



## Tilt-Up Tower Installation Manual

Version 5.8

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## Introduction

Congratulations on your purchase of an Endurance Wind Turbine Tilt-Up Tower System. This manual will help ensure that your tower is installed correctly and will provide you with years of reliable service.

It is recommended that you read this manual in its entirety prior to beginning the installation procedure to familiarize yourself with the process. Direct any questions or concerns to your Endurance dealer.

This manual provides the full installation procedure for installing the tilt-up tower designed as part of the Endurance wind turbine system.

**MODIFICATIONS TO THE TOWER IN WHOLE OR IN PART, OR FAILURE TO PROPERLY FOLLOW THE INSTRUCTIONS PROVIDED IN THIS INSTALLATION MANUAL MAY LEAD TO DANGEROUS CONDITIONS OR VOID ANY WARRANTY. USE OF THE PROPER TOOLS AND EQUIPMENT TO COMPLETE THE TASKS OUTLINED HEREIN ARE REQUIRED FOR PROPER INSTALLATION. PROFESSIONAL ASSISTANCE IS HIGHLY RECOMMENDED.**

### Disclaimer

Endurance Wind Power Inc. accepts no responsibility for damage or injury resulting from work performed as a result of following the instructions in this manual. Whenever working with lifting large, heavy structures overhead, extreme caution is warranted to prevent damage or injury. If there is any question as to the safety of the tower structure or its ability to perform the task required of it, seek professional engineering advice prior to assembling, raising or operating a turbine atop the tower structure. In addition, Follow any local codes while performing the steps presented in this manual. This may include hiring an electrician for making the electrical connections.

**IT IS THE RESPONSIBILITY OF THE OWNER TO ACQUIRE ALL NECESSARY PERMISSION – FROM ZONING BOARDS, UTILITIES OR ANY REGULATORY AGENCIES WITH JURISDICTION OVER YOUR SITUATION – PRIOR TO BEGINNING THE INSTALLATION.**

## Preparation

Assembly of an Endurance tilt-up tower usually takes at least one day, provided all foundations and site wiring has been completed prior to starting the tower assembly. Taller towers typically take longer than shorter versions. It is advised that you provide yourself a full day for the work, and possibly part of a second day to allow any extra time for unforeseen conditions. The best way to ensure a smooth job is to properly prepare the site for work.

It is assumed that the foundations and anchors have been installed, including the winch side anchor and winch foundations (if needed). This manual only deals with installation of the tower and gin pole anchor bases on existing foundations, construction of the tower and gin poles, installing the guy wires and associated hardware, and wiring the tower for the turbine. If the tower foundations have not yet been installed, complete that process prior to beginning the tower installation. A foundation design document is included in Appendix A at the back of this manual.

Complete the process of providing electrical service to the base of the tower prior to beginning the tower construction. A one-line diagram providing details for the electrical service for the Endurance S-250 is provided in Appendix B. Be sure to include a support for the control panel near the tower base.

**ALWAYS FOLLOW THE NECESSARY SAFETY PRECAUTIONS FOR YOUR WORK SITUATION. PROTECTIVE EYEWEAR, HEADGEAR, GLOVES, AND PROPER FOOTWEAR ARE ALL HIGHLY RECOMMENDED.**

Complete all tower foundation work and allow concrete to cure adequately prior to tower assembly.

**BE SURE TO CHECK OVERHEAD FOR ANY ELECTRICAL LINES OR OTHER OBSTRUCTIONS THAT COULD CONTACT THE TOWER DURING ASSEMBLY AND RAISING.**

## *Necessary Equipment*

### **Lifting Equipment**

The tower sections weigh approximately 400 lbs. (180 kg) and will need to be lifted and placed into position in the assembly. A fork-lift or other similar piece of heavy equipment is recommended for positioning the pieces. Suitable straps or chains of sufficient length are required for lifting the tower sections into place. These straps or chains and any other equipment utilized in lifting **MUST** be rated for lifting the weight of the piece. If load ratings for any equipment you plan to use are not available **DO NOT USE IT! ANY DAMAGE RESULTING FROM FAILURE OF YOUR EQUIPMENT IS NOT COVERED UNDER ANY WARRANTY.**

### **Electrical Tools and Supplies**

Most electrical connections will be made using typical wire nuts and terminal blocks, which require no special tools. The following tools and supplies are necessary to complete the electrical work:

- Electricians pliers
- Wire strippers
- Electrical tape (colored as well as black)

### **Mechanical Tools**

Mechanical connections will be made using common English wrenches. The sizes of bolts will be specified below. Other tools needed include:

- Ratchet set with common extensions and sockets
- Box and open-end wrench set (up to 1-1/2")
- Flat and Phillips screwdrivers
- Torque wrench with 250 ft-lbs (350 Nm) capacity
- Spirit level (6" long is sufficient, magnetic preferred)
- 150ft fish tape
- Plumb line
- Cable (Haven's) grips for 1/2" and 5/16" wire rope
- Rope
- Come-along
- Bailing or safety wire
- Sturdy, adjustable stands on which to rest tower and gin pole (e.g., railroad ties or other scrap lumber)

### **Other Recommended Tools and Supplies**

Other common tools that may come in handy are:

- Electric drill-driver
- Hammer
- Mallet
- Common pliers
- Utility knife
- Rags
- Silicone sealant
- Pen or pencil for taking notes about the installation.

## Tower Raising Equipment

The Endurance tower system does not include equipment necessary to raise and lower the tower. You may inquire about winch kits (including cable and blocks/pulleys) available from Endurance Wind Power. Recommended equipment is described here if you wish to acquire it yourself. This manual assumes you will use a 3:1 or 4:1 pulley system to help minimize the required lifting force required to raise the turbine and tower system. Other configurations are permissible with proper engineering analysis and choice of equipment. **BE SURE TO CONDUCT A THOROUGH ENGINEERING ANALYSIS OF ANY ALTERNATIVE LIFTING SYSTEM TO THOSE OUTLINED HERE TO AVOID OVERLOADING ANY COMPONENT OF THE TOWER OF LIFTING SYSTEM. USE OF FEWER THAN 3 BLOCKS IS NOT RECOMMENDED.**

### LIFT OF TOWER ONLY

Tower Height (ft)	63		84		105			126		
Max Pull in Lift Cable System (lbs)	2,400		3,290		3,870			4,740		
Pulley system ratio	3:1	4:1	3:1	4:1	3:1	4:1	5:1	3:1	4:1	5:1
Max winch cable pull (lbs)	800	600	800	600	1,290	970	775	1,580	1,190	950
Required winch cable length (ft)	160 ft	205 ft	160 ft	205 ft	270	360	440	330	430	530
Required min. cable strength (lbs)	4,000	3,000	4,000	3,000	6,450	4,840	3,870	7,900	5,930	4,740
Typical Cable Size (in)*	1/4	1/4	1/4	1/4	1/4	1/4	1/4	5/16	1/4	1/4

### LIFT OF TOWER & TURBINE SYSTEM

Tower Height (ft)	63		84		105			126		
Max Pull in Lift Cable System (lbs)	4,500		5,715		6,230			6,800		
Pulley system ratio	3:1	4:1	3:1	4:1	3:1	4:1	5:1	3:1	4:1	5:1
Max winch cable pull (lbs)	1,490	1,120	1,905	1,430	2,080	1,560	1,250	2,270	1,770	1,360
Required winch cable length (ft)	125	155 ft	165	210	205	255	310	240	310	380
Required min. cable strength (lbs)	7,450	5,580	8,550	6,400	10,390	7,790	6,230	11,350	8,500	6,800
Typical Cable Size (in)*	5/16	1/4	5/16	1/4	5/16	5/16	1/4	3/8	5/16	1/4

\*Wire Rope Requirements:

- Drawn galvanized 6x19 EIP IWRC classification
- Minimum Ultimate strengths: 1/4" = 6,800lbs; 5/16" = 10,540lbs; 3/8" = 15,100lbs
- Safe working load (SWL) limit is 1/5 Minimum Ultimate strength

The above winch cable lengths assume a relatively flat terrain and 20-ft of extra winch cable to account for distance from the ground anchor to the winch and initial windings on the winch drum. Note that a larger number of blocks (up to 5) can be used to reduce the required winch pull, with the trade-off of a longer winch cable length (and hence winch spool capacity). **Select winch cable size by strength.** Higher strength cable may allow for fewer blocks and hence shorter cable, but **be sure to divide cable strength by a safety margin of 5 to determine safe working load (SWL).** The SWL must exceed the max cable pull for the system.

### Recommended Lifting Blocks for Tower Lifting System

The gin pole top end and winch side anchor base are designed to accept a series of up to 5 blocks of the following type: McKissick 404 tailboard blocks, 3in. sheave, max 3/8" wire rope size, 2 metric ton working load limit, stock # 102016 (see example photo at right). An equivalent block may be substituted, but be aware that larger diameter sheave blocks may interfere with each other.

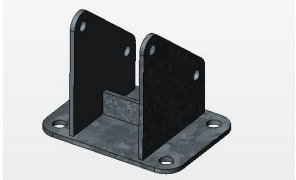

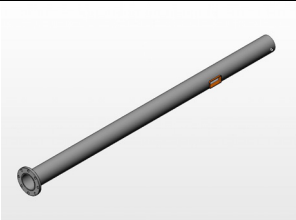
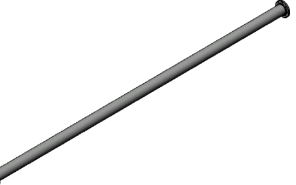
An appropriate winch with a true line pull rating greater than the loads presented in the table above and with sufficient line capacity is required. Alternatively a vehicle can be used to provide the necessary pull force provided it can be operated slowly, smoothly, with sufficient traction (weight) and over the large distance required for the length of cable used in your system of blocks.


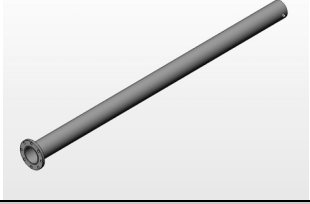
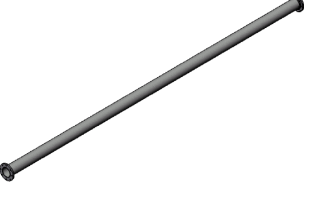
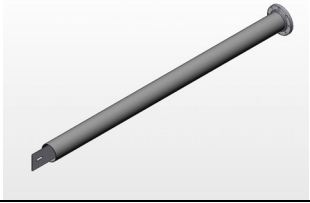


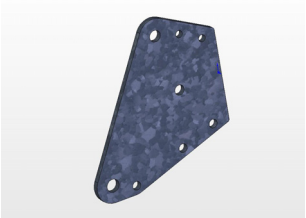
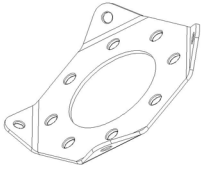
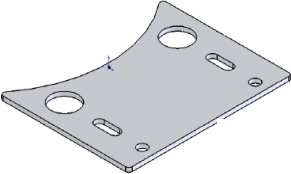
## Tower Parts

The tilt-up tower system is made up of several parts that are installed on a foundation system that includes a center foundation and four surrounding anchor points. The number of tower parts and the length of the tower pipe sections may vary depending upon the total height of the tower. The parts list for the four available tower heights (63, 84, 105 and 126 ft) is provided in the table below.


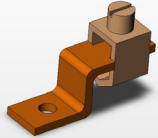
**List of Endurance Tilt-Up Tower System Parts**

Item	Part	Description	Picture or Size	Quantity		
1	Tower Base	Base plate bolted to foundation on which the tower and gin pole pivot.		1		
2	Gin Pole Anchor Base	Base plate bolted to foundation at top end of gin pole; serves as the anchor for guy wires at the winching side of the tower system.		1		
3	Tower Bottom Section	Bottom tower section that pivots on base, with a standard flange at top end and pivot tube on bottom end. It includes an access hole ~40in. from bottom. (Note that gin pole bottom looks similar but lacks this access hole.) Length may be ~9.5-ft or ~21-ft depending on tower height.		1		
4	Tower Main Sections	Main tower sections each ~21ft in length, with a standard flange on both ends. (Note these sections may look similar to the main gin pole section of 126-ft tower, but are of thicker, schedule 40 pipe.)	Tower Height	63	84/105	126
				1	3	5

Item	Part	Description	Picture or Size	Quantity		
5	Tower Top Section	Top tower section has a standard pipe flange at lower end and turbine mating flange at top end. Guy tabs are located on 4 sides and are ~10ft from the <u>top</u> end of the pipe. A wire access hole is located ~40in. from the top end as well. Length may be ~11.5-ft or ~21-ft depending on tower height.		1		
6	Gin Pole Bottom Section	Bottom gin pole section that pivots on base, with standard pipe flange on top end and pivot tube welded in bottom end. Note that tower bottom section looks similar but has an access hole ~40in from bottom end. Gin pole bottom lacks this access hole. Length is ~21-ft.		1		
7	Gin Pole Main Section	Main gin pole section ~21ft in length, with a standard flange on both ends. (Note this section looks similar to the main tower sections, but is of thinner, schedule 10 pipe.) This section is not used for towers systems less than 126 ft tall.	Tower Height	63	84/105	126
				0	0	1
8	Gin Pole Top Section	Top gin pole section with standard flange on lower end and welded-in plate on upper end. Length will vary with tower height and guy radius dimensions.		1		

Item	Part	Description	Picture or Size	Quantity		
9	Removable Gin Pole End Plate	Plate that bolts onto top end of gin pole with holes for attaching tower guys and winch cable blocks.		1		
10	Lower guy attachment plate	¼" thick plate with corners bent down 45 degrees with holes for attaching lower guy wires (not required for 63-ft tower system).	Tower Height	63	84/105	126
				0	1	2
11	Anemometer mount plate	Used to mount the anemometer boom to the tower flange immediately below the turbine.		1		
12	Gin Pole End Plate Bolt, Washers & Nut	Fasteners for attaching Removable Gin Pole End Plate to Gin Pole Top Section. All fasteners are minimum Grade 5 and galvanized or zinc-plated.	¾" x 2" bolt ¾" SAE flat washer ¾" nylock nut	1 2 1		
13	Flange Bolts, Washers & Nuts	The standard 6" tower and gin pole will require eight (8) bolts and nylock nuts, and 16 flat washers per joint. All fasteners are minimum Grade 5 and galvanized or zinc-plated.	Tower Height	63	84/105	126
			¾" x 3.5" bolt ¾" x 4.0" bolt ¾" SAE flat washer ¾" nylock nut	24 0 48 24	32 8 80 40	48 16 128 64
14	Pivot Bolts, Washers & Nuts	The gin pole and tower each require one pivot bolt, with accompanying nylock nut and pair of flat washers. All fasteners are minimum Grade 5 and galvanized or zinc-plated.	1" x 11" bolt 1" SAE flat washer 1" nylock nut	2 4 2		

Item	Part	Description	Picture or Size	Quantity		
15	Guy wires	There is one set of four guys (one guy height) on the 63-ft tower, two guy heights on the 84-ft and 105-ft tower and three guy heights on the 126-ft tower system. The upper guys are 1/2" cable on all systems. One end of each wire is swaged with a thimble for connecting to the tower.	Tower Height	63	84/105	126
			1/2" x ~1.1xTower height	4	4	4
			5/16" x 65-ft	0	4	4
			5/16" x 95-ft	0	0	4
16	Thimbles	Insert into the end of guy wires to form a stable loop.	Tower Height	63	84/105	126
			1/2"	4	4	4
			5/16"	0	4	8
17	Wire clips	Use to clip the guy wire end loops.	Tower Height	63	84/105	126
			1/2"	16	16	16
			5/16"	0	16	28
18	Upper guy tower shackles	For attaching the upper guys to the tower.	Tower Height	63	84/105	126
			3/4" – 4.75 ton SWL	7	4	4
19	Lower/Middle guy tower shackles	For attaching middle and lower guys to the tower.	Tower Height	63	84/105	126
			7/16" – 1.5 ton SWL	0	4	8
20	Ground shackles	For attaching guy turnbuckles to three ground anchors, and gin pole end to ground anchor.	Tower Height	63	84/105	126
			7/8" – 6.5 ton SWL	3	6	6
21	Upper guy turnbuckles	Jaw-jaw type for attaching upper guys to gin pole and ground shackle.	7/8" x 12" – 3.6 ton SWL	4		
22	Lower/Middle guy turnbuckles	Jaw-jaw type for attaching lower and middle guys to gin pole and pear link on ground shackle.	Tower Height	63	84/105	126
			1/2" x 12" – 1.1 ton SWL	0	4	8
23	Pear Link	For Attaching lower and middle guy turnbuckles to ground shackles.	Tower Height	63	84/105	126
			1/2" – 1.45 ton SWL	0	3	6

