Installation Manual

BWC EXCEL 10 Wind Turbine and Tilt-up Lattice Towers

Part # MANTU
Revision 2.2 Preliminary
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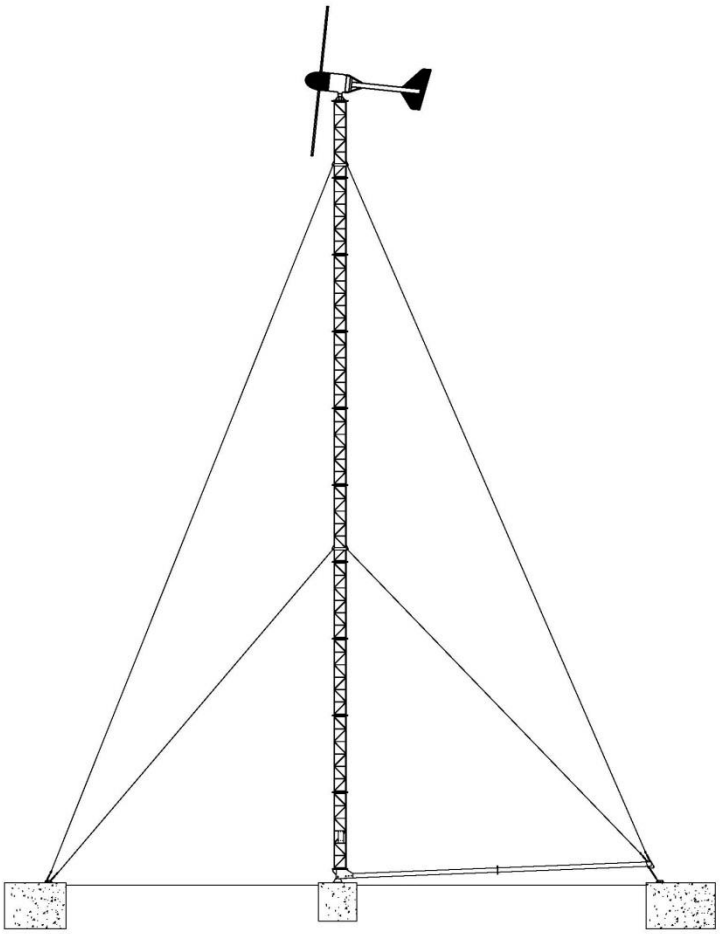

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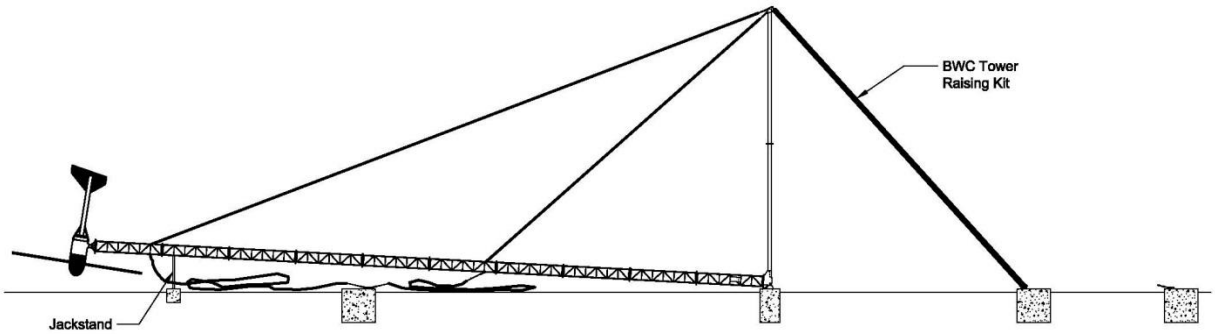
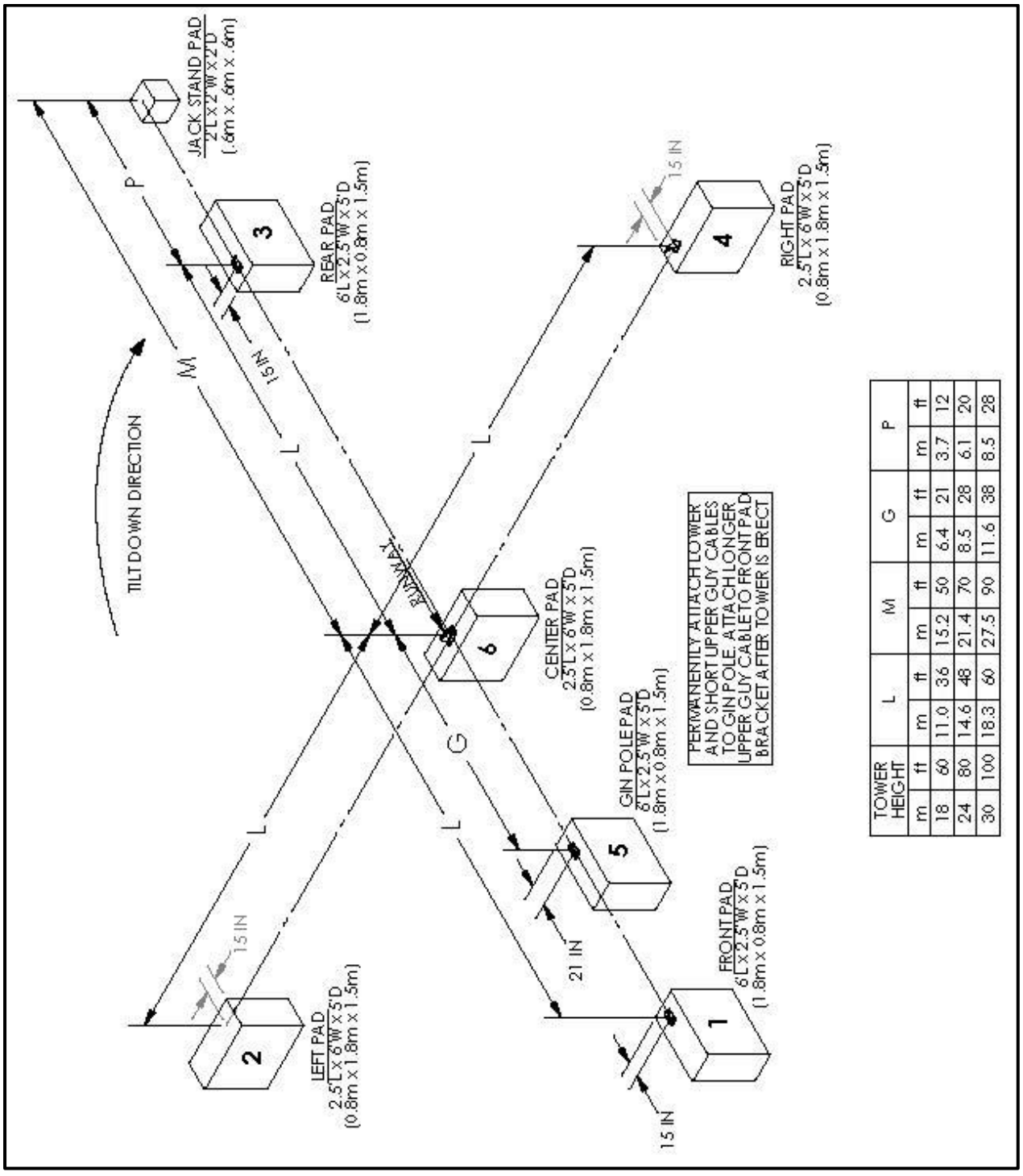


BWC Tilt-up Tower



TOWER HEIGHT		L		M		G		P	
m	ft	m	ft	m	ft	m	ft	m	ft
18	60	11.0	36	15.2	50	6.4	21	3.7	12
24	80	14.6	48	21.4	70	8.5	28	6.1	20
30	100	18.3	60	27.5	90	11.6	38	8.5	28

Figure 1. Tower Plan View

I. Safety

This manual contains important information concerning the installation of your Bergey GL 18 Tilt-up lattice 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 on site.
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. Improper torque on guy line grip clips & no periodic inspection
2. Improper guy line tensioning & no periodic inspection
3. Damaged or lost turnbuckle cotter pins / failure to use stainless steel cotters
4. Improper rigging of tower raising equipment
5. Failure to use safety cables on turnbuckles
6. Side and base concrete pad surfaces not at same elevation
7. Improper torque on tower connections
8. Improper height of installed guy lines
9. Loss of control while using vehicle to raise/lower tower
10. Inadequate anchor pad size in frictionless 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 lb, 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. Tilt-up Lattice Tower Kit

The BWC Tilt-up Lattice (GL) Tower Kit will include a number of 3 m (10 ft) welded tower sections, two gin pole pipe sections, anchor and tower base brackets, bundles of guy cable, bundles of 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 lb 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 lattice 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. An example of the anticipated packing list is included in this chapter. All major items should be properly inspected before delivery is accepted.

D. Corrosion-protected Tower Kits

The standard Tilt-up Tower Kit provides hot-dip galvanized hardware and stainless replacements for corrosion sensitive items like cotter pins. Some critical items such as guy cables and double-grip clips, are simply not available in corrosion-resistant form. The Marine Option for the Tilt-up Tower Kit provides a large container of special corrosion inhibiting grease that should be applied to guy cables and hardware. This application should occur after the tower has been erected and cables properly tensioned, and can be done easily by hand with the tower tilted down. Latex gloves should be worn when handling the grease, which should be renewed periodically during regular tower inspections.

E. Packing Lists

Table 1: Tower Packing List

No.	Description	BOM Qty.			PURPOSE
XLGT		18HD	24HD	30HD	Model
MANTILT	MANUAL TILT TWR INSTALL, EXCEL	1	1	1	Installation Instructions
11500-1 GALV	TOWER SECTION GL18 STD GALV	3	5	7	Middle tower sections - no guy wires
11500-2 GALV	TOWER SECTION GL18 BASE GALV	1	1	1	Base tower section
11550-3 GALV	TOWER TOP SECTION GL18 TILT	1	1	1	Top tower section
11550-4 GALV	TOWER SECTION GL18 TILT GUYED	1	1	1	Middle tower sections - guy wires
11505 GALV	BASE HINGE ASSY, GALVANIZED	1	1	1	Tower base hinge
11411 GALV	TOWER BASE BRKT, TILT UP	1	1	1	Tower base hinge
11405-7 GALV	GIN POLE INNER (217", 3 HOLES)	1	1	1	Inner section - attaches to base hinge assy.
11405-4 GALV	GIN POLE OUTER (19" HACHET)	1			Outer gin pole section
11405-5 GALV	GIN POLE OUTER (101" HACHET)		1		Outer gin pole section
11405-6 GALV	GIN POLE OUTER (217" HACHET)			1	Outer gin pole section
11410 GALV	ANCHOR BRKT, FORE/AFT	3	3	3	Anchor bracket
11552R GALV	ANCHOR BRKT, WIDE GUY RIGHT	1	1	1	Anchor bracket
11552R GALV	ANCHOR BRKT, WIDE GUY RIGHT	1	1	1	Anchor bracket
11406 GALV	JACK STAND, TILT UP TOWER	1	1	1	Tower support when lowered
HBB006	STUD 3/4"-10 x 12" ALLTHREAD	24	24	24	Attach anchor bracket to pads
HNB011	NUT 3/4"-10 A563-DH HEX HDG	24	24	24	Attach anchor bracket to pads
HNB008	PAL NUT 3/4" HDG	24	24	24	Attach anchor bracket to pads
EPC501	EPCON A7 ADHESIVE CARTRIDGE	6	6	6	Bonding anchor bolts to pad
HB8038	BOLT, 1/2”-13 x 8" L SHAPED	4	4	4	Attach jack stand to pad
HN8004	NUT 1/2"-13 HEAVY HEX HDG	4	4	4	Attach jack stand to pad
HN8005	PAL NUT 1/2" HDG	4	4	4	Attach jack stand to pad
HB6002	BOLT 3/8”-16 x 1” HH,SS	3	3	3	Attach winch to bottom tower section
HN6008	NUT 3/8”-16 HH NYLOCK SS	3	3	3	Attach winch to bottom tower section
HW6003	WASHER 3/8” USS FLAT SS 1" OD	6	6	6	Attach winch to bottom tower section
HM0008	ROD GROUNDING 5/8” x 8’ COPPERCL	6	6	6	Ground rod at each pad
HM0042	CLAMP GROUNDING DIRECT BURIAL	6	6	6	Attach tower & anchor rods to grounding rod
11471-1	GROUNDING CABLE ASSM 72"	6	6	6	Attach tower & anchor rods to grounding rod
HM2007	COTTER PIN 5/32" x 1-1/2" 316SS	21	21	21	Exchange pins on guy shackles and turnbuckles

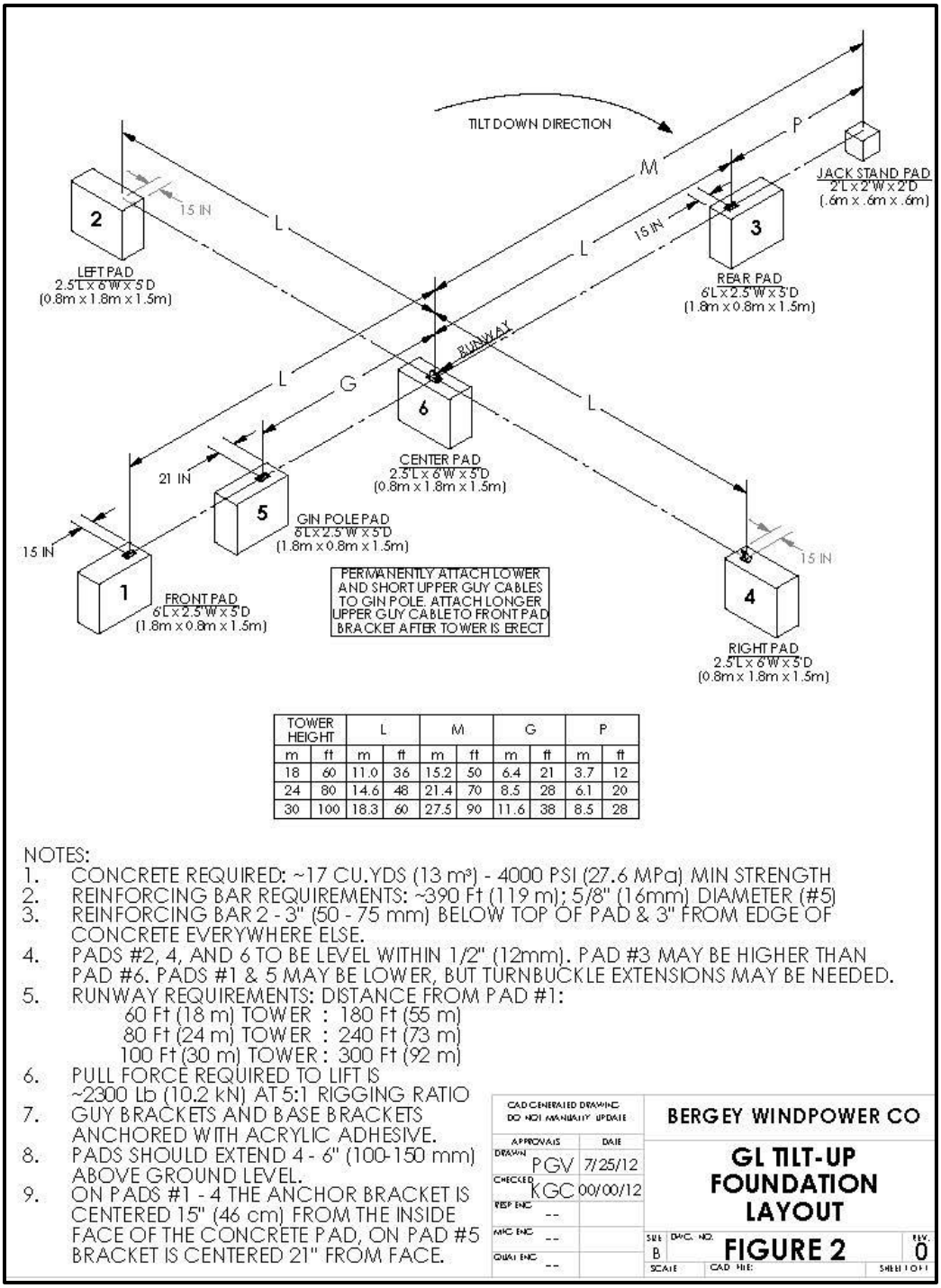
No.	Description	BOM Qty.			PURPOSE
HBB026	BOLT 3/4"-10 x 2-3/4" A325 HDG	52	70	88	Attach tower sections, gin pole sections
HBB024	BOLT 3/4"-10 x 2-1/2" A325 HDG	6	6	6	Attach turbine to top tower section
HBB055	BOLT 3/4"-10 x 2-1/4" A325 HDG	4	4	4	Attach tower base to hinge bracket
HBB027	BOLT 3/4"-10 x 9-1/2" A325	3	3	3	Attach inner gin pole to hinge bracket
HNB011	NUT 3/4"-10 A563-DH HEX HDG	67	85	103	Attach tower sections, turbine & gin pole
HNB008	PAL NUT 3/4" HDG	67	85	103	Attach tower sections, turbine & gin pole
HMC002	TURNBUCKLE 7/8" x 12" JAW & EYE	5	5	5	Attached top guy cable to turnbuckle
HMA005	TURNBUCKLE 5/8" x 12" JAW & EYE	4	4	4	Attached lower guy cable to turnbuckle
HMD002	TURNBUCKLE 1" x 6" JAW & JAW	1			Attach gin pole to anchor pad
HMD003	TURNBUCKLE 1" x 12" JAW & JAW		1		Attach gin pole to anchor pad
HMD006	TURNBUCKLE 1" x 18" JAW & JAW			1	Attach gin pole to anchor pad
HMA001	THIMBLE 5/8" HD	4	4	4	Attach top guy cable to turnbuckle
HM9001	THIMBLE 9/16" HD	1	1	1	Attach top gin pole cable to turnbuckle
HM6002	THIMBLE 3/8" HD	4	4	4	Attach lower guy cable to turnbuckle
HM8005	CLIP 7/16" to 1/2" DOUBLE GRIP	3	3	3	Attach upper gin pole guy cable to turnbuckle (3 per)
HMA010	CLIP 9/16" to 5/8" DOUBLE GRIP	12	12	12	Attach 5/8" guy cable to turnbuckle (3 per)
HM6007	CLIP 3/8" DOUBLE GRIP	8	8	8	Attach 3/8" guy cable to turnbuckle (2 per)
HNA004	PAL NUT 5/8" HDG	24	24	24	For 5/8" double grip clips used on guy cables
HN8005	PAL NUT 1/2" HDG	6	6	6	For 1/2" double grip clips used on upper gin pole guy cable
HN7003	PAL NUT 7/16" HDG	16	16	16	For 3/8" double grip clips used on guy cables.
11553-1	GUY WIRE ASSY, 60' GLT-HD GIN PL	1			Gin pole upper guy cable and standard upper guy cable
11553-2	GUY WIRE ASSY, 80' GLT-HD GIN PL		1		Gin pole upper guy cable and standard upper guy cable
11553-3	GUY WIRE ASSY, 100' GLT-HD GIN P			1	Gin pole upper guy cable and standard upper guy cable
11551-13	GUY WIRE ASSY, 5/8" x 75' 3/4" SHKL	3			Top guy cable
11551-14	GUY WIRE ASSY, 5/8" x 96' 3/4" SHKL		3		Top guy cable
11551-15	GUY WIRE ASSY, 5/8" x 120' 3/4" SHKL			3	Top guy cable
11551-16	GUY WIRE ASSY, 3/8" x 55' 5/8" SHKL	4			Lower guy cable
11551-5	GUY WIRE ASSY, 3/8" x 70' 5/8" SHKL		4		Lower guy cable
11551-17	GUY WIRE ASSY, 3/8" x 87' 5/8" SHKL			4	Lower guy cable
AWR401	WIRE ROPE 1/4" x 6' GALV.	6	6	6	Safety Cables (Install ALL turnbuckle locations.)
HM4006	CLIP 1/4" MALLEABLE	12	12	12	Safety cable clamps
11508-1	FURL CABLE ASSY, 3/16" x 60' SS	1			Cable from turbine to furling winch
11508-2	FURL CABLE ASSY, 3/16" x 80' SS		1		Cable from turbine to furling winch
11508-3	FURL CABLE ASSY, 3/16" x 100' SS			1	Cable from turbine to furling winch
HM3003	THIMBLE 3/16" SS	1	1	1	Attach furl cable to turbine cable
HM3002-B	CLIP 3/16" MALLEABLE SS	2	2	2	Attach furl cable to turbine cable
HB8035	BOLT 1/2"-13 x 1-1/4" A325HDG	6	6	6	Attach ground wires to anchor pads
HN8004	NUT 1/2"-13 HEAVY HEX HDG	6	6	6	Attach ground wires to anchor pads
HN8005	PAL NUT 1/2" HDG	6	6	6	Attach ground wires to anchor pads

