Installation Manual

BWC EXCEL 10 Wind Turbine and Guyed-Lattice Towers

Part # MANGL
Revision 6.5
November 2014

Bergey Windpower Co.
2200 Industrial Blvd.
Norman, OK 73069 USA
TEL: 405-364-4212
FAX: 405-364-2078
E-mail: sales@bergey.com
Web Site: www.bergey.com

Contents

Figures

Tables

I. Safety

This manual contains important information concerning the installation of your Bergey guyed-lattice (GL) tower. We strongly recommend that you read and familiarize yourself with its contents.

At several points in this manual, items of special interest or significant impact are highlighted by one of the following symbols:


DANGER: Hazard or unsafe practice that could cause personal injury or death.


WARNING: Hazard or unsafe practice which could cause product damage.

NOTE: Significant point of interest.

TOWER SAFETY NOTES
1. All persons not directly involved in the installation should stay clear of the area.
2. All persons on or near the tower should wear OSHA-approved hardhats.
3. Tower work should be done by trained personnel.
4. Tower should not be constructed near utility lines. **Injury or death may result.**
5. Climb the tower with proper safety equipment.
6. When working on the tower, use a safety harness and tool belt.
7. Never carry tools or parts in your hands while climbing the tower.
8. Keep the amount of work to be done on the tower to a minimum.
9. Never stand directly below someone who is working on the tower.
10. Never work on the tower if alone onsite.
11. Never climb tower unless alternator is shorted and blades are barely rotating.
12. Stay clear of the tower in the presence or possibility of severe weather of any kind.

TOP 10 REASONS FOR TOWER FAILURE
1. No inspection of tower at recommended intervals
2. Improper guy line tensioning
3. Improper torque on guy line grip clips
4. Improper anchor installation
5. Failure to use safety cables on turnbuckles
6. Construction of base pad above frost depth
7. Improper torque on tower connections
8. Improper height of installed guy lines
9. Stainless steel cotter pins not used
10. Improper installation in corrosive soil

II. Receiving, Handling and Identification

A. BWC Wind Turbine

BWC turbines are shipped in three pieces: two crates plus the tail boom as an unpackaged assembly. Additionally, the controller is shipped in its own box. The contents, weights and dimensions of these pieces are as follows:

1. Powerhead Skid: 1022 lbs., 53” x 74” x 36” (HxWxD)
   a. Mainframe/alternator assembly with tower adapter
   b. Spinner (nose cone)
   c. Tail Fin
   d. Blade, Spinner, Tail Fin attachment hardware

2. Blade Carton: 180 lbs, 16” x 131” x 14” (HxWxD)
   a. Three rotor blades

3. Tail Boom: 145 lbs, 13” x 114” x 24” (HxWxD)

4. Controller Skid: 240 lb, 20” x 48” x 40” (HxWxD)
(May be shipped separately, direct from manufacturer)

Upon delivery, the boxes and contents should be checked for parts and signs of damage. If any damage is found its extent should be noted as precisely as possible. Digital photographs can be helpful in verifying claims against the carrier. BWC should be notified as soon as possible so that the necessary replacement parts can be sent. When reporting a damaged or malfunctioning component of the system, include the item's part number. Do not dispose of damaged goods until they have been inspected by the carrier's claims department.

The blade box, electronics box and powerhead shipping pallet should be retained in storage in case component shipping is required at some later date.

B. Guyed-Lattice Tower Kit

The BWC Guyed-Lattice (GL) Tower Kit will include a number of 3 m (10 ft) welded tower sections, bundles of guy wire, bundles of anchor and grounding rods, and one or more boxes/pallets of hardware and miscellaneous materials. Specific packing lists are provided with each shipment. All major items should be properly inspected before delivery is accepted.

DANGER: The tower sections are heavy, approximately 250 lbs. each. Handling these sections by hand is not recommended because of the risk of back injury. If you must move sections by hand, always use at least four (4) people and make sure to do the actual lifting as much as possible with the legs, not the back. Wear work gloves to avoid injury from rough surfaces. The best way to move GL tower sections is with a forklift, tractor (with a front end loader), or crane.

C. Tower Wiring Kits

Most people choose to purchase a Tower Wiring Kit along with the Tower Kit. The Tower Wiring Kit consists of the down-tower armored cable, connectors and fasteners, a fused disconnect switch that mounts to the tower, and a surge arrestor. Specific packing lists are provided with each shipment. All major items should be properly inspected before delivery is accepted.

D. Packing Lists

Table 1: Tower Packing List

No.	Description	BOM Qty.						UM	PURPOSE
	XLG-	18	24	30	37	43	49		Tower Height (m)
		60	80	100	120	140	160		Tower Height (ft)
MANGL	MANUAL GL TWR INSTALL, EXCEL	1	1	1	1	1	1	EA	Installation Instructions
11500-1 GALV	TOWER SECTION GL18 STD GALV	4	6	8	10	12	14	EA	Middle tower sections
11500-2 GALV	TOWER SECTION GL18 BASE GALV	1	1	1	1	1	1	EA	Base tower section
11500-3 GALV	TOWER SECTION GL18 TOP GALV	1	1	1	1	1	1	EA	Top tower section
11500-8 G	PIER PIN GL TOWER 3/4" x 16-3/4"	1	1	1	1	1	1	EA	Anchor pin for tower base.
HMD001	ANCHOR ROD 1" x 10' OVAL EYE & NUT	3	3	3	3	3	3	EA	Main anchor rod
HND001	NUT 1"-8 A-563 HDG	3	3	3	3	3	3	EA	Clamp anchor plate to rod
11414 GALV	ANCHOR ROD CHANNEL GALV	3	3	3	3	3	3	EA	Anchor rod plate
11114 GALV	PLATE EQUALIZER GL18 GALV	6	6	6	6	6		EA	Turnbuckle attach plate on anchor rods
11573 GALV	PLATE EQUALIZER GL-160 GALV						6	EA	Turnbuckle attach plate on anchor rods
HB6002	BOLT 3/8”-16 x 1 HH,SS	3	3	3	3	3	3	EA	Attach winch to bottom tower section
HN6008	NUT 3/8”-16 HH NYLOCK SS	3	3	3	3	3	3	EA	Attach winch to bottom tower section
HW6003	WASHER 3/8” USS FLAT SS	6	6	6	6	6	6	EA	Attach winch to bottom tower section
HM0008	ROD GROUNDING 5/8” x 8’ COPPERCL	4	4	4	4	4	4	EA	Ground rod at each pad
HM0042	CLAMP GROUNDING DIRECT BURIAL	8	8	8	8	8	8	EA	Attach tower & anchor rods to grounding rod
CAB011	CABLE #2 BARE STRANDED COPPER	18	18	18	18	18	18	FT	Attach tower & anchor rods to grounding rod
HM2007	COTTER PIN 5/32" x 1-1/2" 316SS	3	3	3	3	3	3	EA	Exchange pins on guy shackles
HBB028	BOLT 3/4"-10 X 3-1/4”, A325 HDG	9	9	9	18	18	30	EA	Attach tower section(s) with guy tabs, guy plate to anchor rod on 160' (3).
HNB014	NUT 3/4"-10 PIN-LOCK,HDG	9	9	9	18	18	27	EA	Attach tower section(s) with guy tabs
HBB026	BOLT 3/4"-10 X 2-3/4" A325 HDG	39	57	75	84	102	111	EA	Attach tower sections without guy tabs
HBB024	BOLT 3/4"-10 X 2-1/2” A325 HDG	6	6	6	6	6	6	EA	Attach turbine to top tower section
HNB011	NUT 3/4"-10 A563-DH HEX HDG	48	66	84	93	111	120	EA	Attach tower sections without guy tabs, turbine & guy plate
HNB008	PAL NUT 3/4" HDG	48	66	84	93	111	120	EA	Attach tower sections without guy tabs, turbine & guy plate
HMA001	THIMBLE 5/8” HD			3	3	3	3	EA	Attach top guy cable to turnbuckle
HM9001	THIMBLE 9/16” HD	3	3					EA	Attach top guy cable to turnbuckle
HM6002	THIMBLE 3/8” HD	3	3	3	6	6	9	EA	Attach bottom and middle guy cable to turnbuckle
11507-8	GUY WIRE ASSY, 3/8’ x 55' TAB	3						EA	Bottom guy cable
11551-7	GUY WIRE ASSY, 1/2” x 75' 3/4" SHKL	3						EA	Top guy cable
11507-9	GUY WIRE ASSY, 3/8” x 70' TAB		3					EA	Bottom guy cable
11551-8	GUY WIRE ASSY, 1/2” x 103' 3/4" SHKL		3					EA	Top guy cable
11507-10	GUY WIRE ASSY, 3/8” x 95' TAB			3				EA	Bottom guy cable
11551-9	GUY WIRE ASSY, 5/8” x 132' 3/4" SHKL			3				EA	Top guy cable
11507-11	GUY WIRE ASSY, 3/8” x 90' TAB				3			EA	Bottom guy cable

No.	Description	BOM Qty.						UM	PURPOSE
	XLG-	18	24	30	37	43	49		Tower Height (m)
		60	80	100	120	140	160		Tower Height (ft)
11507-12	GUY WIRE ASSY, 3/8” x 140' TAB				3			EA	Middle guy cable
11551-10	GUY WIRE ASSY, 5/8” x 160' 3/4" SHKL				3			EA	Top guy cable
11507-13	GUY WIRE ASSY, 3/8” x 110' TAB					3		EA	Bottom guy cable
11507-7	GUY WIRE ASSY, 3/8” x 160' TAB					3		EA	Middle guy cable
11551-11	GUY WIRE ASSY, 5/8” x 190' 3/4" SHKL					3		EA	Top guy cable
11507-14	GUY WIRE ASSY, 3/8” x 125' TAB						3	EA	Bottom guy cable
11507-15	GUY WIRE ASSY, 3/8” x 150' TAB						3	EA	Lower middle guy cable
11507-16	GUY WIRE ASSY, 3/8” x 180' TAB						3	EA	Upper middle guy cable
11551-12	GUY WIRE ASSY, 5/8” x 215' 3/4" SHKL						3	EA	Top guy cable
HM6007	CLIP 3/8" DOUBLE GRIP	6	6	6	12	12	18	EA	Attach 3/8" guy cable to turnbuckle (2 per)
HM8005	CLIP 7/16” to 1/2" DOUBLE GRIP	9	9					EA	Attach 1/2" guy cable to turnbuckle (3 per)
HMA010	CLIP 9/16” to 5/8" DOUBLE GRIP			9	9	9	9	EA	Attach 5/8" guy cable to turnbuckle (3 per)
HN7003	PAL NUT 7/16" HDG	12	12	12	24	24	36	EA	For 3/8" double grip clips used on guy cables.
HN8005	PAL NUT 1/2" HDG	18	18					EA	For 1/2" double grip clips used on guy cables.
HNA004	PAL NUT 5/8" HDG	6	6	24	27	27	30	EA	For 5/8" double grip clips used on guy cables & turnbuckle eye to equalizer plate bolts
HMD007	TURNBUCKLE 1" x 12" EYE & EYE						3	EA	Between equalizer plate and top guy cable
HMC003	TURNBUCKLE 7/8" x 12" EYE & EYE	3	3	3	3	3		EA	Between equalizer plate and top guy cable
HMA011	TURNBUCKLE 5/8" x 12" EYE & EYE	3	3	3	3	3	6	EA	Between equalizer plate and second guy cable
HM8008	TURNBUCKLE 1/2" x 9" EYE & EYE				3	3	3	EA	Between equalizer plate and bottom guy cable
HBB025	BOLT 3/4"-10 x 3” A325	3	3	3	3	3		EA	Attach guy plate to anchor rod
HBA008	BOLT 5/8"-11 x 2-3/4" A325 HDG	6	6	6	9	9		EA	Attach turnbuckle eye to equalizer plate
HBA013	BOLT 5/8"-11 x 3" A325 HDG						12	EA	Attach turnbuckle eye to equalizer plate
HNA008	NUT 5/8"-11 HEX A563-DH HDG	6	6	6	9	9	12	EA	Attach turnbuckle eye to equalizer plate
HM4006	CLIP 1/4” MALLEABLE	6	6	6	6	6	6	EA	Safety Cable Clamps
AWR401	WIRE ROPE 1/4" x 6' GALV.	3	3	3	3	3		EA	Safety Cables
AWR402	WIRE ROPE 1/4" x 6' GALV.						3	EA	Safety Cables
11508-1	FURL CABLE ASSY, 3/16” x 60'	1						EA	Cable from turbine to furling winch
11508-2	FURL CABLE ASSY, 3/16” x 80'		1					EA	Cable from turbine to furling winch
11508-3	FURL CABLE ASSY, 3/16” x 100'			1				EA	Cable from turbine to furling winch
11508-4	FURL CABLE ASSY, 3/16” x 120'				1			EA	Cable from turbine to furling winch
11508-5	FURL CABLE ASSY, 3/16” x 140'					1		EA	Cable from turbine to furling winch
11508-6	FURL CABLE ASSY, 3/16” x 160'						1	EA	Cable from turbine to furling winch
HM3003	THIMBLE 3/16” SS	1	1	1	1	1	1	EA	Attach furl cable to turbine cable
HM3002-B	CLIP MALLEABLE 3/16" – SS	2	2	2	2	2	2	EA	Attach furl cable to turbine cable
SX0084	CRATE, TOWER HDWE	1	1	1	1	1	1	EA	Shipping crate

Table 2: Tower Wiring Kit

No.	Description	BOM Qty.						UM	PURPOSE
	XTWK-	18	24	30	37	43	49		Tower Height (m)
		60	80	100	120	140	160		Tower Height (ft)
AXA009	SWITCH DISCONNECT - 600V 60A	1	1	1	1	1	1	EA	Turbine Disconnect
AXA013	HUB FOR XL DISCONNECT SWITCH	1	1	1	1	1	1	EA	Turbine Disconnect
AFA016	FUSE FRS-R-45 (BUS)	3	3	3	3	3	3	EA	Turbine Disconnect
CAB006	CABLE ARMOR TYPE MC 3 x #6 AWG	60	80	100	120	140	160	FT	Tower Wiring
EC0152	CONNECTOR CRS-HINDS TMC285	2	2	2	2	2	2	EA	Turbine Disconnect
HNB002	LOCKNUT 3/4” ELECTRICAL	1	1	1	1	1	1	EA	Turbine Disconnect
HMB006	BUSHING 3/4” PLASTIC INSULATING	1	1	1	1	1	1	EA	Turbine Disconnect
HM0012	CABLE TIE 13-3/8" NYLON BLACK HD	50	50	50	50	50	50	EA	Tower Wiring
EC0153	GROUNDING BAR KIT, DISCONNECT	1	1	1	1	1	1	EA	Turbine Disconnect
HB4010	BOLT 1/4”-20 x 1” HH C/S G5 SS	4	4	4	4	4	4	EA	Attached disconnect to tower
HN4004	NUT NYLOC 1/4"-20 SS	4	4	4	4	4	4	EA	Attached disconnect to tower
HW4001	WASHER 1/4” x 5/8” OD SAE FLAT SS	8	8	8	8	8	8	EA	Attached disconnect to tower
ARR003	ARRESTOR LIGHTNING LA603	1	1	1	1	1	1	EA	Turbine Disconnect

III. Tower Foundation

A. Layout of Foundation

The basic foundation layout is shown below. The three guy radii do not need to have exactly the same length, but the variation between all guy radii on the tower should be kept within +/- 8 percent of the tower height.

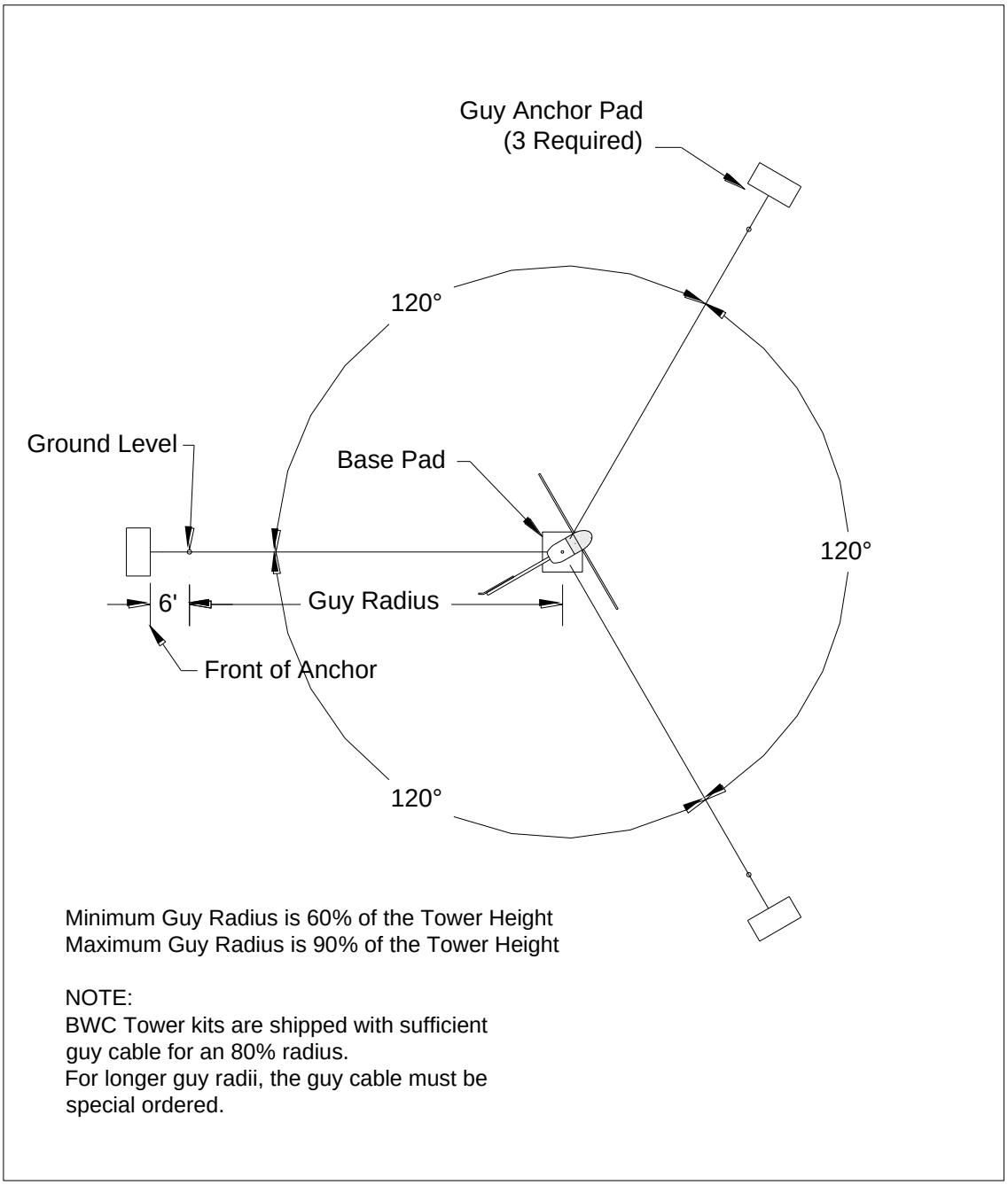


Figure 1: Tower Plan View

The nominal angular spacing for the anchor points is 120°, such that the anchors are equally spaced from one another. Variations are allowable up to ±10° of nominal. Likewise the elevations for the anchor points need not be the same. Variations of ±15 percent in the guy point elevations are allowable, but the nominal upper guy cable-tower angle should be maintained. Note that a downhill anchor location will require a much greater "along the ground" anchor distance to maintain this angle, while an uphill anchor requires less along-the-ground distance. **Figure 2** shows how terrain affects anchor placement and required guy cable length.