Item	Part	Description	Picture or Size	Quantity			
24	Poly rope	Used for gin pole side guys during tower raising.	Tower Height	63	84/105	126	
			½", 3-strand	100ft	150ft	200ft	
25	Tower Electrical Wire Bundle	Electrical wire that runs down the inside of the tower to connect the turbine at the top to the control panel installed near the bottom of the tower. All wires approximately 1.2x tower height.	Tower Height	63	84	105	126
			5 conductor 8 AWG	73ft	94ft	115ft	136ft
			2 conductor 16 AWG	73ft	94ft	115ft	136ft
			4 conductor 18 AWG shielded	73ft	94ft	115ft	136ft
			3 conductor 22 AWG shielded	73ft	99ft	115ft	141ft
26	Kellem Grip Snap Link	Snap link for connecting the Kellem grip holding the tower electrical wire bundle to the hanger inside the top of the tower.		1			
27	Liquid-tight conduit with connectors	Conduit to carry electrical wire from base of tower to control panel enclosure. (Used during turbine installation.)	10ft of 1.5" liquid-tight conduit	1			
			Straight fitting connectors	2			
28	Tower ground lug	Lug for attaching grounding rod to tower bottom.		1			

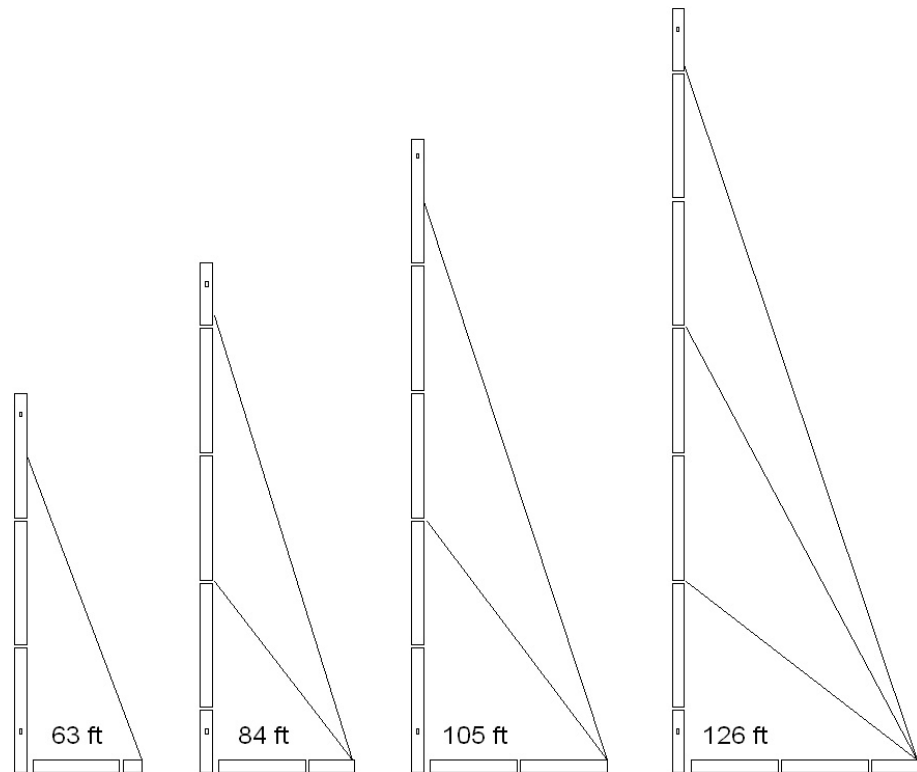
## Assembly Procedure

With the site prepared, tools and equipment at the ready, and all parts organized and accounted for you are ready to begin the tower assembly. There are 10 basic steps in this process:

1. Installing the Tower Base on the center foundation
2. Installing the Winch Anchor Base on winch side anchor foundation
3. Assembling the tower and gin pole pipe sections
4. Installing guy wires and rigging
5. Installing winch cable block and tackle system
6. Raising the gin pole
7. Initial raising of tower and adjusting guy wires
8. Lowering the tower
9. Electrically grounding the tower and guy wires
10. Installing turbine electrical wires inside the tower

The entire process can take up to several hours, so schedule at least a full day for the tasks once all parts are on site and the site is ready for beginning the assembly. Note that taller towers typically take longer to install, so plan accordingly.

At right is a schematic layout of the tower pipe sections and guy wires for each tower height. You may wish to refer to this schematic as you construct the tower to ensure proper placement of pipe sections and guy attachment points.



## Tower and Gin Pole Anchor Base

### Parts Needed:

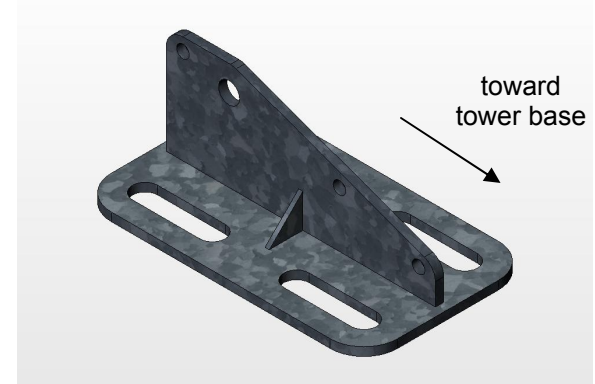
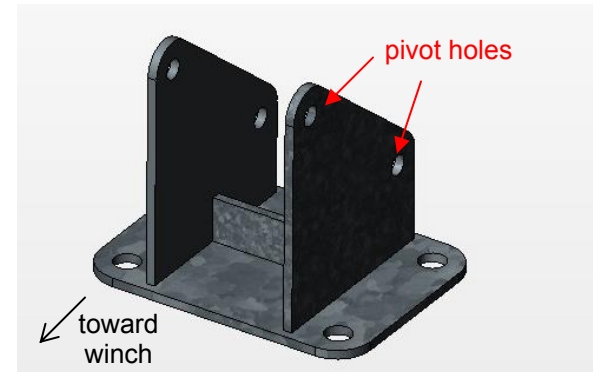
- Item 1 Tower Base
- Item 2 Gin Pole Anchor Base
- Foundation fastener hardware (supplied with foundation anchor bolts)

The tower base has four bolt holes, 12.5" on center by 8.5" intended for 7/8" diameter bolts embedded in the foundation. The 12.5" spaced holes are placed on an axis perpendicular to the direction of tilt for the tower (see Foundation Design Document in Appendix A).

Place the tower base on the bolts already installed in the tower foundation. The tower base has one set of pivot holes higher than the other, with the lower ones intended for the tower. Align the base so the pivot holes for the tower are farthest away from the winch pad (see illustration at right).

**Make certain the base plate is flat, level and aligned with the side guy anchor points.** Level the base by either using non-shrinking grout, or by "floating" it on a set of nuts and washers placed on each foundation bolt below the base plate. Ensure the pivot holes are fairly well aligned with the side guy anchor points. Torque all bolts securing the tower base to the foundation as appropriate for the size bolt used (minimum 200 ft-lbs to maximum 380 ft-lbs for grade 5, 7/8" or 1" bolts).

The Gin Pole Anchor Base is installed in similar fashion to the Tower Base. Leveling the Gin Pole Anchor Base is not as critical as for the tower, but non-shrinking grout or nut-leveling may be necessary where the concrete foundation is not flat enough to provide full support for this piece. The Gin Pole Anchor Base has slotted holes to allow for fine adjustment in cases where the gin pole will be removed after tower installation. Install this piece so that it is oriented as shown in the illustration at right. Tighten the nuts but do not torque them now if you wish to adjust the base to facilitate removing the gin pole following turbine installation.



## *Tower Bottom*

### Parts Needed:

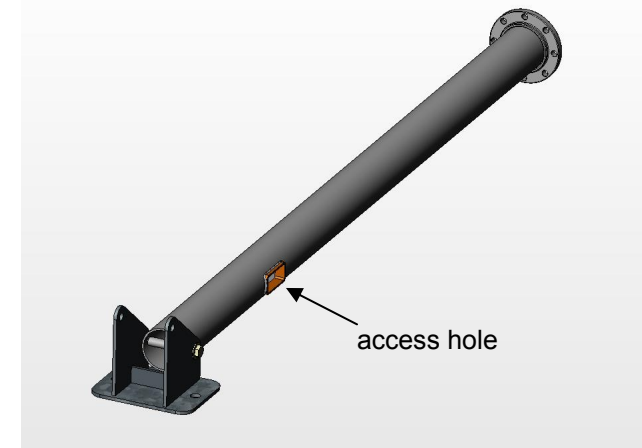
- Item 3 Tower Bottom Section
- Item 14 Pivot Bolt, Washers and Nut

Note the Tower Bottom Section is similar to the Gin Pole Bottom Section (Item 6), except it may be thicker-walled (schedule 40) and it has an access hole ~40in. from the bottom. **Be sure you have the Tower Bottom Section for this installation step and not the Gin Pole Bottom Section by ensuring there is an access hole in it (see picture at right).**

Position the Tower Bottom Section such that the pivot tube on the lower end is aligned with the lower holes on the Tower Base sides. Install the Tower Bottom Section such that the access hole (~40in. from the bottom – see illustration at right) is on the same side the control panel will be installed. If you cannot locate any access hole you probably have the Gin Pole Bottom Section (Item 6). Put it aside and locate the Tower Bottom Section.

Place one flat washer under the head of one of the 1" x 11" Pivot Bolts. Insert the bolt through one side of the Tower Base, into the Tower Bottom Section pivot tube, and through the other side of the Tower Base. Place another washer on the threaded end of the bolt and then thread on the 1" nylock nut. Thread the nut onto the bolt just far enough to minimize sliding of the bolt, but loose enough to allow the washers to spin freely. **DO NOT TORQUE THIS BOLT.**

Rest the upper, flanged end of the tower bottom section on a block of wood or other such item to hold it just off the ground.



## *Tower Main Sections and Lower Guy Attachment Plate*

### Parts Needed:

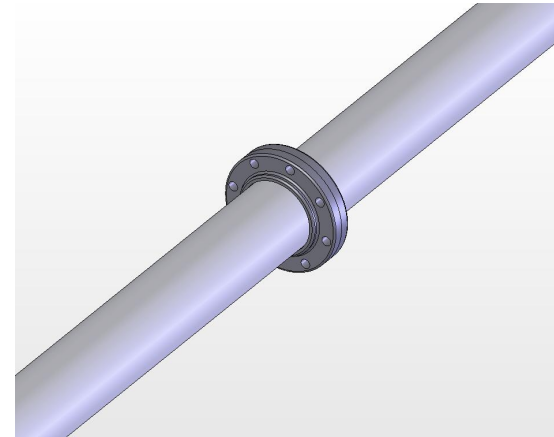
- Item 4 Tower Main Sections
- Item 10 Lower Guy Attachment Plate (not used for 63-ft tower)
- Item 13 Flange Bolts, Washers & Nuts

**For 126-ft tower only:** Note that the tower main sections may look identical to the Gin Pole Main Section (Item 7). Check the wall-thickness of all sections to identify the gin pole section. The gin pole is made from thinner-walled schedule 10 pipe. Mark it and set it aside so as not to accidentally install it as a tower section. **BE SURE NOT TO USE THE GIN POLE SECTION AS PART OF THE TOWER. THIS COULD COMPROMISE THE INTEGRITY OF THE TOWER STRUCTURE AND LEAD TO TOWER FAILURE!**

The number of main sections for your tower depends on the overall height of the tower. All these sections are identical, so the order they are installed does not matter. The sections are also fully symmetric so they cannot be installed incorrectly as long as all the holes in the flanges align with holes on mating tower section flanges. Install the first Tower Main Section on the Tower Bottom Section flange now.

Ensure the flanged end of the Tower Bottom Section is resting on a block of wood or other such item to hold it just off the ground. Line up the first Tower Main Section flange with the Tower Bottom Section flange (see illustration at right). Once aligned, attach the flanges together with eight (8)  $\frac{3}{4}$ " x 3.5" bolts (be sure NOT to use the 4" bolts here) and nylock nuts. Ensure there is a flat washer under both the bolt head and nut. Torque the bolts to 250 ft-lbs.

At this point the tower assembly consists of one Bottom Section and one Main Section. For the 63ft tower you can now skip directly to Tower Top Section installation instructions. For 84ft, 105ft and 126ft towers, a Lower Guy Attachment Plate is installed at this point, between the first and second Tower Main Sections.



### Lower Guy Attachment Plate

The lower guy attachment plate (not used on 63-ft towers) is easily installed between the flanges of the first and second Tower Main Sections. There are two alignment considerations to make when installing the plate:

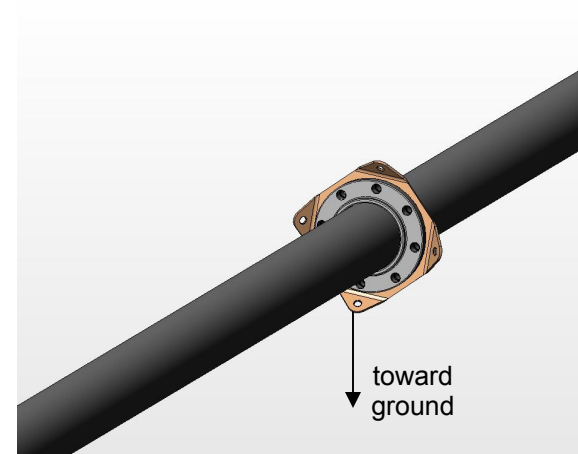
1. Install the plate so the corners bend down toward the base of the tower, and
2. Align the corners so each one points toward one of the four guy anchor points on the ground (i.e. one corner will point toward the ground when the tower is laying down – see illustration at right).

Use eight (8)  $\frac{3}{4}$ " x 4" bolts and nylock nuts to fasten the flanges together. Ensure there is a flat washer under both the bolt head and nut. Torque the bolts to 250 ft-lbs.

Install a third Tower Main Section at this point. For the 84ft and 105ft towers, you can now proceed to the Tower Top Section installation.

**For 126-ft tower only:** Install the second Lower Guy Attachment Plate now, between the third and fourth Tower Main Sections. Be sure to follow the guidelines listed above as done with the first plate. Finally install the fifth Tower Main Section and proceed to the Tower Top Section installation.

Be sure to torque all bolts to 250 ft-lbs.



## Tower Top Section

### Parts Needed:

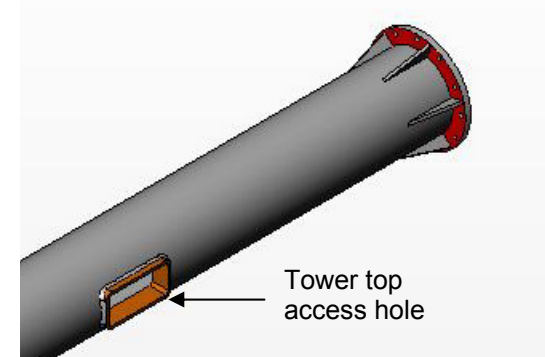
- Item 5 Tower Top Section
- Item 11 Anemometer Mount Plate
- Item 13 Flange Bolts, Washers & Nuts

To install the Tower Top Section, it must be aligned such that the four top guy attachment tabs on the bottom of the section will point toward each of the four guy anchors on the ground. This is easily accomplished by ensuring one of these tabs points toward the ground when the tower is lying down. It is also advantageous to locate the tower top access hole to either side (rather than on the top or bottom) in order to ease wire connections when installing the turbine (see illustration at right).

Once aligned, insert one of the flange bolts and nuts to hold the flanges in place. Locate the best position for the Anemometer Mount Plate on the flange by taking into account the final location of the anemometer (the ~4ft anemometer boom runs parallel to the outer edge of the plate) so that the erect tower does not block it from the prevailing wind direction, and the anemometer does not contact the ground when the tower is lowered. It is recommended that the plate be positioned such that the anemometer boom is angled upward (from the tower to the anemometer) whenever the tower is in the lowered position, as this will minimize water ingress to the anemometer through the boom.

Place the Anemometer Mount Plate over two of the flange holes and finish inserting all the flange bolts and nuts (see photo at right). Don't forget to use a washer under each bolt and nut. Torque all eight (8) bolts to 250 ft-lbs.

The tower sections are now fully assembled and the gin pole will be assembled next.



