

***ENGINEERED ENDEAVORS, INC.***

**COMMUNICATIONS STRUCTURE**

**ASSEMBLY & ERECTION PROCEDURES**

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## 1. Introduction

This document should be reviewed by the Owner and Contractor before erecting the communications monopole. The information contained herein is not all inclusive but should serve as a helpful guide in the erection of the structure. EEI has assumed that the Contractor is experienced in erecting “slip jointed” or flanged pole structures and has the appropriate equipment on site to properly perform the erection of these types of structures.

## 2. Field Inspection

The Contractor should perform a visual inspection of all material before erection of the structure. Specific items to verify on the shafts are

- Review the erection drawings and bill of material. Verify that the shaft sections defined in the bill of material matches the piece numbers on the shafts.
- Verify that the base plate on the bottom section matches the anchor bolt layout in the foundation.
- Examine the structure for any visible damage due to shipping, handling, and/or storage. Also inspect the coatings on the material for any damage and repair as necessary. EEI should be notified immediately if any damage exists during shipping.
- Visually inspect each pole section for straightness by checking every third or fourth flat in a 60° or 90° increment for any curvature in section. A string attached at the top and bottom of the individual sections can be used to help identify any irregularities in the straightness of the pole section.
- Visually inspect each pole section end for squareness, *i.e.*, check the female section for an “egg” shape, which may cause difficulty in erecting the pole. A hydraulic jack can easily be used to square the pole end.

**If discrepancies and/or shipping and handling damages are found, EEI should be notified immediately.** In most instances an experienced erection crew will easily identify any irregularities in the structure and have the proper equipment on site to correct the situation. No modifications should be made to the structure in the field without consulting EEI. The contractor shall conduct the construction and erection operation at all times within compliance of the AISC Manual of Steel Construction (latest edition) and generally accepted construction practices.

## 3. Assembly

If space and lifting capabilities permit, it is preferable to assemble the structure on the ground. The pole is then raised into position in one piece. However, if the pole must be assembled in the air due to space limitations, extra care should be employed to assure that all joints are fully engaged. **The weight of the sections cannot be substituted for the jacking force required to make a joint. Jacking the joints at the time of erecting the sections is necessary for a valid warranty. The information required to check the minimum required slip length is available on the erection drawing.**

### 3.1 Orientation of Shafts

A 2 *in* horizontal weld bead is positioned on matching corners of each shaft section for proper alignment during assembly. These marked corners should be matched at each splice along the pole prior to assembly operations, refer to Figure 1 for complete details. Care shall be taken to ensure that ready access is available to attachments in order for climbing devices, antennas, etc. to be installed without rolling the pole after jacking.

### 3.2 Slip Joint Assembly

Before mating the sections, thoroughly clean the joint area and remove any foreign matter. It is recommended that the targeted slip joint lap on the male section be clearly marked with a non-permanent marking. All EEI erection drawings will specify the target length of overlap for each joint. This will enable the erectors to make a prudent decision regarding the quality of joint.

Assembly nuts or holes have been provided during fabrication both above and below each slip joint. These attachment points are located 180° apart and allow 1 *in* or 1-1/2 *in* high strength bolts to be used for the attachment of a jacking device.

There are several methods, which may be used to jacking the sections together depending on the section sizes and the availability of equipment. Hydraulic or mechanical (chain hoists or turnbuckles) jacking devices are both acceptable.

Whichever type of jacking device is used, the pole sections should be blocked up as shown in Figure 2, when erecting the entire structure on the ground. Sections must be telescoped in the field until the lower edge of the upper section is within 12 *in* of the weld bead orientation mark on the lower section. The sections may be worked up and down to help “walk” the pole sections together. Lubrication applied to the lower section will aid in the slipping process.

**NOTE: DO NOT USE GREASE OR OIL TO LUBRICATE THE POLE SECTIONS AS THIS**

**WILL RESULT IN DISCOLORATION, WHICH IS DIFFICULT TO REMOVE.**

If stacking the sections of the pole is to be completed in the air, all slip joint requirements and orientations must be maintained. Again, the weight of the sections should not be substituted for the jacking force required to make the slip joint a viable structural connection.

A minimum jacking force of 10,000 *lbs* must be applied to each side of the pole during jacking. This force may be applied using two (2) six ton come-a-longs under the full effort of one man each. Jacking forces in excess of the 10,000 *lbs* minimum may be required to achieve the minimum overlap specified and shall be used where necessary. Properly assembled pole sections will not exhibit significant visible air gaps (in excess of 3/16 *in* on opposite flats.) The maximum permissible jacking forces are given in Table 1. Caution should always be used when jacking the pole sections together since the required jacking forces are of large magnitude.

