

SHORT TOWER INSTALLATION MANUAL

ARE Tilt-up, Guyed, Pipe Towers for **ARE110** & **AWP-3.6** Wind Generators
Short Towers – 43, 64, and 85 feet tall



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1) Introduction

This is an installation manual for a set of towers designed and manufactured by Abundant Renewable Energy (ARE) for the AWP3.6 wind generator. These towers are tilt up, guyed, pipe towers, from 43 to 127 feet tall. This manual will only cover towers which are 43, 64 and 85 feet tall. The 106 and 127 foot towers are covered in the "Tall Towers" Manual. All of the towers are based on 4-inch, schedule-10 pipe. The tower consists of a series of 21-foot sections, joined together by couplers. These couplers are the attachment points for the guy wires, except for the top guy attachment, which is made at a point below the wind generator to allow for blade clearance. These towers work in conjunction with a gin pole, which acts as a lever arm to raise and lower the tower. The gin pole is 21 feet long. The tower is secured by the guy wires connected to anchors at three points and to the gin pole for the fourth point. For these towers, there are five concrete foundations that must be created, one for the tower and four for the guy wire anchors.

Tilt-up towers are NOT designed to be climbed at any time.

2) Site Selection and Preparation

The ideal site for a tower is a flat, level field. However, any area in which there is sufficient space for the foundations, and which is reasonably level, will work. A hillside can also be made to work if there is a line available that allows the side guy anchors and the base to be level with each other.

For these towers, the anchors are about 22 feet 6 inches from the base. The site should be free from obstructions and the tower height should extend at least 35 feet above any obstacles in 500-foot radius from the tower (remember that trees grow). See the wind generator installation manual for more information on siting.

The site for the tower will need to be cleared of all trees and brush to allow for the assembly and raising of the tower. The foundation radius from the center foundation is about 27 feet. Additional area will need to be cleared for the tower when it is in the down position. This will be in the down side direction opposite the hoist side. The distance needed to be cleared is 51 feet, 72 feet and 93 feet from the center foundation for the 43, 64, and 85 foot towers respectively.

Drawings D2, D7, D8 D9 and D12 in the appendix can be used to help determine how to select and lay out your site.

3) Tools & Materials List

Foundation:

- Gloves
- Shovel
- Tape measure (50-100 ft.)
- Leveling tool
- Laser level or string
- Site level or transit
- Masonry mortar type "S"
- Clamps
- Rebar bender
- Wire mesh or rebar (see section "5. Tower Foundations", subsection "Center Foundation")
- Wire ties

Tower Installation

- Concrete (min. 5 yards)
- Pliers/channel locks
- Combination wrenches for saddle clamps (7/16" & 1/2") , pivot and pin bolts (3/4", 15/16", 1-1/16"), and turnbuckles (7/8" & 9/16")
- Round file
- Cable cutter
- Galvanizing spray
- Heavy hammer and block of wood
- Rope

4) Parts List

The complete tower kits contents are listed in the tables below.

PART	43'	64'	85'
Foundation Kit:			
Anchors	4	4	4
J Bolts 5/8" x 8"	4	4	4
Nuts and Washers 5/8" galv. (# of each)	8	8	8
Eye Bolts 1/2" x 6"	2	2	2
Nuts and Washers 1/2" galv. (# of each)	4	4	4
Base Plate	1	1	1
Tower and Guy Wire Attachments:			
4 Hole Gin Pole End Fitting	1	1	1
Top Flange Fitting	1	1	1
Top Guy Tangs	4	4	4
Shackles 1/2"	4	4	4
5/8" x 7" Bolts	2	2	2
5/8" Nylok Nuts	2	2	2
J & E Turnbuckles 1/2" x 12"	8	12	16
J & J Turnbuckles 5/8" x 6"	1	1	1
Thimbles 5/16" for Ø3/16" wire	6	11	16
Thimbles 1/2" for Ø 5/16" wire	5	5	5
Saddle Clamps 3/16"	18	33	48
Saddle Clamps 5/16"	15	15	15
Tower and Anchor Attachments:			
Gin Pole Gusset	2	2	2
Pivot Bolt 3/4" x 8"	1	1	1
Pivot Nuts and Washers 3/4" (# of each)	2	2	2
Pin Bolts 1/2" x 6"	5	5	5
Pin Nuts 1/2" Nylok	5	5	5
Pin Washers 1/2"	10	10	10
Shackles 1/2"	4	4	4
4 Hole Equalizer Plates	3	3	3
Gin Pole Equalizer Plate	1	1	1
TOWER SECTIONS			
Gin Pole Section	1	1	1
Tower Base Section	1	1	1
Tower Mid- Section	NA	1	2
Tower Top Section	1	1	1

Hoist Rigging

PART	43'	64'	85'
3/16" Cable	65'	100'	135'
Pulleys 3"	2	3	4
Shackles 3/8"	4	5	6
Saddle Clamps 3/16"	3	3	3
Thimbles 5/16 for Ø3/16" wire	1	1	1

Gin Pole Guy Wires with Crimped Eyes (Qty 2)

Tower Height	3/16"
43 foot	35'
64 foot	35'
85 foot	35'

Tower Guy Wires without Crimped Eyes

Tower Height	Wire Size	Qty	Length
43 foot	NA	NA	NA
	Ø5/16	1	50'
64 foot	Ø3/16"	1	52'
	Ø5/16	1	67'
85 foot	Ø3/16"	1	52'
	Ø3/16	1	73'
	Ø5/16	1	88'

Tower Guy Wires with Crimped Eyes

Tower Height	Wire Size	Qty	Length
43 foot	Ø5/16"	3	50'
64 foot	Ø5/16"	3	67'
85 foot	Ø5/16"	3	88'

Tower Couplers with Guy Wires Attached

Tower Height	Wire Size	Qty of Wires per Coupler	Length
43 foot	Ø3/16"	4	35'
64 foot	Ø3/16"	4	35'
	Ø3/16"	3	52'
85 foot	Ø3/16"	4	35'
	Ø3/16"	3	52'
	Ø3/16"	3	73'

5) Tower Foundations

The foundations are concrete blocks 4 feet deep with a 3 foot square foot print, using steel anchors and reinforcing bar or wire mesh. The foundations are cast in holes dug in the ground. The minimum concrete strength is 2500 psi. Foundations in areas that freeze deeper than 4 feet need modified foundations that extend below the frost line. The depth of the standard foundation can be increased until it is difficult to excavate within the 3 foot square footprint. Then a drilled foundation can be used. No forms are required if the foundations are poured flush with the soil surface. Use forms if the foundation must extend above the soil surface to create a level anchor line. When using forms the depth of the hole should still be a minimum of 4 feet below the surface of the soil and extent below the frost line. Ensure that the soil walls of the holes are undisturbed during the excavation process. This will produce a uniform foundation wall resistant to cracking.

Center Foundation

The center foundation is reinforced using wire mesh or a rebar lattice. Use No. 2 or No. 3 rebar, (1/4" or 3/8" diameter) for the lattice. Wire mesh can be 4x4 (W1.4xW1.4) to 6x6 (W4.0xW4.0).

The center foundation needs to have reinforcement on the sides and top faces of the block. Locate the reinforcement 3 to 5 inches in from the surface of the cube faces. See drawing D10 in the appendix for a typical rebar lattice.

The center foundation supports the tower base. This is anchored to the foundation using 5/8" x 8" J-bolts. See drawings D5 and D9 for locations of the J-bolts. It is suggested to use the tower base or a pattern of the bolt holes to assist in location of the J-bolts.

Outer Guy Wire Anchor Foundations

The remaining foundations are also reinforced using wire mesh or rebar as described for the center foundation, except reinforcement is only required on the top and the side facing the center tower base. Drawing D11 illustrates a typical rebar lattice for the outer foundations.

The outer foundations support anchors for the tower and gin pole guy wires. The steel anchors for the tower guy wires are cast in the concrete at the angle 'A' indicated in Table 1.

Table 1

Tower Height	A
43 feet	57 degrees
64 feet	65 degrees
85 feet	70 degrees

See drawings D2, D3, D4, D7, D8 D9 and D12 for anchor locations.

Get as much of the anchor in the concrete as possible consistent with obtaining proper height and placement. It is fine to increase the excavation size or depth to get more of the anchor in the concrete. If necessary you can use a form and raise the foundation height as required above the soil level to keep the anchor buried in the foundation. Maintain a minimum of a 4 foot deep, 3 foot square block below the soil surface. The eye of the anchor should be no more than 4 inches above the surface of the foundation.

Hoist Anchor

See drawing D12 for possible locations for the hoist anchor. A set of holes are provided in the gusset plates to adjust for higher or lower placement of the anchor. Each hole is a 5 degree adjustment and moves the end of the gin pole 1 foot 9 inches at the hoist anchor.

If the locations shown in drawing D12 for the anchor are difficult to meet, an extension kit consisting of 1/2" chain and a 7/16" shackle is offered to attach the retaining turnbuckle to the gin pole end fitting.

More extreme variations can be used, especially lower hoist anchor placement. You will need to obtain an extended leash for the hoist turn buckle, a longer hoist cable and move the hoist anchor further from the base to keep the angle correct. Consult with ARE for difficult installation adjustments.

Down Side Anchor

The downside anchor eye height is not as critical as the hoist side. The anchor may vary up to a foot higher or lower than the tower base. Please consult ARE for larger variations.

Left and Right Side Anchors

The anchor eye on the left side and right side should be level with, (same height as), the tower base pivot pin. The side anchors are offset 4 inches toward the down side anchor from the centerline of the center foundation. See drawing D3. This allows the side guy wires to become slack during the lowering of the tower reducing the possibility of over tensioning the wires.

The eyebolts for the gin pole guy wires are located on the left and right side foundations. They are offset 4 inches toward the hoist side anchor from the centerline of the center foundation for the same reason. See drawing D3 and D4.

These locations are important and should be held to plus or minus 1 inch.

Pouring the Concrete

Ensure that all anchors, bolts and rebar are securely located before the concrete is poured. If not they may move during the pouring operation, and realignment can be difficult or impossible. If you are pouring from a mixing truck, it is suggested to pour directly over the anchor to avoid displacement.

The foundation should cure for 4 weeks (28 days) before any loads are placed on them, including tightening the nuts on the base plate anchor bolts. Consult ARE if shorter curing times are necessary.

6) Tower Section Preparation

If you purchased a tower kit without pipe, you will need to obtain 21 foot long sections of 4 inch schedule 10 galvanized steel pipe. Do not use any other size or material, as doing so will compromise the design of the tower. Inspect the pipe carefully to ensure that it does not have dents and belled ends. Do not use pipe that is significantly damaged. Consult A.R.E. with any questions regarding the use of slightly damaged pipe. Pipe should be straight with no bows. The pipe that you purchase will need to have some holes drilled to accommodate the assembly of the tower. For these towers, you will need to prepare four pipe sections with three different hole layouts. Note: Some tower sections do not require holes.

The sections you need to drill are:

- Gin Pole Base Section See Drawing 101014
- Tower Base Section See Drawing 101011
- Tower Top Section See Drawing 101013

The following procedure is suggested for drilling holes in the pipe ends that attach to the gusset plates. The holes must be aligned in order to work properly.

- Lay a piece of angle iron at least 2 feet long on the pipe lengthwise. Mark a line on the pipe along one side of the angle iron. This line should extend from the end of the pipe to a point past your last hole.
- Measure, mark and center punch holes.
- On both ends of the line, measure half way around the pipe and mark it.
- Use the angle iron to draw a line between your marks. Measure, mark and center punch the holes.
- Drill pilot holes and finish holes at each location.
- Remove burrs from the edges of the holes and paint with spray galvanizing.

7) Lightning and Grounding Protection

Grounding – The tower should be grounded at each foundation point. Legal requirements in most areas only require grounding of the tower. We recommend grounding the guy wires as well. You will need five grounding rods and 4 to 8 AWG, single strand, bare copper wire. Place a grounding rod near each of the foundations. The grounding rods should be 8 feet long and embedded into the ground so the top of the rod is a minimum of 6 inches below the surface. Connect a ground wire between each of the outer grounding rods, making a circle around the center foundation. Next, make a connection between one of the outer grounding rods and the center grounding rod. These wires need to be buried 18 inches or deeper below the ground (check your local regulations). At each guy wire foundation, attach a ground wire from the grounding rod to the guy wires just above the saddle clamps near the turnbuckle. Never attach the copper grounding wire directly to the working part of a guy wire. Use one guy wire end and chain between each of the guy wires using saddle clamps (See Figure 1). Attach the end of this guy wire to the copper ground wire. Attach a ground wire between the tower base section or gusset and the center grounding rod.