## *Gin Pole Bottom*

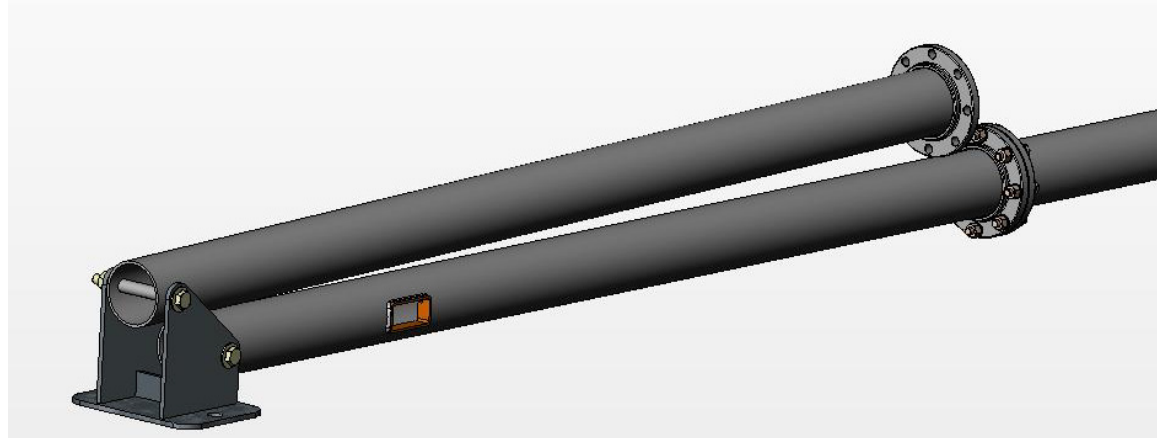
### Parts Needed:

- Item 6 Gin Pole Bottom Section
- Item 14 Pivot Bolt, Washers and Nut

Note the Gin Pole Bottom Section is similar to the Tower Bottom Section (Item 3), except it may be thinner-walled (schedule 10) and it does not have any access hole in it. **IF YOUR GIN POLE BOTTOM SECTION HAS AN ACCESS HOLE, THEN IT IS IN ACTUALITY THE TOWER BOTTOM SECTION. YOU MUST REMOVE THE GIN POLE BOTTOM SECTION FROM THE TOWER ASSEMBLY. USE OF A GIN POLE SECTION IN THE TOWER ASSEMBLY COULD LEAD TO TOWER FAILURE! BE SURE YOU HAVE THE GIN POLE BOTTOM SECTION FOR THIS INSTALLATION STEP AND NOT THE TOWER BOTTOM SECTION.**

Align the Gin Pole Bottom Section pivot tube with the upper set of holes in the sides of the Tower Base. Place one flat washer under the head of the 1" x 11" Pivot Bolt and insert the bolt through one side of the Tower base, through the Gin Pole Bottom Section pivot tube and out the other side of the Tower Base. The Gin Pole Bottom Section is symmetric and as such it does not matter which side faces up. Place another washer on the threaded end of the bolt and then thread on the 1" nylock nut. Thread the nut onto the bolt just far enough to minimize sliding of the bolt, but loose enough to allow the washers to spin freely. **DO NOT TORQUE THIS BOLT.**

Rest the Gin Pole Bottom Section on blocks or a sawhorse of adequate strength so that it rests above the assembled tower sections (see illustration at right). Assembly in this configuration will ease rigging of guy wires between the tower and gin pole.



## *Gin Pole Main/Top Sections*

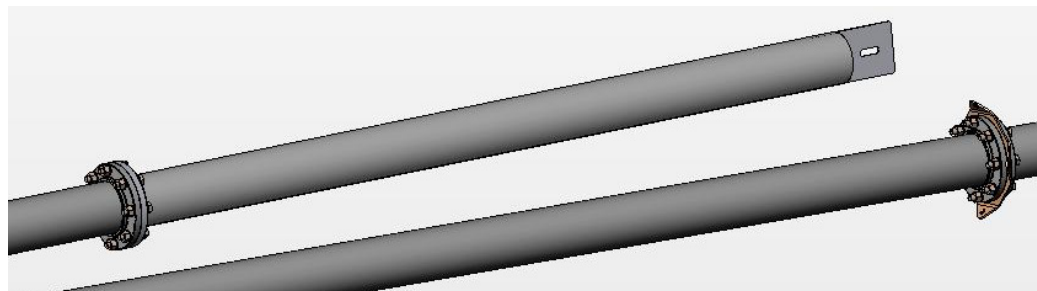
### Parts Needed:

- Item 7 Gin Pole Main Section (for 126ft tower only)
- Item 8 Gin Pole Top Section
- Item 13 Flange Bolts, Washers & Nuts
- Item 9 Removable Gin Pole End Plate
- Item 12 Gin Pole End Plate Bolt, Washers and Nut

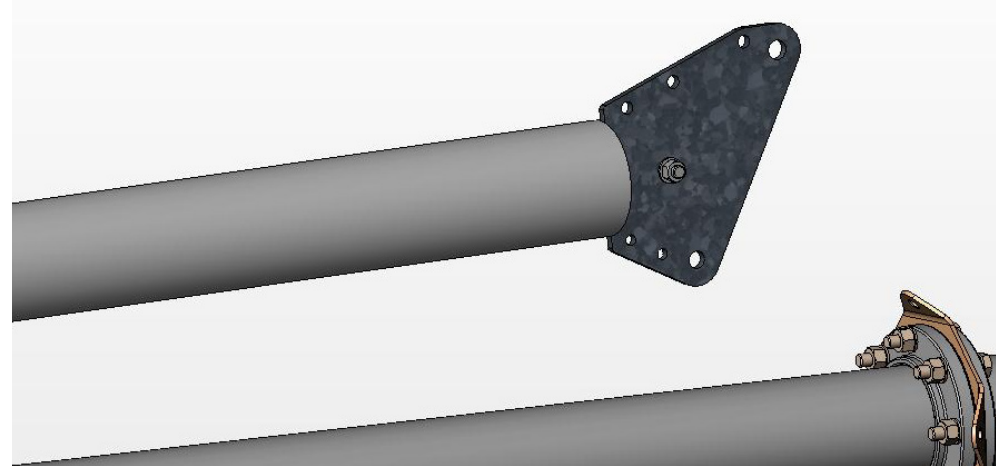
**For 126ft tower only:** install the Gin Pole Main Section to the Gin Pole Bottom Section in the same manner as you installed the Tower Main Sections in the tower assembly. **NOTE THAT THE GIN POLE MAIN SECTION FOR THE 126-FT TOWER LOOKS SIMILAR TO THE TOWER MAIN SECTIONS, BUT IT IS THINNER-WALLED (SCHEDULE 10). USE OF A GIN POLE SECTION IN THE TOWER ASSEMBLY COULD LEAD TO TOWER FAILURE! BE SURE YOU HAVE THE GIN POLE MAIN SECTION FOR THIS INSTALLATION STEP AND NOT A TOWER MAIN SECTION.** Use Flange Bolts with washers and nuts to fasten the flanges of the two gin pole sections as done before with all tower flanges. Torque all the bolts to 250 ft-lbs.

Position the Gin Pole Top Section so the end plate is in a vertical plane (see illustration at right). Align the flange bolts holes with those on the flange on the gin pole section below and secure with Flange Bolts as you did previously in assembling the tower. Torque all the bolts to 250 ft-lbs.

Rest the gin pole assembly on blocks or a suitable sawhorse to hold it above the tower assembly.



Install the Removable Gin Pole End Plate on the top end of the gin pole using the Gin Pole End Plate Bolt, Nut and Washers. It does not matter what side this plate is bolted on, but it must be oriented so that the side with 4 holes will be closest to the ground when the tower is raised (see illustration at right for proper orientation during assembly). Torque the bolt to 250 ft-lbs.



## Ground Anchor Rigging

### Parts Needed:

- Item 20 Ground Shackles (3)
- Item 21 Upper Guy Turnbuckles (3)
- Item 22 Lower/Middle Guy Turnbuckles (3 or 6) (not used on 63-ft tower)
- Item 23 Pear Links (3 or 6) (not used on 63-ft tower)

The guys will attach to the ground anchors using rigging of shackles, links and turnbuckles. These will be installed now, and will help determine the length of guy cables needed for the installation. The exact combination of rigging will be dictated by the type of ground anchors used at your site. This manual shows just one type of installation. Whatever combination used at your site, **BE SURE ALL RIGGING MEETS THE LOAD REQUIREMENTS OR YOU RISK FAILURE OF THE TOWER SYSTEM!**

On the three ground anchors (not including the winch end), install a 7/8" Ground Shackle by placing the pin through the eye in the ground anchor (*see photo at right*). Attach to each of these one (1) Upper Guy Turnbuckle (7/8" or larger). For 84-ft and 105-ft towers, place a Pear Link on the Ground Shackle as well. For 126ft towers, use two Pear Links. Finally, attach a Lower Guy Turnbuckle (and Middle Guy Turnbuckle for 126ft tower) to each Pear Link.

If the Ground Shackle is oriented such that the pin points toward the tower base, ensure that the larger Upper Guy Turnbuckle is located furthest from the tower base on the Ground Shackle so it will be above the Lower Guy Turnbuckle when the tower is raised (*as in photo at right*).

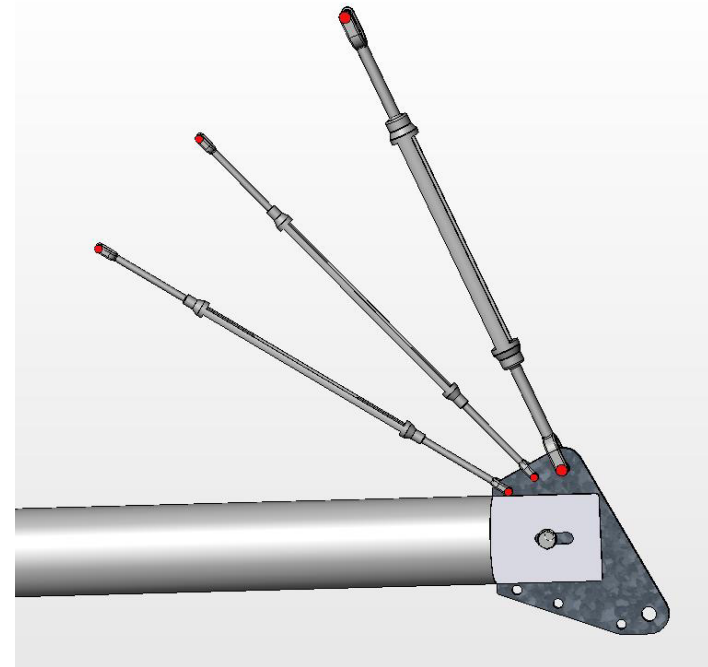


## *Gin Pole Guy Rigging*

### Parts Needed:

- Item 21 Upper Guy Turnbuckles (1)
- Item 22 Lower/Middle Guy Turnbuckles (1 or 2) (not used on 63-ft tower)

On the gin pole end plate, install an Upper Guy Turnbuckle (7/8") in the uppermost hole (farthest from the tower base) on the top-side of the gin pole. For 84-ft and 105-ft towers, install a Lower/Middle Guy Turnbuckle (1/2") in one of the two remaining holes. For the 126-ft tower, install another Lower/Middle Guy Turnbuckle in the remaining hole. Illustration at right shows all three turnbuckles in place on the Removable Gin Pole End Plate for a 126-ft tower.



## Guy Wires

### Parts Needed:

- Item 15 Guy Wires
- Item 16 Thimbles
- Item 17 Wire Clips
- Item 18 Upper Guy Tower and Gin Pole Shackles
- Item 19 Lower/Middle Guy Tower and Gin Pole Shackles

The guy wires are supplied with one end swaged (or clipped) with a thimble. If this is not the case, clip a thimble onto one end (*see illustration at right for proper installation of Wire Clips*). Swaged ends are recommended for the cable ends attached to the tower as inspection of Wire Clips in these locations is problematic.

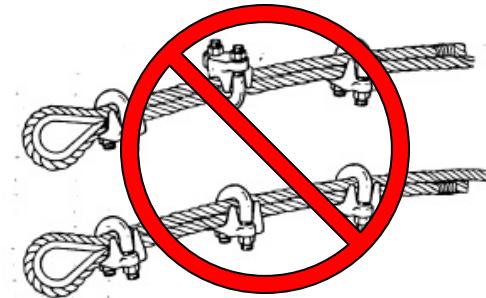
A minimum of 3 Wire Clips are required for each thimble on the 1/2" upper guy (2 Clips are required on smaller guy wire). Slide the first clip up against the thimble, then space the next two clips 6 times the Guy Wire diameter (3" for 1/2" wire rope; 1.75" for 5/16" wire rope).

Attach 1/2" Guy Wires to tabs near the tower top using 3/4" Upper Guy Tower and Gin Pole Shackles. Estimate the needed length of the guys by stretching the side guys to the side anchors. Note that the side guys will tighten as the tower is raised, so allow some slack when the tower is lowered. Make up all Guy Wire lengths accordingly, accounting for changes in ground elevation and turnbuckle lengths. Insert a Thimble and Wire Clips to make up the three ground end attachment points. These may need to be adjusted after the tower is lifted and checked for plumb.

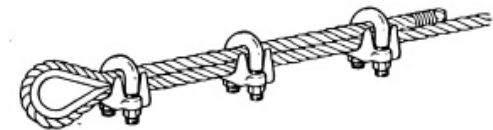
Estimate the length of the gin pole Guy Wires by using the tower geometry and realizing the gin pole may be shy of horizontal when the tower is upright. Be sure to account for the length of the turnbuckles used in connecting the guys to the gin pole.

Torque Wire Clip bolts according to the guy wire size as follows:

Guy Wire Size	1/4"	5/16"	3/8"	1/2"
Bolt Torque	15 ft-lbs (20 Nm)	30 ft-lbs (41 Nm)	45 ft-lbs (61 Nm)	65 ft-lbs (88 Nm)



The wrong way to clip wire rope



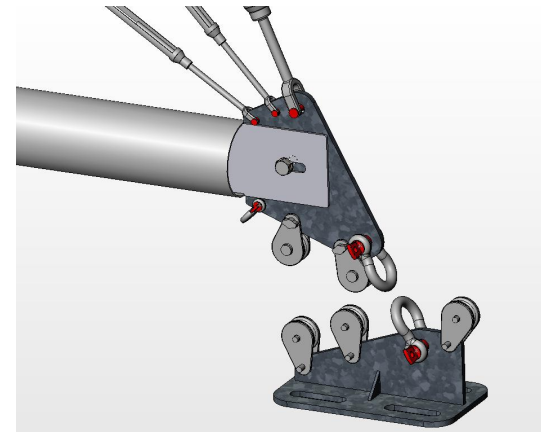
The right way to clip wire rope

## *Winch Cable Rigging*

### Parts Needed:

- Winch cable end shackle (1/2")
- Blocks (not supplied)
- Winch Cable (not supplied)

Install a series of two or three blocks on the Gin Pole Anchor Base, and another one or two blocks to the lower side of the Removable Gin Pole End Plate as shown in illustration at right, threading the winch cable through these blocks as you go. Finally, terminate the winch cable at the Gin Pole End Plate or ground anchor as necessary for your situation using a 1/2" (or other appropriate size) shackle. When finished, ensure the winch cable runs true without crossing itself or being tangled.



## Raising the Gin Pole

### Parts Needed:

- Item 24 Poly Rope

Prepare the gin pole for initial raising by securing it with side guys. Attach the Poly Rope supplied to the gin pole end and back down to the tower side guy anchors (as shown in photo at right). The gin pole side guys will prevent the gin pole from leaning too far to the side during tower lifting. These side guys do not need much strength, and should be snug (not too slack but not tight) when the gin pole is vertical. Rope with adequate stretch is recommended as it may tighten as the tower is raised. Use of wire rope or other non-stretch rope may require it to be played out as the tower is raised.



The gin pole can be raised into position to lift the tower using the same winch and winch cable (provided it is of sufficient length) for lifting the tower. Run the winch cable up over a "temporary gin pole" such as a 12ft ladder or other self-standing structure of sufficient strength positioned just toward the winch side of the tower base, to help start the lift. The photo below shows one such configuration for raising the gin pole on a 126ft tower system.



Be sure all tower guy wires, blocks and shackles are properly secured to the gin pole end before starting the lift. At the start of the lift ensure that the gin pole is being raised and not simply compressed by the winch cable. During the lift check that the side guys do not become too tight, and that the gin pole is not leaning excessively to one side or another. If either case arises, stop and lower the gin pole and adjust the side guys as necessary. As the gin pole reaches vertical ensure that the guys leading back to the tower are not too slack, as this will allow the gin pole to fall past vertical. Put some back pressure on the tower top guy if necessary to control the gin pole until the gin pole lift is complete.

## Initial Tower Raising

### Parts Needed:

- Rope and shackle or snap link (not supplied) to apply back-pressure to down-side guys

A crew of at least three is best for initial lifting of the tower. This allows one person to run the winch while two are available to monitor for problems and to check guy tension. **NEVER STAND UNDER THE TOWER WHILE LIFTING AND BE VERY ATTENTIVE TO NOT OVERTENSION THE GUY WIRES AS THIS CAN BUCKLE THE TOWER!**

Perform a final check on all guy wire attachments to the tower prior to lifting. Address any problems now to prevent problems during the lift.