Table 2: Tower Wiring Kit

No.	Description	BOM Qty.			Unit	PURPOSE
XLGT		18HD	24HD	30HD		
AXA009	SWITCH DISCONNECT - 600V 60A	1	1	1	EA	Turbine Disconnect
AXA013	HUB FOR XL DISCONNECT SWITCH	1	1	1	EA	Turbine Disconnect
AFA016	FUSE FRS-R-45 (BUS)	3	3	3	EA	Turbine Disconnect
CAB006	CABLE ARMOR TYPE MC 3 x #6 AWG	60	80	100	FT	Tower Wiring
EC0152	CONNECTOR CROUSE-HINDS TMC285	2	2	2	EA	Turbine Disconnect
HNB002	LOCKNUT 3/4” ELECTRICAL	1	1	1	EA	Turbine Disconnect
HMB006	BUSHING 3/4” PLASTIC INSULATING	1	1	1	EA	Turbine Disconnect
HM0012	CABLE TIE 13-3/8" NYLON BLACK HD	30	40	50	EA	Tower Wiring
EC0153	GROUNDING BAR KIT, DISCONNECT	1	1	1	EA	Turbine Disconnect
HS3014	SCREW 10-32 X1 PH PLPS MS SS	1	1	1	EA	Turbine Disconnect
HN3001	NUT, 10-32 HEX NYLOCK SS	1	1	1	EA	Turbine Disconnect
HB4010	BOLT 1/4”-20 X1 HH C/S G5 SS	4	4	4	EA	Attached disconnect to tower
HN4004	NUT NYLOC 1/4"-20 SS	4	4	4	EA	Attached disconnect to tower
HW4001	WASHER 1/4” x 5/8” OD SAE FLAT SS	8	8	8	EA	Attached disconnect to tower
ARR003	ARRESTOR LIGHTNING LA603	1	1	1	EA	Turbine Disconnect

III. Tower Foundation

A. Layout of Foundations



TOWER HEIGHT		L		M		G		P	
m	ft	m	ft	m	ft	m	ft	m	ft
18	60	11.0	36	15.2	50	6.4	21	3.7	12
24	80	14.6	48	21.4	70	8.5	28	6.1	20
30	100	18.3	60	27.5	90	11.6	38	8.5	28

NOTES:
1. CONCRETE REQUIRED: ~17 CU.YDS (13 m³) - 4000 PSI (27.6 MPa) MIN STRENGTH
2. REINFORCING BAR REQUIREMENTS: ~390 Ft (119 m); 5/8" (16mm) DIAMETER (#5)
3. REINFORCING BAR 2 - 3" (50 - 75 mm) BELOW TOP OF PAD & 3" FROM EDGE OF CONCRETE EVERYWHERE ELSE.
4. PADS #2, 4, AND 6 TO BE LEVEL WITHIN 1/2" (12mm). PAD #3 MAY BE HIGHER THAN PAD #6. PADS #1 & 5 MAY BE LOWER, BUT TURNBUCKLE EXTENSIONS MAY BE NEEDED.
5. RUNWAY REQUIREMENTS: DISTANCE FROM PAD #1:
   60 Ft (18 m) TOWER : 180 Ft (55 m)
   80 Ft (24 m) TOWER : 240 Ft (73 m)
   100 Ft (30 m) TOWER : 300 Ft (92 m)
6. PULL FORCE REQUIRED TO LIFT IS ~2300 Lb (10.2 kN) AT 5:1 RIGGING RATIO
7. GUY BRACKETS AND BASE BRACKETS ANCHORED WITH ACRYLIC ADHESIVE.
8. PADS SHOULD EXTEND 4 - 6" (100-150 mm) ABOVE GROUND LEVEL.
9. ON PADS #1 - 4 THE ANCHOR BRACKET IS CENTERED 15" (46 cm) FROM THE INSIDE FACE OF THE CONCRETE PAD, ON PAD #5 BRACKET IS CENTERED 21" FROM FACE.

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BERGEY WINDPOWER CO
GL TILT-UP FOUNDATION LAYOUT
SIZE B DWG. NO. FIGURE 2 REV. 0
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Figure 2. Tilt Tower Foundations Layout

The angular spacing for the anchor points is 90 degrees. **The elevations for the surfaces of pads 2, 4 and 6 MUST be the same**. Pad 3, opposite the gin pole, must be at or above the elevation of tower base pad 6, while pads 1 and 5 on the gin pole side may be below the elevation of base pad 6. Note that if pad 5, the gin pole anchor pad, is more than a few inches lower than the tower base pad turnbuckle extension plates will be required. (The gin pole angle cannot be changed.) **Please consult with BWC if you intend to install a tilt-up tower on sloping terrain.**

There are several important concepts that must be understood in the layout of the tower and construction of the concrete pads.

1. Pads shown in Figure 2 are 5 ft (152 cm) thick. If the pads project 6 in (15 cm) above ground level they will extend 54 in (140 cm) below grade. These pads are acceptable for frost depth up to 50 in (127 cm), but in areas with deeper frost the anchor and base pad thickness must be increased to extend the pads below maximum frost depth.

2. Pads shown in Figure 2 are suitable for a broad range of soil type and strength, but non-cohesive soils such as sand will require larger pads to resist vertical loads exerted by guy cables and raising cables. Consult BWC in such cases.

3. The orientation of the tower base pad (pad 6) is important. It must be oriented as shown to resist fore/aft loads developed during the tilt process.

4. The jack stand pad need not extend below frost depth, but if shallow it may be subject to movement during periods of freezing temperatures.

5. The tower site must allow ample room for laying the tower down. There must be a clear area that will not interfere with either the tower structure or the guy cables when the tower is horizontal.

6. If a vehicle will be used to pull the raising cable during tower tilt-up, an unobstructed pathway 180-300 ft (55-90m) long will be required for vehicle travel. The surface of this pathway must provide sufficient traction for the vehicle to be used, and it must allow straight travel of the pull-up vehicle. The toggle block of the tower-raising rigging system will allow a wide range of angles for vehicle travel, though it is best to pull in the direction defined by a line from pad #6 to pad #1. The pull-up vehicle path must not cross an active traffic area because the pull-up cable may remain extended under tension for a significant period of time.

7. The preferred, safest system for tower raising and lowering is a winch properly attached at anchor block #1. Tower raising rigging, including toggle block and double block (if used) is mounted at block #5.

8. Lowering the tower is made easier if the wind is blowing in the direction to help "push" the tower over. Although this is not a prime factor in tower siting, it is worth consideration when planning the site layout.

B. Anchor and Tower Base Footings

The recommended procedure for installing footings and anchor/base brackets is to first place the concrete pads, allow them to fully cure and then mark/drill the anchor bolt holes. The anchor bolts are bonded into these drilled holes with a special fast-setting, extemely strong, temperature-independent structural adhesive. This adhesive method works properly even in freezing temperatures, is less prone to errors and improperly located anchors, and provides attachments that are much stronger and durable than either expansion anchors or L-bolts.

> **NOTE: It is important to mark the locations of rebar before placing concrete, so rebar will not interfere with the drill bit during anchor bracket installation. If marks are placed on wood forms, DO NOT remove forms before holes are drilled or rebar locations are transferred to concrete.**

Some installers may prefer to install L-bolts at the time concrete is placed. BWC will not supply L-bolts for anchor or base brackets, nor do we support the use of this outdated method. L-bolts are difficult to accurately place, they are subject to fatigue failure, and their anchorage strength is much lower than the adhesive anchors supplied.

> **NOTE: L-bolts are supplied as standard equipment for jack stand attachment, and these bolts must be properly installed when concrete is placed.**

The following procedure is used to lay out and install the required concrete pads:

1. Footings are located as shown in **Figure 2**. The "L" spacing locates four guy anchor pads (1-4) which are equally spaced from the center point of base pad 6. **Note that "L" refers to the distance to the nominal center of the guy anchor brackets, not to the "inner" edge of the pad.** The "inner" edge of these anchor pads is 15 in (38 cm) closer to the base pad 6. The "G" spacing locates the center of the gin pole anchor, and again the inner face of this pad is 21 in (53 cm) closer to the base pad. Finally, spacing "P" locates the jack stand pad, installed on the center line through pads 1, 5, 6 and 3. The construction details for all these pads are shown in Figures 3, 4 and 5.

   These pads are designed for normal soil strength of at least 4000 psf (19,500 kg/m^2). For soils of lower strength or low friction, such as pet or sand, larger pads will be required. Please contact BWC prior to installation for advice on proper footing size. Engineering analysis and custom footing design are available from BWC to assist customers or consulting engineers. For most situations, however, the standard pads will be appropriate.

