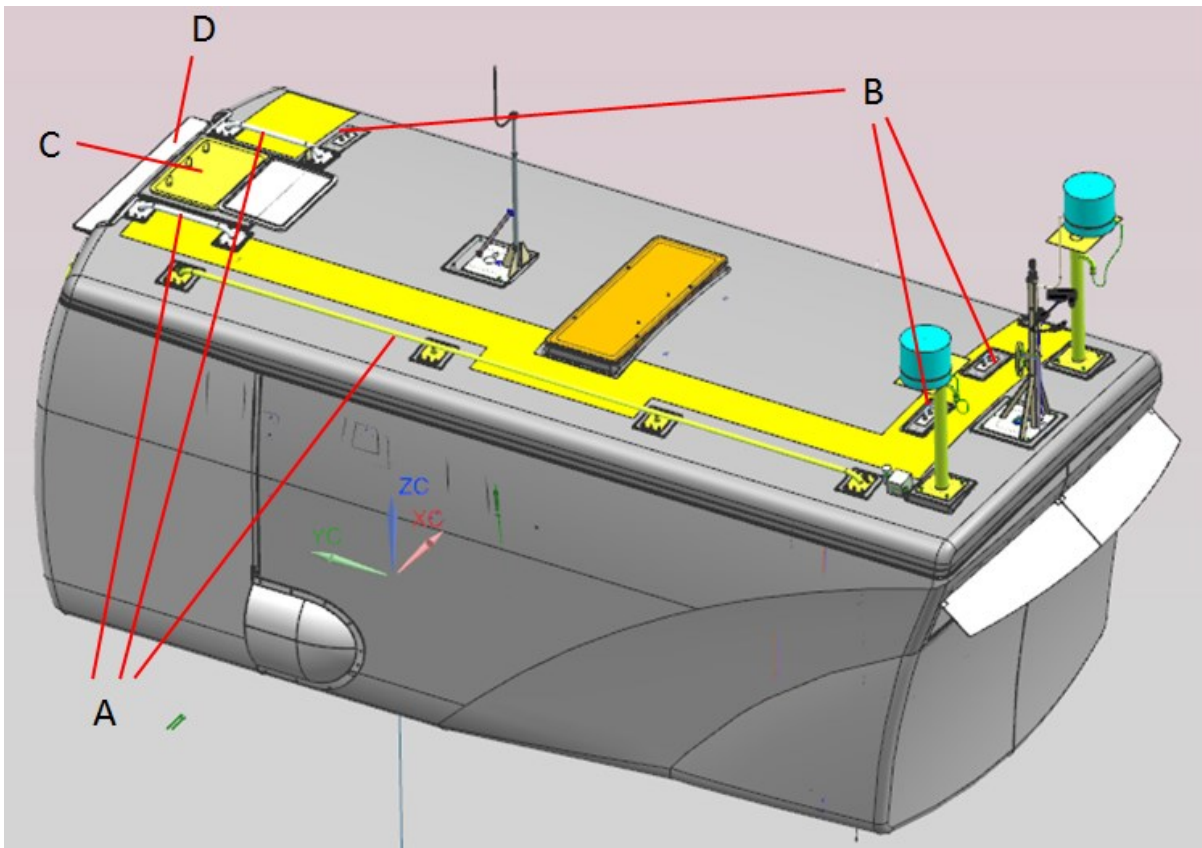


Fig. 36: BTP nacelle enclosure

A – safety anchoring rail

B – hooking points nacelle roof

C – access hatch near rotor hub

D – step for rotor hub access

Walking on the Roof with Ice and Snow

If you have to walk on the roof of the nacelle or climb into the hub, first of all ensure that the rotor blades are in the Y-position before you open the hatch. Otherwise there is danger of injury from falling pieces of ice.

Danger of Slipping and Falling Hazard as a result of icy conditions!



Danger!

There is a high risk of slipping and falling if the roof of the nacelle and the spinner/hub are covered by snow and ice.

Completely remove any snow and ice from the roof before walking on it. Sprinkle sand on the cleared areas

Do not walk on the roof/spinner/hub if the snow and ice cannot be removed completely and the danger of slipping cannot be excluded.

10.8 Entering the Rotor Hub

Maintenance work inside the hub may only be carried out at wind speeds (10 min average value) up to

- 100/103 m rotor: 14 m/s
- 120/130/137 m rotor: 12 m/s



Warning!

Always engage one of the rotor locks.

To engage the rotor lock follow the instructions given in Chapter 6.2 Rotor Lock on page 30.

FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!
(cf. Chapter 12)



Falling Hazard! Warning: strong wind currents!

Before climbing out of the nacelle enclosure through the roof hatch above the gearbox, the lanyard must be hooked on to the rail on the spinner (machines with spinner) or on to the rail on the nacelle (machines without spinner).



Danger!



