SPECIAL SPECIFICATION

6315

Self Supporting Radio Tower

1. **Description.** Design, fabricate, and install self-supporting radio towers in accordance with the plans and with these specifications.

2. **Tower Removal.** If required, remove existing tower as specified on the site information page.

3. **Materials.** Furnish materials in accordance with the following:
   - Item 416, “Drilled Shaft Foundations”
   - Item 441, “Steel Structures”
   - Item 442, “Metal for Structures“
   - Item 447, “Structural Bolting”
   - Item 449, “Anchor Bolts”
   - Item 496, “Removing Structures”

4. **Equipment.** Furnish suitable equipment to assemble and erect the tower at the location shown on the plans.

5. **Design.**
   
   A. **Design Standard.** Design and install the tower in accordance with all the requirements of the latest version of ANSI/TIA/EIA-222 Structural Standards for Steel Antenna Towers and Antenna Supporting Structures, OSHA, and this specification.

   B. **Design Requirements.** Meet the requirements of ANSI/TIA/EIA-222, and the following requirements:
      1. Conform to AISI Specification for the Design of Cold-Formed Steel Structural Members.
      2. Construct tower to height specified on the attached site information page.
      3. Tower must be self-supporting. The tower must be a 3 or 4 sided truss configuration, at the option of the Contractor.
      4. Tower legs must be solid rod, diagonals must be angle or solid rod.
      5. Provide a provision for an antenna system as described on the plans and the site information sheet.
6. Ice loading: 1/2 in. of solid radial ice simultaneous with specified design wind speed. No reduction in wind force as per the current revision of TIA/EIA-222 unless otherwise specified on the plans.

7. Design Wind Speed: 100 mph unless otherwise specified on the plans or Site information sheet.

8. Lighting: Provide a dual lighting system if required. The dual lighting must consist of a top mounted medium intensity strobe for daytime operations and a red LED beacon with 3 red LED L-864 side lights for nighttime operations. Meet the current version of the Federal Aviation Administration (FAA) Advisory Circular AC 70/7460. The lighting system must operate from 120 VAC +/- 10% 60 Hz. Provide lightning protection on the AC input circuit. The lightning protection circuit must consist of MOVs, Isolation Transformer & Surge Protectors. Provide the lighting controller of modular construction and include the following alarm circuits: Form "C," Power Fail, Photocell, Red Beacon Fail, Strobe Fail & Sidelight Fail. Relays on the strobe circuit board must be plug in type. Provide a complete service manual with the strobe control panel. Provide a minimum of 1 spare flash tube in the lighting system package. Mount the strobe circuit in a stainless steel NEMA 4 outdoor housing suitable for mounting adjacent to the tower. Warranty the strobe panel and associated circuits and components a minimum of 24-months. Provide factory training classes and 24/7 technical support for the tower lighting system. Note that TxDOT may voluntarily light the tower. If so, information on voluntarily lighting must be noted on the Site information sheet. Voluntarily lighting must meet the current version of the FAA Advisory Circular AC 70/7460.

9. Antenna Wind Loading: Design the tower for an effective projected area (EPA) of 20 sq. ft. and a combined dead load weight of 240 lb. located at the top of the tower, unless otherwise specified on the plans or the Site information sheet. The specified wind loading and dead load weight does not include the transmission line(s).

10. At a minimum, the top 40 ft. configuration of the tower must be vertical and must be compatible with the mounting details for the antenna assembly listed in the Site information sheet or plans.

6. Design Calculations and Shop Drawings.

A. Submit 3 sets of design calculations and 7 sets of shop drawings and erection drawings for review and approval. Provide submittals bearing the seal of a Registered Professional Engineer licensed in the State of Texas.

B. Ensure the correctness and completeness of the drawings, and also the shop fit and field connections.

C. Send shop drawings to:

Texas Department of Transportation
Attn: TRF-TM Radio Operations
125 East 11th Street
7. **Foundation.** Construct foundations in accordance with Item 416, “Drilled Shaft Foundations,” and the details shown on the plans.