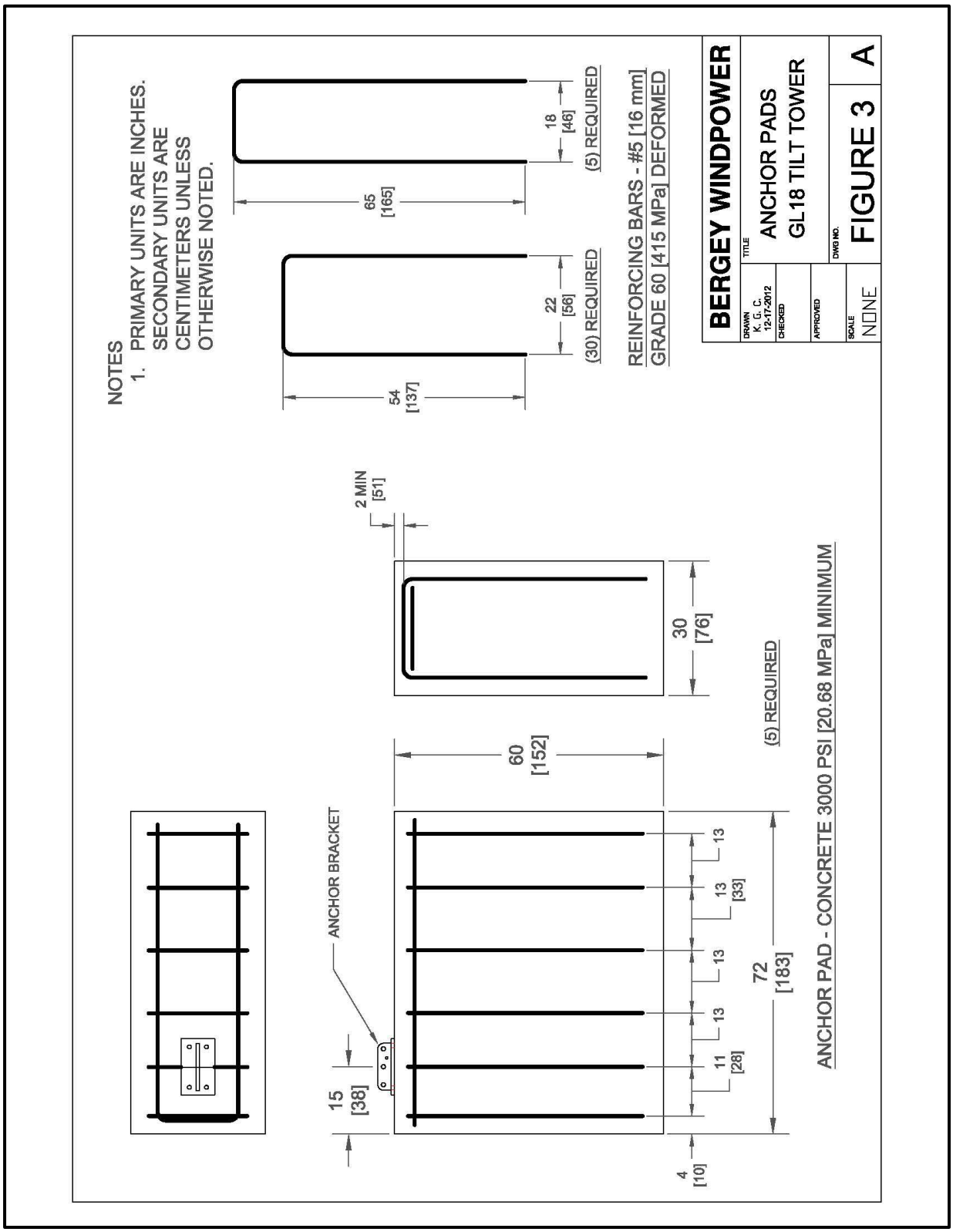


Figure 3. Anchor Pad Reinforcing Bar

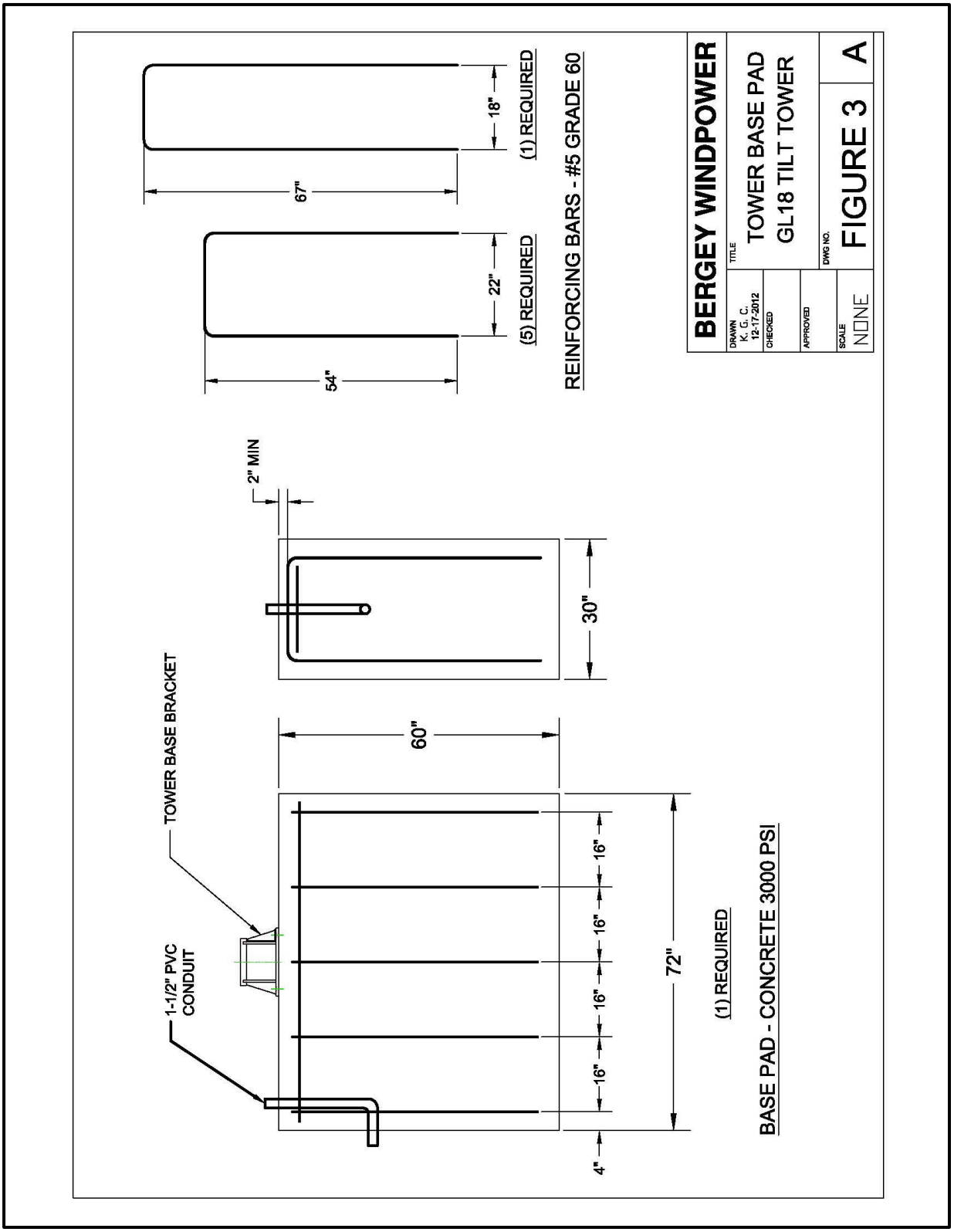


Figure 4. Tower Base Pad Reinforcing Bar

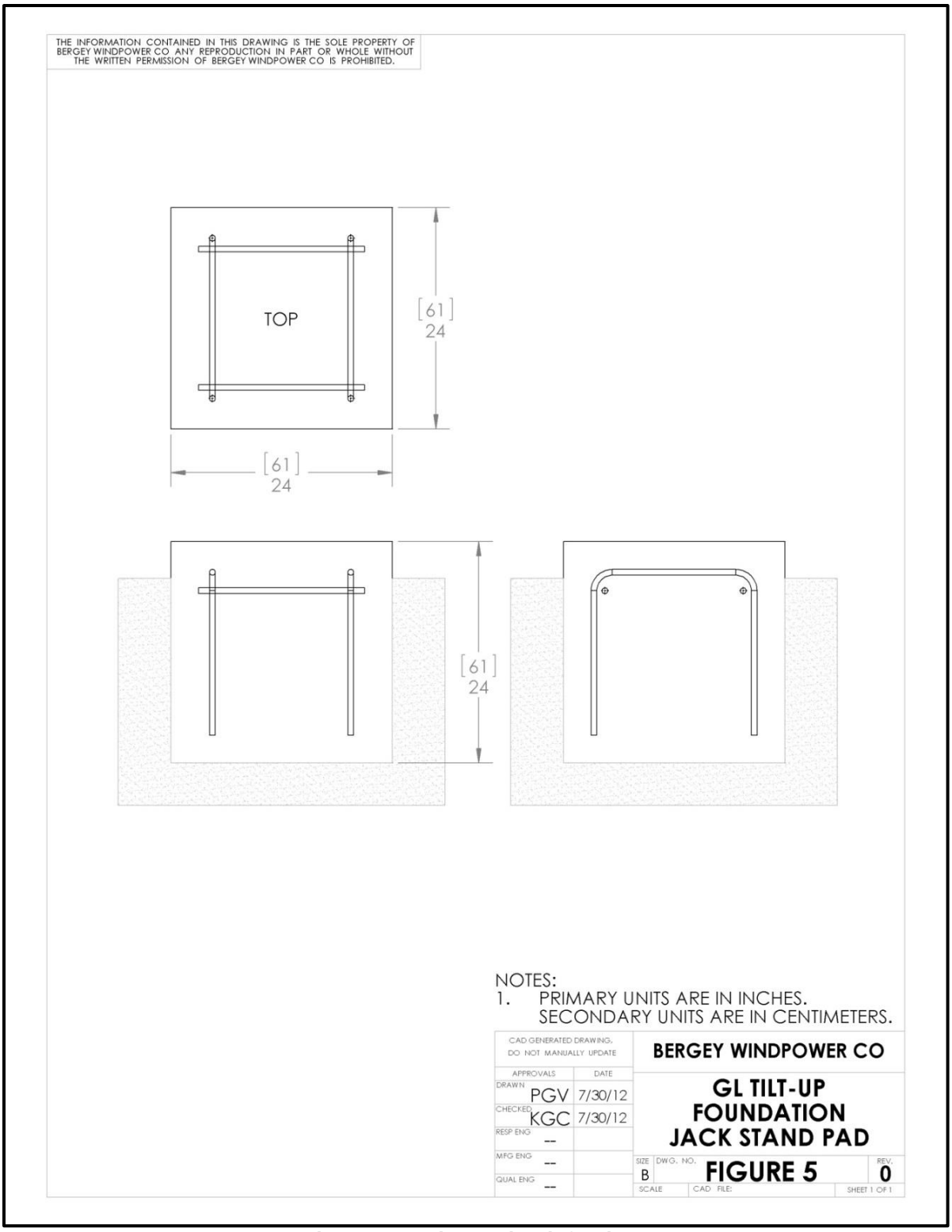


Figure 5. Jack Stand Reinforcing Bar

2. Use of a transit to locate footing positions and elevations is strongly recommended. Spend enough time to optimize the layout orientation and location, in order to minimize the difficulty of getting pads level and assuring proper tilt behavior and lifting cable run. A transit or builder's level must be used to assure exact elevation of concrete forms for pads 2, 4 and 6, as these forms are references for finishing the pads to the correct height. Failure to get these pads level will cause serious problems during raising/lowering operations.

3. Drive stakes at each pad location to mark the "inner" and "outer" extents of the pads, then additional stakes to accurately mark the actual pad dimensions. Carefully excavate to get holes of proper plan dimension and proper depth in correct locations. Remember that pad elevation adjustments may require excavation depth adjustments. Sides of excavations should be vertical, and all loose material should be removed. A backhoe is the recommended excavation equipment.

4. Tie rebar cages carefully, construct and set concrete forms accurately and with sufficient staking to prevent shifting or failure. Forms must be level within 1/2 inch (12 mm) in 5 ft (152 cm) length. Suspend rebar cages in the excavated holes, supported on the forms. Be sure rebar clearance is sufficient at all surfaces. **MARK REBAR LOCATIONS PERMANENTLY ON FORMS**, using saw marks, nails or other methods that will not be lost during concrete placement or interfere with concrete finish work. **In tower base pad #6 remember to *RIGIDLY* locate the electrical conduit that will lead to the planned electrical wire run.**

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

When placing concrete for the jack stand, be sure to properly insert the four 1/2 inch L-bolts included in the hardware kit. It is important to get these bolts properly arranged, and aligned. Use an accurately made plywood template with the four L-bolts double-nutted rigidly to the template. Do not remove the template until concrete is properly cured. A drawing for the template layout is shown below. Alternatively, the required holes may be marked on the template using the base of the jack stand as a pattern.

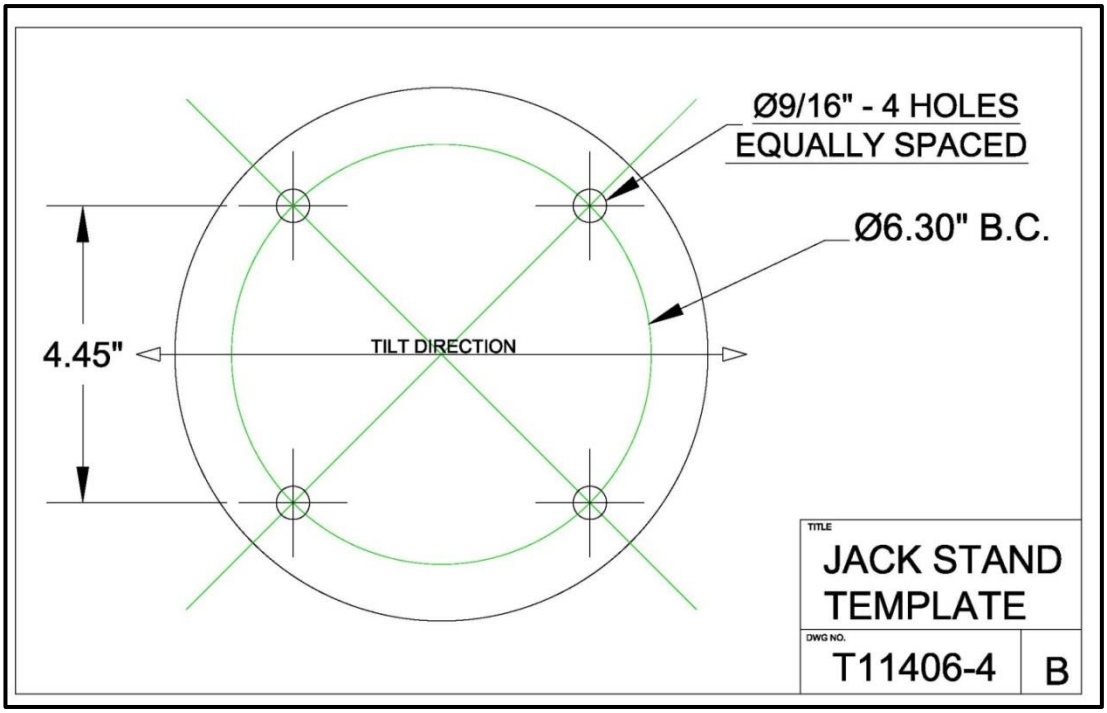
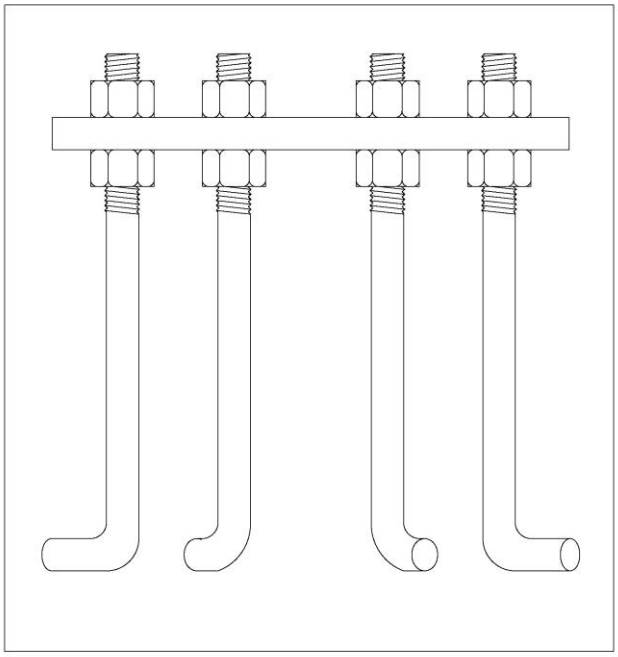


Figure 6. Jack Stand Anchor Bolt Layout



The picture to the left shows four L-bolts double-nutted to a plywood template 1/2" thick. This "cage" of bolts can be pre-positioned on the forms before the jackstand concrete is placed, or the bolts can be worked into the concrete after it is rough-finished. It is difficult to assure proper fill of concrete around all the anchor bolts using the insert-after-finishing method.

5. Place concrete carefully, using a vibrator to assure proper flow into all areas of the excavation and around rebar. Concrete must be at least 4000 psi (280 kg/m^2) strength, with maximum 4" slump. Hand mixed concrete may be used if care is taken to avoid dry spots, inadequate mixing, over-watering or improper fillers such as large rocks, shells, or other weak, low-quality materials.
    a. **BE SURE THE BOLT PATTERN IS ALIGNED PROPERLY IN THE CONCRETE.** The jackstand must be properly aligned so the tower fits properly in the horizontal cross-brace.
    b. It is important to ensure the concrete fills properly around all four bolts, or they will not provide the strength required to properly anchor the jackstand.
    c. Be sure to leave enough space between plywood and concrete surface to adequately finish the concrete. This is a tough proposition with a small pattern. The easiest approach may be to simply embed the lower nuts on the concrete and bring the plywood right down to the concrete surface to provide something close to a decent finish. If the template is slightly smaller than the jackstand base (8 inch) the concrete can be nicely finished right up to the edge of the plywood and any surface roughness will be hidden by the jackstand.
    d. Leave the plywood template in place until the concrete cures. Attempting to remove the template before adequate concrete cure will result in loose anchors and damaged concrete that will be unsuitable to secure the jackstand.

6. <u>After</u> surface puddle has been absorbed, finish the pad surfaces properly with a 3/4" radius at all corners. **TRANSFER REBAR LOCATION MARKS TO FINISHED MOIST CONCRETE.**

7. Minimum cure time for pads is 14 days, but for maximum strength 28 days is recommended. For both strength and surface finish quality, it is important to control the cure process. In hot conditions pad tops should be covered with burlap or similar material and watered down several times a day, at least for the first 3-4 days. In cold conditions the concrete should be covered and insulated to prevent freezing. For specific recommendations refer to a standard construction manual for concrete techniques.

C. Installation of Anchor and Base Brackets

NOTE: Read, understand and carefully follow the bracket instructions that follow. Correct location and orientation of all anchor/base brackets is critical for proper operation of the tower.

1. Use a chalk line to mark straight lines through the pads 2-6-4 and through pads 1-5-6-3. Start by accurately locating and clearly marking the center point of the tower base pad. Measure the radius from this center point to the inner face of each anchor pad (1, 2, 3, 4 and 5). This distance should be (L-1.25) ft +/-1 inch (2.5 cm) for pads 1-4, and (G-1.75) ft +/-1 inch (2.5 cm) for pad 5.

2. Find and mark the center point of each anchor bracket on pads 1-4 at radius L from the tower base center on the center line of each pad. Double check these locations by measuring the diagonal distances between adjacent center points. These distances should be equal within 1 inch (2.5 cm). Rework the bracket center points layout until the diagonal distances agree properly. Accurately mark the center point of the gin pole anchor on pad #5 at radius M on a chalk line mark between bracket centers on pads #1 and 6.

3. Mark two lines, one directed along the pad center line toward the tower base point and the other perpendicular (90°) to the pad center line, through the anchor bracket center points. Make these lines ~24 inch (60 cm) long so the brackets can easily be centered on them. Mark the base brackets to allow proper alignment of bracket centers over the intersections of these perpendicular lines.

4. Layout of anchor and base brackets is shown in **Figure 7**.

5. Use a magic marker to lay out cross lines through these chalk lines where anchor brackets and the base bracket will be centered. Anchor brackets will be centered 18" from the "inner" edge of pads, base bracket will be centered on the base pad. (It may be easier to mark pads 2 and 4 14" from the inner pad face, for side anchor brackets, and 12" from the inner face for fore/aft brackets as shown in **Figure 7**. The front edges of the anchor brackets can be set on these lines. Be sure the brackets are aligned properly.

6. Placement of the tower base bracket is important, because misalignment may position the gin pole turnbuckle attachment point far from the anchor bracket. Misalignment will also cause problems during tilt operations.