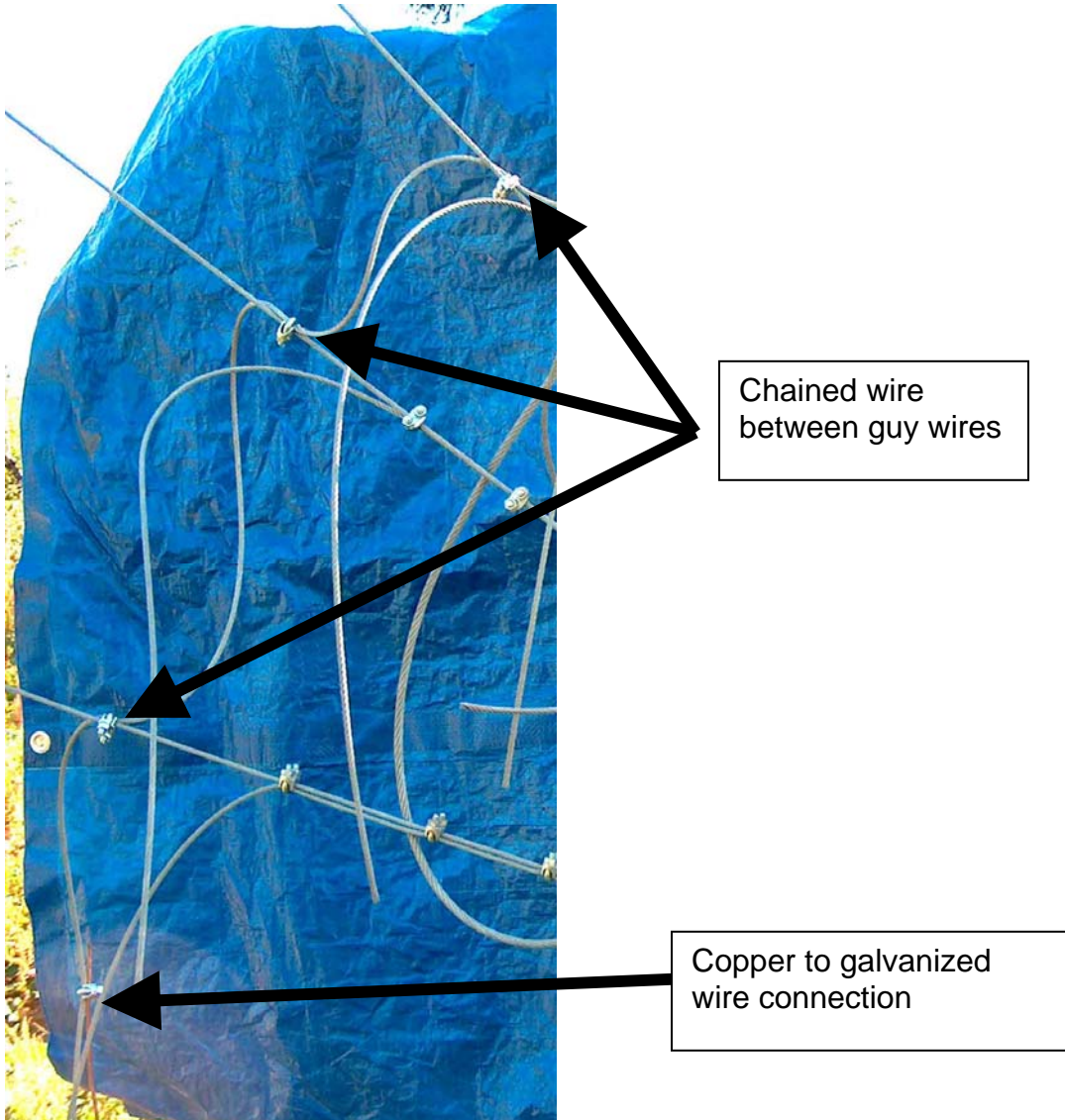


Figure 1

Junction box – We recommend the use of a junction box at the base of your tower for access to the wiring that runs between the power controls and the generator wiring in the tower. This allows a convenient location for maintenance between the generator and the power controls. Additionally, if your generator does not have slip rings in the yaw head, you can easily unwind any twists in the tower wire that may occur due to the generator rotating. It can also serve as a location for an onsite brake switch. We recommend using a lockable enclosure for safety.

Lightning arresters – It is advised that lightning arresters be installed in the wiring of the system. We recommend that one be installed in a junction box at the base of the tower and one in the power room. Consult ARE for available lightning protection packages.

8) Tower Raising Options

There are various options for the raising and lowering of a tilt-up tower. The towers are equipped to be raised and lowered with a vehicle, such as a truck or tractor. They come with a hoist cable and pulleys for raising with a vehicle. The ideal vehicle is a heavy pickup with 4 wheel drive and an automatic transmission. However, there are situations where this is not a viable option.

The other common means of raising a tower is the use of a hand or electric winch or a "grip hoist". An optional hand winch that is setup to be driven with an electric drill and other winches are available from ARE.

Whatever the hoisting method, make sure that it is rated for the load. The 85 foot tower requires 3,000 pounds and the 64 and 43 foot towers are 2,000 pounds. This is for a straight pull. Pulleys will reduce the force and increase the cable length required.

9) Tower Assembly

Step 1 (Base Installation and Anchor Setup)

Base Installation-The start of the tower assembly begins with the base plate. Mount the base plate on the bolts in the center tower foundation and level it. Use 5/8" nuts on the base bolts under the base plate and adjust them to level the base. Next, install the base plate with a 5/8" washer, one on each side of the plate, and a 5/8" nut on top. Tighten the nuts and check for level. If it is not level, readjust until it is level. When you have it level, use a non-shrinking grout under the base plate to make a solid support. (See drawing D9 and Figure 2)

Anchor Set Up-Attach the equalizer plates (uneven triangles with holes) to the side and down anchors. Use the 1/2" shackles provided and make sure that the pointy end of the equalizer is pointing toward the ground. (See Figure 3) Attach the jaw side of the Jaw & Eye Turnbuckles 1/2" x 12" to the equalizer plate. Start with the lowest hole and work up, except always put the last turnbuckle in the top hole. There is one turnbuckle for each tower section, for example the 64 foot tower will have 3 turnbuckles. Adjust the turnbuckles so that they are a little more than half way open. Do this for the left, right and down side foundations.

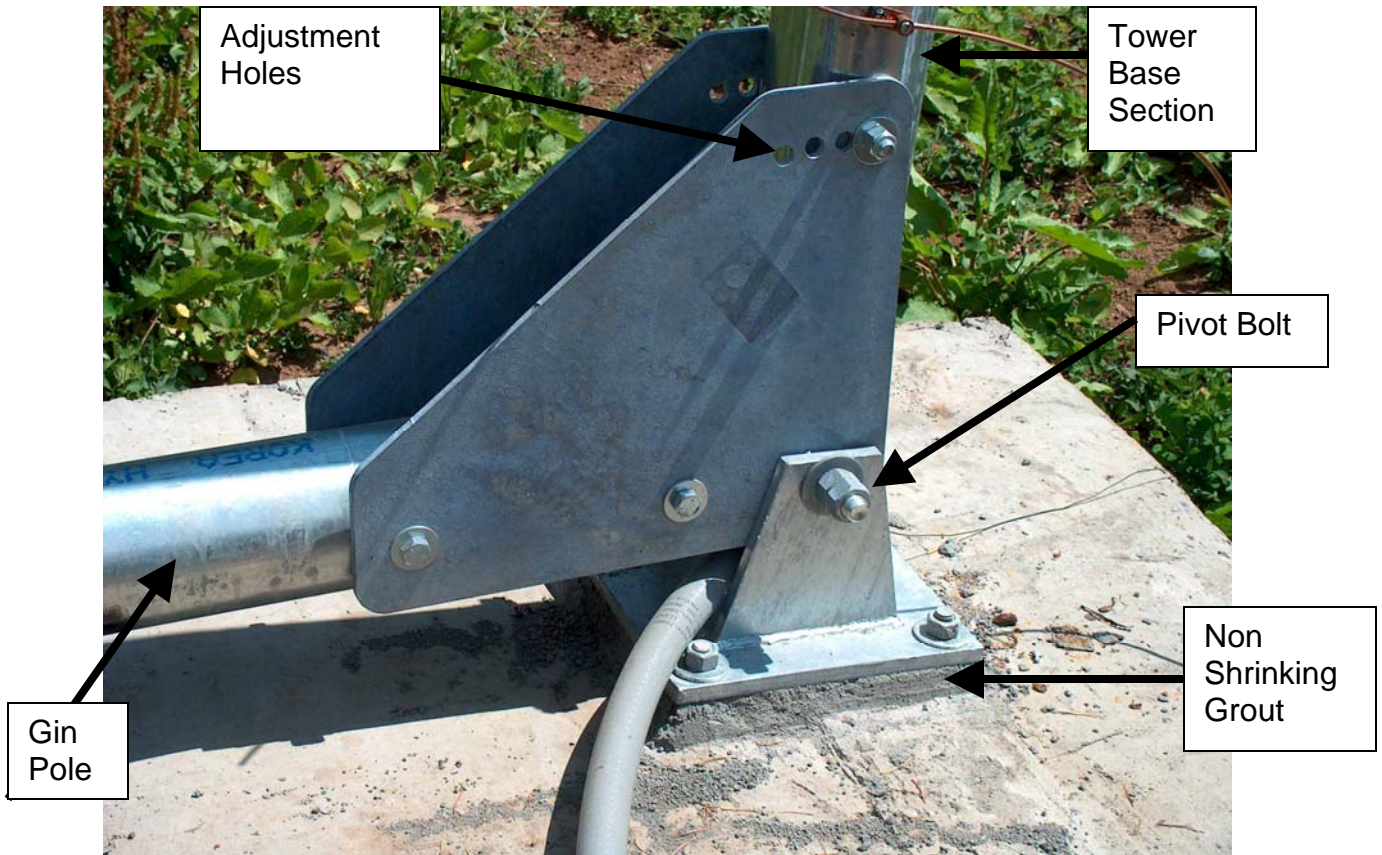


Figure 2



Figure 3

Step 2 (First Tower Section Installation & Raising)

Start with the Tower Base Section laid out between down side anchor and the tower base foundation. Install the Tower Coupler with the 35' guy wires in the top of the tower section. Note: this is the only coupler with all four wires already attached. Attach a separate rope to the coupler. This will be used to hoist the gin pole into position later.

Attach the tower base section of the tower and the side gussets to the base plate with the 3/4" pivot bolt and washers on both sides of the bolt. Hand tighten a 3/4" nut and then use a second 3/4" nut and jam the two nuts together to allow the tower to pivot. Install a 1/2" x 6" bolt through one of the 4 holes in the gusset plates. Include washers on both sides of the bolt and secure with a 1/2" Nylock nut and tighten until snug. (See Figure 2)

Use drawing D12 to determine Gin Pole and Hoist Anchor positioning for adjustment hole selection. (See Figure 2)

Have the Gin Pole Base Section handy. Tilt the tower base section up by hand and attach the gin pole to the tower gussets. Use 1/2" x 6" bolts, washers and nuts as above. Tighten until snug. Caution: do not over-tighten as this will deform the pipe.

Step 3 (Prepare the Gin Pole)

Insert the 4 Hole Gin Pole End Fitting in the Gin Pole Base Section and secure with a 1/2" x 6" bolt, washers and nut. Attach the pulleys using 3/8" shackles to the bottom side of the gin pole end fitting. (See Figure 4) Attach the jaw side of the Jaw & Eye Turnbuckles 1/2" x 12" to the top side of the gin pole end fitting. Start with the hole closest to the center foundation and work back. There is one turnbuckle for each tower section, for example the 64 foot tower will have 3 turnbuckles.

Attach both gin pole guy wires to the gin pole end fitting with a 3/8" shackle. Use the end with the crimped eye.

Attach the hoist equalizer plate (equilateral triangle with holes) to the hoist anchor with a 1/2" shackle. Arrange the pulleys in the holes of the equalizer plate and gin pole end fitting as required to give a clear cable path. Attach the pulleys with 3/8" shackles. Attach the end of the crimped eye of the hoist cable with a 3/8" shackle. See Table 2 for hoist cable end attach point and pulley locations.

Table 2

Tower Height	Number of Pulleys	Hoist Cable End Attach Point	Number of Pulleys Attached to Equalizer Plate	Number of Pulleys Attached to Gin Pole End Fitting
43 foot	2	Equalizer Plate	1	1
64 foot	3	Gin Pole End Fitting	2	1
85 foot	4	Equalizer Plate	2	2

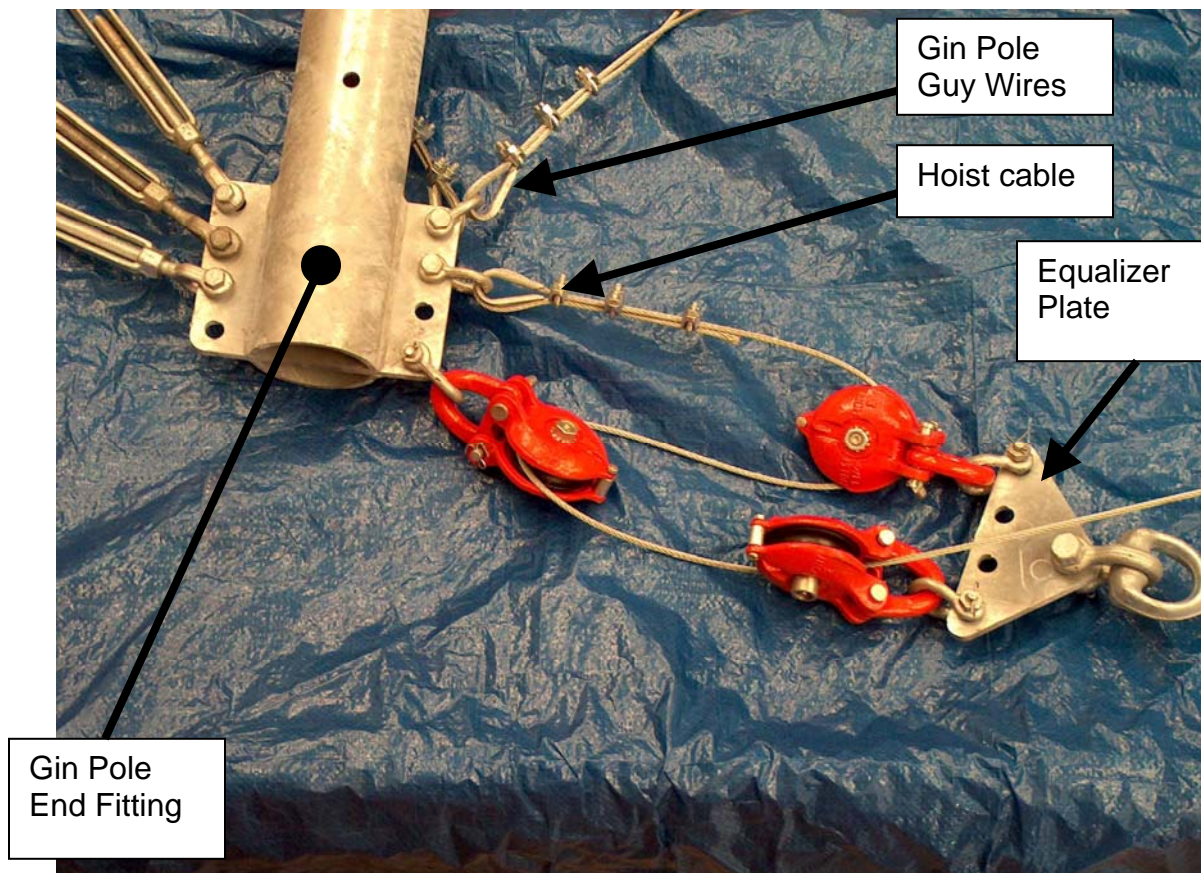


Figure 4

Attach Guy Wires to Gin Pole

Attach the one 5/16" tower guy wire without an eye at either end to the eye of the turnbuckle that is farthest away from the center foundation. Use a 1/2" open thimble. After placing this and all other thimbles, squeeze it closed before installing the wire and saddle clamps. Secure with three 5/16" saddle clamps. Refer to saddle clamp installation procedure in Figure 5, and make the dead end 30 inches long.

