15 Tower Cables


Attention!

Verify Installer LOTO plan and GE LOTO plan are complementary to ensure equipment is de-energized.

Electrical Hazard!

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

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

Substation switch gear racked out, locked out and grounds attached.


Danger!

Substation air switch gear verified open, locked out and grounds attached.

Transformer in PPM Verify Medium Voltage (35kV) switch 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, switch gear (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.

For more detailed information, refer to the Energization Process Flow Chart.

For more detailed information, refer to the Work Instructions Power Cable, Splice and Lug Installation Procedure inside Tower.

Where applicable, refer to latest Work Desk Instructions for Bus Bar and latest revision Field Electrical Drawings for this chapter.

- Bus bar manual 443 for detailed Bus Bar Assembly Instructions
- 1.5Serie_xxHz_WDI_cable_3M-Armorcast for application of adhesive permeated fiberglass
- 1.6-100_2.x_xxHz_WDI_RETR_cable_ArmorcastInst
- Refer to Electrical validation Test 104W2311
- GE1.all_xxHz_SPC_foundation inter _part IV of V.xxxEN DWG: 104W2406 and 104W2407

For tower electric internal based on configuration, consult with GE representative for the appropriate drawing and for other generations not listed.

- Gen 3 – Consult with GE Engineering for latest drawing
- Gen 4 - 103W1416
- Gen 4 ESS - 103W1436

- Gen 5 - 103W1511
- Gen 6, 7 universal - 103W1629
- Gen 10 – 115W2782

Cables must be terminated properly and routed without kinks caused by bending. The radii of bends in conductors shall be sufficiently large to ensure that no injury is done to the conductors or their insulation, covering or sheathing. Non-shielded conductors shall not be bent to a radius less than 8 times the overall cable diameter.

Quantity	Description
2	AC extension cord, 100’
30 ft	Retractable lanyard or temporary rated safety line
2	Bucket, canvas, 5 gallon
ar	Cable tie, ship loose
10	Cable tie, ship loose
1	Container, gasoline
ar	Cable tie, steel (minimum 21)
ar	Wrap, neoprene, 14 feet length cut to size
ar	Crimp tooling – vendor specific
1	Panduit RT2HT cable tie tool
ar	Die set – vendor specific
2	Duffel bag, canvas
1	Generator, 6.5 kW with GFCI
1	Ladder, step, 8'
ar	Heat shrink, ship loose
1	Ladder, extension, 16’
1	Light, drop
ar	Paint pen, blue
ar	Paint pen, red
ar	Paint, tower touch up, exterior
ar	Paint, tower touch up, interior
1	Pliers, channel lock
ar	Radio, two-way
ar	Rags
2	Ratchet, ½-drive
1	Screwdriver set
2	Socket, deep, 19 mm, ½-inch drive
ar	Splices, ship loose
1	Stripper, cable
1	Torch, propane or heat gun
2	Tweaker, slotted
1	Wrench, adjustable, 12”
2	Wrench, combination, 19 mm

15.1 Terminating the Power Cables in the Hub Cabinet

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 the nacelle.

1. Verify all breakers, switches, and overloads in the topbox and hub main controller are in the "Off" position. Place the UPS switch in the "off" position.
2. Retrieve conduit and elbow from topbox and place in hub.
3. Verify all batteries and main switches for each axis box are in the "Off" position.
4. Remove the hub cabinet cover. Do not remove any electrical tape covering wire ends.
5. Terminate cable in the hub cabinet C.
6. Prior to running slip ring cables through the conduit, check all cables for pinched and/or insulation/exposed strands. If damage is found, slip ring must be replaced.
7. Feed cable bundle through conduit and elbow.
8. Feed the cable bundle through the access hole on the side of the hub main control cabinet.
9. Insert the conduit elbow through the cabinet and tighten the flex conduit elbow lock ring.
10. Route cable bundle into wire duct. Un-wrap the tape from slip ring cable bundle.
11. Terminate the conductors using the wiring chart as a guide. Use caution when inserting the ferrules into the terminals. Make sure that the ferrule is inserted into the block and not behind the block. Do not over tighten the screw of a terminal onto the plastic sheaf of the ferrule. Perform a wire pull test on every wire after terminating to ensure that no wires are loose.
12. Salem pitch and ESS Salem pitch hub main control cabinet requires removal of jumper wires. Contact GE representative for the latest wiring chart.

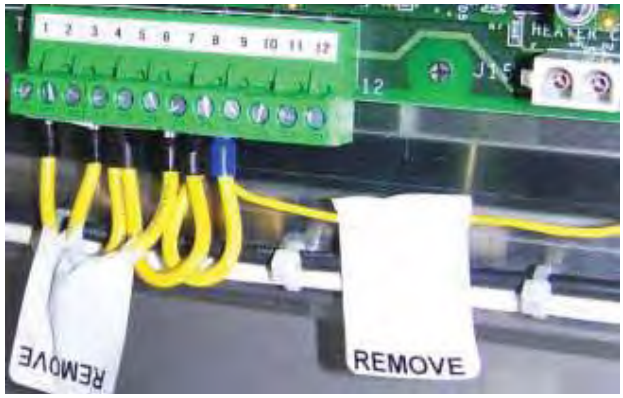


Figure 177: Jumper wires in a ESS

13. Perform a pull test on each conductor to ensure proper termination.
14. Verify wire runs are neat and all wire duct covers are securely fastened.
15. Remove all materials and tooling from cabinet. Close and secure the cabinet doors. Verify the lock clips are engaged (popped out to the locked position).
16. Install straps on hub main control cabinet and each axis box.
17. Clean and properly dispose of trash and debris before exiting the hub.

Note!

Notwithstanding any provision in the supply agreement, GE is not required to energize the gearbox oil pump of any WTG for lubrication purposes, as long as the following conditions are met:

- the blades are positioned between a pitch degree angle of +80 and +90 degrees;
- the rotor and high-speed brake are released;
- 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"
- the WTG Unit is placed in a non-operation mode; and
- the rotor is free to pinwheel.

Do not leave the rotor locked for more than 12 hours without engineering approval.

15.2 Lowering Power, Control, & Communication Cables

Danger!

Before starting work at saddle location either install a temporary hole cover over the hoist hatch opening or use a retractable lifeline to prevent fall hazard.

Figure 178: Work at saddle

1. The crew person located in the nacelle will lower the control and communication cables starting with the largest diameter cable first. Begin lowering one at a time down through the yaw deck opening with assistance from a crew person located on the yaw deck.
2. The crew person on the yaw deck will lower the cables through the platform A and cable collector rings (or PVC tube) and down to the crew person located at the saddle.
3. Provide a sufficient amount of slack between the dual saddle and nacelle so that the cables are not placing a load on the cable bundle. Allow adequate clearance over the hoist, ladder, and safety cable anchor or Haka climb system.
4. The crew person located at the saddle will route the cables over the saddle and form a 1 m/42-inch drip loop, measured from the lower edge of the saddle pinch block. Refer to the Field Electrical Drawings for correct routing of cables over through the pinch block. Continue to lower cables down the next platform.
5. Continue lowering the power, control, and communications cables down through the clearance hole between the tower wall and the platform(s) to the bottom of the tower to the crew person located behind the DTE.

Figure 179: Completed communication cable bundle

While lowering the cables, the weight of the cable must be supported by enough personnel at all platforms until cable reaches the bottom of the tower and it is temporarily secured through the length of the tower.

When securing cables to cable tray(s) verify they are protected against any rough edges and burrs at all places where they would be likely to damage the insulation on conductors, where edge trim or bolt caps are required and are missing correct as required and report to tower manufacturers.

6. Temporarily install two cable ties around each of the power, control, and communication cables against the uni-strut or cable tray located at the saddle platform.
7. Verify the power, control, and communication cables lengths allow for termination in the main controller cabinet at the DTE. Expect the power, control, and communication cables to be 6ft to 12 ft longer than necessary.
8. When lowering and securing the fiber optic cable down the tower, take care not to crush, pinch between sharp objects, or bend sharply (minimum bend radius 113 mm) as this will cause permanent damage to the cable. Ensure tie wraps do not damage the fiber optic.
9. If the aviation lights are installed, lower power and photocell cables with power, control, and communication cables down tower.
10. Lower the fiber optic cable(s) down through the top platform, inside the cable bundle, over and behind the saddle, and down to the bottom of the tower. Support the weight of the cable at each flange by taping to cable tray rung.

The communication cable bundle must be taped as it passes through the platform A and cable collector rings (or PVC tube) as required to keep the bundle uniform and straight.

Refer to the Field Electrical Drawings for correct routing of cables over through the pinch block.

11. After all control and communication cables have been lowered, tape the cables together every 0.5 m/20 inches to form a bundle. Do not use cable ties. Start at the yaw deck and continue down to the saddle pinch block.
12. Beginning below the saddle, secure the fiber optic cable on the outside of the communication cable outside of the saddle pinch block with cable ties every six inches down to the cable tray.

Allow slack on fiber optic cable at nacelle dual saddle and over tower saddle drum to prevent damage during operation.

13. For Gen 7 or later (C channel cable tray), if required by local code, there is an option to separate the power cables from the communication cables in tower cable tray. Two pairs of holes are available in cable tray for that purpose.

    For Gen 6 and earlier (ladder rung cable tray): All the cables will be bundled together and secured to the cable tray beneath the saddle with cable ties on every rung, and routed to the tower cable tray and secured with cable ties on every rung for the first 12 rungs and every third rung after that on the tray.

    The fiber optic cable is routed on the outside of the bundle and secured with cable ties to the cable bundle on every rung for the first 12 rungs on the tray. After 12 rungs, ties can be spaced to every third rung all the way down the tower. Allow enough excess cable to accommodate the bridge at the tower flange connections.

    Finish forming at the bridge locations during rotor, stator, and ground cable installation. Power and communication cables are secured at every rung on the cable bridge and every third rung after that.

14. Gen 7 or later rev 1 bus bar: Communication cable bundle is secured to cable tray with neoprene wrap and steel cable tie.

Base Section

80m tower 2 ties per cable tray

65m tower 1 tie per cable tray

Mid Section

80m tower 2 ties per cable tray

65m tower 2 ties per cable tray

Top Section

80m tower section 2 ties per tray

65m tower section 2 ties per tray

Top Sections with 2.5m trays only get 1 tie.

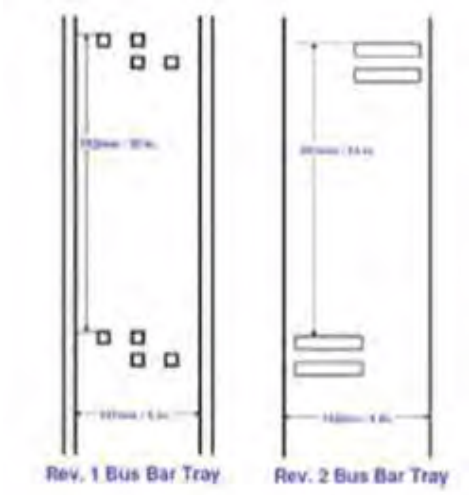


Figure 180: SS tie and liner

15. Separate the fiber optic and Ethernet cable from the bundle. With the rest of the cable bundle pulled slightly away from the cable tray, take a new nylon zip tie and fasten it around the cable bundle. This will allow you to have a tight bundle to measure and cut the Neoprene wrap to size. Refer adjacent Figure.
16. Wrap the Neoprene sleeve 100% around the cable bundle and cut the sleeve with diagonal cutters. Steel tie should not be exposed to the cable bundle. The cable bundle must be protected with the neoprene wrap at all times.

Figure 181: Neoprene cut to size

17. Route the SS zip tie through the slots of the cable tray and around the bundle and Neoprene sleeve. Refer adjacent Figure.

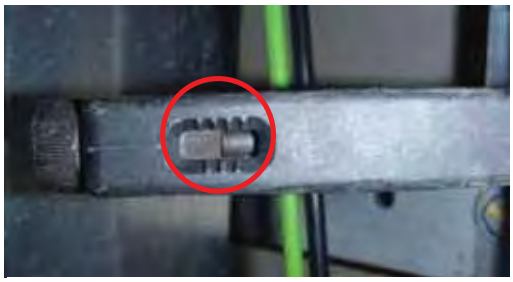
The Neoprene sleeve does not route through the cable tray slots, it only goes around the bundle.

Figure 182: Rev 1 bus bar

18. Close up the SS zip tie by hand. (Refer adjacent Figure).
19. Ensure no sharp edges are in contact with the control cables.

Figure 183: Cable bundle is secured to cable tray with neoprene wrap and steel cable tie

20. Use RT2HT cable tie gun tension setting 4 to install the steel cable ties.



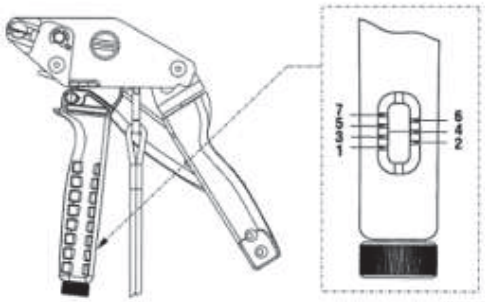


Figure 184: Cable tie gun

Be careful that the Neoprene sleeve spreads flush between the cable tray surface and the cable bundle.

21. Ensure the steel tie is cut evenly with the clasp.

Figure 185: Steel tie cut evenly

22. Route the fiber optic and CAT5 cables outside the steel cable ties. Ensure tie wraps do not to crush, pinch the fiber optic cable.
23. Install nylon cable ties in all remaining bus bar holes.

24. For Rev. 2 bus bar trays, fasten the cable bundle to the tray using two zip ties in an "X" pattern (similar to fastening to a ladder tray) using every set of holes on one side of the tray.
25. Secure the overtwist switch and hoist cables to cable tray along with the power, control, and communication cables. The overtwist switch cable runs down tower in Non-ESS units only. In ESS units, the overtwist switch cable will run to the topbox.
26. Secure the hoist, overtwist, power, control, and communication cables to cable tray on opposite side of barrier strip from rotor, stator, and ground, down to the bottom of the tower. Allow excess cable to accommodate bridge at tower flange connections. Finish forming at bridge locations during rotor, stator, and ground cable installation.

15.3 Lowering Stator, Rotor & Ground Cables (For 1.5/1.6/1.68/1.85 Configuration other than 1.x-100/103 50/60 Hz)

There are possibly two tower variants. One with a PVC tube and one without, for the 1.x 82.5 (other than 1.x-100/103).

For 50 Hz configuration there are possibly two cable variants:

Existing configuration: 3 rotor cables and 4 stator cables (per phase).
New configuration: 1 rotor cable and 3 stator cables (per phase).

1. Identify each rotor and stator ground cables and mark appropriately.
2. The crew person located in the nacelle will separate the cables and check phase markings. Verify cable runs are uniform and cables do not cross.
3. The crew person located in the nacelle will select a cable and begin lowering the cables one at a time down through the yaw deck opening with the assistance of a crew person located on the yaw deck.
4. The crew person located on the yaw deck will lower the cables down through the platform A and cable collector rings (or PVC tube) and down to the saddle. Verify the cables are uniform and do not cross. Prepare cables for splice at saddle (if applicable).

Figure 186: Cables at the yaw deck – dual saddle

5. Provide a sufficient amount of slack between the dual saddle and nacelle so the cables are not placing a side load on the cable bundle. Also allow adequate clearance over the hoist, ladder, safety cable anchor or Haka climb system.
6. The crew person located at the saddle will route the cables over the saddle and form a drip loop approximately 42 to 46 inches, measured from the lower edge of the saddle pinch block. For cable phasing over the saddle refer to GE field assembly drawings based on tower GEN configuration.
7. Temporarily install two cable ties around each cable securing back to itself just below the saddle to support the extra cable weight.
8. Finish forming the center bundle, starting 18 to 24 inches just below the dual saddle. Surround the fiber optic, power, control, and communication cables with the stator, rotor, and ground cables.

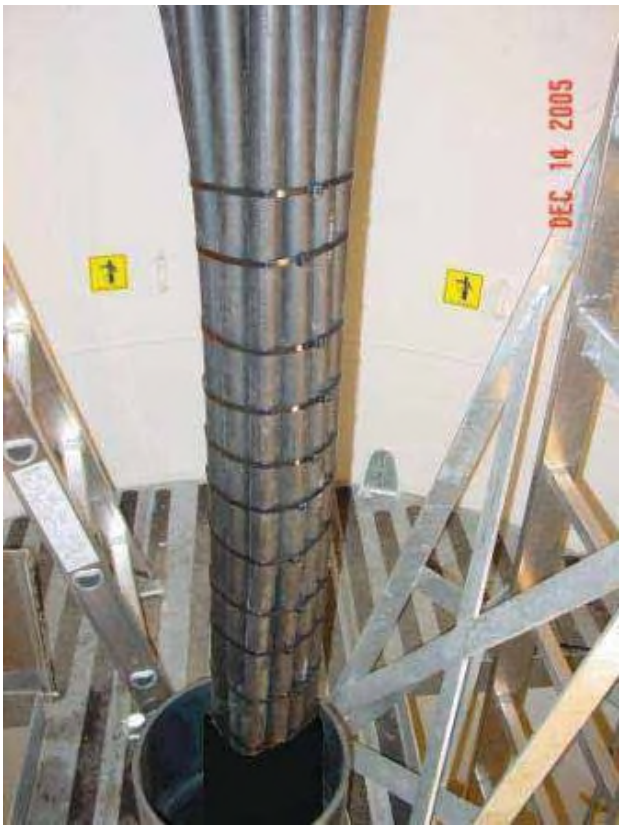


Figure 187: Center bundle below dual saddle

Verify tower platform hatch is closed and is not leaning against the cable bundle to prevent damage to the insulation.

9. Install cable ties approximately every 10 cm/4 inches min - 6 inch max down to approximately one and one half feet below the saddle. While installing the ties, remove the excess length previously provided. The drip loop should be approximately 1067 mm (107cm ±50 mm) below the saddle measured from the bottom of the pinch block or the tie-wrap holes to the bottom of the drip loop.
10. When measuring length of Drip-Loop @ Saddle Deck; you must achieve correct measurement of 1067 mm (107cm ±50 mm). Measure directly down from the bottom of the Pinch block and/or the tie-wrap holes and then directly over to the bottom of the bundle at a 90 degree angle.
11. Verify that there is no movement between the cables once the ties are installed. The bundles should act as a single, solid mass and be uniform in length. The twist should be evenly distributed throughout the cables.
12. Dress the rotor, stator, and ground cables through the pinch block or uni-strut located at the saddle. Tighten the pinch block hardware (bolt heads on outside and nuts on inside) or install cable ties.

    For Gen 6 and earlier: Verify that the two ground cables are routed through cable glands lugged and connected one each to the bus bars and or both grounds to a single bus bar based on configuration.

    For Gen 7: Verify that the two ground cables are lugged and properly connected to the cable-tray end and each cable secured with 2 zip-ties to bus bar bracket.

Figure 188: Dress cable over saddle

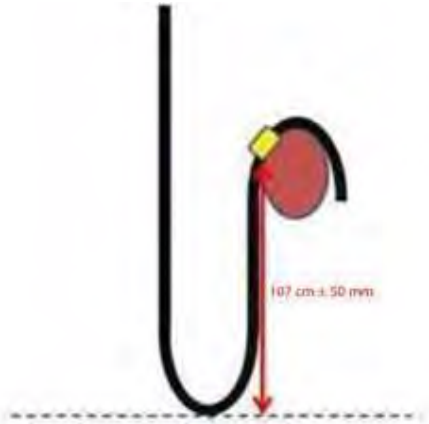


Figure 189: Drip loop measurement pinch block or tie wrap holes

13. Dress the rotor, stator, and ground cables through the transition cable tray and install neoprene and steel cable ties as described below.
    - Measure the neoprene by wrapping around the stator, the rotor cable trefoil or the two ground cables according to where it will be installed.
    - Cut the neoprene according to correct cable bundle size.
    - Secure the neoprene and steel tie to the cable tray rung with 2 nylon cable ties.

- Wrap the trefoil bundle with neoprene and steel tie.
- Adjust the neoprene and steel tie as needed to ensure that the neoprene cut and steel tie buckle is centered in the valley between the two cables. Refer to Figure 182.
- Ensure that the steel tie is cut evenly with the clasp and no sharp edges are in contact with the control cables. Use RT2HT cable tie gun with tension setting 4 to install the steel cable ties.
- Fasten the cable bundles to the lower tray rungs using two zip ties in an "X" pattern.

14. Verify the cables are properly supported at the transition, cut the cable ties holding each cable to itself below the saddle.
15. Dress the rotor, stator, and ground cables through remaining tower top section cable tray.

The electrical cable for the cable overtwist switch is terminated in the topbox. This cable must be routed with the other control and communication cables in the drip loop, over the saddle, and through the pinch block. At the cable tray, this cable must break away from the other control and communication cables and be routed up the small cable trays, using zip-ties to secure the cable to the cable trays. Terminate this electrical cable at the overtwist switch.

15.4 Lowering Stator, Rotor & Ground Cables (For 1.x-100/103 50/60 Hz Only)

1. The cable trefoils should be always installed with distance (2.15 times of outer diameter of cable) between each other.
2. Prepare all spacers by inserting the cables ties as shown in adjacent Figure.
3. Using the file round off the outer top edge of the topmost spacer until you achieve a constantly smooth surface with a radius of approx. 7-8 mm.
4. Repeat this procedure on the outer bottom edge of the under most spacer.

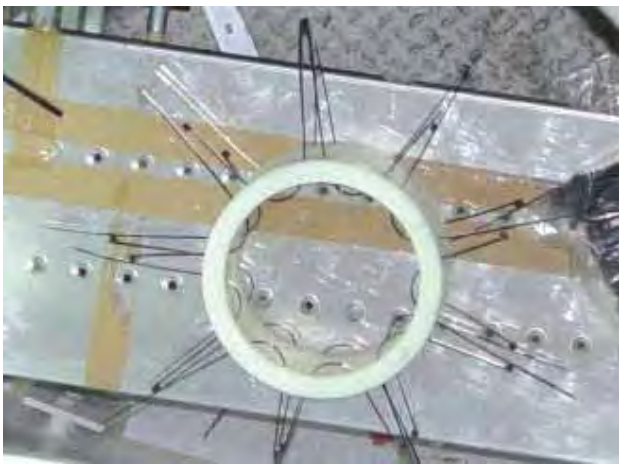


Figure 190: Preparation of spacers

5. Begin with the top spacer at the yaw deck. Install it as shown in previous Figure.
6. Locate equidistant between the twist switch spacer and the waterfall.
7. Locate at approximately** same elevation as the twist switch. Twist switch rope should extend approximately horizontally from switch to this spacer elevation as the twist switch. Twist switch rope should extend approximately horizontally from switch to this spacer.

**Spacer can be slightly lower.

8. Locate equidistant from twist switch spacer and bottom-most spacer.
9. Locate as shown in this graphic – on the vertical at the lowest most point.

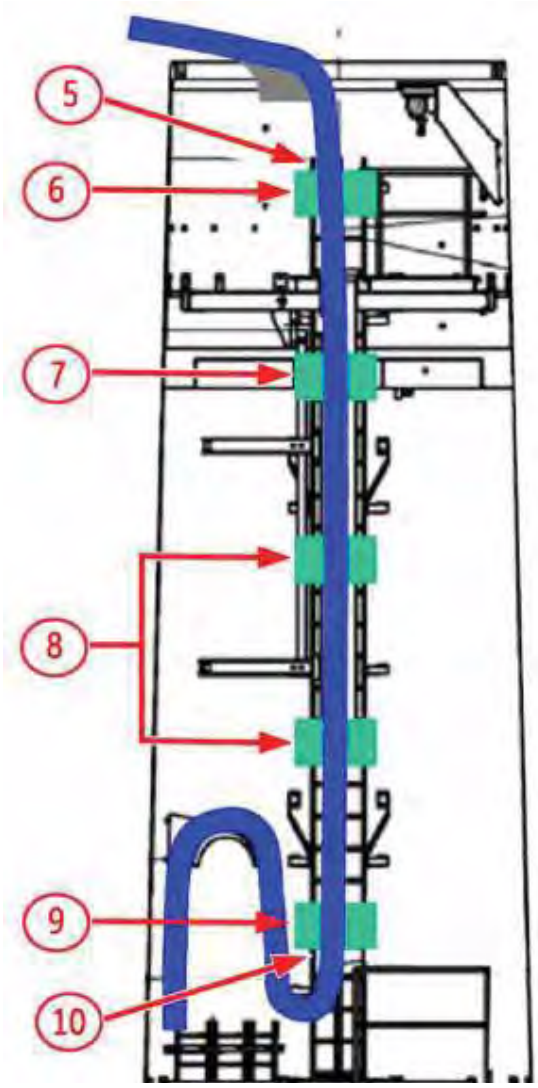


Figure 191: Preparation of spacers

10. Place the first spacer inside the cables so that the already identified cable bundles can be distributed around the spacer.

Figure 192: Inserting the spacers

For 1.x-100/103 50/60 Hz configuration only

Make sure that the heads of all cable ties around the cable bundles are pointing outwards to avoid damages to the other cables.

Figure 193: Heads of cable ties pointing outwards

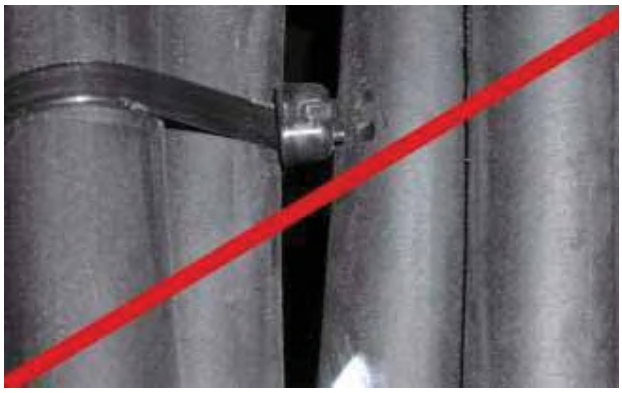


Figure 194: Incorrect position of the cable ties

11. Tie each cable bundle (three bundles: for stator cables, one bundle for rotor cables) with cable ties.
12. Tie together the group of smaller cables coming from the nacelle. Place the fiber optic cable in the center of the bundle.

Exception: local code may require bundle separation. In this case, separate into 2 bundles C1 - C2 per local code requirements.

13. Identify the ground cables (G) and tie them together in one bundle and place it in gaps between two of the cable bundles and use two additional cable ties for each group.
14. Determine the position of each cable or cable bundle allowing the natural position of the cables avoiding twisting them.

The adjacent figure is an example of the distribution of the cables around the spacer:

- Stator cables bundles (UVW) each trefoil will contain 1 cable from each phase of its circuit i.e., UVW for stators and KLM for rotors.
- Ground cable pos. G in gaps between cables bundles (rotor and stator bundles)

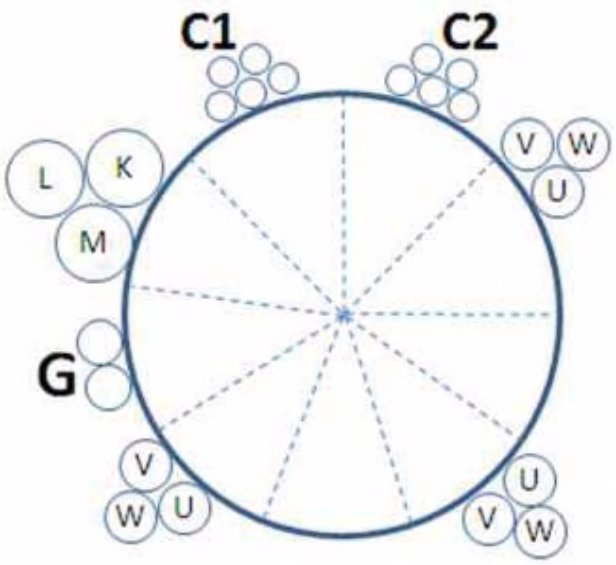


Figure 195: Example - distribution of the cables

15. Repeat steps 2 to 7 for the remaining spacers, using a scaffold for installation of the spacers 2, 3 and 4.
16. The installer located at the cable guide platform has to route the cables over the cable guide platform and form an approx. 1 m to 1.5 m (42 inch)" initial drip loop", measured from the cable tie location to the bottom of the drip loop.
17. If applicable, temporarily install two cable ties around each cable securing it back to itself immediately below the cable guide platform to support the extra cable weight.
18. Starting from the last spacer install cable ties at an interval of approximately 10 cm to a distance of approximately 45 cm below the cable saddle. While installing the ties, remove the excess length previously provided. The drip loop must extend approximately 1 m (42 in) below the cable guide platform measured from the cable tie location to the bottom of the drip loop.
19. Pull the cables through the remaining cable tray in the tower top.
20. Verify that there is no movement within the single cable bundles once the ties have been installed. The bundles must act as a single, solid mass and be uniform in length. The twist should be evenly distributed throughout the cables bundles.
21. Pull the generator stator and ground cables over the cable saddle and secure with cable ties ensuring that the heads of all cable ties around the cable bundles are pointing outwards to avoid damages to the other cables.
22. Pull the ground cables through the transition cable tray and secure with cable ties.
23. Verify that the cables are properly supported at the transition. Cut the cable ties securing each cable to itself below the cable guide platform.
24. Pull the cables through the remaining cable tray in the tower top.

Figure 196: Finished spacers

15.5 Installing the Twist Switch Cable (for 1.5, 1.6, 1.68 and 1.85 Configurations other than 1.x-100/103 50/60 Hz)

1. Select the closest power cable to the twist switch. On the horizontal plane apply four layers of electrical tape to the cable.
2. Connect the twist switch cable to the cable with electrical tape. Tie the twist switch cable in a clove-hitch knot. Using pliers, install the sleeve crimp to ensure the cable does not release. Wrap electrical tape around the loose tail end of the clamp to eliminate sharp edges.
3. Move the twist switch cable out of the way and install a cable tie around the cable bundle one-inch below the top of the opening and another tie 25 mm below the bottom of the opening.
4. Start at the bottom of the opening and wrap 20-mil tape around the cable bundle three times.
5. Wrap the twist switch cable around the cable bundle three times and route through the eyelet, then pull cable until the twist switch activates. Cut the cable just below the eyelet.
6. Remove the cable from the eyelet and unwrap. Terminate the overtwist switch power cable to the overtwist pull switch. Allow for a 5 cm tail below the location where the weight will be crimped. Using pliers, crimp the sleeve crimp and weight onto the cable.
7. Insert the cable into the twist switch PVC tube.
8. Refer to 1.5Serie_xxHz_WDI_cable_3M-Armorcast for application of adhesive permeated fiberglass. Adhesive permeated fiberglass is applied to the cable bundle where it passes through the platform A and cable collector rings (through both the ends of the PVC tube if present).

15.6 Installing the Twist Switch Cable (for 1.x-100/103 50/60 Hz only)

1. Select the closest bundle (trifoil) adjacent to the twist switch and wrap 4 layers of tape to the trifoil.
2. Attach the cable to the closest bundle adjacent to the twist switch. Tie the cable of the cable-untwisting switch in a clove hitch. Using pliers, install a compression joint to ensure the cable cannot be released.
3. Wrap insulating tape around the loose end of the cable and compression joint to prevent sharp edges.
4. Route the cable through the twist switch eyelet.
5. Cut the cable 92 inches measure from the eyelet.
6. Using pliers, crimp the compression joint and the weight on the cable.
7. Insert the cable and weight in the PVC tube of the twist switch.
8. Wrap insulating tape around the loose end of the cable to prevent sharp edges.

92 inches represents the length at which the twist switch will be triggered after 2.5 yaw revolutions, plus additional (as required) inches for attachment of the weight and attachment to the drip loop.

Refer to "1.6-100_2.x_xxHz_WDI_RETR_cable_ArmorcastInst" for application of adhesive permeated fiberglass.

9. Install adhesive permeated fiberglass (e.g., Armorcast) to power cable, exposed to the cable collector rings and 'Platform A' opening to avoid cable wear during operation.
10. The Installation shall be done by wrapping each trefoil of power cables starting approx. 15 cm below and ending approx. 15 cm above the collector ring.
11. To cure the adhesive permeated fiberglass, spray it with pure water after wrapping. Secure the adhesive permeated fiberglass with a cable tie at both ends.
12. Adhesive permeated fiberglass is applied to the trefoil cable bundles where it passes through the yaw deck and the tower mounted cable collector ring above the saddle.
13. Ensure adhesive permeated fiberglass mixture is consistent with manufacturer specification to ensure adhesive permeated fiberglass is adhered to the cables correctly.

15.7 Nacelle Access Ladders

1. Verify nacelle access ladders are installed. If necessary install nacelle access ladders.

Warning!

Fall Hazard, Falling Objects and Floor Opening!

Employees must wear harness with lanyards attached to specific point at all times. Secure tools, materials and waste so that it does not fall through the floor opening!

15.8 Splice Rotor, Stator, and Ground Cables

For insulated bus bar system: refer to Bus Bar Manual 443 and reference drawings for interconnection at saddle cable to bus bar (tower joints) and interconnect (bus bar to DTE transition).

For more detailed information, please refer to the Work Instructions Power Cable – Splice and Lug Installation Procedure inside Tower.

1. Splice the rotor, stator, and ground cables at the cable tray directly beneath the saddle.
2. The splice must be supported above and below the splice with cable ties.

For aluminum cable towers install the aluminum to copper splice.

Figure 197: Connecting cables below the saddle

Figure 198: Connecting cables below the saddle b

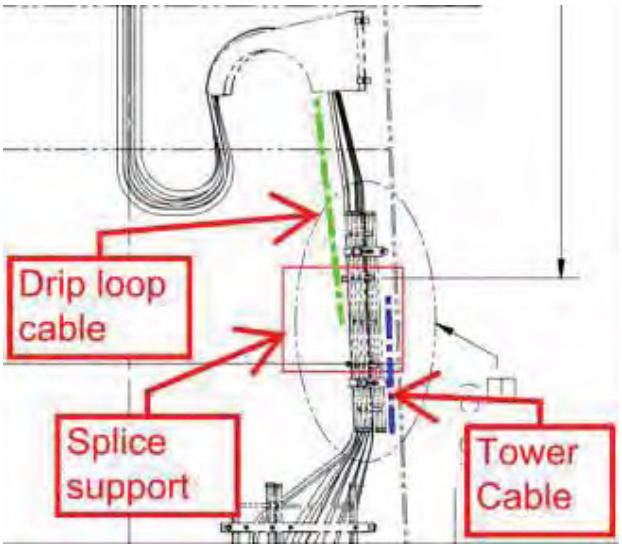


Figure 199: Connecting cables below the saddle c

3. Measure cables for adequate lengths at top to mid cable Tray Bridge to ensure clearance over flange and to attach back to the bridge then cut cables.
4. Remove bridge to allow enough space to make the splice. Splice the rotor, stator, and ground cables at the tower flange connections.

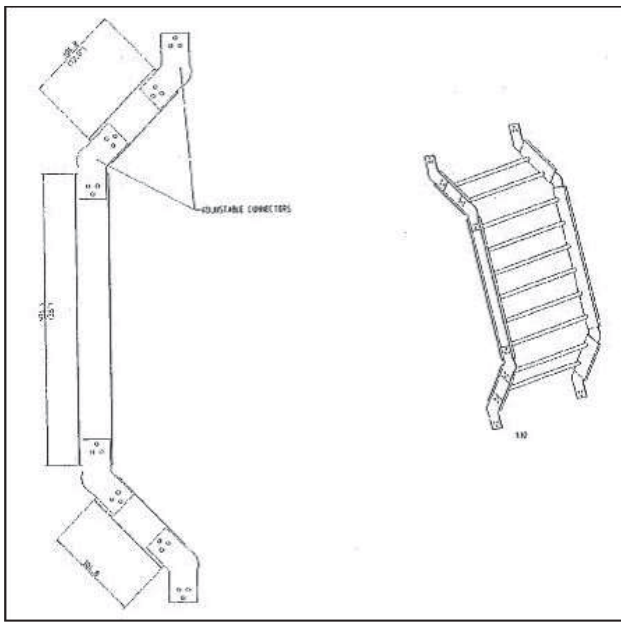


Figure 200: Example cable bridge

5. Re-install bridge and attach all cables to bridge on opposite side of barrier strip from communication cables.
6. If slack is present, install two cable ties crossed and over the first and last rung of cable tray to keep cables from making contact with sharp edges. Power and communication cables are secured at every rung on the cable bridge and every third rung after that.
7. Repeat steps 1 to 5 in this chapter 15.8 to complete the splices for the rotor, stator, and ground cables at the remaining tower flange cable tray bridge connections to the bottom of the tower.

For aluminum cable towers install the aluminum to aluminum cable.

8. Splice the rotor, stator, and ground cables at the transition deck above the DTE. Install the aluminum to copper splice.

Figure 201: Example of cables attached to cable bridge

15.9 Routing & Terminating the Rotor, Stator, Power and Communication Cables from the Tower

Warning!

Hand Crush and cut risk!

Warning!

Slip Hazard!

1. Remove the CFC access cover for stator and rotor cable entry.
   - First loosen up or completely remove the CFC upper cover.
   - Second remove the lower CFC cover.

Keep all small nuts and bolts in container to prevent misplacing hardware.

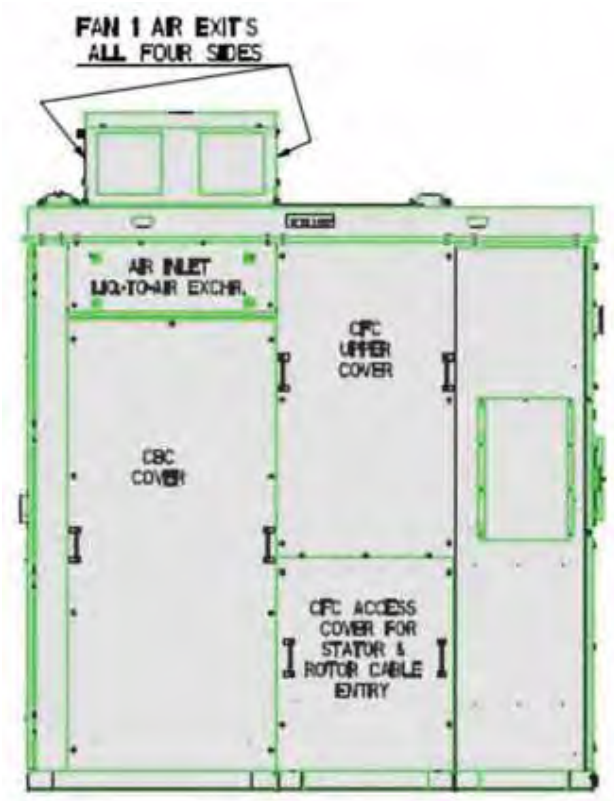


Figure 202: Rear view

2. Open the MCC cabinet door

Figure 203: Front view

3. Adjust the cable trays, small for control and communications cable and large for the stators and rotors.

Refer to drawings provided in the main cabinet door to identify cable access point.

4. Route all stator and rotor cables into the CFC (Converter Filter Cabinet),
5. The radii of bends in conductors shall be sufficiently large to ensure that no injury is done to the conductors or their insulation, covering or sheathing. Non-shielded conductors shall not be bent to a radius less than 8 times the overall cable diameter.
6. Apply tie wraps to secure cables to the tray.

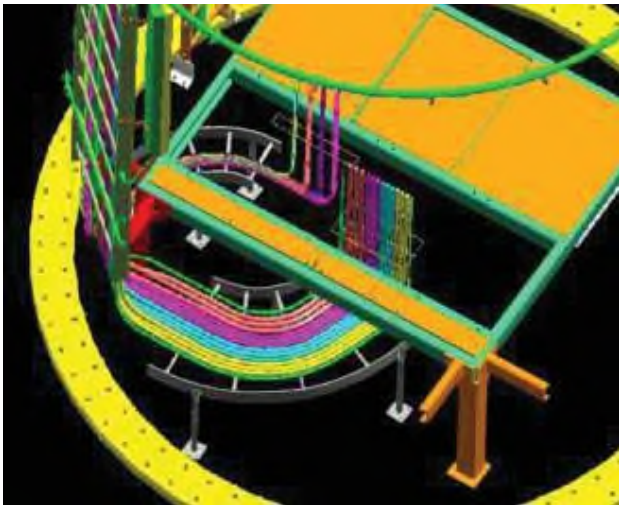


Figure 204: Cable tray location

7. For 60 Hz bus bar configuration, the cable trefoils should be installed with distance between each other. The distance should be more than or equal to 2.15 times of outer diameter of larger power cable. For detailed dimension refer to latest version of controller level power cable assembly for bus bar configuration. The cable trefoils should be fastened by cable cleats both on the vertical and horizontal cable ladders. The zip-ties should also be used to fasten the cable trefoils and grounding cables.

8. Measure the cables for proper cutting lengths. Then pull the stator cables towards the front of the cabinet away from connecting points. Cut the cables ensuring no cable strands or insulation debris fall into or near the termination points.
9. Open the Rotor and Stator generator junction box and un-terminate the lugs.

Figure 205: Example generator junction box

Attention!

Perform electrical validation testing according to procedure (104W2311). Unless the local authority having jurisdiction gives written notification to the Customer that neither third party compliance certification (UL, CSA or ETL Semko) nor electrical validation testing is required. If failed tests are encountered per 104W2311, the customer and the electrical contractor should collaborate to correct the associated construction defects.

10. Attach lugs per WDI lug procedure.
11. Crimp the connectors to the cables per the latest GEWE.all_WDI_cable_crimping.ENxxx.

Verify cables are routed without kinks caused by bending.

12. For required electrical validation testing and OHM checks refer to Document 104W2311 record values in BBCICL and CICL.

Verify gearbox/generator configuration to ensure correct rotation.

13. One crew member will verify correct phasing of the rotor and stator cables and place markers on cables.
14. One crew member will verify correct orientation of the lugs and terminate to bus bars. Torque the rotor cable lugs. In the converter mark with a purple paint pen.

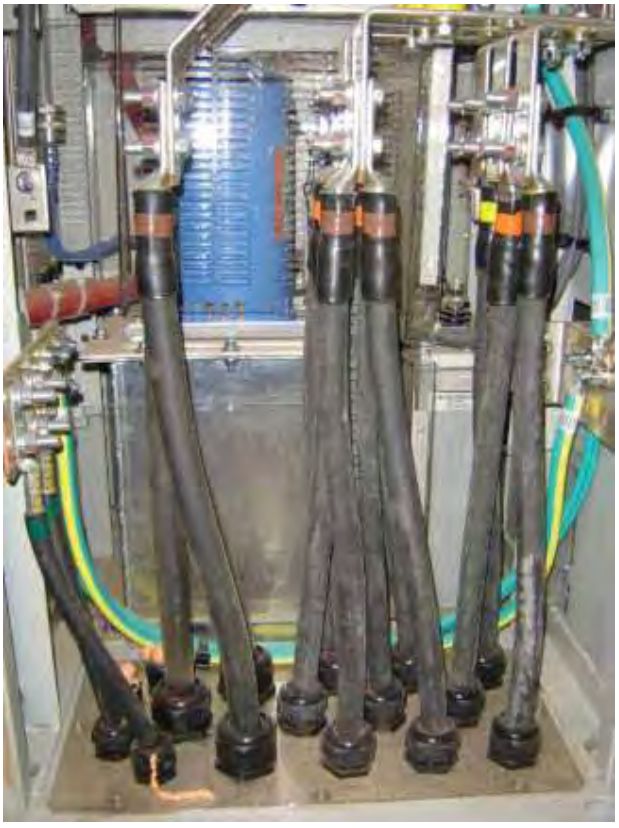


Figure 206: Lugs attached


Attention!

Ensure no loose or misplaced tooling such as torque wrenches, backup wrenches, and cable cutters are left attached to the bus bars, in converter and/or CFC cabinets.

15. **Terminate the rotor and stator lugs to bus bar in the generator junction box, torque and mark with paint pen. Remove all tools, trash and debris and then install junction box cover.**

(Refer to generator specific torque values. Consult with GE site representative.)


Figure 207: Termination point rotor at generator


Attention!

Cutting cables

When cutting around the circumference of the outer insulation of a multi conductor cable, care must be taken not to cut or nick the insulation of the inner conductors. Always inspect for damaged or cut strands near the outer insulation and repair as needed.

Inserting ferrules


Attention!

All wires must be ferruled. When crimping ferrules, always select the proper crimping tool for the job. Do not use a ring crimper to crimp a ferrule and vice versa.

When applying ferrules or ring terminals, make sure that the conductors are stripped to fill the entire length of the barrel. The insulation of the conductors must be fully inserted against the plastic base. No copper should extend from either end of the ferrule or ring.

Always check the crimp for broken or bent pins and make sure the terminal will not pull off the wire.


Warning!

Slip Hazard!

Refer to drawings provided in the main cabinet door to identify access point. Consult with GE representative for the latest point-to-point document.

16. Route the power and control cables in the cable tray and ensure excess cable is neatly lying inside of cable tray. Route cables into the MCC cabinet.
17. Terminate the conductors for the power and control cables into the MCC (Main Control Cabinet) refer to point-to-point wiring list.

Figure 208: Main controller termination point

18. In ESS units, the overtwist cable will be routed to the topbox.
19. In Non-ESS units, also terminate the Hoist cable in the topbox.
20. Verify all wires are ferruled. Use caution when inserting the ferrules into the terminals. Make sure the ferrule is inserted into the block and not behind the block. Do not over tighten the screw of a terminal onto the plastic sheaf of the ferrule.
21. Perform a wire pull test on each wire after terminating to ensure that no wires are loose.
22. Apply foam sealant to any extra holes not used.
23. For every power and control cable, coil the excess length of the cable into no more than three loops. Ensure that every coil of the cable is at least 40 cm (16 inches) in diameter.
24. Use zip-ties to hang every coil of excess cable from the cable tray rungs. If any cable coils are touching the ground, use zip-ties to attach the cable coil to multiple rungs of the cable tray until no cable coils touch the ground.
25. Check every cable to ensure that the excess is coiled into three or fewer loops, the diameter of every coil is at least 40 cm (16 inches), and that no cables are in contact with the ground

26. Route the fiber optic cable.

Attention!

Ensure No sharp bends of fiber optic cable. (Do not exceed minimum 152 mm bend radius).

Figure 209: Routing the F/O cable

27. Ensure routing does not interfere with other wires.

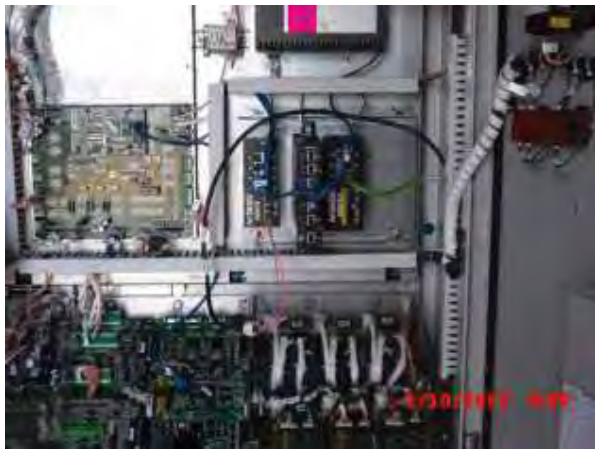


Figure 210: Routing F/O cable

28. Carefully remove F/O cable protective cover ensuring connector is not damaged.
29. Land fiber optic cable at I/O net Ntron Ethernet switch.

Figure 211: Connecting F/O cable

30. Route Ethernet cable from up tower into DTE.
31. If applicable land at SCADA Ntron Ethernet switch Port 1. If not used coil outside DTE in lower cable tray.
32. Coil the excess cable below the cabinet.

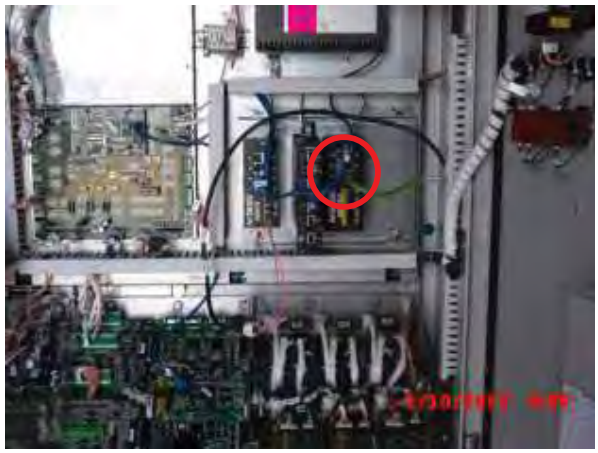


Figure 212: Connecting the etherner cable

33. Route the encoder cable.

Attention!

Ensure No sharp bends or sharp edges on encoder cable.

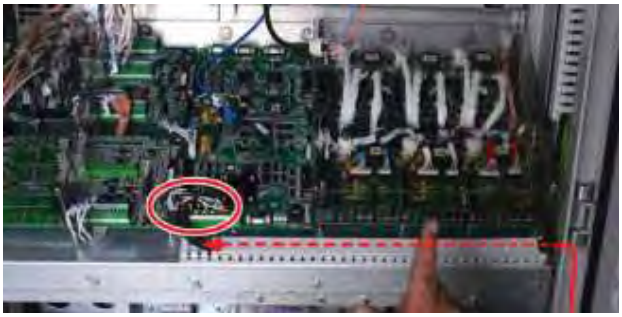


Figure 213: Routing the encoder cable

34. Terminate the encoder wires to MACC card TB1 terminals as per table.
35. Perform a pull check once the wires are terminated.

MACC TB1	Encoder	
	GETS Gbx	Non-GETS Gbx
1	UB	UB
3	0V	0V
5	K0q	K0q
6	K0	K0
7	K2q	K1q
8	K2	K1
9	K1q	K2q
10	K1	K2
12	SHLD	SHLD

Figure 214: Point to point

36. Route the tower light and receptacle cables into the MCC cabinet.
37. Cut the excess tower lights cables to allow for a service loop.
38. Strip cable 4-6 inches. Strip and ferrule the three conductors.
39. Terminate wire 1 (black/line voltage) to X5.1.2,
40. Wire 2 (white/neutral) to X5.1.3,
41. wire 3 (green/ground) to X5.1.4
42. (For CE tower only, also terminate emergency lighting lead to X5.1.1)
43. Coil excess wire and zip tie to frame.
44. If applicable refer to the latest point to point drawing.
45. Cut excess tower receptacles cable to allow for a service loop.
46. Strip cable end 4-6 inches.
47. Strip and ferrule the three conductors
    - Green (ground) to X5.1.11,
    - Black (line voltage) to X5.1.7
    - White (neutral) to X5.1.9
48. Coil the excess wire and zip tie to the frame.

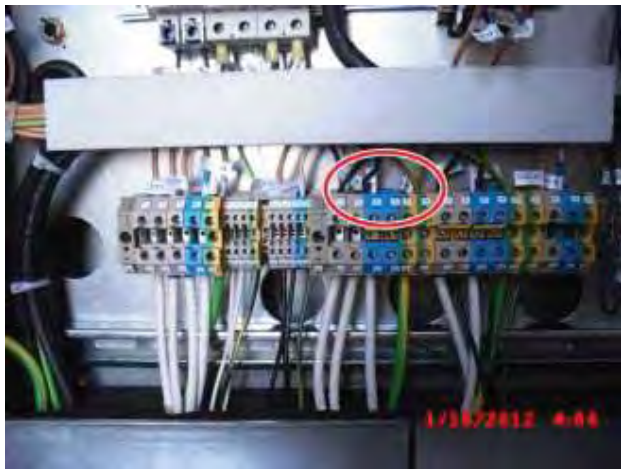


Figure 215: Terminating tower light cables

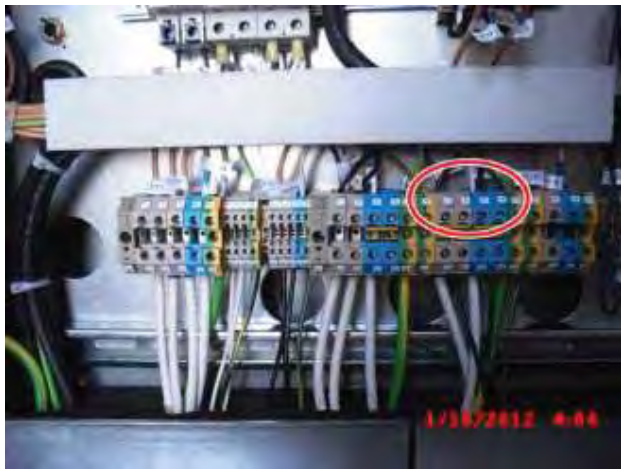


Figure 216: Terminating receptacles

49. Install the UPS (Uninterruptible Power Supply) in the MCC door.
50. Install battery in the front of the UPS per the manufacturer's manual.
51. Attach serial cable to rear of UPS; leave UPS bypassed by connecting inlet and outlet plugs together.

Figure 217: Installing UPS

Attention!

If a tool or hardware is dropped or unaccounted for, do not energize turbine until missing or unaccounted parts or tools are found. Report to the GE site manager immediately if unable to find.

52. 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.
53. Reinstall all ESS cabinet covers and torque bolts to values listed on the cabinet cover.
54. Install floor supports and floor Panels removed during cable installation.

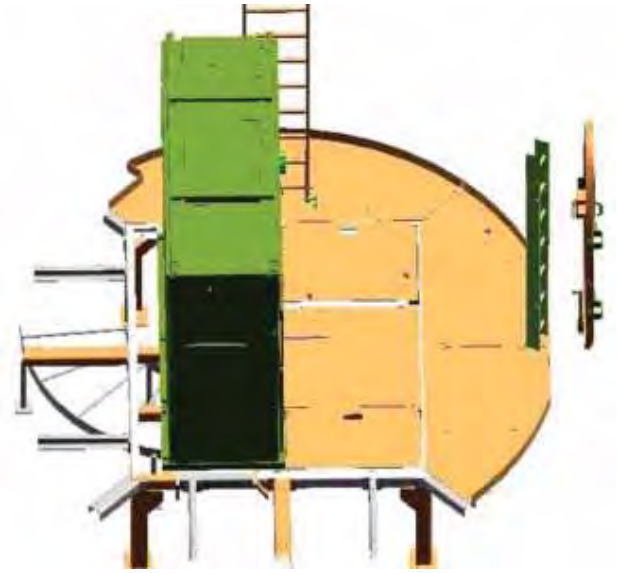


Figure 218: Panels and grounds re-installed

55. Adjust floor panels as required.
56. Torque hardware and mark with paint pen.

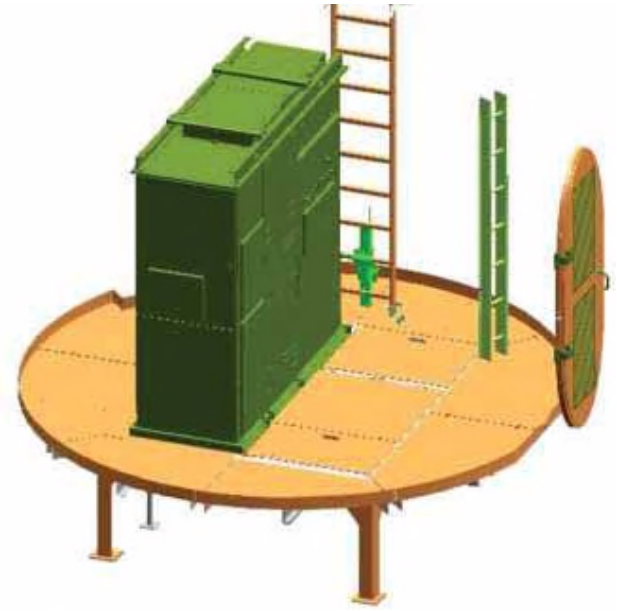


Figure 219: Floor panels adjusted

Attention!

Check the work area before concluding the work!

Remove all loose parts, tools and materials.

57. Remove the pieces of plywood located on top of the DTE. Clean and properly dispose of trash and debris and remove tooling.

15.10 Installing the Flood Lighting

1. If applicable, mount the floodlight and motion sensor fixture approximately two meters above the tower entry door on the outside of the tower.
2. The final adjustment of the light fixture is as required during maintenance activities.
3. Terminate the outlet box and fixture supply wires together. Refer to manufacturer's instructions.
4. Terminate the power cable inside the main controller cabinet.

Figure 220: Installed flood light

15.11 Ground Resistance Test

Prior to final tightening of the lugs at generator and LVDP perform CE measurement test according to 1.5serie_WDI_allComp_Test EN204-1 and submit test results to compliance team.

Consult with GE project management for applicability.

- Perform ground resistance CE test from DTE to nacelle (where required by country electrical code). and
- Ensure that the Grounding Ring(s), Rods Installation and Soil Resistivity Test Verification form that meets the requirements of: GE1.all_xxHz_SPC_foundation inter _part IV of V.xxxEN.00DART DWG: 104W2406 has been fully completed prior to signing mechanical completion certificate and turning the WTG over to commissioning teams.

15.12 Verifying the Generator Alignment

If cables are not installed prior to generator alignment, ensure that the cables are protected from damage and falling objects.

After rotor installation is completed the installer will verify the alignment of the generator in accordance with the work instruction "1.5Serie_xxHz_WDI_generato_GenAlignment". Consult with GE to obtain coupler drawings applicable to every unit, which contain the alignment tolerances. Also, obtain alignment data forms from GE to record all required data.

After alignment is determined to be within tolerances, GE technical advisor will verify and sign form. For record purposes and future reference, GE will place the completed data alignment forms in the job book with other installation records.

16 Remaining Work

16.1 Operator's/Owner's Responsibility

The operator/owner of the Wind Turbine Generator System (WTGS) is responsible for the proper control of the access to the WTGS. This shall include, but not be limited to, proper signage and site security measures to address access to WTG and the surrounding area.

16.2 Checking the Ladder and the Fall Protection Equipment – as applicable

Immediately after the installation of a ladder section, the correct installation of the ladders and fall protection and/or back protection equipment must be checked by a qualified person.

1. Verify HACKA rail system is installed according to manufacturer instructions and has been inspected by certified party.
2. A copy of the inspection form will be placed in the job site book.
3. Original has to be added to the turbine documentation inside the turbine for future reference and inspections.
4. Verify that the inspection books for Hacka sliders and climbing harness are stored in the turbine documentation inside the turbine.

The check must be repeated after every repair.

Later test intervals must be adapted to the respective operational conditions. Intervals depend on the frequency of use, strain during use as well as frequency and gravity of the established tests. In case of guarantee claims, verification of regular checks must be produced.

If climb assist or elevator will be installed refer to manufacturer installation instructions.

16.3 Clearing the WTGS

After completion of all work, the entire WTGS must be cleared.

Danger!

Attention! Prior to completion of the work, check the WTGS – in particular the control cabinets!

Remove all loose parts, tools and materials from the WTGS – in particular from the control cabinets.

Tools and materials left behind in the control cabinets make work unsafe for the service technicians, when the WTGS is commissioned.

16.4 Voltage and Phase Rotation

Attention!

This entire section is critical to quality, to the safe operation of the turbine, and to personnel safety.

Refer to the GE Energization Process Flow Chart (request the latest version from GE).

GE personnel shall be notified of all energization activities per the pre-energization and energization plan and thereto. In accordance with GE EHS policy, no GE personnel shall be a witness to or be nearby when customer performs voltage and phase rotation checks

1. The Installation Inspection Procedure but specifically sections 6, 7, 8 of the IIP and initial punch list items deemed to be critical must be completed prior to performing voltage and rotation checks.
2. Verify phase rotation (to meet state/pole/site specific requirements) and record results in section 17 of the IIP.
3. Verify voltage check (to meet GE specification requirements) and record results in section 17 of the IIP.
4. Section 17 of the IIP, Voltage and Rotation Checks will not be considered complete unless both of the following are true after the checks have been done:
   - WTGS is de-energized (see definition of de-energized state)
   - CRITICAL TO SAFETY: All shields, panels, and doors of the ESS cabinets are completely closed and reinstalled. Verify door latches are working properly. Close all cabinet doors and ensure all "SAFETY SCREWS" are installed in both doors of the LVDP. "SAFETY SCREWS" must be torqued to as labeled BEFORE energizing the cabinet. If screws are missing, DO NOT ENERGIZE and contact GE representative for replacement.
5. If grid is available, proceed to section 17 of the IIP. In the event that GRID power is not available, Section 17 of IIP will be entered as a punch list item and will be closed after Grid Power is available per the requirements of Section 17 of the IIP and Site Energization Plan.

16.5 Mechanical Completion

Mechanical Completion shall be in accordance with the contract language.

16.6 Transport Fixtures

Consult with GE representative to establish the fixture return schedules.

Consult with GE representative for the disposition of parts, fixtures or other that are not returned. Unreturned parts must be discarded in accordance with GE Policy.

1. Down Tower Equipment (DTE)
2. Return small parts, tie-downs and transportation frames to the place of origin.
3. Tower: Return transportation frames, transport braces, tie-downs, small parts and tarpaulins to the place of origin.
4. Nacelle: Disassemble, band and palletize transportation frames and small parts, as required, and load them onto a transport vehicle. Return the feet or welded fixtures, small parts, and shaft cover to the place of origin.
5. Hub: Return small parts, tie-downs, straps and transportation frames to the place of origin.
6. Blades: Disassemble, band and palletize transportation frames and small parts, as required, and load them onto a transport vehicle. Return transportation frames, supports, small parts, tie-downs to the place of origin.

16.7 Loaned Tooling

Any additional loaned tools to the customer must be returned to GE as applicable.

- Loaned E-palms
- Loaned blade edge protectors
- Loaned DTE alignment templates
- Loaned battery chargers

Summary: Amended Application Appendix F (Wind Energy turbine Manufacturer Safety Manuals) Part 3 of 4 electronically filed by Teresa Orahood on behalf of Sally Bloomfield for Northwest Ohio Wind Energy, LLC