As the tower is raised initially, pay close attention to the tension in both tower and gin pole side guys as they will tighten as the tower raises. **IF YOU CAN'T DEFLECT THE TOWER SIDE GUY CABLES EASILY 4-6" BY LEANING ON IT, IT IS TOO TIGHT!** Loosening the turnbuckles can alleviate this tension. If the guys become too tight with the turnbuckles played out before the tower is vertical, the guys will need to be slackened. Lower the tower and adjust the guys accordingly.

### *Applying Back Pressure on Down-Side Guy to Control Lift*

As the tower nears vertical the gin pole weight will tend to pull the tower up and potentially past vertical if allowed (this tendency will be exacerbated without the weight of the turbine atop the tower). This could result in the gin pole hitting the ground and/or a severe impact load on the back guy wire. In order to prevent this, the back guy must be kept under tension as the tower nears vertical. This can be accomplished by having someone apply tension on the back guy by pulling it toward the tower base using a rope attached to the back guy with a shackle. Play out this rope as the winch continues to lift the tower, maintaining tension on the back guy. This method will allow the tower to be brought vertical smoothly and under control.

This method to tension the back guy can also be used to assist in lowering the tower. Pulling on the back guy will tilt the tower from vertical at the start of lowering, then the tower weight can start to lift the gin pole.

### *Completing the Lift and Securing the Tower*

Once the lift is completed secure the end of the gin pole to the gin pole anchor using a series of three 7/8" shackles as shown in the photo at right.



### *Straightening the Tower and Making it Plumb*

Once the tower is upright, check for plumb using a level at the bottom of the tower and sighting up the tower to check for straightness (see photo at right of 126ft tower after lifting and in need of upper guy adjustments). You can also sight along the length of a tower with a plumb line to check that the tower top and bottom are vertical. Do this from two sides to ensure the tower is vertical from all sides.

Make small adjustments using the turnbuckles on opposite sides of the tower, turning one side out and the other in equal amounts. Large adjustments may require adjusting the Wire Clips on the guy wires. Do so using cable (Haven's) grips to temporarily secure the tower and take tension off the end of the guy you wish to adjust.

Adjust the length of rigging between the tower and gin pole so that the gin pole is not resting on the ground but is being held down to the ground anchor by the series of shackles (shown above) and up by the guy wires. The guys should have minimal tension in them with the tower vertical and no external load applied. Check this by testing that all guys easily deflect 4" – 6" when leaning against them.

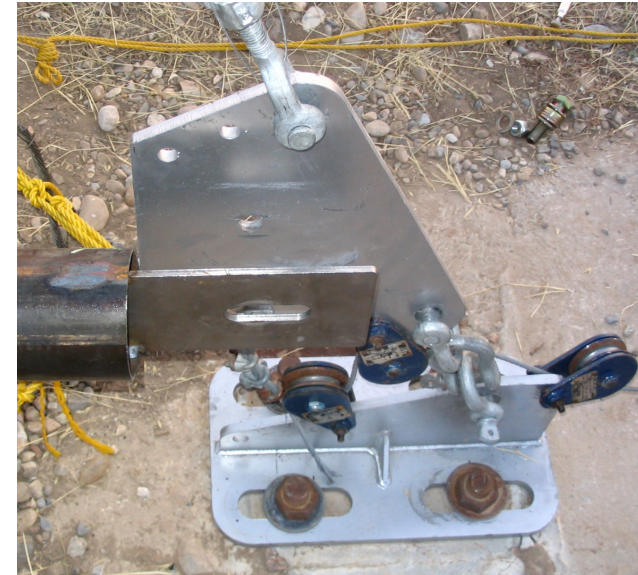


### Gin Pole Anchor Adjustment

The gin pole for the tower system is removable, as it is only necessary for lifting and lowering the tower system. Once the turbine is finally installed, the gin pole may be removed and stored until needed again for turbine maintenance purposes. In order to accommodate the removable feature, the gin pole anchor may need to be adjusted.

With the gin pole end secured to the gin pole anchor, loosen the nuts holding the anchor to the ground just enough to allow movement of the anchor along its slotted holes. **DO NOT REMOVE ANY NUTS.** With the nuts loose, nudge the anchor to roughly align the three shackles holding the gin pole with the angled back edge of the gin pole end plate. The goal is to minimize movement of the gin pole end plate when it is unbolted from the gin pole. The picture at right shows a gin pole anchor properly positioned so that the end plate has moved very little with the gin pole unbolted from it.

Once the anchor is properly positioned, tighten down all four nuts and torque the appropriate amount for size bolt used. Recheck the tower for plumb and make any necessary adjustments to the turnbuckles to make it vertical.



### Final adjusting of tower hardware

Check all guy wires cable clips for properly seating, spacing and fastener torque.

### *Tensioning the Guy Wires*

To adjust the guy tension appropriately, the fundamental frequency of the guys can be used. To use this method, choose one guy and gently sway it so that it moves in one large arc (it will oscillate at the fundamental frequency). Count the number of back-and-forth sways the cable makes while timing the process. You may either count the number of seconds it takes to reach 20 cycles, or the number of cycles that occur in 10 seconds. The table below shows the target measurement for each guy wire.

<b>Tower Height (ft)</b>	<b>Upper Guy</b>		<b>Middle Guy</b>		<b>Lower Guy</b>	
	Seconds per 20 cycles	Cycles per 10 seconds	Seconds per 20 cycles	Cycles per 10 seconds	Seconds per 20 cycles	Cycles per 10 seconds
<b>63</b>	9	22	NA	NA	NA	NA
<b>84</b>	13	15	NA	NA	5	40
<b>105</b>	16	13	NA	NA	6	33
<b>126</b>	20	10	11	18	8	25

Adjust the guy tension by using the turnbuckles, loosening them if the time period is too short or the cycles per 10 seconds is too high, and tightening when the time period is too long or the cycles per 10 seconds is too low. Be sure to adjust the turnbuckles on both sides of the tower an equal amount to avoid drawing the tower out of plumb.

### ***Securing the Rigging Hardware***

After the tower has been raised and all adjustments made, “tie off” the tower hardware. If turnbuckles are not secured they will (over time) wiggle loose. This can be prevented by passing the loose ends of the guys through the eyes and the middle of each turnbuckle in a figure-eight fashion (see *left photo below*). Install cotter keys (or other device) to insure turnbuckle pins are secured and will not wiggle loose (see *center photo below*). Secure shackles with bailing wire passed through the hole in the end of the pin and through the shackle eye (see *right photo below*).



## Tower Preparation for Turbine

### Parts Needed:

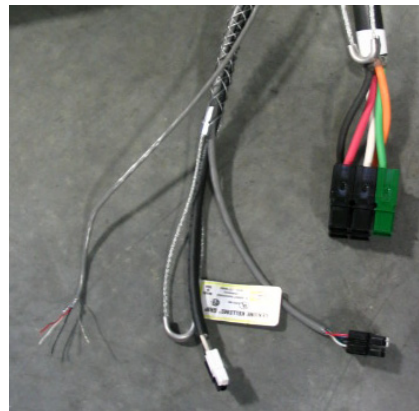
- Item 25 Tower Electrical Wire Bundle
- Item 26 Kellem Grip Snap Link

With the tower assembled and guys adjusted, lower the tower and rest it on a stand of adequate strength. Position this stand just below (toward the tower base) the top guy attachment location to provide room for installing the turbine and blades. Ensure the tower top is at least ~5ft above the ground with the tower resting on the stand. An intermediate stand may be placed approximately halfway down the tower to limit tower sag when in this lowered position.

### *Installing Tower Wiring*

Pull all wires in the tower electrical bundle through the tower so one end of the wires protrudes from the upper access hole near the tower top and the other end protrudes from the lower hole near the tower base. Do this using a fish tape of sufficient length, and inserting the tape from the bottom of the tower (through either the very bottom or through the access hole on the side near the bottom), and feeding it up and out the top of the tower.

There are four sets of wires (some of which may be bundled together) with connectors and Kellem grips installed at the top end of the wires (see photo at near right). Securely fasten the bottom end (opposite these grips and connectors) of the wires (including the anemometer wire that has no connectors) to the fish tape and carefully feed all the wire down the tower, pulling the end out the lower access hole at the tower base. Feed the wires down until there is no more than 1-ft of wire to extend out the upper access hole in the tower (see photo at far right). Secure the installed Kellem grips to the inside of the tower access hole by installing the snap link over the grips and through the small hole drilled in the bottom of the access hole frame.



### Anemometer Wire

Now find the small hole in the tower near the top tower flange where the anemometer boom mount plate was installed (see photo at right). Run the fish tape up through this hole toward the tower top and use it to fish the anemometer wire (the one with no connectors on it) down through this hole.

Secure all the wires so they do not accidentally get pulled out of place prior to installing the turbine.

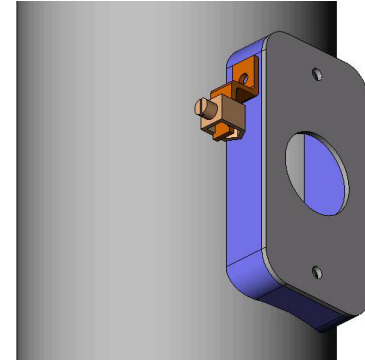


## Electrical Grounding

### Parts Needed:

- Item 28 Tower Grounding Lug

Electrically ground the tower to an adequate ground rod installed in the soil near the base of the tower. The supplied ground lug can be attached to the tower on the side of the lower access hole of the tower bottom section (see *drawing at right*). Alternatively, use a grounding strap or clamp secured around or to the tower. Connect a copper ground wire between the grounding point on the tower and the ground rod. Be sure to leave sufficient slack in the ground wire to allow for lowering and lifting the tower.



Use the pigtails of the guy cables as grounding wires at each of the four guy anchor points. Secure multiple guy wires together using cable clips (spares are included for this purpose – see *photo at right*) and then secure one of the guys to a grounding clamp on a grounding rod properly installed in the ground near the anchor point. Again, be sure to leave sufficient slack in all grounding lines for tilting the tower down and up.



## Final Inspection

Upon completion of all steps in this installation process, inspect all connections and hardware for proper installation and make any adjustments prior to installing the turbine on the tower. Replace any hardware that appears suspect or does not operate as expected.

Your tilt-up tower system is now ready for installation of an Endurance wind turbine.

## APPENDIX A – Foundation Design Document

The following pages contain foundation design drawings for the Endurance S-250 tilt-up towers described in this installation manual. These designs have been deemed sufficient for the Endurance tower and wind turbine assembly when installed properly in the assumed soil conditions and according to manufacturer specifications, and operating within conditions for which the system was designed. Endurance Wind Power does not warranty these foundation designs. Your specific soil type may vary from the assumed types listed in this documentation, and it is solely the responsibility of the owner to assess the adequacy of the designs for local conditions. Any required permits or engineering approval required by local jurisdictions is also solely the responsibility of the owner to obtain.

## Assumed Soil Properties

Soil Class	Description	Allowable Bearing Pressure (lbs/ft <sup>2</sup> )	Lateral Bearing (per foot below grade) (lbs/ft <sup>2</sup> /ft)	Lateral Sliding (coefficient of friction)	Lateral Sliding (resistance) (lbs/ft <sup>2</sup> )	Soil weight (dry) (lbs/ft <sup>3</sup> )
		(lbs/ft <sup>2</sup> )	(lbs/ft <sup>2</sup> /ft)	-	(lbs/ft <sup>2</sup> )	(lbs/ft <sup>3</sup> )
1	Bedrock	12,000	1,200	0.70	0	140
2	Sedimentary and Foliated Rock	4,000	400	0.35	0	130
3	Sandy Gravel and/or gravel	3,000	200	0.35	0	120
4	Sand, silty sand, clayey sand, silty gravel, and clayey gravel	2,000	150	0.25	0	100
5	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1,500	100	0.00	130	90

**PROPRIETARY AND CONFIDENTIAL**  
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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	NAME	DATE	Assumed Soil Properties
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
NEXT ASSY	USED ON	FINISH:			
APPLICATION		DO NOT SCALE DRAWING			
SIZE <b>A</b>	DWG. NO. <b>Foundation-001</b>				REV.
SCALE:1:1		WEIGHT:		SHEET 1 OF 1	

## Maximum Foundation Loads (Endurance S-250)

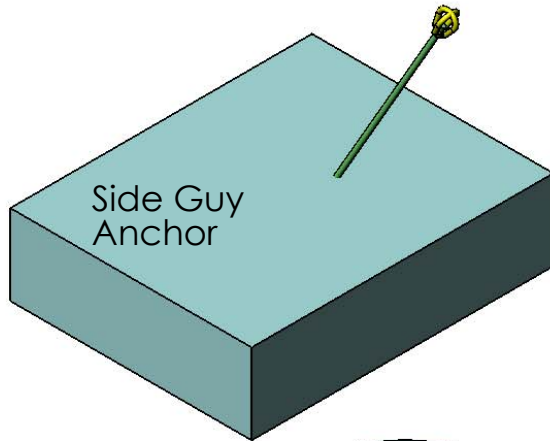
Tower Height	38.4 m	(126 ft)	32 m	(105 ft)	25.6 m	(84 ft)	19.2 m	(63 ft)
Guy Radius	15.2 m	(50 ft)	12.5 m	(41 ft)	9.8 m	(32 ft)	7.0 m	(23 ft)
Guy Elevation(s)	9.8, 22.6, 35.7 m	(32, 74, 117 ft)	12.8, 29.3 m	(42, 96 ft)	11.4, 22.8 m	(31, 75 ft)	16.5 m	(54 ft)
Tower Vertical Force	79.8 kN	(17.9 kip)	69.3 kN	(15.6 kip)	63.9 kN	(14.4 kip)	46.7 kN	(10.5 kip)
Tower Horizontal Force*	17.7 kN	(3.98 kip)	15.8 kN	(3.56 kip)	14.3 kN	(3.21 kip)	14.0 kN	(3.16 kip)
Anchor Vertical Force	38.8 kN	(8.73 kip)	37.7 kN	(8.47 kip)	34.4 kN	(7.72 kip)	28.6 kN	(6.42 kip)
Anchor Horizontal Force	24.1 kN	(5.41 kip)	20.0 kN	(4.50 kip)	18.1 kN	(4.07 kip)	12.2 kN	(2.73 kip)
Anchor pull-out Force	45.7 kN	(10.3 kip)	42.7 kN	(9.59 kip)	38.8 kN	(8.73 kip)	31.0 kN	(6.98 kip)
Max Top Guy Tension	31.0 kN	(6.97 kip)	33.2 kN	(7.46 kip)	30.8 kN	(6.92 kip)	31.0 kN	(6.98 kip)
Max Mid Guy Tension	8.94 kN	(2.01 kip)	N/A	N/A	N/A	N/A	N/A	N/A
Max Lwr Guy Tension	6.96 kN	(1.56 kip)	10.0 kN	(2.25 kip)	8.56 kN	(1.92 kip)	N/A	N/A
Anchor Pull-out Angle	58.2°		62.0°		62.2°		66.9°	
Max. Lifting Cable Pull	25.0 kN	(5.60 kip)	22.4 kN	(5.05 kip)	20.2 kN	(4.55 kip)	19.6 kN	(4.45 kip)
Winch Cable Pull**	5.00 kN	(1.12 kip)	4.47 kN	(1.01 kip)	4.04 kN	(0.91 kip)	3.97 kN	(0.89 kip)

\*Occurs during tower tilt-up.

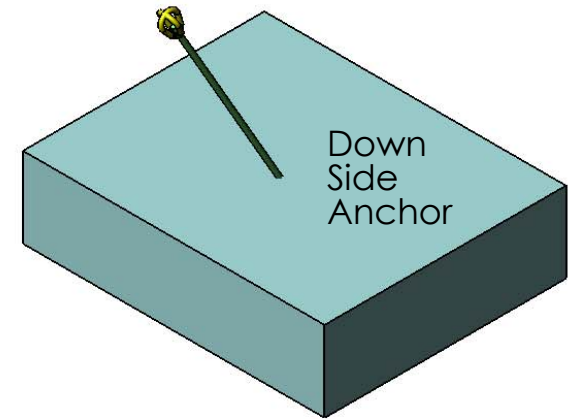
\*\*Assumes 5:1 block & tackle system.