Attach the guy wire that is already attached to the first tower coupler to the turnbuckle closest to the tower base. Pull this wire snug before securing with three 3/16" saddle clamps and a 5/16" open thimble, per the procedure below.

Attach the remaining 3/16" guy wires that are not attached to the tower couplers to the remaining turnbuckle eyes using 5/16" open thimbles. Secure with three 3/16" saddle clamps per guy wire. Install the shortest closest to the tower base and then work outward with successively longer wires. See Appendix Drawing D1 and D6. Refer to the saddle clap installation procedure in Figure 5, and make the dead end 30 inches long.

Saddle Clamp Installation Procedure

1. Locate the first saddle clamp as close to the thimble as possible with the U-bolt over dead end, the live end rests in clip saddle. See Figure 5.
2. Install two more saddle clamps on 6 inch centers securing the guy wire with 3 clamps total.
3. Do not over tighten and deform or damage the wires. (Recommended torque for both 3/16 & 5/16 saddle clamps: 30 in-lb). A nut driver may be used during set-up and while adjusting the tower to vertical. All saddle clamps should then preferably be tightened with a thread-locking compound.

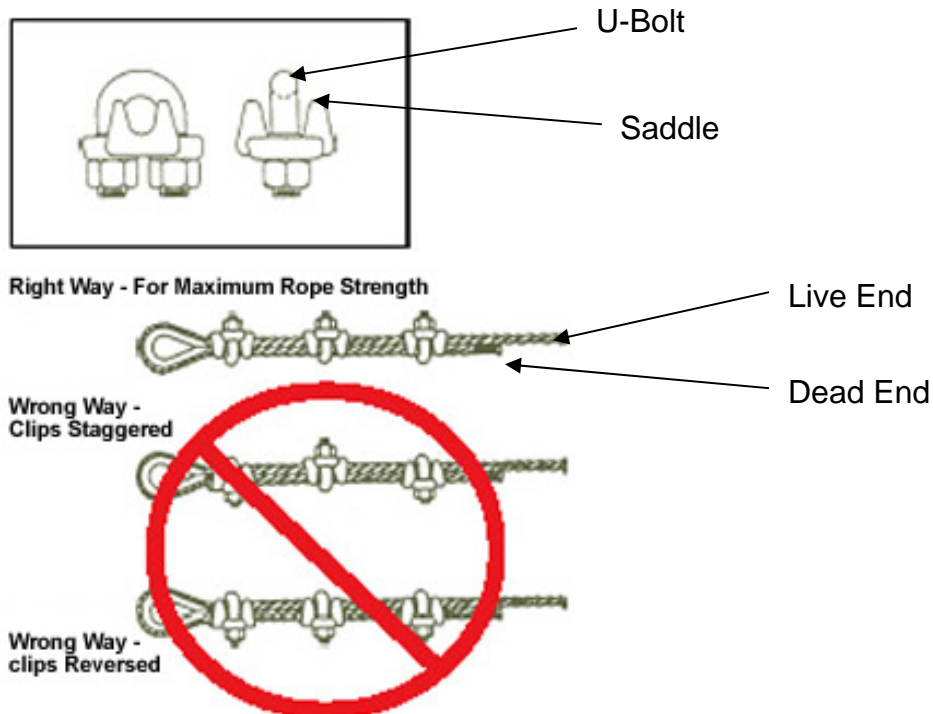


Figure 5

Step 4 (Raising the Gin Pole)

Attach the guy wires between the first coupler on the Tower Base Section and the Left, Right and Down Side foundations. Use a 5/16" open thimble through the eye of the turnbuckle. After placing this and all other thimbles, squeeze it closed before installing the wire and saddle clamps. Pull the guy wires tight and then slack off about 6 inches and secure with three 3/16" saddle clamps. Refer to the saddle clamp installation procedure in Figure 5. The guy wires will be readjusted later during the tuning process, so do not over tighten the cable clamps and damage the wire. Adjust all the guy wires so that the tower section is plumb.

Adjust the hoist side guy wire to hold the weight of the gin pole. Ensure the tower is plumb. Use the turnbuckles to make small adjustments. If larger adjustments need to be made, loosen the saddle clamps, then adjust the wire length. The hoist side and down side guy wires will be tight with no slack due to supporting the gin pole. The left and right side guy wires should have about 4 inches of bow in the wires.

Lift the gin pole to a vertical position and play out the hoist cable as you do so. After you get the gin pole up about 45 degrees it will reach its balance point. Maintain control by holding the hoist cable. Go slow and play out the hoist cable and bring the Tower Base Section toward the ground. When the Tower Base Section is level, secure the hoist wire so the gin pole will be secure as the rest of the tower is assembled.

Step 5 (Gin Pole Guy Wire Attachment)

Attach the gin pole guy wires to their anchors at the left and right side foundations. Use 5/16" open thimbles and three 3/16" saddle clamps at each location. Refer to the saddle clamp installation procedure in Figure 5. Use a level to get the gin pole plumb with the tension adjusted so there is about 4 inches of sag in each wire.

Step 6 (Tower Assembly)

Lay Out-Lay out all of the remaining tower sections and tower couplers and guy wires on the ground. The assembly consists of the Tower Base Section, as many mid sections as required for your tower height, each connected by a tower coupler, and finally a Tower Top Section. Set the tower up square to the line of the side guys and level if possible. This will get you close to level on the first raising. See drawings D1 and D6 for a general diagram of the assembled tower.

Assembly-Install the second tower section onto the first coupler. Install the second coupler. Align the open hole in the coupler guy wire ring with the gin pole. This is the location the hoist side guy wires will attach to in a later procedure.

Install the next pipe section onto the coupler and repeat the procedure until the tower is assembled on the ground. See drawings D1 and D6 for a representative assembly. The tower sections may need to be supported off the ground in order to facilitate assembly.

Guy Wire Attachment-Attach the guy wires that are attached to the lowest tower coupler to the lowest free turnbuckles, at the Left and Right side foundations. Use a 5/16" open thimble through the eye of the turnbuckle. After placing this and all other thimbles, squeeze it closed before installing the wire and saddle clamps. Pull the side guy wires tight and then slack off about 6 inches and secure with three 3/16" saddle clamps. Refer to the saddle clamp installation procedure in Figure 5. The guy wires will be readjusted later during the tuning process, so do not over tighten the cable clamps and damage the wire.

Ensure that the tower sections remain square with the base plate so the tower will be close to vertical when erected.

Next pull the down side guy wire to one of the side guy anchors and mark the distance on the wire with tape. This will be the reference for attaching the guy wire to the downside anchor. Please take care to not cross or tangle the guy wires while you are measuring and marking. Crossed wires could result in damage to the wires or prevent raising the tower.

Attach the down side guy wire in the same manner as the left and right sides except use the tape mark and do not add 6 inches. The length of the guy wire may need to be adjusted to account for a difference in elevation between the down side guy anchor relative to the side guy anchors. If the down anchor is low the guys will be short, you can adjust them after the tower is up. If the anchor is high the guys will be long and you should make an adjustment in the length before raising the tower. Secure the guy wire with saddle clamps.

Repeat the above procedure with each coupler working your way up the tower and up the equalizer plates.

Step 7 (Top Guy Wire Attachment)

The top guy wires are attached 4 feet from the end of the top section with tangs. Install the short leg of the tangs to the tower in 2 locations with 5/8" X 7" bolts. Note: the bolts are a tight fit through the holes in the tower and tangs. (See Figure 6) Tighten snug but do not over tighten and crush the pipe. Attach the Left, Right and Down Side 5/16" guy wires with crimped eyes to the tangs using 1/2" shackles. Attach the other end of the guy wires to the turnbuckles at the Left, Right and Down Side foundations per the above procedure using three 5/16" saddle clamps and a 1/2" open thimble at each location.

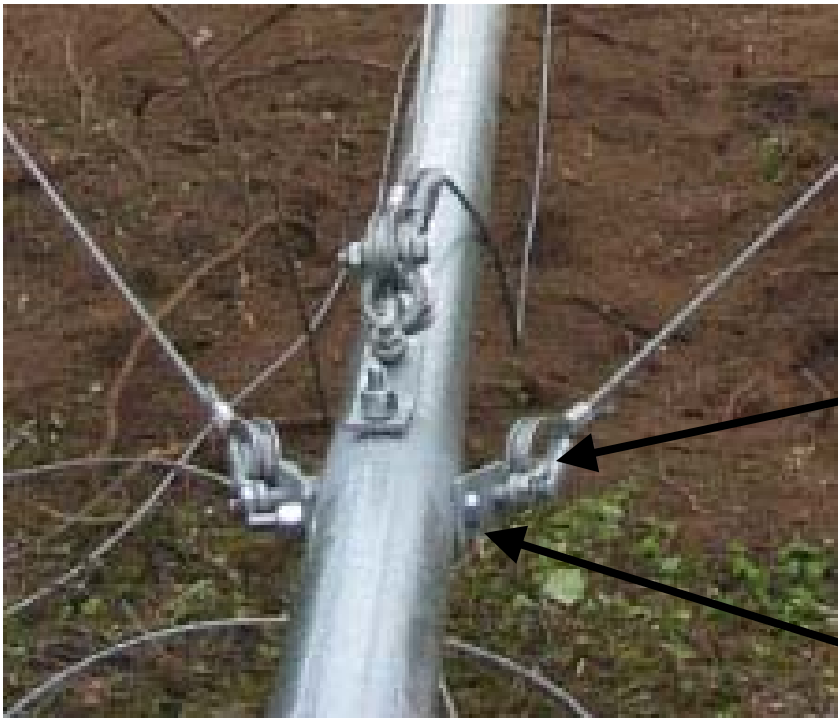


Figure 6

Step 8 (Hoist Guy Wire Attachment)

With the first two tower sections level, attach the second 3/16" guy wire between the gin pole end fitting and the open hole in the second coupler guy wire attachment ring. Use a 5/16" thimble and three 3/16" saddle clamps. Pull the guy wire tight. Don't worry about the excess wire at this time; you can trim the tails after the tower has been adjusted. Refer to the saddle clamp installation procedure in Figure 5. It will be easier to tighten the saddle clamps if the guy wire is led through the coupler from above and fed back on the side nearest the tower base (see figure 7).

Repeat the above procedure for the remaining guy wires attached to the gin pole. Use a 1/2" thimble, three 5/16" saddle clamps and a 1/2" shackle for the 5/16" guy wire. Lift or block each section, so they are level, and then pull the guy wire tight. This will allow the tower to lift evenly.



Figure 7

Step 9 (First Tower Raising)

The tower should now have four guy wires at each coupler and four guy wires attached to tangs on the tower top section. All the guy wires should be attached to their foundations or the gin pole.

The purpose of this first lift is to get the rigging checked and adjusted before the wind generator is attached. Do not install the wind generator at this time. The hoist cable is used to raise the tower. It is commonly pulled with a vehicle. There are winch options available—please consult ARE.

Check that all guy wires are securely attached and that they all lead clear with no tangles or kinks.

Important safety requirements:

- **All people are to remain clear of the tower during hoisting. No one should walk under the tower or rigging during hoisting.**
- **It is critical to raise and lower the tower very slowly. This allows careful monitoring of all equipment and personnel.**
- **Side guy wire tension must be continuously monitored. The guy wires should always have some visible sag or slack in them throughout the entire raising. If there is no visible slack, there is no way to tell if they are getting too tight. If a guy wire gets too tight it can break and the tower can fall.**
- **Gin pole guy tension should also be monitored, but the gin pole guys should have increased sag as the tower is raised.**
- **Remain in contact with members of the lifting team during the entire process, so that any problems can be immediately responded to. Everyone should be authorized to call a stop at any time.**

As the tower is being hoisted, watch for any tangled, snagged, or misled guy wires. The most common place for this to show up is in the down side guy wires. Make sure that the guy wires and thimbles are leading properly from each attachment on the tower and at the anchors.

As the tower nears vertical, the weight of the gin pole will start to balance out the tower weight. At this point a team member can take hold of the top down side guy wire and pull it to the side or you can grab the gin pole and ease it down. The best way to do this is to attach a rope part way up the top-down side guy wire before you start raising the tower. A leash is provided for this purpose (see Figure 8). This will allow the job to be done from a safe location. In that way the descent of the gin pole can be controlled and the guy wires prevented from slapping as the tower comes to the vertical position.



Figure 8

When the tower reaches the vertical position secure the gin pole by installing a jaw and jaw turn buckle between the equalizer plate and the gin pole end fitting. If the turnbuckle cannot be adjusted to secure the gin pole an Extension Kit consisting of 1/2" chain and a 7/16" shackle is offered to attach the retaining turnbuckle to the gin pole end fitting. Also, a set of holes are provided in the gusset plates to adjust for higher or lower placement of the anchor. Each hole is a 5 degree adjustment and moves the end of the gin pole 1 foot 9 inches at the hoist anchor.

When the tower is in its upright position, it may appear crooked due to the guy wires being out of adjustment. This is to be expected and should not be a concern.

Step 10 (Tower Adjustment)

This step will result in the tower being vertically straight and secure. The process begins with checking the lower tower section with a level to ensure that it is vertical in all directions (side to side and front to back). Adjust the guy wire tension so that there is about 4 inches of sag in the side guys of the first guy wire set, while maintaining the lower section's vertical position. Small adjustments can be made with the turnbuckles, but larger adjustments will require loosening the saddle clamps and taking up slack or letting out line. Any time the saddle clamps are moved make sure that tension is maintained on the guy wire.