If, upon completion of the assembly procedure, the pole sections do not meet all specified criteria, Engineered Endeavors, Inc. (EEI) should be contacted prior to proceeding with erection. On all EEI monopoles, the 18 *in* between weld beads or 12 *in* from the bottom of the top section (female) to the weld bead on the bottom section (male) is the ideal situation. This requirement is the same for every slip joint on any monopole EEI supplies. In addition, EEI has taken into consideration that not every joint will be 18 *in* exactly and variances will occur. EEI monopoles have  $\pm 4$  *in* of tolerance in each joint, however, the following criteria must be met or the manufacturers warranty may be voided:

1. The slip joint has been jacked together using the forces shown in Table 1.
2. The slip joint is well seated, *i.e.*, air gaps between sections are less than 3/16 *in*.
3. The top section is not in conflict with any appurtenances on the bottom section, *e.g.*, top section resting on step clip located on bottom section.

**Under no circumstances should the structure be loaded without proper slip joint engagement unless written authorization from EEI has been received!**

**TABLE 1: RECOMMENDED MAXIMUM JACKING FORCES**

Minimum Thickness of Sections Being Assembled ( <i>inch</i> )	Recommended Maximum Total Load ( <i>lbs</i> ) per Side 65 <i>ksi</i> Shaft Material	Recommended Maximum Total Load ( <i>lbs</i> ) per Side 50 <i>ksi</i> Shaft Material
3/16	27,400	21,100
7/32	32,000	24,600

Minimum Thickness of Sections Being Assembled ( <i>inch</i> )	Recommended Maximum Total Load ( <i>lbs</i> ) per Side 65 <i>ksi</i> Shaft Material	Recommended Maximum Total Load ( <i>lbs</i> ) per Side 50 <i>ksi</i> Shaft Material
1/4	36,600	28,200
9/32	41,100	31,600
5/16	45,700	35,100
11/32	50,300	38,700
3/8 and over	54,000	41,500

#### 4. Erection

There are two basic methods of erection

- ① the pole can be assembled completely on the ground and lifted into place

or

- ② lift each individual section(s) into place and making a joint in the air.

Each site is unique in its own way and the contractor should carefully plan all aspects of the pole erection.

#### 4.1 Anchor Based Foundation

The leveling hex nuts on the anchor bolts should be adjusted before installing the pole. They should be in a horizontal plane, turned down on the threading to provide enough room on the bolts for the base plate thickness, the top hex nut and at least one inch of projection for possible adjustment. The top hex nuts should be turned down as quickly as possible after placement on the leveling hex nuts. For proper plumbing of the structure refer to Section 4.5.

#### 4.2 Embedded Foundation

If the structure utilizes an embedded base, installation must be modified from that described above. Typically, the bottom (embedded) section of the pole is installed in the ground first. Prior to

placement of the embedded section, the finish should be inspected and touched up as required. The base section should be supported while the backfill, as specified on the foundation drawing, is placed and compacted, as necessary. Temporary guys, or attachment to a crane may be used to supply this support. The section should be checked periodically during this process to insure the section remains plumb. Care should be taken to assure that the bottom section is vertical before proceeding with the erection of the rest of the pole since there is no adjustment to this type of structure.

### 4.3 Structure Assembly on Ground

Erection of the pole takes place rapidly as the assembled pole may be picked up from a single point with a nylon or padded cable choker and swung into position. The balance point must be field determined as it varies dependent upon the number of arms or other appurtenances installed prior to erection. Experienced crane operators will find no problem in determining the proper lifting point. All attachments to the structure should be made to the main pole member and not to appurtenances such as pole steps, platforms, etc.

**When setting the pole, it is necessary that all splices below the lifting point be tethered together as a safety precaution against pulling apart during erection.**

### 4.4 Aerial Assembly of Structure

In some instances, the contractor may choose to assemble the structure by stacking the individual sections in the air. Close inspection of all components is required in order to ensure proper fit and to determine if any components have irregularities, refer to the Field Inspection section on page 1. This should be performed prior to stacking any of the sections.

The base section is set, initially plumbed, aligned, and secured to the foundation. In proper order, the subsequent sections are stacked and joints are secured, *i.e.*, jacked. Proper engagement of the joint must be verified before the next section is lifted into place, refer to section 3. Assembly.

### 4.5 Plumbing of Structure

After erection, proper plumbing of the poles can be accomplished by adjusting the anchor bolt nuts underneath the base plate. **Do not assume that the pole is plumb based solely on placing a level on the base plate.** The structure can be measured after placement on (or in) the foundation to be sure it is plumb. Ideally, the top of the pole should be directly over the bottom of the pole, making the maximum deviation of the pole shaft from a true vertical line occur somewhere in the middle of the pole. The leveling nuts can be adjusted to accomplish this alignment by raising the leveling nuts

on the anchor bolts in the direction the pole is leaning. Note that a small amount of rotation of the a nut will represent a number of inches of movement at the top of the pole. The taller the pole the more sensitive the adjustment of the leveling nuts will be.