8. **Anchor Bolts.** Provide anchor bolts in accordance with Item 449, “Anchor Bolts”
   
   A. Provide anchor bolt number, spacing and size as required by the design.
   
   B. Assemble the base section of the tower before any foundation work is started. Use the base tower section to manufacture a template which will be used to verify the proper placement of the anchor bolt assemblies in the drilled shaft foundations. Other methods of installing the anchor bolts including using a transit and measurement method or any other similar methods are NOT PERMITTED.
   
   C. Provide a steel template with minimum thickness equal to 0.25 times the bolt diameter for use at the bottom of the anchor bolt cage assembly with the lower nuts tack welded to the template. The width of the template must be a minimum of 2.0 times the bolt diameter with suitable clearances remaining for foundation reinforcement and concrete placement. Provide a similar template with a minimum 1/4-in. thickness at the top of the anchor bolt cage assembly. Provide 2 nuts and 2 washers for the top of all anchor bolts.
   
   D. Galvanize the upper 14 in. of anchor bolts and the anchor bolt nuts. If anchor bolts are not galvanized, Paint the upper 14 in. with 2 coats of a zinc-rich coating containing a minimum of 95% zinc and meeting Federal Specification DOD-P-21035A. Galvanize exposed nuts or coat with the same zinc-rich paint if bolts are painted.
   
   E. Install anchor bolts in the foundation so that approximately 1/4 in. of unthreaded shank is exposed. Do not used grout between base plates and foundations.
   
   F. Bond a minimum of 2 opposite anchor bolts to the steel reinforcement using heavy duty bronze u-bolt mechanical connectors suitable for installation in concrete or an exothermic welding (Cadweld type bonding). Provide a tinned copper 1/0 bonding conductor between the anchor bolts and the reinforcement steel.

9. **Tower Materials.**
   
   A. Provide solid rod tower legs, and angle or solid rod diagonals.
   
   B. Galvanize Tower components. Galvanize individual pieces of truss-type supports before assembly. Reaming of holes during assembly is permitted without galvanizing repair at the holes.
   
   C. Provide assembly bolts, A325 or A490, in accordance with Item 447, “Structural Bolting”. Assembly bolts must be galvanized and have lock washers.
   
   D. Remove sharp burrs and edges, 1/4 in. or greater in thickness, from material for railing and handles.
   
   E. Welded shop splices of solid shapes are permitted with approved welding procedures.
F. Fabrication tolerances for truss-type towers:

<table>
<thead>
<tr>
<th>Part</th>
<th>Dimension</th>
<th>Tolerance – inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truss Sections</td>
<td>Length (unassembled</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>sections)</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>Bolt hole spacing</td>
<td>1/16</td>
<td></td>
</tr>
</tbody>
</table>

10. **Climbing Ladder.** Furnish a climbing ladder designed and constructed to meet all applicable OSHA and ANSI standards.

A. Ladder width must be 16 in. minimum. Install the ladder on the outside of the tower.

B. Mount the ladder on the outside face of the tower between the tower legs. Contact the radio specialist or point of contact before mounting the ladder, to determine where the side mounted antennas are to be mounted. Mount the ladder so that there is minimal effect to the antenna radiation pattern(s). The tower legs must not come in contact with the ground surface. Provide a minimum of 8 to 10 in. between the bottom of the tower legs and the ground surface.

C. The distance between rungs, cleats and steps must not exceed 12 in. and must be uniform throughout the length of the ladder.

D. Design support for a minimum 500 lb. live load. Climbing loads are not to be applied concurrently with design wind loads.

E. No attachments are allowed within 6 in. of the ladder.

F. Provide the tower with a safety climbing cable properly installed and meeting all applicable OSHA and ANSI standards. Provide the fall safety system composed of a 3/8-in. galvanized or stainless steel cable and a fall protection device (wire grab). Provide a 3/8-in. stainless steel fall arrest cable if the tower is within 100-miles of the coastal regions of Texas. Provide a removable fall arrest device, Tuf-Tug Model TT-WG-500, or TxDOT approved equivalent. Obtain prior written approval for an alternate device from TxDOT Traffic Operations Division, Radio Operations. Any alternates must be compatible with TxDOT existing Tuf-Tug fall protection devices. The wire grab devise must be removable from the safety cable when not in use. Indicate the fall safety system on the appropriate section of the tower shop drawings.