The lowest hoist and down side guy wires are unique in that they hold the gin pole from falling into the hoist foundation. The result is that they are tight with little or no sag compared to the other guy wires. Adjust the lowest hoist side guy wire so that it is tight enough that it just supports the weight of the gin pole on the wire not the two bolts in the gussets. Adjust the down guy until the lower section of the tower is vertical. The turnbuckle between the gin pole and the hoist anchor may need to be adjusted to provide slack for this procedure.

Continue by adjusting the other sections so that the tower is visibly in line with the lower section. Allow the amount of sag to increase in each higher guy wire. The longer the guy wires the more sag for the same tension. Tower adjustments may need to be made several times until all the sections are aligned vertically. View tower upward along the pipe for best results.

Each turnbuckle needs to have adjustment room. Adjust the saddle clamps if required to accomplish this. As the tower is stressed in service things will settle in and stretch. The guy wires will need to be adjusted after a couple of months or after the first good windstorm. It should be possible to make these adjustments with turnbuckles only.

Step 11 (Tower Lowering)

Once the tower is vertically aligned, it can be lowered.

Before beginning the tower lowering process, make sure that the hoist cable and pulleys are attached and not tangled or snagged on anything. Make sure that the end of the hoist cable is securely attached to the vehicle (or winch) with minimal slack to prevent an uncontrolled situation.

To begin, release the gin pole turnbuckle and gently pull on the top or preferably the top two, down side guy wires until the tower is pulling on the hoist cable without assistance. At that point use the hoist vehicle (or winch) to slowly lower the tower to the ground.

When lowering the tower use the same caution as when raising the tower. Monitor the tension of the side guy wires to ensure that they do not become over tight. If the foundation attachments are properly placed, the side guys should have increasing slack as they are lowered. This allows the tower to raise and lower without adjusting the guy wires.

The gin pole guy wires should tighten as the gin pole goes up. Monitor them carefully and give them more slack if needed. If adjusted, check the gin pole for vertical and do not take up any of the slack that you added when you next raise the tower.

Step 12 (Re-Raising the Tower)

At this point, it is recommended that a test lift be performed without the machine in accordance with step 7. If this can be done without the need to adjust any guy wires and the tower is straight, the tower can be lowered and the wind generator installed.

Step 13 (The Final Raising of the Tower)

Now the tower is ready to have the wind generator mounted. Lower the tower in accordance with step 9. Block the tower up about three or four feet from the end and about three or four feet off of the ground. This will put the tower at a good height for attaching your AWP3.6.

Follow the instructions in the AWP3.6 Owner's Manual to assemble and attach your AWP3.6 to the tower.

When the machine is attached and ready to go, raise the tower again, per step 7. Use caution. The balance point is different with the wind generator attached and the wind will have more effect on the balance point.

Step 14 (Final Check)

Before leaving the site make a final check of all wires and hardware. Make sure each shackle is secured with either a nut and cotter pin or a wire. All turnbuckle jaw bolts should have Nylok nuts securing the jaw ends. In addition it is good safety practice to weave the end of one guy wire through the turnbuckle eyes and bodies to prevent loosening (see Figure 9). While we recommend that the gin pole guy wires be left in place, they are a tripping hazard and should be marked with surveyors tape. If they must be removed, please mark the lengths for accurate reassembly. Do not lower or raise the tower without the gin pole guy wires attached.

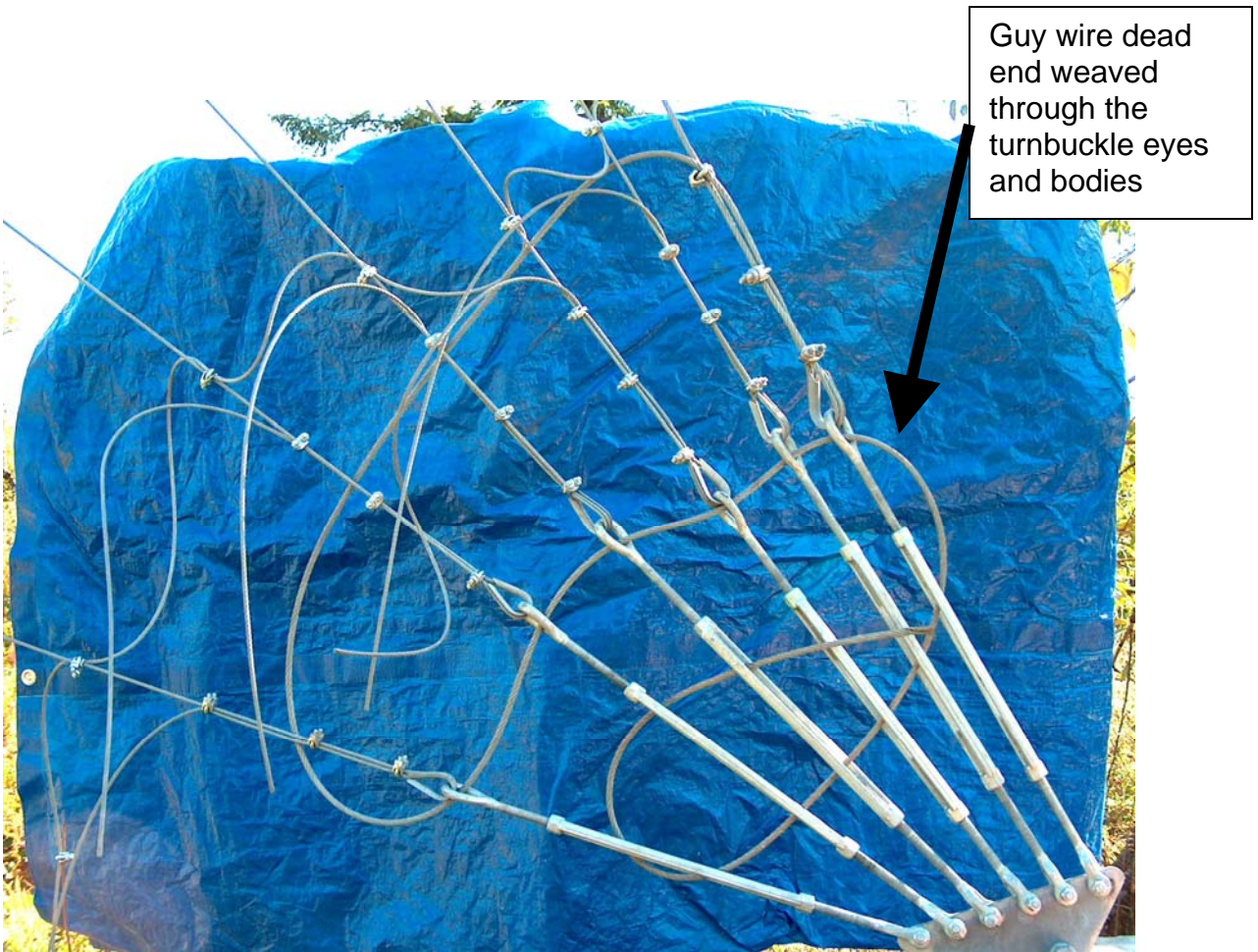


Figure 9

10) Tower Maintenance

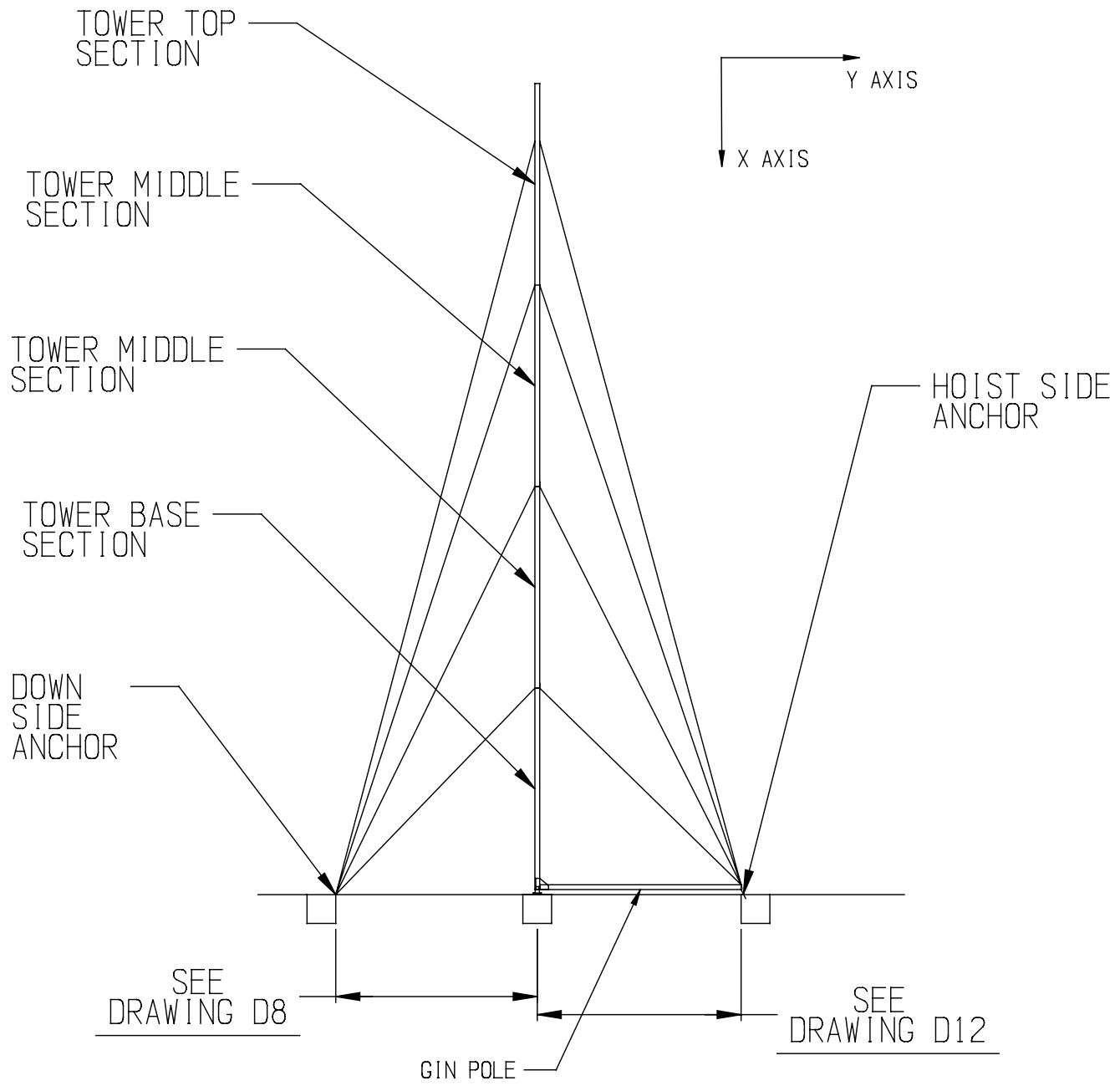
The tower should be inspected every 6 months at a minimum.

- Ensure that all hardware is tight.
- Ensure proper tension exists in the guy wires.
- Inspect for corrosion. If corrosion is found remove any scale, clean and paint.

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED

REV
SH
DWG NO



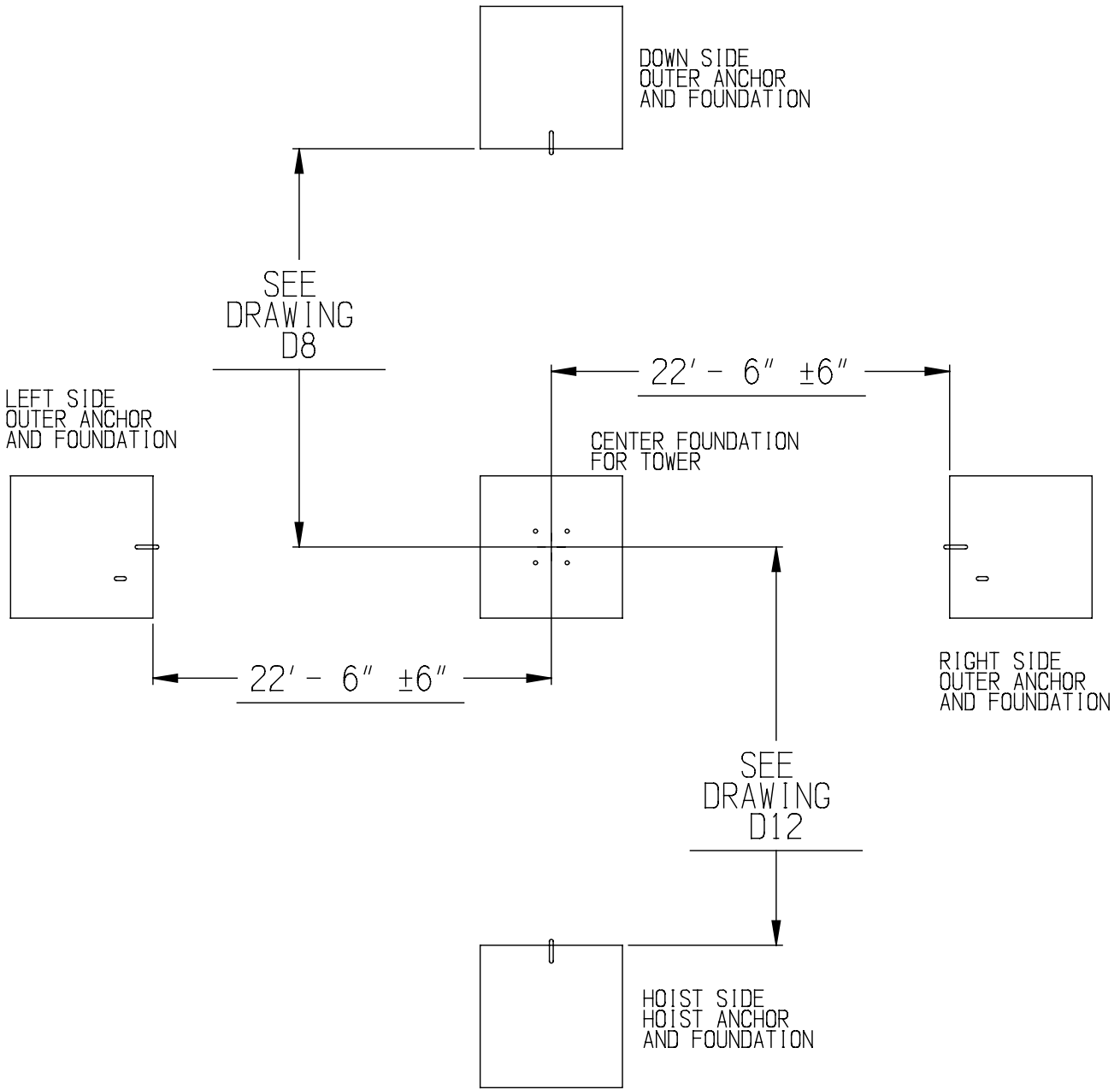
85 FOOT TOWER SHOWN
43 & 64 FOOT TOWERS SIMILAR

