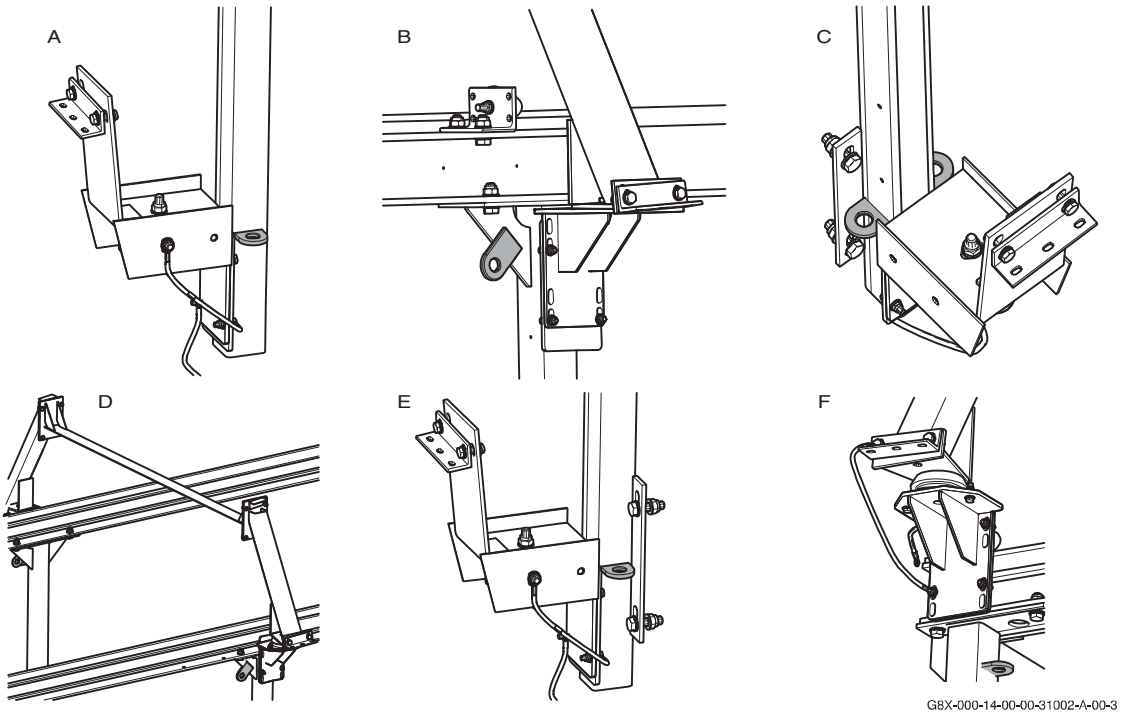

Figure 27: Close-up of the anchor points

4.5.3 ANCHOR POINTS AT THE TOWER

There are towers with certified anchor points. These are located on the middle and top platforms.

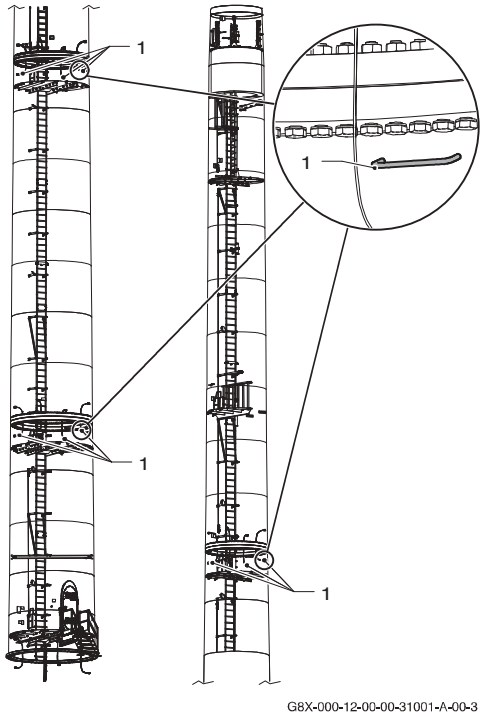

Figure 28: Anchor points at the tower

4.6 LIGHTING

The wind turbine lighting must have a minimum luminance level of 50 lux over the work area and lighting must be available in areas where inspection and maintenance tasks are carried out.

The guide and emergency lights must have a minimum of 10 lux.

More restrictive values may be required depending on the task to be carried out and legislation in effect. In this case, the workers must be equipped with auxiliary illumination; to this end, the wind turbines are equipped with plugs in the work areas.

5 WEATHER CONDITIONS

5.1 WIND CONDITIONS

In the event a discrepancy arises between the wind speed limit as defined by GCT and that defined in the crane manufacturer's manual, the following procedure applies:

- If the crane manufacturer's manual indicates that the suspension of loads is prohibited at wind speeds which are less than those set forth by GCT, the limit established by the manufacturer will always prevail.
- If the manufacturer's manual recommends that the operations be limited to speeds inferior to those set forth by GCT, the criteria to follow as to the operation will be to act per that established by the crane manufacturer, based upon specific conditions, and always obeying the limit established by the automatic load lifting limiter with which the crane is equipped.

5.1.1 WIND SPEED LIMITS FOR GENERAL ACTIVITIES

WORKS TO BE CARRIED OUT	G8X-G9X MAX. SPEED
Access to the turbine	Nacelle 20 m/s
	Lower platform 25 m/s
Locking of the Rotor	12 m/s
Active. General Start-Up Activities	12 m/s when locked
	20 m/s when unlocked
Works outside on the Nacelle roof	12 m/s when locked
	15 m/s when unlocked
Operations inside the cone	12 m/s
Works with basket	12 m/s
Works from the hanging platform outdoors	10 m/s
Vertical Jobs	12 m/s outdoors
	20 m/s indoors
Use of the Hoist	20 m/s
Use of elevators with towrope guides	18 m/s
Use of elevators with fixed, metal guides	20 m/s
Use of HELPCLIMBER LW-50 Helper	15 m/s
Use of TRACTELIFT Helper	20 m/s
Use of CLIMB ASSIST AVANTI Helper	20 m/s
Use of POWER CLIMBER IBEX Helper	15 m/s

Table 2: Wind Speed limits for general activities

5.1.2 WIND SPEED LIMITS FOR ASSEMBLY ACTIVITIES

WORKS TO BE CARRIED OUT	G8X-9X MAX. SPEED
Unloading of sections with one crane	15 m/s
Unloading of sections with two cranes	20 m/s
Unloading of blade cages with one crane	15 m/s
Unloading of blade cages with two cranes	20 m/s
Blade unloading from the cage	18 m/s
Unloading of the hub	20 m/s
Unloading of the Nacelle.	N/A
Assembly of lower sections	18 m/s
Assembly of intermediate sections	18 m/s
Assembly of upper sections	15 m/s
Assembly of Nacelles	15 m/s
Assembly of blades on the ground	18 m/s
Assembly of rotor unit on the Nacelle	12 m/s
Assembly of blades (blade-blade procedure)	14 m/s
Assembly of hubs (blade-blade procedure)	18 m/s

Table 3: Limit Wind Speeds for ASSEMBLY operations

5.1.3 WIND SPEED LIMITS FOR MAINTENANCE ACTIVITIES

WORKS TO BE CARRIED OUT	G8X-G9X MAX. SPEED
Inspection and Repair of Nacelle Elements	12 m/s when locked
	20 m/s when unlocked
Predictive Maintenance	12 m/s when locked
	20 m/s when unlocked
Preventive Maintenance Outdoors	12 m/s when locked
	15 m/s when unlocked
Preventive Maintenance at Hub	12 m/s
Preventive Maintenance at Nacelle	12 m/s when locked
	20 m/s when unlocked
Preventive Maintenance rest of the Tower	20 m/s
Disassembly of the Transmission Shaft	12 m/s
Pitch Control System	12 m/s
Replacement of Brake Elements	12 m/s
Replacement of the Rotor (Hoisting)	12 m/s
Replacement of the Nacelle	15 m/s

WORKS TO BE CARRIED OUT	G8X-G9X MAX. SPEED
Replacement of the Generator	12 m/s
Replacement of the *TOP* Control	12 m/s
Replacement of the Ring	12 m/s

Table 4: Limit Wind Speeds for MAINTENANCE operations -1

WORKS TO BE CARRIED OUT	G8X-G9X MAX. SPEED
Replacement of the Blades	14 m/s when using yaw gearbox-motor
	12 m/s without using yaw gear motor
Replacement of the Gearbox	12 m/s
Replacement of the Switchgear or *GROUND*	15 m/s
Replacement of the Anemometer or Wind Vane	15 m/s

Table 5: Limit Wind Speeds for MAINTENANCE operations -2

NOTE:

In the event a discrepancy arises between the wind speed shown by the anemometers of the wind turbine and the crane, the valid reading will be that of the latter.

5.2 WEATHER CONDITIONS

When lack of visibility due to fog affects the suspension of loads with a crane, the situation must be evaluated to make sure that at all times there is sufficient visibility for hoisting the loads and in the storage areas or those along which the operation is to be carried out. The Director of the Maneuver, Prevention Director and the Crane Driver must all agree that the operation may be effectuated, considering that the Crane Driver is the person who will evaluate the possibility of performing the task.

The wind turbine should be abandoned in the risk of electrical storm, and even the wind farm itself if the substation does not offer sufficiently safe conditions for seeking refuge therein.

In the case of strong winds, hold the tower door firmly when opening it, do not stand in the door aperture and check that no one else is there either.

5.2.1 WORKS WITH ICE AND SNOW

If the client has procedures for operations (validated and approved by GCT), the tasks will be carried out in compliance with the indications described in the document. In case no such procedure is available, the following indications must be followed:

- Access the wind farm when the access may be done with a four-wheel drive vehicle without using chains, though these must be available in the vehicle and their use is restricted to the evacuation from the farm in the event of needing to abandon it due to a worsening of weather conditions. In the event of being in the process of assembly or maintenance and a worsening of weather conditions is appreciated, operations must be suspended immediately and the wind farm evacuated.

  NOTE:

  While circulating within the wind farm, traffic rules and signs established by the owner must be obeyed, and when these do not exist, under adverse weather conditions (fog, snow, intense rain, ice, etc.) or the condition of the road is not optimal, circulation speed is limited to a maximum of 20 km/h

- Access to the farm is prohibited, even if it is possible with an off-road vehicle, when the road limits are not visible due to snow accumulated on them, or even when a part of the road had been cleaned if the limits of the clean area are not visible either.
- When there is ice on the wind turbine blades, carry out the maintenance operations in the manner indicated in the procedure G8X–G9X–03–00–00–00–0–34Z–1–F

Whenever there is evidence of ice on the wind turbine's blades, whether detected through direct observation or revealed by the activation of the alarm indicating the presence of ice, access to the farm for carrying out maintenance operations on the wind turbines must be done as described below:

5.2.1.1 GENERAL WIND FARM ACCESS

During travel to the wind farm where the tasks are going to be carried out, it is possible that other farms will be passed through which sometimes are not controlled by *GCT* remote control. In the event ice is detected on the blades and no special vehicle is available, circulating on wind farm access roads is forbidden until there is visual evidence that there is no longer ice on the blades.

In the event that one is at the substation at the center of the farm branches and the remote control fails which impedes stopping the wind turbine remotely in case of ice on the blades, and no special vehicle is available, circulating on wind farm access roads is forbidden until the ice on the blades has dissipated completely or the remote control is reestablished and the wind turbine may be stopped.

5.2.1.2 ACCESSING THE FARM WITH A SPECIAL VEHICLE

Put the wind turbine to be worked on as well as the preceding and following ones in pause mode, whether from the substation or the operations center.

NOTE:

Do not start up these turbines while the task is being carried out and while operators have not yet returned to the substation or abandoned the farm. The wind turbines preceding and following the one being worked on may be started up if the operators responsible for carrying out the tasks indicate doing so. Tasks remain restricted to those which may be performed inside the wind turbine.

Should it be necessary to access the exterior of the tower, stop the wind turbine until the personnel has returned inside the tower or exited the wind farm.

The start-up of the wind turbines adjacent to the one worked on may only be done at the request of the workers who operate the wind turbine. If there is no coverage, the start-up of these wind turbines may not be done.

5.2.1.3 ACCESS TO THE FARM WITH A NORMAL VEHICLE

Set all of the wind turbines found along the route to the one to be worked on in pause mode, whether from the substation or the operations center and including the preceding and following ones.

NOTE:

In the event of different branches in the farm, in addition to the preceding and following wind turbine to the one being worked on, all of those wind turbines which are within a distance less than 200 meters from the one subject to operations must be set in pause mode.

After accessing the wind turbine, the rest of the turbines - excepting the one being worked on, and the preceding and following ones - may be started up again.

NOTE:

Do not put these turbines into operations while the task is being carried out and while operators have not returned to the substation or have abandoned the farm. The wind turbines preceding and following the one being worked on may be started up if the operators responsible for carrying out the tasks indicate doing so. Tasks remain restricted to those which may be performed inside the wind turbine.

Should it be necessary to access the exterior of the tower, stop the wind turbine until the personnel has returned inside the tower or exited the wind farm.

The start-up of the wind turbines adjacent to the one worked on may only be done at the request of the workers who operate the wind turbine. If there is no coverage, the start-up of these wind turbines may not be done.

Once the maintenance tasks have been completed, put in pause mode all of the wind turbines found along the route to the substation or outside of the park.

6 TASKS UNDER SPECIAL CONDITIONS

6.1 WORKING WITH THERMAL STRESS:

- Prior to starting the tasks in the wind turbines, check the temperature inside the nacelle or outside (ambient temperature) depending on the area in which the tasks are being performed. This temperature check must be done from the control unit of the substation or the touch screen in *GROUND* cabinet, observing the values on the ambient PT100 and nacelle or base PT100 temperature probes.
- Once the temperature is known, the tasks may be performed, as long as the safety measures corresponding to the temperature range present at the moment are observed:
  - **T ≤ -5ºC:** Workers may only carry out planned tasks, as long as the work clothes worn is defined to protect up to a temperature lower than that present during operations, and as long as the equipment to be used are within the margin indicated by the manufacturer in its use and maintenance manual.

    NOTE:

    In these weather conditions, it is recommended to make pauses for hot drinks whenever possible, after notifying the yard supervisor and getting his approval. Follow the instructions in point "Figure 6.1.1 "

  - **-5ºC < T ≤ 28ºC:** Accepted temperature range to perform tasks without requiring any additional safety measures.
  - **28ºC < T ≤ 40ºC (35ºC with prolonged and direct exposure to the sun):** When the temperature of the work area is within this range, the tasks may be performed, as long as the indications contained in point "Figure 6.1.2 " of this section are taken into account.
  - **40ºC < T (35ºC with prolonged and direct exposure to the sun):** When the temperature in the area is above this limit, the tasks may only be carried out if the particular situation of the park has been analyzed and if the conditions under which the tasks are being performed have been clearly defined:
    - Exposure time.
    - Rest periods.
    - Physical load of the tasks to be performed.
    - Specific preventive measures for adaptation to these conditions.

6.1.1 TASKS PERFORMED AT LOW TEMPERATURES

- **HYPOTHERMIA: MEASURES TO TAKE INTO ACCOUNT TO PREVENT IT AND ACTIONS IF NECESSARY.**
  - Below are a series of instructions to recognize if a worker is suffering from hypothermia, the measures to take in order to prevent it and the way to proceed in case it is present.
  - Hypothermia is an abnormally low body temperature. It is a dangerous condition caused when the body loses more heat than the one it may produce. It requires immediate medical attention.
  - In general, hypothermia is the result of the exposure to very cold temperatures. It may also occur at less cold temperatures if there is freezing wind, if clothes are wet or if the worker is placed in a position where he cannot move.
  - Generally, the persons most likely to suffer from hypothermia are:

- Elderly persons that do not have enough heat, food or clothes.
- Adults under the influence of alcohol or drugs.
- Persons that remain outside during long periods of time.

- In general, hypothermia symptoms happen gradually and, with time, they reduce mental and physical capacity. The main symptoms of hypothermia are: shivers, trembles, confusion, clumsiness, memory loss, slurred speech, drowsiness, irritability, hallucinations, slow breathing, cold and pale skin, muttering, tightness and disorientation.
- If the worker is shivering and stops doing it, and confusion and drowsiness increase, the situation is very dangerous, since hypothermia may be mortal.
- In order to prevent the workers from getting to this situation, below you may find a series of safety standards to take into account during the stay and the performance of tasks in the wind turbine:
  - Use the protective clothing adequate for the temperature you are going to be exposed to.
  - Protect yourself in a dry place when you are damp or shivering.
  - Do not drink alcohol.
  - Eat balanced food and remain hydrated.
  - Have hot drinks. In the case of taking bottles with hot drinks to the wind turbine, they must be taken in independent bags from those used for tools, chemical products... and must be correctly identified in order to prevent other workers from handling them or using the for a different purpose.
- If a worker is suffering from hypothermia, the first aid to apply is:
  - Take the affected person to a warm and protected area.
  - Warm his body temperature as soon as possible, beginning from the chest, neck, head and groin. If necessary, use skin-to-skin contact to share body temperature.
  - Replace his wet clothes for dry ones.
  - Help him exercise, if possible.
  - Give him warm drinks (non alcoholic) and feed him.
  - Take the accidented person to the doctor as soon as possible.

6.1.2 TASKS PERFORMED AT HIGH TEMPERATURES

- **HEAT STROKE: MEASURES TO TAKE INTO ACCOUNT TO PREVENT IT AND ACTIONS IF NECESSARY.**
  - During the summer, the temperature and humidity inside the wind turbine may be high because of: the exterior ambient temperature itself, heat generated by the wind turbine's components while operating, the use of certain necessary tools to carry out the tasks and the vicinity of coastal areas. Under these conditions, workers may suffer from an imbalance in the thermal control mechanism of the body, triggering a heat stroke.
  - In order to prevent workers from getting this condition, below are a series of safety standards to take into account while remaining inside and the performance of tasks in the wind turbine:
    - Make a natural ventilation leaving the nacelle roof hatchways open.
    - When possible, provide mechanical help to reduce the physical effort.
    - Drink fresh water frequently and in small quantities (every 15-20 minutes) during the task and after it. Do not wait until you are thirsty to drink. In the case of taking bottles with water, sodas... to the wind turbine, they must be taken in independent bags from those

used for tools, chemical products... and must be correctly identified in order to prevent other workers from handling them or using the for a different purpose.

- Decrease the intensity of the work or make periodical breaks in areas with less heat (perform brief and frequent work-break cycles). Organize yourself so that the tasks that require more physical effort are done in the moments with less heat during the day.
- Avoid eating too much and greasy foods; eat fruit, vegetables, have salt with the meals (in case of hypertension, see the doctor). Do not take alcohol (beer, wine, etc.) or drugs. Avoid caffeine drinks (coffee, cola drinks, etc.) and very sweetened drinks.
- Use fresh fabric clothes (cotton). Protect your head from the sun.
- Avoid driving if you are not completely recovered.
- Go to work well rested. Have a shower and refresh yourself after work.
- If you experienced disorders like cramps, syncopes and discomfort, stop the physical activity and rest in fresh places
- Workers with cardiovascular and respiratory diseases, diabetes, skin diseases, sweat gland diseases, renal insufficiency, gastrointestinal diseases, epilepsy and mental disorders are more vulnerable to heat thermal stress. Taking certain medications alter the natural thermal regulation of the body (antihistamines, antidepressants, tranquilizers, etc.)
- If a worker is suffering from a heat stroke, the first aid to apply is:
    - Take him to a fresh and ventilated place.
    - Take the unnecessary clothes away and give him air.
    - Refresh his skin with cold packs in the head, soaking the rest of the body with fresh water. If the worker begins to shiver, stop.
    - Fan the victim to lower his skin temperature.
    - Turn him around unless he is vomiting or convulsing, in this case put him sideways.
    - Place a soft object (clothes, pillow, cushion...) under his head.
    - If the worker is conscious and is not nauseous, give him liquids like caffeine-free drinks, isotonic drinks or water with salt (a teaspoon of salt each half liter of water).
    - Take the victim to the hospital.

6.2 WORKS IN CONFINED SPACES

Works in confined spaces are the ones performed inside the hub, the blades, and those that require getting inside the connection boxes with adverse natural ventilation, as long as the activity performed inside can generate an accumulation of flammable or toxic pollutants, or an atmosphere with not enough oxygen. In the case of any doubts, consult with the Maintenance Procedure Area and GCT & Health and Safety Department.

To carry out these operations, make a risk evaluation specific for the tasks to perform, and the presence of preventive measures will be necessary while doing it. In addition, it is mandatory to hold a written Work permit that defines the conditions under which it must be performed.

NOTE:

The access to confined spaces will be limited to AUTHORIZED WORKERS.

6.3 WORK DURING NIGHT SHIFTS

If inclement weather or the duration of the work shift imply a loss of visibility, clothes with highly visible, reflective elements must be worn.

When the work shift must be extended, the Health and Safety Coordinator and those responsible for safety in the participating companies must be informed in order to coordinate the activity.

Verify that there are no unmarked or unprotected horizontal openings (ditches, holes, electric cables). If this occurs, eliminate the risks generated.

Any operation different from the resetting of the wind turbine is prohibited from the lower tower platform. When it is necessary, an occupational risk assessment or Health and Safety Plan must be developed to include preventive measures and operations adopted, taking into account the following points:

- When working at night, adequate lighting must be ensured to enable work to be carried out in safe conditions.
- The illumination of work areas must allow workers to have adequate visibility conditions to enable transit throughout these areas as well as carrying out their tasks in these areas without risk to their health or safety.
- Lighting must be adequate for the type of task to be carried out, but in addition to the level of illumination, other important aspects must be considered, amongst which is the lighting control, uniformity, equilibrium of luminance within one's visual field, and integration of natural light.
- The visual demand required by the task is not the only factor to be considered when conditioning the lighting; it is also necessary to take into account if any workers have a visual capacity lesser than the norm, and the negative consequences to personal safety which may result from errors due to poor visibility. This may require an increase to the levels of lighting and an adaptation of other aspects related with illumination in accordance with criteria presented further on.
- Prior to carrying out assembly-related tasks during a night shift, effectuate a review and evaluation of the illumination levels offered by the auxiliary means used to guarantee that the minimum lighting level reached in those areas where work is to be done complies with the table 1 on Minimum illumination levels.

6.3.1 REGULATIONS APPLICABLE TO NIGHT SHIFTS

In accordance with legislation in effect in Spain, night shifts are those carried out between 10:00 pm and 6:00 am. A night-shift worker is one who dedicates, at least, three hours of the daily shift, or at least one third of the annual work time is performed during night shifts, per employment legislation. A company which regularly resorts to night shifts of its workers must communicate this to the labor authorities. For work carried out outside Spain, local legislation in effect must be complied with.

6.3.2 PREVENTIVE MEASURES

- At all times, the load to be manipulated and the crane hook must be fully visible by the crane operator and personnel who intervene in the maneuver. If this is not the case, the maneuver must be suspended.
- The illumination of each working area must be adapted to the characteristics of the task to be carried out there, bearing in mind:
    - The risks to health and safety of the workers who depend on visibility conditions.
    - The visual requirements of the tasks carried out.
- Whenever possible, the work areas must have natural lighting complemented by artificial lighting when the former, alone, does not guarantee adequate conditions for visibility. In these circumstances, preferably general artificial lighting should be used, complemented, furthermore, by localized lighting of specific areas which require higher levels of illumination.
    - The minimum levels of illumination of the work areas are set forth in the following table:

REQUIREMENTS OF THE TASKS	MINIMUM REQUIRED LEVEL (LUX)
Low	100
Moderate	200
High	500
Very high	1.000

Table: 6: Table of minimum illumination levels

- These minimum levels must be duplicated when the following circumstances concur:

1) In areas or installations for general use and on roads when due to their characteristics, condition or use present noticeable risks of falls, collisions or other accidents.

2) In working areas where an error of visual judgment during the realization of tasks may entail a danger for the worker who carries them out or for third parties or when the contrast of illumination or of color between the object to be visualized and the background against which it rests is very weak. Despite the preceding paragraphs, these limits will not apply when the nature of the activities to be carried out impedes them.

- More restrictive values may be required depending on the task to be carried out and legislation in effect. In this case, the workers must be equipped with auxiliary illumination (flashlight, front light...)
- The illumination of the area where a task is carried out shall be measured at the heights at which it is done; in the case of areas for general use at 85 cm measured as of the level at which the worker is, and in roads for the circulation of traffic the level of the same.
- In addition, the lighting of work areas must comply with the following conditions as regards its distribution and other characteristics:

  1) The distribution of lighting must be as uniform as possible.

  2) Try to maintain adequate levels and contrasts of illumination in accordance with the visual requirements of the task, avoiding sudden changes of lighting within a working area and between these and their surroundings.

  3) Avoid direct glare resulting of sunlight or sources of artificial light of high luminance. In no case shall these be placed unprotected within the worker's visual field.

  4) Likewise, avoid indirect glare produced by reflective surfaces located in the working area or its vicinity.

  5) Do not use light systems or sources which hinder the perception of contrasts, depth or distance between object in the working area, or that produce the visual impression of intermittency or which may result in stroboscopic effects.

- The working areas, or parts of these, in which a failure of the normal lighting may imply a risk to the safety of the workers, must have an emergency lighting system for evacuation and safety. To assure the perfect functioning of the auxiliary measures used (power generator set, generator, etc.), a person will be appointed as responsible for guaranteeing the supply of fuel, perfect conditions of the connections and their functioning.
- The lighting systems used must not produce electrical risks, fire or explosion, and must fulfill, to this effect, the provisions of specific legislation in effect.
- These auxiliary means used must be equipped with a minimum level of illumination which allows for safely evacuating the machine when there is a power drop, or all personnel participating in the operations be equipped with autonomous front lights which equally suffice this requirement of lighting for evacuating the machine.
- Any operation which is not included in this annex must comply with the following considerations prior to approval being granted by GCT for its execution:

  1) Previous acknowledgment of the tasks to be carried out: The purpose of this acknowledgment is to determine the areas or jobs which have deficient illumination or cause glare, for which the opinions of the workers must be gathered and a visit done to all areas implicated in the assembly work to be done. The information to be collected and registered is as follows:

     - diagram of the distribution of areas, lights, machinery and equipment;
     - description of the work processes;
     - description of the jobs;
     - number of workers per work area.

  2) Evaluation: As of the records of the inspection, and evaluation of the lighting levels, work areas and jobs must be done.

- The evaluation of lighting must be done during the workshift under normal operating conditions. It may be done by working areas, jobs, or a combination of both.

ACTIVITIES TO BE CARRIED OUT	MINIMUM LIGHTING LEVEL	TECHNICAL RESOURCES
Assembly/disassembly of the main crane	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Elevation cable assembly	500 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Crane movement	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Works inside the wind turbine	200 Lux	Lighting of the tower
Wiring of the tower	200 Lux	Lighting of the tower
Torque values	200 Lux	Lighting of the tower
Elevator assembly	200 Lux	Lighting of the tower
Assembly of Sections	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Hoisting of sections	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Reception of sections	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Retained on the ground	100 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Assembly of the nacelle	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Hoisting of the Nacelle	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Reception of the Nacelle	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Retained on the ground	100 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Assembly of the rotor	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Assembly of the rotor on the ground	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Hoisting of the rotor	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Reception of the rotor	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Retained on the ground	100 Lux	2 lighting tower (6 lights per tower, 1500 w each light)
Assembly of the rotor blade by blade	200 Lux	2 lighting tower (6 lights per tower, 1500 w each light)

Table: 7: Minimum illumination levels

6.3.3 TIME LIMITS FOR INITIATING REPAIRS

Below you can find the approximate time required for the performance of the different operations, in order to plan them without exceeding the workday marked by the existing regulations of the place where the wind turbine is or

will be. Also, always bear in mind that in case natural illumination is not the required to perform the operation, the artificial lighting devices defined in the previous point must be used.

MANEUVER TO BE PERFORMED	DURATION OF THE MANEUVER	OPERATION STATUS
Hoisting of the lower section	1 h	Section being lifted
Hoisting of the lower intermediate section	1 h	Section being lifted
Hoisting of the upper intermediate section	1 h	Section being lifted
Hoisting of the upper section + nacelle	3 h	Section being lifted
Hoisting of the hub	1 h	Load being lifted
Hoisting of the complete rotor (excluding tensioning)	2 h	Placement of tools
Hoisting of the first blade (blade by blade procedure)	3 h 30 min	Blades unloaded from the container

Table 8: Timetable for performing the tasks

7 PROCEDURE IN THE CASE OF ACCIDENT OR DISASTER AND FIRST AID

7.1 PROCEDURES IN THE EVENT OF ACCIDENT OR DISASTER

In the event of an accident or situation which impedes that a person descends by his/her own means, comply with the specifications of the park's emergency plan designed by the owner.

7.1.1 FIRST AID

It is recommended that among the personnel to access the wind turbine, some be trained in first aid, which as the name suggests, is the primary care of an accident victim or someone suddenly taken ill, at the scene of the event, until the arrival of specialized personnel, or until the patient arrives to a hospital. The subsequent evolution of the patient may depend upon the care administered at this moment.

When administering first aid, the general guidelines for action are as follows:

- stay calm.
- act quickly but without precipitation.
- observe the situation before taking action.
- make an initial "in situ" evaluation of the patient.
- do not do anything you do not know how to do.
- keep the patient warm.
- reassure the patient if he/she is conscious.
- do not move the patient unless he/she must be evacuated.
- do not administer food or drink if the patient is unconscious.
- notify the emergency services by the fastest means possible.
- if the victim hangs from a fall arrest device, stand underneath to support his/her weight in our arms (without forgetting to remain fastened at all times), in this way avoiding that this person suffers the "harness" effect.

7.2 PROCEDURE IN THE EVENT OF FIRE

In the event there is any type of fire near the wind turbine, immediately contact the substation to disconnect the grid. The area must be cleared and cordoned off in a radius of 400 m (1,300 ft) from the turbine.

If a small fire starts when one is inside the nacelle, the turbine must always be disconnected from the switchgear.

- From the nacelle, the switchgear is disconnected with the button next to the emergency push-button on the (*TOP*) control cabinet.
- From the base, the switchgear is disconnected by pressing the red button on the switchgear in the high voltage section.

When using fire extinguishers, do not forget there is mid-voltage in the wind turbine, and therefore the extinguishers must be suitable for use in electrically caused fires (20 KV). The fire should be extinguished with suitable powder or CO_2 extinguishers. Under no circumstances should water be used.

Remember that a carbon dioxide extinguisher should never be used in small, enclosed areas without respiratory protection.

IMPORTANT:

Remember: never use water.

Given the nature of the installation, in the event of a fire inside the wind turbine, the main risk for personnel is the lack of oxygen and inhalation of smoke from combustion, which could cause asphyxia of persons present in the installation even if they do not see the fire.

Smoke from combustion will rapidly fill the wind turbine. This circumstance is accelerated by the chimney affect produced by the tubular shape of the installation.