11. **Tower Grounding.**

A. References.

1. NFPA 70 of the current revision of the National Electrical Code
2. NFPA-780---1995
3. UL96A--1998
4. Lighting Protection Institute Standard of Practice LPI—175
5. ANSI T1.313-1997
7. Motorola R56 Standards and Guidelines for Communications Sites Chapter 6, 7 and Appendix C. Note: Soil PH and soil resistivity testing is not a requirement of this specification.

8. Show tower grounding, including the air terminal system, lightning dissipators, down conductor, grounding ring, grounding rods and radio equipment ground conductor on the appropriate sections of the tower shop drawings. Include on the drawings the installation locations of all grounding equipment, including the depths of the grounding rods, grounding ring and the radio equipment grounding conductor.

B. Products and Installation.

1. Indicate intended locations for the following grounding requirements on a separate submittal in shop drawings that indicated the tower intent but focus on the grounding requirements, locations, installation intended and grounding rod location and intended depth. The shop drawings must be prepared by and sealed by an engineer licensed in the State of Texas. All tower grounding, including the air terminal system, lightning dissipators, down conductor, grounding ring, grounding rods and radio equipment ground conductor shall be shown on the appropriate sections of the tower shop drawings. Included in the drawings shall be the installation locations of all grounding equipment, including the depths of the grounding rods, grounding ring and the radio equipment grounding conductor.

2. Provide and install a 2/0 bare tinned stranded copper conductor that shall be run the length of the tower, down the outside leg, secured every 3 ft. with insulated copper tie wire. Securely connect the grounding wire to the topmost section of the tower using an exothermic welding (CADWELD type bonding). Connect the grounding conductor to the tower leg every 75-ft. using exothermic welding (CADWELD type bonding). Connect the base of the grounding conductor to the grounding ring using exothermic welding (CADWELD type bonding).

3. Provide and install a top mounted lightning protection air terminal system on a tower leg opposite any top mounted antenna or tower lighting unit. Adjust the air terminal system to allow the tip of the air terminal to be 10 to 12 in. above the top of the top mounted antenna(s) or the tower lighting system. Provide the following items: 1/2 x 24-in. copper Class II air terminal with tip consisting of a 3/4 in. sphere (Harger 1218CSTAT, or TxDOT approved equivalent), appropriate length of 2-in. diameter galvanized steel pipe, bronze U-bolt pipe and cable clamps with stainless steel bolts and 2/0 bare tinned copper conductor. The copper air terminal must extend approximately 22-in. above the top of the galvanized pipe. Secure the copper air terminal to the galvanized pipe using a bronze u-bolt vertical pipe and railing base clamp (Harger CPRB1.5/2AT12 or TxDOT approved equivalent). Connect a 2/0 bare tinned stranded copper conductor to the copper air terminal base using the clamp on the vertical pipe base. Secure the pipe to the tower using at least 3 equally spaced galvanized brackets. Secure the copper conductor to the galvanized pipe using equally spaced bronze u-bolt clamps, (FCI GAR3903, Harger CPC1.5/2 or TxDOT approved equivalent) at intervals not to exceed 18-in. Attach the 2/0 copper conductor to the tower structure adjacent to the 2/0 copper
down conductor specified in item B above. Torque mechanical pipe clamps to manufacturers’ specifications. Submit information for any alternate air terminal system to TxDOT for approval prior to installation.

4. Maintain a minimum bending radius of 8-in. at all times, applicable to the installation of grounding conductors for each size. Bends curves and connections must be toward the ground location, rod or grounding bar (grounded end) of the conductor. Avoid sharp bends.