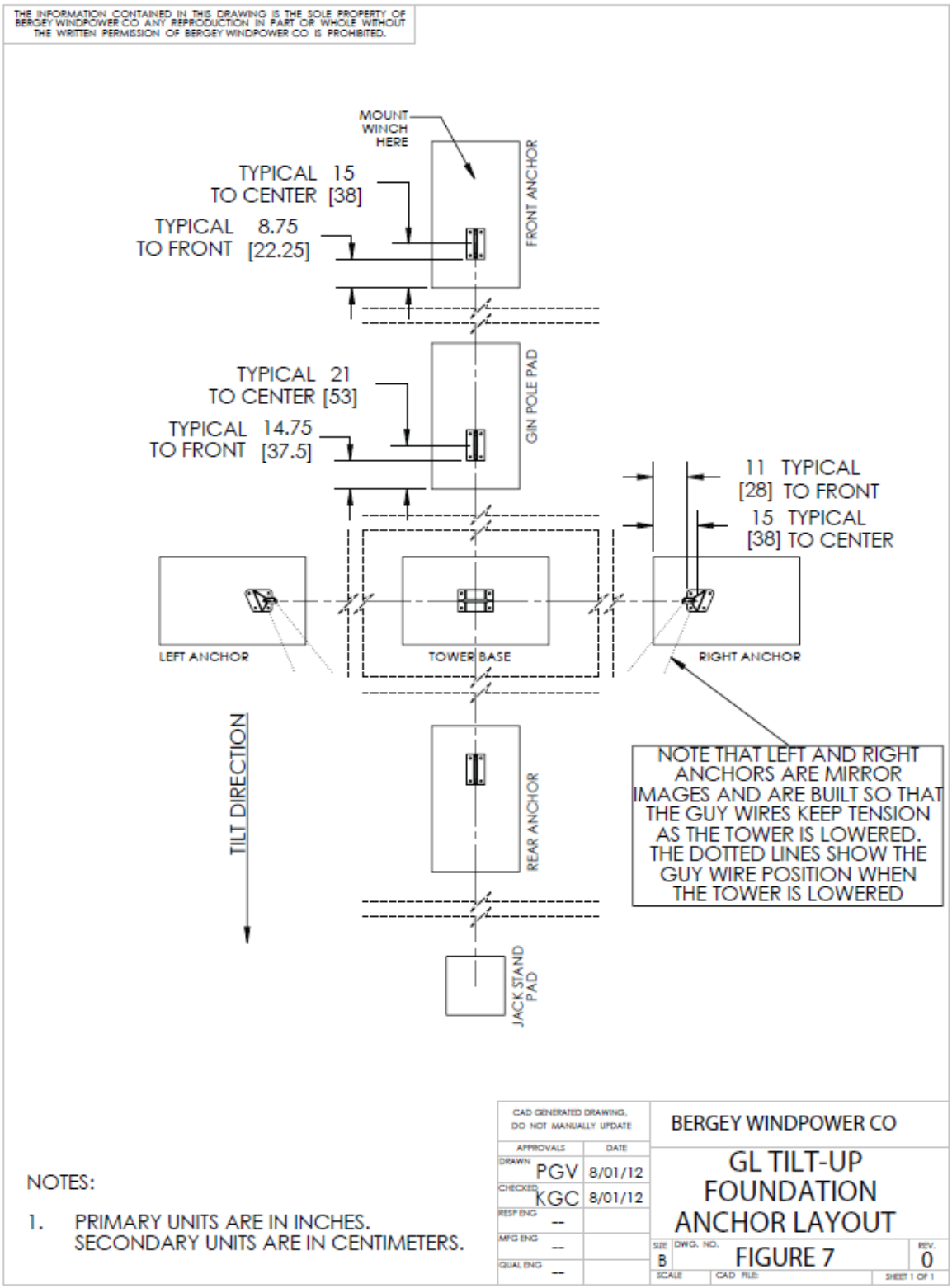


Figure 7: Anchor Bracket Layout Summary

7. Lay out all anchor and base brackets in proper position and orientation. Fore and aft brackets (three large holes, pads 1, 3 and 5) should have the small grounding attachment hole oriented *away* from the tower base. Side anchor brackets (two long tabs on odd angles) present the most challenge. They must be oriented so the tabs lean in toward the tower base, with the angled face of the base plate *away* from the tower base. The long side of the bracket will face toward the gin pole side of the tower, the short side will face toward the jack stand side of the tower, and sighting along the angled face of the bracket from long side to short side will aim at anchor pad #3. The drawing and photos below illustrate this critical layout concept.

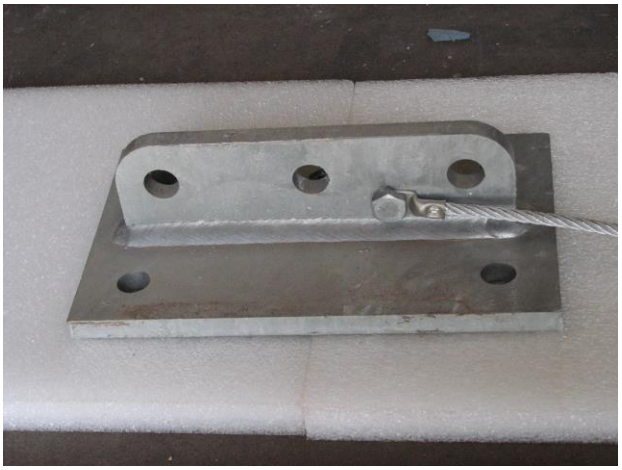
   Mark the center of base pad #6, then lay out the correct radius L or G and the pad lateral center line anchor bracket on pads 1-5. **Double-check locations by measuring diagonal distances 1-2, 1-4, 3-2 and 3-4. These distances must not vary by more than 1 inch (2.5 cm). The same agreement for distances 5-2 and 5-4 must be maintained.** Chalk-string lines should be used to assure linearity of the center marks 1-4-6-3 and 2-6-4, or a transit can be used to accomplish the same task.

   Through the center point mark for each bracket, lay out 90° lines with one line oriented radially (toward the tower base.) Make these lines long enough, ~24" (60 cm), to project beyond the base plates of all brackets. Measure bracket base plates and use a permanent marker to make small center marks on each plate edge. When these center marks are aligned with the 90° lines,the brackets will be correctly positioned. Mark holes and drill.

   The tower base bracket alignment is very important, because any misalignment will prevent proper operation of the gin pole. Exercise extreme care to assure the 90° cross marks for this bracket are perfectly aligned along the 2-4 and 3-5 bracket axes. Again, the chalk line is probably the best way to insure this alignment.

Left (pad # 2) Anchor Bracket

Right (pad #4) Anchor Bracket



Fore-aft Anchor Bracket with Grounding Cable

8. Using the guy and base brackets as templates, mark the pads clearly using magic marker. Use a 7/8" hammer drill to accurately drill holes 10.25 inch (26 cm) at each marked location. Be sure the drill bit remains vertical while drilling. **Start with the lowest possible hammer rate until the hole is started in the correct position. Have a spotter check to insure the drill remains vertical in N-S and E-W directions.**

   NOTE: The anchor studs must not project too far above the concrete, or they will interfere with some of the anchor hardware. We recommend determining the best depth by screwing a nut onto the shortest stud until two or three threads come through. Put the stud through one of the anchor bracket holes and measure the length projecting through the plate. Mark this length on the hammer drill bit with a depth gauge or a ring of masking tape. Drill all holes until the tape ring reaches the concrete surface.

9. *THOROUGHLY* blow all dust out of the holes using a 2 ft (60 cm) length of flexible plastic tubing. Protect eyes from the blowing dust, and plug each clean hole with a rag or paper towel to keep out dust. Blow all dust from the pad surface after holes

are clean, then remove the protective material. **Failure to thoroughly clean the holes will significantly reduce anchor strength and could cause system failure.**

10. BWC supplies six (6) tubes of adhesive with nozzles in each tower kit. To assure proper anchor strength, a fresh tube should be used for each anchor. If a partially used adhesive tube or mixing nozzle is not used for a period of 10-20 minutes, the adhesive will harden and the materials must be discarded.

11. Attach one bracket at a time. Set the anchor bracket in place over the drilled holes, screw nuts onto each anchor stud, then adjust nuts so each stud can be fully inserted into the hole with the nut firm against the bracket base plate. Remove **ONE** stud and then inject adhesive into the bottom of the hole to fill the hole one-third full. Slowly insert a stud into the hole and **spin the stud to assure complete adhesive contact with both stud and surface of the hole.** Be sure to insert the stud until the nut seats against the bracket. A small amount of adhesive should be forced out of the hole. Repeat the process for all four studs of the bracket. Repeat this procedure for all anchor and base brackets.

WARNING: Do not disturb anchor studs before adhesive is fully cured. Glue one stud at a time while leaving the other three in place.

12. Avoid getting adhesive onto the thread surfaces projecting above the anchor bracket, because the threads must be clear to allow proper adjustment of retaining nuts. If the threads become fouled with adhesive, allow it to cure and then remove it with a proper thread chaser.

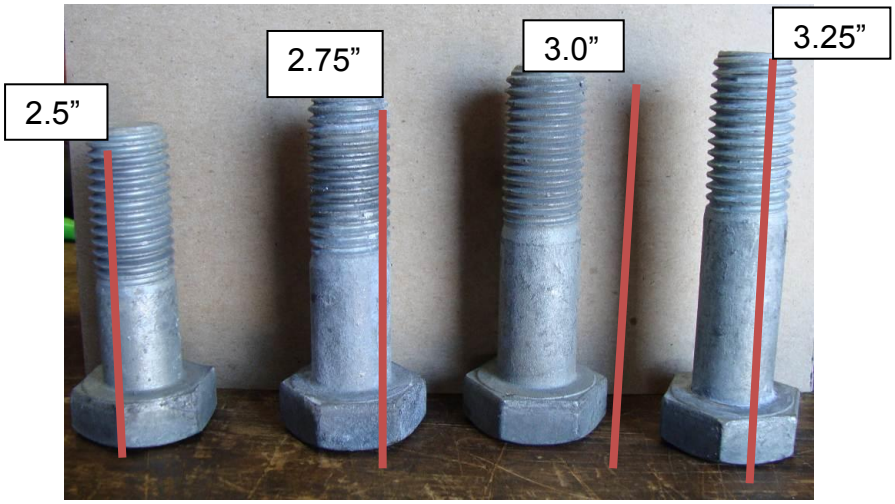
13. If a permanently-mounted winch is to be used to raise/lower the tower, it can be installed at this time. The winch can be located on pad #5, outboard of the anchor bracket. (If the winch is mounted on pad #6, providing a better "fleet angle" and lower attachment bolt stress, a longer tower raising cable {420 ft} will be required for a 100 ft [30m] tower. Consult with the BWC factory.) The method for attaching the winch to the pad will depend on the manufacturer's recommendations, but once again be sure to avoid problems with reinforcing bar in the concrete. The photos below show a winch installation on pad #5 that does not allow use of a snatch block, because the winch is too close to the gin pole anchor bracket. The cable is rigged directly from the winch to the double block on the gin pole. An improved system would put the winch on pad #1, or farther outboard on pad #5, with the cable running first to a snatch block pulley attached to the gin pole anchor bracket before running up to the gin pole block for the first leg of a 4:1 or 5:1 rigging system.

14. Install copper-clad ground rods in desired locations near all anchor pads and base pad. Keep the rods close to the concrete pad and drive them to below the soil surface to avoid later problems with mowers and other equipment. If the rods cannot be driven in the full 8 ft (2.5m), it is advisable to drive extra rods and connect them. A 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. Consult BWC if unusual grounding conditions are encountered.

15. Connect the ring lug of each grounding cable to one of the anchor/base brackets using the 1/2" x 1-1/4" galvanized bolts provided with the tower hardware kit and firmly attach a bronze grounding clamp to each rod. Run the grounding cable along the surface of the concrete pad, over the edge of the pad, and connect at the grounding clamp. Make sure all connections are secure and tight. The cable is difficult to cut, so excess cable can simply be buried.

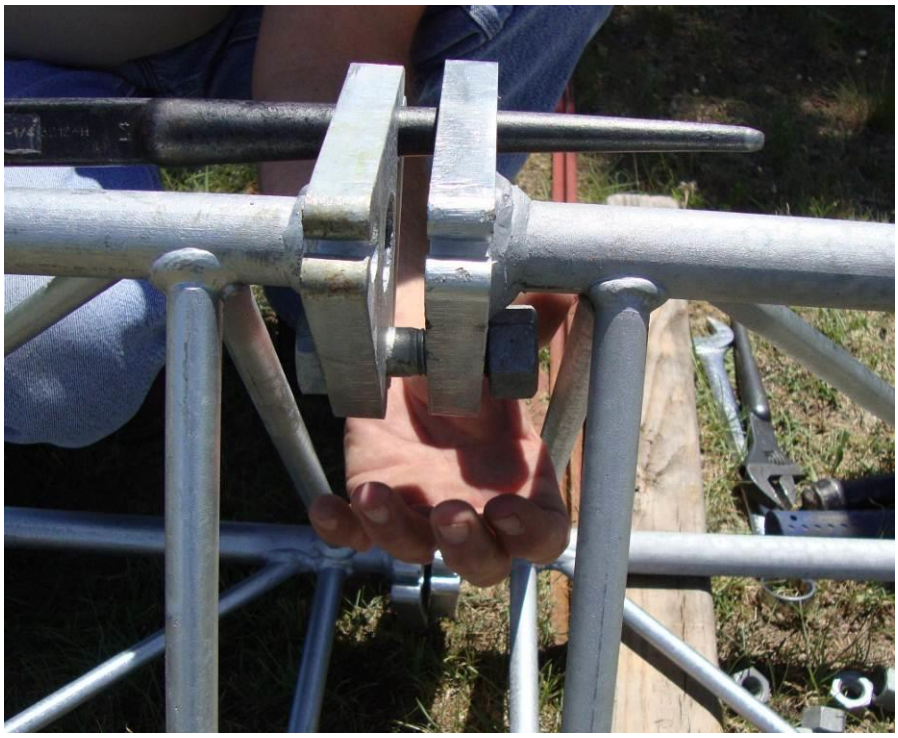
IV. Tower Assembly

All tower sections are bolted together with nine (9) 3/4" x 2.75" bolts, three per leg. There are four different lengths of 3/4" bolts provided in the kit. Sort the bolts to separate ***ALL*** bolts by length, and use proper bolt lengths at all locations. Proper length will assure adequate space for installation of the PAL lock nut. Note that unthreaded shank length increases with bolt length. ***Use of a bolt that is too long will prevent proper joint tightness and lead to failure of the joint.***

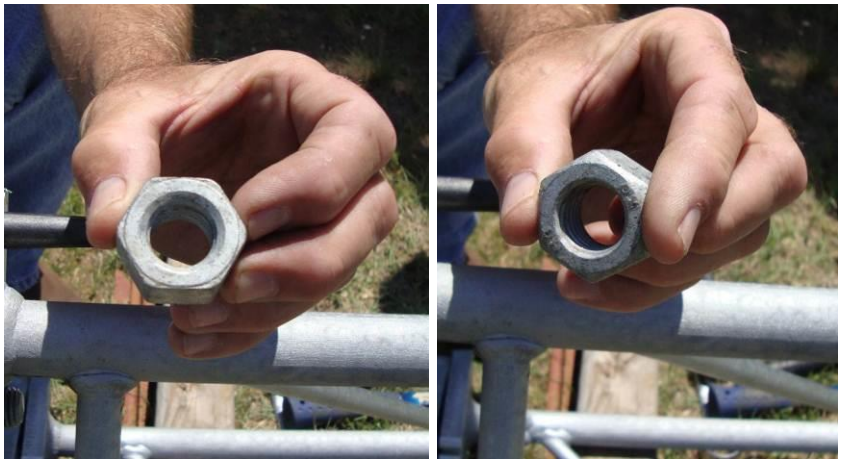


Get proper tools ready. To make installation easier, you will want two spud wrenches, one 1-1/4" and one adjustable (for aligning holes and tightening bolts), a bullpin (to clean out excess zinc), a hammer, and a 1-1/4" box end wrench.

A spud wrench, 18” or longer, can be useful in aligning the flanges of the sections being bolted together. Connect the bolts on the inside of the tower first. Use the 3/4”x2.75” bolts for flange 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.



The pattern of lattice diagonals at joints involving guyed sections will be inconsistent in some tower heights. The photos below show two different diagonal patterns that might result. Either of these patterns is acceptable. The orientation of each individual section is a cosmetic issue, and does not affect the tower's strength.

A. Assemble Tower and Guy Cable Systems

Prepare the installation area for tower erection, clearing the entire area to allow proper, safe activity. Assemble the tower as follows:

1. Lay the base tower section on timbers, close to the base pad. The winch plate and switch plate should be oriented upward so they will be accessible, and the base plate should face the hinge pin bracket. Attach the slotted hinge adapter to the tower base plate with four (4) 3/4"-10 x 2-1/4" bolts, two bolts on the upper corner and one bolt on each lower corner.

2. Continue to attach more tower sections, properly supported on timbers, until the first guyed section is completely attached. It is a good idea to gradually increase the height of timber supports, so the tower will angle slightly upward to allow access to guy lugs on the bottom of the tower. This lower face of the tower is sometimes called the "away" face because it will face away from the gin pole when the tower is fully assembled.

   NOTE: Carefully orient sections with guy lugs attached. The heavy C-channel must always be on the bottom to provide proper, consistent position and orientation of guy lugs and guy cables.

Figure 8 shows guy heights and guy radii for GL18 Tilt towers 60-100 ft in height. To locate lower guy lugs at proper height, the lower guyed section should be turned so the guy lugs are near the top (60 ft tower) or near the bottom (80 and 100 ft towers.) The section layout for tilt-up towers is summarized in Table 3. A summary of guy heights for GL18-Tilt towers is given in Table 4.