Abundant Renewable Energy	SHORT TOWER IN OPERATING POSITION			
	SIZE A	CAGE CODE	DWG NO D1	REV
DESIGNER	SCALE	RELEASE DATE	WEIGHT	SHEET
APPROVED				

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED

NOTE:
NOT TO SCALE



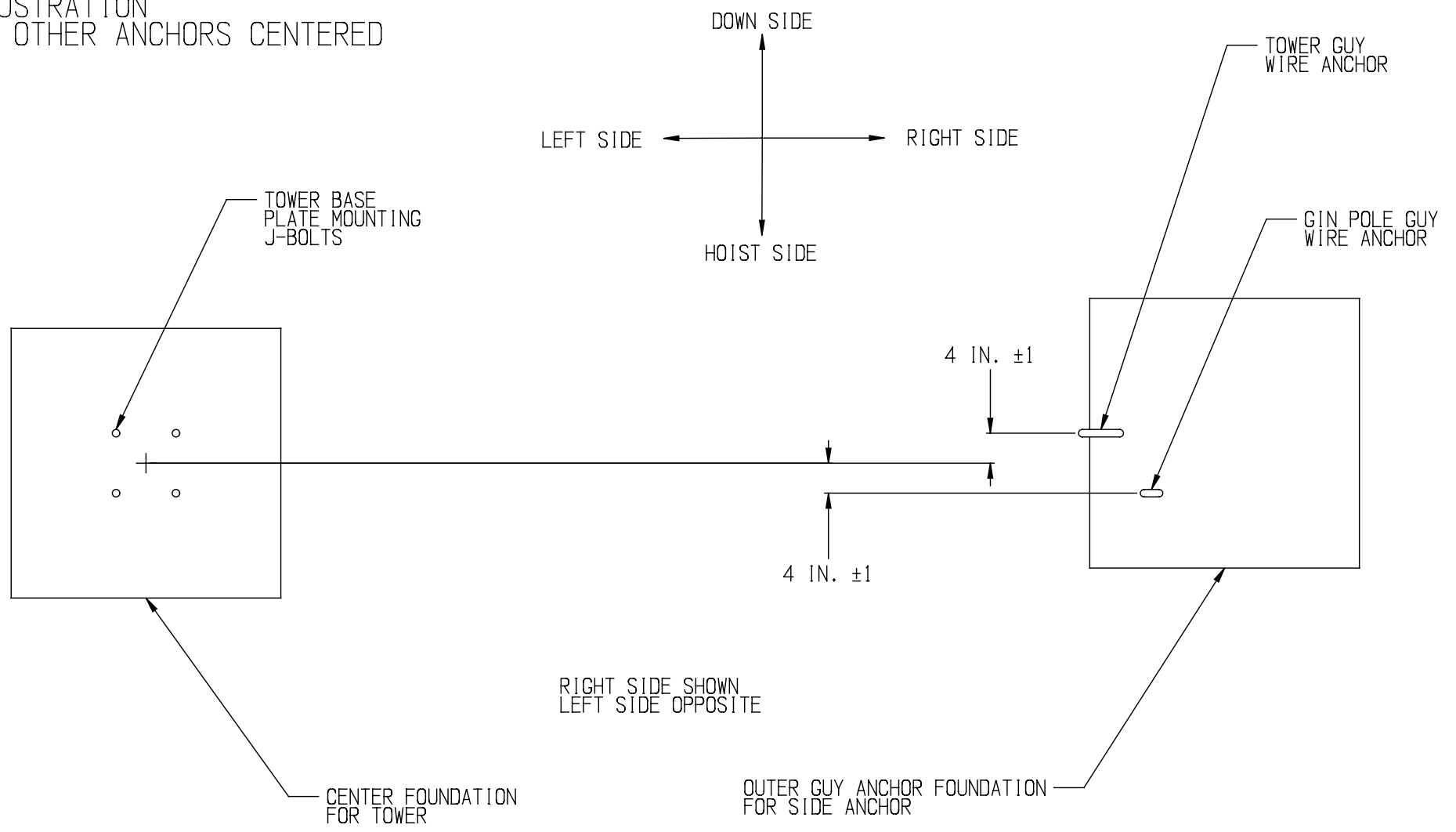
Abundant
Renewable
Energy

FOUNDATION LAYOUT (SHORT)

DESIGNER	SIZE A	CAGE CODE	DWG NO D2	REV
APPROVED	SCALE	RELEASE DATE	WEIGHT	SHEET

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

- NOTES:
 1. NOT TO SCALE
 2. SIDE ANCHOR PLACEMENT ILLUSTRATION
 3. ALL OTHER ANCHORS CENTERED

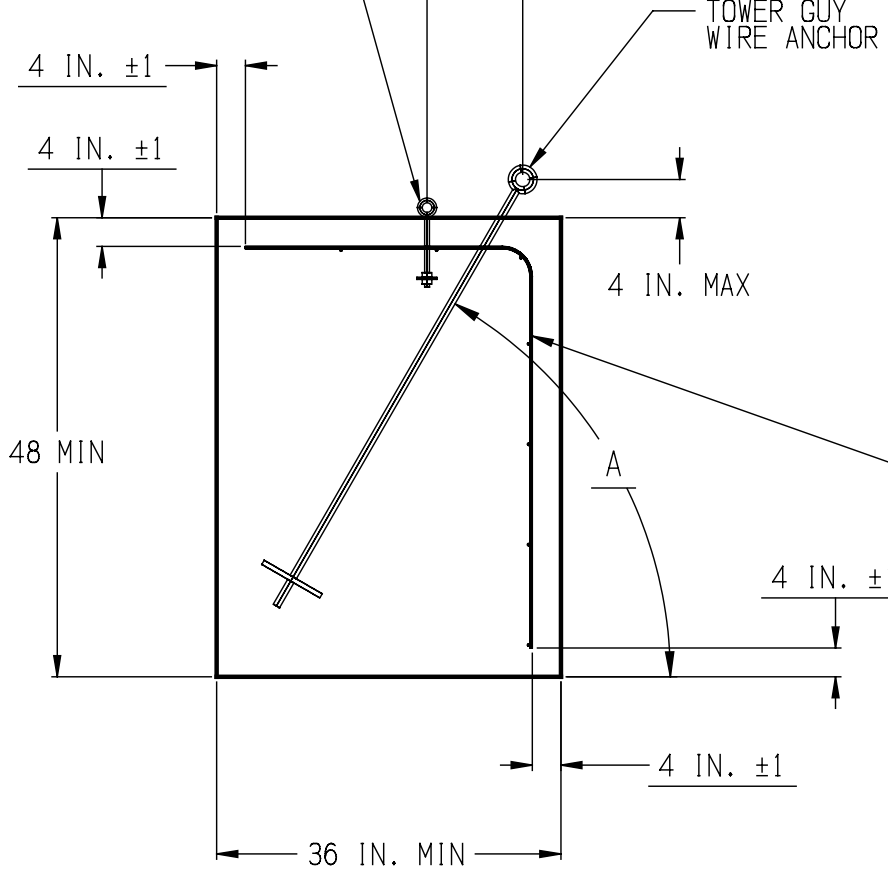


RIGHT SIDE SHOWN
 LEFT SIDE OPPOSITE

Abundant Renewable Energy		SIDE ANCHOR OFFSET (SHORT)			
		SIZE A	CAGE CODE	DWG NO D3	REV
DESIGNER		SCALE	RELEASE DATE	WEIGHT	SHEET
APPROVED					

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

GIN POLE GUY WIRE ANCHOR
LOCATE BOTTOM OF EYE FLUSH WITH TOP OF FOUNDATION



- Notes:
1. Foundation is a minimum of 4 foot deep and 3 foot square.
 2. Min. concrete strength 2500 psi.
 3. Allow concrete to set 28 days.
 4. Cast concrete into hole with undisturbed soil.
 5. "A" is the angle for the anchor rod. See table in Tower Installation Manual for values.
 6. Gin pole guy wire anchors are only needed on the Left and Right side guy anchor foundations.

CONCRETE REINFORCING

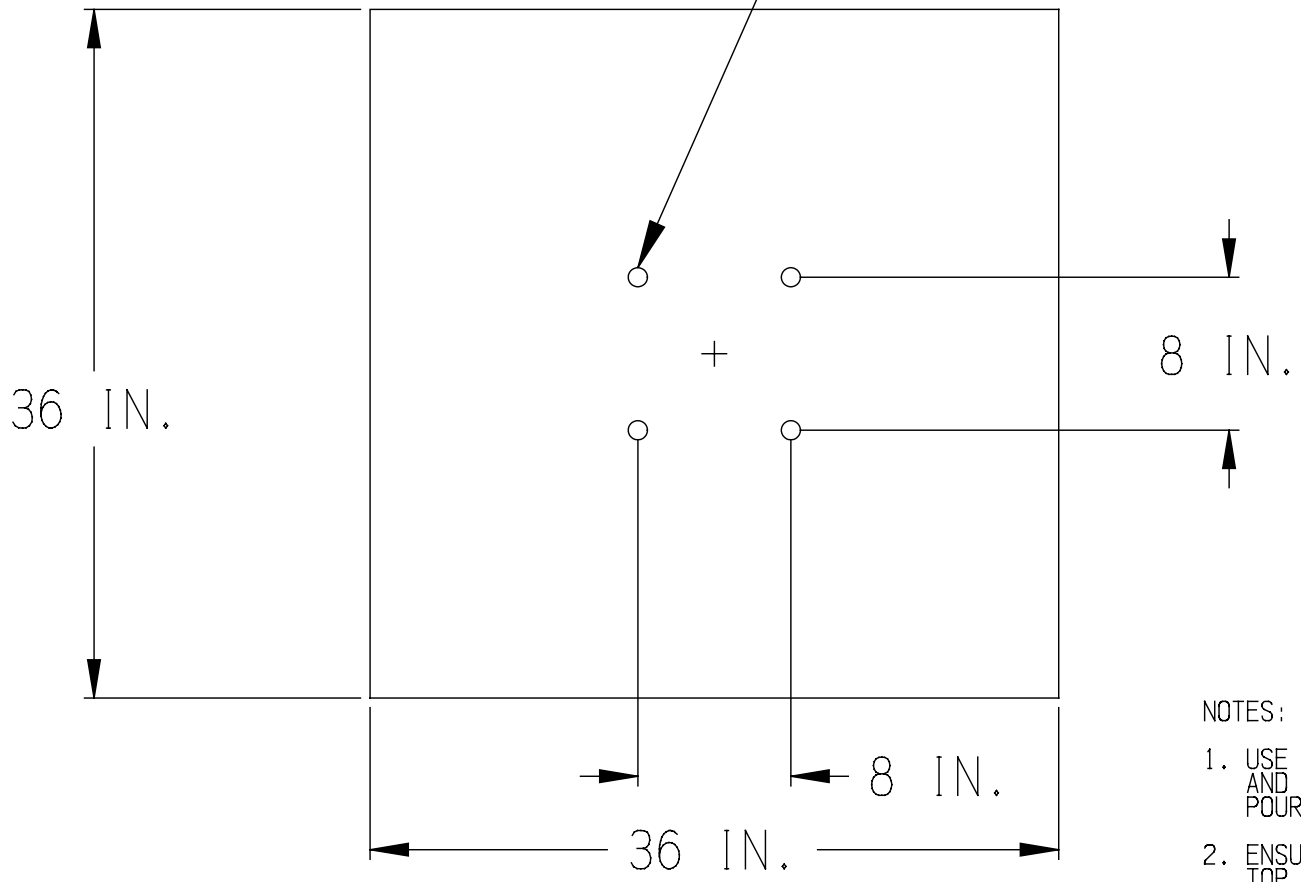
CROSS-SECTION OF TOWER GUY WIRE ANCHOR FOUNDATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS: DECIMALS: ± .X ± .XX ± .XXX ±	CONTRACT NO	
	APPROVALS	DATE
MATERIAL	DRAWN	
	CHECKED	
FINISH	DESIGNER	
	APPROVED	

Abundant Renewable Energy			
TITLE			
Tower Anchor Foundation (SHORT)			
SIZE	CAGE CODE	DWG NO	REV
A		D4	
SCALE	RELEASE DATE	WEIGHT	SHEET

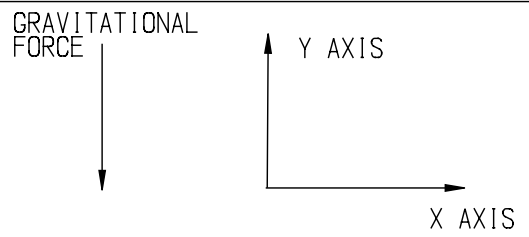
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Install J-bolts provided