5. Ground each tower leg directly to a minimum 8 ft. x 5/8 in. copper clad grounding rod using bare tinned stranded copper 2/0 conductor. Provide ground rods in accordance with the requirements of NASI/UL 467-1984, CSA and ANSI/NEMA GR-1. Provide ground rods manufactured from high strength 1035 cold drawn steel. Provide ground rods with copper plating thickness in accordance with ANSI / UL 467-1984 (ANSI C33.8-1972). Ground connections to the tower footing plates are not acceptable. Protect the 2/0 grounding conductor with 1-in. plastic electrical grade conduit. Place the plastic electrical grade conduit from near the ground rod connection and extended 4 in. above the ground surface. Form the plastic electrical grade conduit so as not to have any sharp bends between the ground rod and the tower leg ground connection. Bury the top of the ground rods below ground surface at a minimum of 24-in. Interconnect each grounding rod to a grounding ring using bare tinned stranded copper 2/0 conductor. Bury the grounding ring below ground surface at a minimum of 24 in. Place the grounding ring a minimum of 36-in. from the tower foundation. Interconnect tower-grounding connections using exothermic welding (CADWELD type bonding). Use of split bolt connectors for grounding connections is not acceptable. Surround the entire grounding system, grounding rods and ring with a minimum of 2 in. of a ground enhancement material such as LORESCO PowerFill, Advanced lightning Technology, Inc (ALT) Ground Enhancement Material Catalog number 3520 or TxDOT approved equal shall.

6. Provide and install a sufficient quantity of insulated copper grounding bars to connect each antenna’s transmission line into the tower grounding system. Provide an insulated copper ground bar a minimum of ¼ in. x 2 in. x 12 in. with 8 pre-drilled 7/16-in. holes. Install the insulated copper grounding bar in close proximity to the connection between the antenna and its associated transmission line (a smaller insulated ground bar is allowable at this location only), at the base of the tower before the transmission line makes the transition towards the radio equipment building, at the entrance to the radio equipment building and inside the radio equipment room/building. Install the insulated ground bus bar in the radio equipment room in close proximity to the ground cable entrance and within 12-inches of the floor. Connect each insulated grounding bar to the tower grounding system using bare tinned stranded copper 2/0 conductor. Connect each vendor supplied transmission line grounding kit(s) to the copper grounding bar using a #2 bare tinned copper conductor.

7. Using the current revision of Motorola R56 design, provide and install a grounding system for interior equipment. Provide a bare tinned stranded copper 2/0 conductor run from the grounding ring into the radio room for connection to the radio...
equipment. Where practical, Bury the equipment grounding cable below ground the surface a minimum of 24 in. Any exception to this installation will be specified on the attached site information page. Install a minimum 8 ft. x 5/8 in. Copper clad grounding rod as near as possible to the radio equipment building entrance. Connect it shall be to the radio equipment grounding conductor using exothermic welding (CADWELD type bonding). Place the top of the grounding rod a minimum of 24-in. below grade level. Provide a ground rod in accordance with the requirements of NASI/UIL 467-1984, CSA and ANSI/NEMA GR-1. Provide a ground rod manufactured from high strength 1035 cold drawn steel. Provide a ground rod with copper plating thickness in accordance with ANSI / UL 467-1984 (ANSI C33.8-1972). Leave a minimum of 20 ft. of the grounding conductor in a coil adjacent to the proposed radio equipment building site if the radio equipment building is not present at the tower site at the time of ground cable installation. If the tower supplier / installation contractor is supplying the radio equipment building after the installation of the tower, the tower supplier / installation contractor must make the installation as specified above.

8. Bond metal objects that are located within 10-ft. of the external grounding electrode system, or are associated with the communications site equipment, to the external grounding system using bare tinned stranded copper #2 conductor.