Table 3. Layout of Sections for GL18 Tilt Towers

60 ft (18m) Tower	80 ft (24m) Tower	100 ft (18m) Tower
Base Section	Base Section	Base Section
Standard Section	(2) Standard Section	(3) Standard Section
Guyed Section - lugs up	Guyed Section - lugs down	Guyed Section - lugs down
(2) Standard section	(3) Standard section	(4) Standard section
Top Section - lugs down	Top Section - lugs down	Top Section - lugs down

Table 4. Guy Levels for 60 - 100 ft (18 - 30m) GL18-Tilt Towers

	60 ft	**80 ft**	**100 ft**
Top	51.8 ft	71.8 ft	91.8 ft
Bottom	28.3 ft	31.8 ft	41.8 ft

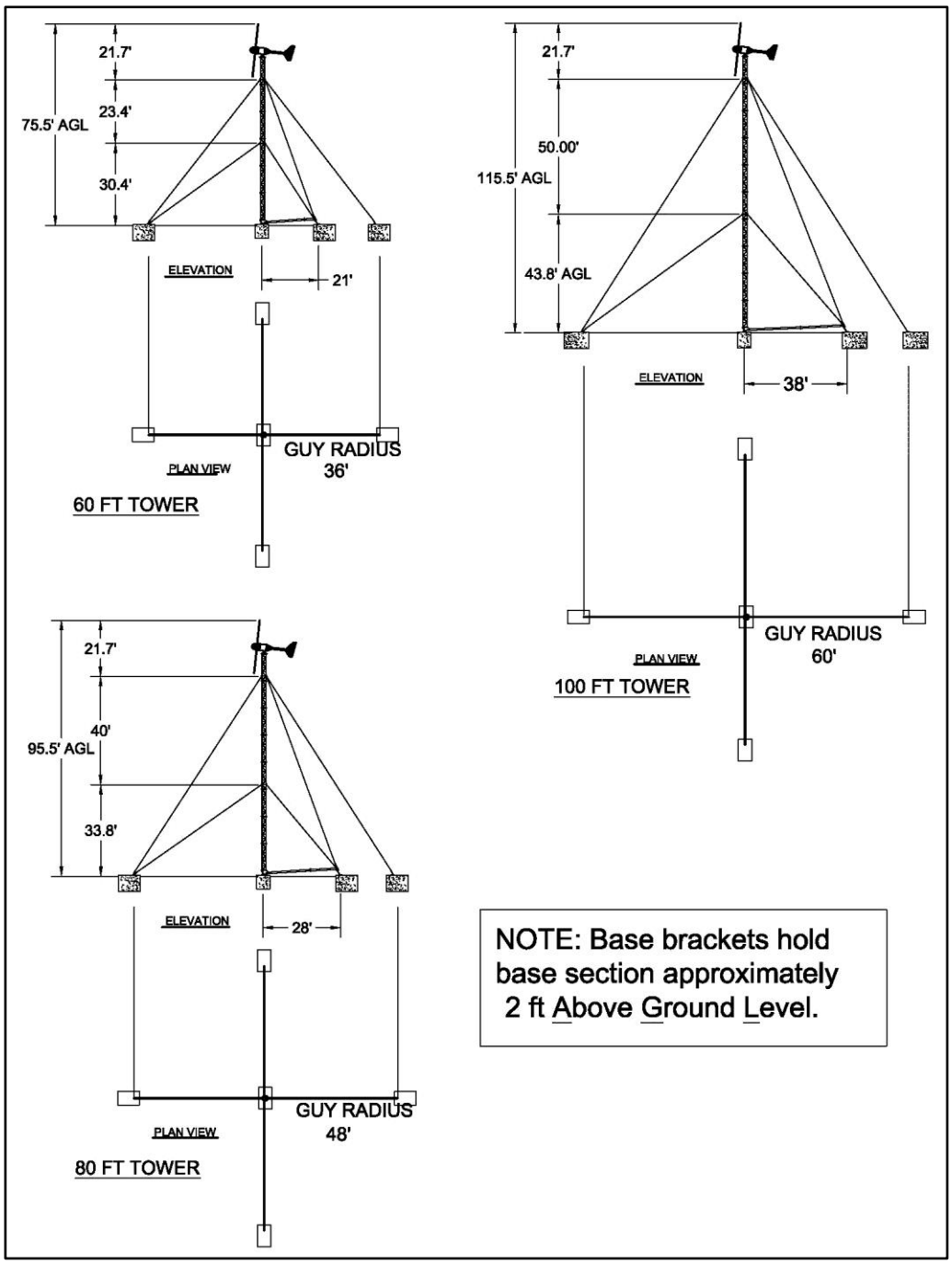


Figure 8. GL18-Tilt 60-100 ft Tower Configurations

3. Extend all 7/8" and 5/8" turnbuckles to their maximum length. Install 5/8" thimbles on the eye of four (4) 7/8" turnbuckles, a 9/16" thimble on the fifth 7/8" turnbuckle, and 3/8" thimbles on all four 5/8" turnbuckles.

   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.

4. *A*ttach the jaw end of a 7/8" turnbuckle (with the 5/8" thimble) to the outside position on the anchor brackets of pads 1-4. Attach the jaw end of a 5/8" turnbuckle to the inner position on anchor brackets 2-4. Attach the 1" jaw-jaw turnbuckle to the innermost hole of the gin pole pad bracket.

5. Unroll all the guy cables 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.

6. Connect the lower guy cables to the lower corner guy lugs of the guyed section using the supplied hardware. Secure the attachment shackle with the included nut, and employ a stainless steel cotter pin to retain the nut. Run the attached cables to the 5/8" turnbuckles on the side anchor brackets (pads 2 and 4.) Pull each cable through the turnbuckle eye as tight as possible by hand, or until the cables are just off the ground, double the cable end back on the main strand, and secure the resulting loop using a proper fist grip clip. Do not apply full torque to the fist grip nuts at this time; torque only to 50-60% of full torque specification. If possible, pull cables taut without adjusting the turnbuckles to increase tension. These two side cables will hold the tower in place on the base hinge.

The photos below show the anchor and hardware for the “left” pad #2.

7/8” turnbuckle furthest from tower
5/8” turnbuckle closest to tower

NOTE: The easiest method to pull a cable tight is to run the cable through the turnbuckle eye, hold the free end tight against the main strand, loosely install a fist grip on the joined cables, then pull the cable tight and be sure it is properly seated in the thimble. 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. While maintaining tension, ram the fist grip as close as possible to the thimble. It should almost touch the thimble- the tighter the better. Tighten the nuts on the fist grip to secure the loop. ***DO NOT OVER-TORQUE THE NUTS OF THE FIST GRIP CLIPS!*** Turn one nut a bit then turn the other. Continue this alternate tightening until the grip is tight. 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.

7. Continue to add sections and build the tower until the top section is in place. Attach 5/8” cable assemblies to the lower corner guy lugs of the top section, and attach these to the 7/8” turnbuckles on the side brackets #2 and #4 similar to the steps previously mentioned.

8. For the third set of upper and lower cables, use the cables already connected to help determine the length, and attach to the turnbuckles on pad 3. Be sure to leave extra cable in the event that the bases are not perfectly level.

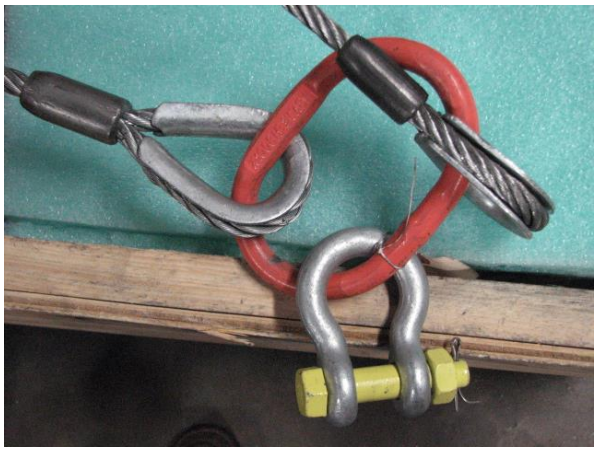
9. Set the inboard gin pole section (3 holes at pipe end) on top of the tower. The pipe end should be set between the plates of the base adapter, while the flange end is held in place by a cradle formed from crossed 2x4 timbers or similar strong pieces fastened to the gin pole with chain or strong cable. (One of the 1/4" safety cables and malleable clips can be used.) Align inner hole of gin pole with upper hole in base adapter.

10. Set ***ONE*** long (9.5 inch) bolt through the adapter plate-gin pole assembly, using the ***INNER*** hole in the gin pole. This will act as the hinge point to allow the gin pole to be moved into the vertical orientation. Secure the bolt with a nut, but do not tighten the nut more than finger tight.

11. Set the outer gin pole section in place, using another cradle on the outboard end and bolting the flanges together to secure the inner end. **NOTE: The wide part of the end "hatchet" plate should be oriented upward.**

12. Attach the double cable set (large oval ring) with the 3/4" shackle to the upper (near side or gin pole side) guy lug on the tower top-section . The 5/8" cable should be closest to the TOP of the tower, the 1/2" cable toward the bottom of the tower. Attach a 3/8" cable assembly to the gin pole side guy lug on the lower guyed section.

13. Connect the 1/2" cable to the eye of a 7/8" turnbuckle and adjust the total length of the cable-turnbuckle assembly according to the table below. Attach the jaw of the turnbuckle to the nearest hole on the SMALL side of the gin pole hatchet plate. This short cable assembly will run only to the end of the gin pole and not to the larger anchor radius. Leave the 5/8" cable hanging loose until after the tower is tilted erect. Connect the 3/8" cable assembly from the lower guyed section to a 5/8" turnbuckle and adjust to the length shown in the table. Attach the turnbuckle to the other hole in the small part of the hatchet. **Table 5** shows *approximate* lengths for the 1/2" and 3/8" cable-turnbuckle assemblies that attach to the gin pole for each tower height. These lengths will be adjusted later to provide exact gin pole position and cable tension. **If anti-corrosion grease will be used on guy cables, the 1/2" and 3/8" gin pole cables should be coated at this time.**



Double-cable for top connection on gin pole side.

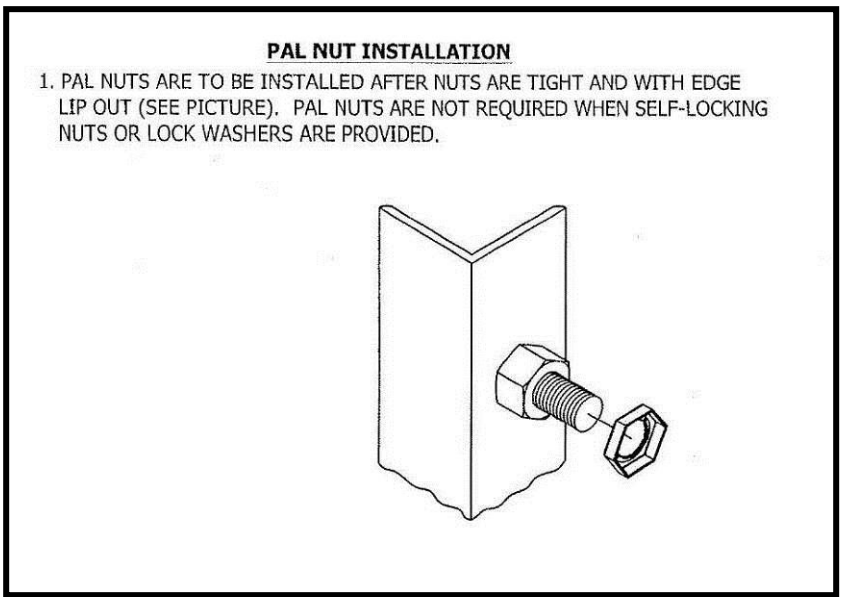
Table 5. Top Gin-pole Cable Assemblies

Tower Height (ft)	1/2" Cable Assy. (ft)	3/8" Cable Assy. (ft)
100	97.1	53.5
80	75.3	40.0
60	54.2	33.0

14. Properly secure all tower and gin pole flange connections. **Use a torque wrench** on all connecting bolt **NUTS**. *The proper tightening torque on all section coupling fasteners is **205 ft-lbs (280 N-m)**.* A method of "full contact plus one-quarter turn" on the heavy duty nuts may be used if a torque wrench is not available. Be sure to use PAL nuts on **ALL** 3/4" hardware. Only one of the long gin pole attachment bolts is installed at this point, and the turbine is not yet attached. They will be torqued and get PAL nuts later.

    In addition, all nuts on fist grip clips will require PAL nuts after the tower has been erected and plumbed.

WARNING: PAL nuts must be installed with correct orientation. Be sure the folded-up edges of the nut is pointed **away** from the heavy duty nut it is locking, as shown in the sketch below.



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

B. Install Tower Raising Kit and Set Gin pole in Place

1. Attach one double block at the OUTER hole on the long side of the hatchet plate (gin pole end plate.) Put the second double block on the MIDDLE hole of the gin pole anchor bracket (pad #5.) Attach the toggle block (snatch block) to the OUTBOARD hole of this same anchor bracket. Refer to Figure 9 for proper placement of double blocks and snatch block.

2. Rig the 4:1 cable system, as shown in **Figure 9**, using the 3/8" x 330' cable provided with the kit. Be sure all cable and fitting connections are tight and secure.

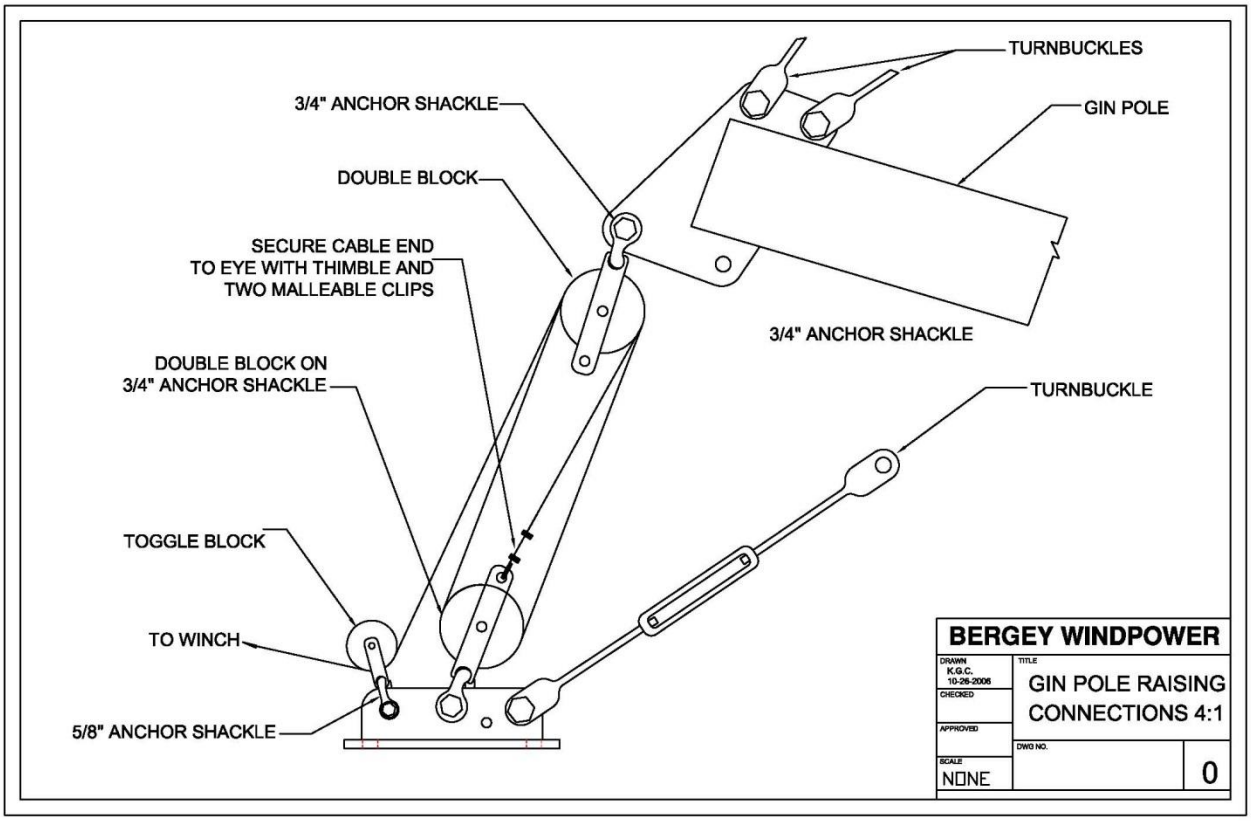


Figure 9. Rigging 4:1 for Raising Gin Pole

3. Construct a cross-tree using strong 4 x4 timbers with the fork 6-8 ft high. Position the cross-tree near the base of the tower, between the gin pole anchor and the tower base. Support the tower raising cables in the fork as high above ground as possible, to create the cable angle that will rotate the gin pole upward as the cable is wound onto the winch. The photos below show the jack stand being used for this purpose, and are included here only to illustrate the procedure. BWC recommends using the timber cross-tree because it is safer and more stable.

4. Continue rotating the gin pole upward until *slight* tension is exerted on upper and lower guy cables. Check to see if gin pole holes can be aligned with base adapter holes. If so, insert the two remaining 9.5" bolts and secure them with nuts and PAL nuts. If the holes cannot be aligned, assess the turnbuckle/cable length adjustments that are required. Lower the gin pole, make necessary changes and repeat the raising procedure. Continue this process until the gin pole can be fully bolted with a small amount of tension in the guy cables. (Note: Remember to position the cross-tree under the cables when lowering the gin pole.)

C. Raise and Plumb the Tower

WARNING: *NEVER* install the turbine until after the proper tilt operation of the tower has been fully tested. Always do a test raising operation of the tower without an installed turbine.

WARNING: Without the turbine installed the gin pole weight will cause the tower to snap into the vertical position suddenly. The gin pole will drop into place with considerable force, unless the tower motion is slowed with a rope as described below. Never stand in the path of either tower or gin pole during tilt operations.

1. With the gin pole properly bolted in place, use the winch system to raise the tower until it is just clear of the ground. Make sure the tower is straight and properly aligned with the anchor bracket on pad #3 (the away-side pad.) Adjust side guy cables until the tower is straight and alignment is correct.

   When the side cables are properly adjusted, two of the gin pole attachment bolts should be easily turned with a wrench. If this is not possible, there is probably a problem with alignment of at least one component in the anchor bracket-base bracket-guy cable system. Assure that guy cable lengths are the same on both sides of the tower, check distances between anchor brackets, and do not continue with the installation until the problem is found and corrected.

2. Tie a long piece of rope to one leg of the tower near the base and place a shackle or pulley on the away-side (pad #3) upper guy cable so it can slide freely on the cable. Pass the free end of the rope through the shackle and back past the gin pole anchor (#5). This rope will be used to help control the tower raising process. Commence pulling hard on the rope when the tower is tilted up to ~60° above the horizontal.