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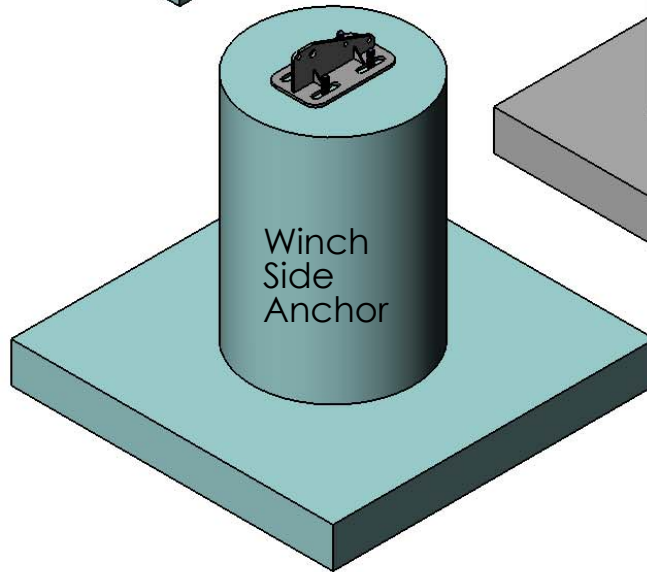
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	NAME DRAWN Dean Davis CHECKED ENG APPR. MFG APPR. Q.A.	DATE 06 Aug 07	Endurance Wind Power  Max. Foundation Loads		
NEXT ASSY	USED ON	FINISH:	COMMENTS:  - IEC Class II - Max 133 mph		SIZE <b>A</b>	DWG. NO. Foundation-002	REV. v1.0
APPLICATION		DO NOT SCALE DRAWING			SCALE:1:1	WEIGHT:	SHEET 1 OF 1



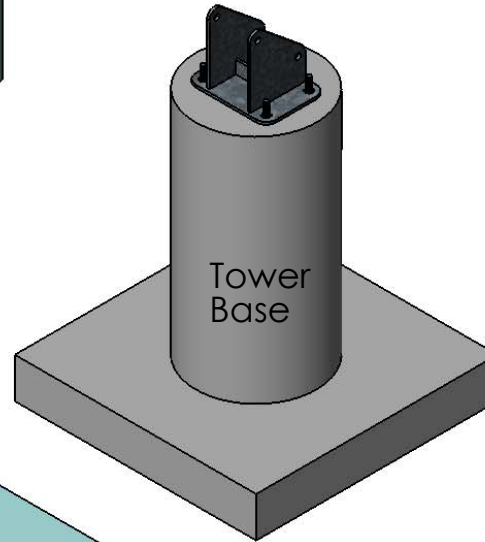
Side Guy Anchor



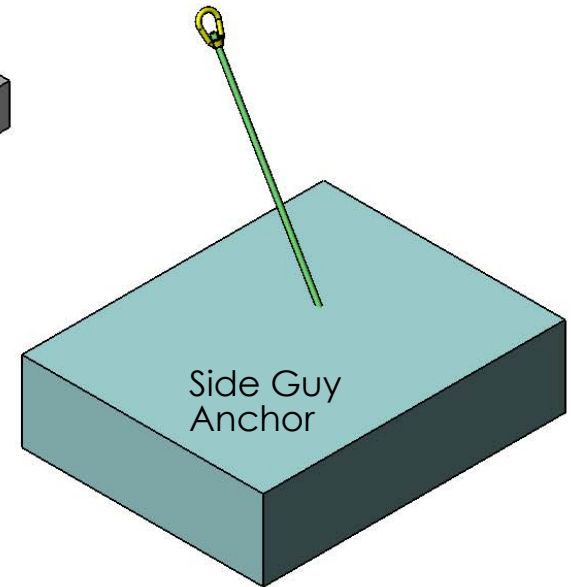
Down Side Anchor



Winch Side Anchor



Tower Base



Side Guy Anchor

Foundation	Shown		Option-1		Option-2	
	Style	Dwg. No.	Style	Dwg. No.	Style	Dwg. No.
Tower Base	Pier & Footing	Foundation-010	Pier	Foundation-011		
Winch Side Anchor	Pier & Footing	Foundation-013	Pier	Foundation-014		
Down & Side Guy	Buried	Foundation-012	Pier	Foundation-014	Pier & Footing	Foundation-013

Concrete minimum compressive strength 3,000 psi

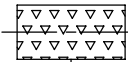
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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±
		MATERIAL:
		FINISH:
NEXT ASSY	USED ON	
APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Dean Davis	07 Aug 07
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		
Tower Heights 63', 84', 105', 126'		

Endurance Wind Power			
Foundation Layout (Isometric view)			
SIZE <b>A</b>	DWG. NO. Foundation-003	REV. v3.5	
SCALE:1:96	WEIGHT:	SHEET 1 OF 1	

Left Guy



Tower Height	X
63 ft	23' ± 2"
84 ft	32' ± 2"
105 ft	41' ± 2"
126 ft	50' ± 2"

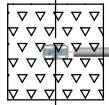
Guy Foundation Type	S
Buried Slab*	X + 25"
Pier/Pier with Footing	X

\*Guy excavation holes assumed 48" deep with anchor set at 60 deg. incline.

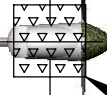
Excavation hole dimensions not to scale

S

X



Winch Guy



Tower Foundation

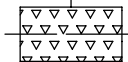


Down-side Guy

S

S

Clearance for lowering = Tower Height + 10ft



Right Guy

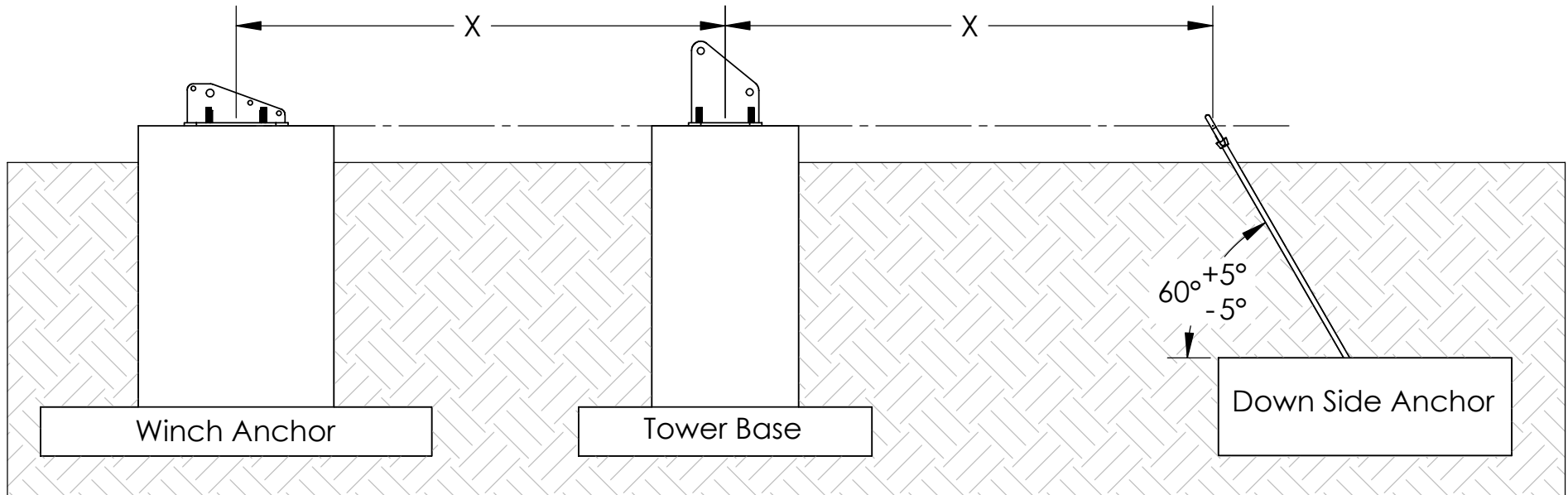
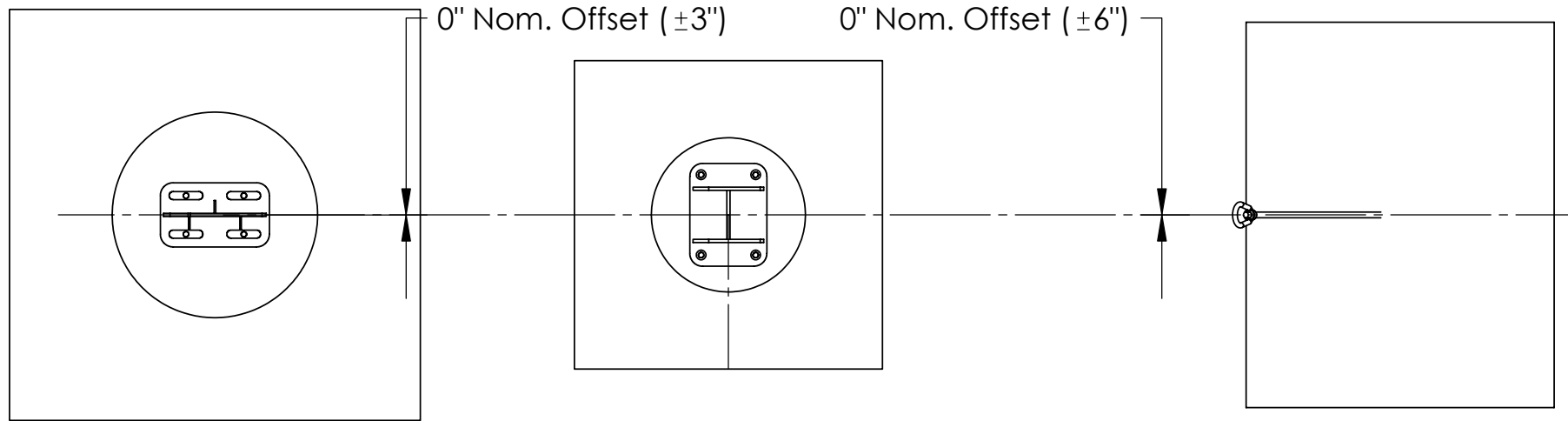
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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	NAME	DATE
DRAWN	David Laina		10 Aug 07	
CHECKED				
ENG APPR.				
MFG APPR.				
			Q.A.	
		COMMENTS:		
NEXT ASSY	USED ON	FINISH:		
APPLICATION		DO NOT SCALE DRAWING		

Endurance Wind Power

S-250 Foundation  
Excavation Layout

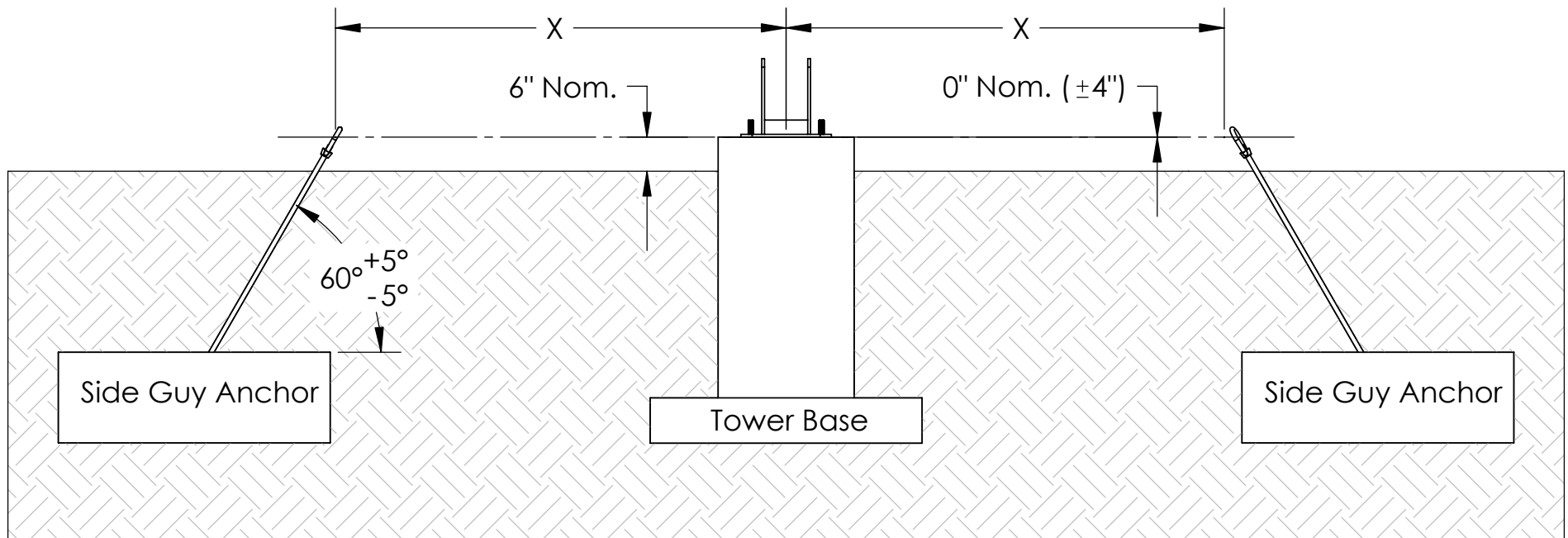
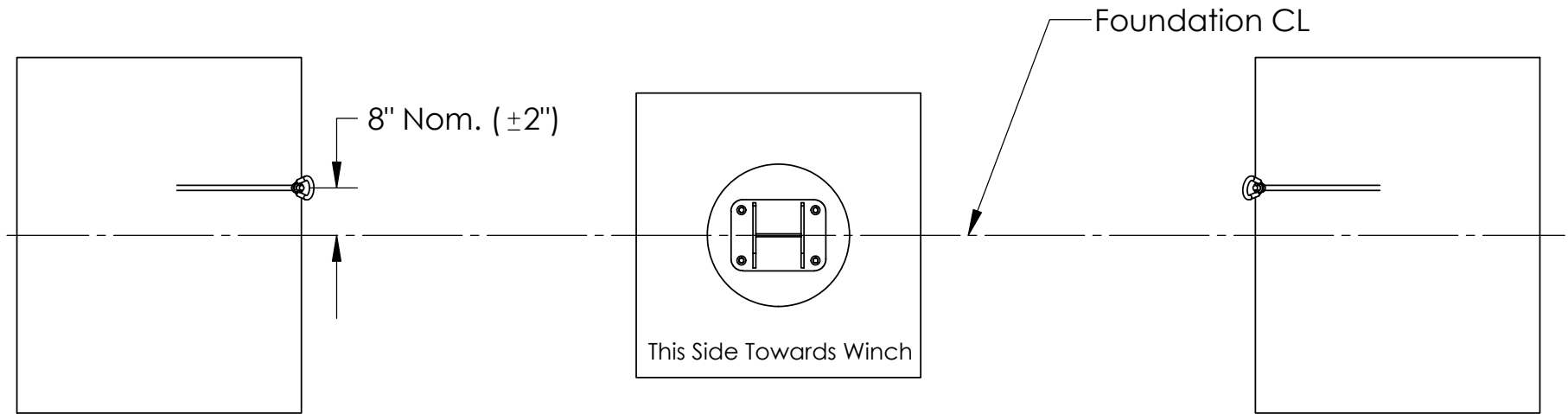
SIZE <b>A</b>	DWG. NO. Foundation-004	REV.
SCALE: 1:128	WEIGHT:	SHEET 1 OF 1



Tower Height	X
63'	23' ±2"
84'	32' ±2"
105'	41' ±2"
126'	50' ±2"

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		DIMENSIONS ARE IN INCHES		NAME		DATE		Endurance Wind Power	
		TOLERANCES:		DRAWN		Dean Davis			
		FRACTIONAL ±		CHECKED				Winch & Down Side Foundation Layout	
		ANGULAR: MACH ± BEND ±		ENG APPR.					
		TWO PLACE DECIMAL ±		MFG APPR.					
		THREE PLACE DECIMAL ±		Q.A.					
		MATERIAL:		COMMENTS:				Tower Heights	
NEXT ASSY		USED ON		FINISH:				63', 84', 105', 126'	
APPLICATION		DO NOT SCALE DRAWING						SIZE <b>A</b> DWG. NO. Foundation-005 REV. v3.4	
								SCALE:1:96 WEIGHT: SHEET 1 OF 1	