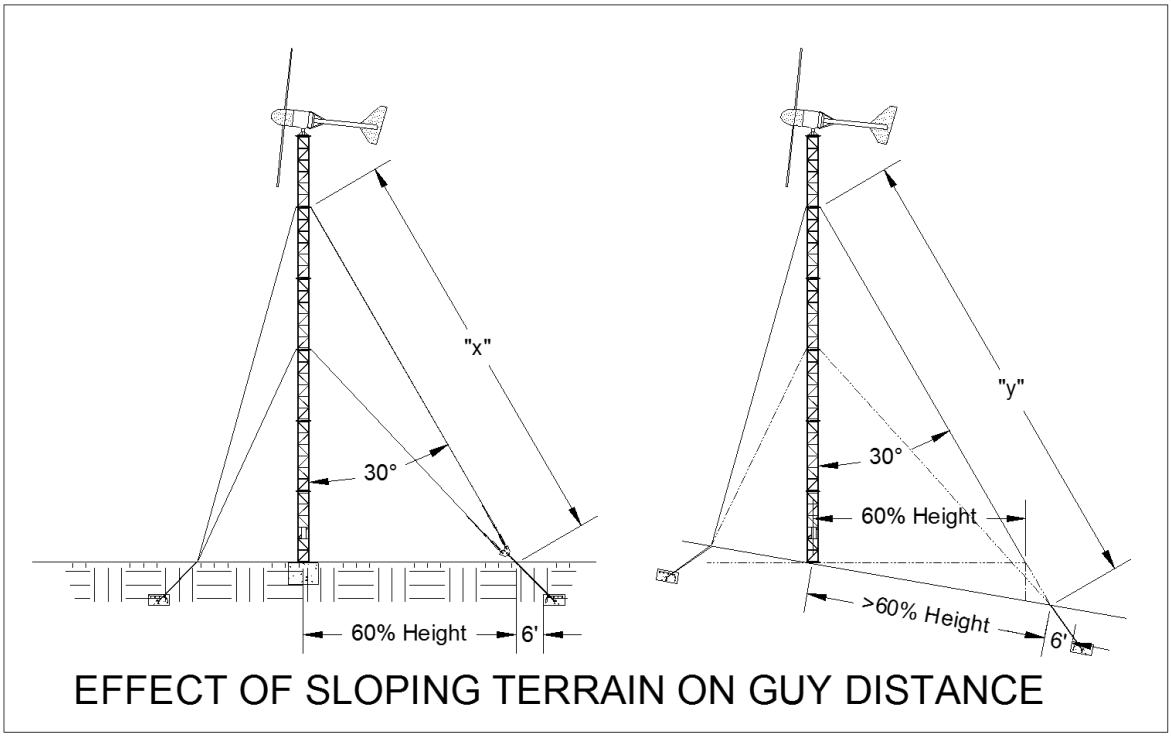


Figure 2: Effect of Sloping Terrain on Guy Cable Length

Table 3: Guy Radiuses

Tower Height (FT)	**60**	**80**	**100**	**120**	**140**	**160**
$GR_{(Min)}$ @ 60% (FT)	**36**	**48**	**60**	**72**	**84**	**96**
$GR_{(Max)}$ @ 80% (FT)	**48**	**64**	**80**	**96**	**112**	**128**

As shown in **Figure** 3**-B**, the anchor points define the corners of an equilateral triangle, with the tower base located exactly in the center. To eliminate the need to plot angles in laying out the tower foundations, **Figure** 3**-A** can be used to show measured coordinate lengths.

Using the ratios in **Figure** 3**-A**, the anchor points and base pad can be marked with a tape measure. Starting at the center point A, measure out a distance equal to GR (the guy radius) and stake it. This will be point B. Put another stake at point C by measuring a distance equal to one-half GR along the line connecting points A and B. Now estimate a

perpendicular line through point C to find and stake points D and E. Points D and E can be checked and adjusted by making sure that distances A-D and A-E are equal to GR. Make a final check by confirming that distances B-D, D-E and E-B are equal.

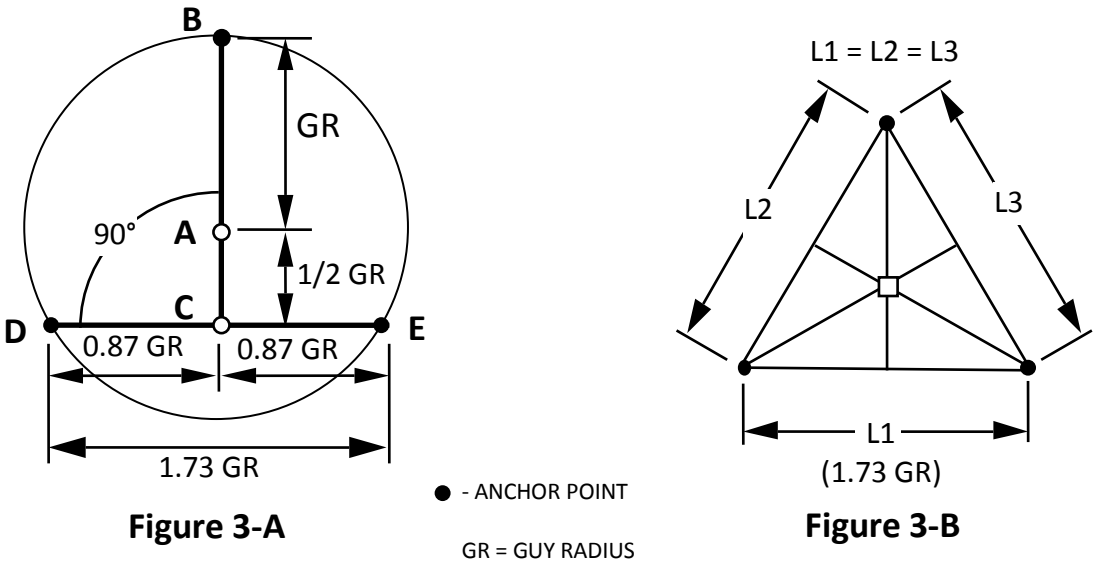


Figure 3-A **Figure 3-B**

Figure 3: Simple Method for Layout of GL Tower Anchors

B. Base Pad

The recommended base pad for most GL towers of 60-120 ft in height is shown in **Figure 4**. For towers of 140-160' in height the base pad may be larger due to the extra loading created by the large tower, depending on the type of soil present on site. Constructing this pad requires only simple forms and steel reinforcing bar. In areas where the freeze depth exceeds 18 in, the depth of the pad must be increased to reduce the likelihood of "frost heaving."

WARNING: The pad should extend down at least 6 in below the frost line.

The base pad hole should be excavated deep enough that approximately 6 in of sand can be placed in the hole prior to pouring the concrete. When finishing the pad surface, a 24 inch diameter circular area in the center of the pad should be finished flat and level, while the surrounding region may be sloped slightly to provide drainage.

NOTE: Insert the pier pin into the concrete of the pad before the concrete sets.

In areas with very deep frost, soil bearing strength may demand very large base pads, requiring many yards of concrete. In these situations, concrete volume may be decreased through the use of a pier-and-pad tower base foundation.

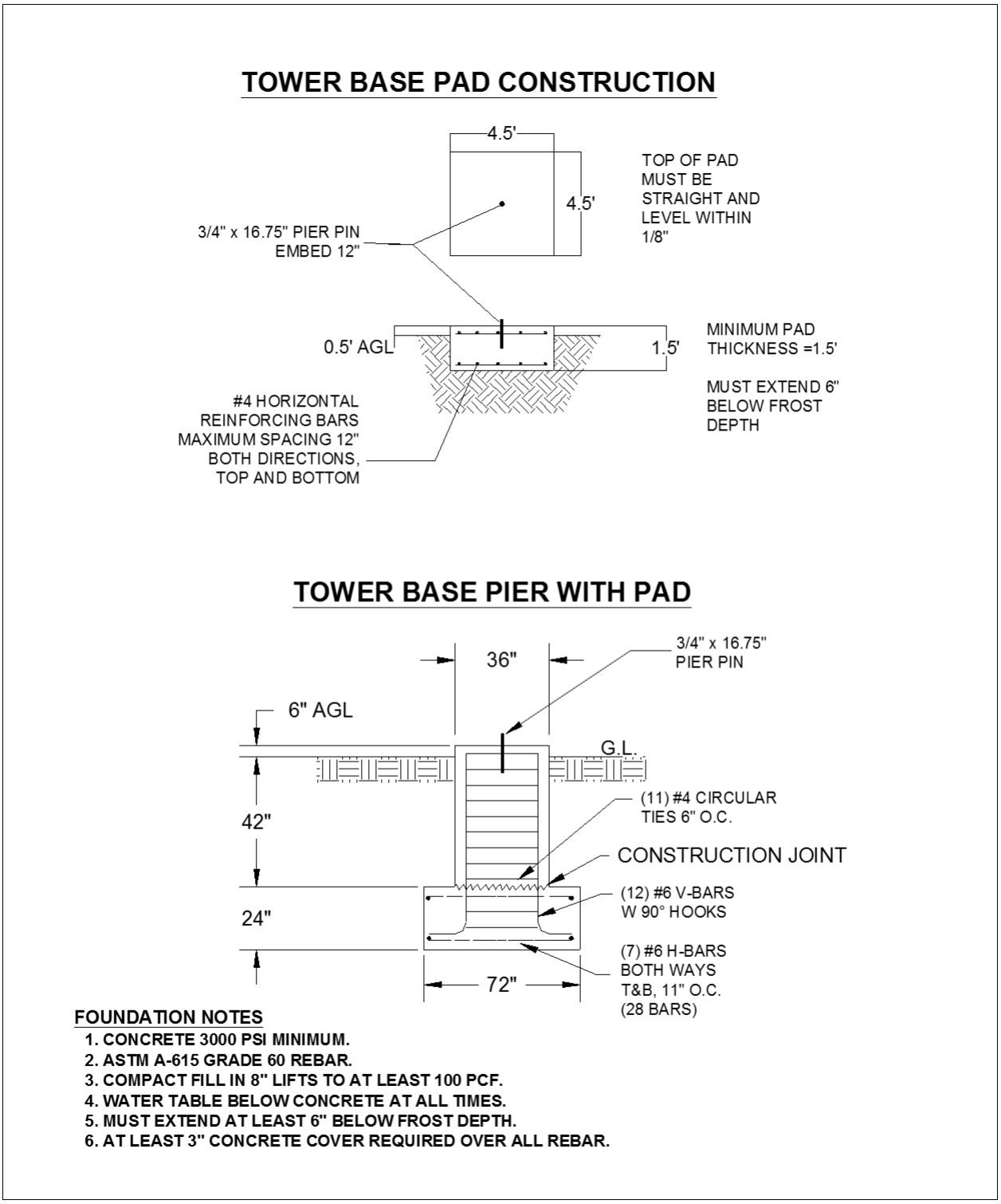
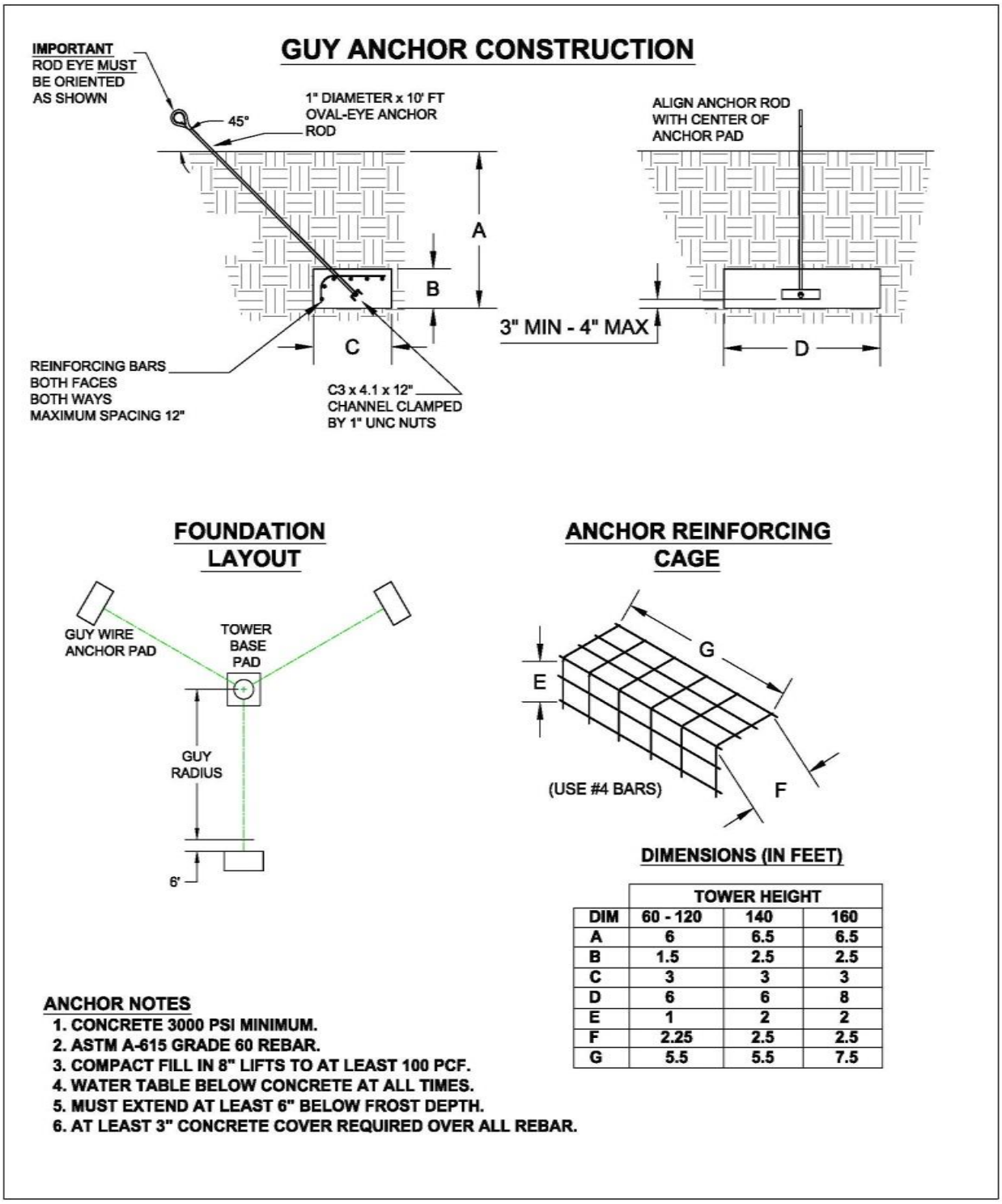


Figure 4: Typical Pad Dimensions



	TOWER HEIGHT		
DIM	60 - 120	140	160
A	6	6.5	6.5
B	1.5	2.5	2.5
C	3	3	3
D	6	6	8
E	1	2	2
F	2.25	2.5	2.5
G	5.5	5.5	7.5

Figure 5: Typical Guy Anchor Dimensions

C. Subsurface Guy Anchors

The generally recommended anchors for GL 60-160 towers are subsurface concrete "sleepers" as shown in **Figure 5**. If the soil strength is less than 2,000 pounds per square foot, however, a larger subsurface pad may be required. Note that the 140' & 160' towers require an excavated hole that is deeper than the standard excavation used for the shorter GL-towers.

Prepare anchor rods before excavating anchor holes. Clamp the anchor rod channel onto the threaded end of the 10 ft long anchor rod using two of the 1" nuts supplied.

WARNING: Coat the anchor rods with fiber reinforced roofing grade tar (where the anchor will be in the ground) to prevent galvanic corrosion. Allow the tar to cure before the rods are incorporated into the sleepers. Alternately, cover the anchor rods with conduit.