3. Continue the tower raising operation and monitor the alignment of the gin pole, tower and anchors 3 and 5. These elements should remain in a proper vertical plane.

4. Stop the raising operation periodically to check side guy cable tension. If brackets were installed correctly tension should remain constant, but it is important to assure that tension does not get too high. Adjust side anchor turnbuckles as necessary.

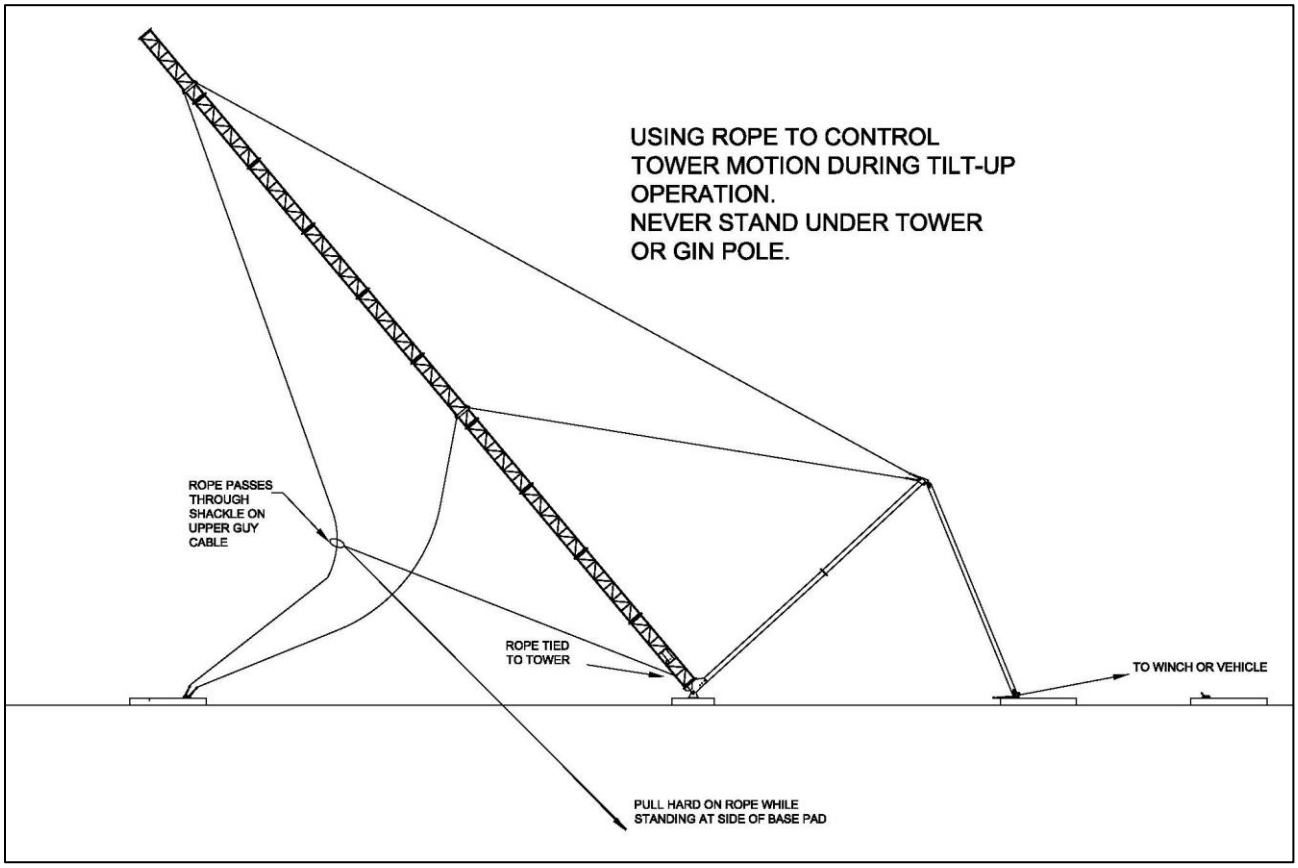


Figure 10: Using Rope to Hold Tension on Rear Guy Cable

WARNING: Failure to monitor side guy cable tension is the single most common error during tilt tower installation and operation. Problems caused by incorrect height and/or position of side and base brackets show up during the raising and lowering operations, and must be controlled by guy cable adjustments.

5. Raise the tower to full upright position, controlling the final stage by holding tension on the control rope. The gin pole should come to rest in a position that will allow proper use of the 1" jaw-jaw turnbuckle to anchor it in place. Install the jaw-&-jaw turnbuckle to the open hole on the "hatchet" plate to anchor the tower in the upright position. Re-rig the tower lifting system to the 5:1 system shown in **Figure 11**.

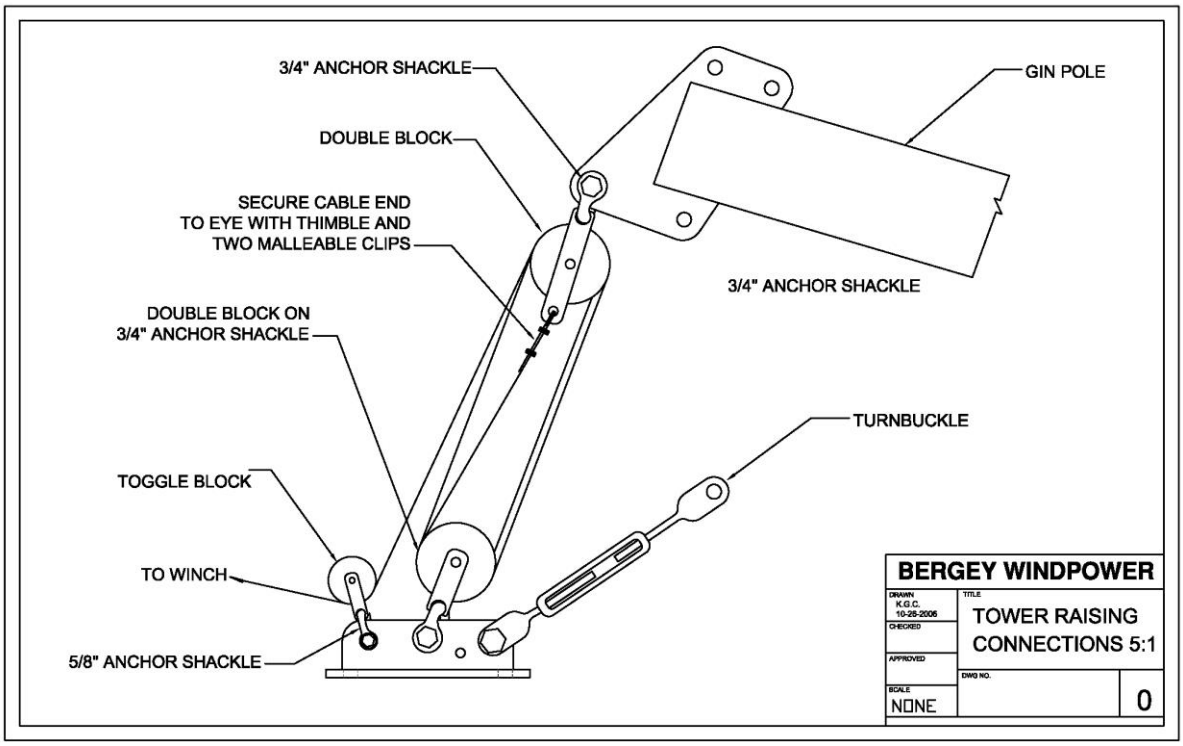


Figure 11: Rigging 5:1 for Tower Tilt Operations

6. Adjust tower plumb and guy tension using turnbuckles. **AT LEAST 50% of turnbuckle adjustment must remain after tower is plumbed.** If this adjustment cannot be achieved, the tower must be lowered, cables adjusted as necessary, and the raising/plumbing process repeated until the system is properly adjusted. See (8.) for proper tilt-down procedure.

WARNING: Guy cables behave like string or rope. They stretch and twist under tension. Turnbuckles will need adjustment after the cables have had time to stretch fully. The cables will try to twist during this process, and the twisting action can unscrew a turnbuckle in just a few hours if the turnbuckle is not properly secured.

7. The 5/8" upper guy cable on the gin pole side continues to hang loose at this point. It will not be connected to anchor bracket #1 until the turbine is connected to the tower and the system is ready for operation.

8. After proper cable adjustment and tower operation are assured, disconnect the 1” turnbuckle and lower the tower to install the turbine and associated hardware. To start the process of lowering the tower, it will again be necessary to exert strong pull on the control rope to "break the tower over" and overcome the weight of the gin pole. **NEVER ALLOW THE PERSON PULLING THE ROPE, OR ANY OTHER PERSONNEL, TO STAND WHERE EITHER TOWER OR GUY CABLES COULD FALL IF CONTROL OF THE TILT OPERATION IS LOST.** Once the tower is tilting down smoothly under its own weight the rope tension is no longer required.

9. Monitor tension in side guy cables during the lowering operation. Development of slight slackness in the cables is acceptable; very high tension must not be allowed to develop. Watch out for the turnbuckles on anchor #3. If they are projecting upward so the tower might come down on them, carefully reach under the tower and flip the turnbuckles so they will lie flat.

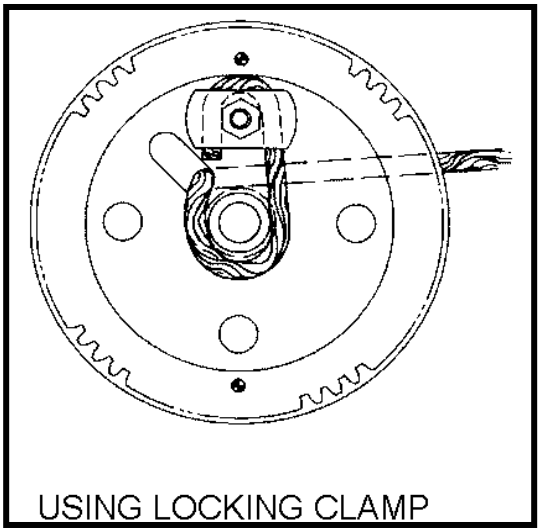
10. Do not install the jack stand yet. Lower the tower onto cribbing or some other strong, stable support that will allow the tower top to come within ~4 ft of the ground. This will allow easy installation of the turbine and associated equipment. The support structure should be located just below the top guy bracket.

D. Install Furling Cable and Winch

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:



E. Install Tower Wiring and Disconnect Switch

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: 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.

V. Wind Turbine Assembly and System Erection

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. The turbine cannot be lifted without a crane, but it should be on a truck or other suitable device for delivery to the tower site. Back the truck up to the tower top so the turbine lower plate is lined up with the tower top plate. **Feed the furling cable through the large hole in the center of the tower top plate** as the turbine approaches the tower. Use the winch to raise the tower, or adjust support material to lower the tower as required. Do not get under the tower during these maneuvers. Be careful to avoid damaging the furling cable while moving tower or turbine.

3. It will probably be necessary to tilt the turbine in order to install the six (6) 3/4" x 2.5" turbine attachment bolts (included in the tower hardware kit.) Partially install two of the attachment bolts in the lower region where the two plates come close together, using tower height adjustments and a spud wrench, so they will hold the system in proper alignment. Pull them snug, but the plates will not yet pull together completely. Use a 2 x 4 or similar pry bar to lift the end of the turbine skid and tilt the connection plates together so more bolts can be installed. Continue to tighten installed bolts and tilt the turbine skid until all six attachment bolts can be installed, torqued and secured with PAL nuts.

4. Use the winch to lift the tower and powerhead, still attached to the shipping skid, until the tower top is approximately 8 ft (2.5m) off the ground, support the tower with cribbing, then install the jack stand. Raise the tower slightly, remove the cribbing,

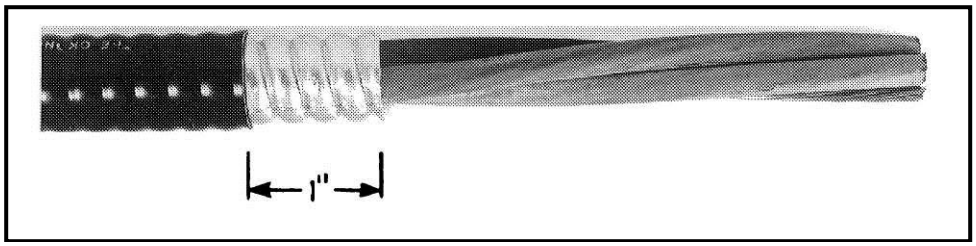
and set the tower down firmly on the jack stand. Remove the shipping nuts from the blade studs, pull the skid free from the alternator and set it aside out of the work area. (It may be easier to pull the truck away to make removal of the skid easier. If this is done, the truck should be returned to its position under the powerhead to make installation of tail boom and blades easier.)

WARNING: *NEVER STAND UNDER A TOWER SUPPORTED ONLY BY THE WINCH CABLE!*

B. Complete Turbine & Tower Wiring Connections

Make electrical connections to the turbine as follows:

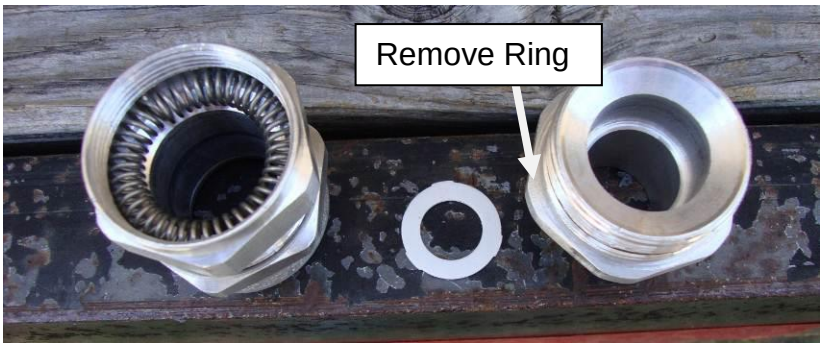
1. Remove the stainless steel cover of the terminal block housing.



   a. Strip the tower top end of the armored cable as shown, 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. Cut off green ground wire at both ends of the cable. It is not needed for this installation.

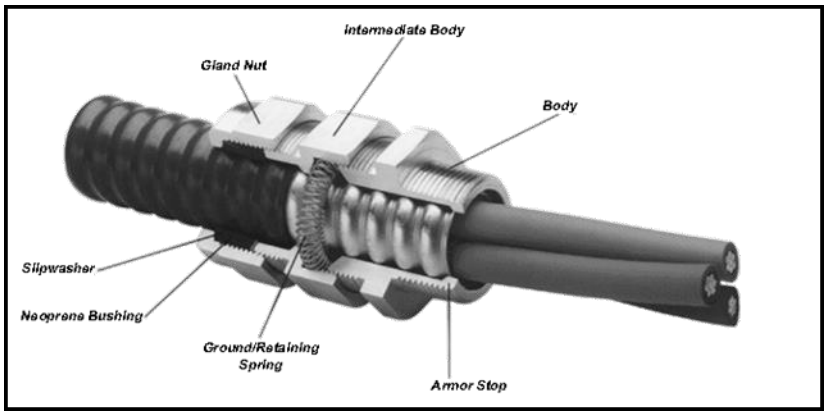
NOTE: Leave at least 8” of insulated conductor exposed beyond the armor.

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

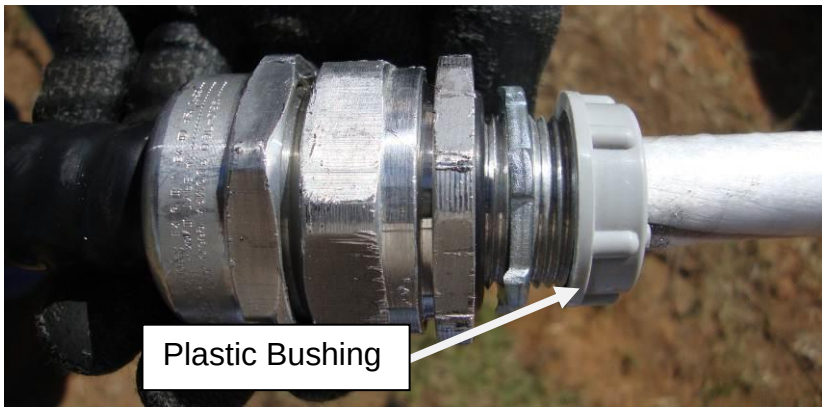


b. It is best to install the connector on the cable before installing the assembly into the junction box. Disassemble the fitting, and remove the plastic ring. Reassemble the fitting.