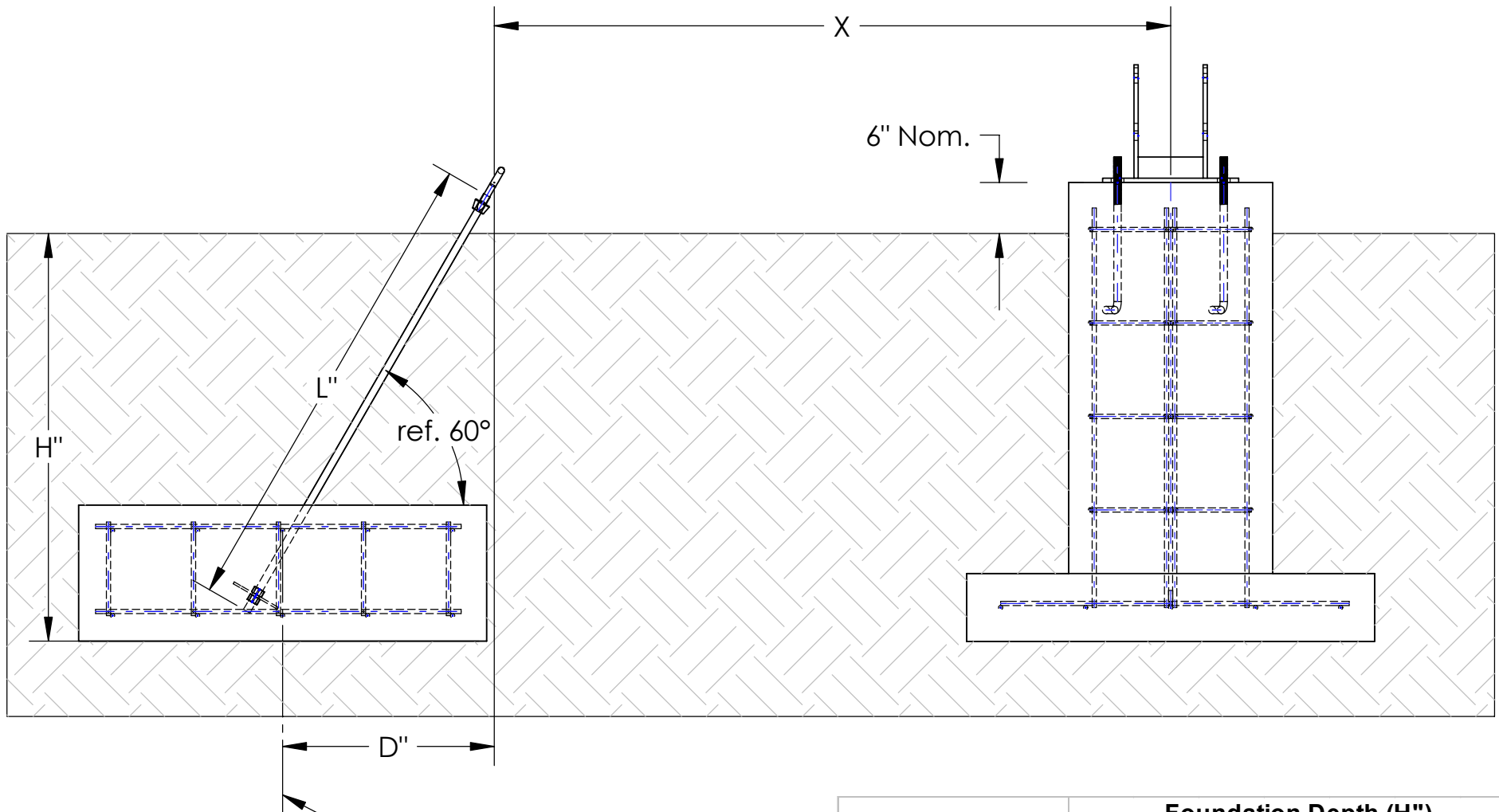
Tower Height	X
63'	23' ±2"
84'	32' ±2"
105'	41' ±2"
126'	50' ±2"

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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±
		MATERIAL:
		FINISH:
NEXT ASSY	USED ON	
APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Dean Davis	07 Aug 07
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		
Tower Heights 63', 84', 105', 126'		

Endurance Wind Power			
Side Guy Foundation Layout			
SIZE <b>A</b>	DWG. NO. Foundation-006	REV. v3.4	
SCALE: 1:96	WEIGHT:	SHEET 1 OF 1	



Foundation Center line

	Foundation Depth (H'')						
	36	42	48	54	60	66	72
Radius Offset (D'')	18	21.5	25	28.5	32	35.5	39
Anchor Length (L'')	43	50	56.5	63	70	77	84

Tower Height	X
63'	23' ±2"
84'	32' ±2"
105'	41' ±2"
126'	50' ±2"

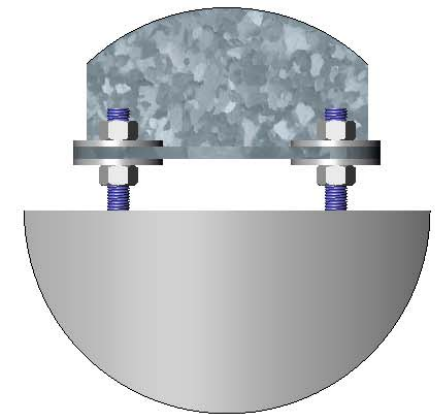
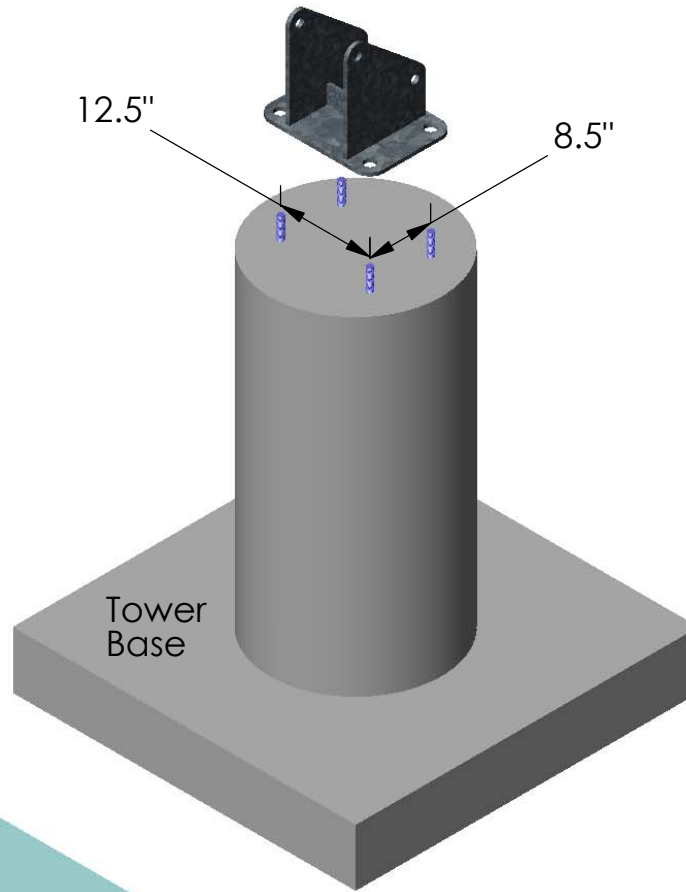
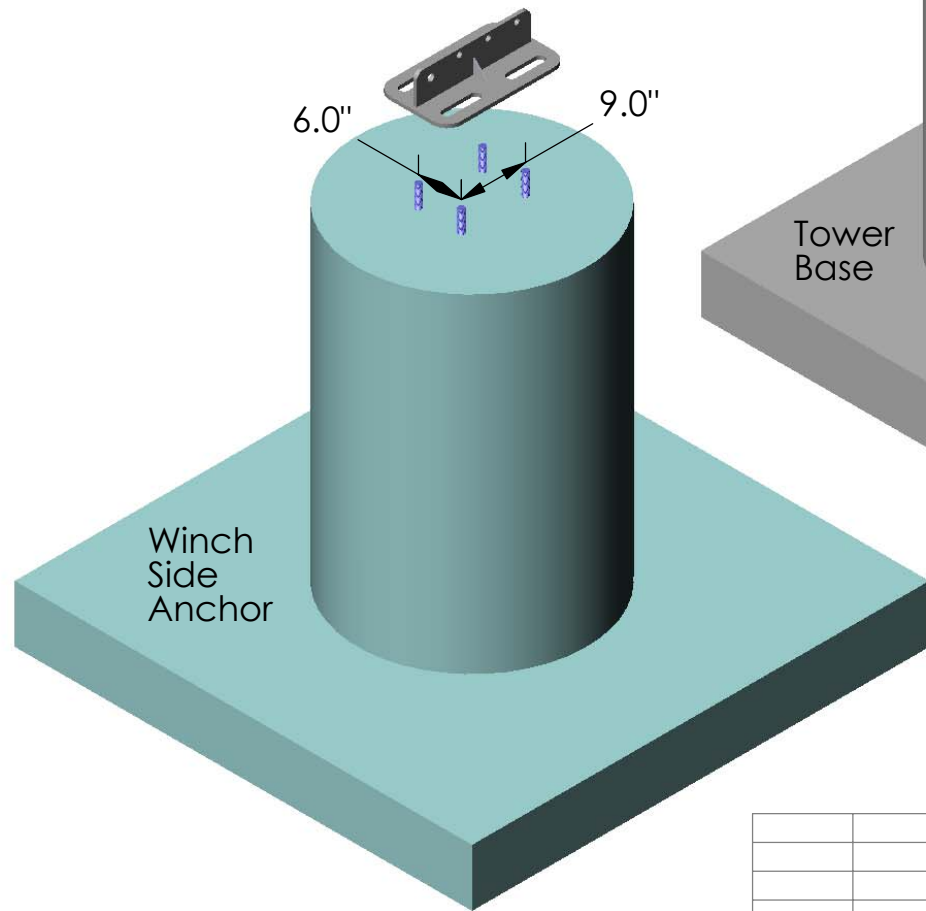
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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE
		MATERIAL:		DRAWN	Dean Davis 07 Aug 07
		FINISH:		CHECKED	
NEXT ASSY		USED ON		ENG APPR.	
APPLICATION		DO NOT SCALE DRAWING		MFG APPR.	
		Tower Heights 63', 84', 105', 126'		Q.A.	
				COMMENTS:	

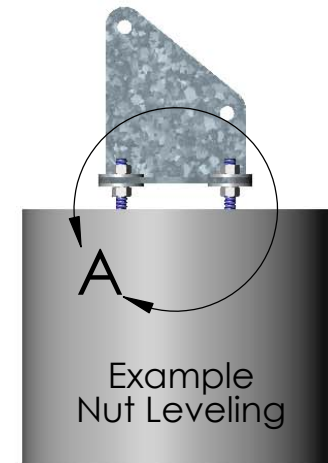
Endurance Wind Power			
Buried Anchor Foundation Layout			
SIZE <b>A</b>	DWG. NO.	Foundation-007	REV. v2.0
SCALE: 1:96	WEIGHT:	SHEET 1 OF 1	

J-bolts  
 dia. 7/8"  
 length ~18"  
 exposed\* 2-4"

\*2" for grout leveling  
 4" for nut leveling



DETAIL A  
 SCALE 2 : 15



All Dimensions in inches

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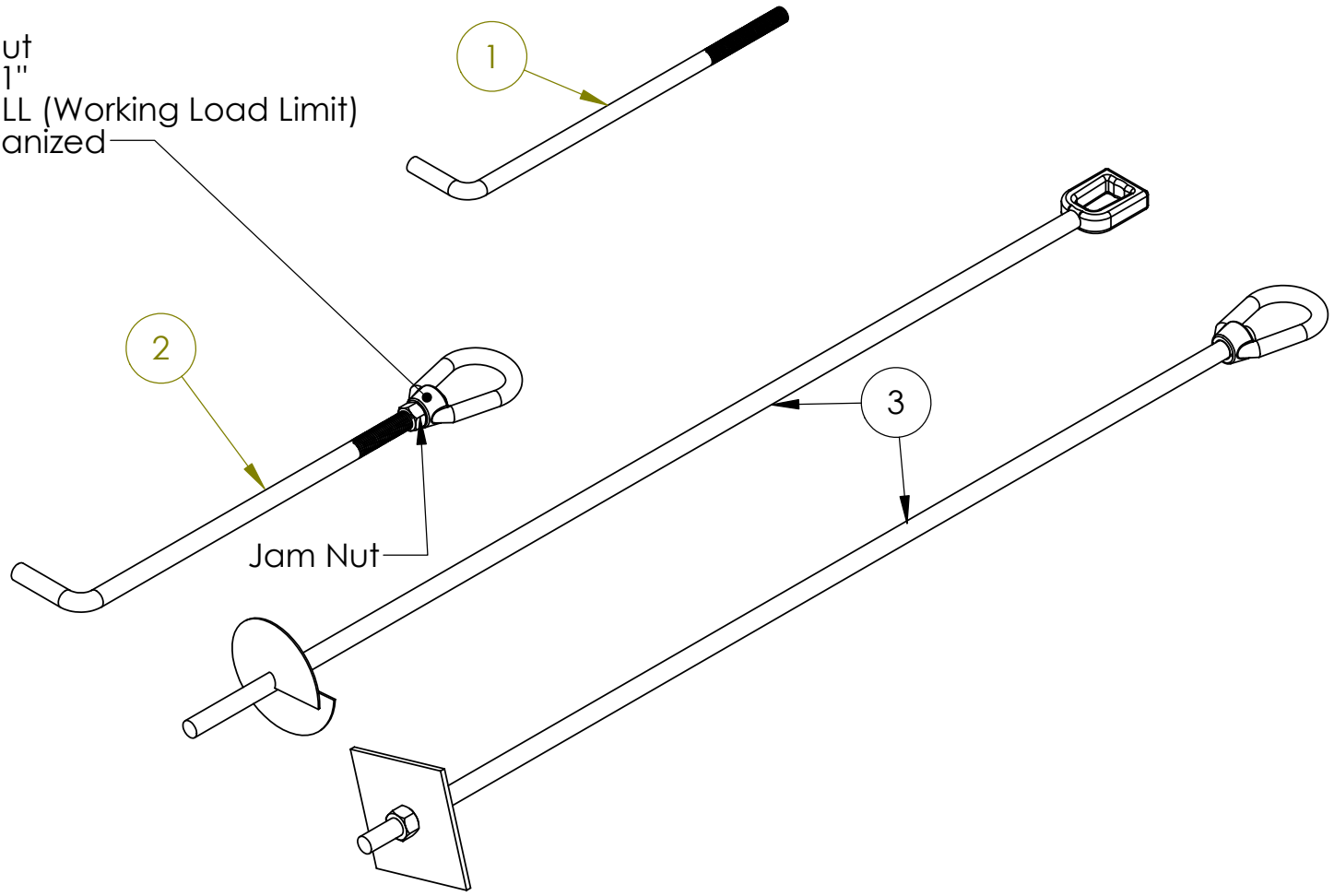
		DIMENSIONS ARE IN INCHES		NAME	DATE
		TOLERANCES:		DRAWN	Dean Davis
		FRACTIONAL ±		CHECKED	06 Aug 07
		ANGULAR: MACH ± BEND ±		ENG APPR.	
		TWO PLACE DECIMAL ±		MFG APPR.	
		THREE PLACE DECIMAL ±		Q.A.	
		MATERIAL:		COMMENTS:	
NEXT ASSY	USED ON	FINISH:			
APPLICATION		DO NOT SCALE DRAWING			

Endurance Wind Power

Base Plate  
 J-Bolt Patterns

SIZE <b>A</b>	DWG. NO.	Foundation-008	REV. v1.0
SCALE:1:48	WEIGHT:	SHEET 1 OF 1	

Eye Nut  
 - Size 1"  
 - 5t WLL (Working Load Limit)  
 - galvanized



#	Description	Size	Length	# Required	Foundation Style
1	Tower base & winch anchor J-bolt	1" or 7/8" dia.	~18"	8	All
2	Guy Anchor J-bolt	1" dia.	~18"	3	Pier or Pier & Footing guy anchors
3	Guy Anchor	3/4" or 1" " dia.	~5'	3	Buried guy anchors

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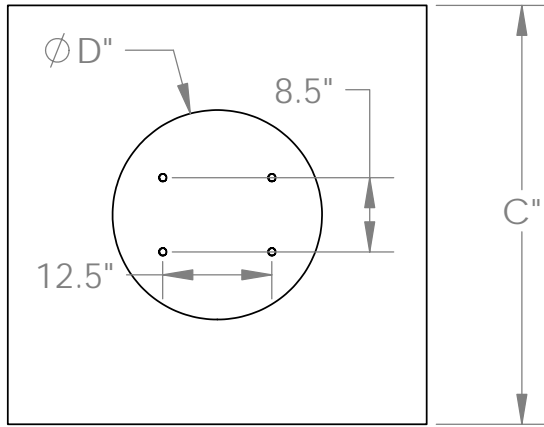
		DIMENSIONS ARE IN INCHES		NAME	DATE
		TOLERANCES:		DRAWN	Dean Davis
		FRACTIONAL ±		CHECKED	06 Aug 07
		ANGULAR: MACH ± BEND ±		ENG APPR.	
		TWO PLACE DECIMAL ±		MFG APPR.	
		THREE PLACE DECIMAL ±		Q.A.	
		MATERIAL:		COMMENTS:	
NEXT ASSY	USED ON	FINISH:			
APPLICATION		DO NOT SCALE DRAWING			

Endurance Wind Power

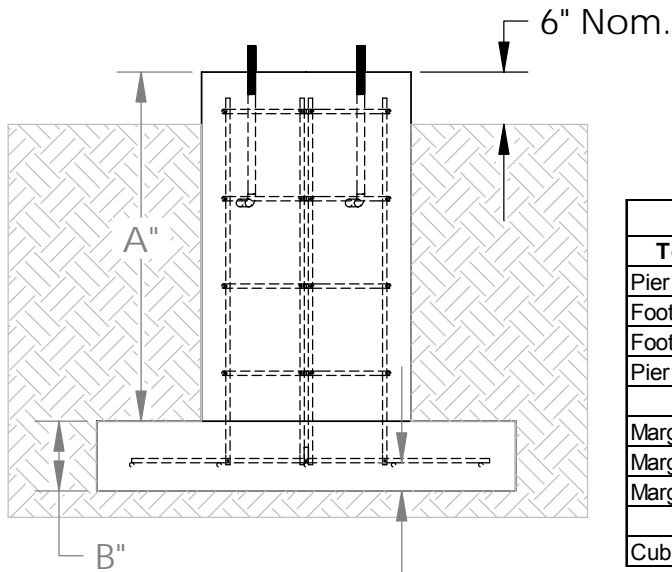
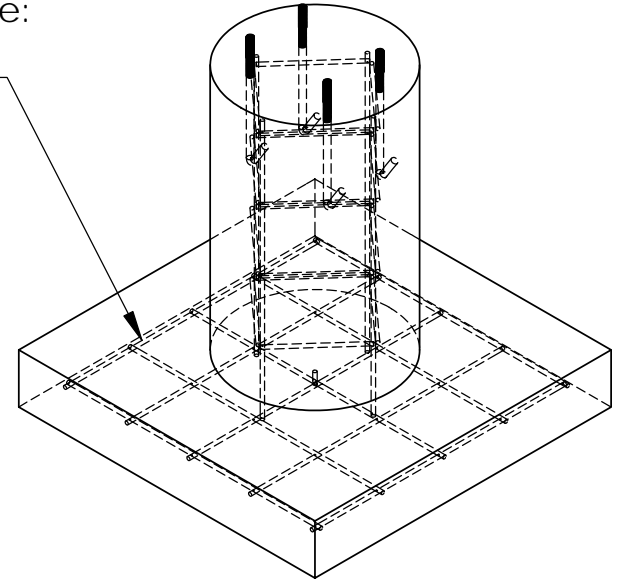
Anchor Hardware

SIZE <b>A</b>	DWG. NO. Foundation-009	REV. v3.4
SCALE:1:1	WEIGHT:	SHEET 1 OF 1

Side Towards Winch



Rebar Cage:  
 - #3 rebar  
 - 10" o.c.