Dig a hole of appropriate size and depth, oriented perpendicular to the GR line. The **front edge** (towards the tower base) of the hole is the reference point for measuring the required anchor radius **(guy radius + 6 ft)**. This job is best done with a backhoe.

A narrow slot should be cut from the center of the long side of the hole, towards the base pad. The slot should extend from about 2' above the bottom of the hole out at a 45° angle from horizontal. This slot will be used for the anchor rod.

Prepare three reinforcing bar "cages". Suspend the cages so that an appropriate amount of clearance is provided. Pass the anchor rod eye through the rebar cage, and then place the cage and rod in the hole so that the rod sits in the slot and the plate is centered in the cage. Check the angle of the anchor rod and support it so that it rests at ~45° above horizontal (55° for 140-160 towers).

NOTE: Make sure the oval-eye at the end of the rod is positioned vertically so the equalizer plates will be vertically aligned when installed.

The concrete shall be placed in direct contact with undisturbed soil; using a vibrator to be sure it fills properly around the rebar and anchors.

WARNING: Do not use forms for concrete work below grade.

After the concrete has cured for at least two days, the hole can be backfilled. Make sure that the backfill is properly compacted.

Backfill each anchor hole in 8” layers, compacting each soil layer to a density of at least 100 pounds per cubic foot (pcf).

Other types of anchoring arrangements may be used for very soft soils or rock. Please consult the Engineering Department at Bergey Windpower for assistance in these situations.

IV. Tower Assembly

Upon arrival on site prepare the installation area for tower erection, following the general site layout shown in
Figure 6 (60-140' tower) or **Figure 7** (160' tower). Plan to lay the tower sections out in a line so that the lift point of the tower is roughly in line with the base pad. Plan for the crane to set up approximately 30'-35' from the base pad, in line with one of the anchors. The tower should be assembled between the crane and the base pad.

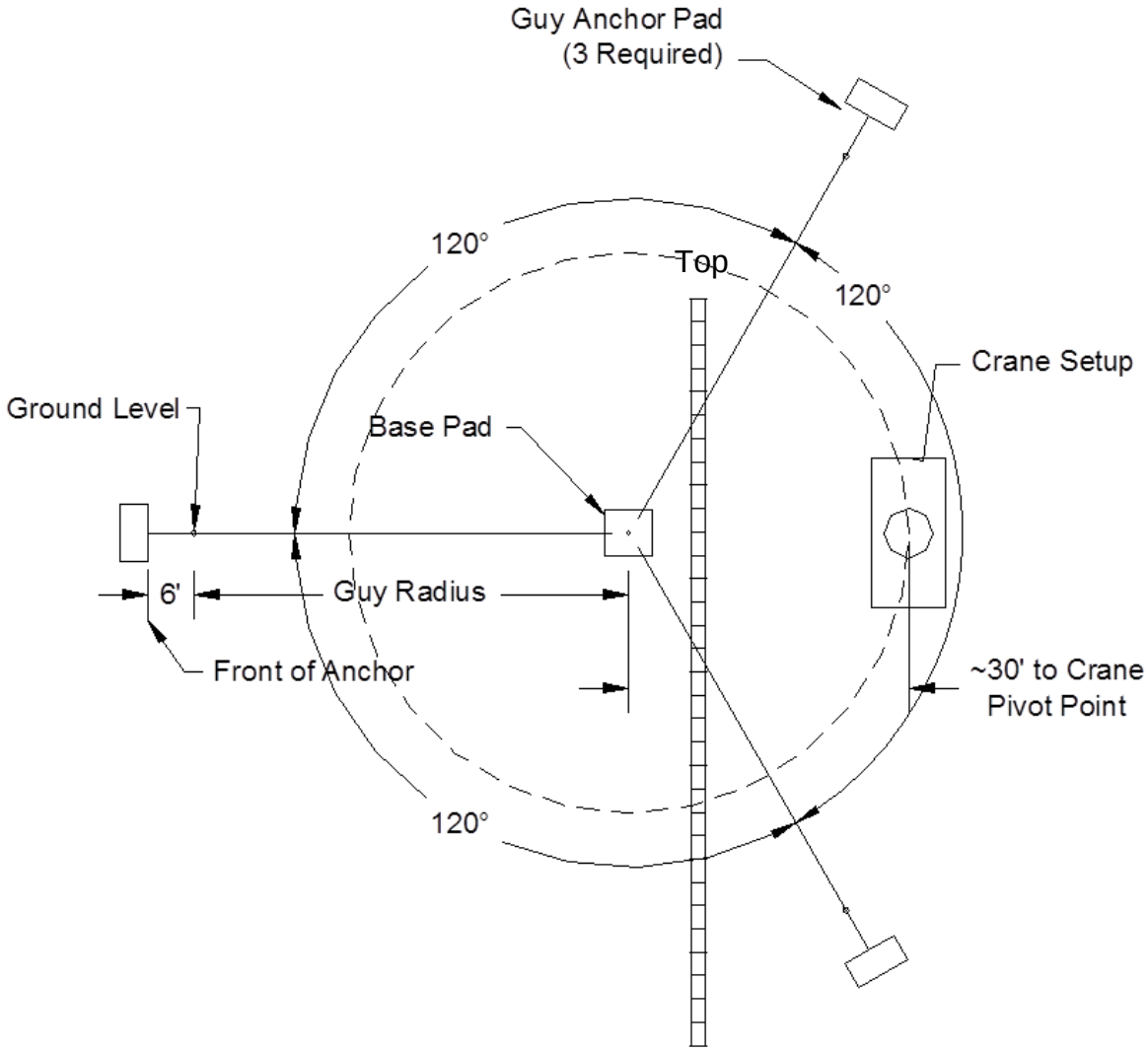


Figure 6: Construction Site Layout Plan View for 60'-140' towers

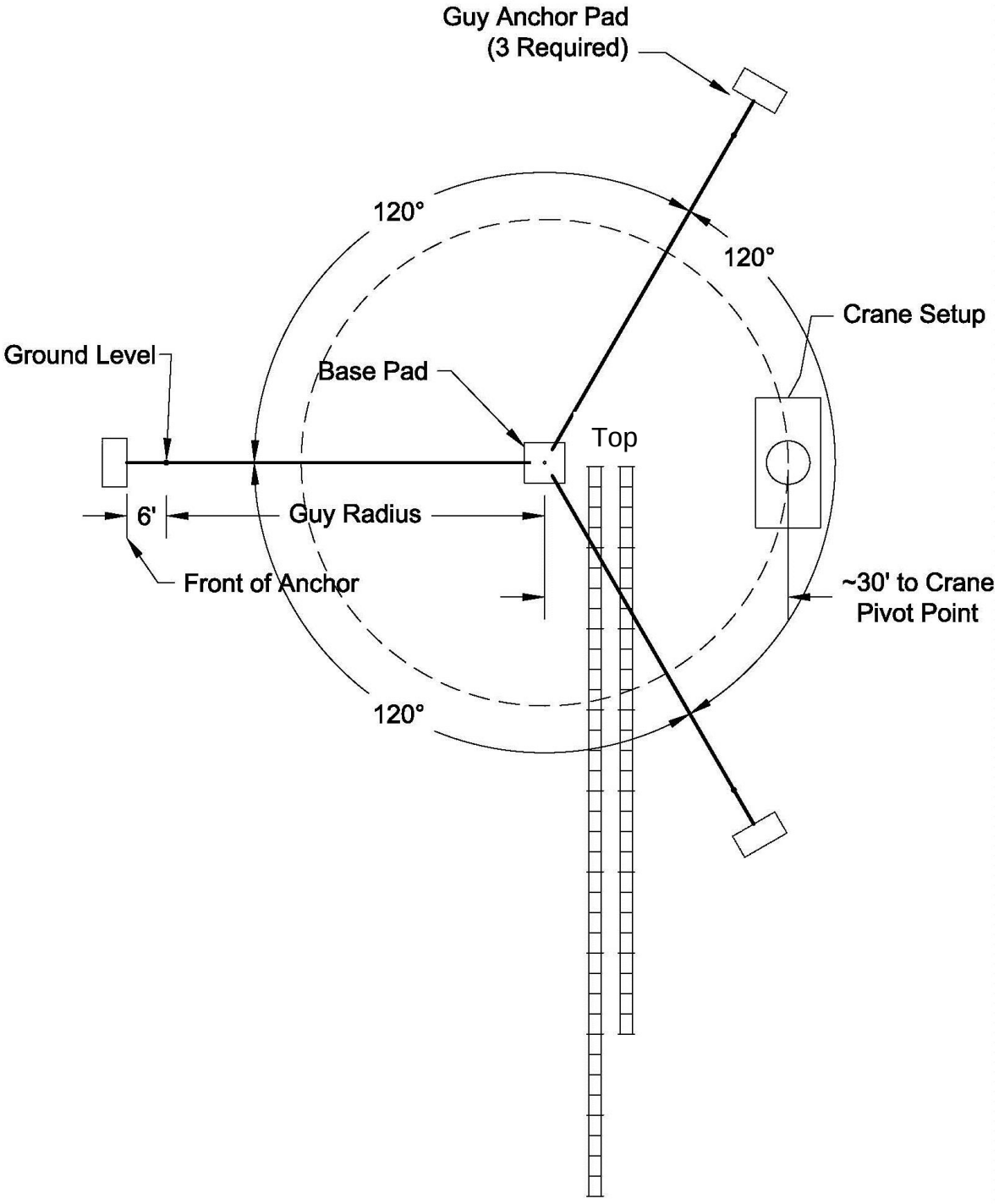
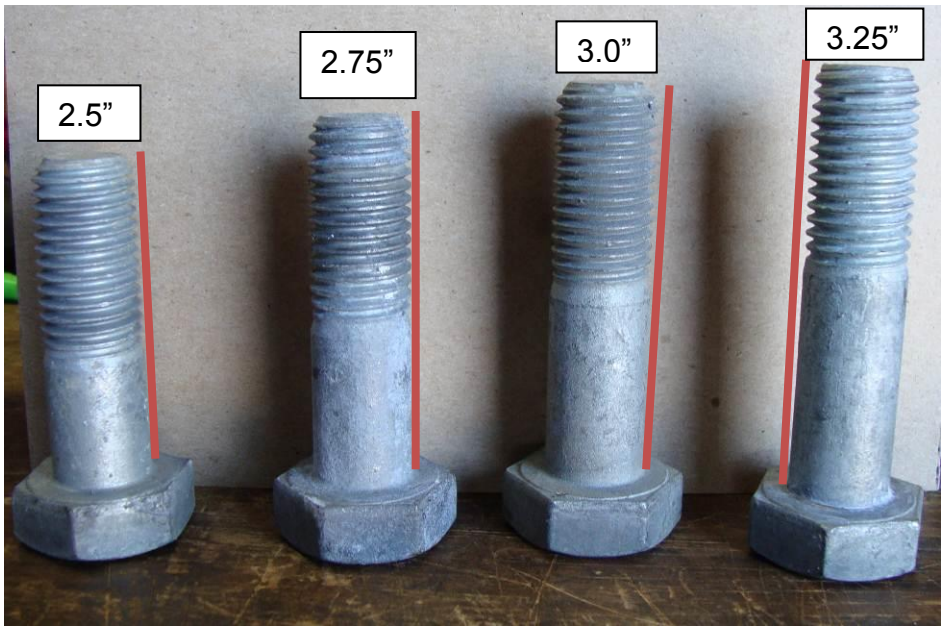


Figure 7: Construction Site Layout Plan View for 160' towers

For 60’-140’ towers, lay out the tower sections in a line so that the lift point of the tower is roughly lined up even with the base pad. *Orient the base section to allow easy access to the winch and disconnect attachment plates.*

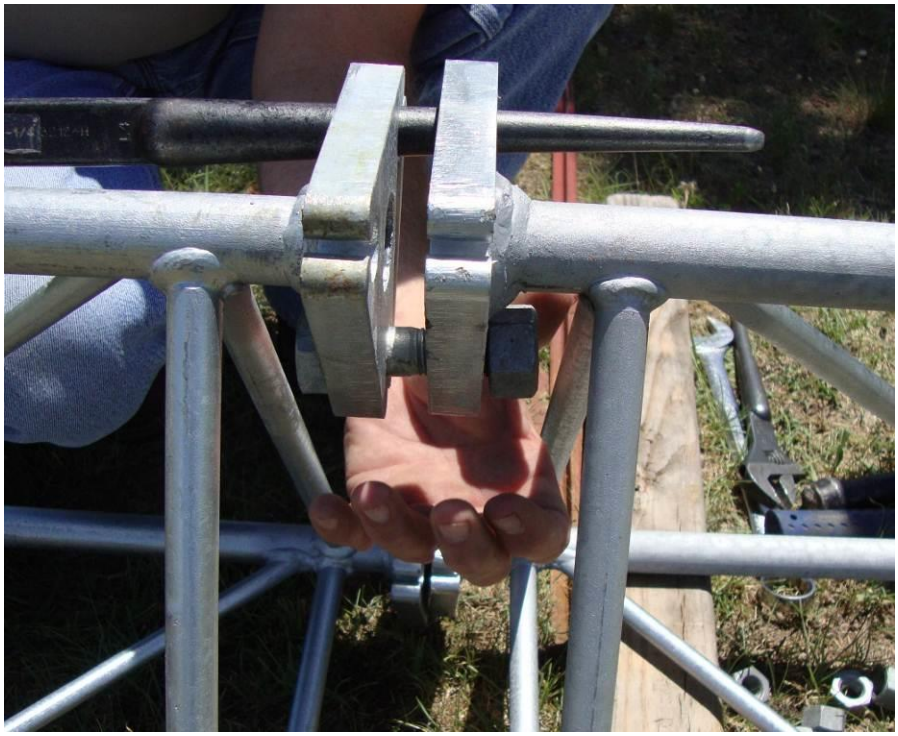
For 160’ towers, lay the sections out in two segments: a 90’ base segment and a 70’ top segment. Lay out the segments so that the lift points are nearest to the foundation, as in **Figure 7**.



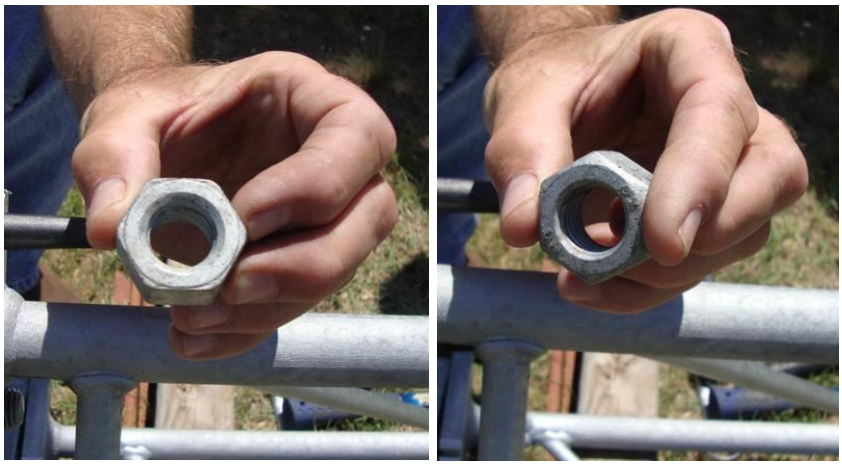
All sections are bolted together with nine (9) 3/4" bolts, three per leg. There are four different lengths of 3/4” bolts provided in the kit. Sort the bolts to separate the shorter and longer bolts.

Get proper tools ready. To make installation easier, you will want two spud wrenches, one 1-1/4" and one adjustable (for aligning holes and tightening bolts), a bullpin (to clean out excess zinc), a hammer, and a 1-1/4" box end wrench.

A spud wrench, 18" or longer, can be useful in aligning the flanges of the sections being bolted together. It is recommended to connect the bolts on the inside of the tower first. Use the 3/4"x2.75" bolts for standard connections. **The nut always goes on top of the connection.**



The nut should be applied with the flat side facing the connection (picture on the left). The writing on the nut should face away from the connection.



Notice from the pictures below there is a correct and incorrect orientation for the towers at the connection point. The picture on the left shows an incorrect connection alignment, where the lattice work is oriented the same direction on each side of the connection. In the picture on the right, you can see the proper alignment, where the lattice work is oriented in the opposite direction on each side of the connection. It should be noted that the orientation of each section is a cosmetic issue, and does not affect the tower's strength.

A. Assemble Tower and Guy Cable Systems

Figure 8 shows guy heights and minimum guy radii for GL18 towers 60-160 ft in height. Attach the guy tabs for lower and middle guy cables at the appropriate joint(s), per **Table** 4. When installing a guy tab, align the tower sections with enough room to fit the tab between sections.