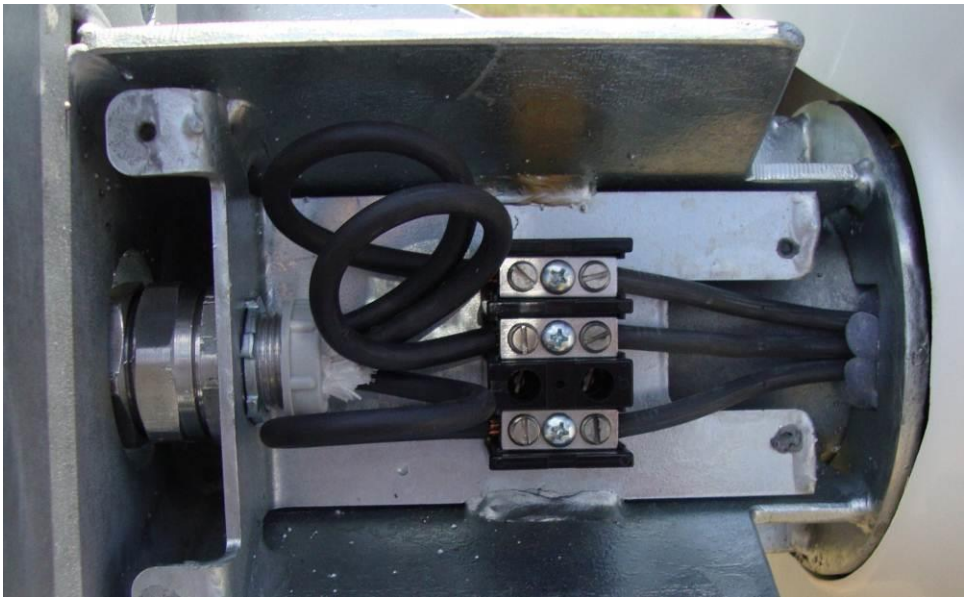
c. Insert the prepared cable into the fitting until the armor rests against the armor stop. Tighten both the intermediate body and the nut to **42 ft-lb (70 N-m)**. Insert the fitting, through the large off-center hole in the tower top plate, into the bottom of the terminal block area. Add the electrical 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 the armored cable below the tower top, so 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 described later 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 U-bolt 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

Attaching the tail boom to the powerhead is a job that requires at least three people. If the truck can be used as a work platform it will make the job much easier. If the truck is not available, use the winch to lift and position the turbine as required. It may be necessary to

remove the jack stand and lower the turbine/tower closer to ground level to attach the tail boom to the powerhead. DO NOT STAND UNDER THE TOWER OR TURBINE DURING THIS PROCEDURE.

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 boom is angled up ~15˚, align the tail bushings with those of the powerhead, then insert the tail pivot pin as shown in **Figure 12**. 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.

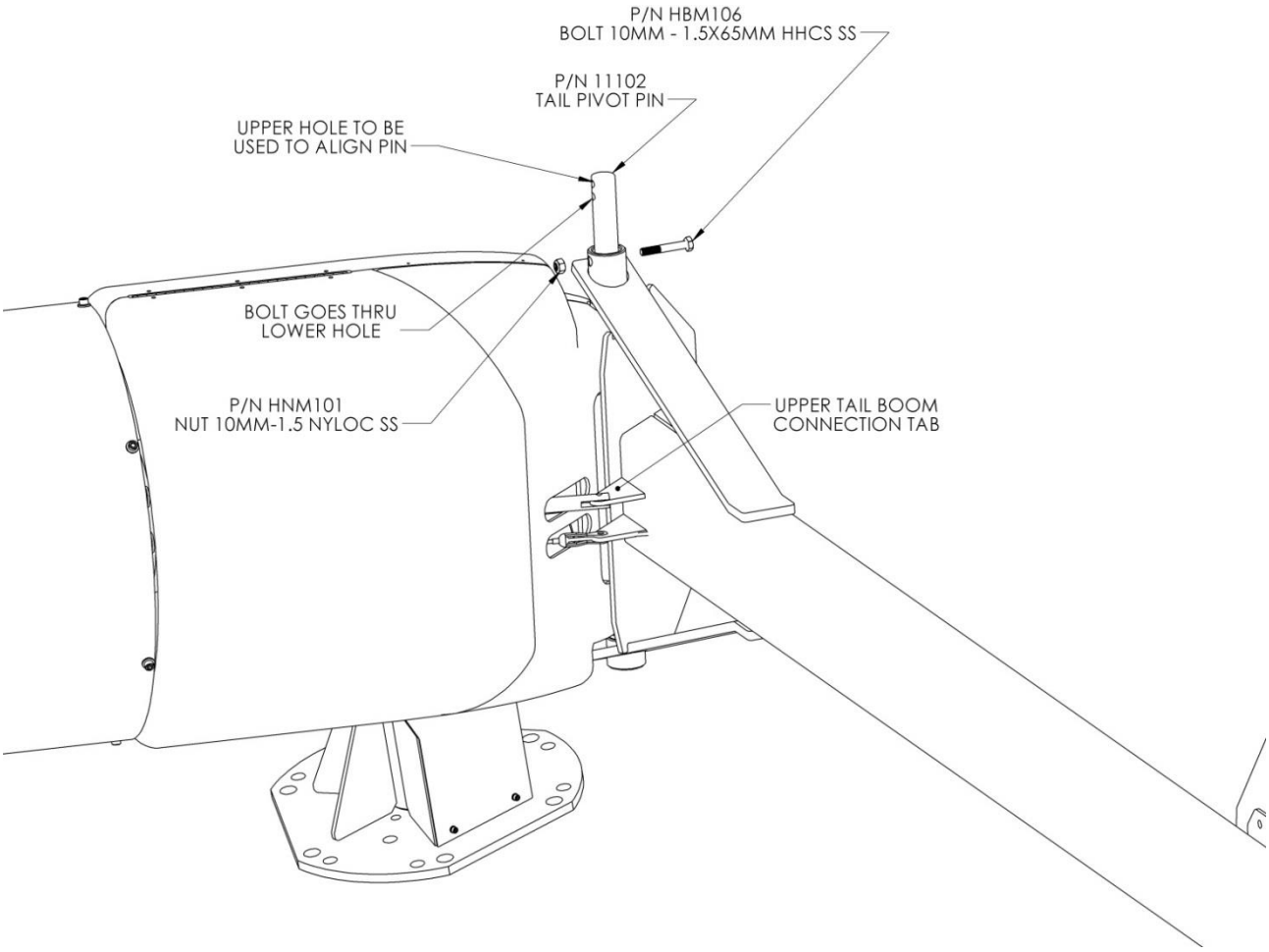


Figure 12: Excel Tail Boom and Pivot Pin System

5. After the pin is in place, install the retaining bolt and nut.

6. Release the tail boom and allow it to swing down (about 45º). It will be necessary to put a piece of 2x4 or a pipe inserted into the end of the tail boom 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.

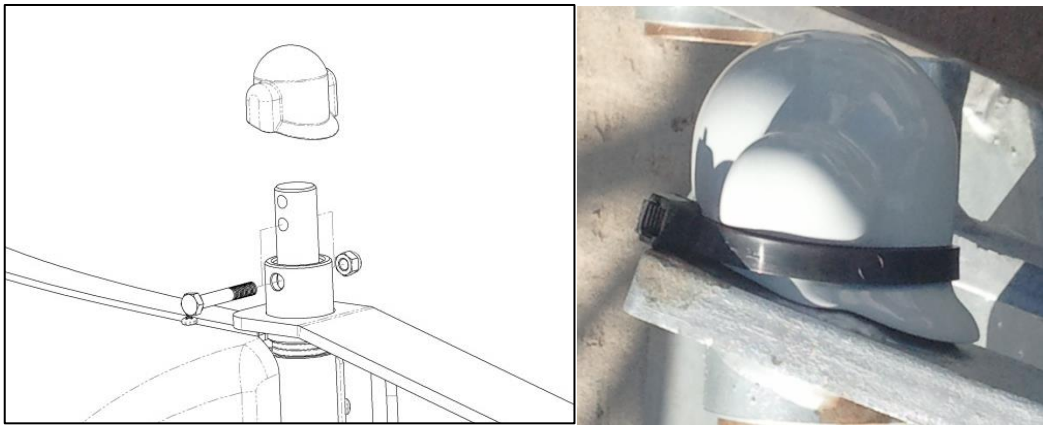


Figure 13: Tail Pivot Pin Cap

8. Place the tail pivot pin cap on the pivot pin and use a zip tie to secure it in place, as shown in **Figure 13**.

D. Install Turbine Blades and Spinner

1. If the jack stand is not in place, use the winch to raise the tower top to a height of approximately 8 ft (2.5 m), support with cribbing, and install the jack stand. Remove cribbing and lower the tower onto the stand. Use a piece of 2” x 4” lumber in 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.


2. Reposition the truck to back straight in under the alternator, so the tail gate or bed is positioned as a convenient work stand to install the rotor blades. Attach the three blades to the powerhead as shown in **Figure 14**, with the hardware provided in the Blade and Spinner Hardware Kit (HK0003). The contents of HK0003 are shown in **Table 5**.

   NOTE: Apply blue thread lock on 3-4 threads of the blade studs **after** each clamp plate is set into place. The thread lock liquid should be in the region right next to the clamp plate, and each nut should be torqued to **150 ft-lb (205 N-m)**. At the 30-day maintenance check, torque each blade clamp nut to the full 150 ft-lb, turn another 1/4 turn, and re-install the spinner with associated hardware. No additional thread lock material will be required.

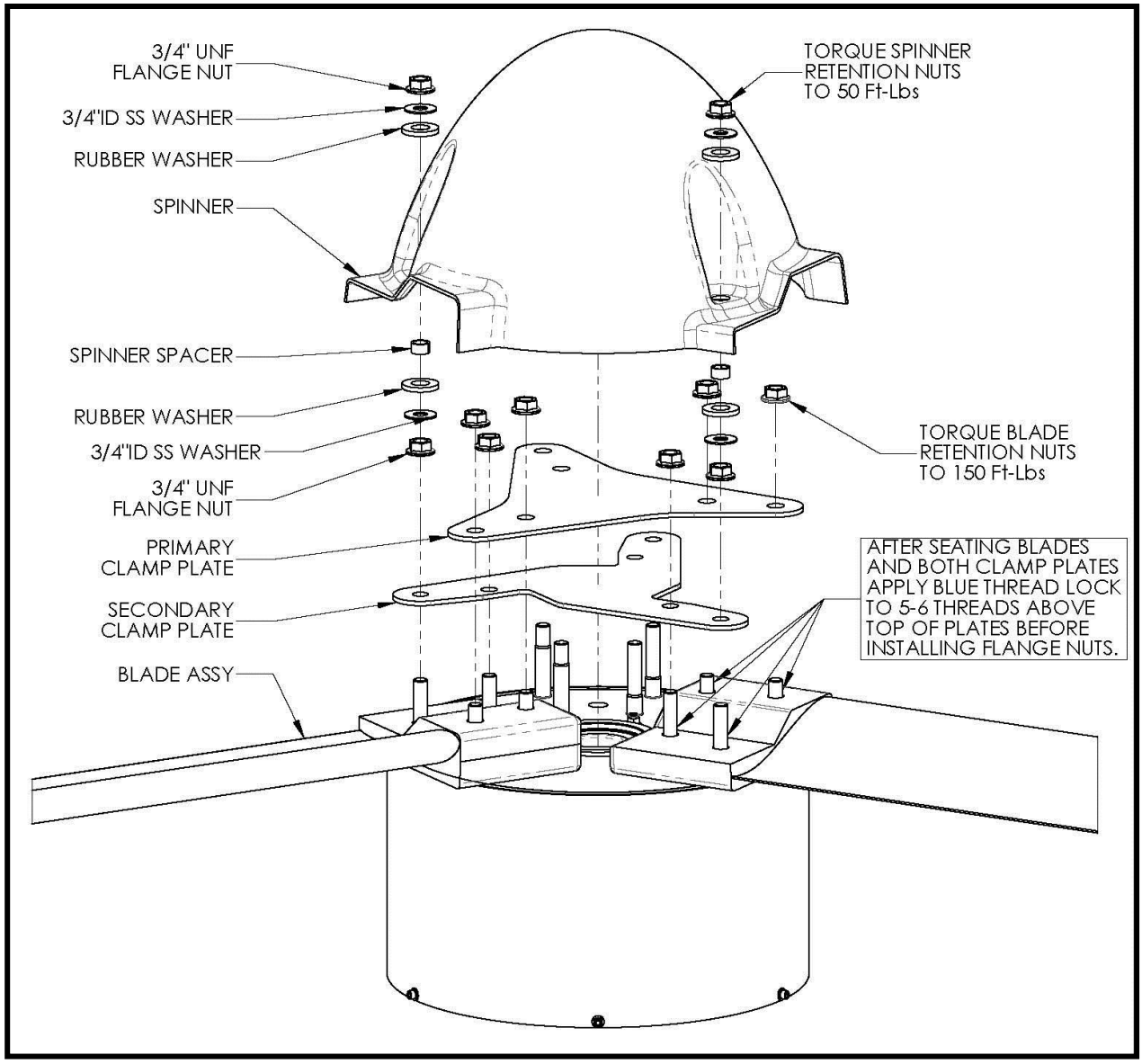


Figure 14: Assembly of Blades, Clamp Plates and Spinner

Table 6. Contents of Blade & Spinner Hardware Kit

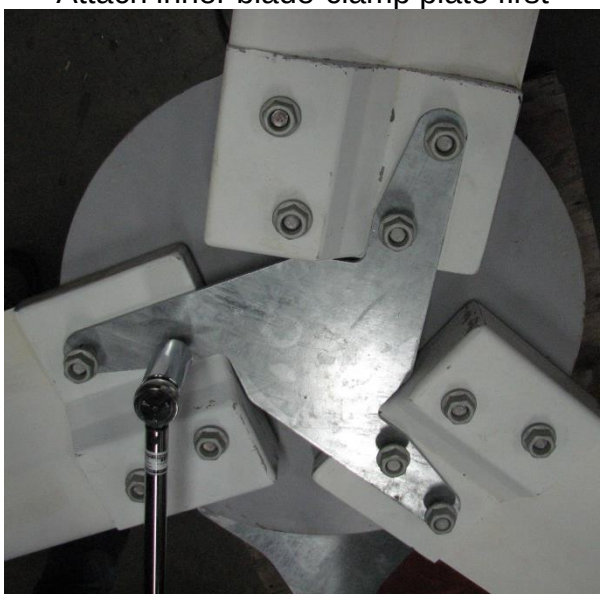
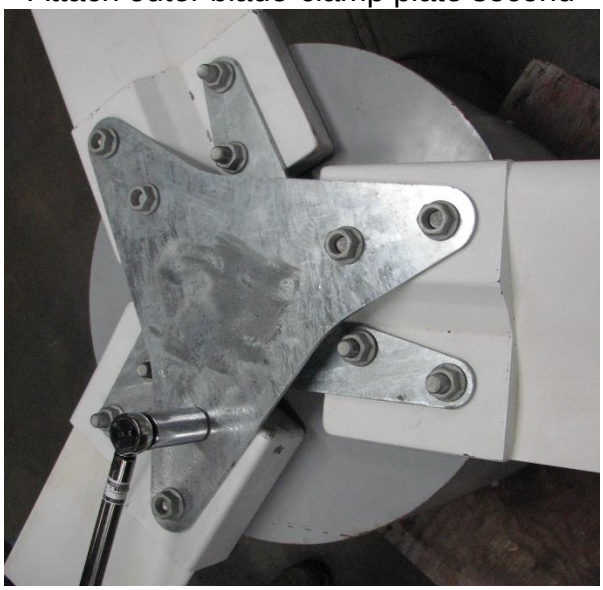
P/N	BLADE HARDWARE KIT	Qty
HNB016PLT	NUT EXCEL BLADE 3/4"X16 PLATED	12
SF0064	THREAD LOCK - BLUE - 2mL	1

	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

3. 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.

   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 completely against the face of the alternator**. Install a flanged Spiralock nut on the two studs in the **thick** section of the root pad and tighten the nuts until just snug. **Leave the thin section unsupported 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 two Spiralock nuts on the thick root pad section. Repeat this process for the third blade.

Attach inner blade-clamp plate first	Attach outer blade-clamp plate second
	

   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 the photo above on the left. 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)** (washers are not required).

   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 the photo above on the right. 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)** (washers not required).

4. Attach the spinner to the powerhead as shown in **Figure 14**, making sure that all hardware is ordered and positioned properly. The recommended procedure is as follows:

    a. Pre-assemble a stainless washer, rubber washer and stainless steel spacer in proper configuration (shown in **Figure 14**), fastened together with a small amount of silicone caulk**. Be sure the stainless spacer is *inside* the rubber 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 them 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 becomes glued to the blade nut, and the stainless spacer sleeve is directed outward along the blade stud.

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

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

    e. Tighten the three spinner attachment nuts to **50 ft-lb (70 N-m)**.

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 clamped under the rubber washers, and is to be expected. **Torque the nuts to the full 50 ft-lb value**. If you have properly positioned the spacers inside the rubber washers you will not harm the spinner.

E. Raising the Tower

1. Attach the furling cable swivel to the turbine furling cable using the 3/16" thimble and two stainless U-bolt clips provided in the Turbine Hardware Kit. 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, **Special Topics,** previously mentioned 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.

2. Use the winch to raise the tower/turbine to the vertical position, making required adjustments to maintain proper tension in side guy cables. Use the rope and shackle again to pull against the upper away-side guy cable and control tower rotation speed.