9. If ground soil conditions do not permit the installation of the ground rods, install a 20-ft. vertical type chemical ground rod system at each tower leg. Example: Lightning Eliminators Consultants, Inc. (LEC) Chem-Rod, Harger Lightning Protection, Inc., Lyncole XIT Grounding or TxDOT approved equal. Install the chemical grounding rods according to the manufacturer instructions. Connect each tower leg to the chemical grounding rod using bare tinned stranded copper 2/0 conductor. Interconnect each chemical grounding rod in a ring using bare tinned stranded copper 2/0 conductor. If possible, bury the grounding ring 2-ft. below the ground surface. Bury and run a length of bare tinned stranded copper 2/0 conductor below the surface from the tower grounding system into the radio room for connection to the radio equipment. Interconnect tower-grounding connections using exothermic welding (CADWELD type bonding). Install the chemical ground rod system according to manufacturers’ instructions and fill with appropriate hygroscopic electrolytic salts. A protective vented cover box system must cover the chemical ground rod. The vented cover must be bolted to the cover box and must be easily removable to access the chemical ground rod system.

10. If ground soil conditions do not permit the installation of the vertical type chemical ground system, provide and install a 20-ft. horizontal (L –shaped) type chemical ground rod system at each tower leg. Example: Lightning Eliminators Consultants, Inc. (LEC) Chem-Rod, Harger Lightning Protection, Inc., Lyncole XIT Grounding, or TxDOT approved equal. Install the chemical grounding rods according to the manufacturer instructions. Connect each tower leg to the chemical grounding rod using bare tinned stranded copper 2/0 conductor. Interconnect each chemical grounding rod in a ring using bare tinned stranded copper 2/0 conductor. If possible,bury the grounding ring 2 ft. below the ground surface. Bury and run a length of bare tinned stranded copper 2/0 conductor below the surface from the tower grounding system into the radio room for connection to the radio equipment.
Interconnect tower-grounding connections using exothermic welding (CADWELD type bonding). Install the chemical ground rod system according to manufacturers’ instructions and fill with appropriate hygroscopic electrolytic salts. A protective vented cover box system must cover the chemical ground rod. The vented cover must be bolted to the cover box and must be easily removable to access the chemical ground rod system.

11. Provide and install a lightning dissipater/array system to protect against lightning strikes at the tower location. Example: Lightning Prevention Systems, Inc. ALS-1000, Lightning Experts Passive-Point Discharge Brush SystemTM or TxDOT approved equal. Submit information for any alternate dissipation system to TxDOT for approval prior to installation.

12. Provide and install 4 transmission line-grounding kits for each transmission line. Install each grounding kit according to manufacturer's instructions. Install the grounding kits at the following locations:

- In close proximity to the connection between the antenna and its associated transmission line;
- At the bottom of the tower before the transmission line turns towards the equipment building;
- At the entrance of the building;
- In the radio equipment room.

13. Perform ground system testing, after installation of the grounding system, using one of the three methods:

- Three-Point/Fall-of-Potential Testing
- Clamp-on Ohmmeter
- Combined Soil Resistivity Testing with Clamp-on Ohmmeter Testing

14. Provide written test results detailing ground system resistance after completion of the installation of the grounding system. Provide the written test results to: Texas Department of Transportation, Attn: TRF-TM Radio Operations, 125 E 11th Street, Austin, Texas 78701-2483. Note the method of ground system testing on the test results. Ground system resistances of less than 10–ohms must be achieved, with 5–ohms or less being the goal. Exceptions may be permitted in unusual circumstances if the impedance goal cannot be met. System Engineering must review such sites. Additional grounding devices may need to be added to achieve desired results. If it is determined that additional grounding enhancements are needed to achieve specified results, 10-ohms or less, Provide a written description of the additional grounding enhancements and why the additional grounding enhancements are needed, for example before and after grounding test results. The Contractor will be compensated for the additional grounding by TxDOT.

12. **Antennas and Feed Lines.** TxDOT will supply the antenna transmission feed line(s) to be installed by the Contractor. Install the transmission line and connector, and equipment grounding cable into the radio equipment building, unless otherwise specified. Provide a cable entry system for the transmission feed line(s) to enter the building.
A. Provide the cable entry system consisting of 4, 4-in. openings. If there are more than 4 transmission lines, provide enough cable entry ports for the transmission lines listed on the Site information sheet. Provide a cable entry boot that is weatherproofed and allows the installation of two 7/8-inch transmission lines in 1 entry port. Cover the remaining unused entry ports with a weatherproof blank entry boot. The antenna(s) to be supplied by TxDOT are shown on the plans.