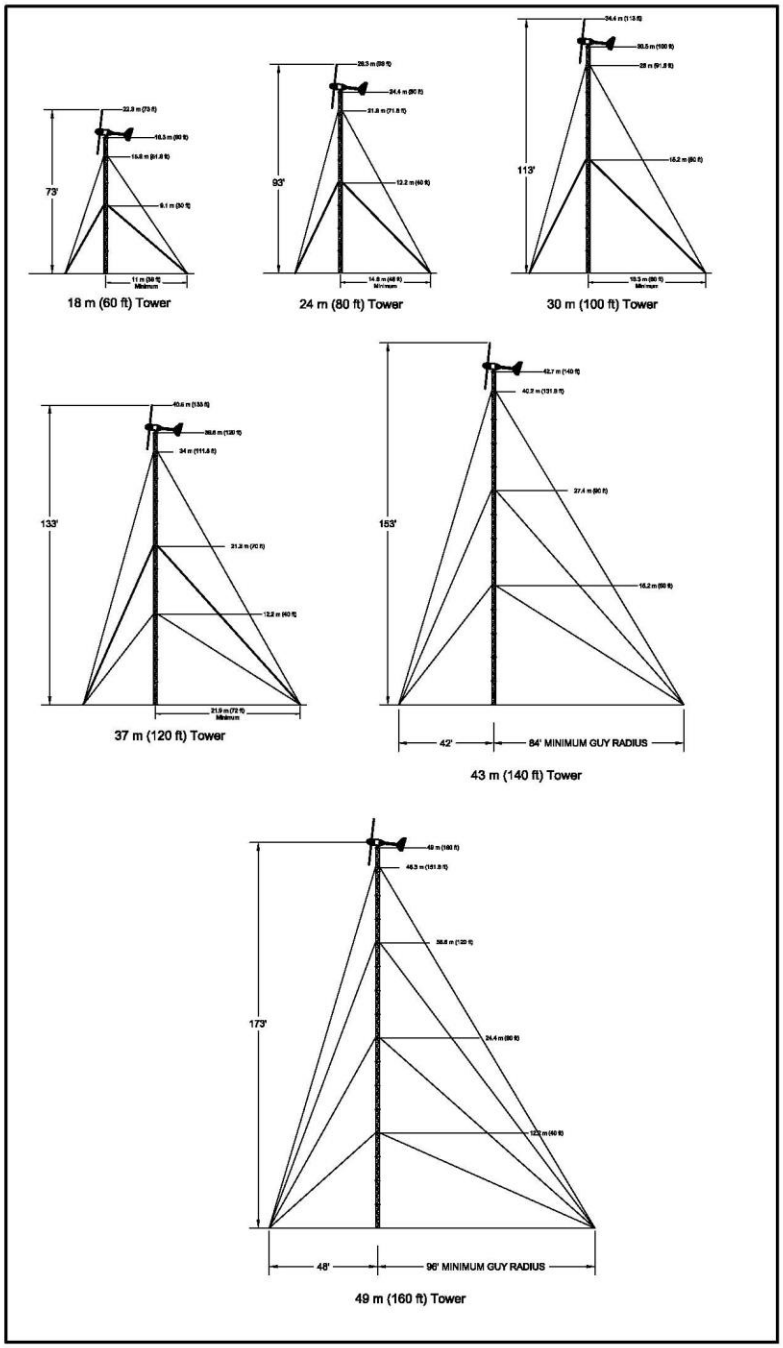
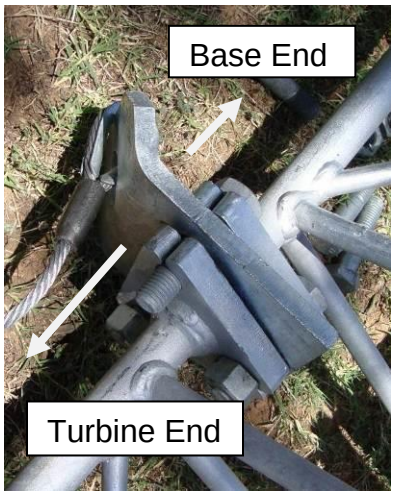


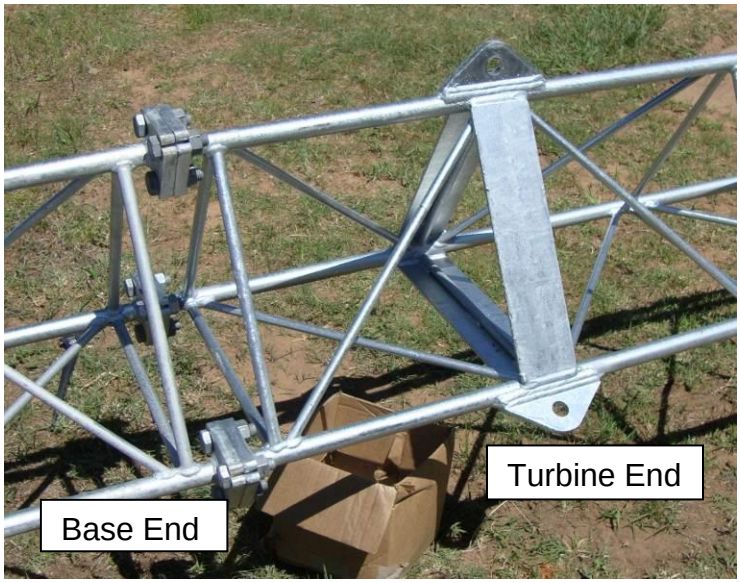
Figure 8: GL 60-160 FT Tower Configurations

Table 4: Guy Levels for 60'-160' GL towers

	60 ft	80 ft	100 ft	120 ft	140 ft	160 ft
Top	51.8 ft	71.8 ft	91.8 ft	111.8 ft	131.8 ft	151.8 ft
Upper Middle	-	-	-	70 ft	90 ft	110 ft
Lower Middle	-	-	-	-	-	80 ft
Bottom	30 ft	40 ft	50 ft	40 ft	50 ft	40 ft



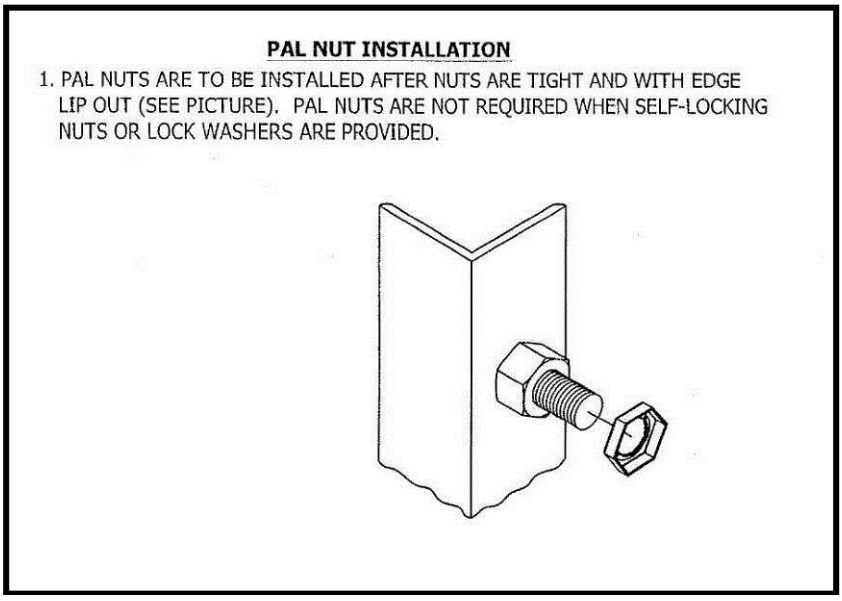
Joints that include guy tabs use 3/4” bolts that are 3.25” in length and heavy “Pin-Loc” locking nuts. A PAL nut is not required where a Pin-Loc nut is used.



When connecting the top section of the tower, the end with the braced guy tabs will be on the bottom.

1. Connect the upper guy cables to the braced guy tabs with the included hardware. Secure the cable with the included nut, and make sure to use the separately supplied stainless steel cotter pin to retain the nut.

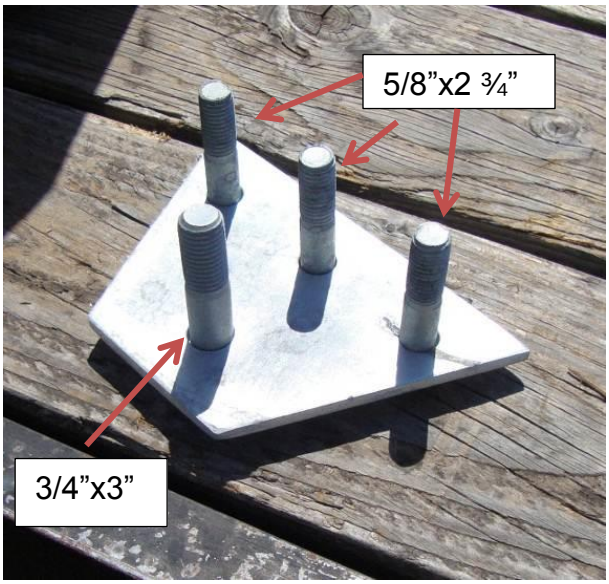
2. Once the tower has been put together, **use a torque wrench** on all connecting bolts. *The proper tightening torque on all section coupling fasteners is **205 ft-lbs**.*



3. Once the connections have been torqued, apply PAL nuts to the connections that do not have pin-loc nuts.

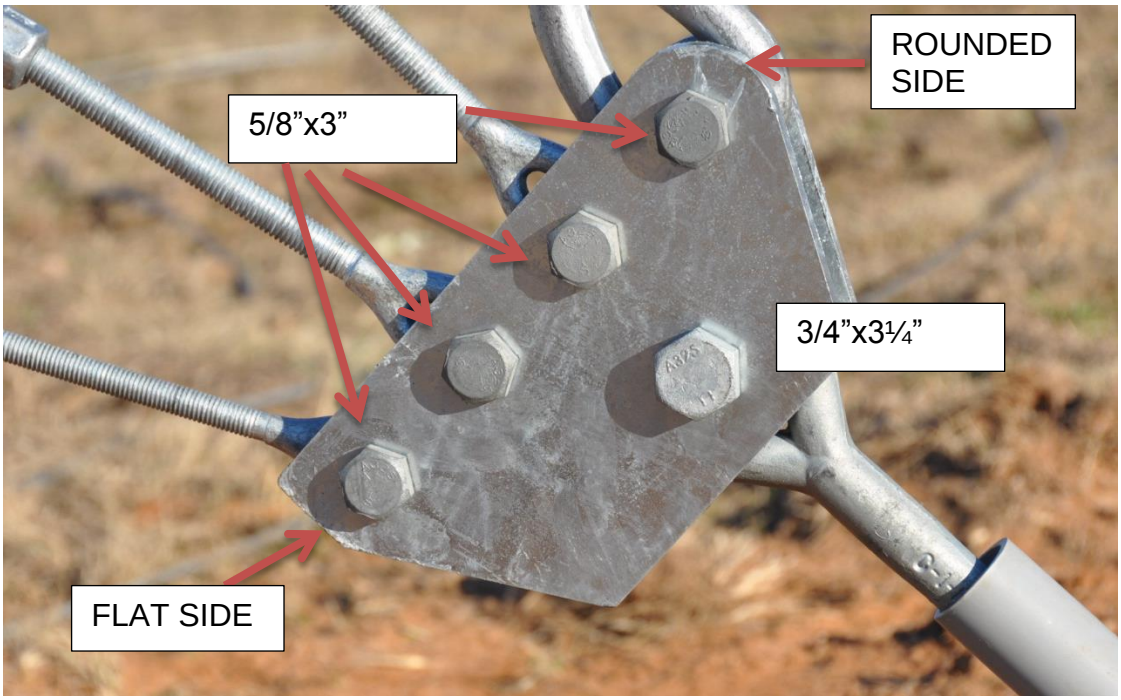
NOTE: When installing PAL nuts, make contact with the structural nut, then turn the nut to 1/4 turn past contact.

The equalizer plates and turnbuckles are the links between the guy wires and anchor rods. The equalizer plates reduce the bending moments applied to the anchor rod. The assembly procedure is as follows:



4. Assemble the 3-hole equalizer plates and turnbuckles, with the “eye” ends of the turnbuckles attached between the equalizer plates. The 3/4" turnbuckles always go in the top 5/8” bolt hole. On 60’ – 100’ towers, only

two guy levels are used so the middle 5/8” bolt hole on the equalizer plate is left empty. The 3/4” bolt hole connects to the anchor rod.



A larger equalizer plate is used for 160’ towers. This plate has a 4-hole configuration. When assembling the plate, remember that the flat side of the plate goes down, while the rounded side goes up, as illustrated in the previous picture.

The thimbles for the guy cables need to be opened up enough to connect to the eye of each turnbuckle. Opening the thimble can be done in one of two ways.

The bigger thimbles for the upper guy cables can most easily be opened by placing the thimble on the tower, resting one side of the thimble along a crossbar. Using a spud wrench, it is easy to pry open the thimble enough to insert the eye connection.

Once the eye has been slipped into the opened thimble, close the thimble. If you are having difficulties opening the thimble, it may be a good idea to secure the thimble to the tower crossbar with a locking wrench.

The smaller thimbles can be opened using two wrenches to pry them open. Simply place the eye in the opened thimble and pry it back to the closed position.

5. Tighten the 3/4" bolt that goes through the eye of the anchor rod until there is a 1/16" gap between the plates and the anchor rod. This allows the equalizer plates to rotate.

6. Tighten the 5/8" bolts for the turnbuckles to the point that the equalizer plates are parallel.

NOTE: Lock all hex nuts with PAL nuts.

7. Take a vise grip and crush the first threads of the bolt. Make sure the nut does not freely twist off the bolt.

8. Unroll the guy wire along the tower.

NOTE: Galvanized wire rope can easily become twisted and tangled if handled carelessly. It is recommended to uncoil the wire by rolling it along the ground.

B. Install Furling Cable and Winch

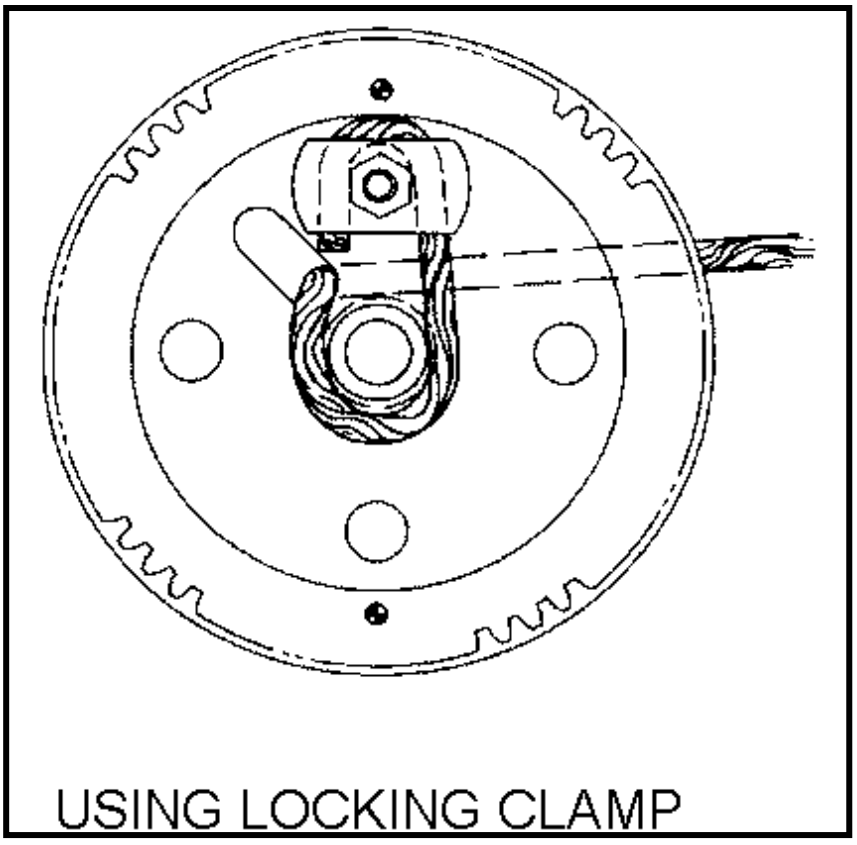
NOTE: When assembling the **160' tower**, you will not connect the furling cable to the winch until the tower has been erected. Secure the swivel at the top section of the top segment, and let the cable trail out of the bottom of the segment. The

cable will be run down the bottom segment of the tower when the two sections are joined.

1. Attach the winch, included on the turbine shipping skid, to the mounting plate welded into the base section above the second set of horizontals. Three 3/8" x 1" stainless steel bolts, with stainless steel washers and nylon lock nuts, are included in the tower hardware kit for this purpose. The winch will mount so the winch body is inside the tower but the winch handle is free to turn outside the tower.

2. Feed the furling cable/swivel assembly, swivel end first, through the tower starting from the base section. The swivel will later be connected to the turbine furling cable.

3. Attach the lower end of the furling cable to the winch by threading the cable through the long slot in the side of the cable drum and securing the cable end as shown:



C. Tower Wiring and Disconnect Switch Installation

1. Pull the armored electrical cable (or other customer-supplied electrical cable) through the center of the tower, starting from the base section. *Do not secure the cable with cable ties at this time.*

NOTE: For **160' towers**, feed the cable through the top segment only. Tie excess cable into a loop at the base of the segment. This will help you run the cable down the base segment of the tower when the two segments are joined.

NOTE: Do not use conduit for tower wiring unless internal strain relief is provided for the conductors.

2. Attach the disconnect switch to the matching plate welded between the second and third horizontals on the base section. Four 1/4" x 1" plated steel bolts, with washers and hex nuts, are provided in the tower wiring kit. Pre-drilled holes in the disconnect switch box match holes in the attachment plate. If a wiring kit was not purchased from BWC, the customer must supply the appropriate switch, and all hardware required to make mechanical and electrical connections. The switch box will need to be drilled to accommodate appropriate attachment bolts.

3. Attach the electrical hub to the top of the disconnect switch using the four screws provided with the hub. This is where the tower wiring cable will attach to the switch box.

NOTE: The tower is now ready for attachment of the EXCEL turbine at ground level. Crane rental cost can be minimized if all possible work is done before the crane arrives on-site.

If some of the steps above could not be accomplished, perhaps because of the tower position on the ground, they can be accomplished after the crane has raised the tower top to allow attachment of the turbine.