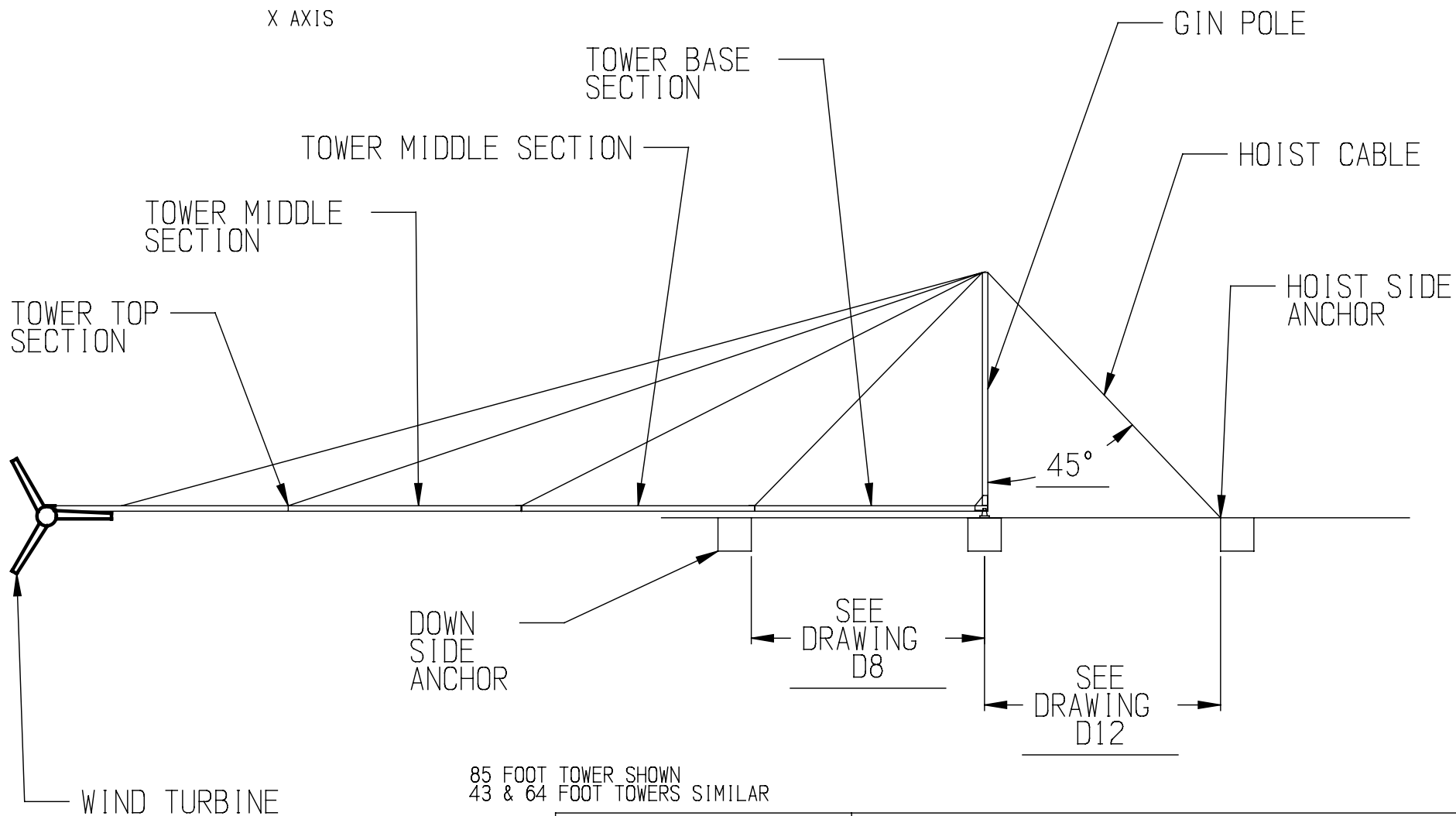


- NOTES: UNLESS OTHERWISE SPECIFIED
1. USE THE TOWER BASE OR A TEMPLATE TO LOCATE AND SECURE THE J-BOLTS BEFORE THE CONCRETE IS POURED
 2. ENSURE 2-3 INCHES OF BOLT EXTENDS FROM THE TOP OF THE FOUNDATION. SEE DRAWING D9

<small>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS: DECIMALS: ± .X ± .XX ± .XXX ±</small> <small>DO NOT SCALE DRAWING</small>	CONTRACT NO		<h2 style="text-align: center;">Abundant Renewable Energy</h2>				
	APPROVALS	DATE					TITLE
	MATERIAL	DRAWN		<h1 style="font-size: 2em;">Tower Base Foundation</h1>			
	FINISH	CHECKED					
	DESIGNER		SIZE	CAGE CODE	DWG NO	REV	
	APPROVED		A		D5		
			SCALE	RELEASE DATE	WEIGHT	SHEET	



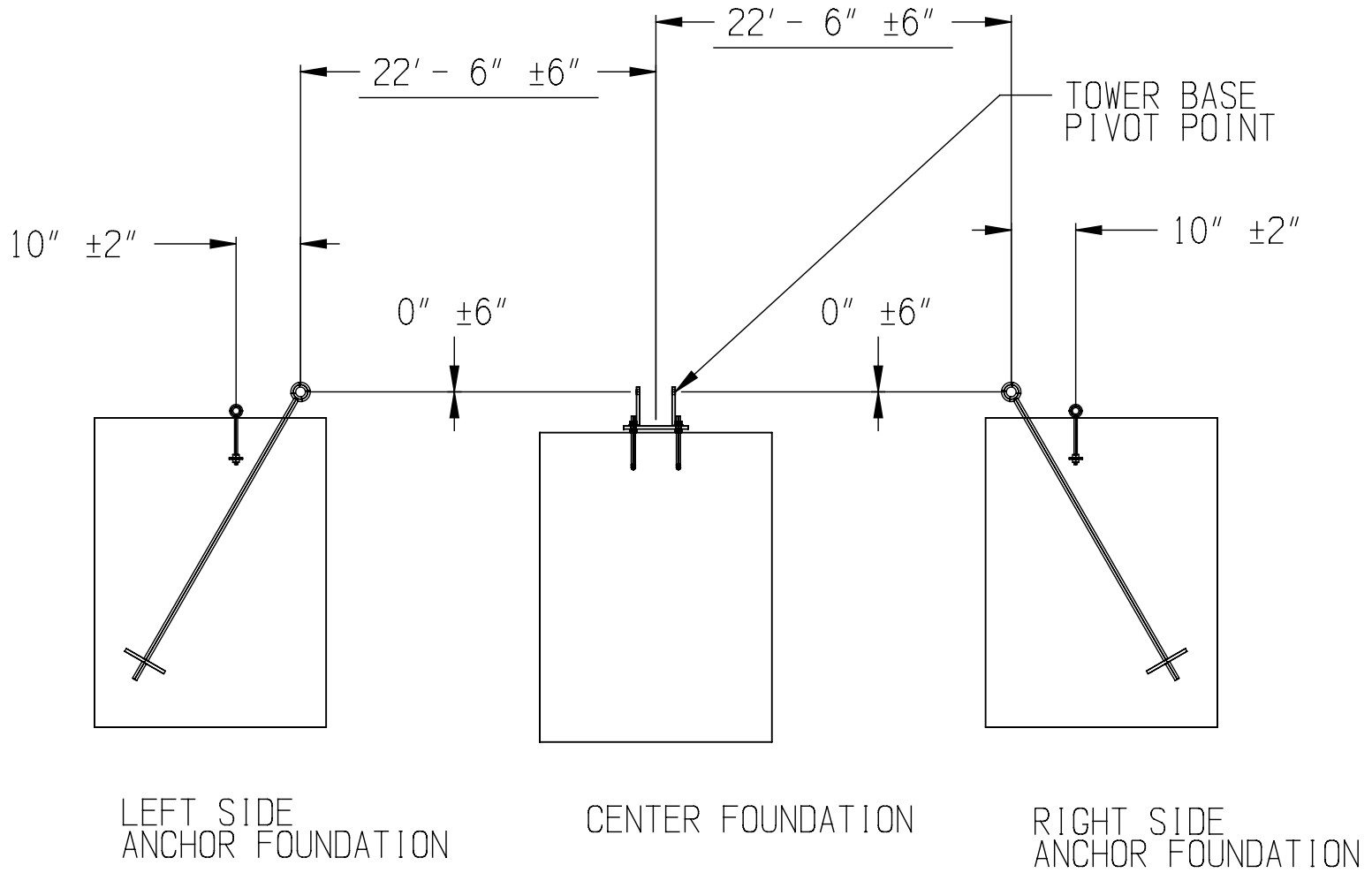
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



Abundant Renewable Energy		SHORT TOWER IN DOWN POSITION			
		DESIGNER	SIZE A	CAGE CODE	DWG NO D6
APPROVED	SCALE	RELEASE DATE	WEIGHT	SHEET	

DRAWING NO. D7		REV A	
REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/12/04	E. DRAPER

NOTES: UNLESS OTHERWISE SPECIFIED



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
LINEAR
FRACTION ± 1/16"
.XX ± .03
.XXX ± .015
ANGULAR
± 1.0°

MODEL NUMBER:
AWP 3.6
MATERIAL:

LEGEND
○ REVISION
○ ITEM
△ NOTE

DRAWN
E. DRAPER
CHECKED
DATE
07/12/04

ABUNDANT RENEWABLE ENERGY

DRAWING TITLE
SIDE ANCHOR ELEVATION (SHORT)

SCALE
NONE

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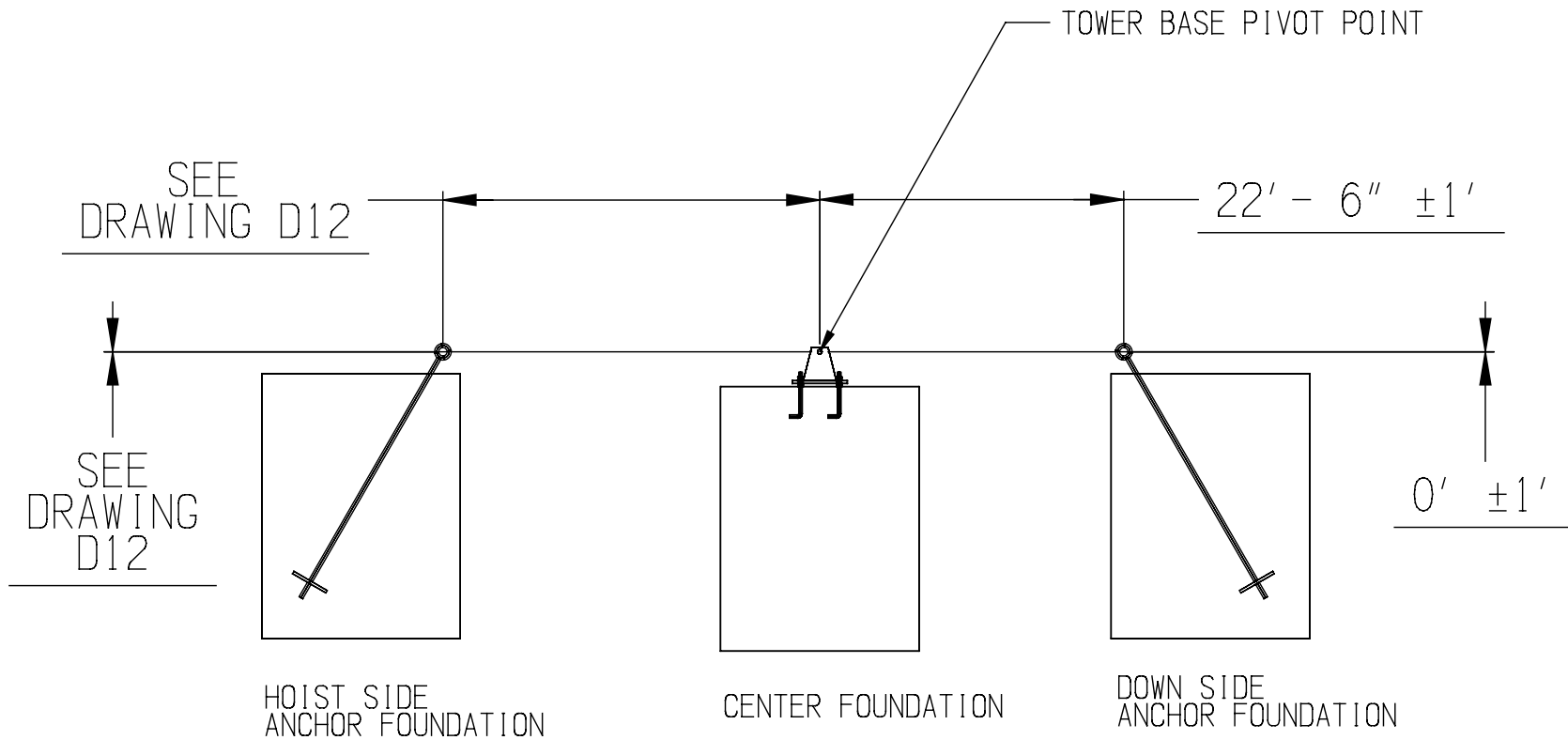
DRAWING NO. D7

SHEET 1 OF 1

REV A

DRAWING NO. D8		REV A	
REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/12/04	E. DRAPER

NOTES: UNLESS OTHERWISE SPECIFIED



UNLESS OTHERWISE SPECIFIED:
 DIMENSIONS ARE IN INCHES
 TOLERANCES:
 LINEAR
 FRACTION $\pm 1/16''$
 .XX $\pm .03$
 .XXX $\pm .015$
 ANGULAR
 $\pm 1.0^\circ$

MODEL NUMBER:
 AWP 3.6
 MATERIAL:
 LEGEND
 ○ REVISION
 ○ ITEM
 △ NOTE

DRAWN
 E. DRAPER
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 DATE
 07/12/04

ABUNDANT RENEWABLE ENERGY

DRAWING TITLE
 HOIST AND DOWN SIDE ANCHOR ELEVATION (SHORT)