All Dimensions in inches

Soil Class	1				2				3				4				5			
Tower Height (ft)	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63
Pier Height (A)	46				46				46				46				46			
Footer Height (B)	8				8				8				8				8			
Footer width (C)	48				48				48				48				60	52	48	
Pier Diameter (D)	24				24				24				24				24			
Margin: Bearing Pressur	7.8	8.6	9.1	11.1	2.6	2.9	3.1	3.8	2.0	2.2	2.3	2.9	1.4	1.5	1.6	2.0	1.5	1.3	1.2	1.5
Margin: Sliding	6.6	7.7	8.3	12.0	2.5	2.9	3.1	4.5	1.8	2.0	2.1	2.9	1.3	1.5	1.5	2.2	1.0	1.0	1.0	1.5
Margin: Overturning	3.1	3.6	3.8	5.4	1.9	2.1	2.2	3.0	1.6	1.7	1.7	2.4	1.5	1.6	1.6	2.2	1.8	1.7	1.5	2.1
Cubic yards	0.84				0.84				0.84				0.84				1.06	0.91	0.84	

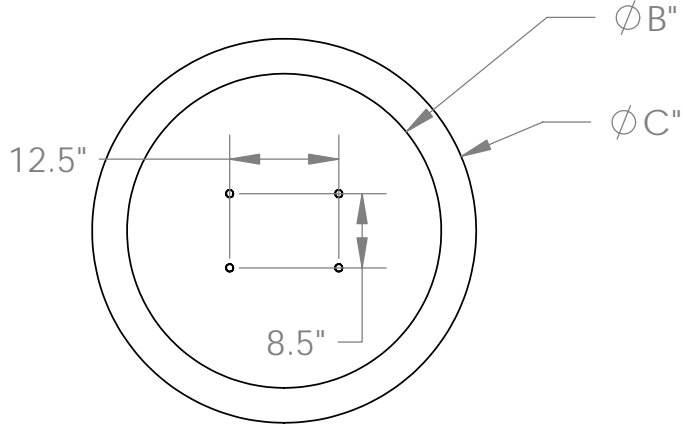
3" clearance

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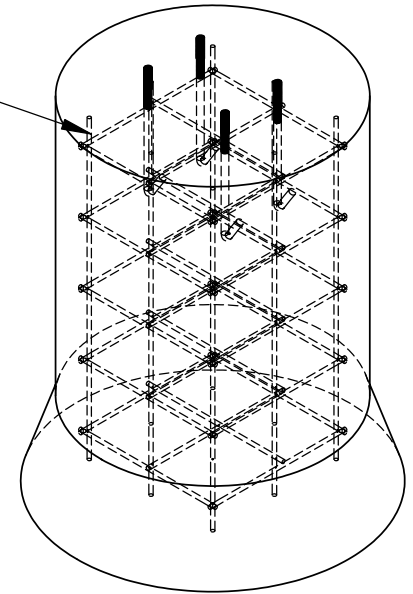
UNLESS OTHERWISE SPECIFIED:	NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	Dean Davis
TOLERANCES:	CHECKED	27 July 07
FRACTIONAL ±	ENG APPR.	
ANGULAR: MACH ± BEND ±	MFG APPR.	
TWO PLACE DECIMAL ±	Q.A.	
THREE PLACE DECIMAL ±	COMMENTS:	
INTERPRET GEOMETRIC TOLERANCING PER:	- IEC Class II	
MATERIAL	- Max 133 mph	
FINISH		
NEXT ASSY		
USED ON		
APPLICATION		
DO NOT SCALE DRAWING		

Endurance Wind Power		
TITLE: Tower Center (Pier & Footing)		
SIZE <b>A</b>	DWG. NO. Foundation-010	REV v1.0
SCALE: 1:24	WEIGHT:	SHEET 1 OF 1

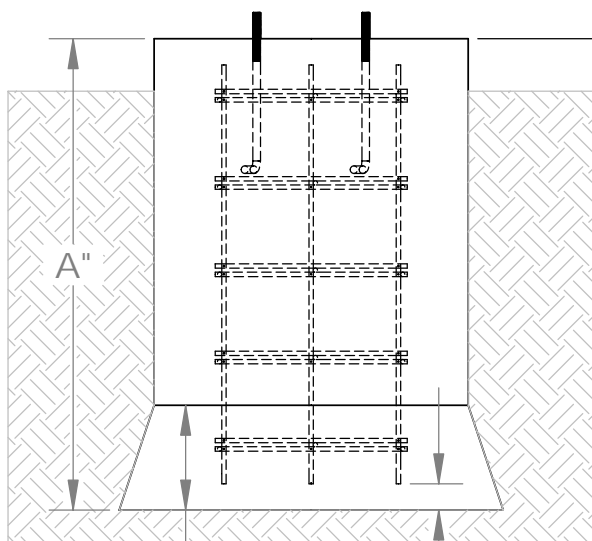
Side Towards Winch



Rebar Cage:  
- #3 rebar  
- 10" o.c.



6" Nom.



All Dimensions in inches

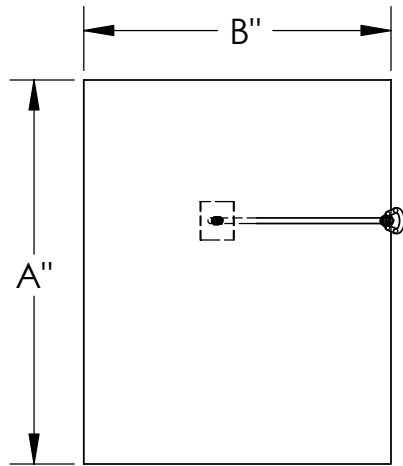
Soil Class	1				2				3				4				5				
	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	
Tower Height (ft)																					
Total Depth (A)	54				54				55				56				61	57	54		
Pier Diameter (B)	24				24				30	28			30				36				
Pier Base Dia. (C)	24				30	28	26	24	34	32	30	28	42	38	32	48	44	42	36		
Margin: Bearing Pressure	2.1	2.4	2.6	3.6	1.1	1.1	1.0	1.2	1.1	1.1	1.0	1.2	1.1	1.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0
Margin: Sliding	6.2	6.8	7.3	7.3	2.3	2.5	2.7	2.6	1.7	1.7	1.8	1.8	1.3	1.3	1.4	1.4	1.0	1.0	1.0	1.1	1.1
Margin: Overturning	2.0	2.2	2.3	2.3	1.0	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.0	1.1	1.1	1.0	1.3	1.3	1.4	1.3	1.3
Cubic yards	0.52	0.52	0.52	0.52	0.55	0.54	0.53	0.52	0.84	0.74	0.72	0.71	0.90	0.87	0.87	0.83	1.43	1.30	1.22	1.18	1.18

12"  
3" clearance

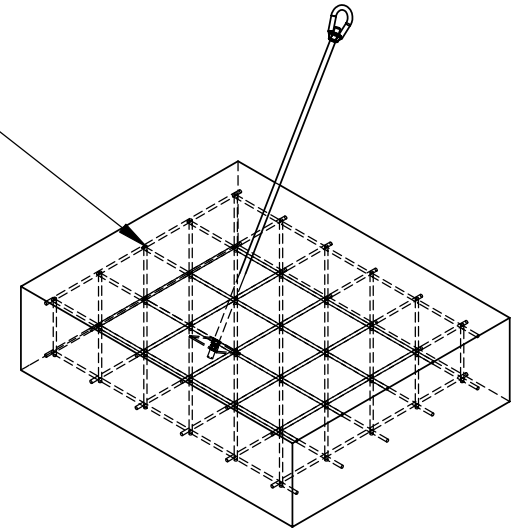
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		UNLESS OTHERWISE SPECIFIED:	NAME	DATE
		DIMENSIONS ARE IN INCHES	DRAWN	Dean Davis
		TOLERANCES:	CHECKED	03Aug07
		FRACTIONAL ±	ENG APPR.	
		ANGULAR: MACH ±	MFG APPR.	
		BEND ±	Q.A.	
		TWO PLACE DECIMAL ±	COMMENTS:	
		THREE PLACE DECIMAL ±	- IEC Class II	
NEXT ASSY	USED ON	FINISH	- Max 133 MPH	
APPLICATION		DO NOT SCALE DRAWING		

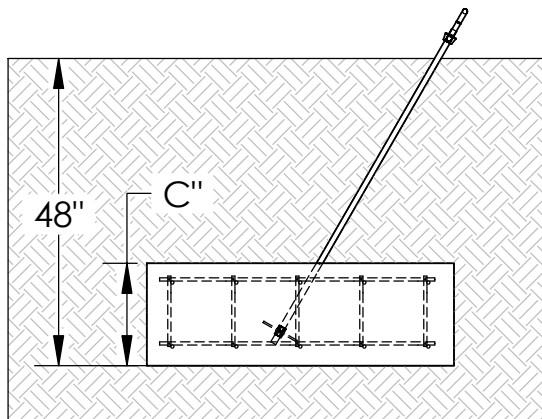
Endurance Wind Power		
TITLE: Tower Center (Pier)		
SIZE <b>A</b>	DWG. NO. Foundation-011	REV v1.0
SCALE: 1:24 WEIGHT:		SHEET 1 OF 1



Rebar Cage:  
 - #3 rebar  
 - 10" o.c.



All Dimensions in Inches



Soil Class	1				2				3				4				5			
	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63
Tower Height (ft)																				
Length (A)	48				54				48				60				72			
Width (B)	48				48				48				48				48			
Thickness (C)	16				16				18				16				20			
Margin: Bearing Pressure	21.2	21.2	21.2	21.2	7.4	7.4	7.4	7.4	5.8	5.8	5.8	5.8	4.2	4.2	4.2	4.3	3.2	3.2	3.2	3.2
Margin: Sliding	4.0	4.8	5.5	8.5	1.5	1.6	1.8	2.9	1.0	1.1	1.1	1.5	1.0	1.1	1.1	1.1	1.2	1.4	1.4	1.6
Margin: Lifting	1.0	1.1	1.2	1.4	1.1	1.0	1.1	1.3	1.2	1.2	1.2	1.3	1.3	1.2	1.2	1.1	1.3	1.2	1.2	1.2
Margin: Overturning	1.4	1.7	1.9	2.4	1.1	1.7	1.8	2.3	1.0	2.0	2.0	2.2	1.1	1.9	1.9	2.0	1.0	1.7	1.7	1.8
Cubic yards	0.79				0.89				0.79				1.11				0.99			

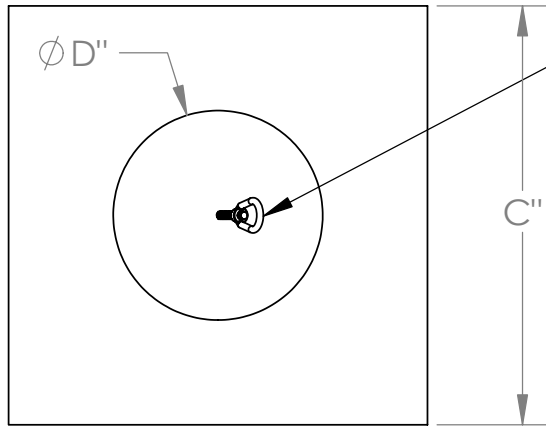
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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE
		MATERIAL:		DRAWN	Dean Davis
		FINISH:		CHECKED	27 July 07
NEXT ASSY		USED ON		ENG APPR.	
APPLICATION		DO NOT SCALE DRAWING		MFG APPR.	
				Q.A.	
				COMMENTS:	
				- IEC Class II - Max 133 mph	

Endurance Wind Power

Buried Guy Anchor  
 Foundation

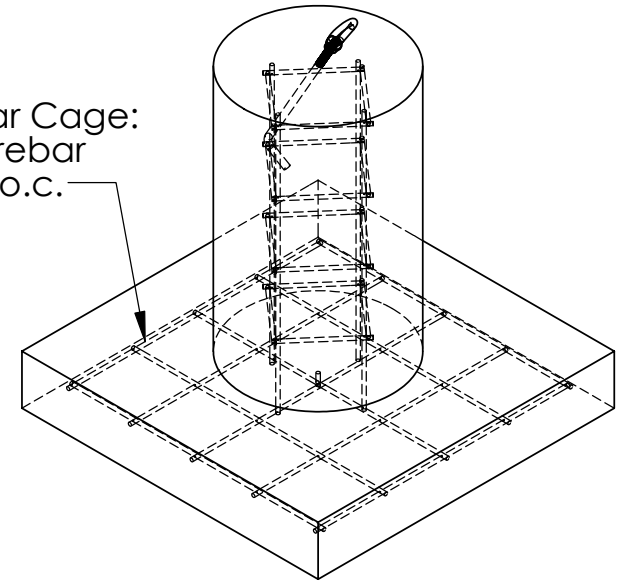
SIZE	DWG. NO.	REV.
A	Foundation-012	v3.4
SCALE: 1:32	WEIGHT:	SHEET 1 OF 1



Guy anchor eye nut shown

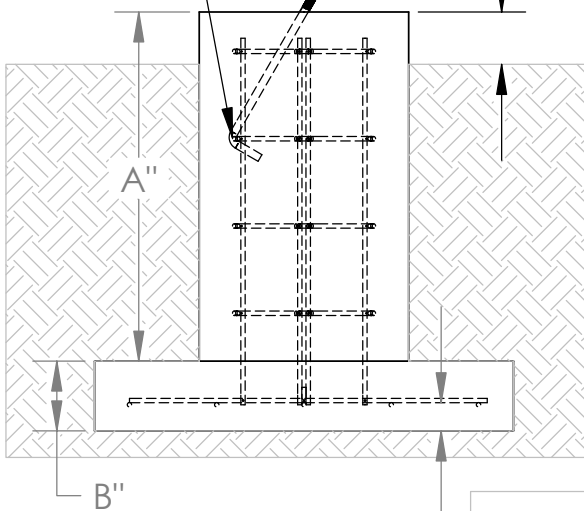
Winch anchor requires four J-bolt pattern (see Dwg. # Foundation-008)

Rebar Cage:  
- #3 rebar  
- 10" o.c.



J-bolt must wrap rebar

6" Nom.