V. Wind Turbine Assembly and System Erection

For 60'-140' wind turbines, the recommended procedure for completing the tower installation is to attach the wind turbine to the tower, complete the tower wiring, attach the furling cable, and then raise the tower/turbine as a complete assembly.

Alternately, for 160' towers, the recommended procedure is to raise and secure the bottom segment of the tower, attach and secure the top segment of the tower, attach the wind turbine, make electrical connections and install the furling winch. This procedure will require the use of three individual lifts.

The installation procedure requires a light duty crane with a lifting capacity of at least 8,000 lbs. (4 tons) at a working height equal to or greater than the tower height. This section assumes that the optional BWC Tower Wiring Kit is purchased with the tower.

The recommended method is as follows:

1. Order a crane to arrive at the construction site. When ordering a crane, there are three things the crane company needs to be told:
    a. The lift weight of the tower (shown in Table 5).
    b. The working radius of the lift (measured from the pivot point of the crane to the base pin of the tower). This value shall be measured on site as the shortest distance to the base pin the crane pivot point can access. The ideal radius for tower installation is approximately 30' (shown in
    c. **Figure** 6).
    d. The tower height. The crane ordered must have a working height equal to or greater than the tower height.

Table 5: Section List and Lift Points for 60'-140' GL Towers

60 ft	80 ft	100 ft	120 ft	140 ft
Lift Weight 2900 lb	Lift Weight 3400 lb	Lift Weight 4000 lb	Lift Weight 4600 lb	Lift Weight 5150 lb
Lift between 45' and 48'	Lift between 60' and 68'	Lift between 75' and 80'	Lift between 90' and 100'	Lift between 110' and 120'
Use at least 60' Crane Height	Use at least 80' Crane Height	Use at least 100' Crane Height	Use at least 120' Crane Height	Use at least 140' Crane Height

NOTE: **160' towers** will go up in 3 lifts: a 90' bottom segment, 70' top segment, and the wind turbine. The two tower segments will be lifted from the top to help each segment hang vertically for ease of installation. The turbine will be raised on a lifting jig, as shown in the Appendix.

NOTE: The head of the crane boom should never get higher than the top guy level. Rotor blade damage can occur if this boom height is exceeded!

A. Assemble and Attach the Tail Boom and Fin

1. Shortly before the crane is scheduled to arrive, attach the tail fin to the tail boom using the hardware provided in the Tail Assembly Hardware Kit. Lay the tail boom on a work surface with the fin mounting plate upward. Position the tail fin on the mounting plate, with the trailing edge bend upward. Eight bolts (3/8”-16 x 1”), 16 flat washers and 8 nylon lock nuts are used. Recommended torque is **20 ft-lb**. Set the tail assembly aside for later use.

WARNING: Anti-seize MUST be used on all stainless steel fasteners.

P/N	TAIL ASSEMBLY HDWR KIT 10kW	Qty
HM5006	CLEVIS PIN 5/16" x 1" SS	2
HM2005	COTTER PIN 1/8x3/4" SS	2
HB6002	BOLT 3/8-16x1 HH,SS	8
HW6004	WASHER 3/8 SAE FLAT SS 13/16OD	16
HN6008	NUT 3/8-16 HH NYLOCK SS	8
HBM106	BOLT M10-1.5x65MM HHCS SS	1
HNM101	NUT M10-1.5 NYLOC SS	1
HM0040	ANTISEIZE COMPOUND - 2mL	1

2. Position the crane so it will be **DOWNWIND** of the tower during the lift. (The tail will orient toward the crane boom, keeping the rotor blades away from the cable.) The boom should lean outward to make initial contact with the tower lifting point; boom movement must then be TOWARD the crane's center of gravity as the lift and tower placement occurs. (During the lift, the base of the tower will skid across the ground as it moves toward the foundation.)

3. Have the crane attach its lifting cable to the tower at a point in accordance with **Table 5**. The rigging can be done with either a strap or a sling, but it should be routed to catch two legs of the tower. The rigging point is well below the top of the tower so that the crane boom will not catch the blades during erection.

DANGER: Never use an open hook when rigging the lifting cable and always ensure that all cables and slings are in good condition prior to use.

DANGER: Do not operate the crane in any way that will introduce a bounce to the tower structure. This will create excessive loading, and may fail the tower.

4. Lift the tower until the top is chest high; support it with a scaffold, jack stands or a strong, stable stack of timbers. The support structure should be located between the flange at bottom of the top tower section and the top guy bracket. After the tower is SECURELY supported, remove the crane line.

5. Use the crane to lift the powerhead, still attached to the shipping skid, clear of the ground using a double-eye nylon strap. Slip one eye over each end of the tail pivot pin and onto the mainframe; hook the crane line to the center of the strap and lift. The shipping nuts can now be removed from the blade studs so the skid can be pulled off and set aside.

6. Direct the crane to move the powerhead until the tower adapter plate meets the tower top plate.

NOTE: Be sure to rotate the tower adapter plate so the large holes for the electrical cables align properly with the hole in the tower. Be careful to avoid damaging the turbine furling cable. Newer top sections have a single 10.5” hole so alignment is not required.

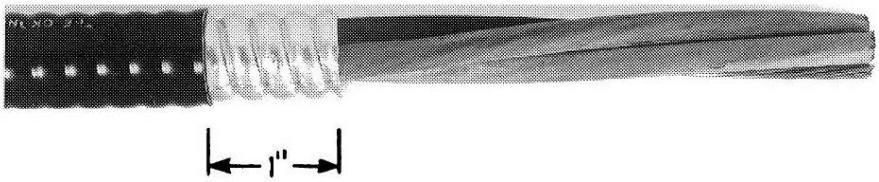
7. Feed the furling cable through the large center hole of the tower top plate, then use one or two spud wrenches to line up the six attachment holes on the two plates.

Bolt the turbine in place using 6 bolts, 3/4" x 2-1/2", with hex nuts and PAL nuts. Remember - **nuts go on top!** This hardware is included in the tower hardware kit. Torque the hex nuts to **205 ft-lb**. PAL nuts are tightened to 1/4 turn past contact. Disconnect the turbine from the crane after the turbine is bolted securely in place.

B. Complete Turbine & Tower Wiring Connections

Make electrical connections to the turbine as follows:

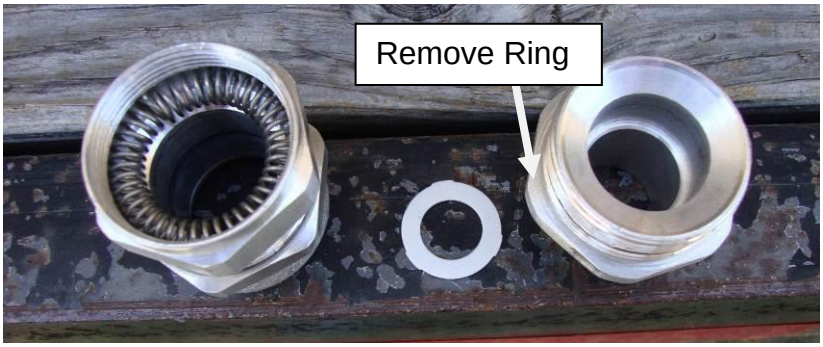
1. Remove the stainless steel cover of the terminal block housing.



a. Strip the tower top end of the armored cable as shown in **Figure 17**, being very careful not to cut the insulation on the three conductors. A special tool may be purchased for this task at most electrical supply distributors.

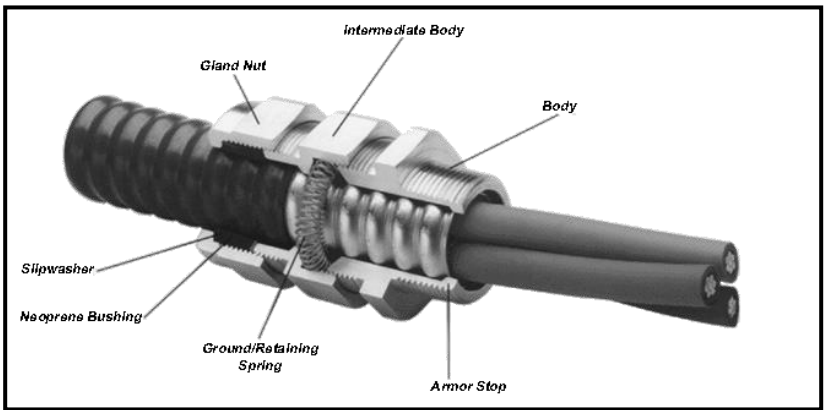
NOTE: Leave at least 8" of conductor exposed beyond the armor.

NOTE: Cut off grounding wire at both ends of the cable. It is not needed for this installation.

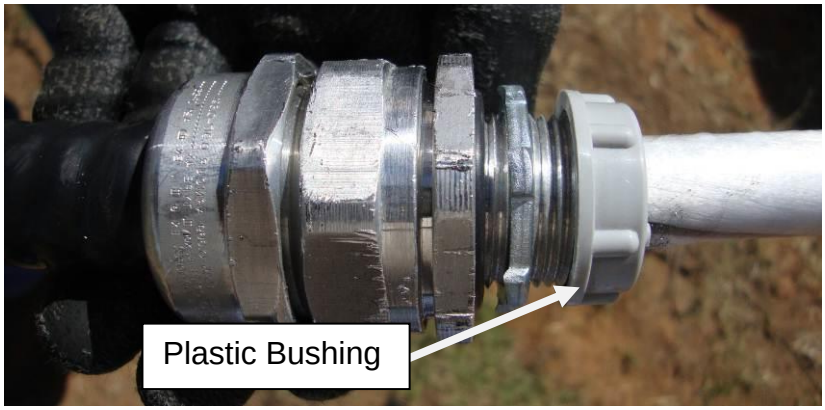


b. It is best to install the connector on the cable before installing the assembly into the junction box. Disassemble the fitting, and remove the plastic ring. Reassemble the fitting.

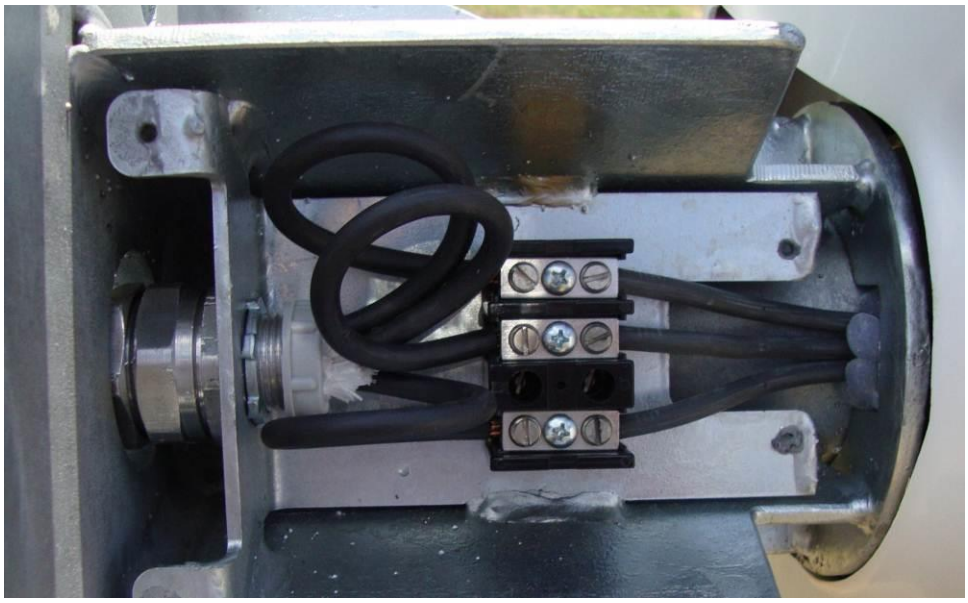
c. Insert the prepared cable into the fitting until the armor rests against the armor stop. Tighten both the intermediate body and the nut to **42 ft-lb**. Insert the fitting, through the large off-center hole in the tower top plate, into the bottom of the terminal block area. Add the electrical locknut and tighten securely. Install the plastic bushing. The bushing is required to avoid chafing and, eventually, short circuits in the tower wiring.



NOTE: The metallic armor must not go beyond the armor stop.



d. Trim each of the conductors to a length that will allow formation of full 360º strain relief loops to each terminal connection. Strip each of the three conductor wires back 3/4" (2 cm), apply anti-oxidation compound to the bare copper and make connections to the terminal block. All three wires are equivalent; there is no polarity or required phase rotation.



e. Perform tests for continuity, ground faults, etc. Correct any problems.

f. Replace the terminal block cover.

2. Form a gentle S-bend in armored cable so that it rests along one of the tower legs that is close to the disconnect switch.

3. Starting from a point 4 ft below the tower top, use plastic zip ties every 4 ft to secure the cable to the tower leg. Shape the cables around flanges to avoid chafing; use a zip tie immediately above and below each flange joint. Continue this process until the cable has been shaped around the lowest flange joint.

4. Prepare the lower end of the armored cable as shown for the connection to the turbine, leaving enough free conductor to make the electrical connections in the disconnect box, and connect tower wiring to the disconnect switch. The armored cable connector screws into the hub; an insulating grommet is not required.

5. A 3-phase surge arrestor such as a Delta LA-603 (included in the tower wiring kit) should be connected to the system at this time. The three wires of the arrestor should be connected to the lower (load) set of switch box terminals, along with the tower wiring conductors. There is no polarity or required phase rotation in these connections; all three wires are equal. Ground the arrestor.

6. Install jumpers between the three lower (load) terminals on the switch box to provide a short circuit, as later described in **Special Topics**. Put the switch in the "ON" position, effectively short-circuiting the tower wiring and alternator.

WARNING: Do not leave the alternator shorted for an extended period of time. Doing so may cause damage to the turbine, and void the warranty.

7. Connect the furling cable swivel assembly to the free end of the EXCEL furling cable, using the 3/16" thimble and malleable clips included in the tower hardware kit. Hold tension on the cable while taking up most of the slack with the winch. Leave several feet of slack in the cable until the tail boom is connected to the turbine.

C. Attach Tail Boom to Turbine

Attach the tail boom to the powerhead. This is a job that requires at least three people. The best approach is to use the crane to lift and position the tail boom.

1. Remove the retaining bolt and washer from one end of the tail pivot pin, which is shipped in the turbine pallet.

2. Work the pin part of the way in to the tail boom. It should move easily, but a spud wrench and hammer can be used if necessary. The pivot pin must not protrude into the space between the bronze tail pivot bushings.

3. Get the tail boom orientation correct by making sure that the furling cable and damper attachment brackets on the tail boom are aligned with the damper and furling cable on the powerhead. The fin will be on TOP.

4. Hold the tail boom in a position so the end with the fin is angled up ~ 15˚ and align the tail bushings with those of the powerhead, then insert the tail pivot pin as shown in **Figure 9**. The pin may need tapping through, but keep in mind that the stainless steel pin can be damaged if it is handled incorrectly. Use a block of wood or rubber mallet on the pin.

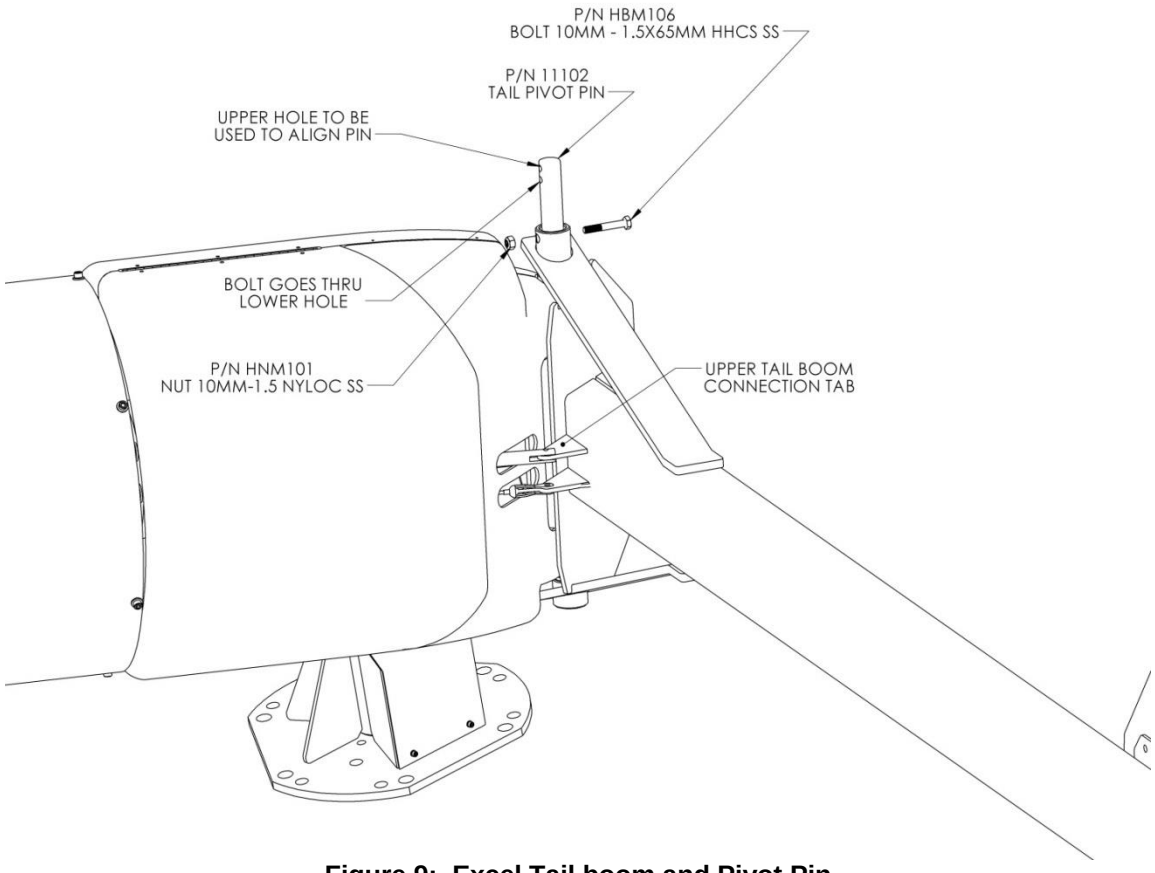


Figure 9: Excel Tail boom and Pivot Pin

WARNING: Anti-seize MUST be used on all stainless steel fasteners.