#### **4.5.1 Final Anchor Bolt Nut Tightening Procedure**

After the monopole has been installed, the anchor bolt hex nuts must be properly tightened to ensure that the structure will perform as designed. This procedure is quite simple but should be carefully followed:

- 1) Utilizing a transit located on two perpendicular axes, the monopole should be plumbed such that the top pole center is directly over the bottom pole center. This can be accomplished by loosening the anchor bolt nuts above the base plate and adjusting the nuts located underneath the base plate.

**DO NOT LOOSEN THE TOP ANCHOR BOLT NUTS MORE THAN ONE TURN AT A TIME OR DRAMATIC STRUCTURE MOVEMENT MAY OCCUR.**

- 2) After pole has been plumbed, snug up all bottom anchor bolt nuts until they are in firm contact with the bottom of the base plate. Use caution when snugging up bottom nuts not to over tighten or the pole will be moved out of plumb.
- 3) Bring all top anchor bolt nuts down to a snug tight condition on the top of the base plate.
- 4) Fully tighten each top anchor bolt nut using the full effort of a single man on a four foot wrench (approximately 600 *ft-lbs.*)

**NUTS SHOULD BE TIGHTENED IN AN ALTERNATING FASHION WORKING DIAGONALLY BACK AND FORTH UNTIL ALL NUTS HAVE BEEN SECURED.**

- 5) Check all bottom anchor bolt nuts to ensure that they have not been loosened in the process. Any nuts, which have been loosened, should be tightened again.
- 6) Re-check the monopole for plumb and re-adjust if necessary.
- 7) Center punch anchor bolt threads above top hex nut. Mark across hex nut face and anchor bolt with red paint such that any loosening of the nut can be easily detected.

## 5. Installation of High-Strength Structural Bolts (ASTM A-325)

### 5.1 Introduction

When installing high strength structural bolts, it is important that they be tightened to a point where proper preload is induced in the fastener. By properly preloading, the fastener stress fluctuations, which lead to fatigue failure and fracture or plastic elongation caused by overload, can be prevented, see Table 2.

**Table 2: Recommended Preload Values for High Strength Bolts**

Nominal Bolt Size ( <i>inch</i> )	Minimum Preload A-325 ( <i>kips</i> )
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1-1/8	56
1-1/4	71
1-3/8	85
1-1/2	103
2	135

### 5.2 Installation

Several methods for inducing preload in connection bolts are available. Each method has its own cost and accuracy factors to be considered.

#### 5.2.1 Torque Wrenches

Torque wrenches may be used for inducing pretension and have the advantage of being relatively simple and providing accuracy to within  $\pm 25\%$ . Although the actual torque requirement will vary with surface condition, amount of lubrication and speed of tightening, reasonably close torque requirements for galvanized bolts are shown in Table 3.

**Table 3: Torque Requirements for Galvanized Bolts**

Nominal Bolt Size ( <i>inch</i> )	Approximate Torque ( <i>ft. lbs.</i> )*/Induced Preload ( <i>kips</i> )
1/2	75/12
5/8	148/19
3/4	263/21
7/8	427/39
**1	**263/21
1	638/51
1-1/8	788/56
1-1/4	1000/71
1-3/8	1461/85
**1-1/2	**1856/99
1-1/2	1931/103
**2	**3375/135

\*Values are based on a K (torque coefficient) value of 0.15 and are generally conservative.

\*\* A-193 thru-bolts (when used with A-53 thru-pipe).

**NOTE: FLANGE PLATES SHOULD BE IN BEARING BEFORE PRELOADING BOLTS, SEE "ALIGNMENT" AND SHIMMING PROCEDURE.**

### 5.2.2 Turn of the Nut Method

The turn of the nut tightening process involves bringing the nut to a “snug tight” condition and then turning the nut a prescribed amount to achieve the required preload. This method is accurate to within  $\pm 15\%$ , but does not allow for variation when trying to determine the ideal “snug tight” condition. This method has the advantage of eliminating the influence of all frictional variables relative to final induced reload.

For installing coarse threaded bolts with grips less than 8 inches, a one-half turn past “snug tight” may still be used, since inducing larger preloads could over stress the thru-pipe in the shaft.