B. Feed the antenna with 7/8 in. foam Heliax coaxial cable unless otherwise specified on the Site information sheet. Provide and install a coaxial cable support system that accepts up to six runs of cables with snap-in hangers. Example: Site Pro 1 Universal T-Bracket, Part Number T600, and the associated Site Pro 1 True-Grip Snap-Ins, Part Number 78SH-3, coaxial cable clips. Install the cable support system every three feet. Submit information for any alternate cable support system to: Texas Department of Transportation, Attn: TRF-TM Radio Operations, 125 E 11th Street, Austin, Texas 78701-2483. Stainless steel wrap lock is not permitted. Provide required cable hoisting grip(s) for the transmission line listed in the Site information sheet.

C. Weatherproof connectors and grounding kits at their juncture with transmission line(s) as follows:

1. Cover juncture with minimum 2 layers of high grade, all-purpose electrical tape (Scotch 33+, or TxDOT approved equal).

2. Next cover with a minimum 1 layer of Vapor-Wrap (Decibel products, or TxDOT approved equal).

3. The third covering must be a minimum 3 layers of all-purpose electrical tape.

4. The final covering must be a minimum 3 coats of electrical coating (ScotchKote, or TxDOT approved equal). Provide weatherproofing material.

D. Cable support (cable ladder) from the tower to the building is required if the distance between the tower and the building is 5 ft. or greater. If a cable ladder is required, it must not be connected to the tower or building. Connect each vertical support pipe as well as the cable ladder to the tower grounding ring using a #2 bare tinned copper conductor. Grounding connections to the vertical support pipes must be exothermic welding (CADWELD type bonding). Provide a minimum of two grounding connections on the cable ladder, adjacent to the tower and building. If the distance is less than 5 ft., install a strain relief cable or galvanized pipe to support the transmission line. Attach the transmission line support cable or pipe to the tower and the building. Connect the cable support system to the tower grounding system using a #2 bare tinned copper conductor. Refer to Motorola R56 Standards and Guidelines for Communications Sites Chapter 6 for more specific grounding details.

E. Prior to tower installation, contact the District TxDOT Radio specialist or designated district TxDOT representative and perform an inventory of all TxDOT supplied items prior to tower erection. This inventory is to determine if all required connectors, antenna jumpers, adapters and normally supplied antenna mounting hardware is available to permit the proper installation of the antennas and transmission line(s).
F. Provide and install any specialized galvanized antenna mounting brackets to mount the antennas to the tower in accordance with the antenna manufacturer’s specifications. The types of antenna(s) to be installed will be listed on the site information sheet.

13. Tower Acceptance. Notify the TxDOT District Radio Specialist or designated TxDOT district representative after the completion of the installation of tower and antenna system. The purpose of this notification is to allow testing of the antenna system by TxDOT. If a failure is noted, work with TxDOT District Radio Specialist or designated TxDOT district representative to resolve and correct any and all problems. System acceptance will occur after a minimum of 5 consecutive failure free days of operation following installation.

14. Photographs. After completion of the tower, provide pictures of the completed tower and grounding system via electronic file standard (JPG), or other suitable format, on CD-ROM. The file must be readable via a Microsoft Windows-based operating system. The minimum camera resolution must be 640 x 480. Send the file to:

Texas Department of Transportation
Attn: TRF-TM Radio Operations
125 East 11th Street
Austin, TX 78701-2483.

15. Measurement. This Item will be measured by each acceptable tower in place of the height and design wind speed specified.

16. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Self Supporting Radio Tower”. This price is full compensation for designing, furnishing, fabricating and installing self supporting radio towers and for materials, tools, labor, equipment and incidentals necessary to complete the work.