5. After the pin is in place, install the M10 retaining bolt and Nylock nut. Recommended torque is **20 ft-lb**.

6. Release the tail boom and allow it to swing down (about 45º). It may be necessary to put cardboard on the ground to avoid scraping the paint on the fin. (A piece of 2x4 or a pipe inserted into the end of the tail boom will also work to keep the fin off the ground).

7. Make sure the fork on the damper strut is centered on the "upper" tail boom connection tab. Adjust the tail boom tab by slightly bending if necessary (this should not be required unless the turbine is damaged in shipping). Attach the damper strut and furling cable to the tail boom using clevis pins and cotter pins provided in Tail Assembly Hardware Kit HK0002. If there appears to be a clearance issue between the damper and the nacelle, it is permissible to file the nacelle to create proper clearance.

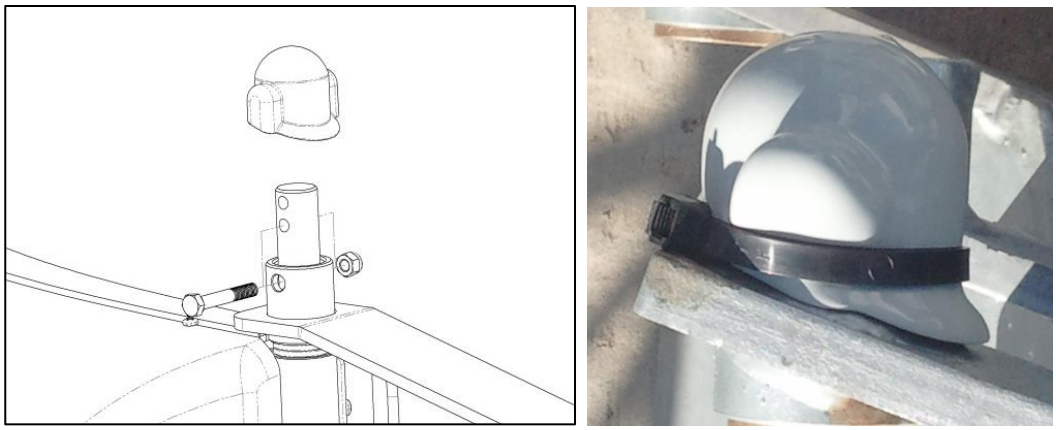


Figure 10: Tail Pivot Pin Cap

8. Place the tail pivot pin cap (P/N 11285) on the pivot pin and use a zip tie (P/N HM0012) to secure it in place, as shown in **Figure 10**.

D. Install Turbine Blades and Spinner

1. Attach the crane lifting line at the final lifting position, as specified in **Table 5**. Use two equal length chokers attached to the top leg and one other leg. **TWO LEGS MUST SHARE THE LIFTING LOAD!**

DANGER: Never use an open hook when rigging this lift, and assure that all cables and slings are in good condition. Each sling should be rated individually for the lift weight.

2. Raise the tower top to a height of approximately 2.5 m (8 ft), then insert a length of 2” x 4” lumber into the open end of the tail boom, allowing it to protrude about 18-36” to prop up the end of the tail boom and keep the fin off the ground. The powerhead will hang down to allow turbine blades to be set in place on the alternator.

3. Attach the three blades to the powerhead as shown in **Figure 11**, with the hardware provided in the Blade and Spinner Hardware Kit (HK0003).

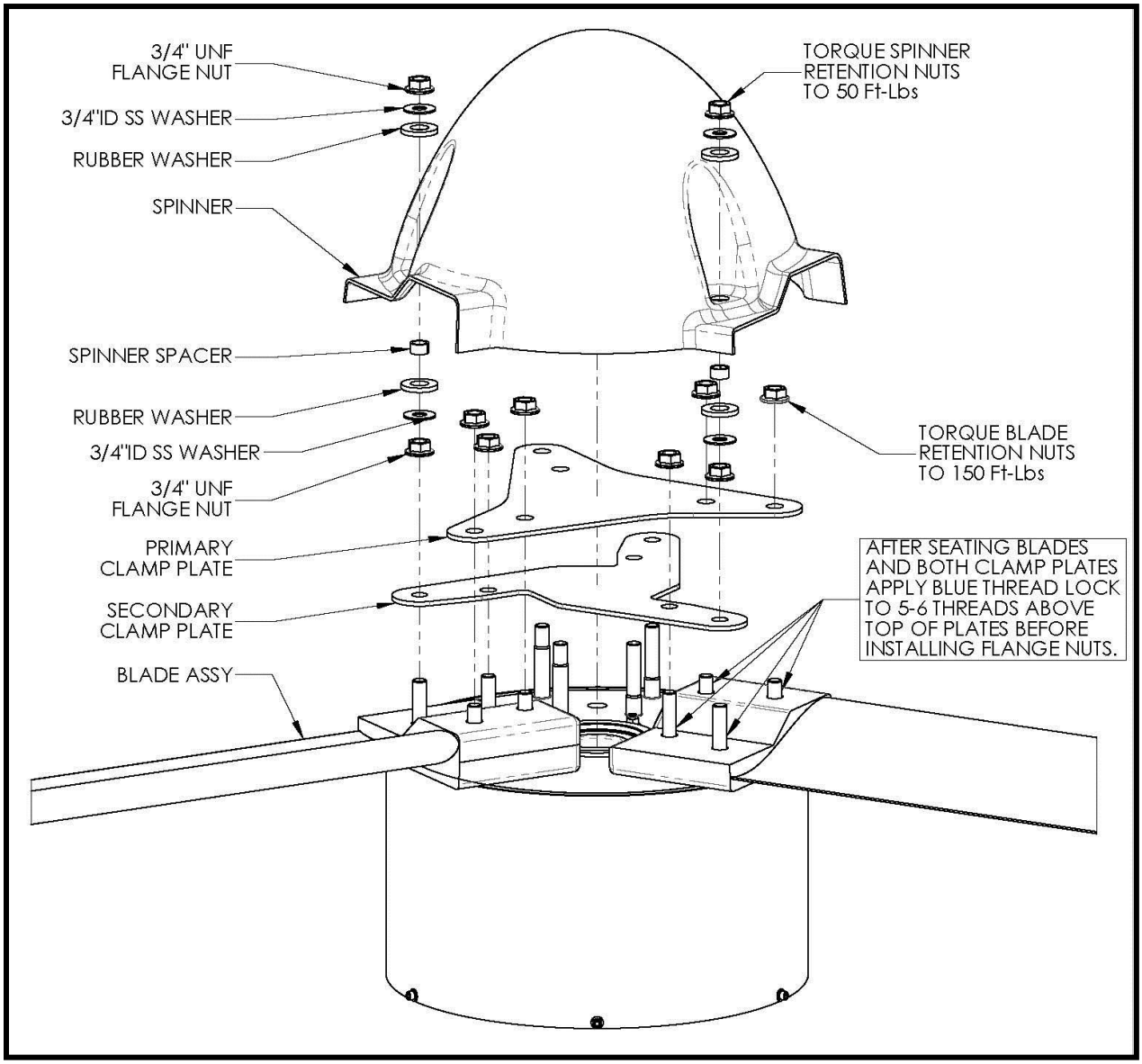


Figure 11: EXCEL Blade, Clamp Plate and Spinner Attachment

Table 6: Contents of Blade & Spinner Hardware Kit

P/N	BLADE HARDWARE KIT	Qty
HNB016PLT	NUT EXCEL BLADE 3/4"X16 PLATED	12
SF0064	THREAD LOCK - BLUE - 2mL	1

	SPINNER HARDWARE KIT	
HNB016PLT	NUT EXCEL BLADE 3/4"X16 PLATED	3
HWB008	WASHER 3/4" x 1.75"OD FLAT, SS	6
11306	WASHER, SILICON 2"OD RED	6
11305	SPACER SPINNER,SPLIT SEAM 1"OD	3

4. A 1-1/8” deep socket and **torque wrench will be required**. Follow the sequence of steps below. Note that at least two workers are needed.

WARNING: **DO NOT USE** anti-seize compound on the blades studs or blade nuts. Doing so will cause the nuts to loosen over time and cause damage to the turbine, and void the warranty.
DO USE blue thread lock to prevent loosening of the nuts.

a. Rotate the alternator until one of the blades can be held horizontal by two workers and set onto the four mounting studs in the alternator. Push the blade onto the studs; it will stay in place on the studs, but the outboard end will need to be supported. **Make sure the blade is properly seated**. Install two flanged Spiralock nut on the studs in the **thick** section of the root pad, and finger tighten. **Leave the thin section unfastened until later**.

b. Rotate the alternator so another blade can be set in place. Be careful to avoid damaging the first blade; a third worker may be needed to hold the tip of the first blade off the ground. Hold the blade in place with Spiralock nuts on the thick root pad section. Repeat this process for the third blade.

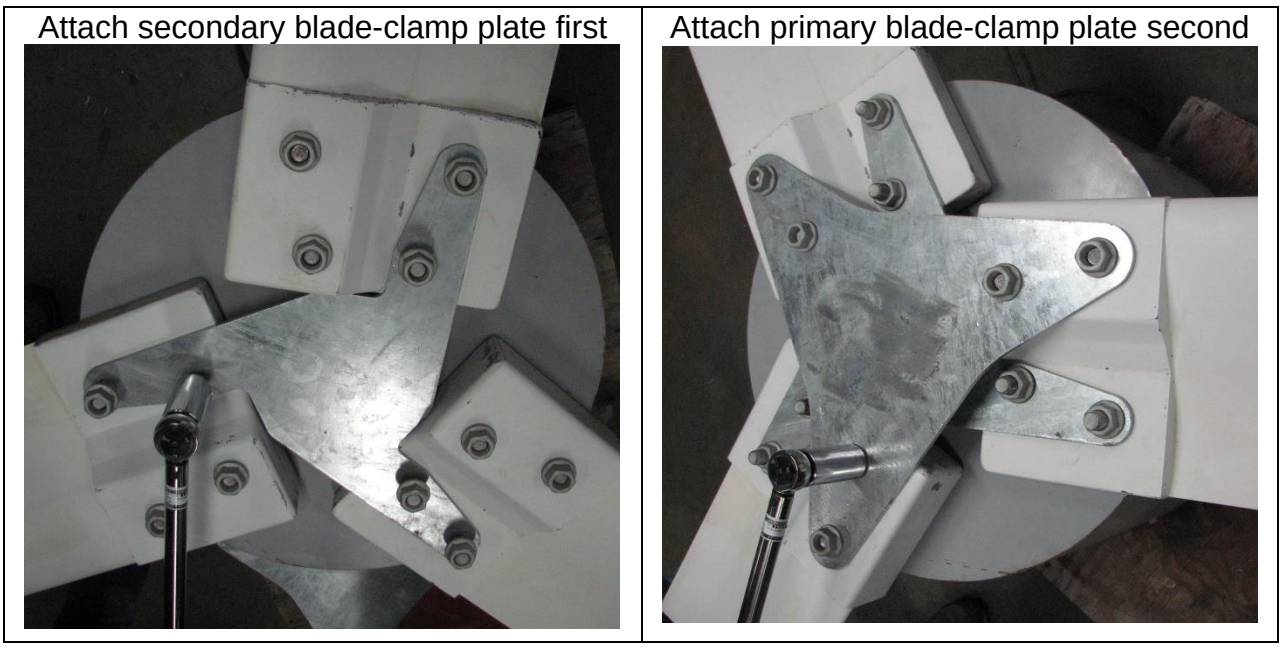


Figure 12: EXCEL Blade, Clamp Plate Attachment

c. Attach the secondary (inner) blade clamp plate so it fits over the six studs in the **thin** sections of the blade root pads. Only one blade clamp orientation will allow this placement, as shown in Figure 12. Apply blue thread lock on 5-6 bolt threads near the clamp plate on all six bolts then secure the clamp plate on the blade roots using six Spiralock nuts, **torqued to 150 ft-lb (210 N-m)**.

d. Remove the nuts on the thick sections of the blade roots and attach the main (outer) blade clamp plate so it fits over the six studs in the **thick** section of the root pads. Only one blade clamp orientation will allow this placement, as shown in Figure 12. Apply blue thread lock on 5-6 bolt threads near the plate on all six bolts then secure the clamp plate on the blade roots using six Spiralock nuts, **torqued to 150 ft-lb (210 N-m)**.

5. Attach the spinner to the powerhead as shown in **Figure 11**, making sure that all hardware is ordered and positioned properly. The recommended procedure is as follows:

a. Pre-assemble a stainless washer, silicon washer and spacer in proper configuration (shown in **Figure 11**), fastened together with a small amount of silicone caulk**. Be sure the spacer is *inside* the silicon washer and against the stainless washer.** Be sure the inner diameters of the stainless washer and spacer are properly aligned. Do this ahead of time for three separate assemblies, and use these assemblies when you are ready to attach the spinner.

b. Use a dab of silicone caulk to position a spacer assembly in place on each of the three attachment studs. The stainless washer is glued to the blade nut, and the spacer is directed outward along the blade stud.

c. Set the spinner in position on the studs, carefully positioning the spinner attachment holes over the spacers. Add the outer silicon washer, surrounding the spacer, and stainless washer resting against the spacer, and then snug the stack with the upper blade nut. Make sure the spacer rests against the upper stainless washer, not against the silicon washer.

d. Repeat steps (b.) and (c.) for the other spinner attachment studs. Be sure that all three spacers are properly positioned *within* the silicon washers, resting against the stainless washers above and below.

e. Tighten the three spinner attachment nuts to **50 ft-lb**.

NOTE: Do not be alarmed by a bit of cracking noise when the spinner attachment nuts are tightened. This is caused by flattening and deformation of the spinner material, and is to be expected. **Torque the nuts to the full 50 ft-lb value**. If you have properly positioned the spacers inside the silicon washers you will not harm the spinner.

6. Prepare the EXCEL wind turbine for tower raising by winching in the furling cable until it is just snug. **DO NOT OVER-TIGHTEN THE FURLING CABLE.**

   The electrical short-circuit previously established in the disconnect switch, together with the furled tail held by the snug cable, will prevent rotation of the turbine blades during the tower raising process.

WARNING: Do not leave the alternator shorted for an extended period of time. Doing so may cause damage to the turbine, and void the warranty.

E. Raising the Tower

1. Raise the tower/turbine to the vertical position and maneuver it over the base pad. The guy wires may be used as tether lines, but it will be necessary to grasp the base section to align the tower properly on the pier pin.

2. Set the tower down on the base pad, with the pier pin through the center hole in the bottom plate, and rotate it as necessary to properly align the guy cables with the anchors.

WARNING: For 60'-140' towers lifted with the turbine in place, the head of the crane boom must never get higher than the upper guy level!

The crane attachment and operation must be conducted with extreme care, to minimize bending loads in the tower during the initial lifting of the tower/turbine assembly. Avoid sudden crane movements, starts and stops, or any other actions that impart dynamic loads to the tower in the initial stage of the lift.

3. Attach each of the guy wires to its turnbuckle by running the cable end through the eye of the turnbuckle, with thimble installed, and looping it back along the "live" section of cable. You can employ a chain-hoist and a guy-grip to pretension the guy wire or several people can pull the wire with sufficient force to achieve the necessary pretension. Lock the cable in position by installing a double-grip clip of proper size as close to the thimble as possible. Add two more double-grip clips to each upper guy cable (a total of three clips on each top guy cable), and one more clip to each lower cable (a total of two clips on each lower guy cable). Do not fully tension double-grip clips until final guy length is determined (the tower is plumb, with guy tension at 90% of desired tension. At this stage it is not necessary to carefully tension the guy wire turnbuckles; they need only be slightly tightened.

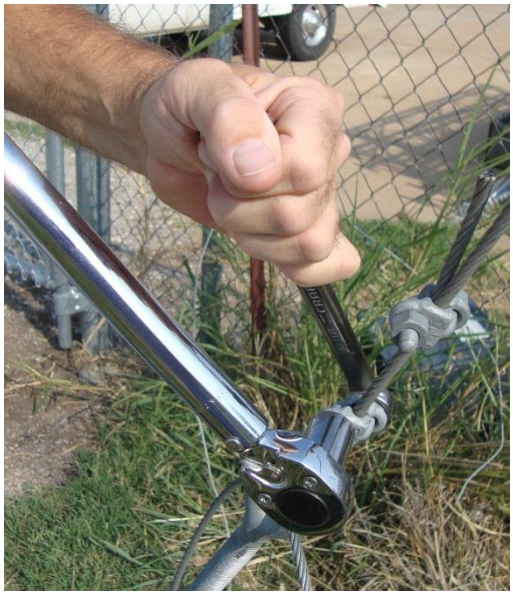
NOTE: The 5/8" wire rope used for the top guys in the 140' and 160' towers is very stiff and heavy, making it more difficult to pull the cable and form a proper loop at the turnbuckle. Proper installation will require a cable come-along with the capacity to pull the cable tight so that the first double-grip clip can be forced properly close to the thimble, allowing proper tension to be developed in the cable.