The use of fire extinguishers in an area of this nature without autonomous respiratory equipment will severely aggravate the effects due to a lack of oxygen in the event of a fire.

In view of the above, in the event that smoke is observed from a fire inside the wind turbine, personnel inside the wind turbine and at levels above the fire at that moment should proceed as follows:

- stay calm.
- do not stop to collect tools or personal objects.
- assemble the emergency descent equipment as described in the instructions with which the personnel should be familiar prior to accessing the generator, and that are indicated on the equipment itself.
- hang down the outside the nacelle by hooking the safety harness to the emergency descent equipment as per the instructions.
- once on the ground, release the hook from the descent device so that a second person may commence the descent.
- if the situation permits, disconnect the main circuit breaker of the wind turbine or notify the control personnel so that they may disconnect it.
- notify wind farm personnel and external fire brigade services by the fastest means possible.

When all personnel have been evacuated from the wind turbine, analyze the possibility of extinguishing the fire using the extinction methods available in the wind farm substation together with autonomous respiratory equipment if entering the wind turbine and in coordination with the public fire brigade services.

When using power generator sets, a fire extinguisher should be kept within close reach.

Special permission is required from GCT when carrying out work which may produce sparks. Before commencing this type of work, clean away any traces of oil, have a portable fire extinguisher handy and, if necessary, use a fire blanket.

Every inspection or maintenance vehicle must carry a portable extinguisher for use in minor fires on the lower platform of the wind turbine tower.

8 PREGNANT WORKERS

- Any pregnant workers may only access the *GROUND* platform of the wind turbine, and are prohibited from accessing any other parts of the same.
- Pregnant workers may only carry out operations executed at ground level, forbidden from works at heights, for example, tasks from elevator platforms, ladders...
- Pregnant women will not be assigned tasks which require lifting, transport of loads, or any other heavy manual tasks. This measure must be respected including up to 3 months after giving birth. Do not exert pulling or pushing forces (+10 kg). When seated, do not handle loads weighing over 3 kg, nor apply force.
- Pregnant women shall not work night shifts.
- Pregnant women shall not carry out work that implies electrical risk.
- Access to and space provided on the job must assure easy and comfortable movement of pregnant women.
- Facilities must be offered so that pregnant women may carry out their tasks in a seated position.
- Tasks assigned to pregnant women, particularly during the final months of the pregnancy, must be flexible enough to allow rest stops. If necessary, work rotation may be planned in such a way as to allow the pregnant woman to regulate her own working rhythm.
- Provide pregnant workers with sufficient rest breaks over the length of the daily work shift.
- Install bathrooms and places for rest adequate for pregnant women to use them comfortably.
- Pregnant women may not handle chemical products having a Safety Data Sheet which identifies risks to the health of the pregnant women and/or fetus.

8.1 ERGONOMIC RECOMMENDATIONS: DYNAMIC POSTURES

- Do not remain standing in a fixed position for more than 1 hour without moving.
- Do not remain for over 4 hours in a fixed position or one combined with movements.
- Do not remain kneeled or squatting.
- Do not carry out continuous (> 1 minute) or repetitious (> 2 times/minute) inclinations toward the side or pronounced turns of the trunk.
- Do not bend the trunk.

8.2 ERGONOMIC RECOMMENDATIONS: STATIC POSTURES

- Do not remain seated for more than 2 continuous hours.
- While seated, intend that the legs do not hang from the seat and that the feet have support.
- Rest the trunk against a backrest.
- Move the legs comfortably underneath the work surface.

8.3 DRIVING

- Avoid continued driving during many hours. Stop every 2 hours or every 200 kilometers traveled. Exiting the road with the vehicle, stretch the legs and breathe fresh air. In any case, at the slightest sign of exhaustion, stop the vehicle on the side of the road and take a nap and/or rest.
- When worn by pregnant women, the safety belt must be placed in such a way that its sudden locking will not oppress the center of the belly, eliminating the possibility that the fetus suffers any damage. Below, there is an information description of a commercial device that may be used to achieve the indicated goal:
- To put on the seatbelt, proceed as follows:
    1) Place the device over the vehicle seat.
    2) Seat on the device and place the safety belt with the horizontal band over the fastening system. Then, fasten the belt to the device

GE Energy

– Original Instructions –

Technical Documentation
Wind Turbine Generator Systems
1.x Series

Installation Manual

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Table of Contents

1 Introduction

This Installation Manual is designed to provide the owner/installer with information on how to install the 1.x Series Wind Turbine Generator System (WTGS) in a safe manner in accordance with the manufacturers' specifications, and is subject to revision by GE Energy. The installation instructions include important warnings, cautions, and notes about installing the wind turbine. These instructions do not cover components not provided by GE Energy.

These instructions apply to the steel tubular tower, nacelle, and rotor blades. The installation requirements and instructions must be followed precisely in order to avoid damage and to guarantee a problem-free and exact installation. It is the owner's/installer's responsibility to meet all safety, local and general regulations that apply for the specific site, task or project during installation.

The wind turbine generators are built in accordance with technical standards and the established safety rules. Nevertheless, dangerous risks can arise for individuals, equipment can be impaired, and materials damaged, if the converter and other devices are operated:

- by personnel who are not trained and properly instructed and/or
- outside of guidelines prescribed by the company

This document applies to the following turbine types:

- 1.5-70.5, 1.5-77, and 1.5-82.5
- 1.6-77, 1.6-82.5, 1.6-87, 1.68-82.5, 1.85-82.5 and 1.85-87
- 1.6-100, 1.7-100 & 1.7-103

2 Safety

Personal Protective Equipment (PPE) must be used in order to ensure that work is carried out without accidents or serious injuries to personnel. Clothing must be suitable for the type of work being performed. Suitable clothing offers protection against accidents. Loose overalls, outer garments with wide sleeves, or trousers with wide legs must not be worn.

Personnel installing the turbine will perform a comprehensive risk assessment or job safety analysis.

2.1 Safety Signs and Notes

2.1.1 Categorization Safety Signs and Notes

The Technical Documentation of GE Energy 1.x Series Wind Turbine Generator Systems uses the following stepped system of safety notices and signs (the general safety signs shown in the following section are replaced by context-dependent safety signs in the further text):

Danger!

Exact description of danger!

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

Warning!

Exact description of danger!

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

Caution!

Exact description of 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 danger!

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

Notes include user tips and useful information.

Notes should be complied with to ensure the correct installation of the Wind Turbine Generator!

All notes and symbols attached directly to the Wind Turbine Generator, such as warning signs, operating signs, rotation arrows, component identification, etc. must be observed.

Notes and symbols directly attached to the Wind Turbine Generator may not be removed and must be maintained in a fully legible condition.

2.1.2 General Safety Notes

Danger!

Head Injury Risk!

Since there is a high risk of head injury, hard hats must be worn on the work site at all times. Workers may trip or fall, or may bang their heads while working in confined spaces. Due to wind conditions and other risk factors, workers may encounter falling, flying or swinging objects.

Warning!

Warning – falling objects!

Never remain in front or underneath the tower opening.

Whilst the tower is being erected any object or material that remained in the tower or inadequately secured cable can fall out of the tower.

Danger!

Foot Injury Risk!

Steel or composite safety boots must be worn to reduce the risk of injury to feet, in particular from striking against and jamming between objects, from encountering falling or rolling objects, and from treading on or against pointed and sharp objects.

Danger!

Hand Crush, Cuts and Burns Risk!

Hands are exposed to mechanical dangers (cutting, grazing, pinching, and crushing), and to danger from heat and cold (from touching hot objects and convected heat). In these cases protective gloves must be worn. Use caution when working around exposed rotating components while the rotor is turning.

Danger!

Eye or Facial Injury Risk!

Eye protection must be used during all work activities, along with using a full-face shield if there is imminent risk of eye or facial injury (when grinding work is being performed).

Warning!

Hearing Risk!

Personnel must wear ear protection when noise levels reach or exceed local regulations.

Danger!

Falling!

When crew persons must climb the tower prior to installation of the permanent safety cable system, personnel must be connected to a temporary fall restraint system to allow ascent to top of tower section.

If an employee is working at a height that exposes them to a potential fall, fall arrest equipment must be used, and 100% tie-off at all the times.

When climbing the tower, double lanyards (Y construction) are to be equipped along with the safety harness and ladder safety device (Ladsafe / Tuf Tug).


Warning!

Climbing Tower Ladder!

Tower ladder sections (aluminum) surpass the fixed ladder codes of OSHA, ANSI and Canadian Provincial Workplace Safety Regulations such as the Alberta Occupational Health and Safety Code, 8, 130(1-5) and PIP Standard STF05501, Fixed Ladders and Cages, published by the Construction Industry Institute and are suitable for a 330-pound load.


Danger!

Climbing Tower Ladder!

Never free climb the tower ladder. Always use the ladder safety system. The ladder safety system is only rated for one climber per tower section, maximum of two people climbing the tower in different tower sections at any given time i.e., (while ascending or descending a ladder section, the ladder section to be climbed must be cleared of any climbers. If multiple climbers are ascending or descending, the tower hatches must be closed before the next climber begins to climb the cleared ladder section. If multiple climbers are climbing to the same section, climber to close the hatch and stand away from the ladder.


Danger!

Overhead Suspended Load!

Never work under a suspended load. Always confirm accurate load center of gravity, lifting gear and equipment securely attached, Make sure all personnel, vehicles, equipment, and materials are clear of the crane tail and load swing. All lifting must be done in strict accordance with the installers lift plan and applicable job safety analysis must be reviewed prior to all lifts.


Danger!

Lifting Heavy Loads!

Prior to lifting all heavy loads, a pre-lift meeting with all parties involved is required. (The crane operator, the rigger, the supervisor, the signalman, and any other personnel involved, such as area safety, tag line holders,). All lifting must be done in strict accordance with the installers lift plan and applicable job safety analysis must be reviewed as well.


Caution!

Blade Handling!

When handling blades on shipping fixture(s)

Specific blade manufacturer's handling instructions must be reviewed with the crews and understood prior to commencing work.

Only use lifting points that are designated by blade manufacturer for lifting.

DO NOT use tie down points for LIFTING.

Only use lifting points that are rated with enough capacity to lift the entire weight of the blade(s).

If unsure, always consult with GE technical advisors prior to handling individual blades and/or blades in shipping fixtures.


Caution!

Blade and Rotor Damage Prior to Installation!

Each site should assess the need for additional blade and assembled-rotor tie-down arrangement. Locations and instances which demonstrate high ground-level winds warrant additional consideration which may include: Additional standard tie-downs and anchor points, further assessment of cribbing and dunnage and the potential for cribbing and dunnage to sink into the ground.


Danger!

Damage to Equipment!

Taglines must remain attached when installing components to stabilize the load where environmental conditions (wind) may cause components to make contact when hoisting.

Using Tandem picks on the nacelle during offloading and staging without the use of a properly sized spreader bar will result in damage to the fiberglass rigging hatch openings. This will result in installation delays, as nacelles with fiberglass damage will not be allowed to be installed until corrected.


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.


Danger!

Low Speed Rotor Lock Use!

Never use the low speed rotor lock to stop drive train rotation; the hydraulic hand brake must be used.


Danger!

Risk of Vortex Shedding-Induced Tower Sway!

If the tower is completely assembled, including the rotor, park the rotor in a Y-position, such that one blade is pointed down, in line with the tower.

Hydraulic Disc Brake and Brake Disc Rotor Lock Use!

The installer must personally ensure all personnel assigned to work activities inside the WTG are properly trained on the use of the hydraulic disk brake and disk rotor lock, to ensure the hydraulic disc brake and Brake disc rotor lock are 100% engaged and locked out before attempting to:


Danger!

After Aligning main shaft during rotor installation, pre tighten and torque hardware after rotor is fully engaged onto the main shaft.

Disconnecting crane and removing crane out of the working area after rotor is installed.

Performing any work outside or inside of the hub after rotor has been installed.

Performing any work inside or outside the Nacelle near exposed rotating components after rotor has been installed.

All employees must ensure the hydraulic disk brake and disk rotor lock is 100 % locked out before exiting to the top of Nacelle.

Electrical Hazard!

Definitions: Turbine de-energized state means that the turbine is completely isolated from the grid by one of the following means:

The unit transformer (PMT) oil switch is open, locked out, and grounds attached.

The substation switch gear is racked out, locked out, and grounds attached.

The substation air switch gear is verified open, locked out, and grounds attached.

The transformer in PPM Verify Medium Voltage (35kV) switch is open, load connector open and ground connectors closed, lock-out and tag-out.

Other GE approved location for isolation, e.g. junction box, air switch, switchgear (requires approval from regional EHS, GFO, and project management prior to proceeding). WTGs must be isolated before installation or commissioning activities on all units connected to a string that is undergoing any electrical testing.

Danger!

Definitions

Grid: The distribution system between points of consumption and production of energy.

Grid Capable: Utility power can be distributed from or to the Wind Turbine Generator System. "WTGS can be energized using electricity from the power company or temporary power for commissioning activities or to produce electricity.

Physical Connection: is defined as any means by which a circuit can be completed or closed.

Physically Open Connection: is defined as an open circuit whose access is controlled by means of a lock and tag (LOTO) – (i.e. a pulled fuse – a parked or non-terminated connection).

Grounds: sufficient size grounds capable of dissipating ground fault potential (per section 2 104W2406).

Note 1: 1.5 series wind turbine generator connect portable generator to turbine – 1.5Serie_xxHz_WDI_genfreqsys_PortableGeno

Note 2: Critical punch list is as defined starting in revision 8 of IIP section 1.4.

Any scenario not addressed by the flow chart requires input from regional EHS, GFO, and project management prior to proceeding.

Tower Rescue System!

Warning!

Tower rescue systems must be available in the event of an emergency; the system is based on turbine configuration. As a result, check the integrity of the seal of the equipment bag on each visit to the nacelle.

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

Perform an additional visual inspection of the system immediately before use. Care and maintain system per manufacturer's recommendations.


Attention!

Environmental Risk!

Follow all applicable local regulations for use, containment, and disposal of all chemical substances.


Attention!

Check Components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided. Please contact the GE site representative if damage is found.

Torque Values

For the correct torque values, please see “Bolt Torque Specifications”.

Uncontrolled increase in torque!

Once the torque tooling has switched itself off after reaching the set torque, it may not be switched on a second time on the same bolt, as this would result in an uncontrolled increase of torque.

2.2 Qualification and Instruction of Installation Personnel

Only trained and instructed personnel may be deployed for the installation. The personnel’s responsibility for the operation of the tools must be clearly defined! A person responsible for monitoring the safety during the installation and preventing any unsafe work practices must be appointed.

It must be ensured that the installation personnel have fully understood the instructions and that all instructions are observed. This is the only way of ensuring that all those involved work in a safe manner and are aware of the hazards.

Equipment shall be made and finished with a degree of uniformity and grade of workmanship complying with the appropriate requirements of the standard and the generally accepted principles of sound and safe practice.

Special attention shall be paid to the mechanical execution of the work, careful and neat running, connection and secure attachment of component parts.

For CWE WTGS, the absolute low temperature limit of installation work is –40 °C for de-energized WTGS and -30 °C for energized WTGS. Please consult with your country and region specific EHS guidelines to ensure compliance to cold weather extreme work practices.

3 Responsibilities

3.1 Constructor's Responsibility

The installation manual is important for the safe installation of the turbine. The site constructor must ensure the installation crews are familiar and comply with these instructions. Furthermore, adherence to local, state, and country regulations regarding safety, environmental protection, electrical codes and related fields is required.

Construction personnel are not allowed to change, add or modify the control and protection system of the turbine without written authorization of a designated GE Energy representative, prior to change or modification. Construction crews must be trained and instructed in the proper installation of the turbine.

The Installer has to ensure that the tools used are calibrated and that the respective calibration/inspection data sheets are available to GE Energy on request.

Daily Tool Log

Failure to perform inspections prior to each shift can allow damaged or sub-standard tooling to be utilized by employees. The Installer assumes responsibility for any re-work associated with damaged or sub-standard tooling found to be the root cause of improper installation per GE specifications. A verification of all 3rd party calibrations certificates is required and a copy will be kept in the site job books on any new or used tooling that measures pressure, force, distance or resistance.

A log of daily checks performed should be documented and may be mandated by the regional Installation Manager. The original logs should be available to GE upon request and the originals will be added to the site job books if deemed necessary.

Tooling requirements!

- Certificate of calibration from the manufacturer
- Send new tool to third party for calibration verification

If tool requires re-calibration,

- Send in to get calibrated and issue new certificate of calibration
- Send to 3rd party for new verification certificate

As long as the tool remains in calibration only the verification certificate has to be renewed each year. All measuring and test equipment must have Identification traceable to a certificate of calibration.

All tool calibration verification services shall be subcontracted.

Examples of calibration requirements are, but not limited to;

- Pressure gauges
- Torque wrenches
- Norbar or equivalent test equipment
- Skidmore or equivalent test equipment
- Electric screw driver
- Multimeters

3.1.1 Multiple Configurations of the 1.x Series

The GE Energy global Installation Manual is intended to cover multiple configurations of the 1.x Wind Turbine Generator System, allowing the use of one installation manual globally, (i.e. Europe, Americas and Asia Poles).

The installer is required to review the entire content of the installation manual including all reference documents with a GE representative to select the appropriate configuration in order to ensure the full scope of installation for each specific project is clearly defined. The most common variations by pole are as follows:

Europe "Eu"	Americas "Am"	Asia "As"

3.1.2 Foundation - Most Common Variations by Pole

Anchor Cage, (Eu, Am, As) Anchor Lug (Eu, Am, As), Foundation Ring (Eu, Am, As)

3.1.3 Pre-Assembled Power Module (PPM) (Eu, As)

The most common PPM unit consists of 2 to 4 pre-assembled platforms. All platforms are pre-assembled at the manufacturing facility prior to shipping. Field assembly requires stacking of PPM sections and routing and connecting cables between the sections depending on the final PPM configuration.

Example of basic PPM is as follows:

- PPM section made of a transformer, Medium Voltage Switch Gear (MVSG) and Low Voltage Switch Gear (LVSG) mounted to a welded platform. (Note: the transformer may be on a separate platform other than the LVSG and MVSG. This can make the difference between a 3- or 4-section PPM unit.) (Eu, As)
- PPM section containing LVDP main controller converter cabinet, extra cabinet, and aviation utility cabinet mounted to a welded platform. (Eu, As)
- PPM section made of the upper PPM platform. (Eu, As)

3.1.4 ESS Electrical System Simplification

Key systems such as Converter/LVDP/MCC are integrated in a single cabinet. The ESS units will require field assembly of the DTC console, mounting of the ESS DTE to DTC console, and attaching the exhaust fan. All tower cables are routed to ESS unit through the bottom.

1.x configurations may require installation of additional auxiliary voltage regulator on the foundation before the DTE platform is installed. Additional wiring from the voltage regulator to the DTE is required.

Contact GE site representative for installation instructions.

3.1.5 Nacelle - Most Common Variations by Pole (Eu, Am, As)

Refer to technical Description and Data 1.x series Wind Turbine 1.5-70.5, 1.5-77, 1.5-82.5, 1.6-77, 1.6-82.5, 1.6-87, 1.68-82.5, 1.85-82.5, 1.6-100, 1.7-100 and 1.7-103. There are minimal variations in regards to installation features.

1.x-100/103 100 m, 96 m and 80 m HH use M36 tower to yaw bolts, earlier configurations use M30 tower to yaw bolts.

1.x-100/103 Hub to main shaft requires 48 bolts, earlier configurations require 44 bolts.

1.x-100/103 WTGS is heavier refer to weights and dimensions specification.

Nacelle types B&C are equipped with front hatch and safety railing. Modular nacelles are equipped with two skylight hatches and multiple tie-off points.

3.1.6 Tower Type - Variations by Pole

2 Sections Base & Top (Eu, Am, As)	3 Sections Base, Mid 1, Top (Eu, Am, As)	4 Sections Base, Mid 1, 2, Top (Eu, Am, As)	5 Sections Base, Mid 1, 2, 3, Top (Eu, Am)	6 Sections Base, Mid 1, 2, 3, 4, Top (Eu)

- For 1.x-100/103 100 m HH, some flanges require M36, M39 and M45 tower flange bolts.
- For 1.x-100/103 96 m HH, some flanges require M36 and M39 tower flange bolts.
- For 1.x-100/103 80 m HH, some flanges require M36 tower flange bolts.

3.1.7 Tower Internals Electrical - Most Common Variations by Pole

The system to energize the rotor and carry the current generated by the stator to the grid can be the three-phase bus bar or three-phase cable assembly copper or aluminum.

3.1.7.1 Three-Phase Cable Systems - also referred to as GEN 1, GEN 2 and GEN 5

The quantity of cables varies depending on 50 Hz or 60 Hz. Conductors are mounted to each tower section through a series of cable trays at tower manufacturing facilities. On-site assembly is limited to connection joints at each tower section, DTE, and WTG to tower transitions. (Refer to cable installation section on this manual for full scope of cable installation.) (Eu, Am, As)

3.1.7.2 Three-Phase Bus Bar System - also referred to as GEN 3, GEN 4, GEN 6 universal, and GEN 7

Also referred to as GEN 3, GEN 4, GEN 6 universal, GEN 7, and GEN 10, the three-phase bus bar system consists of two groups of three-phase assemblies, one for the stator and one for the rotor, each assembly is made of 3 tubular insulated conductors mounted to each tower section at tower manufacturing facilities. On-site assembly is limited to connection joints at each tower section and cable to bus bar upper and lower transitions. (Refer to Bus Bar Manual 443 for insulated bus bar systems and tower cable section on global manual for full scope of cable installation.) (Am)

3.1.8 Tower Internals Mechanical - Variations by Pole

The most common variation is the safety fall arrest system, Haka rail system (Eu, As) or safety cable system (Eu, Am, As). Personnel hatch, ladders and platforms: only minimal variation through poles (Eu, Am, As)

Tower entry door elevations vary; DTEs must be set to match tower entry door elevation. The base sections on GEN 4 require installation of upper most internal ladder prior to installation of the tower at the site. The generation 10 based tower section requires installation of upper and lower ladder sections at the site.

Attention!

For Reinforced Modular Tower Systems (RMTS), review the tower flange bolt-hole pattern for specific tower being installed and confirm correct lifting equipment is sourced.

3.1.8.1 Safety Rail System

Most commonly known as the Haka rail system mounted to each tower section at the tower manufacturing facilities. On-site assembly is limited to upper, lower and connection joints at each tower section and inspection according to protocol EU.AS.

3.1.8.2 Safety Cable System

The safety cable is mounted to the top tower section at the tower manufacturing facilities. On-site assembly is limited to lowering and securing to bottom of tower and inspection according to protocol.

3.1.9 Blades/Rotor

Most common variation is rotor diameter 70.5 m, 77 m, 82.5 m, 100 m and 103 m (Eu, Am, As). (Refer to weights and dimension document and specific vendor drawings for approved lifting points).

- 48.7c carbon blades have 56 stud bolts and must be matched with the hubs that have 1 hole lifting eyes.
- 48.7 and 50.2 glass blades have 68 stud bolts and must be matched with the hubs that have 2 hole lifting eyes.

3.1.10 Hub - Most Common Variations

The most common variations are rotor diameters 54.7 m up to 100 m (Eu, Am, As). There are minimal variations in regards to installation features.

Blade to hub mounting hardware Nuts and Washers (NW):

- 1.5-77 54 NW
- 1.5-82.5 larger casting and bearing, 64 NW
- 1.6-100 larger casting and bearing, 56 NW
- 1.7-100 and 103 larger casting and bearing, 68 NW
- 1.x-100/103 larger hub, heavier, nose cone may be required to be installed in the field
- Shilla type blade bearing has a separate lifting lug threaded hole between two of the blade stud holes

There are three Pitch System Configurations:

1. SSB system requires a pitch drive control box and a portable generator to pitch the blades.
2. 1.5 GE Pitch System relies on axis batteries and a manual control unit (e-Palm) to pitch the blades. Batteries may need to be charged in the field by contractor.
3. GE Pitch System 1.x-100/103 requires e-Palm and 15 kV Gen to supply 400 Volt AC 3 phase power connected to Hub terminal box to pitch the blades.

Please refer to the weights and dimension document for weights and dimension variations.

3.2 Owner's Responsibility

As the owner of the wind turbine, you are responsible for the safety of your staff and obligated to inform or instruct personnel about existing legal regulations and accident prevention procedures.

Ensure the installer follows GE Installation Guidelines and Specifications.

Where major components such as towers are provided by the customer, the installer shall provide the completed quality receiving check list and installation inspection check list for each of the components installed. Documents must prove good equipment condition upon receipt and repaired signatures where applicable prior to installation of equipment and of final inspection IIP.

3.3 GE Energy's Responsibility

GE Energy's responsibilities are to provide the owner/constructor with comprehensive documentation to install a wind turbine generator. GE provides all turbine components, ship loose kits, special tooling, and technical advisors where applicable. GE reserves the right to remove our employees from unsafe working conditions.

3.4 Operations Involving the Use of a Crane

Warning!

Mind the maximum allowable wind speed!

For technical data to calculate the maximum allowable wind speed.

For crane activities especially on parts and systems with a high sail area with respect to system weight refer to the document GE.speci_xxHz_tm_roadcrane_HandlgLiftg.ENxx.

All operations involving the use of a crane may only be carried out based on the respective crane limitations, site/weather specific circumstances and field personal experience. The final decision if work may be executed rests with the crane operator and installer representative based on the lift plan.

4 Terms and Definitions

Term	Definition
AL	Aluminum
Axis cabinet	Blade controller
CB	Circuit breaker
CICL	Cable installation check list
Converter	Synchronizes generator to the grid
CU	Copper
DLO	Diesel locomotive
DTE	DTE or Down tower equipment DTE – 690 V single console (ESS configuration) PPM – Pre Assemble Power Module could be 575 V or 690 V
FMP	Foundation mounting piece
Hub cabinet	Master pitch controller
ICL	Installation check list
IIP	Installation inspection procedure
LVDP	Low voltage distribution panel
LVMD	Low voltage main distribution
LVSG	Low voltage switch gear
m	Meter
(MCC)	Main Controller Cabinet Main controller, condition monitoring, communicates with the topbox
MTS	Modular tower system
MVSG	Medium voltage switch gear
Nm	Newton meter
PDCB	Pitch drive control box
PPE	Personal protective equipment
PPM	Pre-assembled power module
Rotor	Hub/blade assembly
Tension	The act or action of stretching or the condition or degree of being stretched to stiffness
Topbox	Nacelle controller, condition monitoring, communicates with primary cabinet and hub controller
Torque	A turning or twisting force
UPS	Uninterruptible power supply
WTG	Wind turbine generator
ESS	Electrical system simplification
PDC	Power distribution cabinet
CFC	Converter filter cabinet
Type B&C Nacelle	Roof is equipped with front hatch; safety railing and two nacelle lift point covers.
Modular Nacelle	Roof is equipped with two sky light hatches, two nacelle lift point covers, U-bolt safety tie locations (No Safety Railing).
CBC	Converter bridge cabinet

5 Reference Documents

All reference documents must be requested via GE Requisition Engineering!

For Salem pitch system battery charging procedures WDI, consult with GE site representative.

5.1 Technical Specification

Document Name	File Name
Bolt Torque Specifications	1.xSerie_xxHz_TSP_BoltTorque

5.2 Work Instructions

Document Name	File Name
Work Instructions - Power Cable – Splice Installation Procedure inside Tower	GEWE.all_WDI_cable_crimping
Work Instructions – Measurement Lightning Arrester Resistance/PE Conductor, Insulation, Resistance Test and Voltage Measurement to EN 60204-1	1.5serie_WDI_allComp_Test EN204-1
Work Instructions - Installation of adhesive permeated fiberglass to protect the cables at the yaw deck level	1.5Serie_xxHz_WDI_cable_3M-Armorcast
Work Instructions - Installation of adhesive permeated fiberglass to power cables at the collector ring and the yaw deck	1.6-100_2.x_xxHz_WDI_RETR_cable_ArmorcastInst
Generator Alignment	1.5Serie_xxHz_WDI_generato_GenAlignment
Insulated Bus Bar System (Package)	GE Canada Manual 443 (Package)
Salem pitch system procedure	1.5Serie_xxHz_WDI_blade_ExorePalm10x

5.3 Check Lists

Contents	Document name
Installation Check List	1.5_1.6_speci_xxHz_ICL_allComp_ICL
Cable Installation Check List	1.5_1.6_speci_xxHz_ICL_Cable_CICL
BBCICL	1.5Serie_xxHz_ICL_Cable_BBCICL
Installation Inspection Procedure	1.5_1.6_speci_xxHz_ICL_allComp_IIP
Electrical Validation Procedure	104W2311
Torque Report for all Bolted Connections	1.5Serie_xxHz_ICL_BoltTorqueCL

If equipment will be shipped to a lay down area for long-term storage refer to Technical Guidelines for Storage of Wind Turbine Generator Systems (GE.all_xxHz_STM_allComp_xxxxxxxxxxxx).

If the GE receiving inspector is not on site, GE provides a copy of the Receiving Checklists to the customer to perform the equipment receiving inspection. Contact the GE representative for the latest revisions. The customer will provide to GE the copies of the completed inspection checklist prior to start of the installation activities.

Provide a copy of the Receiving procedures on EX works projects only. If equipment for two different projects is shipped to the same-long term storage area, the customer is responsible for maintaining equipment assignment for the project it was intended for to insure the correct configuration is delivered to the correct location.