SCALE
 NONE

DRAWING NO. D8

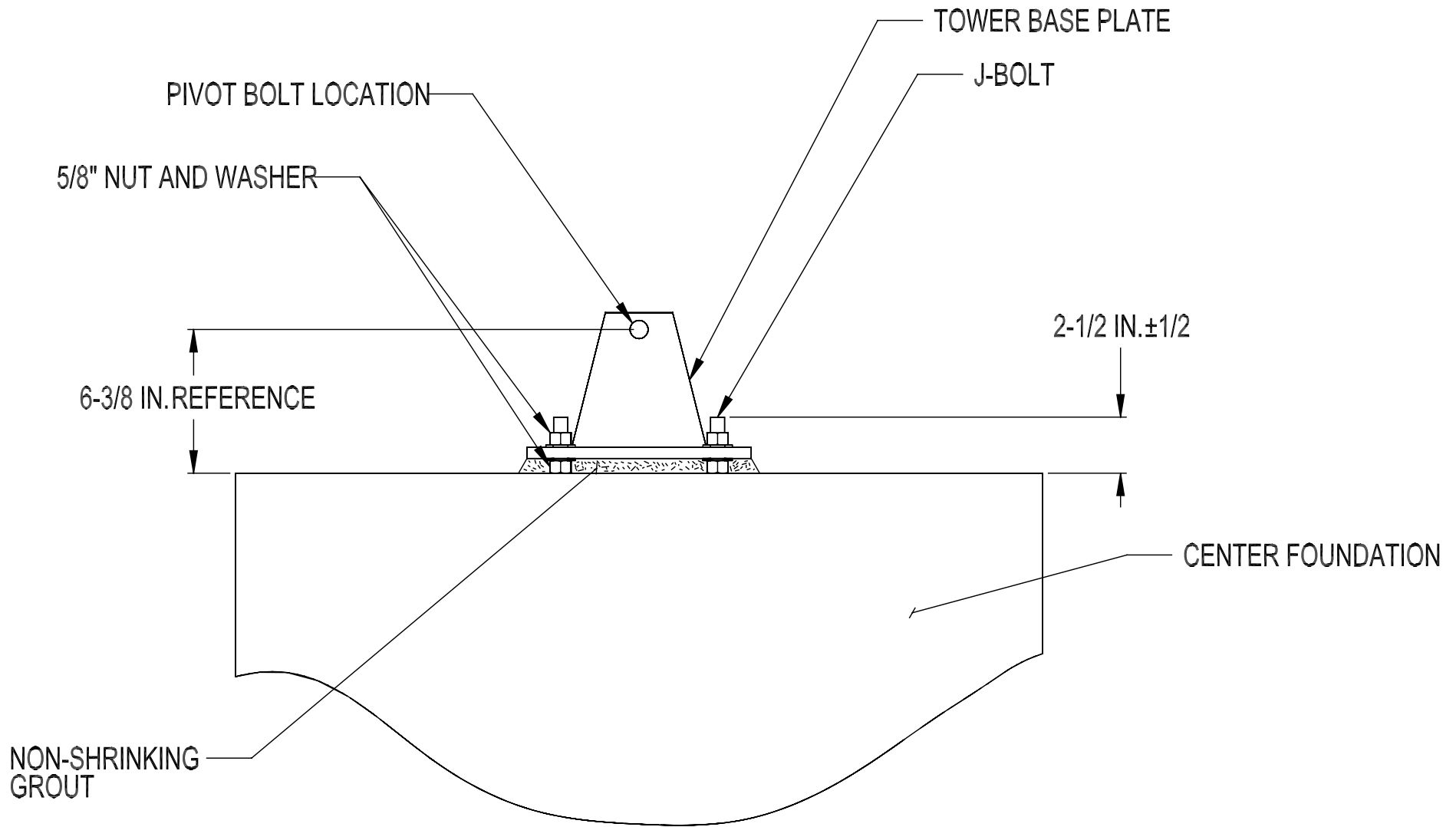
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REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/014/04	E.DRAPER

NOTES: UNLESS OTHERWISE SPECIFIED



UNLESS OTHERWISE SPECIFIED:
 DIMENSIONS ARE IN INCHES
 TOLERANCES:
 LINEAR
 FRACTION ± 1/16"
 .XX ± .03
 .XXX ± .015
 ANGULAR
 ± 1.0°

MODEL NUMBER:
 AWP 3.6

MATERIAL:

LEGEND
 ○ REVISION
 ○ ITEM
 △ NOTE

DRAWN
 E. DRAPER

CHECKED

DATE
 07/14/04

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DRAWING TITLE
 J-BOLT AND TOWER BASE INSTALLATION

SCALE
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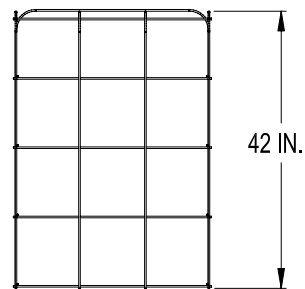
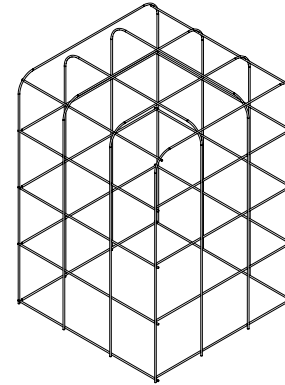
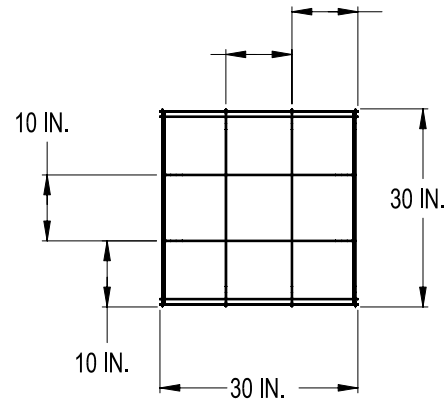
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REV A

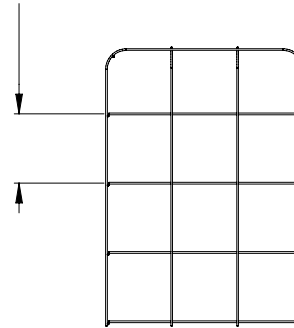
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REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/14/04	E. DRAPER

NOTES: UNLESS OTHERWISE SPECIFIED

1. MAXIMUM DIMENSIONS FOR A 4 FOOT DEEP, 3 FOOT SQUARE HOLE ADJUST FOR LARGER HOLES ENSURING THE REINFORCEMENT IS LOCATED 3 TO 5 INCHES FROM ANY SURFACE



10-1/2 IN. TYP.






TYPICAL REINFORCEMENT

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
LINEAR
FRACTION $\pm 1/16"$
.XX $\pm .03$
.XXX $\pm .015$
ANGULAR
 $\pm 1.0^\circ$

MODEL NUMBER:

MATERIAL:
#2 OR #3 REBAR
($\varnothing 1/2"$ OR $\varnothing 3/8"$)

LEGEND
 REVISION
 ITEM
 NOTE

DRAWN
E. DRAPER
CHECKED

DATE
07/14/04

DRAWING TITLE
CENTER FOUNDATION REINFORCEMENT

SCALE
NONE

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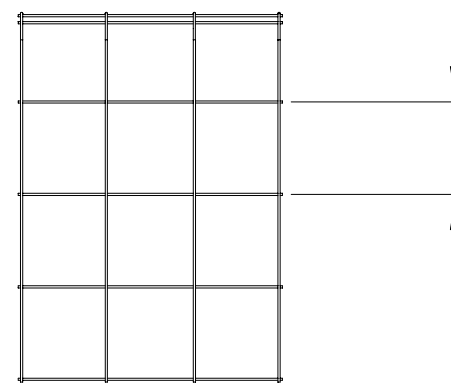
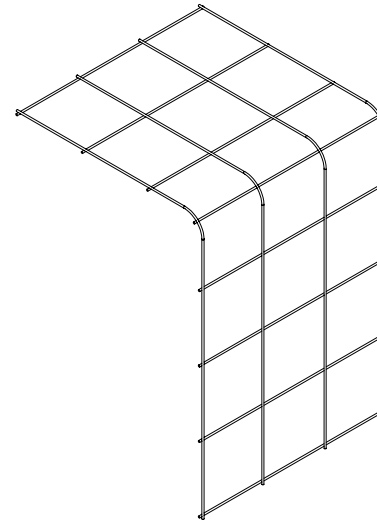
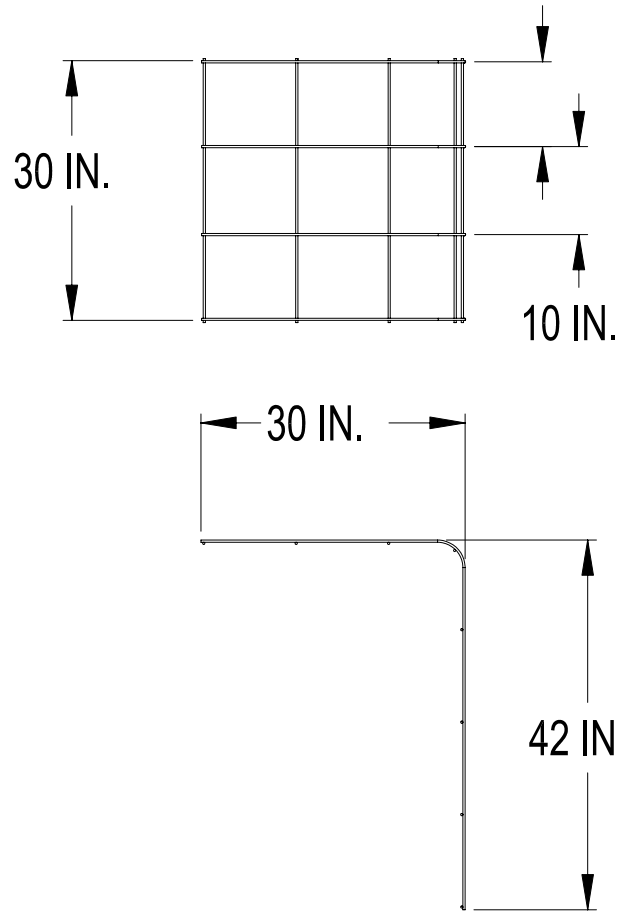
DRAWING NO. D10

SHEET 1 OF 1
REV
A

DRAWING NO. D11		REV A	
REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/14/04	E.DRAPER

NOTES: UNLESS OTHERWISE SPECIFIED

1. MAXIMUM DIMENSIONS FOR A 4 FOOT DEEP, 3 FOOT SQUARE HOLE
ADJUST FOR LARGER HOLES ENSURING THE REINFORCEMENT IS
LOCATED 3 TO 5 INCHES FROM ANY SURFACE



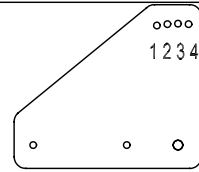
TYPICAL REINFORCEMENT

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: LINEAR FRACTION $\pm 1/16''$.XX $\pm .03$.XXX $\pm .015$ ANGULAR $\pm 1.0^\circ$	MODEL NUMBER:			DRAWING TITLE OUTER ANCHOR FOUNDATION REINFORCEMENT	
	MATERIAL: #2 OR #3 REBAR ($\varnothing 1/2''$ OR $\varnothing 3/8''$)	LEGEND ○ REVISION ○ ITEM △ NOTE	DRAWN E. DRAPER CHECKED	DATE 07/14/04	SCALE NONE
			DRAWING NO. D11		REV A

POSSIBLE LOCATIONS FOR HOIST ANCHOR

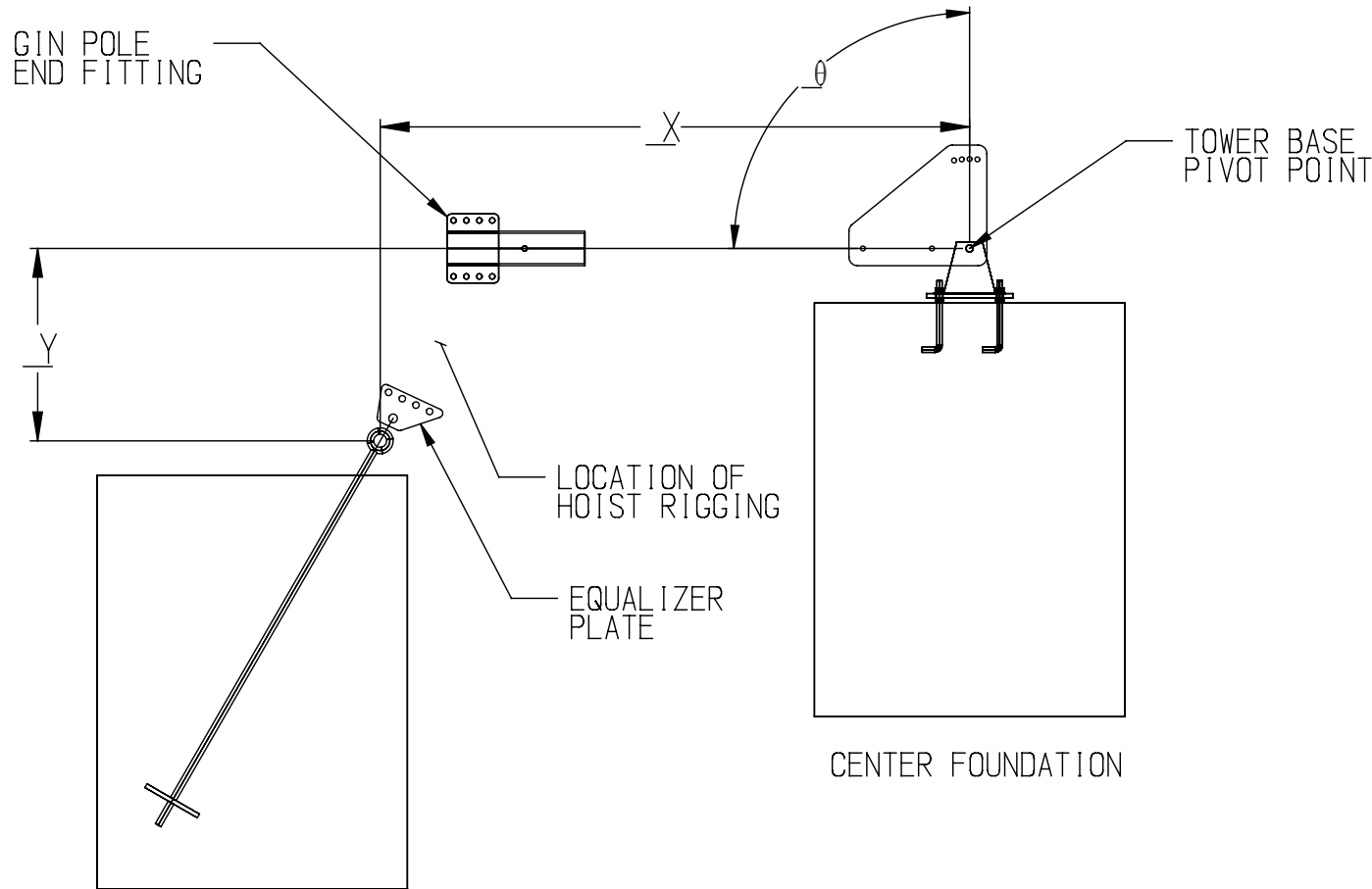
DRAWING NO. D12			REV A
REV	DESCRIPTION	DATE	REV. BY
A	NEW RELEASE	07/12/04	E.DRAPER