Danger!

Danger to health or life when entering a confined space!

The hub is considered a confined space. Review and follow the High Risk Operations Procedure HS13.1 "Confined Spaces Entry" if you need to access to this area.

Only trained or oriented personnel are permitted to enter the rotor hub. The hub may only be entered at wind speeds (10 min average value) up to

- 100/103 m rotor: 14 m/s
- 120/130/137 m rotor: 12 m/s

10.9 Activation of the Wind Turbine Generator System



Danger!

Danger of accident!

The WTGS must remain shut down as long as personnel are in the plant. Before it is returned to service by authorized personnel, check without fail that nobody is in the plant. Otherwise the danger of an accident arises!

Proceed as follows to return the WTGS to service:

1. Make an entry in the service life card of the WTGS.
Read the yield in the menu "WTGS data" / Yield data / and enter in the service life card.
2. Check that no errors are present.
3. Press the "Reset" button and than the "Start" button.
4. Switch off "Repair/Maintenance" mode.
5. For Standard Bachmann units only (without web pages): Activate the remote monitoring program:
 - Telephone list
Activate the checkbox in the menu "Configuration" / "Call list" / and confirm.
 - PC
Activate the checkbox in the menu "Configuration" / "PC" /.
 - SMS
Activate the checkbox in the menu "Configuration" / "SMS" /.
 - Cityruf paging service
Activate the checkbox in the menu "Configuration" / "Cityruf" /.
 - Fax
Activate the checkbox in the menu "Configuration" / "Fax" /.

NOTE: Line 3 not applicable to WTG without a Turbine PC

6. Initiate a test alarm in the Main Menu / Service Functions -> "Send Test Alarm".
7. Inform the remote monitoring division and check that the test error arrives.
8. Inform the operator / customer.

11 Information on Maintenance and Troubleshooting

Only trained or instructed staff may be deployed!

Trainee personnel or personnel undergoing orientation or general training may only carry out work on the wind turbine generator system under the constant supervision of an experienced person.

Personnel must familiarize themselves with the work environment around the wind turbine generator system before starting work!

As it is possible to start the plant by means of the remote monitoring system, the WTGS must be shut down for maintenance work as described in Chapter 10.2 Shut-down of the Wind Turbine Generator System on page 61. In addition, the service switch on the control cabinet must be placed in the "Maintenance" or "Repair" position. Once the maintenance or repair work has been completed, the service switch must be returned to the "Automatic" position.

Maintenance/inspection of the cable winch in the tower is the responsibility of the operator and must be carried out in accordance with the operating and maintenance instructions of the supplier of the cable winch.

Time limits for recurring tests/inspections prescribed or stated in the operating manual must be adhered to.

Suitable workshop equipment is essential for carrying out maintenance measures.

Work on electric equipment of the WTGS may only be carried out by a skilled electrician or a equipment specific trained technician (US), or by instructed persons under the guidance and supervision of a skilled electrician in accordance with the electrical engineering regulations.

Personnel may only enter the blades after finishing a training on the Blade Rescue Procedure.

Any safety equipment which has to be dismantled to carry out maintenance and repair work must be re-installed and checked immediately after the maintenance and repair work has been completed!

The wind turbine generator system, in particular the connections and bolted connections, must be cleaned of any oil, consumables and process materials, dirt or old preservative agents at the beginning of any maintenance/repair/conservation work.

Only entrust experienced persons with the fastening of loads.

Individual components and larger modules which need to be exchanged must be carefully attached and secured to lifting gear, in order to minimize the danger that emanates from them. Only use suitable lifting gear and load suspension devices which are in a technically perfect condition and have an adequate load bearing capacity!

Follow the operating instructions of the winch manufacturer.

Never stay or work below suspended loads.

Use the specified or other safe ascent equipment and working platforms to carry out installation work above head height. Wear fall protection equipment when carrying out maintenance work at great heights. Keep all handles, steps, safety rails, platforms, stages and ladders free of dirt.

Ensure that consumables and process materials and replacement parts are disposed of safely and in an environmentally-friendly manner!



Attention!

Fire Hazard!

As a principle the storage of combustible and easily flammable material in the wind turbine generator system is **not** permitted.



Danger!

Risk of Damage to the Wind Turbine Generator!

The rotor lock and the high speed shaft brake must always be released before leaving the turbine. Make sure that the machine is idling.



Danger!

Risk of Damage to the Wind Turbine Generator!

After finishing work on the high speed shaft brake, make sure that the pressure on the hydraulic system of the brake has been released. Check that the pressure gauge reads 0 bar.

11.1 Hot Work

11.1.1 Scope

This chapter provides items to consider when hot work must be accomplished. Since the need to accomplish hot work can be the result of many scenarios, this chapter is not a detailed plan for accomplishing hot work. The involved maintenance team and/or facility owner should use this as a source of information to assist in development of the specific safe work practices and supporting documents required to authorize hot work activities. In all cases, work shall be conducted in accordance with the applicable corporate and governmental health and safety rules and regulations, the site safety plan, and a hot work permit.