5.4 Drawings

Component	Contents
Serrated Blade Outline	103W3050
Down Tower Assembly Outline – ESS/690V	115W2051
Tower Segments C/G Pick Points Flanges	Please request based on tower configuration
Nacelle C/G Pick Points 1.6-100 Machine Head Outline	104W1926 123W2105
1.6-100 Rotor Assembly Outline	108W6301
Hub C/G Pick Points Hub C/G Pick Points XLE Hub	104W1925 115W1035
1.6-100 Hub Assembly Outline	108W6300
1.7-100 and 1.7-103 Hub	103W3327
Assembly Hub Steps/Casting Assy	103W3179
Blade (GE 37c) Lift and Support Configurations Blade (GE40XLE) Lift and Support Configurations	For GE 37c contact GE engineering for latest drawing 115W1562 Follow the blade manufacturer's handling instructions

Component	Contents
Support and Lift Locations - Carbon Fiber Blade (48.7c)	103W3049
Support and Lift Locations - Glass Blade 48.7 m	114W3337
Support & Lift Locations – Glass Blade 50.2 m	103W2754
LM42.1P2	For LM42.1P2 contact GE engineering for latest drawing
LM40.3P	104W1776
Blade (LM) Transport, Handling and Storage	104W2051 Follow the blade manufacturer's handling instructions
LM34P3 Lifting, Handling Drawing	104W2527
Component Level Weight Chart	104W1435
Site Roads and Crane Hard Standings	1.5serie_WDI_roadcrane_xxxxxxxx or 1.5Series_60Hz_TM_allComp_RoadandCrane.EN_US
1.6_1.7-100 Weights and Dimensions	1.6_1.7-100_xxHz_GD_allComp_ContrDocW&D.ENxxx
(Am) Electrical Field Assembly	For cable phasing refer to GE field assembly drawings based on tower configuration. GEN 4 – 103W1416 GEN 4 ESS – 103W1436 GEN 5 – 103W1511 GEN 6, 7 – 103W1629 GEN 10 – 115W2782
Assembly Electrical PPM	Please request based on PPM configuration
Sign board document	1.5Serie_xxHz_WDI_signboard (language based on region)
Energization Process Flowchart	1.5Series Equipment only Energization Process Flowchart
Specification Handling and Lifting	GE.speci_xxHz_tm_roadcrane_HandlgLiftg.ENxxx

6 Materials, Parts, and Tools

6.1 Parts

6.1.1 Parts Ship Loose

There are four categories of ship loose kits as follows:

- Bulk items shipped for all units, such as fragile, chemical, and small parts. Tower entry steps are delivered upon request.
- Bus bar loose parts, BB repair kit and Tower Touch paint
- Items shipped as a kit for each turbine, such as platform extensions and DTE leg extensions, tower and nacelle bolts, over twist hardware, heat shrink, and splices. These items are typically delivered palletized.
- Items shipped as a kit inside of major components, such as nuts and washers for the rotor assembly, hub nuts and washers for mounting rotor inside nacelle, and lugs for the stator cables (PCK) inside DTE, tower bus bridges inside towers. If shrink-wrap material is damaged, it must be repaired to prevent damage from dust or rain.
- Parts shipped late from GE or a vendor to close shortage issues.

Tower bolts are shipped in tower kits. Do not mix tower bolts; always maintain kit integrity (1 kit to 1 tower). Bolt information is recorded in ICL. All bolts nuts & washers used for any particular tower flange assembly must be from the same manufacturer.

Please Note:

Consult with GE representative for a sample-packaging list for all parts shipped loose kits including BUS-BAR parts as they may vary by pole and contractor may be required to stage these parts at the site inside components prior to installation.

Refer to manual 443 for bus bars PLS including lug kits.

Back feed hardware/ground grid lugs are customer's responsibility.

Bulk Shipments / Ship Loose Kit Acceptance (Future MSL)

Each package contains a packing slip attached to either the outside or inside of the container. The installer is responsible for verifying all bulk shipments / ship loose kits are received in full as they arrive on-site. Complete quality form WFFOF-PSL-007 "Ship Loose Kit Acceptance Form" and provide it to the GE Energy representative within two working days. The installer will be responsible for supplying shortage items at their expense if not noted on form or the form is not provided to the GE Energy representative within two days of ship loose kits arriving on-site.

The installer is responsible for maintaining custody and security of the components until installed.

6.2 Installer-Supplied Materials and Tools Mechanical

The installer is required to design and procure all rigging and lifting devices, provide equipment offloading/staging plan, and provide a project specific lift plan(s). Ensure rigging and lifting design is safe and does not damage GE equipment/subcomponents when it is attached to the lifting points or any part of the GE equipment.

The sail area and drag coefficient of the rotor must be incorporated through the lift plan. Static loads and dynamic loads must be verified by the crane operator. Personnel not involved in crane lift operations must leave the crane work zone (danger zone) before lift operations start.

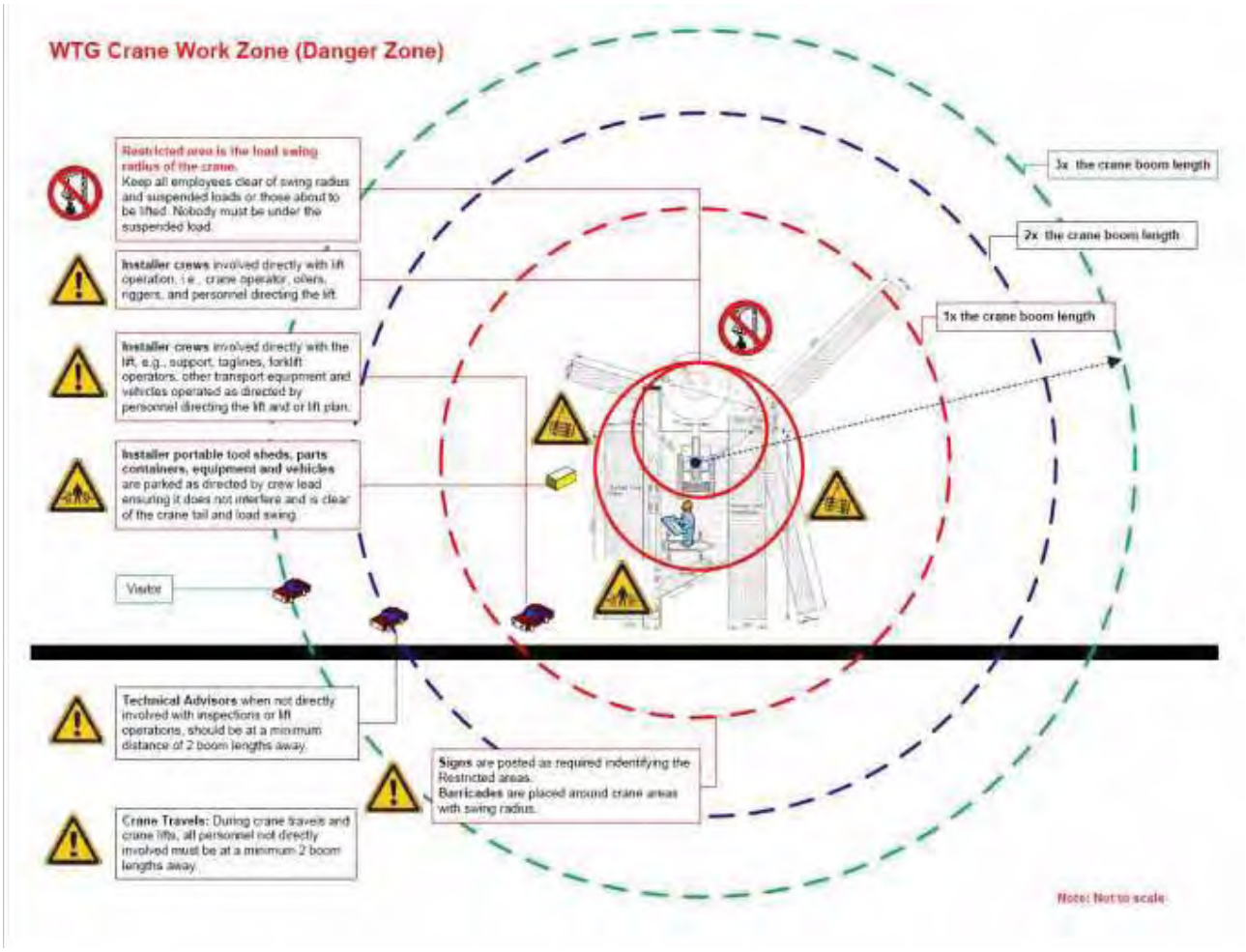

Figure 1: Lift operations danger zone

The roads and pads must meet the requirements of the 1.x Series Typical Road, Crane Pad & Turbine assembly area specification. Offloading Staging activities plan must include site survey and knowing the general characteristics of the roads and condition of the soil for equipment safe/unrestricted travel, offload, staging and Installation.

Staging plan must include Safety and Equipment damage preventive measures including but not limited to resetting equipment to prevent damage due to poor cribbing/matting configuration, soft ground due to

potential freeze thaw cycles, rain, melting ice or flood zone, Potential damage due to extreme weather conditions such as high winds. Proper cribbing/matting and tie off arrangement should be factored in, and must be sufficient to support weight of the components.

GE Energy will provide reference documents for typical weights, dimensions and center of gravity for **lifting** GE-provided components only. Any attempt to deviate from standard lifting points and/or methods must be reviewed by GE engineering prior to application to ensure that no damage to subcomponents will occur. The materials, parts, and tools required to install a wind turbine are listed in the tables below and these items are provided by installer. The quantities provided are for a single turbine. The "ar" in the quantity column references "as required".

Quantity	Description
2	Adapter, ½" female to male ¾-inch drive
2	Adapter, ¾" female to male 1-inch drive
2	Adapter, 1" female to male ¾-inch drive
1	Adapter, universal, ¾-inch drive
6	Bag, 5 gallon, canvas
4	Bag, duffel, canvas
ar	Bag, trash, 35 gallon
1	Band saw, Porta-band
ar	Battery charging kit (1.6-77, 1.6-82.5, 1.6-87, 1.68-82.5 and 1.85-82.5)
4	Bar, connecting, 2'
1	Bar, crow, 5'
4	Brush, wire
6	Bucket, 5 gallon, plastic
2	Bull pin, 37 mm diameter
1	Calibration tool, Skidmore Wilhelm
2	Caulking gun
ar	Cleaner, bio-degreaser
2	Container, gasoline, 5 gallon
4	Container, trash, 40 gallon
ar	Cribbing, wood block, 6"x6"x12'
4	Cut-off wheel, (steel)
1	Cutter, steel cable
ar	Desiccant material (humid sites only)
1	Drill bit set, 8 mm to 12 mm
2	Drill, heavy duty, ½-inch drive
2	Drive, deep socket, 24 mm, ½-inch drive
2	Drive, impact, heavy duty, ¾-inch drive
ar	Duct tape
4	Extension cord, 100', 10 AWG
2	Extension, 12", ½"-inch drive
2	Extension, 12", ¾-inch drive
2	Extension, 8", ¾-inch drive
ar	Fall restraint system, for each tower section not including top section, based on tower lengths
2	File set, 12"

Quantity	Description
2	File, thread, metric
ar	Foam insulation, pipe, anchor bolt diameter specific (not for FMP)
4	Generator, portable, 6.5 kW, with GFCI
1	400 volt AC (+/- 10%) 3 phase power generator (400 VAC generators are not common in some countries, however you can use a 480 VAC generator with the output voltage turned down to 440 VAC on the pitch system), use a 4c-6AWG cable as required
ar	Grinding disk for fiberglass
ar	Grinding wheel, 5 in, (steel)
ar	Grinding wheel, 9 in, (steel)
10	Grout, 70 pound bag
2	Guide, angle iron, 2”x2”x10’
2	Guide, angle iron, 2”x2”x12’
2	Hammer, shop, 4-lb
2	Hammer, sledge, 10-lb.
ar	Heater, cold weather sites only
4	Qualified hydraulic or electrical torque tooling
2	Knife, utility
2	Ladder, extension, 16’
2	Ladder, step, 10’
1	Level, laser kit
ar	Lubricant, MoS2 Anchor Brand Jet Lube
ar	Rigging & Bar for Nacelle per lift plan
ar	Rigging for Blades per lift plan
ar	Rigging for DTE per lift plan
ar	Rigging for Hub per lift plan
ar	Rigging for PPM per lift plan
ar	Rigging for Tower per lift plan
ar	Sandpaper, medium grit
1	Sawzall, reciprocating
2	Scraper, metal
1	Screwdriver set
2	Shovel, square
ar	Sock, blade, based on blade manufacturer requirements
2	Socket, 2”x12”, special, 1” drive (not for FMP)
2	Socket, deep, 19 mm, ½-inch drive
4	Socket, deep, 24, ½-inch drive
2	Socket, deep, 9/16”, ½-inch drive
2	Socket, impact, 30 mm, ¾-inch drive
2	Socket, impact, 32 mm, ¾-inch drive
2	Socket, impact, 36 mm, ¾-inch drive
2	Socket, impact, 38 mm, ¾-inch drive
2	Socket, impact, 41 mm, ¾-inch drive
2	Socket, impact, 46 mm, ¾-inch drive
2	Socket, impact, 46 mm, 1-inch drive
2	Socket, impact, 50 mm, ¾-inch drive

Quantity	Description
3	Socket, impact, 50 mm, 1-inch drive
3	Socket, impact, 55 mm, 1-inch drive
4	Socket, impact, 60 mm, 1-inch drive
4	Socket, impact, 75 mm, 1½ inch drive
2	Socket, impact, deep, 46 mm, ¾-inch drive
2	Socket, impact, deep, 55 mm, 1-inch drive
ar	Softener, nylon straps
ar	Spill kit, based on site risk
ar	Sponge, refill, mop
1	Strap, ratchet type, 30' (optional)
1	Strapping, kit, 5/8'' (cutter, dispenser, sealer, & tool included)
ar	Strapping, seal, 5/8, double notch
ar	Strapping, steel, 5/8'' x 0.017''
ar	Straw, 70 lb. bale, string wound
2	Tagline, nylon rope, 150', ¾"
2	Tagline, nylon rope, 20', ¾"
2	Tagline, nylon rope, 300', ¾"
4	Tagline, nylon rope, 50', ¾"
2	Tagline, nylon rope, 500', ¾" (150 m ¾" up to 200 m ¾" for 100 m HH tower)
2	Tank, 500 gallon, trailer mount
2	Tape measure, 10'
2	Tape measure, 100'
2	Tape measure, 25'
3	Tarp, poly 10'x20' (cold weather)
1	Thread chaser for hub M36x4
1	Thread chaser for nacelle M30x3.5 mm
ar	Tower rescue / evacuation system
4	Trowel, concrete finishing (not for FMP)
2	Trowel, grout, 6" (not for FMP)
2	Universal swivel, 1-inch drive
2	Vacuum, shop, wet/dry
2	Washer, pressure with 120' hose
1	Wheel barrow, 2 wheel (not for FMP)
8	Wood block, 4"x4"x18" (not for FMP)
1	Wrench, adjustable, 12"
2	Wrench, adjustable, 15"
2	Wrench, Allen set, 1.5 to 10 mm
2	Wrench, Allen, 12 mm
2	Wrench, Allen, 14 mm
2	Wrench, combination, 19 mm
6	Wrench, combination, 2"
6	Wrench, combination, 2-⅜"
6	Wrench, combination, 24 mm
2	Wrench, combination, 30 mm
2	Wrench, combination, 50 mm

Quantity	Description
2	Wrench, combination, 9/16”
4	Wrench, impact, ¾-inch drive
4	Wrench, impact, 1-inch drive
ar	Wrench, torque, 250 ft.-lbs.
ar	Wrench, torque, 600 ft.-lbs.
1	ITH nut runner, pinion, plate
1	Shaft Hog alignment system
1	Magnetic mounting plates
1	35" Chain extension set
1	Enerpac hand pump
1	Enerpac hose assembly, 6 foot
1	Enerpac cylinder, 15 ton
1	30mm combo wrench
1	46mm hammer wrench
1	Sledge hammer
2	Leather bottom tool bags
2	Adjustable wrench
1	Mobile tool container for kit
2	Caliper, digital dial

* The tower manufacturer will provide touch-up paint (interior and exterior).

6.3 Installer-Supplied Materials and Tools Electrical

Quantity	Description
ar	Bag, trash, 35 gallon
2	Bag, duffel, canvas, closable top
ar	Cleaner, bio-degreaser
1	Container, gasoline
ar	Crimping tool, cable, hydraulic with die set (360° vendor specific) - Copper
ar	Crimping tool, cable, hydraulic with die set (vendor specific) - Aluminum
ar	Cutter, cable, hydraulic, remote power (535 dlo or 1000 kcmil aluminum)
3	Cutter, diagonal
2	Extension cord AC, 100’, 10 AWG
1	Ladder, step, 8'
1	Ferrule crimping tool, Crimpfox UD6
1	Ferrule crimping tool, Crimpfox, 25
2	Generator, portable, 6.5 kW, with GFCI
ar - Grounds:	Grounds capable of dissipating ground fault potential, i.e. bolted connections
2	Light, drop
2	Multimeter, Fluke 83
ar	Multipurpose cable pulling lubricant
3	Oil, Hytool, Dextron2 type F (gallons)
1	Panduit RT2HT cable tie tool
1	Pliers, channel lock, 12”

Quantity	Description
3	Radio, two-way
2	Ratchet, ½-inch drive
ar	Retractable lanyard or temporary rated safety line, 30 ft
ar	Heat gun
1	Sealant, spray foam, expanding
1	Screwdriver set
2	Socket, deep, 19 mm, ½-inch drive
ar	Stripper, cable, 535 dlo or 1000 kcmil aluminum
2	Strippers, wire, 22 AWG to 4 AWG
ar	Tape, electrical, 4-color, based on country specific electrical code
ar	Tester, voltage, light pen, 1000 V AC
ar	Torch, propane or heat gun
ar	Tweaker tool, slotted
1	Vacuum, shop, wet/dry
2	Wrench, adjustable, 12”
4	Wrench, combination, 19 mm

6.4 GE Energy-Supplied Tools

Any GE owned tools provided during the installation phase must be returned to GE Energy upon completion of project installation. GE Energy reserves the right to bill the buyer (installer) in accordance with contractual agreement for all broken and unaccounted tooling.

Quantity	Description
ar	Pitch drive control box (if applicable)
ar	Hand held, EXOR for (Salem pitch system) (if applicable)
ar	Protector blade, trailing edge (SET)
ar	DTE ESS alignment template

Additional Tool Orders

Additional tool orders must be submitted to GE Energy 8 weeks in advance at the expense of the requestor.

7 Assembly and Installation of ESS (Electrical System Simplification)

BOM number for material procurement 115W6299G001.

GE does not provide tools or materials.

Quantity	Description
1	Brush, 1”
2	Controller keys – GE provided
1	Crimp tooling, cable hydraulic with die set (vendor specific) contact GE representative for cable sizes.
1	Cutter, cable
1	Die set
1	Generator 6.5 kW, with GFCI
ar	Heat shrink
1	Level, 4’
4	Lugs, earth ground
ar	Multipurpose cable pulling lubricant, Greenle Gel-Q
ar	Rags
1	Ratchet, ½-inch drive
ar	Rigging
1	Socket, 19 mm, ½-inch drive
1	Strap, ratchet, 30’
1	Stripper, cable
2	Tagline, nylon rope, 20’
1	Tape measure, 10’
ar	Tape, electrical, 4-color, per local electrical code
1	Heat gun
1	Wrench, combination, 19 mm
1	Wrench, combination, 24 mm
1	Wrench, torque 250, ½“ drive
1	Socket 10mm ½“ drive
1	Socket deep, 13mm½-inch drive
1	Socket deep, 17 mm, ½-inch drive
1	Wrench, Allen, 5 mm
ar	Shrink wrap material
ar	Shrink wrap tape
ar	Galvanize compound spray
1	Pliers
1	Pry bar 2 ft
1	Ladder 6 ft A-frame

7.1 Preparing the Foundation

Attention!

Check the Components!

All the components must be checked for visible damage, deformation and cracks prior to assembly!

Please contact the GE site representative if any damage is found.

1. Verify that the utility cables stubbed up out of the foundation are long enough to terminate inside the PDC cabinet. Confirm the phase sequence as follows:
   - Line 1 – Phase A
   - Line 2 – Phase B
   - Line 3 – Phase C
   - Ground
2. Verify that the earth/ground copper conductors are stubbed out of the foundation.
3. Confirm that the grounding ring(s), the installation rods and the soil resistivity test verification report are complete in accordance with 104W2406 chapter 3.3.

Attention!

Meet grounding resistivity requirements!

The grounding resistivity requirements must be met before the tower is erected. Where applicable, ground wires must be terminated at every stage of the installation process.

4. Verify that the WFMS fiber optic cables are routed through the conduit and are free of damage.

7.2 Attaching the Legs to the Square Platform Frame

Warning!

Foot injury risk!

Warning!

Hand crushing risk!

1. The platforms are shipped to the site, packaged in groups of 2 to 4 as shown in Figure 3.
2. Unbolt the yellow shipping bars to un-stack the platforms.
3. Stage one set of platform hardware at each pad.

The yellow shipping bars and the hardware will be discarded.

Figure 2: Platform packaged in groups of 2 and 4

4. A complete set of hardware is provided attached to each platform. Refer to the BOM or the packing list and ensure all hardware items are accounted for.
5. Report any missing or damaged parts to GE representatives within 2 working days (48 hrs).

6. Attach the rigging to the square platform and lift it approx. 3 ft above the floor.

Figure 3: Square platform

7. Attach the 4 platform legs to the square platform using bolts. Tighten the bolts, torque and mark with a paint pen. Refer to the Bolt Torque Specification.

Attention!

Please make sure to observe the given torque values!

Figure 4: Platform legs

8. Install the two floor hatches and bolt the center floor panel to the square platform. Refer to BOM for the parts callout.

Figure 5: Floor hatches and central floor panel

7.3 Placing Platform Frame on Pad

Warning!

Foot Injury Risk!

Warning!

Tripping Hazard/Impalement!

Warning!

Hand Crush Risk!

1.x configurations may require installation of additional auxiliary voltage regulator on the foundation before the DTE platform is installed. Additional wiring from the voltage regulator to the DTE is required.

Contact GE site representative for installation instructions.

1. Ensure transformer cables and grounds are secured out of the way to prevent damage when placing the ESS platform over the foundation.
2. From the tower door center line, count number of bolts and install 2 foundation anchor bolt nuts approximately 8 in from the foundation floor on the 9th and 10th anchor bolts as shown in Figure 6.

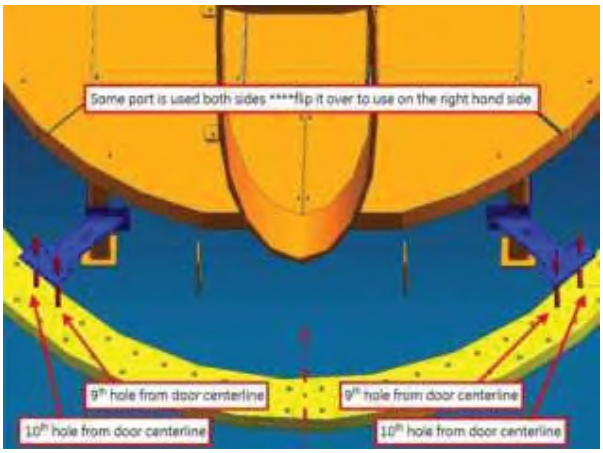

Figure 6: Centering over the foundation

3. Install ESS alignment templates and secure with anchor bolt nuts. Ref Figure 7.
4. Lift the platform and place it centered over the foundation. The two hatch doors must be nearest to the tower entry door.
5. The Power Distribution Cabinet (PDC) side must be placed over the conduits.
6. Adjust the platform main frame as necessary over the foundation to allow proper clearance for the tower flange during installation and clearance between the tower wall, support beams and floor panels.

   Refer to dimensions provided in GE.all_xxHz_SPC_foundation inter _part IV of V.xxx

Figure 7: ESS alignment template

7. Inspect the ESS platform parts for exposed metal surfaces and corrosion.
8. Remove corrosion and using medium grit sandpaper, clean exposed surfaces and spray cold galvanized compound.
9. Attach the adjustable legs to the two cable trays and place below the ESS platform console for later use during cable installation.

Figure 8: Cable trays

7.4 Installing ESS Cabinet onto the Platform

Warning!

Foot Injury Risk!

Warning!

Hand Crush Risk!

Danger!

Overhead Suspended Load!

Warning!

Tripping Hazard!

Danger!

Tipping Hazard!

ESS Units are top heavy.

- Ensure the crates are secured during offloading and storage.
- Ensure crate is staged in hard level surface area.

If soft ground conditions exist use matting as needed to prevent crate from tipping over

Attention!

Check Components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

Please contact the GE site representative if damage is found!

1. If applicable, prior to offloading, inspect the shock and tilt indicators and document ESS shipping condition on bill of loading as indicated on the warning labels.

Figure 9: Inspecting shock and tilt indicator

Danger!

Tipping Hazard!

ESS Units are top heavy.

- Ensure the crates are secured during offloading and storage.
- Ensure crate is staged in hard level surface area.
- If soft ground conditions exist use matting as needed to prevent crate from tipping over.

2. Lift the ESS shipping crate using a forklift. The crates must be handled with caution to prevent damage.

Figure 10: Shipping crate

3. Using a pry bar and a set of pliers, open all sheet metal clips to remove the plywood covers.

Figure 11: Removing plywood covers

4. Remove all plywood covers and place out of the working area.
5. Cut 4 small holes out of the shipping material to expose the lifting points of the ESS cabinet. If installing the fan at this point, cut the plastic bag at the bottom of the cabinet.
6. When removing the bag to install the exhaust fan maintain integrity of the bag for re-use.
7. Attach 4 slings to the lifting points located on top of the ESS/DTE unit.

Figure 12: Lifting points

Only use approved lifting points to lift the ESS cabinet. Lifting points are identified as shown on Figure 12.

8. Instruct the crane operator to center the crane hook over the cabinet and connect the rigging to the crane hook.
9. Instruct the crane operator to hoist enough to hold the load.

10. Remove all shipping bolts.

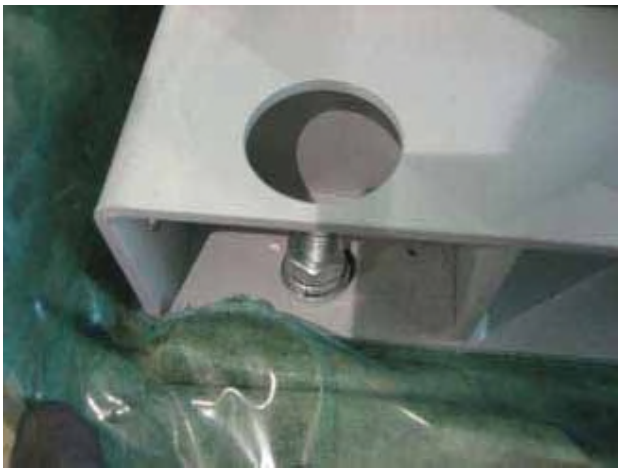

Figure 13: Shipping bolts

Danger!

Overhead Suspended Load!

Never work under a suspended load. Make sure all vehicles, equipment, and materials are clear of the crane tail swing.

11. Lift cabinet over the platform.
12. Ensure exhaust fan hole is protected to prevent moisture and dust entering ESS during lift.

Figure 14: Lifting ESS cabinet

13. The ESS cabinet must be oriented with the PDC cabinet over the conduits.
14. Align cabinet with mounting bolt holes. Secure the cabinet to the frame using hardware provided.
15. Torque all M 16 bolts and mark with paint pen. Refer to the Bolt Torque Specification.

Attention!

Please make sure to observe the given torque values!

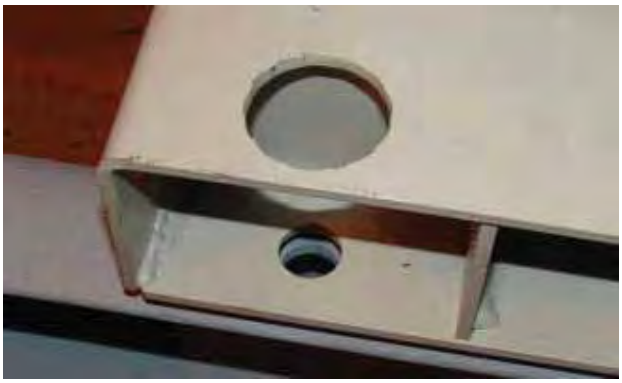

Figure 15: Aligning cabinet with mounting bolt holes

16. The shrink-wrap must be maintained to protect from rain, dust and wind until tower is completely assembled. If the shrink-wrap is damaged, repair as needed, this may include application of new shrink-wrap or tarp to seal against potential moisture due to rain or dust due to wind or site equipment operations. Always ensure the exhaust FAN is completely sealed.

A- Shrink Wrap

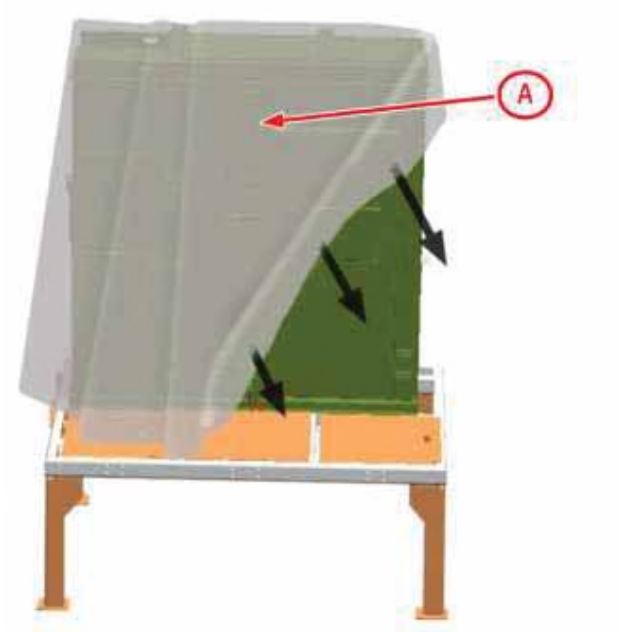

Figure 16: Shrink-wrap to protect from rain and dust

13. The ESS cabinet must be oriented with the PDC cabinet over the conduits.
14. Align cabinet with mounting bolt holes. Secure the cabinet to the frame using hardware provided.
15. Torque all M 16 bolts and mark with paint pen. Refer to the Bolt Torque Specification.

Attention!

Please make sure to observe the given torque values!

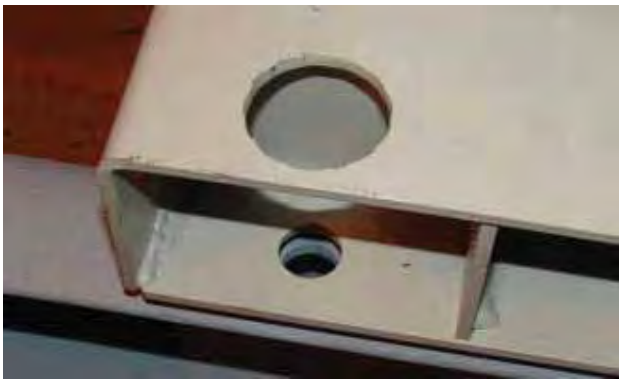

Figure 15: Aligning cabinet with mounting bolt holes

16. The shrink-wrap must be maintained to protect from rain, dust and wind until tower is completely assembled. If the shrink-wrap is damaged, repair as needed, this may include application of new shrink-wrap or tarp to seal against potential moisture due to rain or dust due to wind or site equipment operations. Always ensure the exhaust FAN is completely sealed.

A- Shrink Wrap

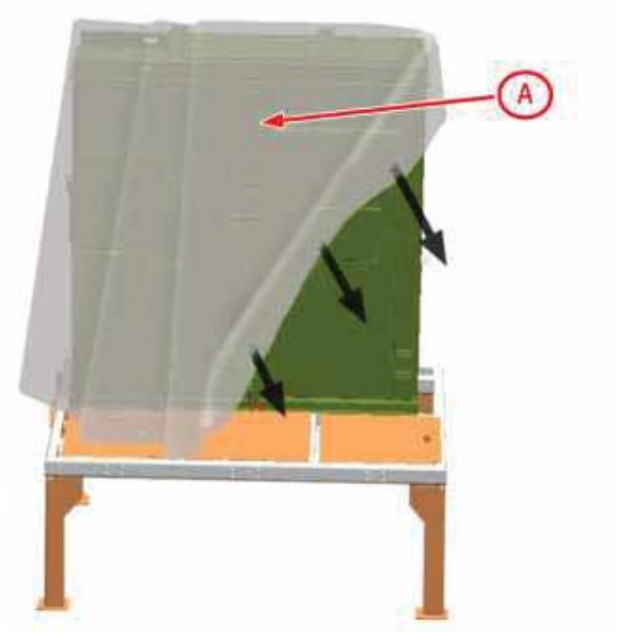

Figure 16: Shrink-wrap to protect from rain and dust

7.5 Installing Exhaust Fan Assembly

Attention!

If the fan is installed immediately before the installation of the nacelle, additional tarping may be required to prevent cabinet water damage.

Warning!

Falling Hazard!

Warning!

Tripping Hazard!

Slipping Hazard!

Warning!

Hand Crush Risk!

1. Cut the bottom of the DTE cabinet plastic bag to remove and uncover the exhaust fan mounting area for installation of the exhaust fan. Place the plastic cover aside out of the working area for later re-use.
2. Remove the four M 5 Tapetite screws and discard cover above the MCC (Master Control Cabinet)

Figure 17: Discarding the cover above the MCC

3. Remove exhaust fan from crate. Save the fan plastic cover for later use to cover fan after installation.
4. Remove the top cover from the fan assembly by removing the 4 screws

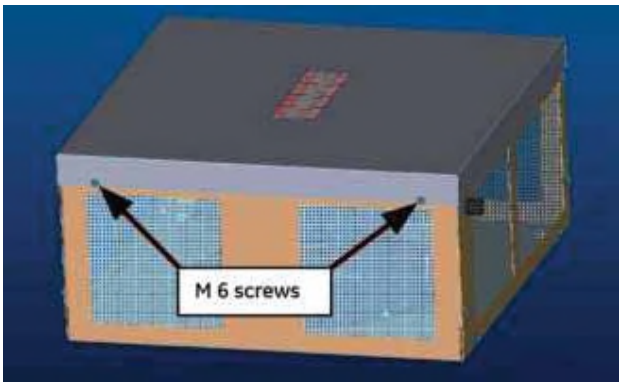

Figure 18: Removing top cover from the fan assembly

5. Lift the exhaust fan assembly, place it on top of the ESS unit and secure with bolts.
   The exhaust fan must be oriented with the terminal board to the front of the DTE.
6. Bolt down the exhaust fan assembly with the supplied hardware.
7. Torque the bolts per manufacturer instructions and paint mark it.

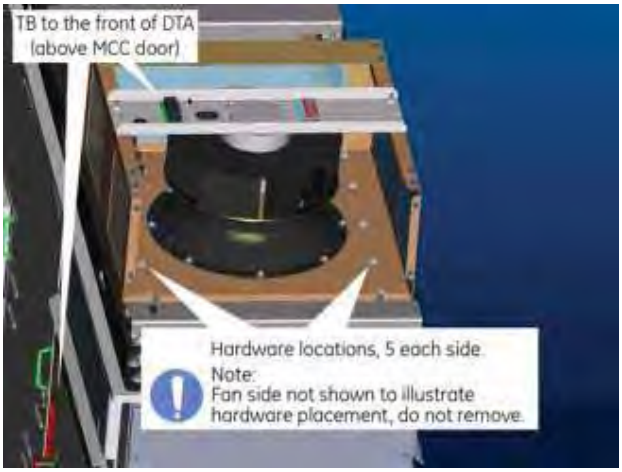

Figure 19: Fan assembly

8. Route the exhaust fan cable (shown in green) over the lift bracket and into the fan housing as shown. Terminate wires as per drawing provided.
9. After wiring, re-assemble the fan cover

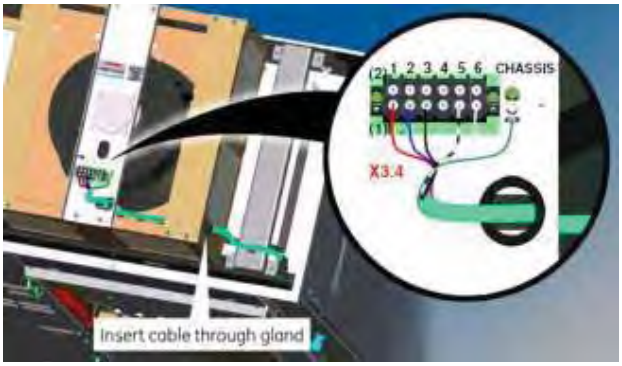

Figure 20: Routing exhaust fan cable

Verify ESS cabinet is not damaged prior to installing the tower.

10. Upon completion of the fan installation replace the plastic cover.

Ensure the ESS unit is completely covered to protect from rain, dust and wind until tower is completely assembled. Ensure area between the ESS cabinet and exhaust fan is completely sealed. If the Shrink-wrap is damaged, repair as needed, this may include application of new shrink-wrap or tarp over the complete unit to seal against potential moisture due to rain or dust due to wind or site equipment operations.

7.6 Attaching Extension Beams and Floor Sections

Warning!

Falling Hazard!

Warning!

Tripping Hazard!

Slipping Hazard!

Warning!

Hand Crush and Cuts Risk!

Warning!

Head Injury Risk!

Low place overhead under the platform!

Step to be performed after base section is installed. Install tower section(s) according to Installation Manual, install foundation grounds and proceed to next step.

1. After the base section has been installed, install all platforms.
2. Attach 4 corner and 12 floor supports starting at door entrance and continue until all floor supports are installed around the platform.
3. Install all deck plates surrounding the ESS cabinets.

Do not tighten bolts until all deck plates and hardware is installed.

Figure 21: Attaching extension beams and floor sections

4. Torque all the M12bolts (grade 8.8) and mark with a paint pen.

Attention!

Please make sure to observe the given torque values!

Figure 22: M12 bolts torqued and marked with a paint pen

5. Attach the ladder to the platform floor using hardware and bolts provided.

Figure 23: Attaching ladder to the platform floor

Two platforms will be removed to gain better access to the cable termination points during the cable installation

7.7 Routing and Terminating PMT Low Voltage Cables

Attention!

Prior to beginning this section, ensure that the PMT is de-energized according to the definition of de-energized state.

Section 7.6 can be completed prior to installation of base section.

Warning!

Falling Hazard!

Warning!

Tripping Hazard!

Slipping Hazard!

Warning!

Hand Crush and Cuts Risk!

Danger!

Danger from electrical voltage!

First de-energize the system to prevent electric shock if work has to be carried out on electrical components.

Danger!

Turbine de-energized state means the turbine is isolated from the grid by one of the following means:

- Unit transformer oil switch is open, locked out and grounds attached.
- Substation switchgear racked out, locked out & grounds attached.
- Substation air switch gear verified open, locked out & grounds attached.

Danger!

Back feed available means unit transformer oil switch is closed and voltage is present in DTE.

Danger!

Refer to the energization process flow chart prior to performing voltage and phase rotation checks.

1. Remove the 2 panels that cover the lower left side of the PDC cabinet and disconnect panel grounds from door to cabinet.
2. First Loosen the top panel,
3. Then remove 2 lower panels. (Keep all small bolts in container to prevent misplacing of hardware)
4. Remove ESS platform horizontal steel section to allow installation of power and neutral cables.
5. Remove ESS cabinet horizontal steel section (at the power distribution cabinet PDC) to allow installation of power and neutral cables.

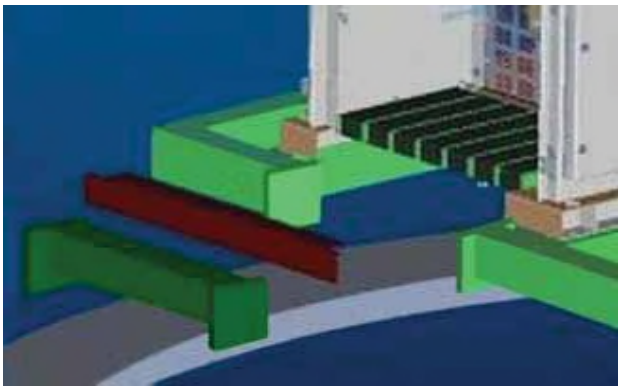

Figure 24: Horizontal steel section

6. Verify if local code requires unistruts and clamps. If not required, remove the unistruts to prevent cable wear.

Figure 25: Unistruts

7. Verify correct phase rotation sequence of all cables. Refer to drawings provided in the main cabinet door to identify cable access point.
8. Route power and neutral cables correctly, by pushing through the neoprene slot separators in the PDC/ESS Cabinet. Use cable gel to prevent damage.

Figure 26: Routing power and neutral cables

9. Measure each power and neutral cable.

Note: to prevent cable strands from falling on to other electrical connections, lean cable against the outside of the cabinet, pull cable away from electrical connections and cut to length.

Pull the cables outside of the cabinet when stripping and crimping the cables.

10. Crimp lugs according to lug and splice procedure.
11. Apply heat shrink based on manufacturer's application instructions.
12. Terminate the low voltage cables to the bus bars in the PDC cabinet.

Hardware arrangement for AL9CU lug with aluminum cable to copper bus refer to GE.all_xxHz_SPC_foundation inter _part IV of V.xxx

13. List the torque used to connect copper or aluminium power cables lugs to bus bar in ESS cabinet in ft-lbs. (Refer to site specific torque values)
14. Inspect inside the cabinet on top and around connectors and remove any debris that can potentially cause an arc.

Vacuum and/or remove any debris, i.e. wire strands, metallic shavings, and tools, un-accounted for hardware and animal/rodent debris.

Figure 27: Installing low voltage cables

7.8 Crimping and Terminating the Neutral Cables to the Ground Bus Bars

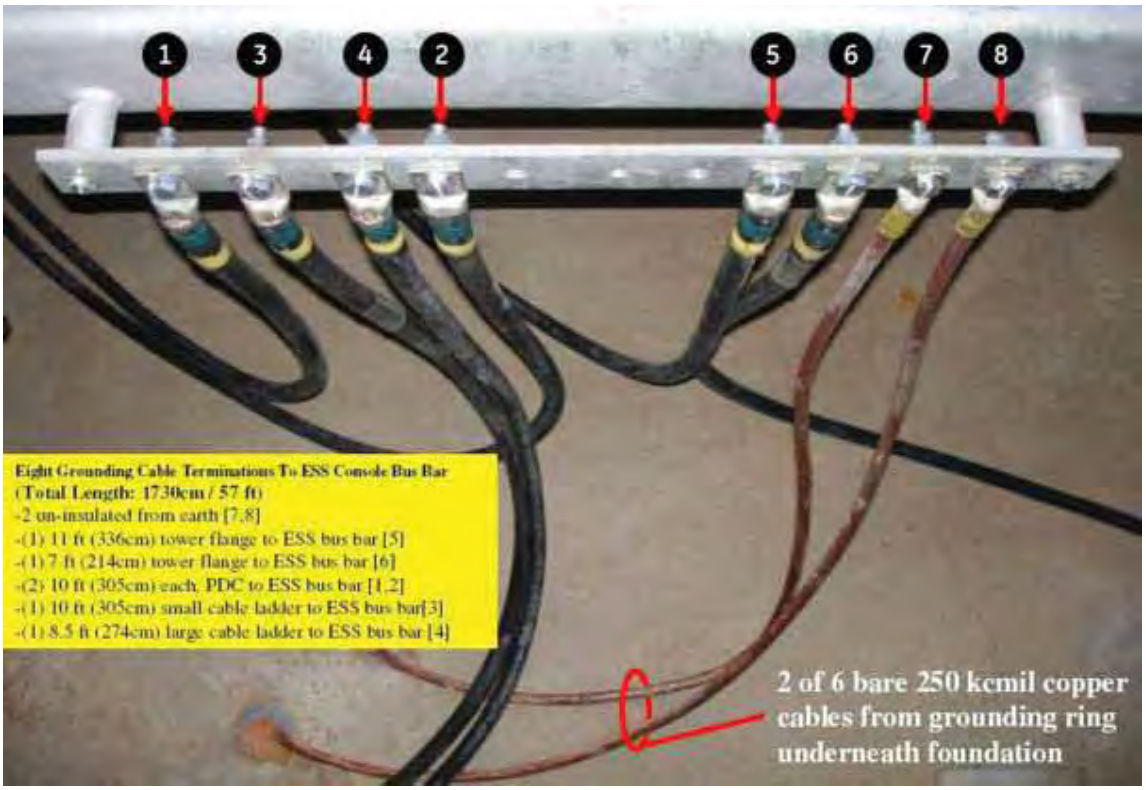

Figure 28: ESS console bus bar

Warning! Falling Hazard!

Warning! Head Injury!

Warning! Tripping Hazard!

Slipping Hazard!

Warning!

Hand Crush and Cuts Risk!

1. Two grounding cables terminate between the ESS platform grounding bus bar and the (PDC) cabinet grounding bus bar. Mark with a paint pen.

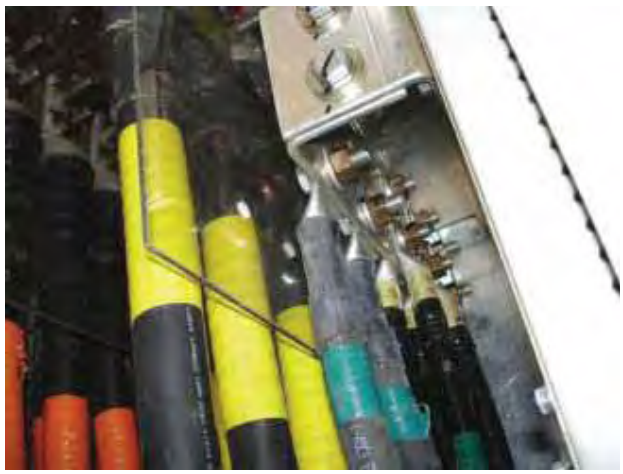

Figure 29: Two grounding cables

2. Two-250 kcmil insulated grounding cables connected from tower flanges, 180 degrees apart, to the console grounding bus bar.

Figure 30: Two 250 kcmil insulated grounding cables

3. Two-250 kcmil bare copper cables from the electrical grounding ring underneath the concrete foundation terminated to the console grounding bus bar. Mark with a paint pen.

Figure 31: Two 250 kcmil bare copper cables

4. Two-250 kcmil insulated grounding cables (1-per cable tray) connected from the small and large cable ladders underneath the console terminated to the console grounding bus bar. Mark with a paint pen.
5. Ensure all insulated grounding cables are supported with cable ties as required underneath the ESS platform.
6. Remove all tools, materials, and hardware from all cabinets.
7. Inspect inside the cabinet on top and around connectors and remove any debris that can potentially cause an arc.

Vacuum and/or remove any debris, i.e. wire strands, metallic shavings, and tools, un-accounted for hardware and animal/rodent debris.

Figure 32: Two 250 kmcil insulated grounding cables

8. Reinstall the ESS platform horizontal steel section for power and neutral cables insertion.
9. Reinstall all ESS cabinet covers and torque bolts to values listed on the cabinet cover.
10. Ensure the ESS unit is completely covered to protect it from rain, dust and wind until tower is completely assembled. If the shrink-wrap is damaged, repair as needed, this may include application of new shrink-wrap or tarp to seal against potential moisture due to rain or dust due to wind or site equipment operations.

8 Foundation/FMP

The laying of the foundations is not part of this Instruction Manual. It is assumed that the foundations were already laid in accordance with the applicable specification.

There are two basic types of foundations:

- Foundations with anchor bolts
- Foundations with a foundation mounting part

8.1 Tools and Materials

Quantity	Description
ar	Bolt, nut, washer set
1	File set, various, 12”
1	Level, laser or standard
1	Paint pen, purple
ar	Paint, tower touch up, exterior
ar	Paint, tower touch up, interior
ar	Sandpaper, medium grit
1	Vacuum, shop, wet/dry

8.2 Preparing the Anchor Cage Foundation

1. Inspect the foundation for cracks/damage; report any foundation damage to customer prior to erection activities.
2. Tap each bolt lightly to break it free of cement seepage. Bolt sleeves should be sealed to prevent water from entering into the sleeve.
3. Clean debris from the entire foundation surface.
4. Install the leveling shim plates. This will allow adjustment of tower.
5. Remove the nuts and washers from the anchor bolts.
6. Place the nuts and washers on the foundation at a sufficient distance from the anchor bolts so they can be easily acquired when placing them back onto the bolts after tower base section is lowered.
7. Anchor bolt threads are protected to prevent grout from adhering to threads when grout is poured. (This allows for stretching of the bolts when tensioned).

8.3 Preparing the FMP Foundation

1. Inspect the FMP interior, exterior, and flange for exposed metal surfaces, corrosion, burrs, and high spots.
2. Remove burrs and high spots using a course half-round file and buff the surface using medium grit sandpaper. Remove corrosion using medium grit sandpaper.
3. Paint exposed metal surfaces of the interior and exterior of FMP.
4. Verify the mounting part is level using a level or reference certificate from civil installer.
5. Verify bolts, tools, and materials are staged inside the FMP with enough clearance from flange.

8.4 Verifying that the Foundation is Level

To ensure correct installation, a horizontal tower base is required!

1. Using a laser level, shoot four points per quarter between shim locations, and mark the results at each location. Return to the highest point recorded within the circumference and use as a reference point.
2. From reference point adjust the shim locations to ensure the minimum grout thickness as required by foundation design.
3. Mark entry door and do not put shims directly underneath the door.

9 Tower

Quantity	Description
2	AC extension cord, 100’
ar	Cable tie, ship loose
1	Container, gasoline
ar	Crimp tooling –vendor specific
ar	Decals, warning label
ar	Die set – vendor specific
2	Duffel bag, canvas
1	Fall restraint system
1	Generator, 6.5 kW with GFCI
ar	Heat shrink, ship loose
1	Ladder, extension, 16’
1	Ladder, step, 10’
1	Laser level kit
2	Plywood, 4x8 feet
1	Pressure washer, with 120’ hose
ar	Rigging
ar	Splices, ship loose
1	Stripper, cable
4	Tagline, nylon rope, 50’
1	Water tank, 500 gallon
4	Wood blocks, 4x6 inches
1	Wrench, combination, 9/16 inch
1	Mop, sponge, heavy duty
1	Socket, deep, 24 mm, ½-inch drive
1	Socket, deep, for anchor bolts
ar	Paint, tower touch up, interior
1	Qualified wrench, torque, hydraulic or electric
1	Socket, for FMP bolts
1	Ratchet, ½” drive
1	Wrench, impact, 1 inch drive
3	Radio, two-way
1	Socket, 17 mm, ½-inch drive
ar	Paint pen, purple
ar	Rags
ar	Paint, tower touch up, exterior
ar	Tape, Duct
1	File set, various, 12”
1	Caulking gun
1	Screwdriver set
1	Wrench, combination, 24 mm
ar	Sikaflex®, 262, ship loose
ar	Sandpaper, medium grit
ar	Bag, 35 gallon

9.1 Inspecting the Tower

Attention!

Check Components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.

Warning!

Do not stage materials or stand on ladder while in horizontal position!

1. Inspect all bolted connections for loose or missing hardware at ladder to tower wall, platform to tower wall, cable tray to tower wall and cable clamps to tray.
2. Inspect the bolted connections at Haka climb system to ladder or safety cable stand-offs to ladder. Install or tighten as necessary.
3. Using temporary ¼ poly rope, secure the transition stator, rotor and ground cables to tray as required, preventing load of cables from breaking during tower base installation.
4. Inspect the interior, exterior, and flanges for exposed metal surfaces, corrosion, burrs, and high spots.
5. Inspect tower section for dents, weld damage, paint damage, loose or broken hardware on all platforms and bus bar brackets,
6. Inspect ladders for damage to include ladder hardware/safety cable stand offs, safety cable anchor and all mounting hardware is marked as torqued.
7. Inspect flanges for flatness/abnormalities.
8. Check rotor/stator/ground cables for damage and that they are secured to prevent falling when the base is installed.
9. Check all hatches, safety rails, tie-off points, light fixtures, light switches, receptacles, cable tray and electrical wiring, bus bar and cages, and security of bus bar boots for any damage.

9.2 Preparing the Tower

9.2.1 Insulated Bus Bar System

Verify bus bar runs are attached to the tower correctly and bolted connections are marked as torque through the complete length of the tower section. Look for dents, scratches, torn or loose insulation, and exposed conductors.

If applicable ensure all assembly parts to make the connections at the tower flanges are secured to tower prior to lifting. Refer to manual 443 for parts list.

Caution!

Do not walk or stand on bus bar cages or cable tray!

For the generation 8 and 10 tower design, the rotor and stator cable terminations are to be performed prior to setting the tower on the foundation. Proceed to section 15.8 (which will refer to the bus bar manual 443).

In bus bar manual, perform step 3.4.31 for cable installation at the base of the bus bars.

Gen 8 towers have same cable and bus bar arrangement as Gen 7. Follow detailed instructions for Gen 7 towers where distinctions exist.

Following termination of the cables:

- Check that cables are properly zip tied to the cable ladder on the tower base, and
- Check that the remaining length of cable is secure so that the cables remain contained when tower base is lifted on to the foundation.

9.2.2 Cables

For more detailed information, please refer to the Work Instructions "Lug and Splice Installation inside the tower".

Warning!

Crushing danger!

Prior to using the hydraulic press, study the Operating Instructions and Safety instructions contained therein.

1. Remove burrs and high spots from flange face using a course half-round file and buff the surface using medium grit sandpaper. Remove corrosion using medium grit sandpaper and spray cold galvanized compound.
2. Tower internal cleaning: Any loose, lightly imbedded or accumulated dirt/debris must be removed from the tower internal surfaces to prevent short or long term contamination by falling down tower to the electrical components.
3. Tower external cleaning: Any material or contaminate that affects the life expectancy of the coating and any accumulated mud or other material that can become dislodged during operation must be removed. Cosmetic appearances are GE´s decision for level of cleanliness if WTG installation is in GE scope.
4. Repair any damaged paint surfaces preparing surface and applying the paint or primer per manufacturer's instructions.
5. Strip cables at tower top based on splice manufacturer's recommendations.
6. Slide 1 short and 1 long heat shrink over the cables and back out of working area.
7. Install and crimp the cable splices onto the power cables using hydraulic press. Perform a pull test to ensure that connectors are not loose. Cover the spliced cables with plastic bag and tape closed.
8. Verify the cables are secured with ties and clamps in the cable tray. Verify the cables are secured below the deck to prevent damage to cables and the DTE.

Figure 33: Connectors attached prior to lifting tower

The cables at the bottom end of the first tower section are **not** prepared!

9. Install light tubes and lens cover in light fixture (if applicable).
10. Install the tower safety decals in accordance with local regulations. Refer to WDI sign board.
11. Install the temporary fall restraint system to allow ascent to top of base section.
12. Put the bags with bolts, nuts, washers, Sikaflex® (or equivalent) and tools on the top platform and attach them to the railing.
13. Tower base sections could possibly be shipped with the lower and upper most section ladder loose to prevent shipping damage. Remove tie wraps holding the ladder, using the brackets provided to secure the ladders to the tower and tighten and mark the bolts.

Figure 34: Light fixture

9.3 Rigging the Tower

1. Attach 4 tag lines to the base end of the tower.
2. Instruct the main crane operator to center the crane hook over the load. Attach rigging, remove the slack, and hold the load.
3. Instruct the tail crane operator to center the hook over the load. Attach appropriate rigging, remove slack, and hold the load.
4. Attach the two tag lines to the bottom flange. The tag lines are used to stabilize the load and position the tower.

9.4 Installing the T-Flange Base Section

Warning!

Warning – falling objects!

Never remain in front or underneath the tower opening.

While the tower is being erected any object or material that remained in the tower or inadequately secured cable can fall out of the tower.

Danger!

Hazard - working under suspended loads!

Never stay underneath suspended loads!

Attention!

Collision hazard!

Lower tower section slowly and carefully. Any collisions between the tower section and the console must be avoided as this may lead to damage.

1. Instruct the tail crane operator to tension the hoist enough to allow removal of the shipping fixture. Remove shipping fixture.
2. Instruct the main crane operator to hoist tower into the upright position.
3. Instruct the crane operator to slowly lower the tower section onto a wood mat with sufficient dimensions and load capacity as shown in the adjacent Figure.
4. Unhook the lifting plate on the bottom tower flange from the auxiliary crane.
5. Detach the tail crane hoist.
6. Prepare the foundation for applying grout in accordance with manufacturer's instructions.
7. Place four wood blocks on the foundation spaced every 90 degrees between the anchor bolts as a safety precaution.
8. Instruct crane operator to begin lowering tower to just above DTE and stop. Verify clearance (orientation) for base section ladder and DTE to avoid damage to DTE.
9. Crew persons holding tag line will guide the tower down over the DTE.

Figure 35: Removing the counter plate from bottom tower flange

Figure 36: Lifting the first tower section

10. Instruct crane operator to lower tower until the entry door is aligned relative to the DTE and the bolt holes in the bottom flange are aligned with the anchor bolts and stop. Remove the wood blocks.
11. Orientate the tower door in reference to DTE and site specific orientation.

Figure 37: Placing the first tower section over DTE

Warning!

Crushing hazard!

When setting down the tower, ensure that your hands and feet are not too close to the tower flange.

12. Instruct crane operator to lower the tower until it is sitting firmly on the leveling hardware. Install washers (with chamfer facing away from flange) and nuts onto the anchor bolts on the outside of tower only. Turn the nuts two full turns.

Attention!

Ladder Damage Hazard!

Take care not to damage the ladder when climbing up tower to check the level or to disconnect the crane.

13. This step is critical to quality and to safe operation of turbines.

    One crew person will climb base section and measure the level of the top flange in four places. If base is out of level, return to bottom of tower. The ground person will make adjustments to the shim packs as required to bring top flange into level. This step may be performed several times to ensure base section is level. The crew person measuring level at top flange must return to bottom of tower before proceeding to next step.
14. If tower is level and base section will be plastic set (grout is applied at this time), then proceed to section 9.4 step 15. If tower is level and base section will be wet set (grout will be applied after mid-section is installed), install remaining washers and nuts then proceed to section 9.4 step 18.
15. Instruct the crane operator to hoist tower until bottom flange is resting against the top nuts at the leveling shim locations.
16. Install the four wood blocks at leveling shim locations to provide a safety barrier from crush points. Apply grout into grout trough according to manufacturer's recommendation. Refer to manufacturer's recommendation for curing time.
17. Remove wood blocks. Instruct crane operator to lower tower down onto the bottom leveling shim plates.
18. One crew person will climb tower and verify level and remove rigging.

Caution!

Wear ear protectors!

Ear protectors must be worn when working with an impact wrench.

For the correct torque values, please see "Bolt Torque Specifications". Refer to foundation drawing for correct torque tension values.

19. Tighten the top nuts with an impact wrench to approximately 100-foot pounds at the leveling shim pack locations (two nuts on both sides of the shim packs). For GE foundation design, refer to Bolt Torque Specifications (1.xSerie_xxHz_TSP_BoltTorquexx) mentioned in chapter 5.1. For all other designs refer to manufacturer design specifications.

20. Install all washers with chamfer facing away from flange and all nuts onto the inside and outside anchor bolts. (Nut manufacturer markings must be visible). Tighten all nuts with an impact wrench to approximately 100-foot pounds and mark with a paint pen.

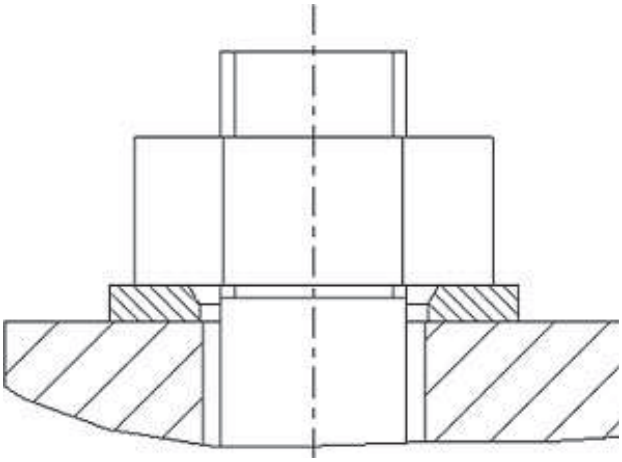

Figure 38: Alignment of washers

21. Place pieces of plywood across the tops of the DTE to PROTECT against damage from falling materials or DAMAGE to BLOWOUT PANELS.
22. Install the tower door step and handrail assembly. Align the step to allow the door to open completely.

Attention!

If stairs are removed during final grading, Ensure stairs are correctly reinstalled and door closes correctly.

Figure 39: Entry steps installed

23. Ensure that the tower doorstop is installed on the correct side of the tower door and adjusted correctly.

Warning!

Install earth ground to base section bottom flange and DTE immediately after setting tower section.

Warning!

Critical to quality and for the safe operation of the turbine!

For T-flange towers, do not install additional tower mid(s) or top section until the grout has cured according to manufacturer instructions and 100 % of the foundation bolts have been tensioned.

Additional towers section could be erected if calculations are provided showing that excessive stresses and deformations are not being imposed on the tower base flange when other sections are installed prior to the grout reaching its full strength. Refer to 104W2407.

24. **Attach one ground lead to the metal tower door entry step outside of tower.**

9.5 Tower Shipping Fixtures

Return the shipping fixtures, braces, tie-downs, hardware and end tarps to place of origin.

9.6 Installing the MTS L-Flange Base Section

Warning!

Warning – falling objects!

Never remain in front or underneath the tower opening.

Whilst the tower is being erected any object or material that remained in the tower or inadequately secured cable can fall out of the tower.

Danger!

Hazard - working under suspended loads!

Never work underneath suspended loads!

Attention!

Collision hazard!

Lower tower section slowly and carefully. Any collisions between the tower section and the console must be avoided as this may lead to damage.

Warning!

Crushing hazard!

When setting down the tower, ensure that your hands and feet are not too close to the tower flange.

1. Apply a continuous (NO GAPS) 12 mm bead of Sikaflex® or equivalent on the face of the FMP. Cover the area of the outside edge ensuring no gaps so that water cannot penetrate inside the tower.
2. Instruct the crane operator to position the tower over the DTE with entry door aligned relative to console.
3. Crew persons holding tag lines will guide base section down over DTE. The tag lines can be removed once the tower is ready to set in place.
4. Instruct crane operator to lower tower until the bolt holes in bottom flange are aligned with FMP. A bull pin can be used to assist with flange-to-flange alignment.
5. Install mounting hardware and instruct crane operator to lower tower to final position.
6. One crew person will climb tower and measure the level of top flange.