3. Anchor the gin pole with the 1” jaw-and-jaw turnbuckle.

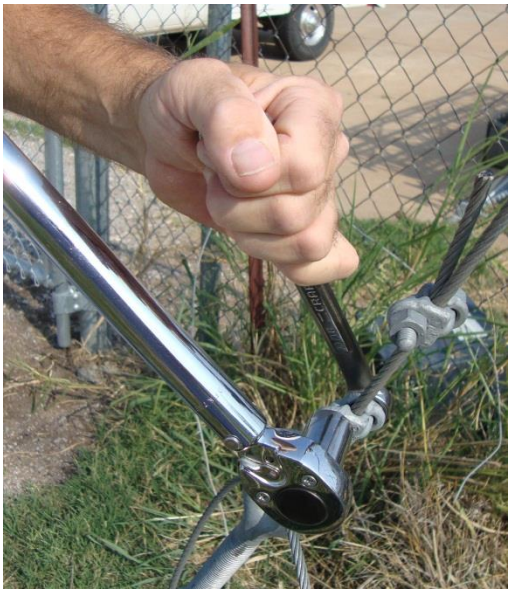
4. Pull the 5/8" upper guy cable (part of the gin-pole-side double cable that has been hanging loose until now) out to anchor #1, pull as tight as possible by hand, and secure it with three double-grip clips. Adjust the turnbuckle to provide full tension, then **loosen the upper gin pole turnbuckle until the 1/2" cable loses tension and has considerable droop.** The 5/8" cable to anchor #1 will support the upper segment of the tower, while the 3/8" cable to the gin pole will support the lower segment. The 1/2" cable is fully tensioned only during tilt operations.

5. Use the turnbuckles to adjust the tower to 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.

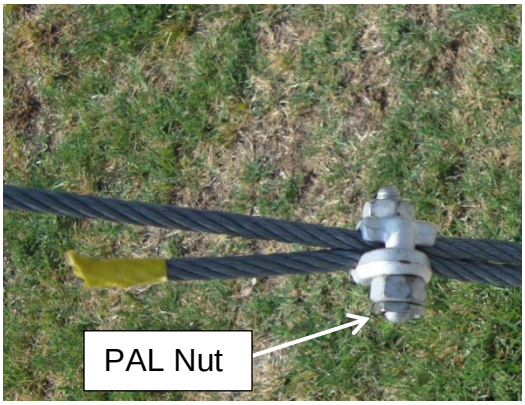
6. Tension all double-grip clips to the proper torque, as specified in **Table 7**. Secure all double-grip clips with PAL nuts.

Table 7. Required Torque on Double-rip 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.

7. Tension the guy wires using the procedure found in **Chapter 7**.

8. After the proper tension is achieved, the turnbuckles should be locked with a safety wire. Lengths of 1/4" wire rope, with proper malleable clips, are provided for this purpose. 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 1/4" malleable clips supplied in the tower hardware kit 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.

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.

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

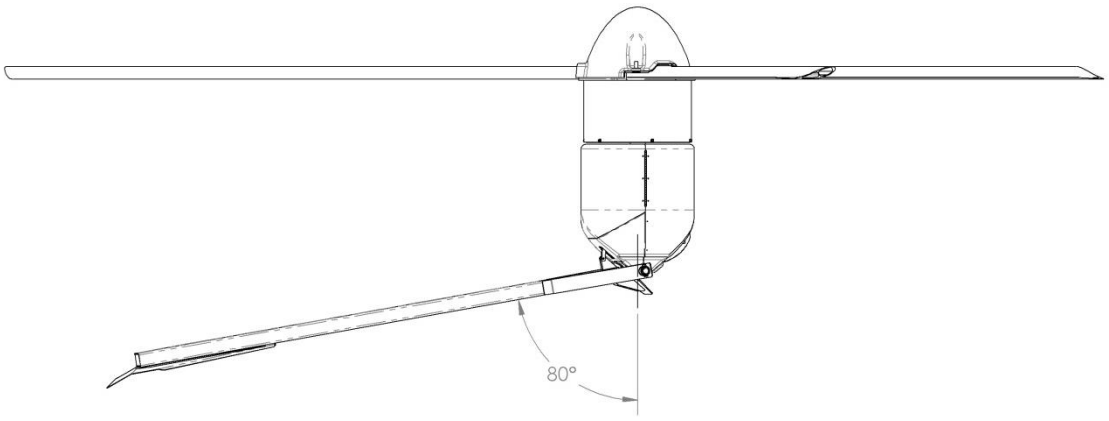
Purpose: Determines whether the manual furling system, including the tail damper, is operating properly.

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. 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 in **Special Topics**.

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. Remove all three conductors from the grid side of the disconnect box. Bridge the connections in the box using the #10 AWG wire. This will create a short circuit for the tower when the disconnect switch is turned “ON.”

Setup for TEMPORARY shorting

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 at the fundamental natural frequency.

A. Determining the Proper Frequency of the Guy Cable

To determine standard frequencies for each guy level of each tower, see **Table 8** below. Note that these standard guy lengths assume tower installation on a flat surface. If non-standard guy cable lengths are used, see **Section E** for the advanced method for determining proper guy cable frequency.

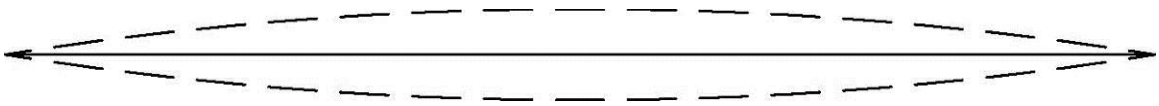
Table 8: Time Required for 20 Oscillations (in seconds)

Guy Level	60 ft Tower	80 ft Tower	100 ft Tower
Top	7	10	12
Bottom	5	7	9

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

Make sure the tower is plumb.

1. 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.)

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

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

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

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

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

7. 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:
Height of tower guy bracket (above base) - 90 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 15 is a useful chart 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 15** 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.

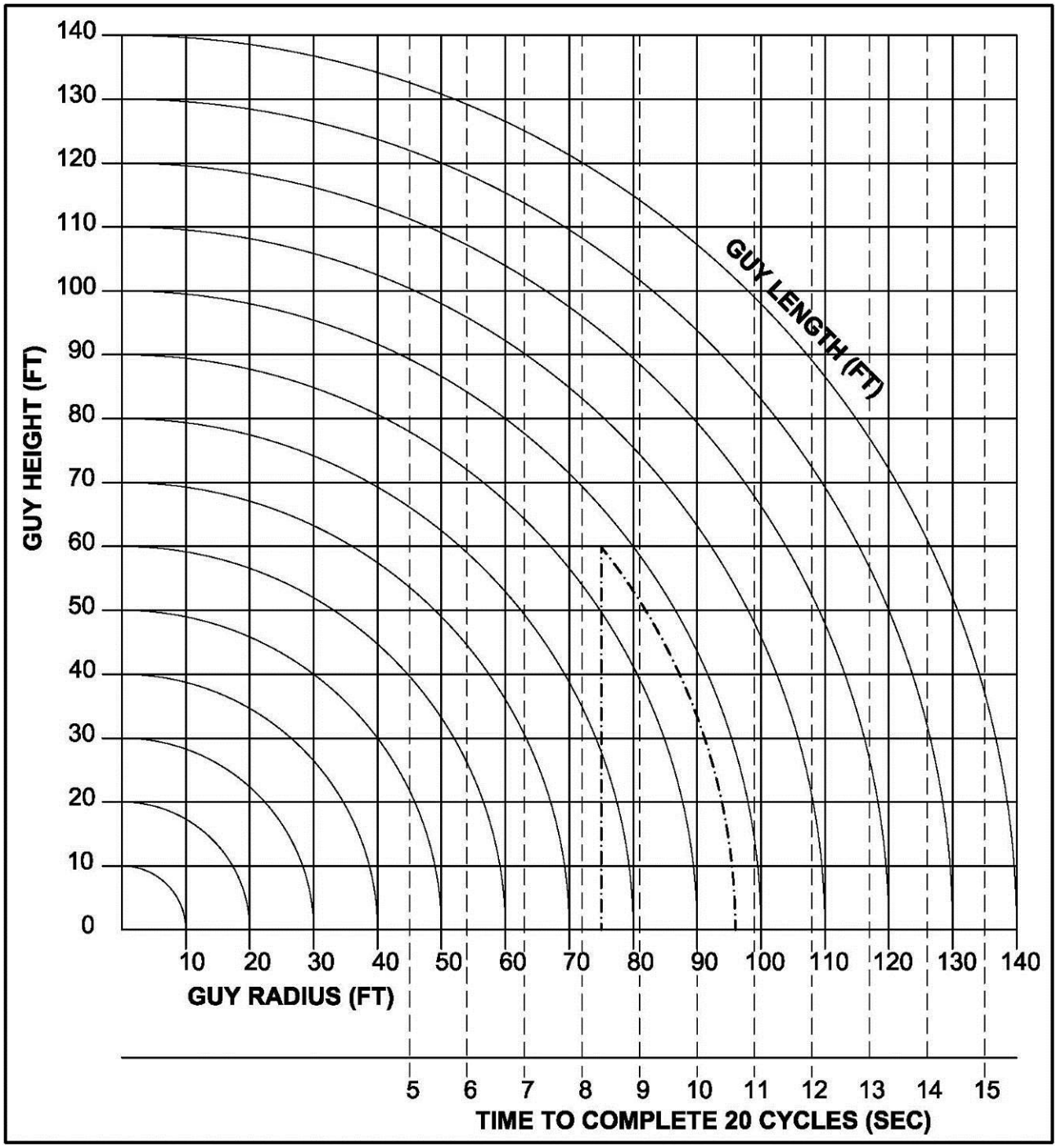


Figure 15: Chart to Determine Natural Frequency of Guy Cables

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. Grounding rods still connected.
    h. PAL nuts still engaged.
    i. Anchor bracket nuts properly tight.

2. **IMPORTANT - Check guy cable tension and adjust as required.** See Chapter 7 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” section of **Chapter 6**. Climb the tower or tilt it down. 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. Torque blade nuts to 150 ft-lb (205 N-m) plus 1/4 turn.
    b. Check front bearing for seal integrity and grease loss.

7. Reattach spinner, adding hardware as described in **Chapter 4,** and torque spinner nuts to **50 ft-lb** (Be sure to get rubber washers and stainless spacers properly positioned).

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 if yaw bearing leaked.

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. Inspect the full length of the tower as follows:
    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:

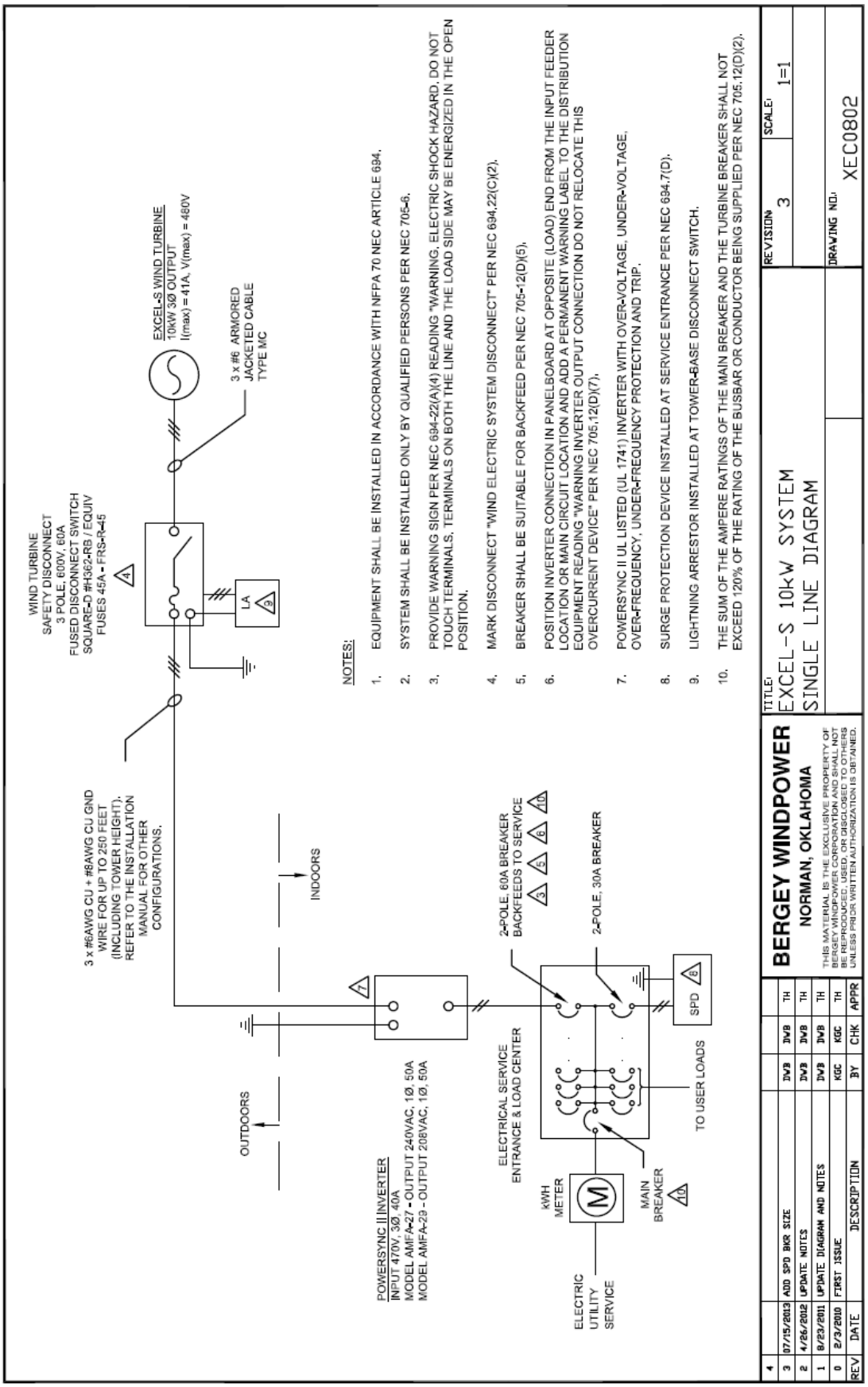
Telephone: 405-364-4212
FAX: 405-364-2078
Email: service@bergey.com

XI. Appendix

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

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.


WIND TURBINE
SAFETY DISCONNECT
3 POLE, 600V, 60A
FUSED DISCONNECT SWITCH
SQUARE-D #H362-RB / EQUIV
FUSES 45A - FRS-R-45
EXCEL-S WIND TURBINE
10kW 3Ø OUTPUT
I(max) = 41A, V(max) = 460V
3 x #6 ARMORED
JACKETED CABLE
TYPE MC
LA
3 x #6AWG CU + #8AWG CU GND
WIRE FOR UP TO 250 FEET
(INCLUDING TOWER HEIGHT).
REFER TO THE INSTALLATION
MANUAL FOR OTHER
CONFIGURATIONS.
OUTDOORS
INDOORS
POWERSYNC II INVERTER
INPUT 470V, 3Ø, 40A
MODEL AMFA-27 - OUTPUT 240VAC, 1Ø, 50A
MODEL AMFA-23 - OUTPUT 208VAC, 1Ø, 50A
2-POLE, 60A BREAKER
BACKFEEDS TO SERVICE
2-POLE, 30A BREAKER
ELECTRICAL SERVICE
ENTRANCE & LOAD CENTER
kWH
METER
MAIN
BREAKER
SPD
TO USER LOADS
ELECTRIC
UTILITY
SERVICE
NOTES:
1. EQUIPMENT SHALL BE INSTALLED IN ACCORDANCE WITH NFPA 70 NEC ARTICLE 694.
2. SYSTEM SHALL BE INSTALLED ONLY BY QUALIFIED PERSONS PER NEC 705-6.
3. PROVIDE WARNING SIGN PER NEC 694-22(A)(4) READING "WARNING, ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH THE LINE AND THE LOAD SIDE MAY BE ENERGIZED IN THE OPEN POSITION.
4. MARK DISCONNECT "WIND ELECTRIC SYSTEM DISCONNECT" PER NEC 694.22(C)(2).
5. BREAKER SHALL BE SUITABLE FOR BACKFEED PER NEC 705-12(D)(5).
6. POSITION INVERTER CONNECTION IN PANELBOARD AT OPPOSITE (LOAD) END FROM THE INPUT FEEDER LOCATION OR MAIN CIRCUIT LOCATION AND ADD A PERMANENT WARNING LABEL TO THE DISTRIBUTION EQUIPMENT READING "WARNING INVERTER OUTPUT CONNECTION DO NOT RELOCATE THIS OVERCURRENT DEVICE" PER NEC 705.12(D)(7),
7. POWERSYNC II UL LISTED (UL 1741) INVERTER WITH OVER-VOLTAGE, UNDER-VOLTAGE, OVER-FREQUENCY, UNDER-FREQUENCY PROTECTION AND TRIP.
8. SURGE PROTECTION DEVICE INSTALLED AT SERVICE ENTRANCE PER NEC 694.7(D).
9. LIGHTNING ARRESTOR INSTALLED AT TOWER-BASE DISCONNECT SWITCH.
10. THE SUM OF THE AMPERE RATINGS OF THE MAIN BREAKER AND THE TURBINE BREAKER SHALL NOT EXCEED 120% OF THE RATING OF THE BUSBAR OR CONDUCTOR BEING SUPPLIED PER NEC 705.12(D)(2).
BERGEY WINDPOWER
NORMAN, OKLAHOMA
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TITLE:
EXCEL-S 10kW SYSTEM
SINGLE LINE DIAGRAM
REVISION 3
SCALE: 1=1
DRAWING NO.: XEC0802
REV | DATE | DESCRIPTION | BY | CHK | APPR
3 | 07/15/2013 | ADD SPD BKR SIZE | DVB | DVB | TH
2 | 4/26/2012 | UPDATE NOTES | DVB | DVB | TH
1 | 8/23/2011 | UPDATE DIAGRAM AND NOTES | DVB | DVB | TH
0 | 2/3/2010 | FIRST ISSUE | KGC | KGC | TH

SERVICE INSPECTION CHECKLIST

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 Cable Tensions or Frequencies: _____
- ☐ 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

- ☐ Blades 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 _____