Given the inherent risks to personnel and equipment, alternatives to hot work should be fully considered and be given preference wherever possible.

11.1.2 Preparation

Once the need for hot work is identified, a team of the appropriate personnel should be assembled to conduct an evaluation of risks and countermeasures. This team should also be charged with identifying, where possible, alternatives to hot work:

Identify the actual hot work to be accomplished:

- welding - creates sparks, slag, fumes and heat
- cutting - creates sparks, slag, fumes and heat
- grinding - creates sparks, fumes and localized heat
- other

Identify the location of the work:

- down-tower
- up-tower
- machine head
- other

Identify the potentially ignitable materials within the expected hazard zone created by hot work sparks, slag and heat:

- composite materials (e.g., fiberglass)
- insulation
- lubricants
- other

Define the protective measures to be implemented prior to initiation of hot work:

- removal of excess lubricants
- installation of fire blankets/fire shields
- deployment of hand-held fire extinguishers (optional feature)
- assignment of dedicated "fire watch" personnel to monitor the operation (this may include a down-tower watch for up-tower hot work)

Define the work team size and Personnel Protective Equipment (PPE) requirements:

- consider the available space at the work location
- ventilation versus fume masks versus air line respirators

11.1.3 Documentation

A hot work permit should be issued for the duration of the work, posted in the work area, and filed upon completion of the hot work.

The appropriate documentation of the repair/hot work is to be filed upon completion of the work.

12 Power Disconnection and Isolation Procedures (Lockout/Tagout Instructions)

Pursuant to EN 50308 and OSHA standard 29 CFR 1910.147, wind turbine generator systems must be equipped with devices to disconnect and isolate them from all their energy sources during inspection and maintenance work.

These disconnecting/energy-isolating devices are prescribed for all mechanical, electrical and hydraulic energy sources.

GE Renewable Energy advises the plant operator/owner to develop specific procedures for the power disconnection and isolation of every individual subsystem.

Local and national regulations must be taken into account when developing workplace-specific Lockout/Tagout instructions.

The disconnection/isolation points are marked in the plant-specific circuit diagrams and hydraulic schematics, which are supplied with the respective WTGS.

Procedures for the Lockout/Tagout of power disconnection and isolation devices must consider the following aspects:

12.1 Identification of Installations, Processes, Circuits

- Individual mechanical,
- electrical or
- hydraulic subsystems

12.2 Preparation for Shutdown/Notification of Affected Employees

All personnel who may be affected must be notified before Lockout/Tagout devices are installed and after they have been removed. In addition to this procedure, authorized employees must be aware of any additional safety requirements prescribed for working on this type of equipment.

Affected employees who work on or near an installation, which is about to be disconnected, and on which Lockout/Tagout devices are to be mounted must be notified thereof.

12.3 Identification of Energy Sources and Strengths

- electrical
- hydraulic
- mechanical

12.4 Deactivation of Energy Sources and the Mounting of Energy Control Devices

The power disconnection and isolation devices (e.g. disconnecting switches or load interrupter switches, valves etc.) must be positioned in such a way that they interrupt the energy flow to installations, processes or circuits. The authorized employees are obliged to mount and secure Lockout/Tagout devices to these. They must hereby ensure that the power disconnection and isolation devices are "locked out" until further notice and remain in their safety or "Off" position.

12.5 Control of Stored Energy



Danger!

Residual risks from stored energy!

FOLLOW THE RESPECTIVE LOCKOUT/TAGOUT INSTRUCTIONS!
(cf. Chapter 12)

The authorized employee must ensure that all potentially hazardous energy in any form (stored, residual, chemical or potential energy) is relieved, dissipated, contained, discharged or otherwise controlled. Additional measures may be necessary to prevent the re-accumulation or re-storage of energy, in order to protect personnel. Stored energy can form e.g. in batteries, capacitors, through gravity or in chemical lines.

12.6 Verification of Isolation

The authorized employee must verify that the isolation and de-energization of the respective installation, process or circuit has actually been carried out before maintenance work may be started. The check must confirm that the installation, process or circuit has achieved a "zero" energy state. (Test equipment, circuit activation attempts, measuring devices, visual inspections, etc. can be used to verify the zero energy state.) The check must start with a visual inspection of the status of the isolation device.