Caution!

Wear ear protectors!

Ear protectors must be worn when working with an impact wrench.

For the correct torque values, please see “Bolt Torque Specifications”.

Uncontrolled increase in torque!

Once the torque wrench has switched itself off after reaching the set torque, it may not be switched on a second time on the same bolt as this would result in an uncontrolled increase of torque.

7. Tighten nuts using the one-inch impact wrench in one-third circle jumps to 40 - 60% of final torque value.
8. Verify no gap is present between bottom flange and FMP. If a gap is present between flanges, do not proceed until gap is closed, ensure Sikaflex® was applied properly and contact GE site representative for further instructions.
9. Perform the final torque using qualified tooling. Legibly record torque values in 3 locations: ICL, Daily Torque Log and on the tower wall next to the flange bolts directly across from the ladder.
10. One crew person will climb the tower and remove rigging. And instruct crane operator to move out of work area.
11. Install the tower door entry step and handrail assembly. Align the step to allow the door to open completely.
12. Install the tower doorstop on the correct side of the tower door.
13. Attach one ground lead to the metal tower door entry step outside of tower.

9.7 Temporary Wiring Power Outlets and Lighting

1. Identify the cable for tower lights and place a strip of white tape around cable.
2. Identify the cable for tower receptacles and place a strip of red tape around cable.
3. Route the cables through the tower entry door. Verify the door is secured in the open position and cannot close.
4. Connect a male connector plug to the end of each cable. GE Energy does not provide this plug.
5. Verify termination of wires to plug according to local code standards.
6. Cut the cable tie and connect the plugs to a multiple outlet connected to a portable generator.

10 Tower Mid Section

Quantity	Description
2	AC extension cord, 100’
ar	Bolts, nuts, and washers
2	Bucket, canvas, 5 gallon
1	Bull pin to align flanges
ar	Cable tie, ship loose
1	Caulking gun
1	Container, gasoline
ar	Crimp tool –vendor specific
ar	Decals, warning label
ar	Die set –vendor specific
2	Duffel bag, canvas
1	Fall restraint system
1	File set, various, 12”
1	Generator, 6.5 kW with GFCI
ar	Heat shrink, ship loose
1	Ladder, extension, 16’
1	Ladder, step, 10’
1	Mop, sponge, heavy duty
ar	Paint pen, purple
ar	Paint, tower touch up, exterior
ar	Paint, tower touch up, interior
1	Pressure washer, with 120’ hose
3	Radio, two-way
ar	Rags
1	Ratchet, ½” drive
ar	Rigging
Ar	Sandpaper, medium grit
1	Screwdriver set
ar	Sikaflex®, 262, ship loose
1	Socket, 60 mm, ½-inch drive
1	Socket, impact, 75 mm, 1½-inch drive
1	Socket, deep, 24 mm, ½-inch drive
ar	Splices, ship loose
1	Stripper, cable
2	Tagline, nylon rope, 150’
1	Water tank, 500 gallon
1	Wrench, combination, 24 mm
1	Wrench, combination, 60 mm
1	Wrench, combination, 9/16 inch
1	Wrench, impact, 1” drive
1	Qualified wrench, torque, hydraulic or electric

10.1 Inspecting the Tower

Attention!

Check components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.

Warning!

Do not stage materials or stand on ladder while in horizontal position!

1. Inspect all bolted connections for loose or missing hardware at ladder to tower wall, cable tray to tower wall and cable clamps to tray.
2. Inspect the bolted connections for the Haka climb system to ladder or safety cable stand-offs to ladder. Install or tighten as necessary.
3. Using temporary ¼ poly rope, secure the transition stator, rotor and ground cables to the tray. This is required in order to prevent cables from breaking due to loads during tower base installation.
4. Inspect the interior, exterior, and flanges for exposed metal surfaces, corrosions, burrs, and high spots.
5. If applicable cable towers verify the cable tray bridge is temporarily attached to tray.
6. Inspect tower section for dents, weld damage, paint damage, loose or broken hardware on all platforms and bus bar brackets,
7. Inspect ladders for damage to include lad safe hardware/safety cable stand offs, safety cable anchor and all mounting hardware is marked as torqued.
8. Inspect flanges for flatness/abnormalities.
9. Check rotor/stator/ground cables for damage and that they are secured to prevent falling when the base is installed.
10. Check all hatches, safety rails, tie off points, light fixtures, light switches, receptacles, cable tray and electrical wiring, bus bar and cages, and security of bus bar boots for any damage.

10.2 Preparing the Tower

10.2.1 Insulated Bus Bar System

Verify bus bar runs are attached to the tower correctly and bolted connections are marked as torque through the complete length of tower section. Look for dents, scratches, torn or loose insulation and exposed conductors.

If applicable, ensure all assembly parts to make the connections at the tower flanges are secured to tower prior to lifting.

Caution!

Do not walk or stand on bus bar cages or cable tray!

10.2.2 Cables

For more detailed information, please refer to the Work Instructions "Lug and Splice Installation inside the tower".

1. Remove burrs and high spots from flange face using a course half-round file and buff the surface using medium grit sandpaper. Remove corrosion using medium grit sandpaper and spray cold galvanized compound.
2. Tower internal cleaning: Any loose, lightly imbedded or accumulated dirt/debris must be removed from the tower internal surfaces to prevent short or long term contamination by falling down tower to the electrical components.
3. Tower external cleaning: Any material or contaminate that affects the life expectancy of the coating and any accumulated mud or other material that can become dislodged during operation must be removed. Cosmetic appearances are GE´s decision for level of cleanliness if WTG installation is in GE scope.
4. Repair any damaged paint surfaces preparing surface and applying the paint per manufacturer's instructions.
5. Slide 1 short and 1 long heat shrink over the cables and back out of working area.
6. Strip cables at top of tower based on splice manufacturer's recommendations. Do not prepare the cables at the bottom of the tower at this time.
7. Slide heat shrink over cables and move back out of working area.
8. Install and crimp the cable splices onto the power cables using hydraulic press. Perform a pull test to ensure connectors are not loose.
9. Verify cables are secured with cable ties and clamps in the cable tray.
10. Install light tubes and lens cover in light fixture (if applicable).
11. Install the tower safety decals.
12. Install the temporary fall restraint system to allow ascent to top of segment.

10.3 Rigging the Tower

Warning!

Warning – falling objects!

Never remain in front or underneath the tower opening.

Whilst the tower is being erected any object or material that remained in the tower or inadequately secured cable can fall out of the tower.

Danger!

Hazard - working under suspended loads!

Never work underneath suspended loads!

Attention!

Collision hazard!

Lower tower section slowly and carefully. Any collisions between the tower section and the console must be avoided as this may lead to damage.

Warning!

Crushing hazard!

When setting down the tower, ensure that your hands and feet are not too close to the tower flange.

1. Instruct the main crane operator to center the crane hook over the load. Attach rigging, remove the slack, and hold the load.

Figure 40: Lifting gear attached to tower – main crane

2. Instruct tail crane operator to center the hook over the load. Attach rigging, remove the slack, and hold the load.
3. Attach the two tag lines to the bottom flange. The tag lines are used to stabilize the load and position the tower.

Figure 41: Lifting gear attached to tower – tail crane

10.4 Installing the Tower

1. Instruct tail crane operator to tensions the crane hoist enough to allow removal of shipping fixtures. Remove shipping fixtures.
2. Instruct main crane operator to hoist the tower into the upright position.
3. Instruct the crane operator to slowly lower the tower section onto a wood mat with sufficient dimensions and load capacity as shown in adjacent Figure.
4. Unhook the lifting plate on the bottom tower flange from the auxiliary crane.

Figure 42: Removing the counter plate from bottom tower flange

5. Detach the tail crane hoist and remove rigging from bottom flange. The tag lines can be removed once the tower is ready to set in place.

Figure 43: Lifting the tower section

6. Critical to quality: Apply a continuous (NO GAPS) 12 mm bead of Sikaflex® or equivalent on the face at the top flange of tower base section. Cover the area between the outside edge and the holes ensuring no gap so water cannot penetrate inside the tower.

Figure 44: Applying sealing material onto the flange

Warning!

Crushing hazard!

Never place hands in between the two flanges when lowering the tower section.

7. Instruct the main crane operator to hoist and carefully lower tower onto top of base section. A bull pin can be used to align the flanges.

Danger!

Personnel must be tied off and clear!

Personnel must be 100% tied off and clear of the load at all times. To minimise the risk, personnel must stay below the flange, until the tower section is near or directly over the tower to be installed. Do not reach outside the tower flange perimeter.

Figure 45: Connection the tower section

8. Align the ladders connecting the base and id sections (Ladder alignment supercedes tower marks). Verify all cables are free of pinch points as the tower is lowered.
9. Install four bolts on each quarter. Hand-tighten the 16 nuts.

Caution!

Wear ear protectors!

Ear protectors must be worn when working with an impact wrench.

Attention!

Steps 9, 10, 11, and 12 are critical to quality and to the safe operation of the turbine.

10. Instruct the crane operator to lower the tower to allow installation of remaining nuts, washers, and bolts. Install all washers with chamfer facing away from flange. All nut manufacturer markings must be visible. Tighten nuts using an impact wrench in one-third circle jumps to 40-60% of final torque value.
11. Connect the ladder between the tower base and the mid sections and torque the bolts to 25 to 30 ft-lbs. For Haka rail climb system, install splice plates to top and mid-section connection. Install the U-bolt to ladder rung.
12. One crew person will climb the tower and remove the rigging. Instruct crane operator to move rigging out of work area.
13. Verify no gap is present between tower flanges. If a gap is present, do not proceed until gap is closed, ensure Sikaflex® was applied properly and contact GE Energy Site Representative for further instructions.

14. Perform the final torque using qualified torque tooling and mark with a paint pen. Legibly record torque values in 3 locations: ICL, Daily Torque Log and on the tower wall next to the flange bolts directly across from, the ladder.

Figure 46: Performing the final torque

15. Route and secure tower light and receptacle power cords maintaining alignment (do not cross cables). Terminate power cables to each respective light and receptacles and test to ensure both are in good working condition.
16. Install the tower flange grounds after removing paint or coating from the ground boss mounting face.
17. Wet set grout application, install formwork and apply grout refer to manufacturer's recommendation for curing time.

Figure 47: Tower flange grounds

Critical to quality and for the safe operation of the turbine!

For T flange towers, do not install additional tower mid(s) or top section until the grout has cured according to manufacturer instructions and 100 % of the foundation bolts have been tensioned.

Additional tower sections could be erected if calculations are provided showing that excessive stresses and deformations are not being imposed on the tower base flange when other sections are installed prior to the grout reaching its full strength. Refer to 104W2407.

Bolt torque marks need to be long enough that it is visible beyond bolt caps. Legibly record torque values in 3 locations: ICL, Daily Torque Log and on the inside tower wall underneath the tower door.

Figure 48: Foundation anchor bolts clearly marked

10.5 Installing Additional Mid Sections (if applicable)

Repeat section 11 for towers with additional mid sections.

10.6 Tower Shipping Fixtures

Return all shipping fixtures, braces, tie-downs, hardware, and end tarps to place of origin.

11 Tower Top Section

Quantity	Description
2	AC extension cord, 100’
2	Bucket, canvas, 5 gallon
1	Bull pin to align flanges
ar	Cable tie, ship loose
1	Caulking gun
1	Container, gasoline
ar	Crimp tool – vendor specific
1	Cutter, cable (safety cable)
ar	Decals, warning label
ar	Die set- vendor specific
2	Duffel bag, canvas
1	File set, various, 12”
1	Generator, 6.5 kW with GFCI
ar	Heat shrink, ship loose
1	Ladder, extension, 16’
1	Ladder, step, 10’
ar	Lubricant, spray
1	Mop, sponge, heavy duty
ar	Paint pen, purple
ar	Paint, tower touch up, exterior
ar	Paint, tower touch up, interior
1	Pressure washer, with 120’ hose
3	Radio, two-way
ar	Rags
1	Ratchet, ½” drive
ar	Rigging
ar	Sandpaper, medium grit
1	Screwdriver set
ar	Sikaflex®, 262
1	Socket, 60 mm, ½-inch drive
1	Socket, deep, 24 mm, ½-inch drive
ar	Splices, ship loose
1	Stripper, cable
2	Tagline, nylon rope
ar	Tape, electrical
1	Torch, propane or heat gun
1	Water tank, 500 gallon
1	Qualified wrench, torque, hydraulic or electric
1	Wrench, combination, 2-3/8 inch
3	Wrench, combination, 24 mm
2	Wrench, combination, 50 mm
1	Wrench, combination, 9/16 inch
1	Wrench, impact, 1” drive

11.1 Inspecting the Tower

Attention!

Check components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.

For T flange towers, do not install additional tower mid(s) or top section until the grout has cured according to manufacturer instructions and 100 % of the foundation bolts have been tensioned.

For 2-section towers, the top section can be erected if calculations are provided showing that excessive stresses and deformations are not being imposed on the tower base flange when top section is installed prior to the grout reaching its full strength. Refer to 104W2407.

Caution!

Do not stage materials or stand on ladder while in horizontal position!

1. Inspect all bolted connections for loose or missing hardware at ladder to tower wall, platform to tower wall, cable tray to tower wall and cable clamps to tray.
2. Inspect the bolted connections for the Haka climb system to ladder or safety cable stand-offs to ladder. Install or tighten as necessary.
3. Using temporary ¼ poly rope, secure the transition stator, rotor and ground cables to tray as required preventing load of cables from breaking during tower base installation.
4. If applicable cable towers verify the cable tray bridge is temporarily attached to tray.
5. Inspect the interior, exterior, and flanges for exposed metal surfaces, corrosion, burrs, and high spots.
6. Inspect tower section for dents, weld damage, paint damage, loose or broken hardware on all platforms and buss bar brackets,
7. Inspect ladders for damage to include lad safe hardware/safety cable stand offs, safety cable anchor and all mounting hardware is marked as torqued.
8. Inspect flanges for flatness/abnormalities.
9. Check rotor/stator/ground cables for damage and that they are secured to prevent falling when the base is installed.
10. Check all hatches, safety rails, tie off points, light fixtures, light switches, receptacles, cable tray and electrical wiring, bus bar and cages, and security of bus bar boots for any damage.

11.2 Preparing the Tower

11.2.1 Insulated Bus Bar System

Verify bus bar runs are attached to the tower correctly and bolted connections are marked as torque through the complete length of the tower section. Look for dents, scratches, torn or loose insulation and exposed conductors.

If applicable ensure all assembly parts to make the connections at the tower flanges are secured to tower prior to lifting.

Caution!

Do not walk or stand on bus bar cages or cable tray!

Verify safety cable anchor is bolted correctly to the ladder.
Check safety cable for damage.

11.2.2 Cables

For more detailed information, please refer to the Work Instructions "Lug and Splice Installation inside the tower".

1. Remove burrs and high spots from flange face using a course half-round file and buff the surfaces using medium grit sandpaper. Remove corrosion using medium grit sandpaper and spray cold galvanized compound.
2. Tower internal cleaning: Any loose, lightly imbedded or accumulated dirt/debris must be removed from the tower internal surfaces to prevent short or long term contamination by falling down tower to the electrical components.
3. Tower external cleaning: Any material or contaminate that affects the life expectancy of the coating and any accumulated mud or other material that can become dislodged during operation must be removed. Cosmetic appearances are GE´s decision for level of cleanliness if WTG installation is in GE scope.
4. Repair any damaged paint surfaces preparing surface and applying the paint per manufacturer's instructions.

5. Put the bags with bolts, nuts, washers, Sikaflex® (or equivalent) and tools on the top platform and attach them to the railing.
6. Verify the overtwist pull switch is installed to the underside of the top platform.
7. Uncoil the safety cable to the bottom of the top section. Attach the remainder of the coil to the ladder ensuring that the cable is not kinked.

Figure 49: Overtwist switch mounted below platform

8. If the tower top section has a large PVC tube, contact requisition engineering to determine if this site requires removal of the PVC tube. This should occur prior to the tower erection. If required, then remove and discard appropriately. Contact GE Engineering for removal instructions.
9. If PVC tube removal is required, verify the rubber protector is installed on the yaw deck opening and on the two PVC tube brackets below the yaw deck.
10. Critical to safety: Verify the tower hoist is properly mounted onto the tower frame. Inspect all hoist mounting brackets looking for missing or cracked welds. Ensure hoist is level after the installation.

Refer to hoist manufacturer installation/mounting instructions.

Figure 50: Tower hoist installed

11. One crew member can install the hoist power cable twist lock connector onto the hoist power cable. Secure hoist cable to tower wall and connect the twist lock connectors at the hoist and cable.
12. In Non ESS Units one crew member can terminate the overtwist switch cable. Route cable next to the tower lights and receptacles and lower to the platform at the saddle and secure out of the way. In ESS units the overtwist switch cable is already terminated in the topbox and is connected to the overtwist switch when the control and communication cables are dropped from the machine head after the tower is erected.
13. Secure the hoist and overtwist cables with cable ties to the lighting cable, one tie every three feet.
14. Verify cables are secured in cable tray with cable ties and clamps.
15. Install light tubes and lens cover in light fixture.
16. Install tower safety decals.

11.3 Rigging the Tower

Danger!

Hazard - working under suspended loads!

Never work underneath suspended loads!

Attention!

Collision hazard!

Lower tower section slowly and carefully. Any collisions between the tower section and the console must be avoided as this may lead to damage.

1. Instruct the main crane operator to center the crane hook over the load. Attach rigging, remove the slack, and hold the load.
2. Instruct the tail crane operator to center the crane hook over the load. Attach rigging, remove the slack, and hold the load.
3. Attach the four tag lines to the bottom flange. The tag lines are used to stabilize the load and position the tower.

11.4 Installing the Tower

1. Instruct the tail crane operator to tension the crane hoist enough to allow removal of shipping fixture. Remove shipping fixture.

Warning!

Warning – falling objects!

Never remain in front or underneath the tower opening.

Whilst the tower is being erected any object or material that remained in the tower or inadequately secured cable can fall out of the tower.

2. Instruct the main crane operator to hoist the tower into the upright position.
3. Instruct the crane operator to slowly lower the tower section onto a wood mat with sufficient dimensions and load capacity as shown in the adjacent Figure.
4. Unhook the lifting plate on the bottom tower flange from the auxiliary crane.
5. Detach the tail crane hoist and remove rigging from bottom flange. The tag lines can be removed once the tower is ready to set in place.

Figure 51: Removing the counter plate from bottom tower flange

6. Apply a continuous (NO GAPS) 12 mm bead of Sikaflex® on the face of the mid-section. Cover the area between the outside edge of the flange and the holes ensuring no gaps so water cannot penetrate inside the tower.

Warning!

Crushing hazard!

When setting down the tower, ensure that your hands and feet are not too close to the tower flange.

Personnel must be 100% tied off and clear of the load at all times. To minimize risk personnel must stay below the flange, until the tower section is near or directly over the tower to be installed. Do not reach outside the tower flange perimeter.

7. Instruct the crane operator to carefully lower the tower over the mid-section enough to allow for alignment. A bull pin can be used to align the flanges. Align the ladders (Ladder alignment supersedes the alignment marks). Verify that all cables are free of pinch points.
8. Install four bolts on each quarter. Hand-tighten the 16 nuts.

Caution!

Wear ear protectors!

Ear protectors must be worn when working with an impact wrench.

For the correct torque values, please see “Bolt Torque Specifications”.

Uncontrolled increase in torque!

Once the torque wrench has switched itself off after reaching the set torque, it may not be switched on a second time on the same bolt as this would result in an uncontrolled increase of torque.

Attention!

Steps 8, 9, 10 and 11 are critical to quality and to the safe operation of the turbine.

9. Connect the ladder between the tower mid and the top sections and torque the bolts to 25 to 30 ft-lbs. For Haka rail climb system, install splice plates to top and mid-section connection. Install the U-bolt to ladder rung.
10. Instruct the crane operator to lower the tower to allow installation of remaining nuts, washers, and bolts. Install all washers with chamfer facing away from flange. All nut manufacturer markings must be visible. Tighten nuts using an impact wrench in one-third circle jumps to 40 – 60 % of final torque value.
11. One crew person can climb the tower top section and remove the rigging only if the nacelle will be installed immediately. If the nacelle will not be installed at this time, the crane must maintain 50 % of the load of any additional tower sections.
12. Verify no gap is present between tower flanges. If a gap is present, do not proceed until gap is closed, ensure Sikaflex® was applied properly and contact GE Energy Site Representative for further instructions.

For Europe Pole: Before the last tower section is mounted, the site manager must assure there is enough time and no obstacle in mounting the nacelle immediately afterwards. If for any reason the top section is mounted

but the nacelle cannot be mounted, the following rules must be observed to prevent wind induced vibration, perpendicular to the wind direction:

- If the wind exceeds 10.5 m/s, the duration of such situation shall be limited to one week maximum.
- In order to minimize tower vibrations during that week, it is advised to wind a rope of minimum 15 mm around the tower. Utilize ropes that do not damage the tower painting. Hoist about 5 times the tower height of rope on top of the tower. Lower one end down and firmly tighten it to the outside staircase (close to tower). The rope must be wound at least 30 times on a 61.4 m tower and 50 times around a 100 m tower. The rope must be mounted if the turbine is without machine head for 1 week or longer, unless other measures are taken.

13. Perform the final torque using qualified torque tooling and mark with a paint pen. Legibly record torque values in 3 locations: ICL, Daily Torque Log and on the tower wall next to the flange bolts directly across from the ladder.

The following 2 steps only have to be performed for ladders with safety cables.

14. Uncoil and lower the safety cable to the bottom of the tower base section. Care must be taken to ensure that the safety cable is not kinked. Thread the cable through the eyebolt. Install the thimble, remove all of the slack in the cable and tighten the clamps (2 each). For Haka rail climb system, install splice plates to top and mid-section connection. Install the U-bolt to ladder rung.
15. Tension the safety cable until the sway is removed (do not over tension). Cut off excess cable using steel cable cutters. Leave a two-inch tail. To prevent injury wrap electrical tape around the end of the cable tail until there is not exposed strands.
16. Remove the temporary fall arrest system from all previous segments.
17. Route and secure tower light and receptacle power cords maintaining alignment (do not cross cables). Terminate power cables to each respective light and receptacles and test to ensure both are in good working condition.

Refer to hoist manufacturer installation, mounting and operation instructions.

18. Install the tower flange grounds. Ensure the face of the lug is cleaned of all paint to facilitate a good connection.
19. After top tower is installed, loosen hoist hardware. Adjust to sit level and re-tighten hardware.
20. Chain Type Hoist only,
    - Remove all chains from chain bucket.
    - Mount chain bucket and torque per manufacturer's instructions.
    - Place the chain back into the bucket "tail end first" ensuring no knots or damaged links are present and add chain lubrication as required.

11.5 Tower Shipping Fixtures

Return all shipping fixtures, braces, tie-downs, hardware and end tarps to place of origin.

12 Nacelle

Quantity	Description
2	AC extension cord, 100’
2	Bar, connecting, 2’
ar	Bolts, nuts, and washers
2	Bucket, canvas, 5 gallon
1	Caulking gun
1	Container, gasoline
2	Duffel bag, canvas
1	File set, various, 12”
1	Generator, 6.5 kW with GFCI
1	Knife, putty
1	Ladder, extension, 16’
ar	MoS2 anchor brand jet lube, spray
1	Mop, sponge, heavy duty
ar	Paint pen, purple
1	Pressure washer, with 120’ hose
3	Radio, two-way
1	Ratchet, ½-inch drive
ar	Rigging
ar	Sandpaper, medium grit
ar	Sikaflex®, 262, ship loose
1	Socket, 46 mm, ½-inch drive
1	Socket, 50 mm, ½-inch drive
1	Socket, deep, 19 mm, ½-inch drive
1	Socket, deep, 24 mm, ½-inch drive
2	Tagline, nylon rope, 500’ (150 m ¾" for 80 m HH and up to 200 m ¾" for 100 m HH tower)
1	Water tank, 500 gallon
1	Wrench, Allen, 10 mm
1	Wrench, Allen, 12 mm
1	Wrench, combination, 24 mm
1	Wrench, combination, 50 mm
1	Wrench, crescent, 12-inch
1	Wrench, impact, 1-inch drive
1	Qualified wrench, torque, hydraulic or electric
1	Socket, 60 mm, 1-inch drive (for 1.x-100/103)

If this is an ESS unit, ensure the correct equipment configuration is staged at pad, i.e. ESS FOUNDATION – ESS DTE – BASE SECTION – ESS NACELLE – ESS HUB.

12.1 Inspecting the Nacelle

Check components!

Attention!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.

Attention!

Remove gearbox oil sample handle and place inside topbox or zip tie handle in closed position.

Attention!

Nacelles of the type B&C are equipped with front hatch and safety railing. Modular nacelles are equipped with two sky light hatches. When climbing on top of nacelle roof from the ground, always ensure the ladder is secured with rope to the rail or hooking eye.

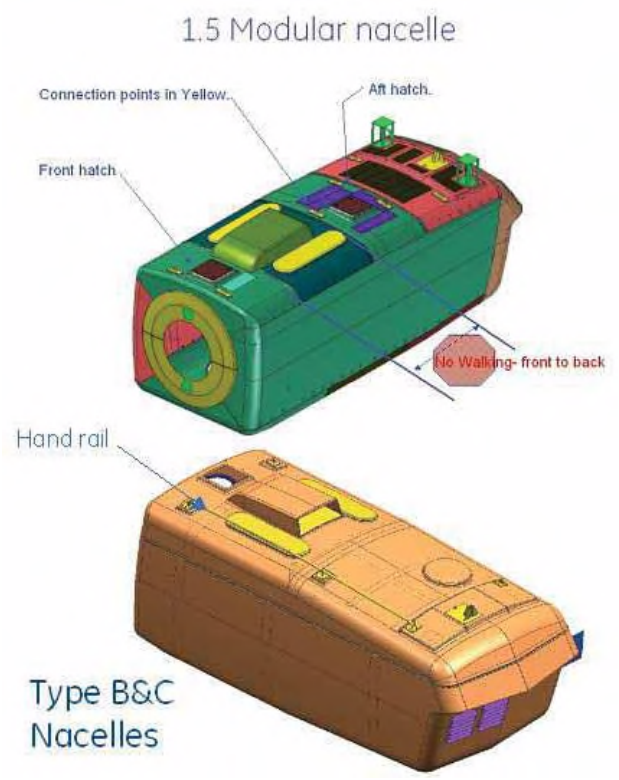

Figure 52: 1.5 Series modular nacelle

12.2 Preparing the Nacelle

1. Clean and remove all shipping tape from exterior of nacelle, tape covering mounting flange (except shrink wrap/tape covering slip ring cables). Apply touch-up paint as necessary.
2. Remove excess water from interior of nacelle as required.
3. Verify the cables are secured in a loose knot around itself to protect cables from pinching and covered with shrink-wrap. Remove tarp for return shipping (if applicable).
4. Check the main shaft hub adapter for burrs and high spots or any foreign debris and correct as needed.

   If flanges have rust inhibitor, remove from main shaft hub adapter using a putty knife (if applicable). The flange face must have even coating of zinc plating (looks like gray paint).

Figure 53: Slip ring wires secured

5. Remove all shipping materials and all tread from the weather station. Erect the weather station bracket and bolt in place using hardware provided. Torque hardware and mark with a paint pen.

Figure 54: Weather station

- For modular nacelle, access to the area between weather station and interior of nacelle is by the rear roof hatch. Use the ladder mounted in the rear to get to the rear roof hatch. Replace the ladder on rear wall hangers AFTER the roof work is done. Areas without non-slip surface between hatches, specifically along hatches for machine head lifting and oil cooler exhaust, **are not tread safe.**
- No walking is permitted in the area between the two access HATCHES
- When working on front of nacelle top roof use the FRONT hatch, when working on rear of the nacelle top roof such as anemometer FAA lights use the REAR hatch.
- No more than one person may attach to the same tie-off point at the same time. Always attach to different U-bolt safety tie locations. Safety tie off points are painted yellow.

6. – If applicable install the anemometer and wind vane to the weather station.
   - Loosen the bolts, as needed using a 10 mm socket and socket wrench.
   Note: Do not remove the nut completely from the bolt; only loosen it, until the bolt is halfway through the nut.
   - Slide the bolt, washers and ring terminal toward the rotor until the nut touches the mounting stub on the mast.
   - Mount the wind vane (V 200 mm CL-to-CL) and anemometer (A 150 mm CL-to-CL) as labeled "This side towards the rotor". Ensure pins are not damaged when connecting the anemometer and the wind vanes.
   - Tighten the bolt using a 10 mm socket and socket wrench. Torque bolt to 7 Nm (5 ft-lbs) and torque stripe.
   Note: Make sure the ring terminal is positioned in the sensor slot while tightening the bolt.
   - Add Loctite red (permanent) to the threads of the anemometer and the wind vane. Check the Loctite for type blue or red!

7. If applicable, ensure the ultrasonic anemometer/wind vane installed by the manufacturer is not damaged.

Figure 55: ultrasonic anemometer

8. Install the optional aviation lights. Primary Aviation light location is on left by handrail and additional location on right hand side for 2 strobe requirements. Refer to site-specific documentation. The aviation posts will be secured using the bolts and washers already provided on the nacelle roof. Remove the existing M10 bolts and washers; install the new wiring and the aviation posts. Next, reinstall the M10 bolts and the washers. Finally, cover the bolts and the washers completely with Sikaflex or other approved sealant. Next completely seal around the perimeter of the newly installed aviation post base-plate with a bead of Sikaflex or other approved sealant.

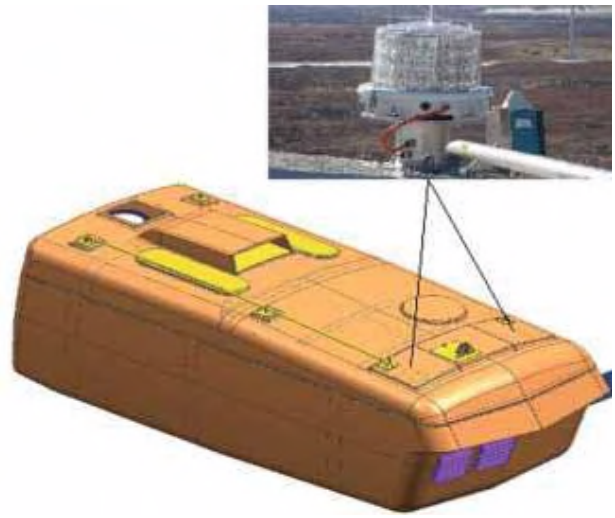

Figure 56: Aviation lights

Danger!

Hydraulic Disc Brake and Brake Disc Rotor Lock Use!

The installer must personally ensure all personnel assigned to work activities inside the WTG are properly trained on the use of the hydraulic disk brake and disk rotor lock, to ensure the hydraulic disc brake and brake disc rotor lock are 100% engaged and locked out before attempting to:

After aligning main shaft during rotor installation, pre tighten and torque hardware after rotor is fully engaged onto the main shaft.

Disconnecting crane and removing crane out of the working area after rotor is installed.

Performing any work outside or inside of the hub after rotor has been installed.

Performing any work inside or outside the nacelle near exposed rotating components after rotor has been installed.

All GE employees must ensure the hydraulic disk brake and disk rotor lock is 100% locked out before exiting to the top of nacelle.

9. Verify all hub-mounting nuts and washers are present.
10. Use the hydraulic hand pump to apply the brake. Turn the hydraulic hand pump relief valve clockwise and pump the arm of the hand pump to activate brake.
11. Hydrep units: Open the bleed valve manually by pressing the black rubber knob and holding it (for 10 seconds minimum and/or as required) until the system pressure is completely released (gauge reading falls to zero psi, and caliper is observed to be fully retracted. Double check the pressure remains at zero and the caliper remains retracted after 5 minutes).

Refer to 1.5Serie_60Hz_WDI_PMT_brakehydra_StrtMaintESS, "Start-up and Maintenance of the Hydrep Active Brake at the High-Speed Shaft".

12. Hydac/Svendborg units: To release the brake turn the pressure relief valve counter clockwise until the gauge reads zero bars. To apply turn valve clockwise.
13. If applicable, verify a step ladder is in the nacelle. Using rope or tie wraps, secure the step ladder near the yaw deck / tower access. This ladder is used to help reach the access ladder. When the work is complete secure the ladder out of the working area to prevent damage to cables.

Figure 57: Hydraulic pump

14. Pull the pin out of the brake disc rotor lock to disengage the lock and rotate counter-clockwise.
15. Remove the shroud of the high-speed coupler.


Figure 58: Brake disk rotor lock

16. Install the rotating tool (refer to gen alignment procedure).

12.3 Rigging the Nacelle

1. Remove the two nacelle lift point covers and place inside nacelle.
2. Attach the lifting beam to the crane. Instruct the crane operator to position the lifting beam over the nacelle and guide rigging to the lifting points.
3. Attach rigging to front lift points. Attach rigging to the left and right rear lift points.

Warning!

Use caution when attaching rigging so damage does not occur to hydraulic power unit, yaw motors, or any cables.

4. Attach the one tagline to the main-shaft bolt hole (top of the flange) and one tagline to the rear-lifting lug of the generator.

Danger!

Hazard - working under suspended loads!

Never work underneath suspended loads!

Attention!

Collision hazard!

Lower nacelle slowly and carefully. Any collisions between the tower section and the nacelle must be avoided as this may lead to damage.

5. Instruct the crane operator to lift the nacelle approximately 12 inches from the ground or transport. Stabilize the load and verify the nacelle is level. Remove the shipping fixture. Proceed to next steps if installing from ground staged.
6. Instruct crane operator to set nacelle back on the ground with the crane holding approximately 80% of the load.
7. Using a hammer wrench, loosen the bolts mounting the shipping fixture. Remove the fixture mounting bolts from the inside of nacelle.
8. Verify the slew ring to tower flange-mating surface is clean.

Attention!

Prior to installing the nacelle remove the shipping plastic & shipping material from the yaw bearing and rear of nacelle

Inspect hub-mounting surface for dirt, ice or grease prior to erecting. Clean the inspection window in front covers of the main shaft prior to lifting and orient toward top of nacelle.

12.4 Nacelle Shipping Fixtures

1. Disassemble, band and palletize as required, load fixtures and hardware onto transport vehicle.
2. Return the feet or welded fixtures, hardware and shaft cover to place of origin.

12.5 Installing the Nacelle

Warning!

Damage to Equipment!

During installation of the rotor, when less than ideal installation conditions exist (i.e., high winds or less experienced installation team), consult with onsite GE representative for instructions to protect slip ring cables during the installation.

Danger!

Hazard - working under suspended loads!

Never work underneath suspended loads!

Attention!

Collision hazard!

Lower nacelle slowly and carefully. Any collisions between the tower section and the nacelle must be avoided as this may lead to damage.

Warning!

Crushing hazard!

When receiving the nacelle, always ensure that hands and feet are not between the nacelle and the flange.

1. Instruct the crane operator to hoist the nacelle into position above the tower top section. While the nacelle is being hoisted the tower crew can apply lubricant onto 100 % of the threads of the bolts.

Figure 59: Hoisting the nacelle

2. The tower installation crew must align four-hole openings of the yaw deck and tower flange. Connecting bars can be used to assist with alignment of bolt holes. Install four sets of two bolts and washers into the threaded holes of the yaw deck.

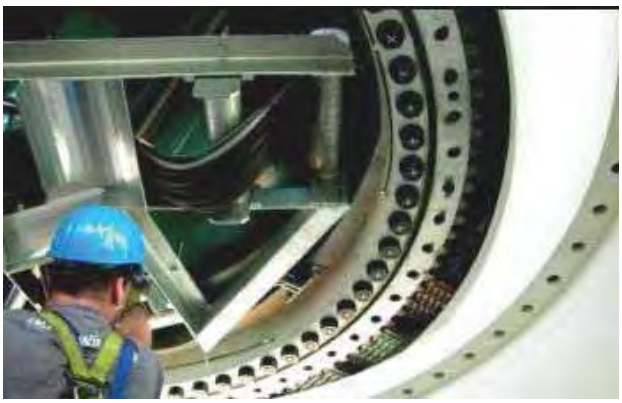

Figure 60: Aligning the nacelle

3. Install the remaining washers and bolts in the yaw deck. After all bolts are installed, instruct the crane operator to fully lower the nacelle onto the tower flange. Tighten all bolts with an impact wrench in one-third circle jumps to 40 – 60 % of final torque value.

Figure 61: Tightening bolts

Note!

If bolts do not fully engage due to bad threads contact GE prior to final torquing and or disconnecting the crane.

Note!

If required, use the step ladder to help reach the nacelle access ladder. When the work is complete secure the ladder out of the working area to prevent damage to cables.

4. Remove the crane rigging. Instruct crane operator to move rigging out of work area. The tag lines can be removed.
5. Critical to quality and safe operation of the turbine: Perform the final torque using qualified torque tooling and mark with a paint pen. Legibly record the torque values in 3 locations: ICL, Daily Torque Log and on the tower wall next to the flange bolts directly across from the ladder.
6. Refer to Bolt Torque Specification for final torque value.
7. Install the two lift point access covers.
8. Install the lights into the fixtures and replace the lens covers.
9. Terminate optional aviation light. Refer to manufacturer's instructions.

Figure 62: Torquing bolts

10. Inspect the interior of the tower for scrapes and bare metal surfaces. Apply latex based paint using manufacturer's instructions.

12.6 Hub


Attention!

Rigging Requirements!

Standard 1.5 hubs require three each M39 threaded swivel hoisting rings (Type WBG-8).

The 1.x-100/103 is heavier and requires 3 lifting plates with 2 bolts per plate.


Attention!

48.7c carbon blades have 56 stud bolts and must be matched with the hubs that have 1 hole lifting eyes.

48.7 and 50.2 glass blades have 68 stud bolts and must be matched with the hubs that have 2 hole lifting eyes

Quantity	Description
ar	Cribbing
1	Ladder, step, 10’
3	Radio, two-way
Per lift plan	Rigging
2	Tagline, nylon rope, 20’
1	Tape measure, 100’

12.7 Inspecting the Hub

Carry out the hub receiving inspection. Inspect the hub for signs of shipping damage. Contact the GE site representative if damage is found.


Attention!

Check components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.


Attention!

Check components!

If this is an ESS unit ensure the correct equipment configuration is staged at pad, i.e. ESS FOUNDATION CONDUIT LOCATION - ESS DTE - BASE SECTION - ESS NACELLE - ESS HUB.

Attention!

Critical to safety!

Only use devices designed for lifting the hub. Do not use the transportation "Transportation Tie Down Brackets" for lifting the hub. The transportation tie-down brackets are only used during transportation, they not load rated for lifting. Moving of hub prior to blade assembly is to be done using three load rated swivel lifting rings affixed to the three lifting pick points. Refer to the applicable hub outline 104W1925 - S, SL, SLE; 115W1035 - XLE hub; 108W6300 - 1.6-100 hub outline with single hole rotor lifting eye; 103W3327 hub outline with double hole rotor lifting eye.

Attention!

Critical to safety!

Rotors cannot be assembled with intent to store. Rotors not installed within 30 days after must begin a documented maintenance cycle. GE will provide the lubricant and directions, but it is the installer's responsibility for executing and submitting documentation to GE.

12.8 Lifting the Hub (Typical 1.5/1.6 Configuration Other than 1.x-100/103)

1. Remove the transportation tie-down brackets from the hub. Secure the transportation tie downs for return to place of origin.
2. If not load rated, do not use the transportation tie-down brackets for lifting the hub!

Figure 63: Transportation tie downs

3. Attach the 3 lifting lugs to the bearing ring threaded hole of the hub.
4. Standard 1.5 hubs other than 1.x-100/103 require 3 each M39 threaded swivel hoisting rings (Type WBG-8). Consult with GE representative.

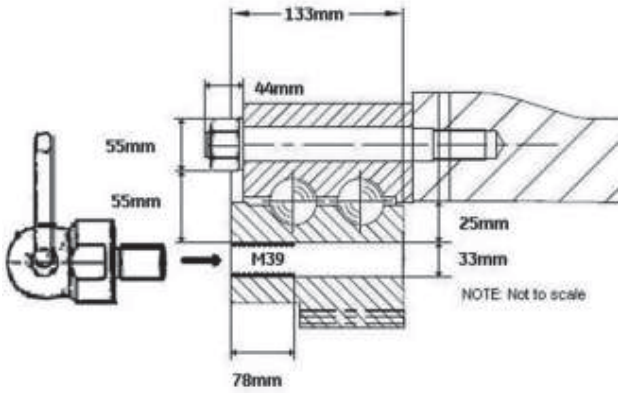

Figure 64: Swivel hoisting ring

5. Prepare the area for hub staging with cribbing. Verify that the staging area is level to eliminate loading on the blade bearings when manually pitching blades.
6. Install a tag line to stabilize the load.
7. Instruct the crane operator to hoist the hub and off-load onto cribbing for assembly of rotor. It must be a minimum of 18 inches from ground to hub flange (40 m blades require a minimum clearance of 24 inches from the ground to the hub flange).

Figure 65: Swivel hoist connecting point

8. To protect the hub from elements, remove the shipping materials only if final assembly can be accomplished immediately (store with shipping materials attached).
9. Remove all the dirt or non-permanent surface coating materials from the interior and exterior bearing face. Clean the hub and apply touch-up paint as necessary.

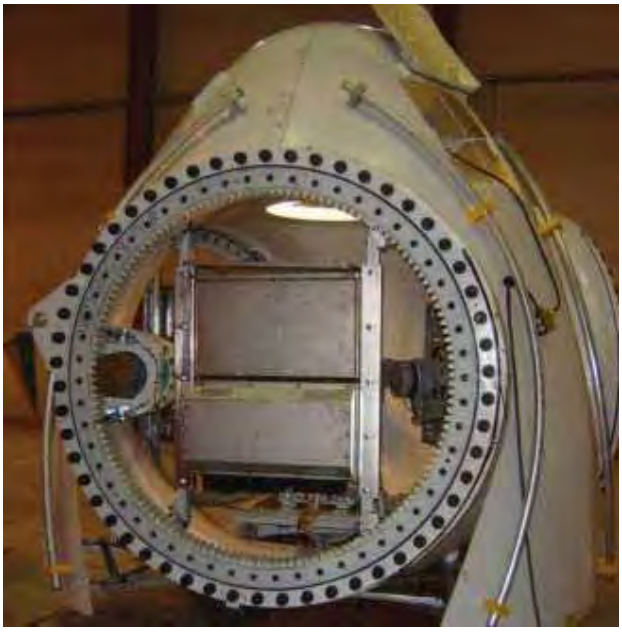

Figure 66: Clean exterior bearing face

12.9 Lifting the Hub (1.x-100/103 Configuration)

Attention!

Please check the outline drawing for the lifting point. Below pictures are for reference only!

1. If required remove the transport tarp from the hub to attach rigging.
2. To protect the hub from elements, remove the shipping materials only if final assembly can be accomplished immediately (store with shipping materials attached).

Figure 67: Hub transportation

3. Offload the nose cone near the area where the rotor will be assembled.

Figure 68: Nose cone transportation

4. **Mount the lifting gear to the bearing of the hub for unloading it from the trailer.**

Request the blade dimensions, weights, bearing bolt-hole pattern and bearing dimensions to design the lifting equipment.

5. **When designing lifting equipment for the hub:**
   - Ensure that the lifting plate clears the bearing seal to prevent damage.
   - Ensure that the lifting plate clears the bearing mounting hardware.

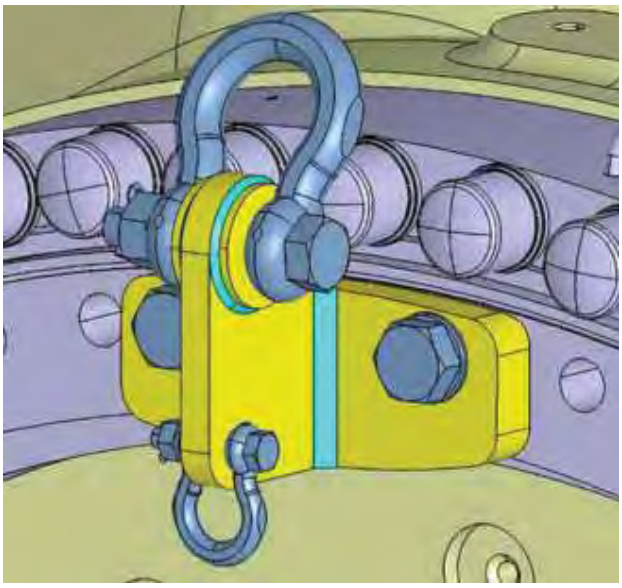

Figure 69: 1.x-100/103 hub lifting gear

Attention!

In locations with limited spacing issues, the assembling of the rotor at the working area can be accomplished by using a hub table that allows the installation team to mount the blades to the hub without any support underneath the blade tip.

Note: Hub table is installer's responsibility to procure. GE can provide “technical Guidance” for the hub fixture.

Figure 70: 1.x-100/103 hub lifting locations

6. **Attach a guide rope to the transportation frame to stabilize and safely offload the hub.**
7. **Lift the hub from the transportation trailer.**
8. **Secure the transportation tie downs for return to place of origin.**

Figure 71: Guide rope on transportation frame

9. The hub must be set down on a firm horizontal surface and must support the weight of an assembled rotor. Lay a wooden bed over the area for setting down the hub. Check that the area is horizontal, in order to exclude stressing of the blade bearings during the manual blade pitching.
10. Ensure that there is a clearance of 24 inches from ground to hub flange to allow blade pitch.
11. Detach the guide rope from the hub. Detach the lifting lugs to the bearing ring of the hub.

Figure 72: 24 inch clearance to allow blade pitch

12. If applicable remove any dirt or temporary surface coatings from the inner and outer bearing surface.
13. Clean the hub and touch up if any damage to the paint.

Figure 73: Clean coating from the bearing surface

14. Ensure that the correct quantity of blade mounting hardware nut/washers is at hand.

Figure 74: Blade mounting hardware

15. Remove the bearing metal covers bolted to the hub covering the bearing teeth to prevent damage to the studs and allow access to the torque bolts.

Figure 75: Bearing metal cover

16. If the hub will be stored, leave the temporary dust cover in place.
17. If the rotor will be assembled immediately after it is offloaded, replace the temporary dust cover with a suitable walking/working platform leaving access points for conductors as required.

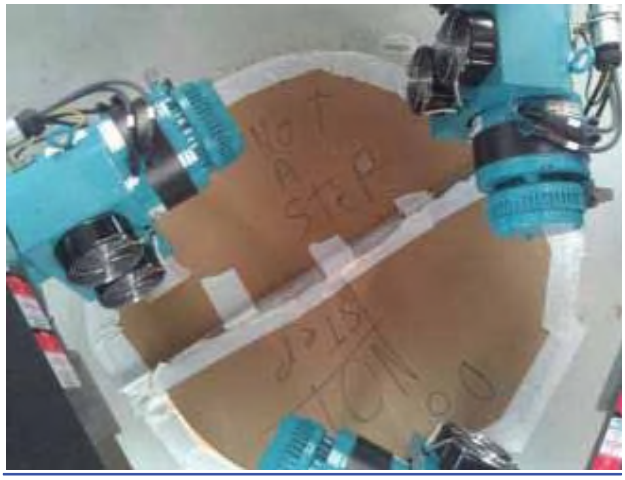

Figure 76: Temporary dust cover

13 Blades

Rigging requirements!

Rigging requirements are based on the site lift plan. Consult with GE to obtain equipment outline drawings, containing bolt hole patters and approved lifting points weights and dimensions.

Quantity	Description
ar	Brush, wire
1	File set, various, 12”
1	Generator, 6.5 kW with GFCI
1	400 volt AC (+/- 10%) 3 phase power generator (400VAC generators are not common in some countries, however you can use a common 480 VAC generator with the output voltage turned down to 440VAC on the pitch system) use a 4c-6 AWG cable as required.
1	Ladder, step, 10’
ar	MoS2 anchor brand jet lube, spray
ar	Paint pen, red
3	Radio, two-way
ar	Rags
1	Ratchet, ¾-inch drive
Per lift plan	Rigging
ar	Sandpaper, medium grit
1	Socket, 50 mm, ¾-inch drive
2	Tagline, nylon rope, 100’
1	Wrench, combination, 50 mm

13.1 Inspecting the Blades

Attention!

Check Components!

All components must be checked for visible damage, deformation and cracks prior to assembly!

The components must be stored and mounted in such a way that any damage that could adversely affect the standing stability or load-bearing capacity and could thus cause potential accidents is avoided.

Please contact the GE site representative if damage is found.

1. Check the blade support position and the blade condition. Blade must no touch the metal fixtures. Report to GE representative as required.
2. Inspect the blade studs for damaged threads/bearing and inspect the blade mating surfaces for high spots or protrusion.
3. Inspect the studs for corrosion.
4. Ensure that the blade root access doors in 40 m blades are closed and handles in locked position.
5. Ensure that the blade closeout cap hardware is tight on 37 m blades.
6. Inspect the blade tip drain holes for blockage (all three blades). Inspect by applying a small amount of compressed air to the drain hole verifying free flow of air into the blade cavity. If blockage is encountered, contact GE representative.
7. All blade damages must be reported and blade repair must be done in accordance with manufacturer’s recommendations.

13.2 Offloading the Blades

Caution!

Blade Handling!

When handling the blades on shipping fixture(s),

Specific blade manufacturer's handling instructions must be reviewed with the crews and understood prior to commencing work.

Only use lifting points that are designated by blade manufacturer for lifting.

DO NOT use tie down points for LIFTING.

Only use lifting points marked in yellow that are rated with enough capacity to lift the entire weight of the blade(s).

If unsure, always consult with GE technical advisors prior to handling individual blades and/or blades in shipping fixtures.

Blade is not designed to support tip fixture stand with TE.

1. Attach the rigging to the blade fixture approved lifting points.
2. Install the tag line to stabilize the load.

Refer to manufacturer's recommendations for staging blades.

If blades are not installed immediately, always secure the blades during storage to prevent damage during high winds.

- Ensure ground level according to manufacturer's requirements.
- Secure the blades to proper anchor points.
- Secure all 40 m and longer blades at root end and tip with ropes to proper anchor points to prevent gusty winds from flipping the blades.
- Also secure the leading edge of each blade (at manufacturer's blade support markings) with tag lines to the anchor points.
- To ensure no blade damage occurs; use protective matting between the blade and the tag lines.

Figure 77: Blade offloading lifting points

Figure 78: Blade offloading lifting points

13.3 Preparing the Blades

1. Correct the damaged threads and remove high spots with a file.
2. Remove the corrosion with a wire brush.
3. If threads and high spots cannot be corrected or corrosion cannot be removed, contact GE site representative.

Attention!

Please check the outline drawing for the lifting point. Below pictures are for reference only.

4. Remove all the dirt or non-permanent surface coating materials on the studs, blade end face, and the bearing face, and remove any water and debris from the root end of blade. Check carefully and remove any shipping bracket washers lodged between the blade closeout and inside wall of the blade.

Figure 79: Clean flange

5. Apply lubricant as per Bolt Torque Specification to 100 % of the threads on the blade studs. Shake the can thoroughly for a minimum of one minute. The lubricant will have a silvery appearance (if clear, continue shaking the can).
6. Highlight the 0-reference mark on the face and inside edge of the blade using a red paint pen.

Figure 80: Reference marking

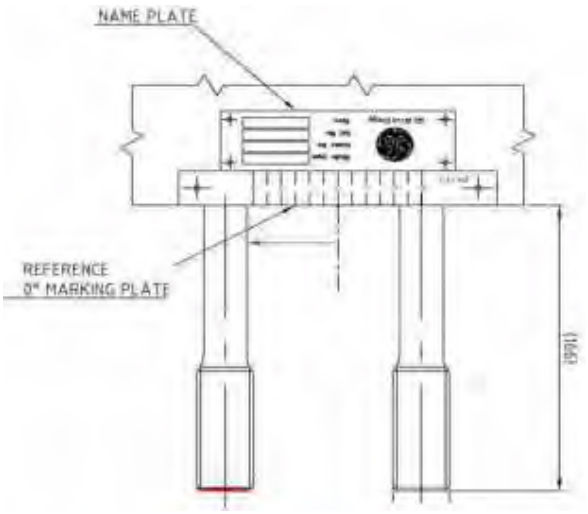

Figure 81: Reference marking

7. Place a red paint pen line marking across the face of the blade flange centered with the 0 reference mark.
8. Highlight the end of the stud directly left of the 0-reference mark using red paint pen.

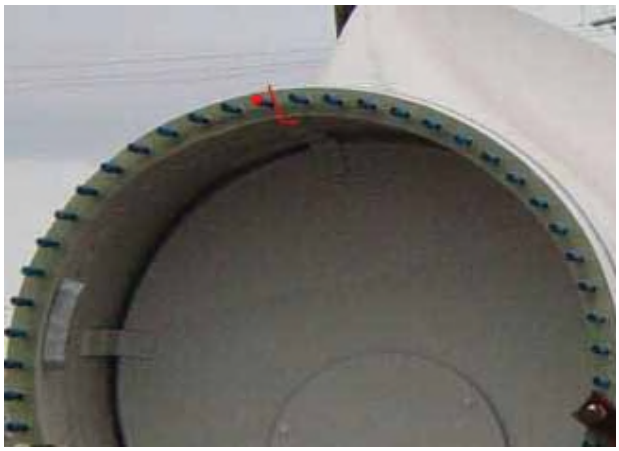

Figure 82: Line on blade flange and stud highlighted

9. Verify that the root close outs or access doors on all the three blades are properly closed.

Figure 83: Blade closeout

13.4 Rotor Blade Handling

Quantity	Description
1	AC extension cord, 100’
1	Adapter, ½” f to m, ¾-inch drive
1	Adapter, ¾” f to m, 1-inch drive
1	Adapter, 1” f to m, ¾-inch drive
1	Adapter, universal, ¾-inch drive
ar	Bag, 35 gallon
3	Blade sock
2	Bucket, canvas, 5 gallon
ar	Cleaner, bio-degreaser
3	Container, 40 gallon, trash
1	Container, gasoline
ar	Cribbing
1	Cutter, diagonal
1	Chain fall, 10 ton
2	Duffel bag, canvas
1	Extension, 12 inch, ¾-inch drive
1	Extension, 12 inch, 1-inch drive
1	File set, various, 12”
1	Generator, 6.5 kW with GFCI
1	Hammer, 10-lb
1	Hammer, 4-lb
1	Knife, utility
1	Ladder, step, 10’
1 set	Leading & trailing edge protection caps
1	Light, drop
4	Mop, sponge, heavy duty
ar	Nuts & washers, blade install
ar	Nuts & washers, rotor install
1	Outlet, 3-way, 30Amp, w/GFCI
ar	Paint pen, blue
ar	Paint pen, red
ar	Paint pen, white
1	Pitch Drive Control Box for SSB or Exor ePalm 10 (PDCB)
1	Pliers, channel lock
1	Pressure washer, with 120’ hose
1	Punch set
3	Radio, two-way
ar	Rags
1	Ratchet, ½-drive
ar	Rigging
ar	Sandpaper, medium grit
1	Socket, 50 mm, ¾-inch drive
1	Socket, 50 mm, 1-inch drive
1	Socket, 55 mm, ¾-inch drive
1	Socket, 55 mm, 1-inch drive
20	Straw, 70-lb bales

Quantity	Description
3	Tagline, nylon rope, 100’
3	Tagline, nylon rope, 500’ (150 m ¾" for 80 m HH and up to 200 m ¾" for 100 m HH tower)
1	Tape measure, 100-ft
1	Tape measure, 25-ft
3	Trailing edge protector
1	Water tank, 500 gallon
1	Wrench, Allen, 14 mm
1	Wrench, combination, 2-3/8”
1	Wrench, combination, 24 mm
1	Wrench, combination, 55 mm
1	Wrench, impact ¾-inch drive
1	Wrench, impact, 1-inch drive
1	Wrench, torque, 250 ft-lb
1	Wrench, torque, 600 ft-lb
1	Qualified wrench, torque, hydraulic or electric

Blades may be shipped with the trailing edge facing up or in a 0 to 45-degree position.

If shipped with trailing edge facing up, use spreader bar for hoisting.

If shipped in a degree position, first rotate blade so the trailing edge is facing up, then remove the root fixture. Use trailing edge and/or leading edge protectors per manufacturing drawing when handling blades.

If unsure, always consult with GE Blade Engineers prior to handling individual blades and/or blades in shipping fixtures.

1. The Rotor blades are marked with the center of gravity. These marks help to balance the blades.

Figure 84: Center of gravity marking

2. Several marked fastening points are located on each rotor blade. Support the blade for lifting or storage as labeled in accordance with specific blade manufacturer drawings. Consult with GE representative for specific blade drawings.

Figure 85: Lift here, support points markings

Attention!

Do not deviate the sling location from blade manufacturer specified lifting locations under any circumstances without written approval from the GE blade engineer.

Blades LE/TE protectors must be used in accordance with the blade specific manufacturer drawing.

3. After the rotor blade has been lifted off the trailer, remove the top section of the tip fixture #5 if rotor will be assembled.
4. Loosen the threaded torque bar #6.
5. Remove the pin rod #7 holding the top portion of the padding.

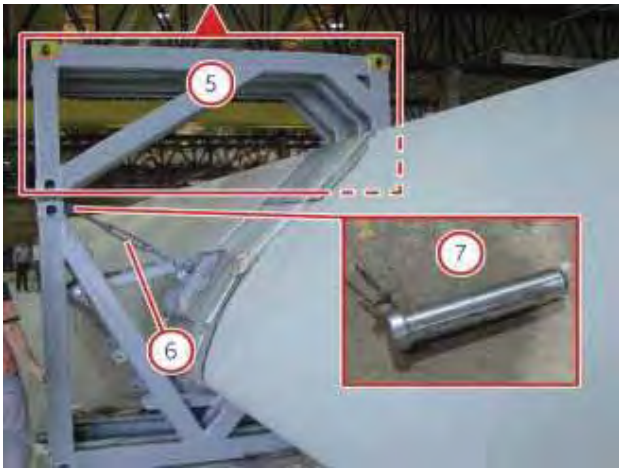

Figure 86: 48 m GE tip fixture positioning

6. Lift the top portion of the padding #8 up and away from the blade.
7. Remove the entire bracket #9 from the fixture to prevent blade damage when rotating the blade.
8. Replace all the brackets with its associated hardware after the blade is removed from the fixture.

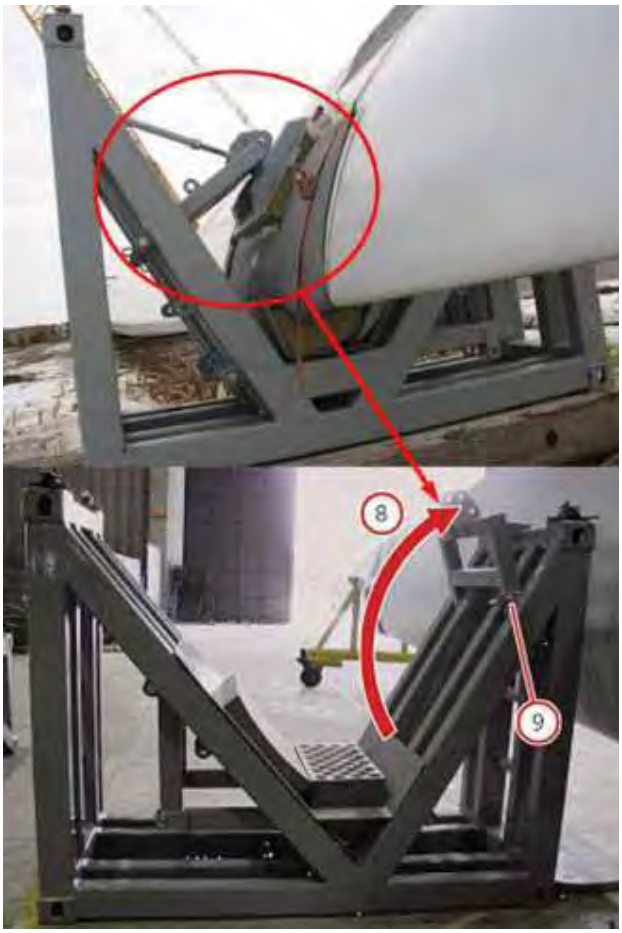

Figure 87: Lift padding and removing

9. Position the cranes to lift the blades at specified lifting locations "per specific blade drawing". For single or double crane lift.
10. Using properly sized lifting equipment, secure a line to the upper left corner of the root fixture. This will be used to slowly lift the root fixture until the blade tip rotates into vertical position as required per blade specific drawing.

Figure 88: Lifting root fixture

Using Double Crane Lift

11. Place and center the LE & TE protective caps at specified lifting locations "per specific blade drawing".
12. Place and center the slings at specified lifting locations "per specific blade drawing". Refer to drawing for min sling width and length.

Figure 89: Lifting root fixture

13. While supporting the root fixture with a separate crane or forklift, lift both the blade and the root fixtures onto a vertical position, and then remove the root fixture.
14. Remove the transportation frame and place out of the work area.

Attention!

Do not deviate the sling location from blade manufacturer specified lifting locations under any circumstances without written approval from the GE blade engineer.

Figure 90: Removing root fixture

Using Single Crane Lift

15. Place and center the LE & TE protective caps at specified lifting locations "per specific blade drawing".
16. Place and center the slings under the spreader bar at specified lifting locations per drawing. Refer to the drawing for min sling width and length.

Figure 91: Placing slings and spreader bar

17. Adjust the slings above the spreader bar so that the hook is on the same vertical line as blade CG (Center of Gravity).

The Chain fall or spreader must not make contact with the blade.

Attention!

Do not deviate the sling location from blade manufacturer specified lifting locations under any circumstances without written approval from the GE blade engineer.

Figure 92: Lifting with spreader bar

18. Lift the blade by the root fixture, rotate the blade so that the TE is vertical (up) with a separate crane or forklift.
19. Care must be taken to ensure that the trailing edge does not lean and place too much pressure against the slings.
20. Once the blade is vertical and stabilized, lift the blade with the main crane until load is supported.

Figure 93: Lifting blade until load is supported

21. Once the blade is stabilized remove the transportation frame and place out of the work area.

Figure 94: Placing frame out of work area

22. If the blade is not balanced during lifting, use the chain fall to adjust the sling length above the spreader bar to keep the blade balanced during lifting.

Attention!

Do not deviate sling location below spreader bar from blade manufacturer specified lifting locations under any circumstances without written approval from the GE blade engineer.

Figure 95: Balancing the blade

23. Disassemble, band and palletize as required, load fixtures and hardware onto the transport vehicle.
24. Return the shipping fixtures, supports, hardware, and tie-downs to place of origin.

13.5 Preparing the Hub

1. Verify that the nuts and washers are staged in the hub for blade assembly.
   - SLE hub requires 54 per blade
   - SE and XLE require 64 per blade
   - 1.6-100, 1.7-100 and 1.7-103
     - o 48.7c carbon blades have 56 stud bolts and must be matched with the hubs that have 1 hole lifting eyes
     - o 48.7 and 50.2 glass blades have 68 stud bolts and must be matched with the hubs that have 2 hole lifting eyes
2. Remove the shrink-wrap material around the outer edge of hub bearing prior to installing each blade. Do not remove from all the three bearings at once.
3. Rotate the blade bearing ring to the desired position for blade installation.

There are three pitch system configurations

- SSB uses pitch drive control box
- 1.5 GE Pitch System operates via axis batteries
- GE Pitch System 1.x-100/103 Requires 400 volt AC 3 phase power connected to hub terminal box to pitch the blades

13.5.1 SSB Units

1. Connect the Pitch Drive Control Box (PDCB) to the portable generator.
2. Disconnect the pitch motor connector (of the blade to be pitched) and mate to the connector from the PDCB.
3. Operate the SSB PDCB according to SSB manual.
4. For SSB systems, actuate the blade bearing 360° in each direction to ensure sufficient lubrication is present in the bearing. If you have problems rotating the bearing or notice anything unusual (bearing gets stuck and does not rotate) contact the GE site representative to check or add grease, as necessary. If the bearing does not actuate, verify the pitch motor fan plug at the junction box is properly mated. Also verify that the portable generator is producing enough amperage to power the PDCB.

Figure 96: Connecting PDCB to pitch motor connector

13.5.2 GE Pitch Systems (For 1.5/1.6 configuration Other than 1.x-100/103)

1. Connect the e-palm 10 for GE pitch system according to 1.5Serie_xxHz_WDI_blade_ExorePalm10x.Enxxx.

Figure 97: Connecting e-palm

2. ALC sensor nut verification. Identify the Axis 1 by marking the blade bearing stud closest to the hub shaft flange.

Figure 98: Marking axis 1

13.5.3 GE Pitch Control System (For 1.x-100/103 Hub)

Follow the steps below to operate the GE pitch system.

- 2.5Serie_xxHz_WDI_blade_ExorePalm10x.En

Attention!

E-palms are a delicate electronic device. Care must be taken of these units including storage in warm environment to prevent battery failure.

Abused or failed e-palms must be sent by customer to vendor for repair.

Attention!

Ensure cables are properly secured to prevent from accidently pulling cables and creating an arc flash.

1. Use the correct tool (flat blade screw driver width 5.5 mm) to connect the 400 volt AC (± 10%) 3 phase power to the pitch terminal box. (400 VAC generators are not common; however you can use a common 480 VAC generator with the voltage turned down to 440 VAC on the pitch system).
2. Zip-tie all the three 89° limit switches.

The bearings will not pitch using the Exor ePalm10 handheld if the 89° limit switches are not activated.

Figure 99: Connecting 400 VAC 3 phase power

Figure 100: 89° limit switch

3. Add the following jumpers to the AEPC card in the axis cabinet 1:
   - terminal points TB1.2 to TB1.9
   - terminal points TB1.4 to TB1.8
   - terminal points J8.1 to TB1.3
   - terminal points J8.2 to TB1.1

4. Switch the AC disconnect in axis box 1 to 'ON' position.
5. Wait several minutes for the DC link to charge.
6. To jog, use the Exor ePalm handheld.
7. Make sure that the handheld E-stop is out.
8. Press in the E-stop bypass button on the axis 1 control cabinet and keep pressed in until the handheld is connected.

9. Unplug the E-stop bypass plug on the axis 1 cabinet.

Figure 101: E-stop bypass button

Figure 102: E-stop bypass plug

10. ALC sensor nut verification. Identify the Axis 1 by marking the blade bearing stud closest to the hub shaft flange.

Figure 103: verifying ALC sensor nut

11. Plug the Exor ePalm10 handheld into the axis cabinet 1 plug. If the HTM file cannot be found unplug it, wait a minute and plug it back in.
12. Release the E-stop bypass button.

Figure 104: Pitch terminal box

13. Turn the 'auto/manual' switch to 'manual'.

If the handheld is removed without pressing the bypass switch the turbine safety chain will open.

Figure 105: Selecting pitch mode ('manual')

The following overview is displayed:

Handheld

F1 IP Address View
F2 Jog View
F3 Cal View
F4 Status View
F5 Rotor Assembly

14. If the hub is on the ground (not connected to rest of turbine) press F5 for hub assembly mode.

The following page is displayed:

Assembly Request Set

F8 Return

15. Navigate to the Jog View by pressing the F2 button.

The following page is displayed:

Jog View
F8 Home
F7 Cal View
F1 Axis 1 Jog View
F2 Axis 2 Jog View
F3 Axis 3 Jog View

16. Navigate to the view for the blade to be jogged by pressing F1, F2 or F3.

The following overview is displayed:

Axis 1 Jog
F8 Home
F7 Cal View
F1 Fwd
F2 Rev
F3 Stop
F4 FFWd
F5 FRev

17. Make sure that the E-stop pushbuttons on the handheld and axis box 1 are out.
18. Press the dead-man switch so that it clicks once, neither all the way in nor all the way out.
19. Press the F1 or F4 button to go toward the 90 degree limit switch or F2 or F5 to go toward the 0 (zero) degree limit switch.
20. Verify that the nuts and washers for the assembly of the rotor blade are available in the hub.
21. Remove the shrink-wrap from the outer edge of the hub bearing before you install the respective rotor blade.
22. Rotate the blade bearing ring to the desired position for blade installation.

Warning!

E-palms are a delicate electronic device. Care must be taken of these units including storage in warm environment to prevent battery failure.

For Salem pitch systems it is not required to pitch bearing to 360°. Immediately after the blades are pitched for storage or installation, place the battery box switches in the off position on each axis cabinet and install a single tie wrap to the battery switches on all the three switches.

13.6 Attaching the Blades

Warning!

Crushing Hazard!

During the approach of the rotor blade to the hub, ensure that nobody is located between the rotor blade and the hub.

Caution!

Blade and Rotor Damage Prior to Installation!

Each site should assess the need for additional blade and assembled-rotor tie-down arrangement. Locations and instances which demonstrate high ground-level winds warrant additional consideration which may include: Additional standard tie-downs and anchor points, further assessment of cribbing and dunnage and the potential for cribbing and dunnage to sink into the ground.

1. Before mounting the first blade, ensure that the pitch gear rings are free of debris. The pitch gears must be greased as per WDI "2.5 pitch gearing grease application".
2. Follow the respective recommendations of the blade manufacturer when attaching the lifting gear to the rotor blades.
3. Attach the guide ropes to stabilize the load.
4. Carefully lift the rotor blades from the transportation frames to avoid damage. Follow the respective recommendations of the blade manufacturer.

Figure 106: Bringing the rotor blade to hub

Attention!

Crushing hazard!

During Installation always ensure that hands, feet, and body are not between any potential pinch points

5. A minimum of two persons should maintain control of the blades with the guide ropes during the alignment and installation of the blades on the hub.
6. Verify that the two limit switches on each blade are not damaged.

Figure 107: Guiding the rotor blade

Figure 108: Guiding the rotor blade

14 Assembling the Rotor

Danger!

Hazard - working under suspended loads!

Never work under suspended loads!

Warning!

Crushing hazard!

During rotor assembly ensure that hands, feet, and body are not positioned between the blade flange and the hub flange!

Caution!

Wear ear protectors!

Proper ear protection must be worn when working with any electrical or hydraulic impact tooling!

Attention!

For the specific torque values, refer to “Bolt Torque Specifications”.

Attention!

Uncontrolled increase in torque!

Once the electric or hydraulic torque wrench has reached the final set torque value switch the tool to the off position and remove from bolt. Do not reset or switch on the tool on the same bolt as this will result in an uncontrolled increase in torque.

Attention!

Rotors must be completely assembled once work begins; no partially torqued assemblies are allowed. Once a rotor is assembled, it must be immediately final torqued. Assembly without torquing exposes individual bolts to undue stress and can lead to potential failure.

14.1 Assembling the Rotor

14.1.1 Kaydon Type Blade Bearings

The threaded hole on the bearing which is used for the lifting lugs will be used as the reference mark for installing the blades. The blade stud to the left of the zero reference plate will mate with the threaded hole on the bearing.

Figure 109: Identifying threaded hole in Kaydon bearing

14.1.2 Shilla Type Blade Bearings

Align the red paint pen line that is on the face of the blade flange with the centre of the bearing threaded hole.

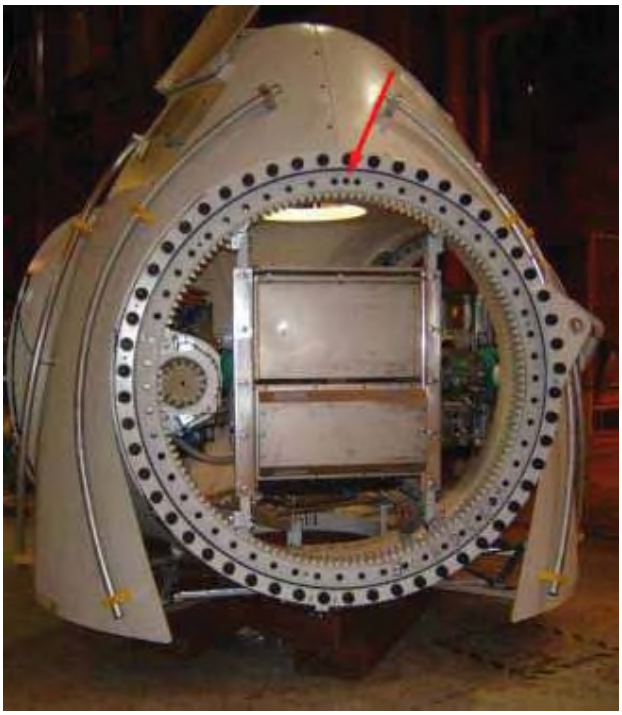

Figure 110: Identifying threaded hole in Shilla bearing

1. Utilizing the cranes and the PDCB/e-Palm, align the blade screw bolts through the pitch bearing flange holes on the hub. Take precaution while installing the blade screw bolts so that no bolts are bent.

Danger!

Crushing hazard!

During Installation always ensure that hands, feet, and body are not between any potential pinch points.

Figure 111: Aligning blade screws to bearing flange

2. The top edge of the blade flange must make contact with the bearing flange. Ensure that the gap is less than 5 mm around the entire blade to bearing connection prior to releasing the blade from the crane.

Figure 112: Checking the flange contact

3. Ensure that the corrosion inhibitor has been removed from the inner bearing face prior to installing the washers and nuts.

Danger!

Rotating parts - Pinch point -Crushing hazard!

When working with hydraulic and pneumatic torque tooling, ensure that your hands and any part of your body are not between any pinch points (e.g. any part of your body is not between the tool reaction arm and back up pressure surface

Ensure personnel have been properly trained on the safe use of hydraulic and pneumatic tools.

4. Position the washers on the top-most six studs with the chamfer on the ID pointing out. All nut manufacturer markings must be visible. Do not use lubricant on the washer or nut faces.
5. Lower the blade down (crane still holding full weight of blade) to ensure that contact is made on the top part of the bearing. The top edge of the bolting face must contact the bearing and the gap must be less than 5 mm at all other locations.

Figure 113: Topmost six nuts

6. Install the nuts and washers (shipped inside the hub) on the studs using the star pattern (Rolling Triangle).
7. Using an impact wrench create a torque between 50 to 95% of the pre-torque value specified in "Bolt Torque Specification" for the given blade type.
8. At least six nuts must be installed at each of the three positions prior to removing the crane load. All other accessible bolts can be torqued with a circumferential pattern. The detailed torque pattern is defined in "Bolt Torque Specification".
9. Position blocks/fixtures with pressed straw bales or other soft support under the manufacturer labeled support points of the blades to ensure that the blade tip does not make contact with the ground. Once the third blade is installed, the weight should be evenly distributed and the blade support blocks/fixtures can be removed.
10. Repeat all applicable steps as required for all three blades. All the three blades must be installed prior to 100 % final torque.
11. Individually pitch every blade in the clockwise direction to install and torque the remaining washer and nuts from 50 to 95% of the pre-torque value in "Bolt Torque Specification" for the given blade type.
12. Pitch the blade to install and torque all the remaining nuts and washers.
13. For Non-GE pitch systems, if the pitch box cannot move the blade, attach the crane or forklift to the blade with a six-inch-wide sling in a choker hitch (only at the blade root) and pull the blade in the same direction as the PDCB is attempting to rotate the blade. If the hub is not on level, loading can occur on at least one blade bearing.
14. With a calibrated manual torque wrench, achieve 100% of the pre-torque specified in "Bolt Torque Specification", moving in a star pattern (Rolling Triangle) considering hub obstructions. The detailed pattern is defined in "Bolt Torque Specification". At least six nuts must be torqued in a star pattern (Rolling Triangle) at each of the three positions. All other bolts can be torqued in a circumferential pattern. After every nut is torqued, apply a paint pen mark across the nut and bearing face.

15. Pitch the blade in clockwise direction to expose all remaining nuts and torque as done previously in this step. Every nut must be torqued as stated above in previous step regardless of earlier torque value used, as the first studs are likely to have lost some tension. This is necessary to avoid losing track of which nuts have been torqued (as blade is pitched to reach all studs).

Figure 114: Torque using calibrated manual torque wrench

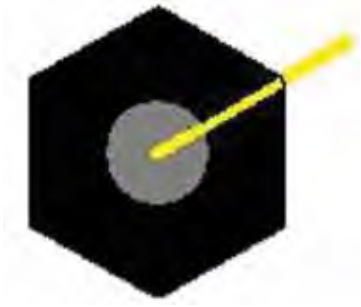

Figure 115: 100% pre-torque value

16. Complete the 120 degree turn of nut rotation as specified in "Bolt Torque Specification" with an accuracy of ±5° in a star pattern (Rolling Triangle) while considering hub obstructions. The detailed pattern is defined in "Bolt Torque Specification". Place the paint alignment marks across every stud, nut, and the surrounding bearing surface before rotating to the next nut. This is necessary to avoid losing track of which nuts have been torqued (as the blade is pitched to reach all studs).

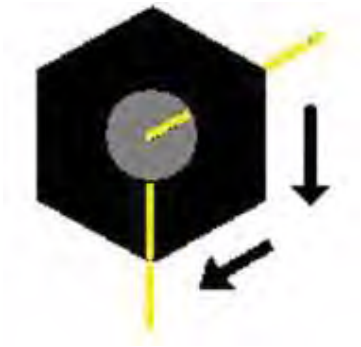

Figure 116: 120° nut rotation

14.2 Assembling the Rotor (For 1.x-100/103 Rotor Configuration)

Attention!

Hazard – working under suspended loads!

Never work under suspended loads!

Danger!

Crushing Hazard!

During rotor assembly always ensure hands, feet, and body is not between the blade flange and the hub flange!

During rotor assembly ensure that hands, feet and body are not positioned between the blade flange and the hub flange!

Attention!

Wear ear protection!

Proper ear protection must be worn when working with any electrical or hydraulic impact tooling!

Attention!

For specific torque values refer to the "Bolt Torque Specification."

Attention!

Uncontrolled increase in torque!

Once the electric or hydraulic torque wrench has reached the final set torque value switch the tool to the off position and remove from bolt. Do not reset or switch on the tool on the same bolt as this will result in an uncontrolled increase in torque.

1. **The blade stud to the immediate left of the 0 degree reference mark must mate with the hole to the right of the zero mark on the hub provided by manufacturing.**

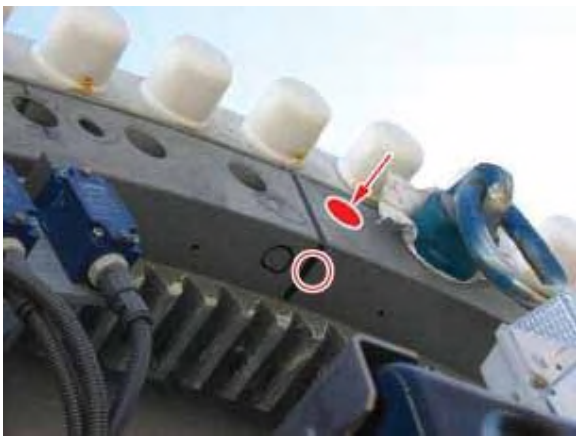

Figure 117: Identifying the hole

Figure 118: Identifying the hole

2. Utilizing the cranes and the PDCB/e-Palm align the blade screw bolts through the pitch bearing flange holes on the hub. Take precaution when installing the blade screw bolts that no bolts are bent.

Danger!

Crushing hazard!

During Installation always ensure that hands, feet, and body are not between any potential pinch points.

Figure 119: Blade to hub alignment

3. The top edge of the blade flange must make contact with the bearing flange. Ensure that the gap is less than 5 mm around the entire blade to bearing connection prior to releasing the blade from the crane.

Warning!

Wear hearing protection!

Proper hearing protection must be worn when using the impact wrench!

Figure 120: checking the contact

4. If applicable remove the corrosion inhibitor from the inner bearing face prior to installing the washers and nuts.
5. Position the washers and nuts (located inside hub) on the exposed bolts at the 3 and 9 o'clock position. Install the washers with the bevel on the inside diameter pointing outwards toward the nut. The nuts should be installed with the marks pointing outwards. Do not apply any lubricant to the washer or nuts.
6. Using an impact wrench tighten the exposed bolts on the 7 to 9 and 2 to 4 O'clock positions to achieve a torque value between 50-95% of the final pre-torque value. Correct pre-torque value is specified in the Work Instructions for the bolted connections. Do not exceed 95% of initial torque value! (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx).
7. All accessible hardware must be installed and impacted at the exposed positions before removing the crane load.

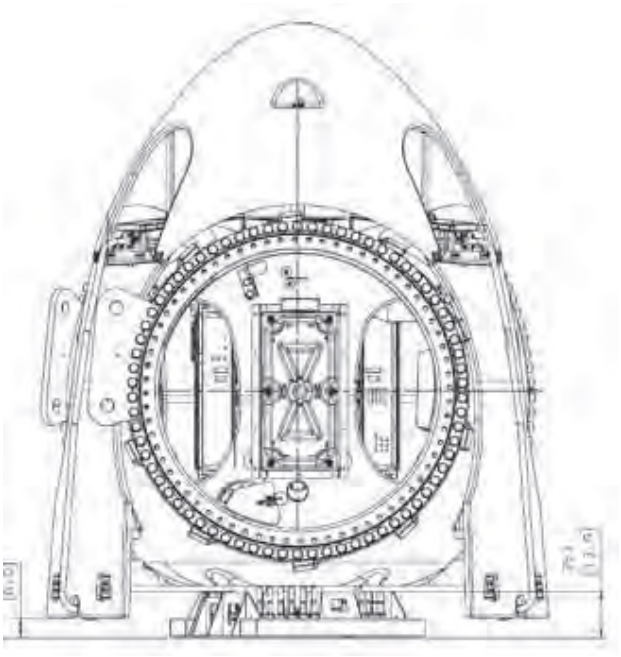

Figure 121: Exposed positions

Figure 122: Exposed positions

Warning!

Rotating parts -Pinch point - Crushing hazard!

When working with hydraulic and pneumatic torque tooling, ensure that your hands and any part of your body are not between any pinch points (e.g. any part of your body is not between the tool reaction arm and back up pressure surface

Ensure personnel have been properly trained on the safe use of hydraulic and pneumatic tools.

8. Position the blocks/fixtures with the pressed straw bales or another soft support under the manufacturer labeled support points of the blades to ensure the blade tip does not make contact with the ground. Once the third blade has been installed, the weight should be evenly distributed and the blade support blocks/fixtures can be removed.
9. Refer to WDI for rotor assembly table if used.
10. Remove crane and repeat steps 1 through 8 for the other two blades. All the three blades must be installed before any blade can be rotated and the nuts are tightened up to 100% of the pre torque value.
11. Once rotor is assembled remove all the blade supports from the area.
12. Pitch the blades as required to expose and impact remaining hardware to 50-95% of the pre-torque value.
13. Use a calibrated torque wrench to torque all the accessible nuts to 100% of the pre torque value specified in Work Instructions for the bolted connections (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx).
14. Torque the bolts using the bolt torque pattern specified in the Work Instructions for the bolted connections (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx).
15. Pitch the blades as required to expose and pre-torque the remaining hardware.
16. Once pre torque is complete, check between the bearing surface and the blade flange to ensure that there are no gaps. If a gap is present repeat the steps 12 through 15 till no gaps are present.
17. Mark the bolts with a visible paint pen once the pre torque value has been attained. A straight line is marked from the bolt end face, nut, and washer and bearing face.

Figure 123: Blade support

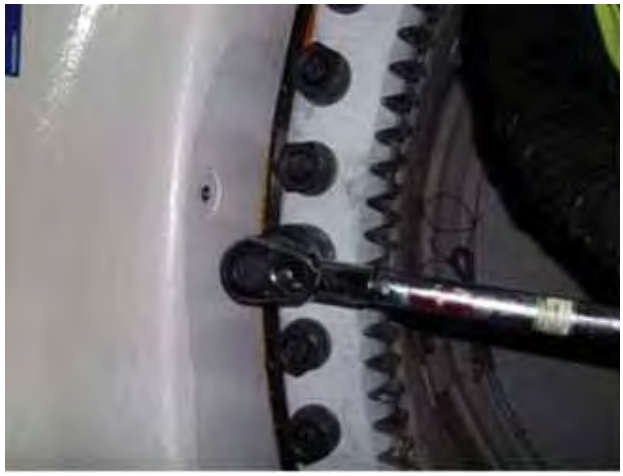

Figure 124: Torquing the nuts using a calibrated torque wrench

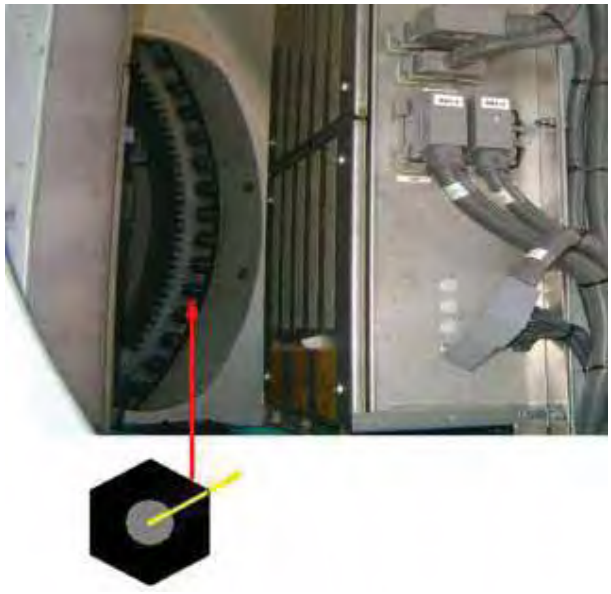

Figure 125: Nut at 100% pre-torque

Warning!

Rotating parts -Pinch point - Crushing hazard!

When working with hydraulic and pneumatic torque tooling, ensure that your hands and any part of your body are not between any pinch points (e.g. any part of your body is not between the tool reaction arm and back up pressure surface

Ensure personnel have been properly trained on the safe use of hydraulic and pneumatic tools.

Figure 126: Tool

18. Apply the final nut turn 120° or two flats with an accuracy of ± 5°as specified in the Bolt Torque Specification (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx). The final nut turn can be achieved in any desired bolt pattern.
19. Make a color alignment mark on the screw bolt, nut and surrounding bearing surface of each bolted connection before going to the next nut.
20. This is necessary to avoid losing track of which nuts have been tightened (as the blade is pitched to reach all the screw bolts).

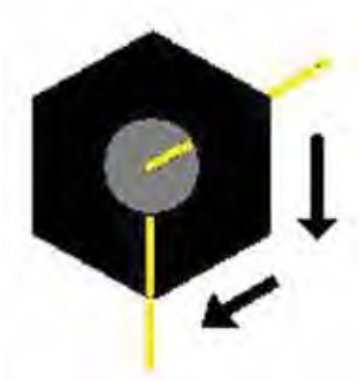

Figure 127: Final nut turn 120 degree or 2 nut flats

21. Pitch the blades as required to access and apply final nut turn (120° or two nut flats with an accuracy of ± 5°) to the remaining bolts.
22. If stud rotates more than 10 degrees during nut turn contact GE site representative.
23. Repeat steps 12 through 22 for the remaining blades.

The following steps apply to all configurations.

24. CRITICAL TO QUALITY: after completion of rotor assembly, using a calibrated hand torque tool perform a torque inspection of 10% of the bolts (different locations within each blade circle) on all 3 blades. Refer to (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx).
25. CRITICAL TO QUALITY: If any nut moves more than 3 mm measured tangent to the washer edge (allowing for some flex of the stud shank), an error has occurred during installation. In this case, the nut must be fully loosened and all installation, pre-torque and nut turn step to be repeated on affected nut. Then repeat step 24 but with a 100% torque inspection and repeat this step as applicable.

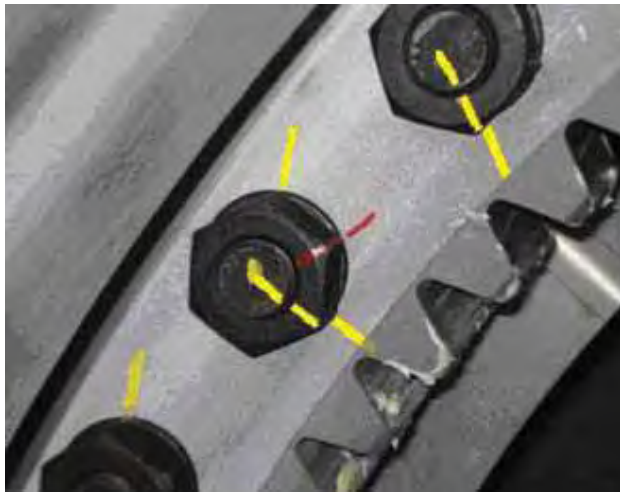

Figure 128: 10% bolt marked with red paint pen

The following steps apply to all configurations.

26. Verify the alignment of each blade by pitching the blades (individually) to 0 degrees. Rotate until the blade is in the horizontal position and the zero reference mark is in the hub sight.
27. In this blade position, mark the 0° position on the trailing edge of the rotor blade using the 0° referencing plate attached to the blade bearing.

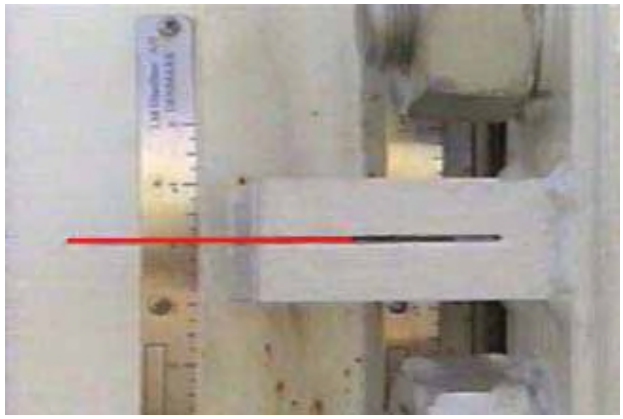

Figure 129: Zero reference mark in the hub sight

28. Also mark the inner-to-outer race of the blade bearing transition on the interior of the hub casting.

29. For 1.x-100/103 configuration, mark on the pitch motor side with a marker pen.

Figure 130: 1.x-100/103 - Extending the 0° marking on the interior of the hub casting on the pitch motor side with a marker pen

30. For 1.5/1.6 configuration other than 1.x-100/103 mark on the opposite side of pitch motor with a marker pen.

Figure 131: 1.5 - Extending the 0° marking on the interior of the hub casting on the opposite pitch motor side with a marker pen

31. Verify that the hand rail and nose cone bolts have been torqued and are marked with a paint pen.

Figure 132: 1.x-100/103 - checking the hand rails and nose cone bolts

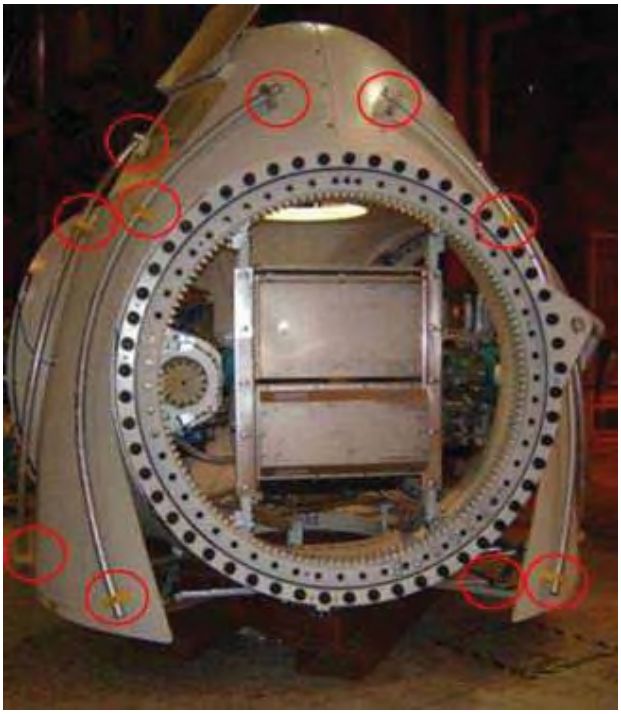

Figure 133: 1.5/1.6 (non 1.x-100/103) hub-checking the hand rails

32. Install the cover plates/steps over the pitch bearing teeth.
33. Torque and mark the bolts with a paint pen.

Figure 134: Installing the steps over the pitch bearing teeth

Figure 135: Installing the steps over the pitch bearing teeth

14.3 Assembling the Nose Cone and Final Rotor Assembly Work

1. Attach the lifting gear to the three lifting lugs of the nose cone.

Danger!

Crushing hazard!

During Installation always ensure that hands, feet, and body are not between any potential pinch points.

Figure 136:Fastening points of the nose cone

2. Instruct the crane operator to slowly lift the nose cone and position it onto the hub.

Figure 137:Lifting the nose cone

3. Bolt the nose cone to the rotor hub. Torque and mark the bolts with a paint pen. Refer drawing 103W3179 (Assembly Hub Steps/Casting Assy.) to check for thread locking compound requirements.
4. Remove the lifting gear.

Figure 138:Bolting on the nose cone

5. Inspect all the three blades for handling damage and report damage to GE site representative. All fiberglass damage must be repaired prior to rotor installation.
6. On 1.6-82.5 units mark the target nut stud for advance controls. If applicable refer to 1.5Serie_xxHz_CM_allComp_AdvancedCTRL ENxxx. If the sensor stud markings are not present on hub studs, contact GE Site representative for instructions to validate the correct placement of the target nut.

7. Prior to installing the rotor, check sensor stud markings are present.

Use an inspection mirror.

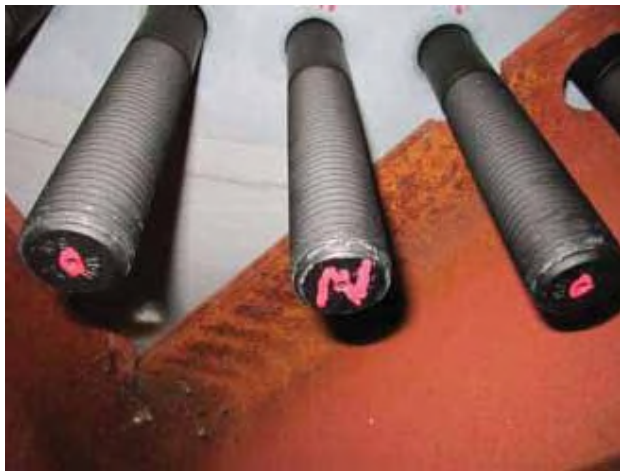

Figure 139: Checking sensor stud markings

8. On 1.6 – 100 units, studs are marked by manufacturing. If applicable reference 1.5Serie_xxHz_CM_allComp_AdvancedCTRL ENxxx. If the sensor stud markings are not present on hub studs, contact GE Site representative for instructions to validate the correct placement of the target nut.

9. Prior to installing the rotor, check sensor stud markings are present.

Figure 140: Checking sensor stud markings

The following steps apply to all configurations.

10. Verify that the light fixtures are not damaged.
11. If applicable verify that the oil sight glasses for each pitch drive are protected from impact damage.
12. Clean and properly dispose of all trash and debris before exiting the hub.
13. Verify that the entire hub is clean and free of debris and loose tools that can cause damage.
14. Secure any loose cable bundles that will flap back and forth to prevent damage.
15. Clean and remove all debris from the interior of the hub with bio-degreaser cleaner.

Figure 141: Desiccant packs

Attention!

For long-term storage "Installed Units" consult GE engineering prior to removing desiccants packs.

Attention!

Risk of Equipment Damage!

Please make sure that no loose equipment remains in or on the hub!

Loose material left inside the hub will tumble when the rotor brakes are released and the rotor starts to spin creating dust debris damaging electrical components.

Loose material such as desiccant packs, manuals, cable ties, tools, and rags must be removed from the hub cabinets.

Loose cables must be secured with cable ties to prevent flopping back and forth against other components when the rotor is spinning.

Bolted desiccant packs must be securely bolted to the cabinets.

The following steps are to be performed on the day when rotor will be installed.

16. If applicable (rotor will be installed) all three blades must be rotated to –90 degrees (trailing edge facing up).
17. If applicable (rotor will be installed) on 1.x-100/103 meter configuration disconnect the 400 V power cable.
18. If applicable (rotor will be installed) cut the cable ties from the limit switches.
19. If applicable (rotor will be installed) ensure that the battery switches are in the off position and zip tied.
20. If applicable, ensure that the pitch boxes are de energized and verify that the manuals and desiccant packs in the hub main controller and axis boxes are removed.
21. Verify that all the cabinet doors are properly latched, ratchet straps are installed and loose strap ends are secured and or cut off as required to prevent loose end from being pinched between the flanges during rotor installation.
22. Re-install the manhole cover; ensure that the Allen wrench and hardware are secure.
23. Ensure all hatches are secured.
24. For 1.x-100/103 meter configuration, ensure that the hardware is secured and manhole cover is tethered and mounted.
25. Clean and remove all debris from the exterior of the rotor assembly as required.

For Battery Operated Hubs; Installer should ensure the hub battery voltage is a minimum of 12 volts per battery prior to rotor installation.

14.4 Lifting the Rotor

14.4.1 Typical 1.6 -100 Rigging Configuration

If the rotor will be installed at this time, attach two shackles (50-ton load-bearing capacity) and two four-foot slings to the lifting lugs on the hub. Attach the two slings to the large crane hook.

Figure 142: Rotor lifting equipment

14.4.2 Lifting Gear for Rotor Spider (for Certain 1.x-100/103 Blade Configuration Only)

Attention!

This type of Rotor Spider lifting gear may be required for certain 1.x-100/103 glass blade configurations only. Consult with GE for applicability!

Please refer to outline drawing for the lifting point. Below pictures are for reference only.

1. Unscrew the threaded rods, in order to retract the safety bolts.

Figure 143: Unscrewing threaded rods

2. The safety bolts must securely engage in the load-bearing plates of the rotor for lifting.

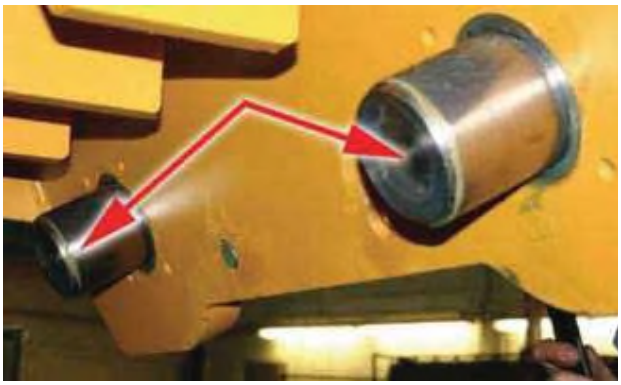

Figure 144: Pins of the rotor lifting gear

3. Adjust the lifting gear to the respective rotor diameter in accordance with the manufacturer's instructions.

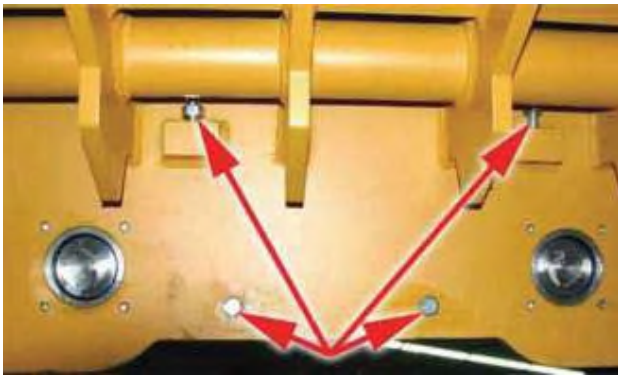

Figure 145: Adjusting screws

Retracted safety bolts, before the lifting gear is placed on the rotor.

Figure 146: View of the lifting gear

4. Verify that the pins of the adjustable lifting gear are securely locked as shown in Fig. 130 and Fig. 131.

Figure 147: View of the lifting gear

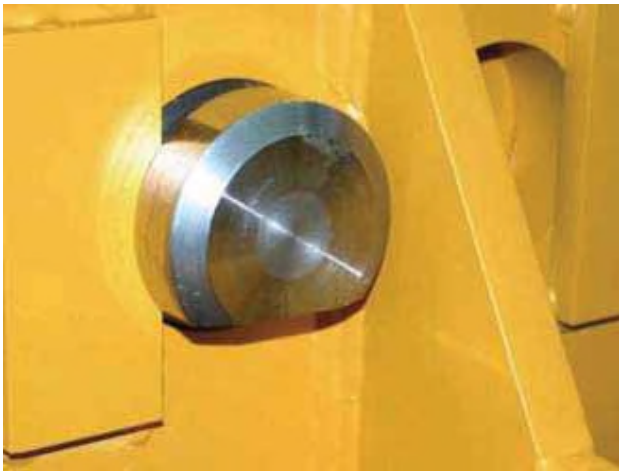

Figure 148: View of the lifting gear

14.4.2.1 Attaching the Rotor Lifting Gear

1. Attach the lifting gear to the main crane.

Figure 149: Bringing the lifting gear to the rotor

2. Bring the lifting gear to the rotor spider.

Figure 150: Mounting the lifting gear

3. Mount the lifting gear in accordance with the manufacturer's instructions.

Figure 151: Lifting gear attached to the rotor spider

14.4.3 Lifting Gear for Rotor (for 1.5/1.6/1.68/1.85)

If the rotor will be installed at this time, attach two shackles (50-ton load-bearing capacity) and two four-foot slings to the lifting lugs on the hub. Attach the two slings to the large crane hook.

Figure 152: Rotor lifting equipment

14.5 Installing the Rotor (Hub with Blades)

Attention!

Check the wind speed!

The rotor may only be installed in accordance with section 3.4 'Operations Involving the Use of a Crane'.

Attention!

Lift Plan!

The sail area and drag coefficient of the rotor must be incorporated through the lift plan. Static loads and dynamic loads must be verified by the crane operator. Personnel not involved in crane lift operations must leave the crane work zone (danger zone) before lift operations starts.

Any person not involved with installation or crane lift operations should be a minimum of two lengths of the crane boom height away from the work being performed.

Attention!

Critical to quality, to the safe operation of the turbine and to personnel safety!

Attention!

When lifting the rotor ensure blade tips do not make contact with the ground.

1. Verify that the foundation bolts have been tensioned/torqued, and all tower flange bolts have been torqued. The GE Energy technical advisor will have the option to verify all paint pen marks are present at all bolted connections and tower exterior is clean and free of damage prior to rotor installation.
2. Inspect the interior and exterior pitch bearing seals. Look for cracked, gapped, missing or otherwise damaged seals. The seals must be smoothly seated around the entire bearing perimeter. If the seal is damaged contact the GE site representative.
3. Prior to lifting the rotor, all three blades must be rotated to – 90 degrees (trailing edge facing up).
4. If the rotor cannot be installed at this time, pitch all three blades back to the 0 degree position. Secure the rotor with ropes to suitable anchoring points. Also secure the leading edge of each blade (40 cm from the tip) to anchoring points using guide ropes. Place protective mats between the blade and the guide ropes to prevent damage.

Attention!

Equipment Damage!
Remove jumpers after rotor is installed!!

The following "Jumper Terminal Block" jumpers to AEPC card in axis cabinet 1: terminal points TB1.2 to TB1.9, terminal points TB1.4 to TB1.8, terminal points J8.1 to TB1.3, and terminal points J8.2 to TB1.1 must be removed after the rotor is installed.

Re-install the factory terminal block.

Attention!

Risk of equipment damage!

Close the axis box panels; close the hub main access hatch and ensure all the hardware is present and secure.

5. Place and center the LE & TE protective caps at specified lifting locations "per specific blade drawing".
6. Place and center the slings at specified lifting locations "per specific blade drawing". Refer to drawing for minimum sling width and length.
7. Attach the sling to the crane hook.

Figure 153: Placing LE&TE protective caps

Attention!

If blades have serrations!

Tail pick crane will have to be disconnected using a man lift.

The tail pick protective caps will have to be removed after rotor installation with man basket.

14.5.1 Placing Tag Lines on Serrated Blades

1. Place the straps for taglines on the second and third blades.
2. Place the trailing edge protector cap to prevent damage.
3. Secure the TE cap with small ratchet strap.
4. Attach the arrester rope to each strap.

Attention!

If blades have serrations the taglines will need to be removed with man basket after rotor is installed.

Figure 154: Placing taglines on serrated blades

14.5.2 Placing Taglines on Non Serrated Blades

1. Place blade bags over the tips of second and third blade. Attach an arrester rope to each bag.
2. Do not tie tag lines to hub handrails, tie tag lines to rigging only.

Figure 155: Mounting blade bags on non serrated blades

Danger!

Life-threatening hazard - working under suspended loads!

Everybody must leave the danger area!

The banksman may not give a signal to raise or lower until everybody has left the danger area.

Never stay under suspended loads!

Attention!

Check the components!

All components must be checked for visible damage, deformations and cracks which could affect their bearing capacity before assembly. Findings have to be reported to the GE site representative.

The components must be stored and assembled in such a way that damages, which could adversely affect their stability or bearing capacity and thereby lead to safety hazards is prevented.

Danger!

Crushing hazard!

During Installation always ensure that hands, feet, and body are not between any potential pinch points.

Attention!

Weather conditions!

The crane operator is responsible for monitoring the weather conditions at all times and determining when a safe lift of the rotor is possible. The guide ropes must be secured to a suitable point (fastening point on a vehicle) at all times.

8. **Reach under the hub and loosen the guide pin (approximately 2.5 cm) directly beside the handrail between the two lifting lugs. This will allow the rotor to be installed more easily.**
9. **Remove the nuts and washers from the transportation frame below the hub.**

Attention!

Do not remove the hub bolts!

The bolts and the threads could be damaged.

Figure 156: Damaged stud

Attention!

Check for foreign debris on flanges!

The hub is a friction-critical connection and must therefore be thoroughly cleaned of all foreign debris or dirt. If any foreign debris is found on the surface or pinched between the flange after the installation, the rotor may have to be removed and cleaned.

10. Lift the rotor by means of the main and support crane, so that the lower rotor blade cannot touch the ground while the rotor is being set upright.

Attention!

There must be permanent communication between the erecting engineers and the crane operators while the rotor is being set upright by the cranes, in order to lift the rotor without any danger.

11. The rotor is set upright by the main crane, while the support crane lowers the bottom rotor blade.
12. Remove the lifting gear of the support crane from the rotor. Instruct the operator of the support crane to swing the jib out of the lifting area to ensure the main crane does not collide with the guide ropes.

Figure 157: Setting the rotor upright

Figure 158: Setting the rotor upright

13. The rotor can be safely guided from the ground by means of the two guide ropes attached to the rotor blades per blade manufacturing instructions.
14. Maintain the tension of the guide ropes to control the rotor movement.
15. Any tag line pull or tug for flange alignment must be done manually. Pulling the tag line with a moving vehicle is not authorized.

Figure 159: Guide ropes on the rotor

16. Verify that the high-speed shaft shroud in the nacelle is removed to allow manual rotation of the high-speed coupler when mating the rotor to the main-shaft.
17. Instruct the crane operator to lift the rotor so that it is in level with the main shaft.
18. Rotate the high-speed coupler to align the hub studs with the main shaft.

Figure 160: Lifting the rotor level with the main shaft

Warning!

Rotating Parts!

Untied long hair, loose clothing (e.g. flapping coats, tops with wide sleeves or trousers with wide trouser legs) as well as scarves, ribbons, headscarves or jewellery may not be worn during the installation work! There is a fundamental danger of injury through being caught, pulled in or picked up by rotating components! Clothing must be adapted to the respective work and the weather conditions.

Warning!

Rotating Parts!

During application of the rotor lock always ensure that hands, feet, and body are not between the any potential pinch points e.g. high speed coupling, brakes disc, mounting flanges.

Warning!

Rotating parts -Pinch point - Crushing hazard!

When main shaft is rotating, ensure that your hands and any part of your body are not in contact with the pinch point of main shaft. Also ensure clothing and PPE is not subject to being caught in rotating parts (e.g. any part of your body is not between the main shaft and nacelle wall, hub and nacelle wall).

Ensure personnel are properly trained on safe operations of low speed rotor lock and secondary brake.

Hydraulic Disc Brake and Brake Disc Rotor Lock Use!

The installer must personally ensure all personnel assigned to work activities inside the WTGS are properly trained on the use of the hydraulic disk brake and disk rotor lock, to ensure the hydraulic disc brake and brake disc rotor lock are 100% engaged and locked out before attempting to:

Attention!

After aligning the main shaft during rotor installation, pre tighten and torque hardware after rotor is fully engaged onto the main shaft.

Disconnecting crane and removing crane out of the working area after rotor is installed.

Performing any work outside or inside of the hub after rotor has been installed.

Performing any work inside or outside the nacelle near exposed rotating components after rotor has been installed.

All employees must ensure the hydraulic disk brake and disk rotor lock is 100% locked out before exiting to the top of nacelle.

Attention!

Important!

In case of damaged hub bolts during rotor installation:

If damaged bolts can be exchanged by hand tools or by hand, a maximum of two bolts may be exchanged while rotor is mounted. All other exchanges/repairs have to be done on the ground.

19. Instruct the crane operator to move the rotor so that it fully engages with the main shaft.

Attention!

Risk of equipment damage!

The rotor must be guided precisely to prevent damage to the slipring wires.

Figure 161: Approach of the rotor spider

20. Re-tighten the guide pin.

Attention!

Important!

If for any reason the rotor is mounted in wrong position, rotor position to be corrected immediately at the time of installation/before torquing the hub bolts.

Warning!

Wear hearing protection!

Hearing protection must be worn when using the impact wrench.

Warning!

Pinch point - Crushing hazard!

When working with hydraulic and pneumatic torque tooling, ensure that your hands and any part of your body are not between any pinch points (e.g. any part of your body is not between the tool reaction arm and back up pressure surface.

Ensure personnel are properly trained on safe operations of hydraulic and pneumatic tools.

21. Install washers and nuts on all accessible hub adapter bolts by means of an impact wrench.
22. Install the sensor nut on the stud marked N.

Figure 162: Tightening the nuts

23. **Turn the hydraulic hand pump relief valve clockwise and pump the arm of the hand pump to activate brake.**
    - Hydrep units: Open the bleed valve manually by pressing the black rubber knob and holding it (for 10 seconds minimum and/or as required) until the system pressure is completely released (gauge reading falls to zero psi, and caliper is observed to be fully retracted. Double check the pressure remains at zero and the caliper remains retracted after 5 minutes). Refer to 1.5Serie_60Hz_WDI_PMT_brakehydra_Strt MaintESS.ENxxx "Startup and Maintenance of the Hydrep Active Brake at the High-Speed Shaft".
    - Hydac/Svendborg units: To release the brake turn the pressure relief valve counter clockwise until the gauge reads zero bars. To apply turn valve clockwise.

Figure 163: Hydraulic disc brake and hydraulic hand pump

Warning!

Rotating parts -Pinch point - Crushing hazard!

Warning!

Low speed rotor lock is not to be used to stop rotation!

Never use the low speed rotor lock to stop drive train rotation. The hydraulic hand brake must be used to stop the rotation.

Figure 164: Low speed rotor lock

24. Engage the rotor lock prior to removing the lifting equipment.
25. Pull the pin out and turn the handle clockwise to engage and counter clockwise to disengage.

Attention!

Failure to pull the pin out prior to turning the handle will damage the rotor lock.

26. Prior to removing the lifting gear from the rotor install a minimum of 16 nuts with 80 - 90% of the final torque must be drawn.
27. Disconnect the rigging from the lifting lugs. Instruct crane operator to remove the crane from the work area.
28. The lifting gear can be removed after the threaded rods have been unscrewed.

Warning!

Fall Hazard!

Falling Objects!

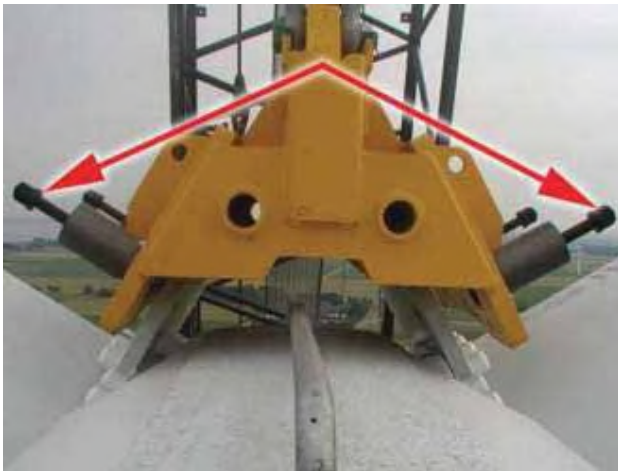

Figure 165: Detaching the lifting gear

29. Instruct the crane operator to remove the crane from the work area before releasing rotor lock and secondary brake to allow the blade rotation to install and torque the remaining hardware and removal of blade socks.
30. Remove the blade bags and the guide ropes.

Warning!

Overhead Hazard!

Figure 166: Detaching the lifting gear

Attention!

Equipment damage!

As the rotor is pin-wheeling, listen within the nacelle for any loose materials, parts or tools remaining in the hub with the brake and rotor lock disengaged. Reapply the brake prior to installing the washers and nuts and disengage the brake prior to rotating the rotor.

Warning!

Rotating parts -Pinch point - Crushing hazard!

When main shaft is rotating, ensure that your hands and any part of your body are not in contact with the pinch point of main shaft. Also ensure clothing and PPE is not subject to being caught in rotating parts (e.g. any part of your body is not between the main shaft and nacelle wall, Hub and nacelle wall).

Ensure personnel are properly trained on safe operations of low speed rotor lock and secondary brake.

Attention

The following steps are critical to quality, to the safe operation of the turbine, and to personnel safety.

31. Apply the final torque to all the hardware in hub adapter using qualified torque tooling in accordance with the 1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx.
32. Place a paint pen mark across each stud, nut and flange face.
33. Clear the hub adapter flange area and disengage brake disc rotor lock then hydraulic rotor brake. Slowly rotate the rotor with the taglines to allow installation of the next set of accessible nuts. Reapply rotor lock after acquiring desired position of rotor.

Figure 167: Tighten the bolted connections

Warning!

Rotating parts -Pinch point - Crushing hazard!

When working with hydraulic and pneumatic torque tooling, ensure that your hands and any part of your body are not between any pinch points (e.g. any part of your body is not between the tool reaction arm and back up pressure surface.

Ensure personnel are properly trained on safe operations of hydraulic and pneumatic tools.

34. Verify that the ALC target sensor nut is located as marked in previous chapter.
35. For 1.6-82.5, during rotation of the rotor to install the nuts, stop the rotor with the reset proximity sensor centred one stud to the right of the reset nut as shown in Figure 167.
36. For the 1.x-100/103, during rotation of the rotor to install the nuts, stop the rotor with the reset proximity sensor centred between the target nut and the next nut to the right as shown in figure 169).
37. 1.6-82.5 and 1.x-100/103: With the rotor stopped as discussed in steps 35 or 36 as applicable, confirm that blade 1 is in the upright position, using the marks made in section 13.5.3, step 10. Also confirm that the blade bearing is horizontal at this time.

Figure 168: Target sensor nut installed correctly

38. Picture is showing blade bearing Axis 1 level.
39. Target nut must have 100% clearance from any obstructions during revolutions of rotor and main shaft of nacelle.

Blade bearing – not level

Blade bearing level

Blade bearing – not level

Figure 169: Checking blade bearing level – view from nacelle hatch

40. For 1.x-100/103; verify that the proximity sensor is correctly installed.
41. When blade #1 is approximately vertical in the 12:00 position. Stop the rotor so that the bearing is level (horizontal position). The proximity sensor is located at approximately the 2 o'clock position.
42. Verify that the proximity sensor is between two studs see figure.
43. The target nut will be installed to the left of the proximity sensor.

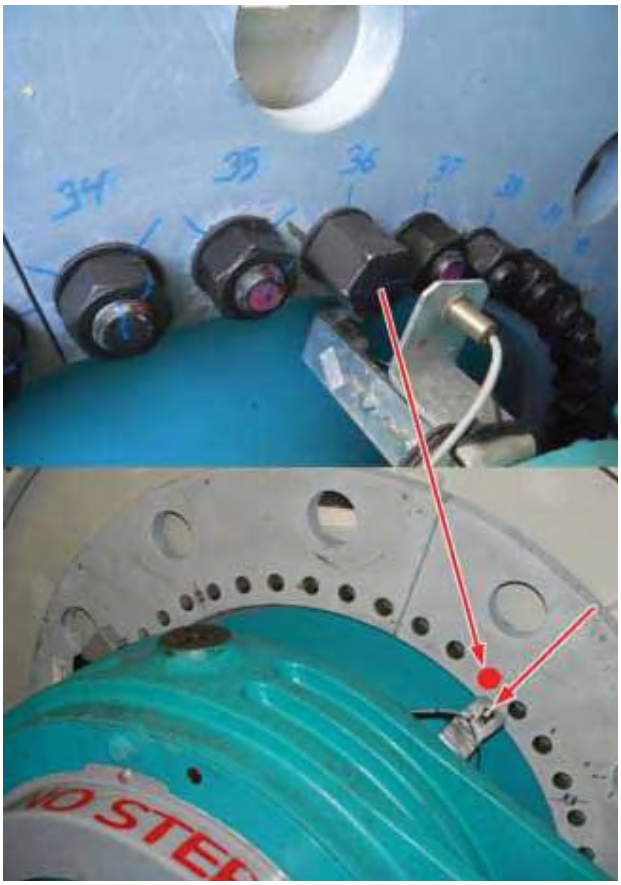

Figure 170: Sensor nut installed correctly

44. Repeat the steps as required. Tighten all the hub adapter nuts by means of a qualified torque tool.
45. Details of the required torques can be found in the Bolt Torque Specification (1.xSerie_xxHz_TSP_BoltTorquexx.ENxxx).
46. Mark the bolts, nuts and adjacent flange surface of each bolted connection with a permanent line.
47. Legibly record torque values in 3 locations: ICL, Daily Torque Log and mark the torque values on the fiberglass for later reference.

Figure 171: Marking the bolted connections

14.6 Inspections

If during an IIP inspection any bolt is found loose or not torque marked, all bolts in the circle must be inspected and torqued as required.

1. Ensure that the hub-mounting bolts are 100% torqued.
2. Lock the rotor prior to next steps.
3. Using a multiplier and calibrated mechanical torque wrench perform a 10 % torque inspection on hub adapter nuts. 10 % torque inspection will be spread out evenly on the hub adapter flange.
4. Re-install the hub adapter flange cover.

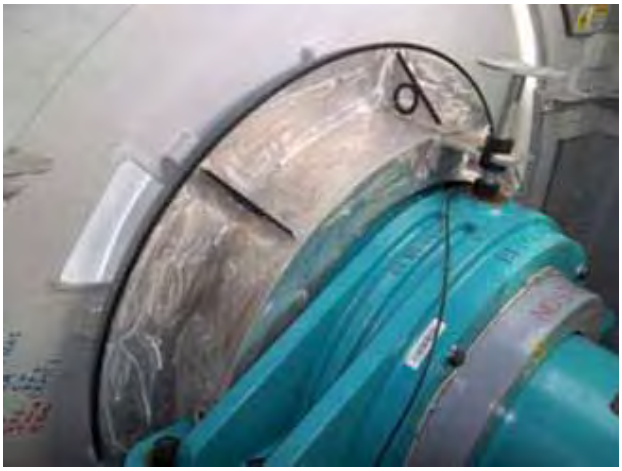

Figure 172: Hub adapter flange cover

Warning!

Rotating parts -Pinch point - Crushing hazard!

When main shaft is rotating, ensure that your hands and any part of your body are not in contact with the Rotating parts of main shaft and high speed shaft. Also ensure clothing and PPE is not subject to being caught in rotating parts (e.g. any part of your body is not between the main shaft and the high speed shaft or brake disc.

Ensure personnel are properly trained on safe operations of low or High speed rotor lock and secondary brake.

14.6.1 Checking Brake Pad and Disc for Uniform Distance

1. Apply the brake disc rotor lock.
2. Bleed the pressure from the system.
3. With the brake completely open, inspect the air gap between the brake pad and disc for uniform distance.
4. If uneven distance, adjust the brake as follows:
   - Loosen the lock nut
   - Adjust the air gap between the brake pad and the disc by turning the screw. (Adjustment gap consult with GE rep)
   - Tighten the lock nut

Figure 173: Checking air gaps

5. Verify that the two nacelle top rigging hatches are installed.
6. Ensure access hatch is closed and latches are engaged.
7. Once the rotor is installed, the high speed coupling cover must be completely installed, all hardware must be accounted for and snug tight.

Warning!

Rotating parts -Pinch point - Crushing hazard!

When main shaft is rotating, ensure that your hands and any part of your body are not in contact with the pinch point of main shaft. Also ensure clothing and PPE is not subject to being caught in rotating parts (e.g. any part of your body is not between the main shaft and nacelle wall, Hub and nacelle wall).

Ensure personnel are properly trained on safe operations of low speed rotor lock and secondary brake.

8. Release the brake disc rotor lock.

Attention!

The installer must ensure rotor and high-speed brake are released after crane has moved out of the area and work has been completed. Never leave rotor lock and brakes applied overnight.

Hydrep units: Open the bleed valve manually by pressing the black rubber knob and holding it (for 10 seconds minimum and/or as required) until the system pressure is completely released (gauge reading falls to zero psi, and caliper is observed to be fully retracted. Double check the pressure remains at zero and the caliper remains retracted after 5 minutes).

Refer to 1.5Serie_60Hz_WDI_PMT_brakehydra_StrtMaintESS.ENxxx, "Startup and Maintenance of the Hydrep Active Brake at the High-Speed Shaft".

9. Using a multiplier and calibrated mechanical torque wrench perform a 10 % torque inspection on nacelle and tower flanges. 10 % torque inspection will be spread out evenly as possible.

Figure 174: 10% Inspection

10. Perform a 10% torque inspection of anchor bolts. 10% torque check marks need to be clearly visible for future maintenance inspections.

Figure 175: Example anchor bolt 100% torque and 10% marks

11. In order to provide a reliable corrosion protection, the flanges are painted once again. Clean the scuff marks from tower interior. Apply touch up paint as necessary.

Figure 176: Apply touch up paint

12. Ensure all the work is inspected in accordance with the Installation Checklist (ICL) and Installation Inspection Procedure (IIP).
13. Disassemble, band and palletize as required, load blade fixtures and hardware onto the transport vehicle.
14. Return the shipping fixtures, supports, hardware, and tie-downs to place of origin. Refer to Blade fixture return manual.

Summary: Amended Application Appendix F (Wind Energy turbine Manufacturer Safety Manuals) Part 2 of 4 electronically filed by Teresa Orahood on behalf of Sally Bloomfield for Northwest Ohio Wind Energy, LLC