X ±2"	Y ±2"	GIN POLE GUSSET HOLE	θ
22' 1-1/2"	+1' 9-5/8"	1	80°
22' 4-1/8"	-0' 0-3/4"	2	85°
22' 4-7/8"	-1' 11-1/4"	3	90°
22' 3-5/8"	-3' 9-3/4"	4	95°



NOTES: UNLESS OTHERWISE SPECIFIED

1. GUSSET HOLE #3 CREATES A 90° ANGLE BETWEEN THE GIN POLE AND THE TOWER BASE SECTION (SHOWN)



HOIST SIDE ANCHOR FOUNDATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
LINEAR
FRACTION ± 1/16"
.XX ± .03
.XXX ± .015
ANGULAR
± 1.0°

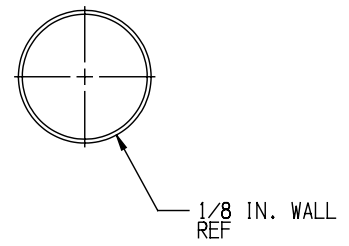
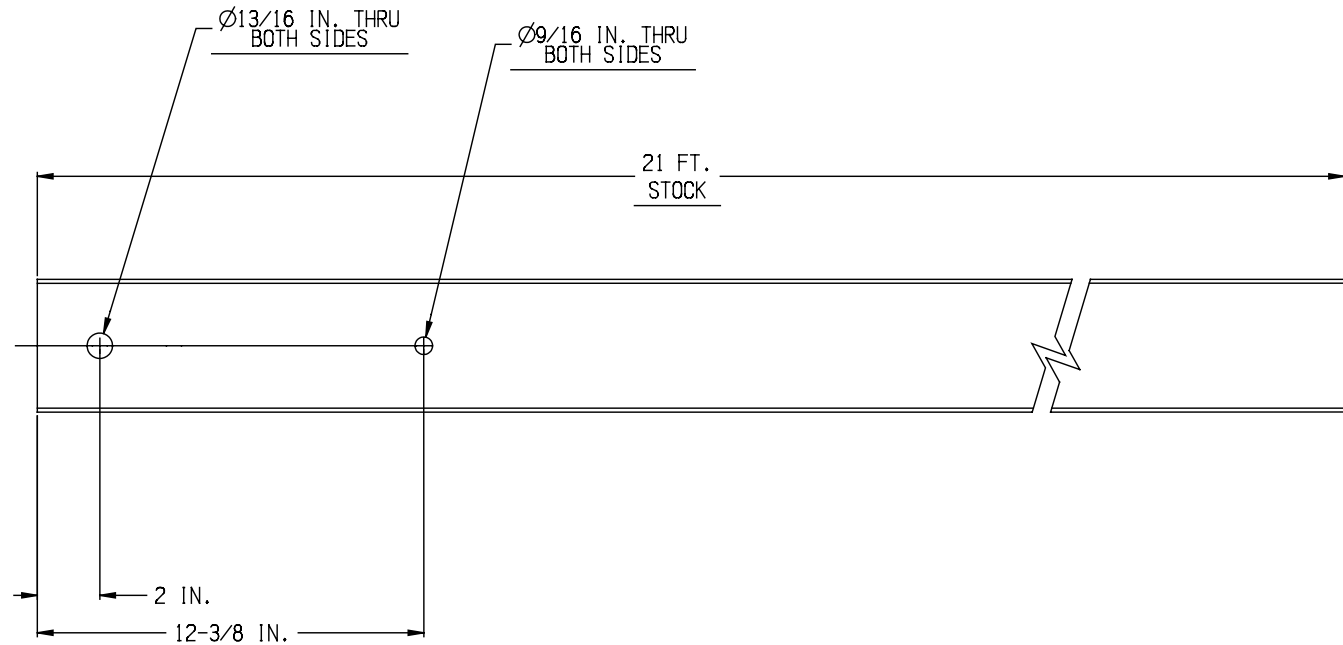
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MATERIAL:		
LEGEND	○	△
REVISION	ITEM	NOTE

DRAWN E. DRAPER	DATE 07/12/04
CHECKED	

ABUNDANT RENEWABLE ENERGY	
DRAWING TITLE HOIST AND DOWN SIDE ANCHOR ELEVATION (SHORT)	
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DRAWING NO. D12	REV A
SHEET 1 OF 1	

101011 REV A

R	DATE	ECN #	CHANGE	DR
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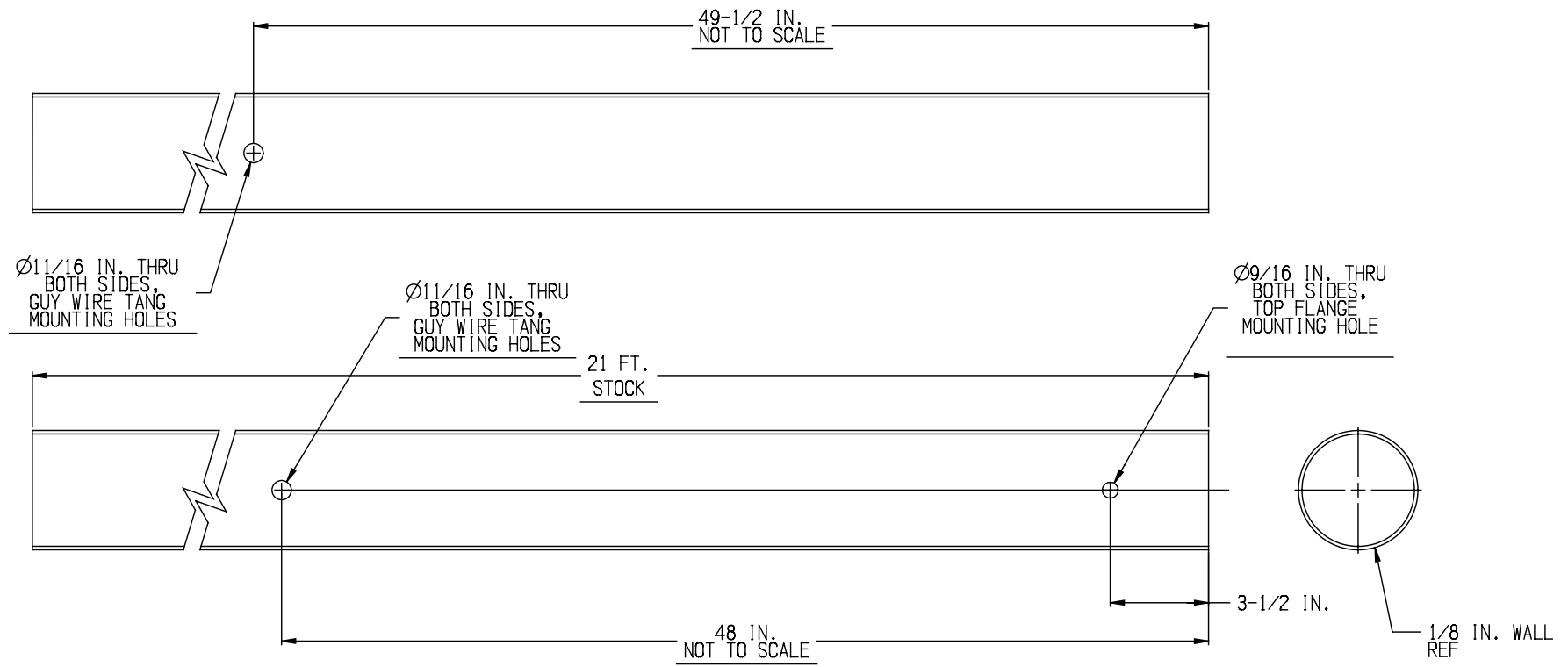


NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS ARE INCHES
2. MAT'L: 4 INCH SCHEDULE 10 PIPE
3. BREAK SHARP EDGES
4. FINISH: GALVANIZED

TOLERANCES: .X± 0.25 .XX± .030 .XXX± .010	DR	CK	SCALE:	ABUNDANT RENEWABLE ENERGY
	CW		1:1	
DO NOT SCALE DRAWING	DATE 09-18-02		TITLE TOWER, BASE SECTION	
	APP'D			
THIS DRAWING IS PROPRIETARY. THE INFORMATION HEREIN IS CONFIDENTIAL AND REQUIRES WELLS TECHNOLOGIES APPROVAL FOR USE OR DUPLICATION				SIZE DWG# A 101011
CUST RWP	PROJ TOWERS		REV	A

R	DATE	ECN #	CHANGE	DR
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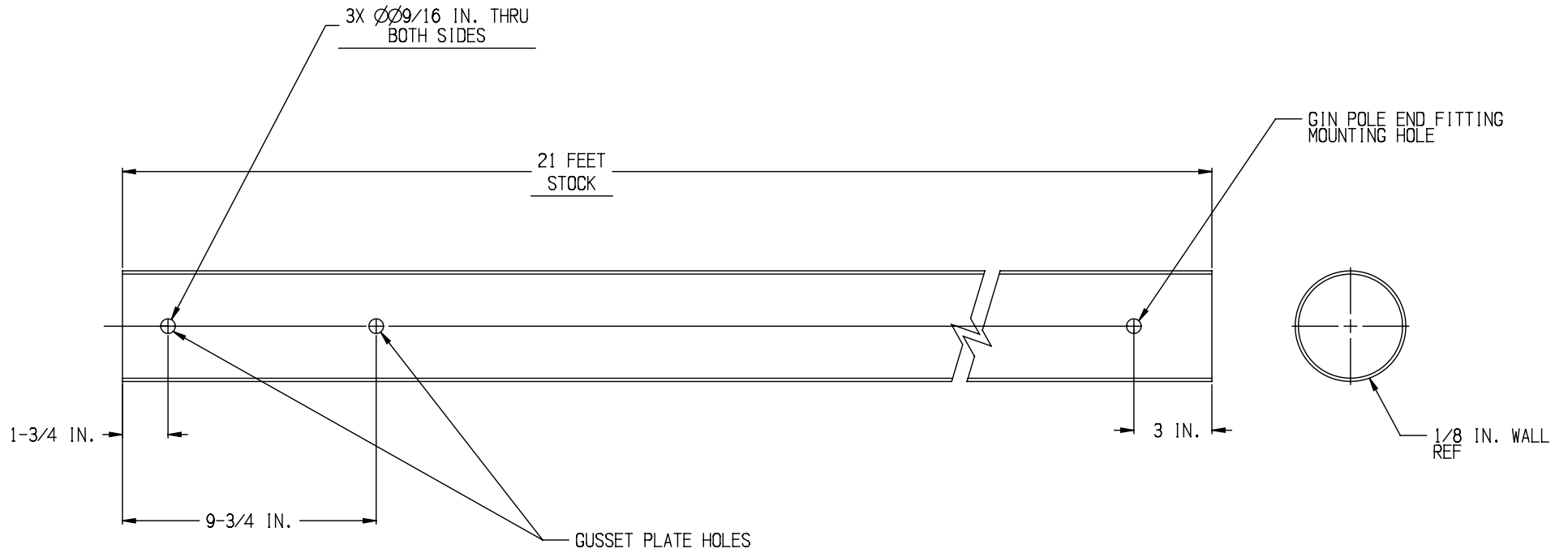


NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS ARE INCHES
2. MAT'L: 4 INCH SCHEDULE 10 SEAMLESS PIPE
3. BREAK SHARP EDGES
4. FINISH: GALVANIZED

TOLERANCES: .X± 0.25 .XX± .030 .XXX± .010	DR	CK	SCALE:	ABUNDANT RENEWABLE ENERGY
	CW		None	
DO NOT SCALE DRAWING			DATE 09-18-02	
THIS DRAWING IS PROPRIETARY. THE INFORMATION HEREIN IS CONFIDENTIAL AND REQUIRES Abundant Renewable Energy's APPROVAL FOR USE OR DUPLICATION			APP'D	
TITLE Tower, Top Section				SIZE DWG# REV A 101013 B
CUST RWP		PROJ TOWERS		

R	DATE	ECN #	CHANGE	DR
---	------	-------	--------	----



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS ARE INCHES
2. MAT'L: 4 INCH SCHEDULE 10 PIPE
3. BREAK SHARP EDGES
4. FINISH: GALVANIZED

TOLERANCES: .X± 0.25 .XX± .030 .XXX± .010	DR	CK	SCALE:	ABUNDANT RENEWABLE ENERGY
	CW			
DO NOT SCALE DRAWING	DATE 09-20-02		TITLE GIN POLE, BASE SECTION	
	APP'D			
THIS DRAWING IS PROPRIETARY. THE INFORMATION HEREIN IS CONFIDENTIAL AND REQUIRES WELLS TECHNOLOGIES APPROVAL FOR USE OR DUPLICATION				SIZE A
CUST RWP		PROJ TOWERS		
				REV A