12.7 Reconnection of the Installation to the Supply

The authorized employee must carry out the following measures before returning the installation to service:

- Inspection of the work area to ensure that all items which are not required for the operation of the installation have been removed and that all the guards have been replaced, that the machine/installation, process or circuit is operational and that all personnel are in a safe location.
- Removal of all locks, tags and other Lockout/Tagout devices from all power disconnection and isolation devices by the authorized employee who previously attached these LOTO devices.
- Notification of affected personnel that the energy supply is about to be restored to the machine/installation, process or circuit.
- Visual inspection and/or cycle test to verify that the service or maintenance work has been successfully completed. Provided that the work has been completed, the machine/installation, process or circuit may be returned to service. Otherwise, the requisite procedural steps must be repeated.
- Correct sequential run-up of the installation, process or circuit.

WTGS operators must ensure that suitable disconnection regulations are available for their plants and construction sites and that they are implemented. GE Renewable Energy has developed installation-specific Lockout/Tagout procedures for the activities listed below. This list does not claim to be complete, however. It may be advisable to develop additional procedures as a result of changes to installations or to comply with construction site-specific disconnection regulations.

ANNEX: Items and Installations which are subject to Inspection pursuant to the Accident Prevention Regulations

Article to be tested	Test before the initial operation	Exceptional tests	Regular tests	Proof of test	Regulations
Winches	To be checked by a technically competent person		Regular check by a technically competent person in accordance with the manufacturer's instructions and operational conditions.	Inspect and test log book and inspection sticker	Manufacturer's instructions
Doors Emergency exits	To be checked by a technically competent person. Doors must be executed so that they are self-closing, open in the direction of escape and can be easily opened from the inside at all times without auxiliary means.		Regular check by the operator. Once a year by a technically competent person.	Documentary evidence	Manufacturer's instructions
Escape routes			In case of danger, the work areas must be able to evacuated via escape routes or escape equipment. It must be ensured that at least one escape route can also be used in the case of a power failure. Escape routes or escape equipment are: routes via ladders and abseiling devices.		
Hoisting passenger suspension device	To be checked by an expert. In addition to the experts of the Technical Inspection Association (TÜV), only experts for the inspection of hoisting passenger suspension devices who are authorized by the trade association are considered to be experts for the purposes of this safety regulation. The operator must ensure that a test run is carried out at the installation location in all directions of movement with the working load of the passenger suspension device in the presence of the supervisor before the initial operation.	The operator must ensure that hoisting passenger suspension devices are subjected to an exceptional test by a qualified person after cases of damage or particular events which could affect the carrying capacity, as well as after any repair work.	All components of the hoisting passenger suspension device must be inspected for operational safety by a technically competent person at least once a year. Shorter test intervals may arise as a result of the service conditions. The manufacturer's instructions are to be followed.	Documentary evidence	Manufacturer's instructions
Fire extinguishers (optional feature)			Regular check by a technically competent person or expert in accordance with the national regulations.	Inspection sticker or test report	

Article to be tested	Test before the initial operation	Exceptional tests	Regular tests	Proof of test	Regulations
Personal protective equipment against falling (safety harness)	Inspection of the fall protection rail by a technically competent person.		Users must check the PPE for its proper condition and reliable operation before it is used. A technically competent person must inspect the PPE for perfect condition at regular intervals. The manufacturer's instructions must be followed.	Inspect and test log book, inspection sticker	Manufacturer's instructions
Abseiling device	To be inspected by a technically competent person.	To be inspected by a technically competent person after any use.	Users must check the abseiling device for its proper condition and reliable operation before it is used. A technically competent person must inspect the abseiling device for perfect condition at regular intervals. The manufacturer's instructions must be followed.	Inspect and test log book, inspection sticker	Manufacturer's instructions
Ladder		A technically competent person checks the orderly condition of mechanical ladders after any alterations or repairs.	A technically competent person checks the orderly condition of the ladders and steps once a year. Irrespective of this, the user must check the suitability and condition of the ladders before use. The manufacturer's instructions are to be followed.	Inspect and test log book, inspection sticker	Manufacturer's instructions
Electrical equipment	Check by a qualified electrician or under the supervision of a qualified electrician. (Also after alteration or repair) The test before the initial operation in accordance with Section 1 is not necessary if the manufacturer or installer confirms that the electrical installations and equipment are designed to comply with the provisions of this accident prevention regulation.		At specified intervals: The intervals are to be calculated in such a way that any defects which can be expected to arise are found in due time. The relevant electrotechnical regulations are to be complied with for the check. At the request of the trade association, an inspection and test log book with specified entries is to be kept. The manufacturer's instructions are to be followed.	Inspect and test log book	Manufacturer's instructions
First aid box (optional feature)	Pursuant to the Law on Medical Devices, which has been in force since 1st January 1995*, bandaging materials must have a CE-marking but do not have to have a use-by date. If a use-by date is stated, however, the Law on Medical Devices prohibits further use after expiry of the use-by date under penalty of a fine. First aid material without a use-by date must only be replaced in the event of soiling or damage. With the exception of plaster material, it remains usable over a long period, provided that it is stored in a clean and dry place.				