3" clearance

All Dimensions in inches

Soil Class	1				2				3				4				5			
	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63
Tower Height (ft)	54				54				54				54				54			
Pier Height (A)	54				54				54				54				54			
Footer Height (B)	8				8				8				8				8			
Footer width (C)	48				60	56	52	48	64	60	56	52	68	64	60	56	72	72	64	56
Pier Diameter (D)	24				30	28	26	24	32	30	28	26	34	32	30	28	36	36	32	28
Margin: Bearing Pressure	17.8	17.8	17.8	17.8	6.2	6.2	6.2	6.2	4.9	4.9	4.9	4.9	3.7	3.7	3.7	3.7	2.9	2.9	2.9	2.9
Margin: Sliding	3.8	4.6	5.2	8.2	2.0	2.1	2.1	2.8	1.3	1.4	1.4	1.9	1.0	1.1	1.1	1.5	1.3	1.6	1.4	1.7
Margin: Lifting	1.2	1.3	1.4	1.7	1.8	1.7	1.6	1.6	2.0	1.8	1.7	1.8	2.0	1.8	1.8	1.9	2.1	2.2	1.9	1.7
Margin: Overturning	1.5	2.0	2.3	3.6	1.2	1.3	1.2	1.5	1.1	1.1	1.0	1.3	1.1	1.1	1.0	1.3	1.2	1.5	1.1	1.1
Cubic yards	0.92				1.44	1.25	1.08	0.92	1.63	1.44	1.25	1.08	1.84	1.63	1.44	1.25	2.07	2.07	1.63	1.25

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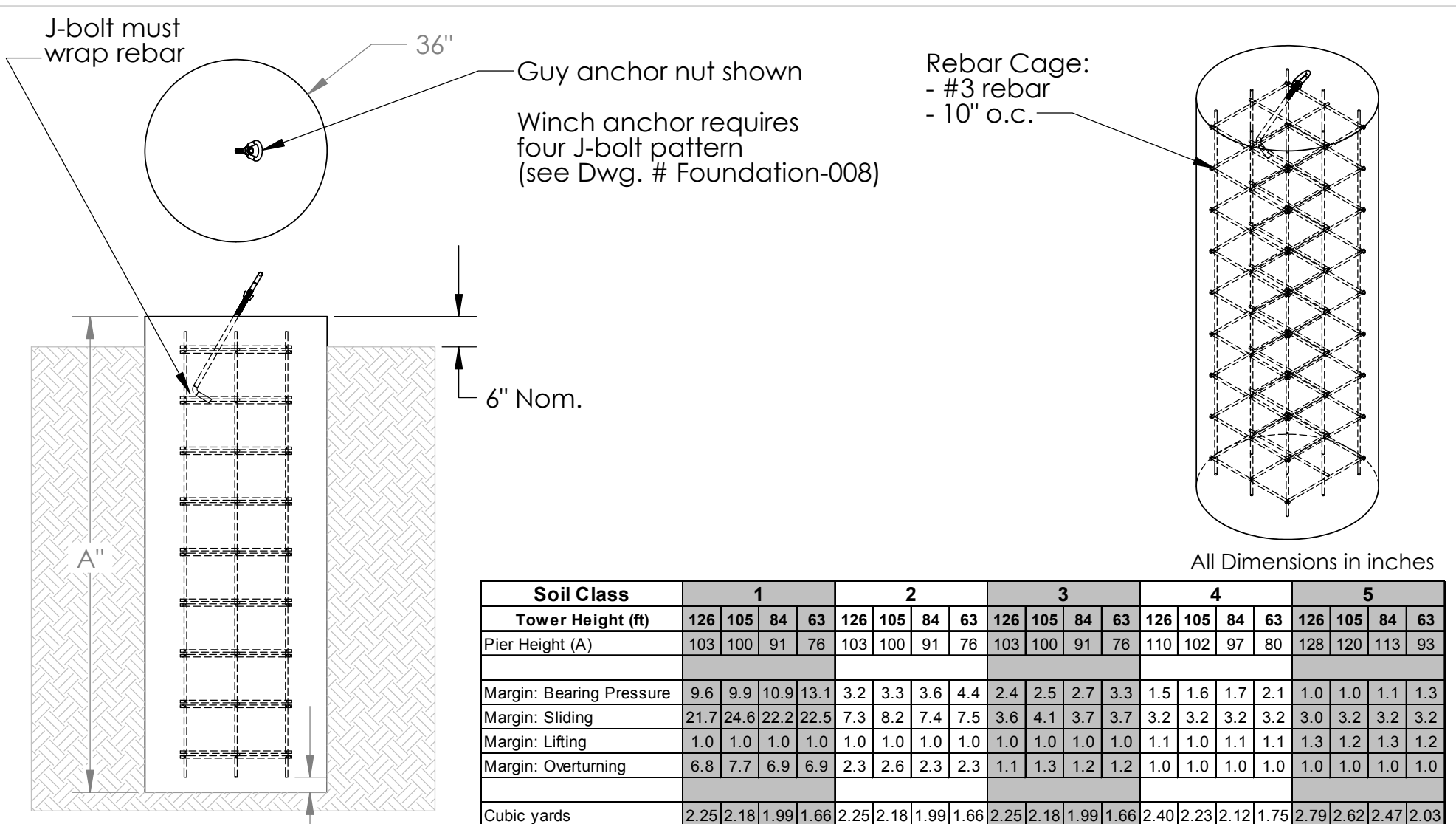
		UNLESS OTHERWISE SPECIFIED:	NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN Dean Davis	27 July 07
		INTERPRET GEOMETRIC TOLERANCING PER:	CHECKED	
		MATERIAL	ENG APPR.	
		FINISH	MFG APPR.	
NEXT ASSY	USED ON		Q.A.	
		APPLICATION	COMMENTS:	
		DO NOT SCALE DRAWING	- IEC Class II - Max 133 mph	

Endurance Wind Power

TITLE:  
Guy & Winch Anchor  
(Pier & Footing)

SIZE DWG. NO. REV  
**A** Foundation-013 v3.4

SCALE: 1:24 WEIGHT: SHEET 1 OF 1



Soil Class	1				2				3				4				5			
Tower Height (ft)	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63	126	105	84	63
Pier Height (A)	103	100	91	76	103	100	91	76	103	100	91	76	110	102	97	80	128	120	113	93
Margin: Bearing Pressure	9.6	9.9	10.9	13.1	3.2	3.3	3.6	4.4	2.4	2.5	2.7	3.3	1.5	1.6	1.7	2.1	1.0	1.0	1.1	1.3
Margin: Sliding	21.7	24.6	22.2	22.5	7.3	8.2	7.4	7.5	3.6	4.1	3.7	3.7	3.2	3.2	3.2	3.2	3.0	3.2	3.2	3.2
Margin: Lifting	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.1	1.1	1.3	1.2	1.3	1.2
Margin: Overturning	6.8	7.7	6.9	6.9	2.3	2.6	2.3	2.3	1.1	1.3	1.2	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cubic yards	2.25	2.18	1.99	1.66	2.25	2.18	1.99	1.66	2.25	2.18	1.99	1.66	2.40	2.23	2.12	1.75	2.79	2.62	2.47	2.03

3" clearance

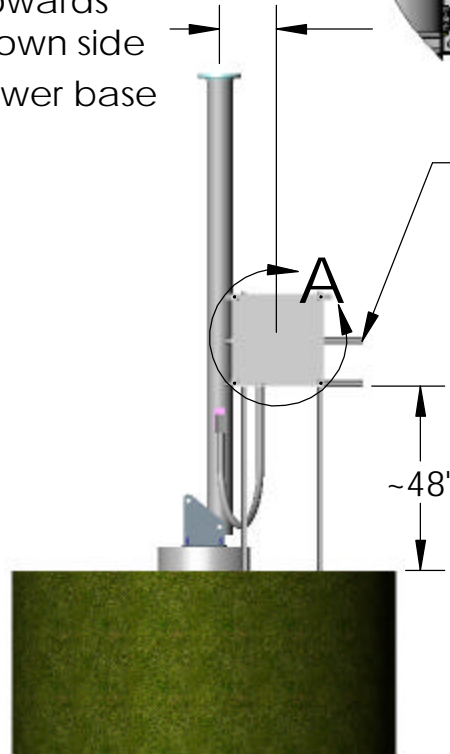
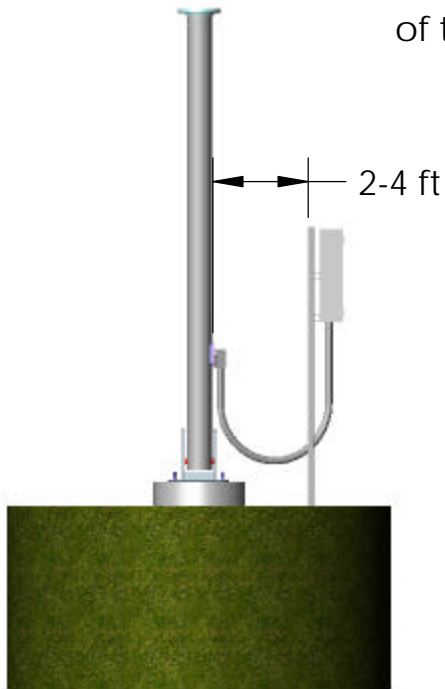
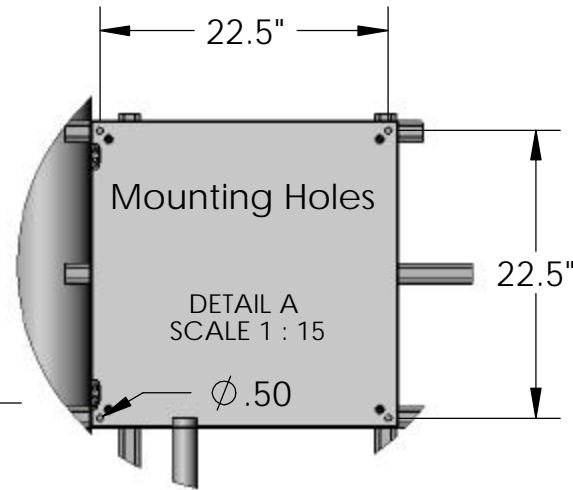
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		UNLESS OTHERWISE SPECIFIED:	NAME	DATE
		DIMENSIONS ARE IN INCHES	DRAWN	Dean Davis
		TOLERANCES:	CHECKED	03Aug07
		FRACTIONAL ±	ENG APPR.	
		ANGULAR: MACH ± BEND ±	MFG APPR.	
		TWO PLACE DECIMAL ±	Q.A.	
		THREE PLACE DECIMAL ±	COMMENTS:	
		INTERPRET GEOMETRIC TOLERANCING PER:	- IEC Class II - Max 133 MPH	
		MATERIAL		
		FINISH		
NEXT ASSY	USED ON	APPLICATION	DO NOT SCALE DRAWING	

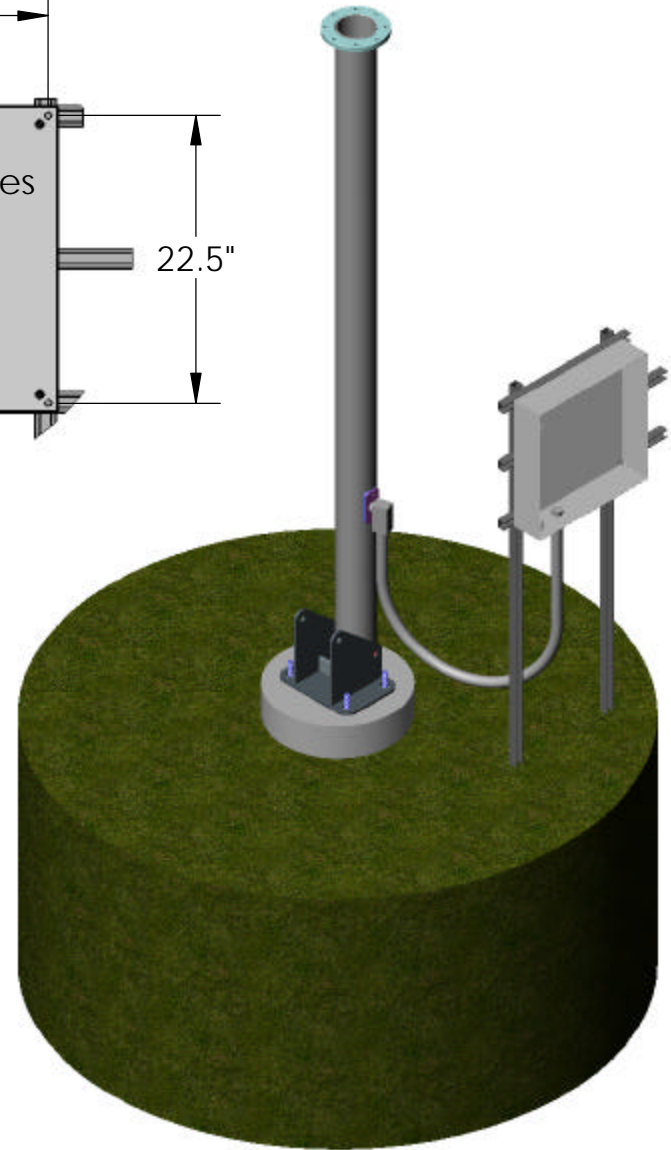
Endurance Wind Power		
TITLE: Guy & Winch Anchor (Pier)		
SIZE <b>A</b>	DWG. NO. Foundation-014	REV v3.4
SCALE: 1:24 WEIGHT:		SHEET 1 OF 1

A support structure is needed for supporting the turbine control enclosure as well as grid electrical power disconnect switch, service outlet and any other necessary junction boxes. This drawing provides the dimensions and location for that support structure as well as one example of its construction. Be sure to include an adequate support as part of your tower foundation installation.

Enclosure should be set towards the tilt down side of the tower base



Extended Unistrut can be used for support of tower base disconnect



Enclosure, 3/8" mounting bolts, sealing washers and flex conduit included with turbine. Mounting frame provided by installer.

Wire & conduit lengths included with turbine/tower package are sized for this recommended location. Contact EWP for custom lengths if your situation varies.

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		DIMENSIONS ARE IN INCHES	NAME	DATE	
		TOLERANCES:	DRAWN	Dean Davis	18 Mar 08
		FRACTIONAL ±	CHECKED		
		ANGULAR: MACH ± BEND ±	ENG APPR.		
		TWO PLACE DECIMAL ±	MFG APPR.		
		THREE PLACE DECIMAL ±	Q.A.		
		MATERIAL:	COMMENTS:		
		FINISH:			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

Endurance Wind Power

Control Box Support

SIZE	DWG. NO.	REV.
A	Foundation-015	1.1
SCALE:1:100	WEIGHT:	SHEET 1 OF 1

## APPENDIX B – Endurance S-250 One-Line Electrical Service Diagram

The following page contains an electrical one-line diagram for the Endurance S-250 turbine. Details are provided for the necessary electrical service at the base of the tower (or the final location of the control panel). Your local electrical codes could alter the details provided in this diagram and must be obeyed. The services of a licensed electrician may be required and are highly recommended.

1-line diag. v1.7



Example:  
Tower control panel tied (with nipple) to gutter box. Tower base lockable disconnect shown on far right



Example:  
Optional 120VAC service outlet at base of tower



Example:  
kWh meter



Example:  
Single slot 70A breaker box with 40A breaker

#8 SOW in tower (4-conductors + grnd (grnd may be separate conductor))

Quick-disconnect power connections made inside tower at tower top access panel

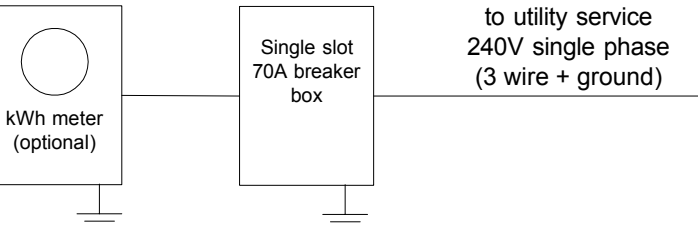
Lockable disconnect 3 pole, 60A 240V knife switch (general duty safety switch - Square D 40274-383-02)

2 Hots & Neutral run through knife switch, ground passes through box.

#8 THHN in conduit 3-conductors + grnd between all enclosures (All enclosures grounded)

(QO Load Center, 40A breaker - Square D QO2-4L70S)

to utility service 240V single phase (3 wire + ground)



Optional winch or service outlet at base of tower (120VAC or 240VAC or both). Outdoor rated

#8 SOW in flexible conduit between tower base and control panel (4-conductors + grnd)

#8 THHN in flexible conduit or straight nipple (3-conductors + grnd)

#8 or larger\* THHN buried in conduit or direct bury cable (3-conductors + grnd)

\*Wire size based on distance between tower base and utility tie & allowable voltage drop (VD)‡.

Wire size AWG	2% VD longest allowable run (ft)	3% VD longest allowable run (ft)	4% VD longest allowable run (ft)
#3/0	430	1170	1920
#2/0	340	930	1530
#1/0	270	740	1210
#1	210	590	960
#2	170	460	760
#4	110	290	480
#6	70	180	300
#8	40	120	190

‡ Assumes 105' tower running #8 wire up to tower top.