**NOTE: IT IS PARTICULARLY IMPORTANT WHEN USING THE TURN OF THE NUT METHOD, THAT PARTS BEING JOINED HAVE PROPER BEARING WHEN BOLTS ARE TIGHTENED. SEE “ALIGNMENT AND SHIMMING PROCEDURE”.**

## 6. Alignment and Shimming Procedure

Due to the length of most members, which are joined using flange type connections, any variation in plate alignment or flatness will result in noticeable deviations at the ends of the members being joined. For this reason, care should be taken when bolting flange plated members to ensure proper appearance and serviceability as follows:

- 1) Members should be placed on timbers and leveled to a point where the centerline of the pole sections is straight in the horizontal plane.
- 2) Members should be aligned so that the centerline running down the top flat of the sections is straight.
- 3) Bolts should be put in ALL holes and drawn up “snug” while ensuring that sections remain aligned.
- 4) If the flange area around any of the bolts is not in good contact, horse shoe type washers should be slipped in as needed.

NOTE: WHEN LOCK WASHERS ARE PRESENT, A “SNUG TIGHT” CONDITION REQUIRES THAT THE SPRING WASHERS BE FLATTENED.

## 7. Erection of Platform and Antenna Mounts

If a strict tolerance for antenna alignment is required, EEI would suggest the following additional

instructions for erecting the platform and antenna mounts. Since the platform and mounts are made of galvanized steel and bolt holes are *\_ inch* larger than the bolt diameter, movement exists between all pieces. If erected properly, the movement can be used to the erector's advantage by providing the necessary movement to achieve antenna plumbness. Without maintaining levelness throughout the platform, the antenna mount may not have enough adjustability to achieve the desired tolerances or overcome the inadequate erection, therefore, the objective is to keep all parts level from the center out to the corners.

The monopole structures themselves should be properly erected. This includes jacking the sections together and ensuring the shafts are plumb. If sections are not jacked together properly, significant displacements (*i.e.*, *6 inches* or more) can be observed at the slip joints after the monopole is in operation. In addition, the top plate should also be level, anchor bolt nuts can adjusted to achieve the required plumbness. Do not assume that the top plate is level based on the fact that the base plate is level.

1. The platform should be assembled on a level surface. Due to field conditions, this may be a difficult task, however, to achieve the plumbness requirements, this must be accomplished, *e.g.*, using blocks (wood or concrete), shims, jacks, and/or temporary supports (horses).
2. Starting with the center hub and triangular platform assemblies, strict tolerance on levelness should be maintained (less than  $0.1^\circ$ .) Pieces can be moved slightly in all directions due to oversized bolt holes. If needed, hardened flat washers can be used as shims.
3. Once the platform is level and erection is completed, the corner "T" mounts (if purchased) and antenna mounts can be bolted to the face of the platform.
4. Since slight imperfections exist on all steel parts and if a strict tolerance is needed (*i.e.*,  $0.5^\circ$  maximum down tilt and side tilt plumbness), the required plumbness can be achieved in a number of ways.
  - ① The corner plates on the platform can be shimmed with washers or steel chips.
  - ② The corner "T" mounts (if purchased) can be shimmed.
  - ③ The antenna mounts themselves can be moved and shimmed.

A combination of the three may also be required. Loosening, shimmed and tightening bolts can achieve a certain degree of levelness and plumbness. In the same manner, a certain degree of unevenness can also be introduced to the structure.

*Note:* A block wedge is suggested as a tool to achieve levelness. Once the structure is level,

shims can be used to fill the gaps before tightening bolts.

5. The final piece will be the antenna mount. The pipe mount should be installed and checked for plumbness. To achieve the required plumbness in the side and down tilt directions, bolts can be tightened and loosened, thereby creating the adjustment in the pipe mount, which can be moved back and forth and side to side, approximately  $\pm 5^\circ$ . If additional movement is required, a small jack can be used to displace the two plates welded to the pipe mount that sandwich the "T" mount. The plate's only need to be moved slightly, a maximum of 1/16 *inch* to get considerable movement in the pipe mount. Caution should be used not to introduce other problems into the pipe mount and in achieving levelness in other directions, *e.g.*, side tilt.
6. For the side tilt tolerance, if plumbness is not achieved by simply bolting the pipe mount to the platform, the left or right side of the mount must be shimmed. This can be accomplished by using a block wedge to level the pipe mount to the required tolerance and shimming the gaps with washers or steel chips. For best results, do not loosen all four bolts at one time, working on two (*e.g.*, top, bottom, side, or diagonals) bolts will give the best results.
7. Items 4, 5, and 6 should be done simultaneously to give maximum flexibility when leveling all pipe mounts. However, based on field experience it was determined that side tilt should be plumbed first before proceeding to down tilt. Loosen bolts only slightly for keen movements. Once the side tilt is plumb, then proceed to plumb the down tilt. Loosen only the top two bolts for best results in plumbing the down tilt.

After the platform is level and the pipe mounts are plumb, all bolts should be rechecked for tightness. Levelness is definitely achievable but tight restrictions on erection must be maintained even under the most difficult field conditions.