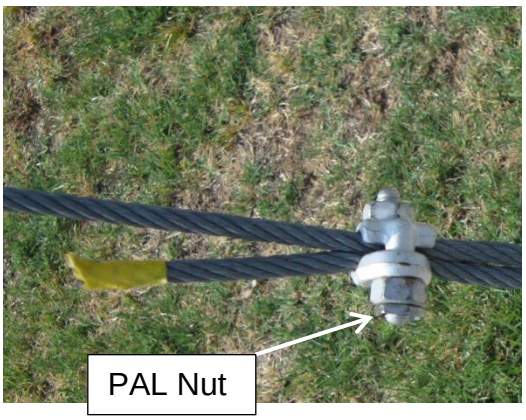
4. Use the turnbuckles to move the tower towards vertical and set tension on the guy wires. Use a lineman's level or a transit to get the tower as close to vertical as possible. It is sometimes necessary to re-install a guy cable to take up slack or extend a cable's length beyond the range of the turnbuckle. Bear in mind that the cables will stretch over time and will need periodic tightening. Therefore, leave at least 50% of unused threading on each turnbuckle.

5. Tension all double-grip clips to the proper torque, as specified in **Table 7**. Secure all double-grip clips with PAL nuts.

Table 7: Required Torque on Double-grip Clips

5/16"	3/8"	1/2"	5/8"
30 ft-lb	45 ft-lb	65 ft-lb	130 ft-lb





WARNING: Correct torque is crucial for proper function of double-grip clips. Use a calibrated torque wrench and a box wrench, properly aligned (with the box wrench angled toward the torque wrench), and do not over-torque the nuts. Tighten both nuts simultaneously.

WARNING: PAL nuts must be installed on double-grip clips to ensure maintenance of proper torque. If PAL nuts are not installed, the clips could loosen and cause tower failure. Also, trim excess guy cable after installing clips.

WARNING: Do not re-use double grip clips. If a cable must be re-installed, new double-grip clips must be purchased and used.

6. After the guy wires are secure and adjusted, the crane rigging can be released. This will require someone to climb the tower. When installing a **160' tower**, once the base segment is released from the crane, the top segment will be lifted and bolted onto the bottom segment. The top segment will then be secured and released from the crane in the same manner used with the bottom segment. The turbine will be raised and attached in a third lift, using the procedure outlined later in this chapter.

NOTE: Excess guy cable should be trimmed off at each anchor after clips are installed.

7. Tension the guy wires using the procedure found on page 63.

8. After the proper tension is achieved, the turnbuckles should be locked with a safety wire. The ¼" safety wires cables and ¼" malleable clips are part of the tower hardware kit. Feed the cable through the centers of the turnbuckle shells and the cable thimbles. Complete the loop by overlapping the ends of the cable. Use the malleable clips to secure the overlapped ends of each safety cable. Both the turnbuckle shell and the thimbles attached to the guy cables must be restrained from rotating.

DANGER: Turnbuckles can unscrew completely in a few hours of strong wind. Do not leave the installation site until safety wires are installed. Failure to install safety wires will void the warranty on both tower and turbine if the tower fails due to separation of a turnbuckle.

F. Secure and Ground the Tower

1. Ground the tower, switch box, and guy anchors with the copper-clad ground rods and hardware provided in the tower hardware kit. If the rods cannot be driven in the full 2.5m (8 ft), it is advisable to drive extra rods and connect them. Another strategy for grounding in rocky soil is to lay the rods

horizontal in a trench. No matter what grounding bar orientation is used, it is important to have the rods in moist soil for effective grounding.

NOTE: When assembling and installing the tower and turbine, as well as during the grounding process and commissioning and inspection of the tower and turbine, all state, federal, and local codes and regulations shall be followed.

If there is some reason why the installer prefers to erect (and fully secure) the tower before installing the turbine (such as the installation of a **160' tower**), it can be done. The tower wiring cable should be installed and secured to the top section of the tower, and the furling cable should be strung in place, also temporarily tied to the top section of tower, before the tower is erected. The turbine should then be installed as follows:

Make sure the breaker box is set up to create a shorted circuit upon turbine connection. This is required to keep the blades from spinning once the turbine's electrical connection is made and the lifting jig is removed.

Raise the main turbine body (powerhead), blades and tail as a complete assembly. For this purpose a lifting "strongback" fixture should be used to keep the turbine level and straight, with the tail boom in line with the turbine centerline. The fixture is available through BWC as part 11156-KIT. A drawing for the strongback design is shown in the **Appendix**.

Make furling winch connection and electrical connections, as described above. After connections are made, remove the jig from the turbine. Move the jig to near side of the turbine, and have the crane operator lower it to shoulder level to make strap removal from the turbine easier.

VI. Electrical Connection

The electrical output of the wind turbine is a three-phase alternating current (AC). We strongly recommend the installation of a fused three-phase AC disconnect switch between the wind turbine and the Powersync II, as shown in the one-line drawings in the **Appendix**. This switch is commonly referred to as an Accessible Disconnect Switch (ADC). A 60A weather-tight switch box with 45A fuses for the 240 VAC, 60Hz or 220VAC, 50Hz system is recommended. The fuses will help protect the alternator in the event of a wiring, controller, or load short circuit. The fused disconnect switch is normally installed at the base of the tower.

WARNING: Do not install a “short circuiting switch” that will provide dynamic braking of the alternator. These switches can be easily misused, leading to serious damage to the alternator. Such damage is not covered by the BWC warranty.

Please refer to the **Appendix** for recommended wire sizes for the tower-to-Powersync II wire run.

The Powersync II inverter must be installed indoors, near the main breaker enclosure if possible. The Powersync II is designed to operate in a clean environment and should never be installed outdoors as it is not weatherproof and will be damaged by rain. A minimum of six inches of clearance is required on the top, bottom and sides of the Powersync II to ensure adequate air flow through the enclosure.

WARNING: The Powersync II inverter must not be installed in another enclosure.

The Powersync II should be connected to a dedicated breaker installed in the main breaker box, in accordance with NEC 694. System grounding is accomplished by attaching a wire, #8 AWG minimum, from the grounding lug inside the Powersync II enclosure to the panel ground inside the main breaker box. Additionally, the tower “bond” ground wire should be connected to the grounding lug inside the Powersync II enclosure. The three AC connections from the wind turbine can be connected to the Powersync II terminals in any order; there is no required phase orientation.

DANGER: Do not attempt to make the Powersync II connections with energized leads. Always have the wind turbine fully disconnected and the circuit breaker switched to “off” before making the Powersync II connections.

All wiring should conform to the National Electric Code or other governing local electrical code. The use of electrical conduit for wiring between components is highly recommended. All terminations should be coated with an anti-oxidation compound to prevent corrosion.

WARNING: All loads should be equipped with fuses or circuit breakers to avoid hazards from accidental short circuits.

VII. Commissioning

Before the EXCEL wind turbine system is allowed to operate, a number of system checks must be made:

A. Furling Winch and Damper Operation

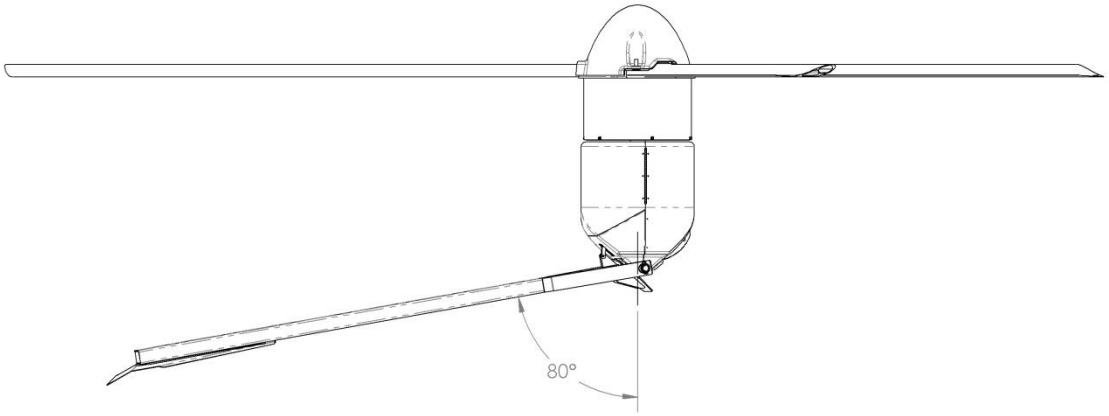
Purpose: Determines whether the manual furling system, including the tail damper, is operating properly.

Tools and Equipment Required:

None

Procedure:

1. Furl the turbine using the procedure outlined in the turbine Owner's Manual. Use caution when operating the winch - proper control of the handle must be maintained at all times. Crank the winch until the tail just makes contact with the bumper. The tail will not rotate around 90 degrees, so it will not be parallel with the blades at its stopping point.



WARNING: Do not over-tighten the furling cable. The tail will not make a 90° angle with the turbine when it is fully furled. Over tightening will damage the furling system. Stop cranking the winch as soon as the tail boom just makes contact with the bumper.

2. While firmly grasping the furling winch handle, rapidly unwind the furling cable. This should cause the furling cable to go slack for a few seconds. If you do not see the cable go slack, there may be a problem with the damper.

B. Alternator Output Check

Purpose: Determines whether the output of the turbine at the base of the tower is balanced on all three electrical phases.

Tools and Equipment Required:

- Volt-ohm meter

NOTE: This test requires that the turbine run unloaded (with no electrical load). It will not harm or endanger the turbine to allow it to spin without a load, regardless of wind speed.


DANGER: The output voltage of the turbine can be very high and poses a shock hazard.


DANGER: Make sure the disconnect box is not connected to the power grid when testing alternator output.

Procedure:

1. Set volt-ohm meter to the AC voltage scale.

2. Switch the disconnect box at the base of the tower to the “OFF” position. Make sure the disconnect box is not hooked up to the grid. Open the switch box cover.

3. Use the volt-ohm meter to measure the AC voltage between each of the three phases on the turbine side of the disconnect. The three phase-to-phase readings should be within a few volts of each other, though they will not be the same. Do not measure phase to ground. Typical phase-to-phase voltage is approximately 1volt per rpm.

C. Power Wiring Check

Purpose: Determines whether the wiring from the turbine to the controller has continuity and is adequately insulated.

Tools and Equipment Required:

- 500 V Meggar (insulation breakdown tester)

Procedure:

1. Stop the wind turbine, using the procedure outlined in Special Topics.

2. Using a 500 V Meggar (insulation breakdown tester) check the resistance between the shorted tower and ground. Consult Meggar manufacturer manual for detailed instructions on the use of a Meggar. If the reading is below 50 MΩ the fault must be traced and corrected. The most likely problems are an inadequately insulated connection or a cut in the insulation of the wire.

3. Check the resistance from wire to ground of each of the three power wires that lead from the disconnect box to the inverter. Consult Meggar manufacturer manual for detailed instructions on the use of a Meggar. If any of the readings are below 50 MΩ the fault must be traced and corrected. The most likely problems are an inadequately insulated connection or a cut in the insulation of the wire.

4. Turn disconnect switch off. Remove shorting wires.

 **DANGER:** When removing shorting wires, make sure the disconnect switch is turned to the “OFF” position. Leaving the switch in the “ON” position poses a shock hazard.

5. Reconnect the grid side wires to the disconnect box.

Additional commissioning tests may be required for the controller and its output wiring, please refer to the Owner’s Manual for a list of these tests.

D. Damper Clearance Check

Purpose: To make sure the damper rod is not rubbing against the nacelle.
Tools and equipment required:

- File (if necessary to improve clearance)

Procedure:

1. Stop the wind turbine, using the procedure outlined on page **61**.

2. Climb the tower and inspect the damper rod, specifically where it comes out of the nacelle.

3. If there is inadequate clearance (it looks like the damper will rub against the nacelle), use a file to clear the nacelle away from the damper rod.

4. Turn disconnect switch off. Remove shorting wires.

 **DANGER:** When removing shorting wires, make sure the disconnect switch is turned to the “OFF” position. Leaving the switch in the “ON” position poses a shock hazard.

5. Reconnect the grid side wires to the disconnect box.

E. Special Topics

Purpose: Procedure for Stopping the Wind Turbine Prior to Climbing the Tower
Tools and Equipment Required:

- Two 6” pieces of #10 AWG insulated copper wire, stripped 3/4” at each end.
- Flat bladed screwdriver.

Procedure:

1. Furl the wind turbine.

2. Switch the tower disconnect switch to "OFF."

3. Switch the inverter grid-tie breaker to “OFF” (if installed).

DANGER: Failure to turn the grid-tie breaker to the “OFF” position may result in electrocution, causing serious injury and death.

4. Bridge the connections on the load side of the disconnect switch (bottom side) using the #10 AWG wire. This will create a short circuit for the turbine when the disconnect switch is turned “ON.”

WARNING: Do not leave the alternator shorted for an extended period of time. Doing so may cause damage to the turbine, and void the warranty.

WARNING: Failure to disconnect the power cable from the disconnect box may result in serious damage to equipment.

DANGER: Failure to disconnect the power cable from the disconnect box may cause danger of electrocution, leading to serious injury and death.

5. Stand at the base of the tower and wait for a lull in the wind. When the rotor has slowed, turn the disconnect switch to the "ON" position. The alternator should come to a smooth stop with no loud, intense “growling”. If the alternator does not come to a stop within 1 minute, turn the disconnect switch to the "OFF" position, wait for the wind speed to drop further and try again.

WARNING: You must turn the disconnect switch to the "OFF" position if the rotor does not stop turning within 1 minute or makes excessive growling noise to avoid serious alternator damage. Never let a short-circuited alternator run for a period of longer than 1 minute at rpm greater than 10.

WARNING: Do not leave the alternator shorted for an extended period of time. Doing so may cause damage to the turbine, and void the warranty.

VIII. Tensioning Guy Cables

BWC recommends a method for setting the pretension on guy cables for guyed towers, called the oscillation method. It is based on the time required for the guy cable to complete 20 oscillations its natural frequency.

A. Determining the Oscillation Time of the Guy Cable

To determine oscillation time for each guy level of each tower, see **Table 8** below. Note that these times assume tower installation on a flat surface and a 60% guy radius (GR). If other guyline lengths are used, see page **64** for the advanced method for determining proper guy cable frequency.

Table 8: Time required for 20 oscillations (in seconds)

Guy Level	60 ft Tower	80 ft Tower	100 ft Tower	120 ft Tower	140 ft Tower	160 ft Tower
Top	7	10	12	15	17	20
Mid hi	N/A	N/A	N/A	11	14	16
Mid lo	N/A	N/A	N/A	N/A	N/A	14
Bottom	5	7	9	9	11	12

B. Oscillating the Guy Cable

Any cable under tension will tend to oscillate at a certain natural or fundamental frequency that depends on its tension, weight per foot and length. It is very important that the oscillation is started by moving the cable back and forth at this frequency. The cable should trace out the pattern shown below in a regular, consistent way without whipping or distorting into other shapes.

NOTE: The frequency of oscillation is independent of the magnitude of the oscillation.

Adjust the cable tension, using the turnbuckle, until the proper frequency of oscillation is observed.

C. Testing and Tensioning the Cable

1. Make sure the tower is plumb.

2. Stand at one anchor and move the top guy cable back and forth at the natural frequency that corresponds to its current tension. (Establish the cable shape shown above.)

3. Measure the number of seconds required for the cable to complete 20 *complete* cycles. (One complete cycle includes *both* an “up” and a “down”.)

4. Compare the measured time period with the recommended value.

5. If required, adjust the tension and repeat steps (1) through (3). Increasing tension increases cable frequency and *reduces* the time required for 20 oscillations.

6. Adjust every top guy cable by the same amount as the first top cable.

7. Repeat steps 2-6 with the middle guy cables (if present), matching the oscillations to the table.

8. Repeat steps 2-6 with the lower guy cables, matching oscillations to the table.

D. Cautions, Hints and Suggestions

1. Use common sense. If it appears that a cable is becoming much too tight, stop tightening it. You may be doing something incorrectly.

2. The oscillation method cannot be used in all wind conditions. If the wind speed is above 15 mph, your readings will not be accurate due to the additional forces exerted on the tower by the wind. Furling the turbine and stopping the rotor may reduce these additional loads, allowing the use of this procedure in winds up to ~20 mph.

3. Do not use the oscillation method for cable types different from those recommended by BWC.

4. Cables at the same height on a tower are “coupled”; increased tension in one cable will result in greater tension in the other cables. It is important to establish proper cable tension while maintaining the tower in the vertical, plumb position. This is achieved by tightening all three guy lines at each guy level the same amount every time a cable is tightened.

5. Do not attempt to use the oscillation method if ice is present on the cable. The extra weight of ice on the cable will invalidate results.

E. Advanced Method for Determining Proper Guy Cable Frequency

1. Determine the length of the cable (in feet) from the tower guy bracket to the anchor. On sloping terrain, this can be done with the law of cosines, as seen in the example.

2. Divide this cable length by 9.

3. This quotient gives the number of seconds that are required for the properly tensioned cable to make 20 complete cycles.

4. The process is very sensitive to the time period. Doubling the time required to make the 20 oscillations will result in 1/4 the desired guy tension. Therefore, we recommend the tension be adjusted until the time period is within 1 second of the recommended value.

EXAMPLE: Assume the following geometry for a 100' tower:
Height of tower guy bracket (above base) - 91.8 ft
Guy Radius (along ground) - 70 ft
Downhill slope (from base to anchor) - 0.02 ft/ft
This gives a total cable length of 113 ft according to the formula:

$$Length = \sqrt{Height^2 + Radius^2 + 2 \times (Height \times Radius \times \cos(90 + \arctan(Slope)))}\ .$$

Dividing by 9 and rounding gives 13 seconds to complete 20 oscillations.

F. Use of Graph to Determine Natural Frequency of Guy Cables

Figure 13 is a useful graph for determining both guy cable length and time required for 20 oscillations at proper natural frequency and tension. Instructions for use of the graph, including an illustrated example, are included with the graph. Note that the graph in **Figure 13** is for use on relatively flat topography.

EXAMPLE: (Shown in dash-dot lines below)
Guy Level = 60 ft; Guy Radius = 75 ft

METHOD: Read up from 75 on the radius axis and across from 60 on the height axis to their intersection. Follow the arc around to see that the guy cable length is 96 ft. Read straight down from 96 to the bottom axis (seconds for 20 oscillations) to find that 10.75 seconds correspond to the proper natural frequency.

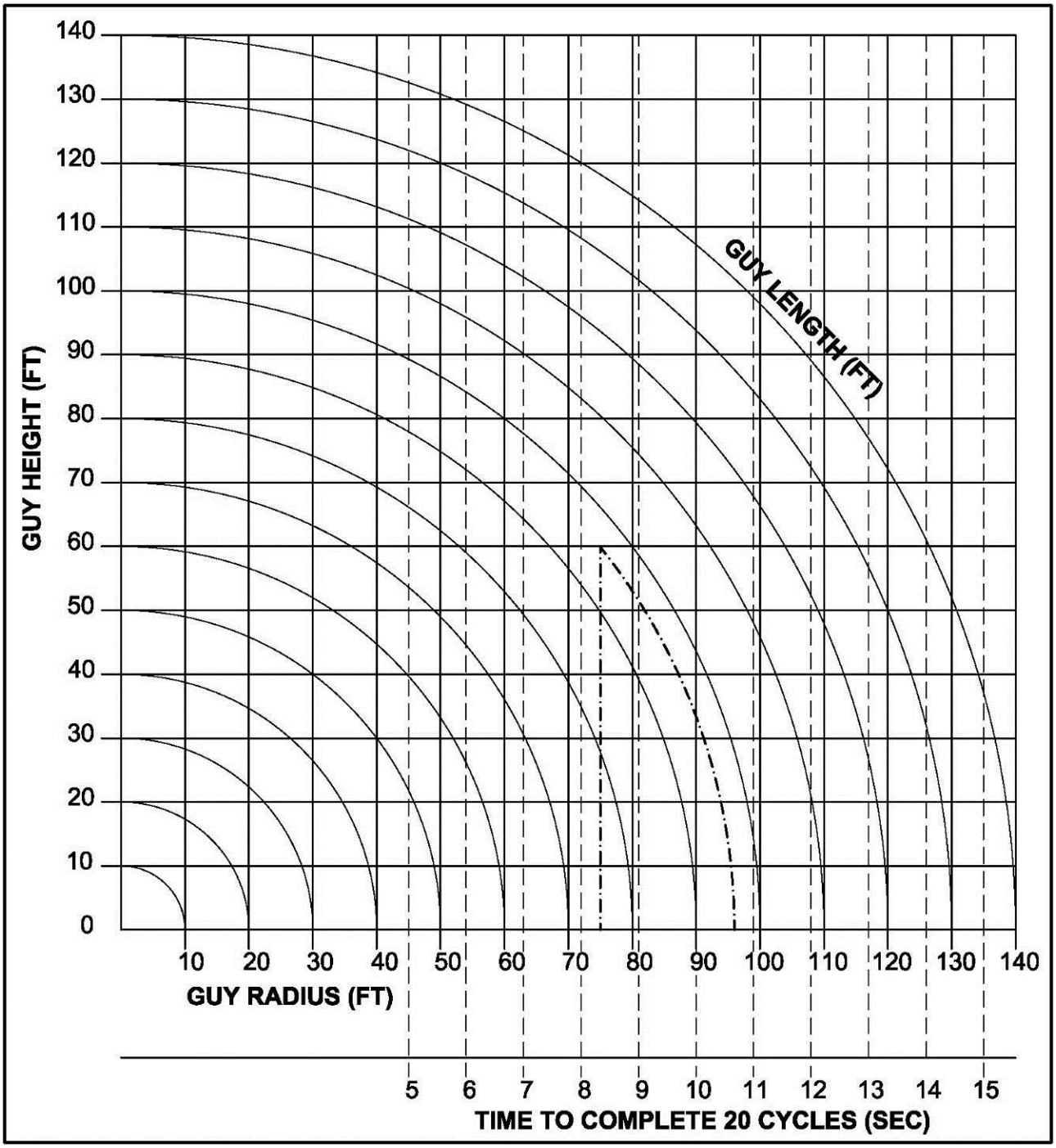


Figure 13: Graph to Determine Natural Frequency of Guy Cables

IX. Inspections and Maintenance

The BWC EXCEL installation should be inspected after 30 days, and again 180 days after installation. Following these two inspections, the tower should be inspected every two years and after any particularly severe weather event. Inspection should be done on days when the wind is below 7 m/s (16 mph). **Take pictures of inspected items.** A service inspection checklist is in the **Appendix**.

Checklist for Inspections

1. **IMPORTANT - Inspect each anchor point.**
   a. All hardware is secure.
   b. All safety wires are properly installed.
   c. No slippage on double-grip clips.
   d. No damage to cotter pins, where used.
   e. Proper torque on double-grip clips.
   f. Thimbles in good condition.
   g. Equalizer plates in good condition.
   h. Grounding rods still connected.
   i. PAL nuts still engaged.
   j. Look for anchor rod movement.

2. **IMPORTANT - Check guy cable tension and adjust as required.** See **Chapter VIII** for detailed instructions for tensioning guy cables.

3. Furl wind turbine and check to see that the damper restricts the tail's unfurling to a period of at least five (5) seconds when the winch cable is rapidly released.

4. Furl turbine and short alternator using the procedure given in the “Special Topics” on page **61**. Climb the tower. Always use proper safety equipment.

5. Inspect blades for:
   a. Cracks near the hub.
   b. Condition of the leading edge protection tape.
   c. Tip, leading edge, or trailing edge damage.

6. Remove spinner and hang it on the machine.
   a. Check torque on the blade nuts (value should be **150 ft-lbs**).
   b. Check front bearing for seal integrity and grease loss.

7. Reattach spinner as described in on page **49.**

8. Open hatch on the nacelle. Use a small rope to lash the hatch open.

9. Check rear alternator bearing for seal integrity and grease loss.

10. Inspect mainframe for cracks.

11. Remove slip-ring cover plate. Make the following inspections:
    a. Check brushes for ease of movement in the brush holder.
    b. Check slip rings for signs of arcing damage.
    c. Clean excessive grease from the slip-rings where yaw bearing has leaked onto them.

12. Inspect damper. Minor leakage around the front seal is acceptable.

13. Inspect furling cable (particularly at the ball end/fork attachment to the tail boom) and furling cable conduit. Be alert for fraying where the cable enters the conduit.

14. Check for cracks or loose hardware on the tail boom and fin.

15. Check tail pivot pin, pin retainer bolts, and tail pivot bushings. Outside diameters of bushings should be concentric.

16. Close nacelle and check that all of its fasteners are secure.

17. While descending the tower, inspect the following:
    a. Check that the tower wiring is properly secure.
    b. Check all fasteners. Replace missing PAL nuts.
    c. Look for any cracks in the tower structure.
    d. Check furling cable, swivel and malleable clips.

18. Check furling winch and make sure that the furling cable is not twisted. If the cable is twisted, check the swivel.

19. Check connections on all ground rods and hardware. Be sure all contact surfaces are clean and free of oxidation.

20. Inspect surge arrestor(s). Any sign of scorching or heat should trigger replacement.

21. Remove alternator shorting connection. Check disconnect switch.

22. Switch disconnect switch to "OFF" and unfurl the wind turbine. Listen to the sound of the machine as it speeds up. No mechanical sounds, such as a "clunking" or "banging," should be heard. Watch for any new or significant vibration. The turbine operation should be very smooth.

23. Inspect wire run, particularly all electrical connections.

24. Check controller per the instructions provided in the Owner’s Manual.

X. Trouble-Shooting Problems

Refer to the Owner's Manual for the specific model of turbine you own for a guide to the causes and remedies for operational problems.

For special assistance, please contact the Service Department at Bergey Windpower Company:

Telephone: 405-364-4212
FAX: 405-364-2078
Email: service@bergey.com

XI. Appendix

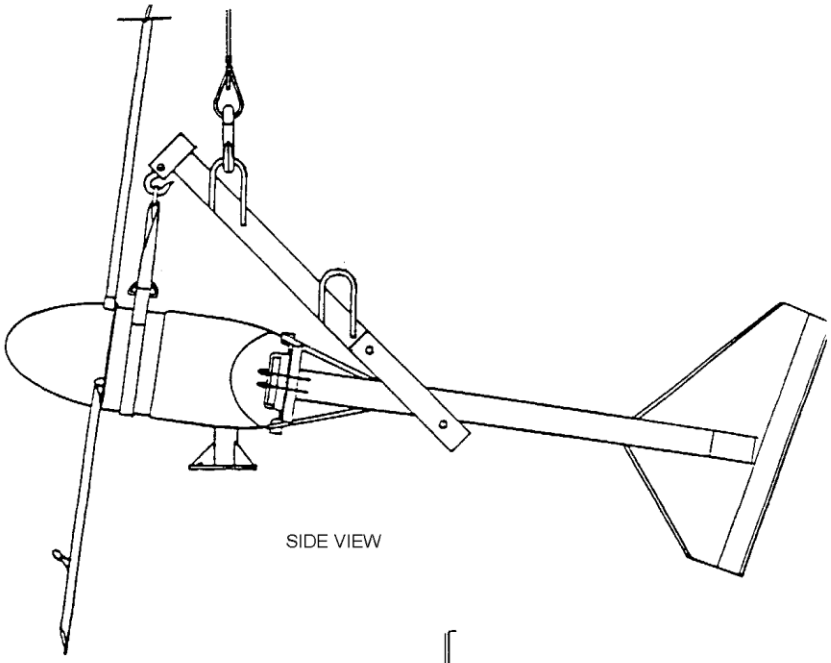
A. WIRE SIZING

Wire run limit for performance equal to WindCAD estimation						
tower height, feet (6awg)	60	80	100	120	140	160
AWG	wire run distance to base of tower (feet)					
6	210	190	170	150	130	110
4	340	300	270	240	210	180
3	420	380	340	300	260	220
2	530	480	430	380	330	280
0	850	771	690	610	529	449
00	1080	980	880	780	670	570
000	1370	1240	1110	980	850	720

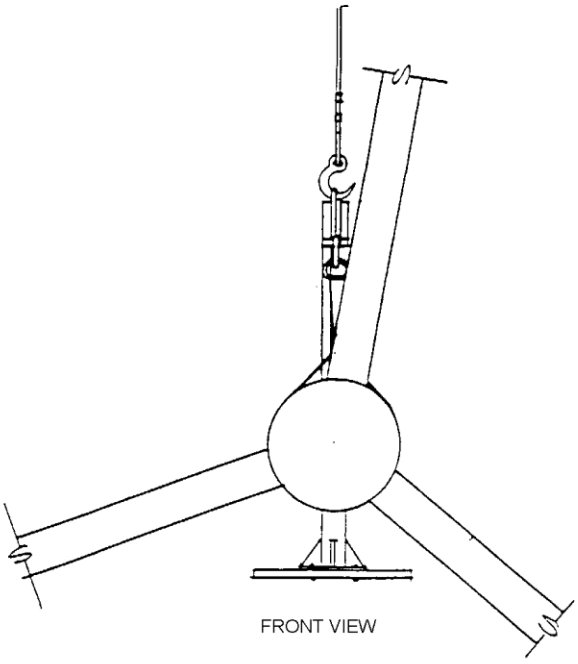
Recommended Wire Size for BWC EXCEL Installations

Note that wire run lengths correspond to performance values estimated by WindCAD. Annual Energy Output losses of 4.5% were factored into the WindCAD model to account for energy losses due to wire sizing.

B. LIFTING FIXTURE (STRONGBACK)



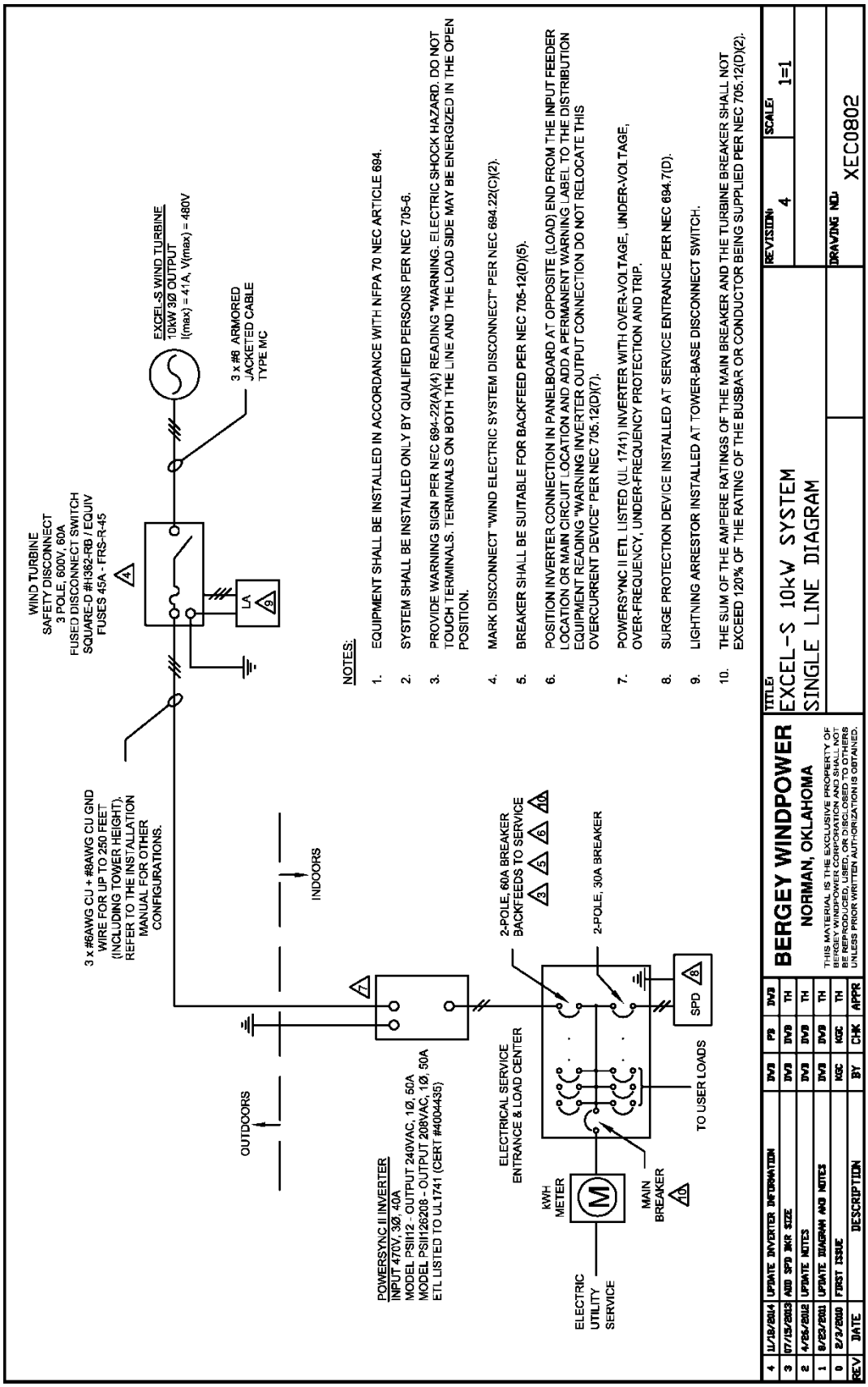
SIDE VIEW



FRONT VIEW

STRONGBACK FIXTURE FOR LIFTING BWC EXCEL (CRANE REQUIRED)

C. ELECTRICAL SINGLE LINE DIAGRAM



D. SERVICE INSPECTION CHECKLIST (GL/GLT TOWERS)

Customer Name: _____ Date: _____

Inspector: _____ Location: _____

Directions: Inspect ALL applicable areas. Check off all inspections performed. Make note of anything unusual or interesting, and describe all adjustments made. Include numeric settings (torque, tension, frequency, etc.) where appropriate. Submit pictures with this form.

GUY CABLES & HARDWARE

____ Tension Checked ____ Tension Adjusted

Time required for 20 oscillations (in seconds)

Guy Level	60 ft Tower	80 ft Tower	100 ft Tower	120 ft Tower	140 ft Tower	160 ft Tower
Top	7	10	12	15	17	20
Mid hi	N/A	N/A	N/A	11	14	16
Mid lo	N/A	N/A	N/A	N/A	N/A	14
Bottom	5	7	9	9	11	13

____ Equalizer Plate Hardware ____ Threads Peened
____ Double Grip Clips (Three on upper cables, two on lower and middle cables. Check torque.)
____ Stainless Steel Cotter Pins on Turnbuckles and Shackles (where applicable)
____ Safety cables in place ____ Thimbles in good condition
____ Grounding rods ____ PAL nuts in place
Anchor lengths showing above ground _____in _____in _____in

TOWER HARDWARE

____ Locking Hardware installed at all Flanges and Connections
____ Missing Hardware Replaced Location(s): _____
____ Tower Wiring Secure and Properly Connected

POWERHEAD

____ Blade Visual Inspection Observations:
____ Blade Torque Checked Observations:
____ Tail Pivot Observations:
____ Furling Hardware Observations:
____ Damper & Tube Observations:
____ Electrical Connections Observations:
____ Spinner & Hardware Observations:

ELECTRICAL

____ Controller Connections Controller S/N: _____
____ Other Components (Surge Arrestor, Transformer, kWH meter, etc.)

NOTES: