



Document Title:

115kV/230kV Transmission Guyed Steel Poles (Type A, Type B & Type C)

Document Type:
Specification

Engineering Type
Equipment Specification

Document No.:
4751.008

Department:
Transmission Engineering

Version:
05

Effective Date:
03/27/2025

For other, specify here

Shared document with: N/A

** Select the Departments impacted by the document (If apply)*

For other, specify here

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Related/Referenced Documents

[4751.001 Luma Transmission Design Criteria Document & Manual.Pdf](#)

[4752.199 Polymer Line Post Insulator 38, 115 & 230 kV.pdf](#)

Version History

| Version | Date | Revision |
|---------|------------|--|
| 01 | 11/21/2021 | First Issue |
| 02 | 01/27/2021 | Second Issue |
| 03 | 05/11/2022 | Third Issue |
| 04 | 12/02/2024 | Update to specification format, Reorganize and elaborate more details in the document including adding new document sections and updated existing document sections. Reducing from 8 type of steel poles to 3 types of steel poles (A, B, & C). Update calculations for loading and reference drawings were updated. |
| 05 | 03/05/2025 | Removed reference to flange joints from Section 4. Update calculations for loading and reference drawings were updated. |

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1. Scope

- 1.1. This specification covers the minimum requirements of LUMA for design, materials, fabrication, welding, galvanizing, inspection, and shipment of steel poles to be used in the construction of 115 kV and 230 kV transmission lines.
- 1.2. The requirements of this specification are to be considered additive to other requirements found in related industry standards such as ASTM, ANSI, NESC and ASCE among others.
- 1.3. The document will serve as a basis for the manufacturing of guyed steel poles to be used in the electrical transmission grid with the best intention to improve and offer better solutions for the electrical system.
- 1.4. The purpose of the document is to establish the basic criteria for the creation of poles and that they are in accordance with the norms, standards, and applied loads established according to Industry Standards such as ASTM, ANSI, NEMA, NESC, NEC, ASCE, among others.
- 1.5. In addition, we will be able to acquire a reliable and fully compliant system. We will provide all the parameters to be established to withstand weather increases, including increased hurricane winds, and structural load factors will be considered.
- 1.6. The reference to specifications of organizations such as ASTM, ISO, EN (European Norm) together with drawings and loading diagrams shall be considered part of this specification. Referenced specifications shall be the latest edition, unless specially stated otherwise.
- 1.7. Manufacturers must be ISO-9001 certified.
- 1.8. All requirements of this specification and the related industry standards shall be followed unless specific written exception has been submitted for consideration and approval by LUMA.

- 1.9. The approval of the document for such exceptions shall be obtained prior to the start of fabrication and shall become a permanent part of the manufacturer's project files.

2. Referenced Documents (Codes, Guidelines, Regulations, and References)

- 2.1. Design, materials and fabrication of steel poles shall be in accordance with latest edition of international Codes and Standards listed:
 - 2.1.1. ASCE /SEI 48-19 - Design of Steel Transmission Pole Structures
 - 2.1.2. ASCE MOP 74-20 - Guidelines for Electrical Transmission Line Structural Loading, Fourth Edition
 - 2.1.3. ASTM A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
 - 2.1.4. ASTM A385 - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
 - 2.1.5. ASTM A572 - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
 - 2.1.6. ASTM F3125 - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength
 - 2.1.7. ASTM A354 - Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
 - 2.1.8. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2.1.9. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 2.1.10. ASTM A780 - "Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings"

- 2.1.11. AWS D1.1 - Structural welding code – Steel
- 2.1.12. EN 10025 - Hot rolled products of structural steel
- 2.1.13. EN 10149 - Hot-rolled flat products made of high yield strength for cold forming
- 2.1.14. EN 10080 - Steel for the reinforcement of concrete
- 2.1.15. ISO 898 - Mechanical properties of fasteners made of carbon steel and alloy steel
- 2.1.16. EN ISO 10684 - Fasteners – Hot dip galvanized coatings
- 2.1.17. EN ISO 15614 - Specification and qualification of welding procedures for metallic materials
- 2.1.18. EN ISO 9606 - Qualification testing of welders — Fusion welding
- 2.1.19. ASNT – American Society of Non-Destructive testing
- 2.2. The manufacturer shall demonstrate to LUMA compliance with the above standards and these specification requirements.
- 2.3. If any two standards differ in test methods and requirements the one with the more stringent method and requirement shall be used and approved by LUMA.

3. Material

3.1 General

- 3.1.1. All material supplied shall conform to ASTM Specification A-6 or equivalent EN standard, “General Requirements for Delivery of Rolled Steel Poles, Shapes, Sheet Piling and Bars for Structural Use” unless herein modified.

3.2 Poles, Arms, Attachment Plates and Brackets

- 3.2.2. The material shall conform to ASTM A-572 or equivalent EN 10025 or EN 10149. The steel shaft shall be high strength, low alloy, structural steel, Grade 65 (min.) or equivalent EN standard.
- 3.2.3. Arms, attachments plates and brackets shall be minimum Grade 50 or equivalent EN.

- 3.2.4. Silicon content in high strength steel shall be controlled to produce a galvanized finish that is uniform in appearance and without dark discolorations.
- 3.2.5. The steel used for the pole shaft and arms shall have a silicon content of less than 0.06%.
- 3.2.6. Arms shall be designed so that the end of the arm is at the specified height and a positive inclination under a loading of initial conductor tension, 80°F, no wind, and overload factors refer to Table 15.4 from *4751.008 LUMA Transmission Design Criteria Document & Manual*.
- 3.2.7. Arm attachment plates and post-insulators supports shall be welded to the pole shaft.
- 3.2.8. The cross section of the arm members may be 4, 6, 8 side polygonal, unless otherwise specified.
- 3.2.9. The diameter of the outboard arm at the pole attachment location shall equal the diameter of the inboard arm at the pole attachment location.
- 3.2.10. Any design deviation from this shall be noted in the proposal and is subject to approval by the Owner.
- 3.2.11. All connections of arms to poles shall be designed with two thru vangs, with each one welded to two (2) faces of the pole section and with the arm brackets bolted to the thru vangs.
- 3.2.12. Bolted connections of the thru van connection shall be designed as bearing type connection.
- 3.2.13. For the connection of the post insulator for poles Type “C” shall use the 115/230 kV post insulator bracket assembly provide in the appendix E.
- 3.2.14. Arms shall be sealed at the tip with a steel plate and a bolt to prevent insect ingress.
- 3.2.15. The pole arms shall be bolted to the Steel Pole.
- 3.2.16. All structural plate material, and weld consumables furnished shall be mill-certified.
- 3.2.17. The tensile strength of any steel that is welded shall be limited to the requirements of ASTM A6.

3.3 Fasteners

- 3.3.1. All connection bolts shall be galvanized hex-head conforming ASTM F3125 or A-354 or ISO 898.
- 3.3.2. Bolts shall hot dipped galvanized to ASTM A-153 or EN ISO 10684.
- 3.3.3. Nuts shall be cut to proper class and size and galvanized so that a nut tapped to dimensions conforming to ASTM A-563 grade DH or ISO 898, may be assembled by hand effort on galvanized bolts.
- 3.3.4. The Supplier shall furnish all the required bolts, nuts, and washers (if requested) for the installation of all parts of the steel poles, plus 10 percent extra.

4. Design Requirements

4.1 Language and units

- 4.1.1. All correspondence, literature, drawings, and markings shall be in the English language.
- 4.1.2. Dimensions and tolerances shall conform to ANSI Y14.5M.
- 4.1.3. Dimensions shall be in the U.S. customary units.
- 4.1.4. If fabricating in SI units, both U.S. and SI units shall be shown on the drawings.
- 4.1.5. Conversion dimensions shall be 1 inch = 25.4 mm.
- 4.1.6. Conversion dimensions may be rounded off to the nearest 1/32 of an inch (0.794 mm), provided the rounded dimension falls within the design limits.

4.2 Design Code

- 4.2.1. Published theories that are accepted as good engineering practices by the industry shall be used in making the design.
- 4.2.2. Stress calculations shall be based on elastic analysis with maximum stress in main members being limited to the specified yield strength of the steel being used.

4.2.3. The main design standard shall be ASCE /SEI 48 latest edition, Design of Steel Transmission Pole Structures.

4.3 **Analysis Method**

4.3.1. The pole designs shall include second order (non-linear) analysis including structure loadings resulting from displacements due to deflection.

4.4 **Pole Cross Section**

4.4.1. The pole shall have a dodecagonal shape.

4.5 **Helicopter Lift Requirements**

4.5.1. Helicopter lifting provision shall be included in the design for each pole section.

4.5.2. The overhead ground wire or similar connection points are acceptable for this purpose, given it is structurally checked.

4.6 **Design Limitations**

4.6.1. The maximum section length limit is 50 feet as a whole section.

4.6.2. The maximum number of sections allowed shall be 3.

4.6.3. The bottom section of the pole shaft shall have a maximum dimension of 60 in. including the bearing plate.

4.6.4. The pole shall be symmetrically designed about both the major and minor axis, such that the strength required in any one direction shall be required in all direction about the longitudinal axis.

4.6.5. The pole shall have a constant and uniform taper throughout the entire length insofar as it provides the most economical design possible.

4.6.6. If the pole is welded longitudinally, an automatic, submerged arc welding machine shall be used.

4.6.7. Should the Fabricator use a fabrication concept other than as specified, prior written approval shall be obtained from LUMA Transmission engineering Standards.

- 4.6.8. Each pole shall be symmetrically for easy installation.
- 4.6.9. The pole shall have suitable slip joints clearly marked for proper sections matching.
- 4.6.10. Minimum plate thickness for all pole components (Or any structural member) shall be 3/16 inch.
- 4.6.11. For poles with slip joint connections, the taper shall be no less than 0.125 in/ft.
- 4.6.12. Design and fabrication of steel poles shall be using slip joint type connection. No other type of connection will be accepted.
- 4.6.13. The taper shall not exceed 0.5 in/ft, unless it has been approved by LUMA Transmission engineering Standards in writing.
- 4.6.14. The poles shall have a thru pipe hole 1-1/2" in diameter at 3'-0" above ground line. A bar inserted thru pipe would permit rotating the guyed structure for alignment with the power line.
- 4.6.15. The maximum section weight should be limited to 14,000 lbs.
- 4.6.16. The w/t ratio shall not exceed 35 for all sections.
- 4.6.17. End plates of arms shall have a minimum thickness of 3/4 inches.
- 4.6.18. Minimum embedment length require for all 88.5 ft guyed structures shall be 10 feet.

4.7 **Deflection Requirements**

- 4.7.1. The pole shall be designed to resist, in addition to all other loads and their appropriate overload factors, the effect of deflection due to the loading specified including the dead load of the pole (P-Delta effect).
- 4.7.2. Deflections shall be limited to 8 % of the above ground height under intact case (hurricane condition) as specified in loading charts.
- 4.7.3. Arms shall not deflect vertically more than 12 inches at the end of the arm under any loading condition.
- 4.7.4. Poles shall not be cambered.

4.8 Connection Design

- 4.8.1. The connections for vangs, brackets, or stiffeners attached to the pole shaft, shall be designed to distribute the loads sufficiently to protect the wall of the pole from local buckling. Through-thickness stresses shall be limited to 36 ksi. The w/t ratio limit shall not exceed 35.
- 4.8.2. All multi-section poles shall be slip-jointed, with the edge of each section permanently match-marked to indicate alignment during structure erection. Any alternative connection method shall be pre-approved by the LUMA Transmission Standards.
- 4.8.3. OPGW ring plates and DE vangs must be designed for a maximum factored tension presented in the loading charts.
- 4.8.4. Conductor ring plates and DE vangs must be designed for a maximum factored tension presented in the loading charts.
- 4.8.5. The plate thickness shall not exceed 7/8”.
- 4.8.6. For bearing capacity check of the plate, consider the pin size to be 3/4”.
- 4.8.7. All connections, including arm connections, must be designed to resist 100% moment capacity of the shaft at the location of the connection.

4.9 Design Calculations

4.9.1 Calculations Content:

- 4.9.1.1. Manufacturers shall submit design calculations and data with the quotation for each pole type and height.
- 4.9.1.2. Design calculations shall contain information specified below:
 - 4.9.1.2.1. A summary page including pole top and bottom diameter, height and length, weights, file name, weight, and quantity of bolts, length of bolts, base reactions.
 - 4.9.1.2.2. The controlling loads and loading case.

- 4.9.1.2.3. General dimensions, including butt and tip diameters, wall thickness, taper, weight of the pole, and the center of gravity.
- 4.9.1.2.4. Drawing presented in structure configuration, dimensions, weights, etc. and stress diagrams or computer printout of maximum loading, indicating the loading condition that controls.
- 4.9.1.2.5. Ultimate moment, maximum stress, and the neutral axis in each ten (10) foot section of the pole, at the attachment points, and at the ground line.
- 4.9.1.2.6. Maximum design unit stresses in compression, tension, shear, bearing, and bending for pole, arms, flange plate, and connection bolts. Indicate limiting slenderness ratio values used in design.
- 4.9.1.2.7. Maximum ground line reactions:
 - 4.9.1.2.7.1. Overturning moment, horizontal shear, and vertical loading.
 - 4.9.1.2.7.2. Uplift or bearing.
- 4.9.1.2.8. Maximum and normal deflection for each load case.
- 4.9.1.2.9. Guy tensions with overload factors.
- 4.9.1.2.10. Maximum stresses of all arms, braces, cross arms, and their connections.
- 4.9.1.2.11. Wind load shall be applied in a direction that produces the worst-case loading on the structure.
- 4.9.1.2.12. Pole shall be designed to withstand all shipping and construction loads (including lifting loads).
- 4.9.1.2.13. Pole lifting requirements shall be furnished by the manufacturer and pre-approved by LUMA.
- 4.9.1.3. Structures shall be designed to meet the loading requirements as stated on the Loading charts specified by each structure which form part of this document.
- 4.9.1.4. The loadings used shall include the specified safety factors (See Appendix D).

4.9.1.5. The supplier is responsible for the design proposal which shall include and comply with the following:

4.9.1.5.1. Design parameters, Loading diagrams and all the calculations.

4.9.1.5.2. Must include the total actual moments, moments for inertia furnished, and w/t for polygonal sections and splices and at least every 5 feet along the pole shaft (Summary Table).

4.9.1.5.3. General dimensions and details of all the structural components including but not limited to:

4.9.1.5.3.1. Base Diameter

4.9.1.5.3.2. Top Diameter

4.9.1.5.3.3. Reactions of the poles and reactions of guys (when applicable)

4.9.1.5.3.4. Pole deflections

4.9.1.5.3.5. Pole weight

4.9.1.5.3.6. Base reactions due to Design loads shown on loading charts

4.9.2 **PLS POLE**

4.9.2.1. Manufacturers shall submit PLS-POLE model (M4) design files for each structure type and height with the quotation. PLS-POLE files shall be named as specified in the structure drawings.

4.9.3 **Final Design Calculations:**

4.9.3.1. Final design calculations shall be submitted for approval before fabrication commences, together with the shop drawings.

4.9.3.2. After approval two final original set (24" x 36") plus one electronic file with the drawings in AutoCAD shall be sent for LUMA's files.

4.9.3.3. All drawings shall include a unique identifying order number.

4.9.3.4. Final design calculations and input files shall be included on an electronic file for LUMA's use.

4.10 **Vibration Considerations**

4.10.1. The manufacturer shall evaluate and take the necessary measures to minimize the potential for vibrations caused by wind-induced vortex shedding of structure members.

4.10.2. The manufacturer shall recommend dampers or spoilers as required to eliminate vibrations or specific recommendations for avoidance of vibration that can lead to fatigue.

4.10.3. The manufacturer shall consider in their design vortex shedding failures of arms and arm connections.

5. **Fabrication**

5.1 **General**

5.1.1. Fabrication of steel poles, anchor bolts, bolts, nuts, and hardware shall conform to the applicable standards of the ASTM, NEMA and ASCE/SEI 48 (latest edition) or EN equivalent except as otherwise specified herein.

5.1.2. All fabrication and galvanizing facilities utilized for LUMA Transmission pole structures shall be qualified by the LUMA Transmission Standards team prior to fabricating.

5.1.3. LUMA or its representatives shall have access to the manufacturing plant and finishing facilities for inspection.

5.1.4. LUMA shall be immediately notified by the manufacturer of any changes to the notification schedule or manufacturing and galvanizing facilities.

5.2 **Fabrication Drawings**

5.2.1. After a PURCHASE ORDER has been issued and before fabricating any poles, manufacturer must furnish "For Review", fabrication drawings of the poles containing all the information specified in this section.

- 5.2.2. Poles shall not be manufactured until the fabrication drawings have been reviewed and comments submitted in writing by the LUMA Transmission Engineering Standards.
- 5.2.3. The fabrication drawings shall include the following:
- 5.2.3.1. The drawings shall include dimensions for all attachments (vangs, brackets, jacking nuts, climbing details, etc.), their referenced orientation and location on the structure.
 - 5.2.3.2. Overhead ground wire and insulator attachments on the pole shaft or its arms shall be shown on drawings.
 - 5.2.3.3. All connecting parts shall be marked for identification with a welded plate and these markings shall be clearly shown on approval fabrication drawings.
 - 5.2.3.4. Name plate information.
 - 5.2.3.5. Location, type and size of welds and bolts.
 - 5.2.3.6. Clearly distinguish between shop and field welds and bolts.
 - 5.2.3.7. Clearly identify the quantity and location of long seam welds.
 - 5.2.3.8. Pole layout and details showing hole locations, orientation, dimensions, size, and positioning.
 - 5.2.3.9. Attachment and joist points
 - 5.2.3.10. Pole specification data including reference drawing number, working and ultimate moments, C.G., I.D. and O.D. at the top and bottom, and tip and butt thickness at top and bottom.
- 5.2.4. Shop detail drawings applicable to design and/or detail (and to changes when fabricating to LUMA details) are to be forwarded to the LUMA transmission engineer in Adobe PDF or CAD/DXF format for approval prior to fabrication.
- 5.2.5. Drawings shall include the following general assembly information:
- 5.2.5.1. Weight schedule – For general structures and by sections
 - 5.2.5.2. Bill of material

- 5.2.5.3. Member mark numbers
 - 5.2.5.4. Member dimension
 - 5.2.5.5. Member quantities
 - 5.2.5.6. Bolt and nut size, length, and quantities
 - 5.2.5.7. Ground-line reactions
 - 5.2.5.8. Grounding Connections
 - 5.2.5.9. Loading Criteria
- 5.2.6. Upon approval by LUMA, the manufacturer shall provide final sealed drawings on LUMA's title block with drawing numbers furnished by LUMA.
- 5.3 Welding**
- 5.3.1 General**
- 5.3.1.1. All welding shall be performed by welders, welding operators, and tackers certified for the type of welding to be performed.
 - 5.3.1.2. All welding shall be performed by certified operators using procedures in accordance with Section 5, AWS D1.1 or equivalent EN ISO 15614 and EN ISO 9606.
 - 5.3.1.3. All welder performance certification records, weld procedures specifications, and weld procedure certifications records shall be developed and properly maintained in accordance with the applicable requirements of AWS D1.1 Structural Welding Code – Steel.
 - 5.3.1.4. Records of welding procedure and welding operator test results shall be kept for five years by the Supplier and shall be available for review by LUMA.
 - 5.3.1.5. Circumferential seams, longitudinal seams in the female slip-joint area and Base plate shall be complete penetration welds.

- 5.3.1.6. Arm bracket joints, and post-insulator bracket joints welds shall be full penetration or equivalent ninety percent partial penetration with a fillet overlay to develop the full strength of the arm shaft.
- 5.3.1.7. The post insulator bracket welds shall be designated to carry the specified loading requirement without any permanent damage.
- 5.3.1.8. Longitudinal welds in pole section shall have 60 % minimum weld joint penetration (per ASCE 48.19 §7.2.3).
- 5.3.1.9. Longitudinal seams in the female slip-joint area and base plate shall be complete penetration welds.
- 5.3.1.10. All welding must be done prior to galvanizing.
- 5.3.1.11. Backing bars, when utilized, shall follow the requirements of AWS D1.1 and be seal-welded to the pole shaft.
- 5.3.1.12. The butt joints of backing bars shall be 100% penetration welds and shall be made to occur in the middle of a flat rather than the bend lines of pole shaft.
- 5.3.1.13. Base plate, flange plate, and arm shaft to bracket joints shall be complete joint penetration welds.
- 5.3.1.14. All flange connections shall be shop fitted and preassembled after fabrication of pole to ensure proper fit and alignment.
- 5.3.1.15. Longitudinal welds in pole section shall meet requirements of ASCE-48 –19, sections 6.3.4, 6.3.5, 6.4.1 and 7.2.3.
- 5.3.1.16. Each pole section shall be formed and welded with longitudinal seams.
- 5.3.1.17. Circumferential welds are not permitted in the pole shaft from 3 feet above grade to the full extent of embedded section.
- 5.3.1.18. Welding of pole bottom/bearing plate to the pole shaft is permitted.

5.3.2 Welding Inspection and Testing by manufacturer

- 5.3.2.1. The manufacturer shall indicate and adhere to the welding procedures and processes to be used in the various joints or seams on their fabrication drawings.
- 5.3.2.2. The manufacturer shall indicate the inspection methods which will be used to qualify welds and will furnish certified inspection reports when requested by LUMA Transmission Engineer.
- 5.3.2.3. Records shall be kept for five (5) years by the manufacturer.
- 5.3.2.4. Ultrasonic and visual inspection shall be performed on all complete joint penetration (CJP) groove welds.
- 5.3.2.5. As a minimum, ultrasonic testing shall include longitudinal straight beam for lamination or laminar tearing adjacent to CJP groove welds in accordance with AWS D1.1 UT procedure, and all steel plates over 1 ½ inches thick in accordance with ASTM A435 as applicable to the manufacturer's established procedures.
- 5.3.2.6. Nondestructive testing shall be performed with established procedures and qualified personnel in accordance with AWS D1.1 and ASNT-TC-1A.
- 5.3.2.7. Nondestructive testing of welds and weld repairs shall not be performed until the base metal is at ambient temperature.
- 5.3.2.8. Ultrasonic testing of post-galvanized baseplate to shaft welds for the detection of toe-cracks, shall not be performed until 48 hours after galvanizing.
- 5.3.2.9. The manufacturer shall have an established procedure that demonstrates effective examinations of this type and shall be demonstrated as requested by LUMA.
- 5.3.2.10. The acceptance/rejection criteria for nondestructive testing of CJP groove welds and adjacent areas shall be in accordance with AWS D1.1.
- 5.3.2.11. All welding electrodes used for weld joints and deposited weld metals shall meet, as a minimum, an impact value of 15 ft-lbs at -4° F as measured by the standard Charpy V-notch test.

5.3.2.12. They shall equal or exceed the specified physical properties of the base metal being welded when tested with the applicable AWS specification for welding electrodes.

5.3.2.13. Repair area of removed hot-dip galvanizing:

5.3.2.13.1. When it is required to remove galvanizing to make a weld or other repair the manufacturer shall repair the galvanizing per following section of “Quality and Finish” in accordance with ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

5.3.2.13.2. However, “hot stick” (zinc soldering) repairs will not be allowed for the repair of zinc coating on weld repairs.

5.3.3 **Welding Inspection by LUMA**

5.3.3.1. Independent non-destructive testing may be requested by LUMA as approved by the LUMA Transmission Standards Engineer and /or LUMA Transmission Design Engineer through a 3rd party NDT testing agency (professional), hired and compensated by LUMA.

5.3.3.2. The Professional shall have established procedures that demonstrate effective examinations of this type and shall be demonstrated as requested by LUMA or representative.

5.3.3.3. Acceptance/Rejection shall be demonstrated with a qualified procedure by the Professional and determined by LUMA.

5.3.3.4. **Straight Beam Ultrasonic Testing (UT):**

5.3.3.4.1. Professional shall perform straight beam UT through the bottom of baseplates in accordance with AWS D1.1 (latest edition) and qualified procedures.

5.3.3.4.2. Lamination testing shall be performed prior to any other testing and the results documented.

5.3.3.4.3. Acceptance/Rejection criteria shall be per AWS D1.1.

5.3.3.5. Shear Wave Ultrasonic Testing (UT):

- 5.3.3.5.1. Professionals shall perform Code UT on complete joint penetration groove (CJP) welds in accordance with AWS D1.1 (latest edition) and qualified procedures.
- 5.3.3.5.2. Professional shall perform “informational” UT on galvanized baseplate to shaft CJP welds for longitudinal cracks in accordance with a qualified procedure using a 45-degrees and 70-degrees transducer.
- 5.3.3.5.3. The acceptance criteria shall be zero cracks as demonstrated and established in accordance with the Professional’s qualified and approved procedures, and the results documented and reported to the Owner.

5.3.3.6. Magnetic Particle testing (MT) or Dye Penetrant Testing (PT):

- 5.3.3.6.1. When weld base metal discontinuities or defects are detected by UT on the surface, Professional shall perform MT or PT on the detected indications and remainder of the baseplate to shaft weld for longitudinal cracks.
- 5.3.3.6.2. In surface preparation for the NDT performed by the Professional, the manufacturer shall completely remove any galvanizing or coatings from the baseplate to shaft CJP weld and adjacent base metal at a minimum of 1” from the edge of the weld toe areas.
- 5.3.3.6.3. When the manufacturer has notified the Professional of a crack removal, Professional shall perform MT or PT during the excavation of crack repairs to validate complete removal of the crack prior to any welding on the repair area.
- 5.3.3.6.4. The acceptance criteria shall be in accordance with AWS D1.1 (latest edition).

5.3.3.7. **Metal Hardness testing:**

- 5.3.3.7.1. Professional shall perform hardness tests on the baseplate to shaft CJP weld and the heat effected zones (HAZ) of the CJP weld on the baseplate and shaft sides.
- 5.3.3.7.2. Acceptance/rejection criteria shall be per AWS D1.1 as a minimum.
- 5.3.3.7.3. Metal hardness not to exceed 200 in Brinell scale.

5.3.3.8. **Repair area of removed hot-dip galvanizing:**

- 5.3.3.8.1. After the removal of galvanizing and crack repair by welding, the manufacturer shall repair the galvanizing in accordance with ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

5.4 **Pole Shafts**

- 5.4.1. Cross section shape shall be the same over the entire pole shaft unless prior approval is obtained from the LUMA Transmission & Substation Standards Engineering.
- 5.4.2. Taper shall be in the range of 0.125 to 0.5 inches per linear feet.
- 5.4.3. Any changes to shaft diameter shall be approved by LUMA Transmission Lines Engineering Standards.
- 5.4.4. Shaft sections shall be pre-fitted for a telescoping type of assembly unless otherwise specified.
- 5.4.5. The upper section at a joint shall telescope over the lower section by not less than 1-1/2 times the outer section diameter including the manufacturing tolerances.
- 5.4.6. Structure sections shall be numbered to relate to the structure identification in the Bid Sheet and, at joints, both sections shall be clearly marked so that the related faces can be correctly matched in the field assembly.
- 5.4.7. Eight (8) 1 inch diameter heavy hex-nuts per splice joint shall be welded (over holes on galvanized structures only) to accommodate a hydraulic jacking device for field assembly.

- 5.4.8. Each section shall have two (2) pairs of nuts, each pair located diametrically opposite walls of the pole shaft.
- 5.4.9. The nuts shall be spaced 30 inches from center to center, parallel to the long axis of the pole and located as to be clear of the section overlap and not less than 24 inches apart when the joint is fully telescoped.
- 5.4.10. All nuts must be oriented so that two (2) flats are perpendicular to the long axis of the pole.
- 5.4.11. Each pole shaft section shall have lifting attachments and/or holes with the capacity to lift each pole section into a plumb position.
- 5.4.12. This may be accomplished by either designating elements of the pole shaft as acceptable lifting points or by installing specific capable attachments and designating them on the drawings.
- 5.4.13. Round lifting hole centerlines shall have a maximum edge distance of 6-inches from the top of the pole section and a minimum diameter of 2-inches.
- 5.4.14. Where vertical slotted lifting holes are provided in pole walls, the clear distance from the top of the pole section to these holes may not exceed 4-inches.
- 5.4.15. Unless otherwise required by the drawings, poles shall not be sealed.
- 5.4.16. All poles shall have a vented pole top.
- 5.4.17. The pole shall have a bolted metal top cap.
- 5.4.18. The bolt diameter shall not be less than 1/2" and the cap will not exceed the pole top diameter by more than 1 inch.
- 5.4.19. Base-plated poles shall have a free-draining base connection detail.
- 5.4.20. Embedded poles shall incorporate a bearing plate with a center opening adequate for internal coating and drainage.
- 5.4.21. The bearing plate shall have a hole at the center of plate not larger than 30% of the total base diameter.

5.4.22. The poles shall have a fastening system between all pole sections to ensure sections will not come loose when lifted by the helicopter.

5.5 Direct Embedded Structures

5.5.1. Direct embedded structures shall be designed so that the embedded section will be as indicated on the drawings.

5.5.2. Each pole shaft shall have provisions for bolted ground clamp, consisting of a plate capable of receiving a NEMA 2-hole pad or a ground lug attachment, located 18-inches above the ground line.

5.5.3. The specific attachment number will be included in the structure drawing.

5.5.4. Pole shafts shall include a steel bearing plate under the shaft walls having a minimum thickness of at least 3/16 inch.

5.5.5. All direct embedded poles shall have the entire embedded length galvanized.

5.5.6. The poles shall have a corrosion-resistant coating covering from 6 ft below to 6 ft above ground line.

5.5.7. This coat shall be suitable for the below grade protection of galvanized surfaces and shall be applied as per the manufacturer instructions after galvanizing.

5.5.8. The application thickness shall conform to the coating manufacturer instructions.

5.5.9. Approved below-grade coatings are Corrocote Classic, Chemthane 2260, Rocathaan Hotspray or equivalent Polyurea approved by LUMA.

5.5.10. Embedded Structures shall have a ground sleeve of 3/16 in, 5.5 ft above ground level and 5.5 ft below ground level.

5.5.11. Ground sleeve should not be considered for the final capacity of the structure.

5.6 Climbing and Working Provisions

5.6.1. Pole vendors shall provide fall protection anchorage in accordance with OSHA requirements.

- 5.6.2. All 115 & 230 kV transmission line pole shafts shall include provisions for the use of removable step bolts.
- 5.6.3. Each step bolt (which is not a fall protection anchorage) shall be capable of withstanding a minimum of 450 pounds ultimate load, applied to the outer edge of the step bolt, without causing failure to the bolt or to the point of attachment.
- 5.6.4. Step bolts shall be supplied starting at 15 ft above the ground level. Such bolts shall be the removable type $\frac{3}{4}$ " -10 UNC 2A x 8" LG Type, hot dipped galvanized with 2-inch thread length and the unthreaded section shall have an abrasive surface.
- 5.6.5. The supplier can propose an equivalent step bolt.
- 5.6.6. The detail of the proposed step shall be submitted to LUMA for approval.
- 5.6.7. Step bolts shall be spaced at a minimum of 14 inches center to center, staggered appropriate for climbing the pole easily.
- 5.6.8. Additional step bolts shall be installed 4' -0" below each arm and ground wire attachment to facilitate work on these areas.
- 5.6.9. Pole steps orientation and vertical specified spacing shall be shown on drawings.

5.7 **Quality and Finish**

- 5.7.1. Quality control and manufacturing tolerances shall be such that there will be no problems encountered during field assembly of the finished product.
- 5.7.2. The Supplier shall provide upon request, procedures detailing the galvanizing process.
- 5.7.3. For galvanized finish, steel shall be hot dip galvanized after fabrication is completed per the requirements of ASTM 123.

5.8 **Modifications**

- 5.8.1. Structures are to be fabricated in accordance with detailed drawings furnished by the manufacturer for approval of LUMA Transmission Lines Engineering Standards.

- 5.8.2. Any modifications must be approved by LUMA Transmission Lines Engineering Standards in writing.
- 5.8.3. For fabrication only orders (engineering completed previously or by others), minor deviations in member layout to accommodate variations in shop practices will be permitted provided that these deviations do not materially alter the configuration of the structures and do not reduce the strength of the structures.
- 5.8.4. When such deviations in member layout are made, drawings showing these deviations shall be submitted to LUMA Transmission Lines Engineer for approval and the originals of such drawings shall become the property of LUMA upon completion of the order.

6. Identification

6.1 Pole Bottom Section

- 6.1.1. Each pole shall include (welded) one steel plate at 5 feet from the ground elevation with the following information clearly stated:
 - 6.1.1.1. Manufacturer:
 - 6.1.1.2. Manufacture Date:
 - 6.1.1.3. Owner: PREPA
 - 6.1.1.4. Purchase Order No.:
 - 6.1.1.5. Moment at Base (Ft-k):
 - 6.1.1.6. Shear at Base (Kips):
 - 6.1.1.7. Axial Load at Base (Kips)
 - 6.1.1.8. Weight (lbs.):
 - 6.1.1.9. Pole Length (ft):
 - 6.1.1.10. Pole Name (As indicated in appendix drawings)

6.2 All Pole Sections

6.2.1. Each section shall be identified:

6.2.1.1. T= Top, M= Middle, B= Bottom & Purchase Order Number –

6.2.1.2. Pole Name (As indicated in appendix drawings)

6.2.1.3. Example: T-0142510.

6.3 Arms

6.3.1. Each arm shall be identified and Purchase Order Number:

6.3.1.1. C= Conductor, O= OHGW

6.3.1.2. Pole Name (As indicated in appendix drawings)

6.3.1.3. Example: C-0142510.

7. Galvanizing

7.1. The Supplier shall provide upon request procedures detailing the galvanizing process.

7.2. All steel work, including bolts, shall be hot-dipped galvanized in accordance with ASTM Specifications A-123, A-153 or EN ISO 10684.

7.3. Fabrication should be complete prior to galvanizing.

7.4. No bending, welding, working, or machining of structure members shall take place after galvanizing.

7.5. The inside of tubular members shall be readily visible and accessible for post-galvanizing cleaning and repair as needed.

7.6. All holes must be punched or drilled before galvanizing and the holes must be sealed with a removable plastic cap, to seal the pole to prevent water.

7.7. The coating quality shall be determined as described in the ASTM A123 Standard.

7.8. The Supplier shall provide upon request a detailed inspection procedure and evidence that ultrasonic test is performed on base and flange plate welds after galvanizing.

- 7.9. The steel shall be suitable for hot dip galvanizing.
- 7.10. The steel shall have a Si (Silicon) and P (Phosphorus) contents:
- 7.10.1. $Si \leq 0.030$
- 7.10.2. $Si + 2.5P \leq 0.090$
- 7.11. Hot dipped galvanizing process is required that every section of the pole shall be covered in single submersion end to end in a single bath.

8. Quality Control

8.1 General

- 8.1.1. The Supplier shall be ISO 9001 and ISO 14001 certified.
- 8.1.2. The manufacturer shall have an established quality management system with a quality program that will ensure conformance to the project requirements and this specification.
- 8.1.3. All project related documentation that is required by the quality control program and project requirements shall be available to LUMA or its representative upon request and kept in record retention by the manufacturer for a minimum period of five (5) years.

8.2 Certified Mill Test Reports

- 8.2.1. Mill test reports certificates shall be furnished for steel plates used for the fabrication of pole shaft, base plate and all accessories where loads are applied.
- 8.2.2. Certificate of conformance shall be furnished for bolts.
- 8.2.3. All project material test reports and documentation (inspection and test records) shall be kept for a period of five years and be available on request by LUMA for all material.

8.3 Control Plan

| NATURE | DESIGNATION | CONTROL | |
|-----------------------|--|--------------------|-----------------|
| | | TYPE | FREQUENCY |
| Welds | All welds | Visual | 100% |
| | Longitudinal welds at 100% penetration | Ultrasonic test | 20% |
| | Circumferential welds at 100% penetration of pole shaft on base plate | Ultrasonic test | 20% |
| | Other welds | Dye penetrant test | 20% |
| Dimensions | Pole sections and accessories | Dimensional | 10% |
| Identification | Presence, position and orientation of markings on all pole elements and fittings | Visual | Random Sampling |
| Galvanization | Thickness | Magnetic gauge | 10% |
| Packing | Quantitative control of packing and telescoping (if any) of shafts and their accessories | Visual / Counting | 100% |

Table 1: Quality Control Plan

8.4 Inspection

- 8.4.1. The pole supplier shall allow LUMA or its representatives to verify that the finished products and materials supplied correspond to the requirements of these specifications.
- 8.4.2. LUMA shall have the option of performing partial or complete Supply Conformance Assessment (SCA) inspections as deems necessary.
- 8.4.3. All sections of the manufacturer's plant concerned with the work shall be always open to LUMA or its representative while the work is being performed to allow LUMA to make on-site inspections.
- 8.4.4. The manufacturer shall advise the LUMA or its representative one week prior to the beginning of fabrication of the LUMA's order.

- 8.4.5. The manufacturer shall include an estimated completion date, including final surface preparation.
- 8.4.6. The intent of this notification is to allow LUMA to exercise the option of factory inspection any time during fabrication.
- 8.4.7. SCA inspector is to be allowed to inspect finish product and project documentation for acceptance of structures by LUMA.
- 8.4.8. The manufacturer shall formally notify LUMA two (2) weeks prior to the initial start of the project fabrication as contractually ordered with the location(s) of the manufacturing and galvanizing (if applicable) facilities.

8.5 Documentation

- 8.5.1. The manufacturer shall be responsible for retaining all LUMA documents such as design calculations and fabrication drawings for at least 5 years.
- 8.5.2. The manufacturer shall be responsible for the accuracy of all drawings and shall also be responsible for notifying the LUMA Transmission Line Engineering Standards of any revisions made after furnishing the original drawings.
- 8.5.3. Any errors in the detailed drawings shall be corrected by the manufacturer at the manufacturer's expense.
- 8.5.4. The manufacturer, by accepting a PURCHASE ORDER from LUMA, acknowledges that LUMA has the right to use the final shop fabrication detail drawings in any manner beneficial to LUMA, including use by other manufacturers in the fabrication of like structures for LUMA.
- 8.5.5. All calculations and drawings shall be provided on paper and electronic form.
- 8.5.6. Drawings shall be provided in AutoCAD format.
- 8.5.7. Calculations may be in Adobe PDF format.

- 8.5.8. Final shop fabrication detail drawings shall be submitted in Adobe PDF format with or prior to the delivery of the structures.
- 8.5.9. These drawings shall show all the details necessary to fabricate the structures.
- 8.5.10. Review of drawings by LUMA shall not serve as a complete check but will indicate only that the structure appears to be in general conformance with the contract documents.
- 8.5.11. Review of the drawings by LUMA does not relieve the manufacturer from responsibility for the correctness of the details on the drawings.

9. Tolerances

9.1. The permitted variation (tolerance) from a stated dimension, the length of elements, outside diameter, straightness, etc. shall be as follows:

9.1.1. Mean outside diameters

9.1.1.1. Measured at slip joint level:

9.1.1.1.1. $\pm 1\%$ with ± 0.1 in minimum

9.1.2. Ovalization

9.1.2.1. The dimensional percentage noted for two measurements taken between two perpendicular diameters at slip joint level:

9.1.2.1.1. less than 3 % [$(D_{\max} - D_{\min}) / D_{\max} < 3\%$]

9.1.3. Length of pole elements

9.1.3.1. - 1 in / + 3 in

9.1.4. Members Straightness

9.1.4.1. less than 0.3 % of 3 feet member length

9.1.5. Twisting

9.1.5.1. less than 1.5 degrees per 10 feet member length

9.1.6. Location of welded pieces

9.1.6.1. $\pm 1\%$ on lengths indicated on our approval drawings, except if there is slip joint between crossarms where a 6 in tolerance shall be added

9.1.7. **Slip joint length:**

9.1.7.1. ± 6 in

10. Packing and Shipping

- 10.1. Each part, assembly or sub-assembly shall be packed in such a manner as to minimize structural damage or damage to galvanizing.
- 10.2. Any damaged part shipped will be replaced by the manufacturer.
- 10.3. Shipments shall consist of complete structures and shall be accompanied by a packing list of all parts which will be identifiable by structure number and type.
- 10.4. All bolts, nuts and locknuts shall be bagged and securely attached to each structure or identified in a way that enables efficient match-up with their respective pole shafts.
- 10.5. Material should be delivered on open platforms, which are free of foreign material that could cause damage.
- 10.6. Air circulation should be provided between the floor of the platform and the bundle.
- 10.7. Proper bulk heading and suitable vertical and horizontal spacers should be used to prevent damage and facilitate unloading.
- 10.8. Pole delivery will not be accepted without LUMA's Transmission Lines Engineering Standards approval.
- 10.9. Pole bolts will be delivered using UV resistance recipients or wooden cases adequately identified with its order number and pole belonging.
- 10.10. Cardboard boxes and unidentified cases will not be accepted.
- 10.11. Bid price shall include costs for transportation, delivery, and trailers standby time of 10 working days at LUMA's Warehouse 17 in Palo Seco, Toa Baja or project site.
- 10.12. LUMA will be responsible of unloading the poles.

10.13. Supplier shall notify LUMA at least 2 weeks prior to delivery of poles and hardware and shall submit a delivery schedule including dates and details of shipments.

11. Compliance

11.1. Should any piece or equipment fail to meet the requirements of these specifications within the warranty period, it shall be optional for the LUMA Transmission Lines Engineering Standards to accept or reject the pole or its appurtenance and direct the manufacturer to proceed at once with making alterations or furnish such new pole or parts as may be necessary to make it meet the warranty and requirements.

11.2. All expenses for furnishing any replacement pole or parts shall be borne by the manufacturer.

12. Structure Types

12.1. The following structure types are pre-engineered steel pole structures, designated as standard structure types for 115 kV & 230 kV single circuit transmission lines, based on legacy structures from PREPA. These LUMA standard structure types should be preferred to be implemented in line design unless design conditions require engineered structures.

12.2. The following Appendixes, A, B and C, illustrate the proposed design configurations of the specified poles. However, manufacturers can modify and optimize the proposed configurations in coordination with LUMA and in compliance with the requirements set forth in the table in Appendix D. Final designs (shop drawings) shall be submitted to LUMA for approval before proceeding with the manufacturing.

| STRUCTURE TYPES | | | |
|--|---|--|--|
| TYPE | A | B | C |
| STRUCTURE DESCRIPTION | Tangent Single Circuit Guyed Steel Pole | Strain Single Circuit Guyed Steel Pole | Dead End Single Circuit Guyed Steel Pole |
| IDENTIFICATION | A-SC-GS-88.5 | B-SC-GS-88.5 | C-SC-GS-88.5 |
| LUMA WAREHOUSE NUMBER | 026-82448 | 026-82450 | 026-82452 |
| DESIGN LINE ANGLE | 0° - 3° | 0° - 10° | 45° - 90° |
| MAXIMUM TENSION FOR CONDUCTOR | 60% RBS | 60% RBS | 60% RBS |
| MAXIMUM TENSION FOR SHIELD WIRE | 60% RBS | 60% RBS | 60% RBS |
| HORIZONTAL SPAN | 800 FT | 800 FT | 800 FT |
| VERTICAL SPAN | 800 FT | 800 FT | 800 FT |
| *STRUCTURE DRAWING | See Appendix A | See Appendix B | See Appendix C |
| *LOADING TREE REFERENCE | See Appendix D | See Appendix D | See Appendix D |

Table 2: Structure Types

13. Loading Specifications

13.1 Loading Cases

13.1.1. Please refer to Appendix D for loading cases.

13.2 Deflection

13.2.1. Deflections shall be limited to 8% of the above ground height of the structure for Intact loading case, without the overload factor.

13.3 Guy loading

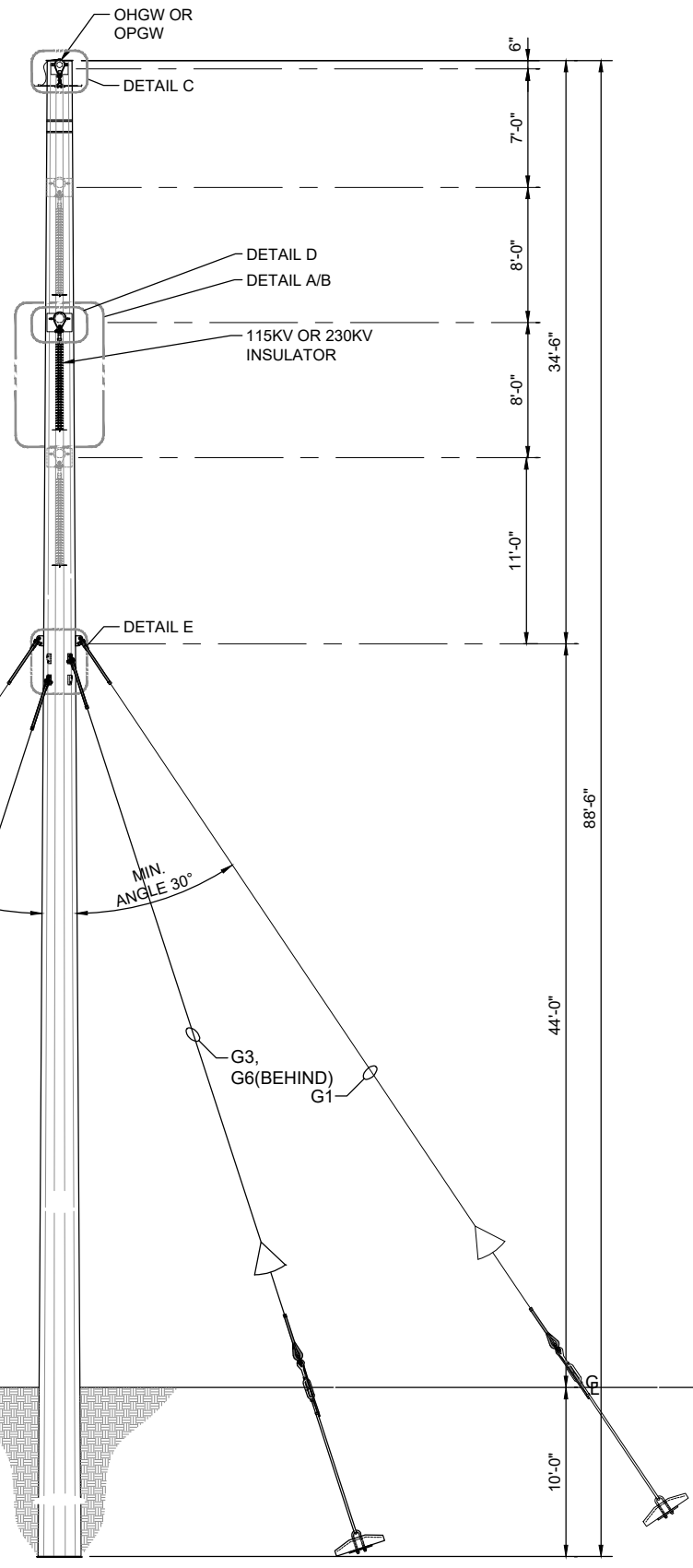
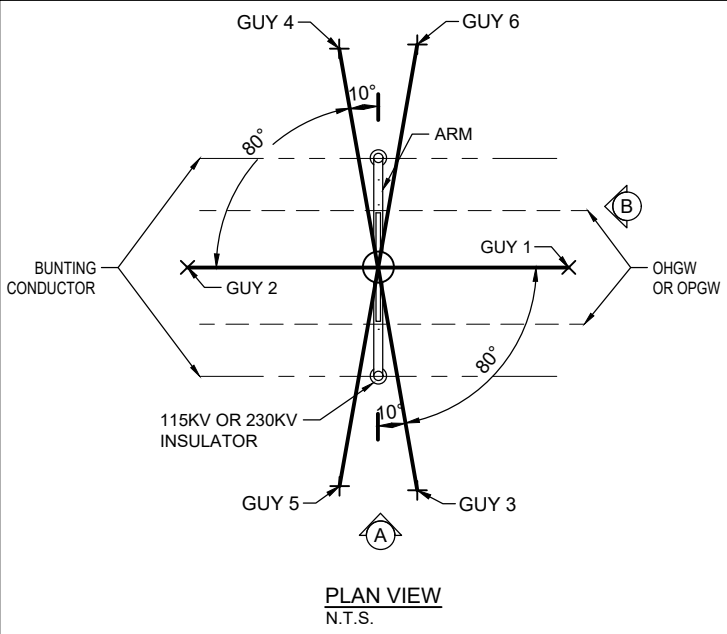
13.4.1. It shall be limited to 65% of 73,350 lbs.

14. Cables Specifications:

| CABLE SPECIFICATIONS TABLE | | | | |
|---------------------------------------|----------------------|---------------------------------------|-------------------------------|-----------------------------------|
| CONDUCTOR TYPE | DIAMETER (inches) | WEIGHT (lbs./ft) | RATED BREAKING | 60% @ Design Tension |
| | | | (lbs) | (lbs) |
| Conductor: 1192.5 MCM/ACSR Bunting | 1.302 | 1.343 | 32,000 | 19,500 |
| OHGW: 3#6 AWG "Alumoweld" | 0.349 | 0.178 | 10,280 | 6,270 |
| OPGW-DNO-12494 | 0.608 | 0.381 | 18,231 | 11,120 |
| GUY SPECIFICATION | WIRE | COEFFICIENT OF LINEAR EXPANSION | RATED BREAKING STRENGTH | MODULUS OF ELASTICITY (KSI) |
| Wire | 19#5 Alumoweld | 0.0000072 per degree F | 73,350 | Strand 23,000 |

Table 3: Cable Specification Table

APPENDIX A

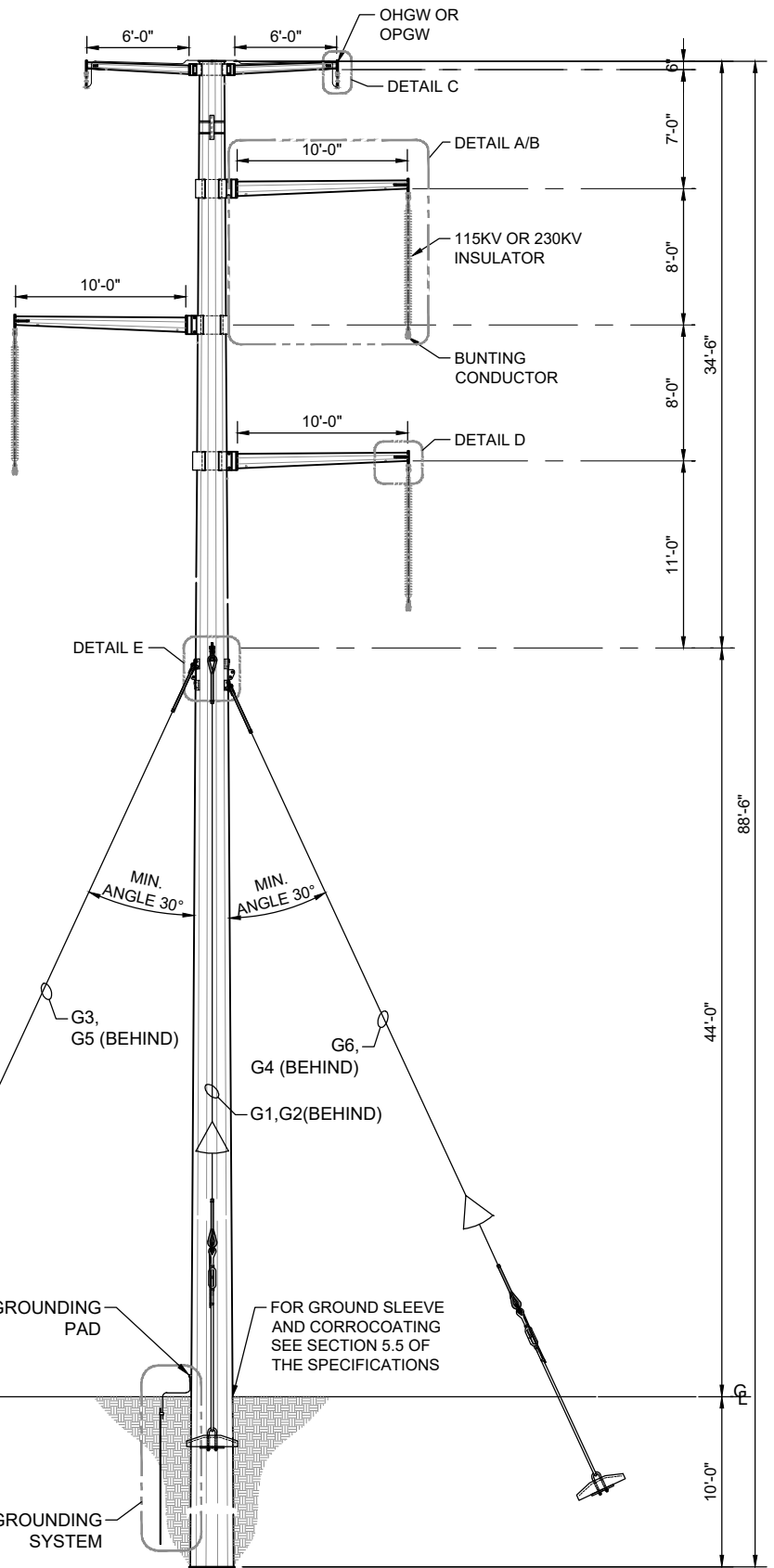
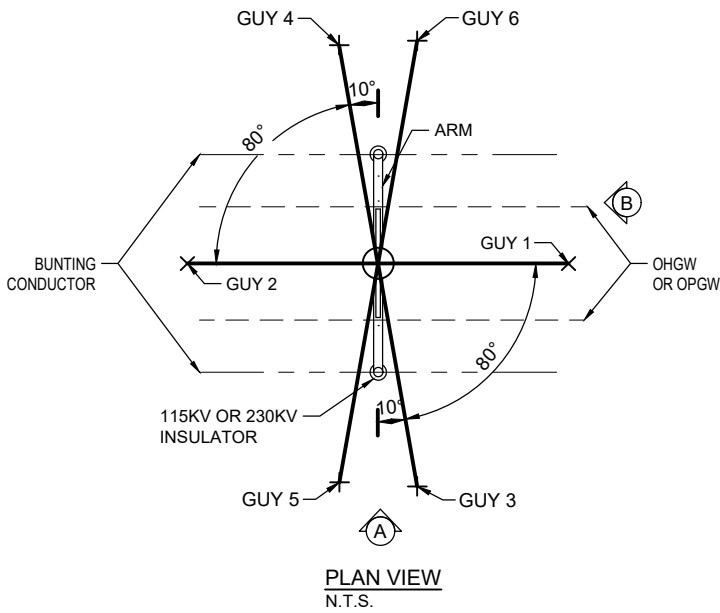


RECOMMENDED DESIGN CONDITIONS:
 HORIZONTAL SPAN = 800'
 VERTICAL SPAN = 800'
 GUYS MINIMUM ANGLE = 30°
 MAXIMUM ALIGNMENT LINE ANGLE = 0° - 3°

| | | | | |
|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-A R01 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 1 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
 TYPE A-SC-GS-88.5
 ELEVATIONS-SPECIFICATIONS
 TRANSMISSION ENGINEERING





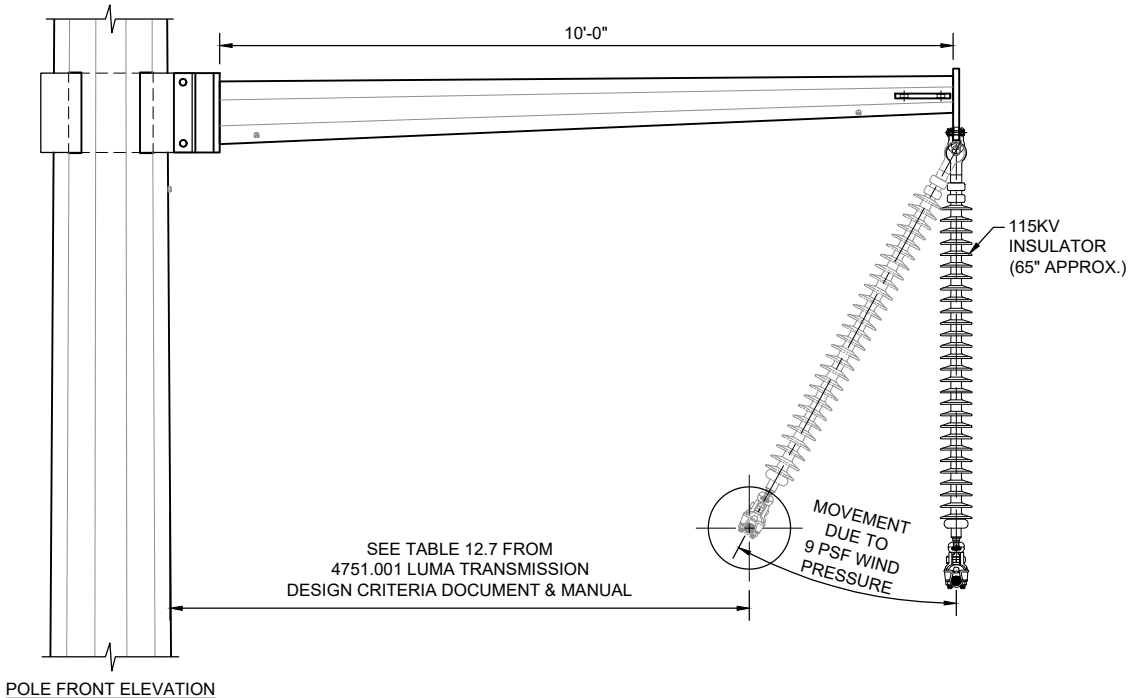
ELEVATION-B
SCALE: 3/32"=1'-0"

RECOMMENDED DESIGN CONDITIONS:
 HORIZONTAL SPAN = 800'
 VERTICAL SPAN = 800'
 GUYS MINIMUM ANGLE = 30°
 MAXIMUM ALIGNMENT LINE ANGLE = 0° - 3°

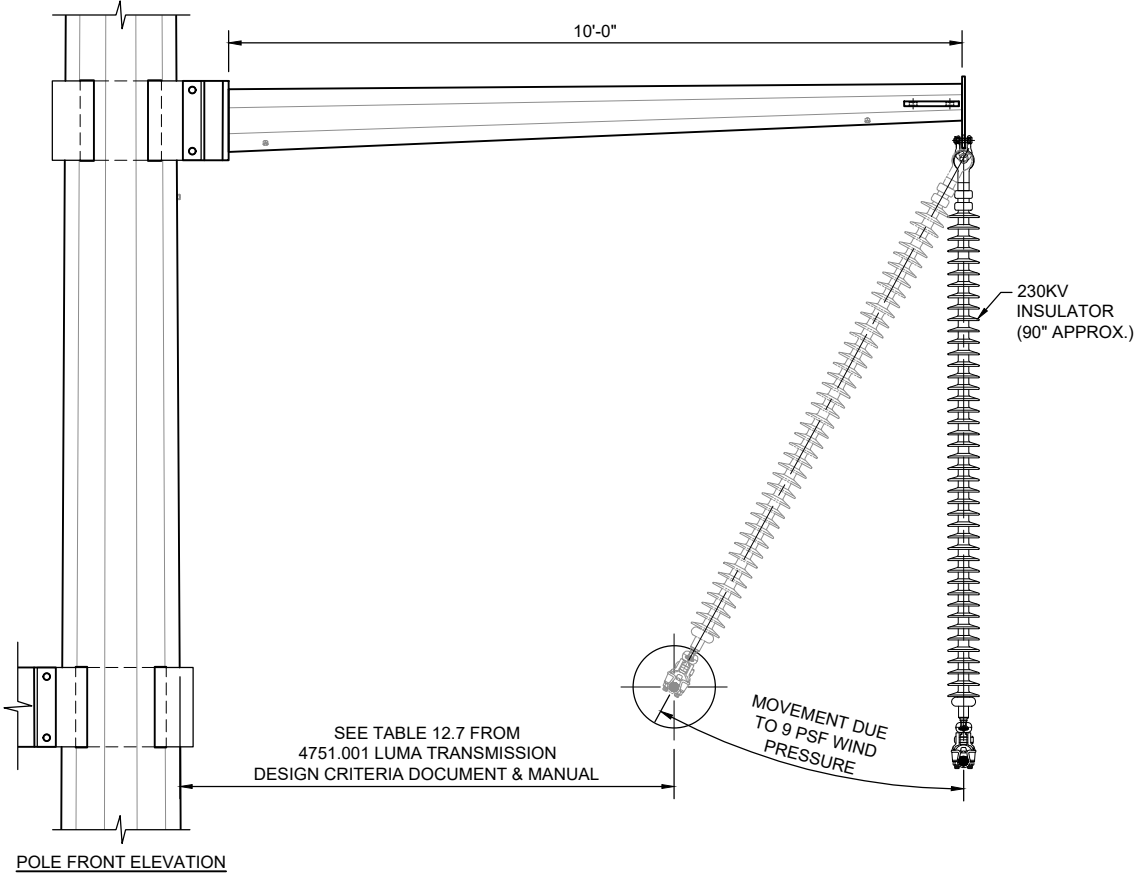
| | | | | |
|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-A R01 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 2 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
 TYPE A-SC-GS-88.5
 ELEVATIONS-SPECIFICATIONS
 TRANSMISSION ENGINEERING





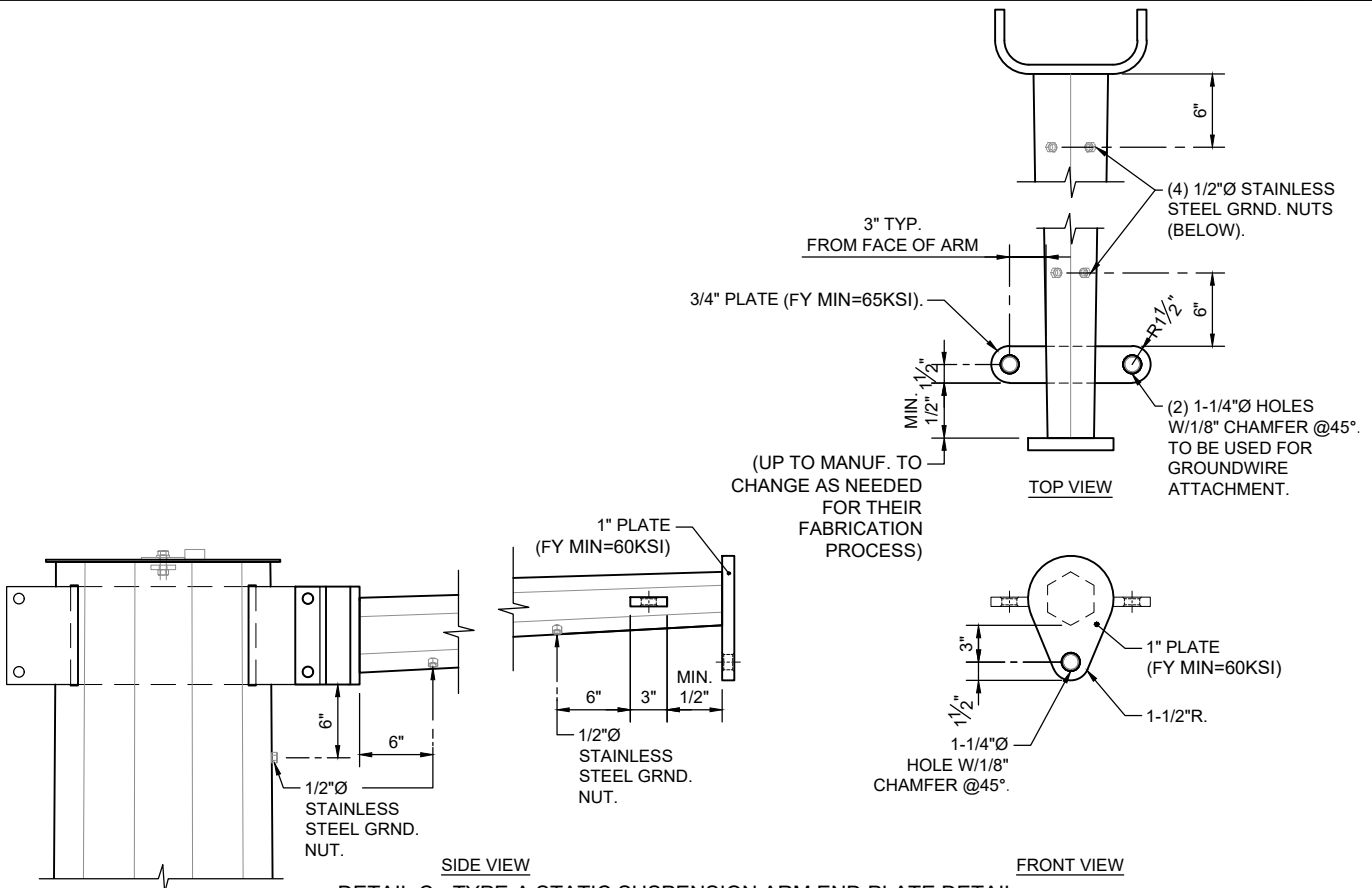
DETAIL A - 115KV SUSPENSION INSULATOR - ARM CLEARANCE CHECK
SCALE: 3/8"=1'-0"



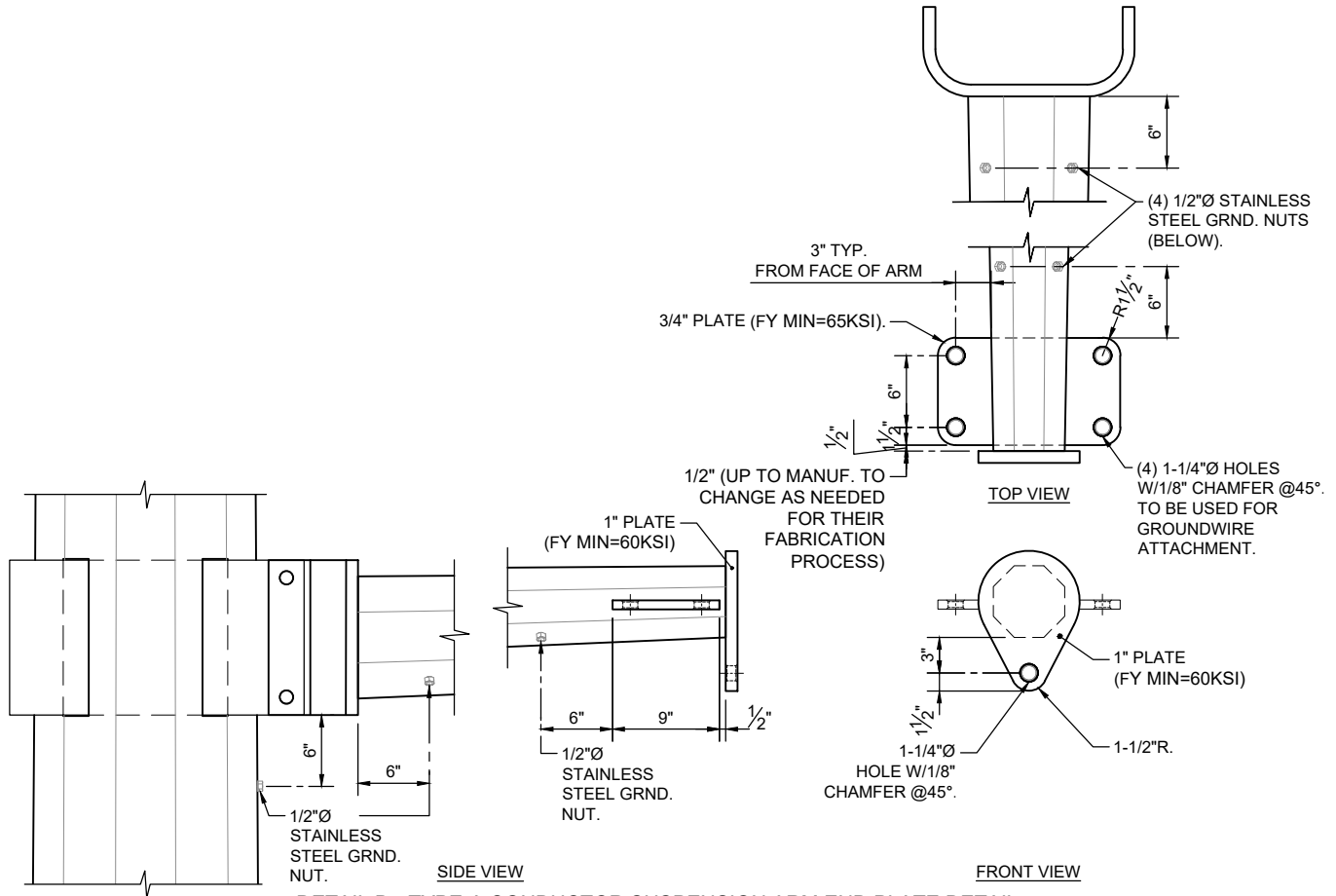
DETAIL B - 230KV SUSPENSION INSULATOR - ARM CLEARANCE CHECK
SCALE: 3/8"=1'-0"

| | | | | | |
|------------------------------|----------------------|--------------------|-------------------------------------|-------------------|--|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN | SINGLE CIRCUIT GUYED STEEL POLE TYPE A-SC-GS-88.5 ARM CLEARANCES CHECK-SPECS. TRANSMISSION LINE ENGINEERING |
| REVIEWED OSCAR BENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-A | R01 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 3 OF 5 | | |





DETAIL C - TYPE-A STATIC SUSPENSION ARM END PLATE DETAIL
SCALE: 3/4"=1'-0"

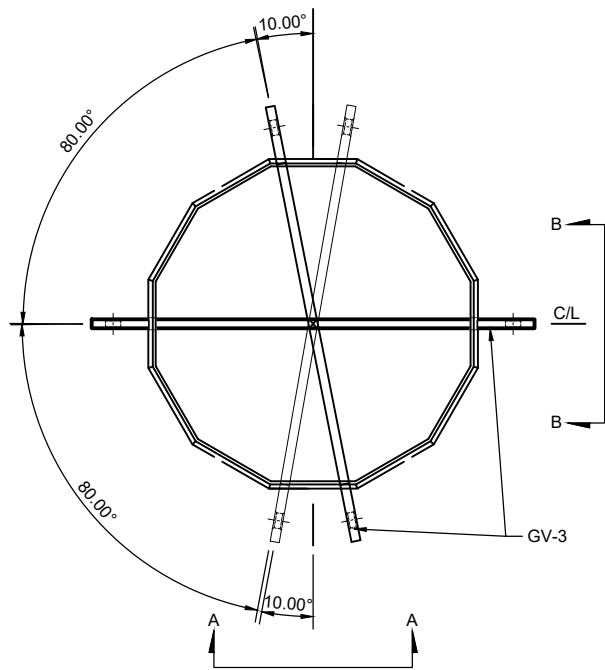


DETAIL D - TYPE-A CONDUCTOR SUSPENSION ARM END PLATE DETAIL
SCALE: 3/4"=1'-0"

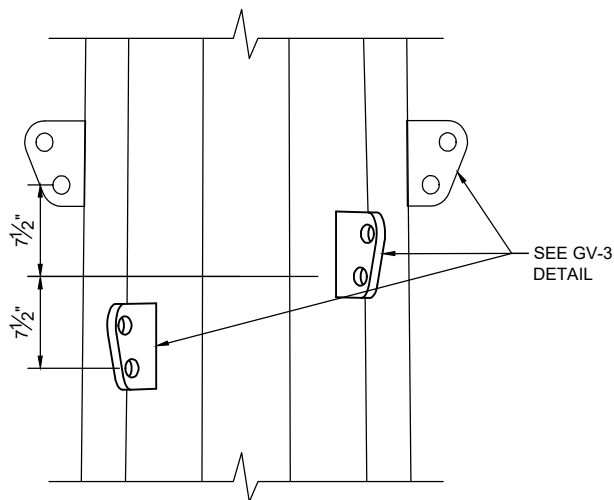
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|------------------------------|----------------------|--------------------|-------------------------------------|-------------------|
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| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-A | R01 |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 4 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
TYPE A-SC-GS-88.5
ARMS END PLATE DETAILS-SPECS.
TRANSMISSION LINE ENGINEERING

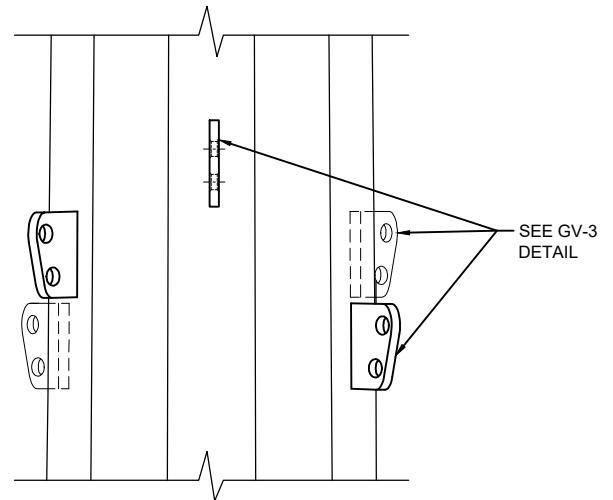




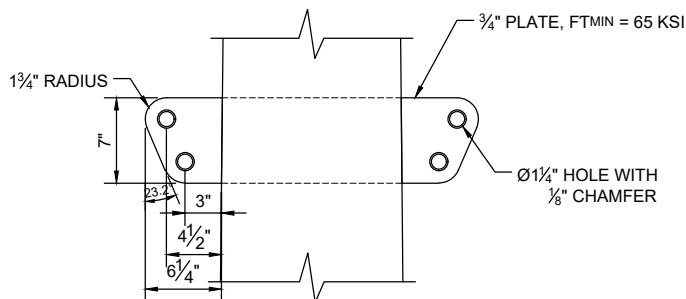
TOP VIEW
SCALE: 3/4" = 1'-0"



DETAIL E VIEW A-A
SCALE: 3/4" = 1'-0"



DETAIL E ELEVATION VIEW B-B
SCALE: 3/4" = 1'-0"



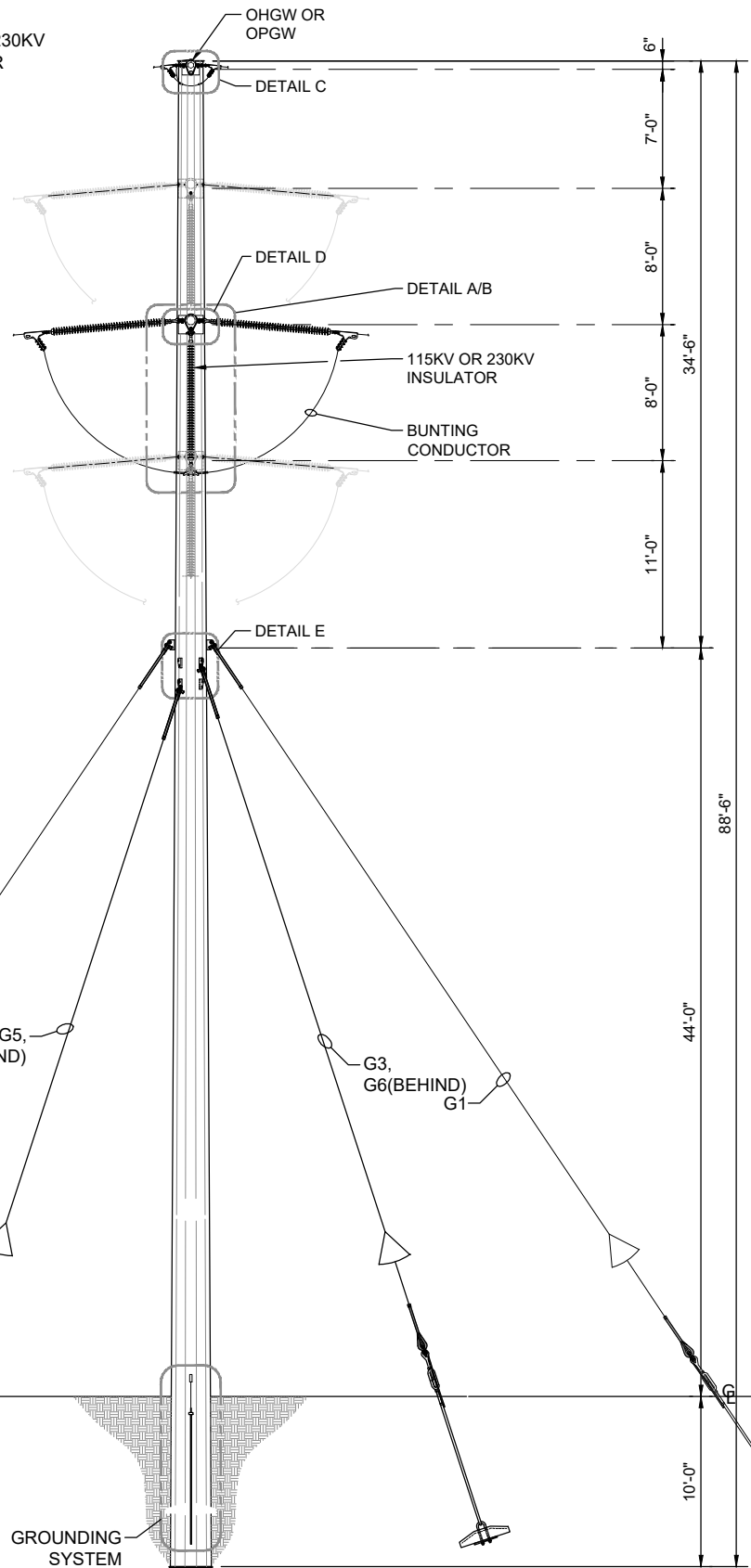
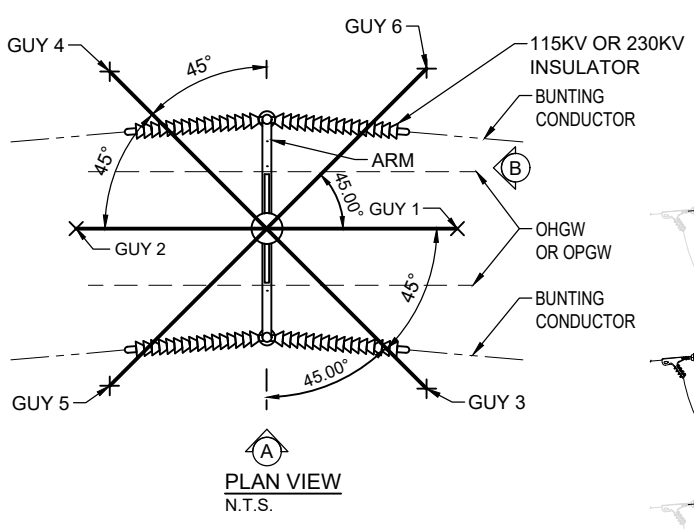
GUY VANG DETAIL 3
SCALE: 3/4" = 1'-0"

| | | | | |
|------------------------------|----------------------|--------------------|-------------------------------------|-----------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE 3/4" = 1'-0" |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-A | R01 |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 5 OF 5 | |

115 - 230KV STEEL POLE TYPE - A
TYPE A-SC-GS-88.5
GUYING CONFIGURATION AND DETAIL
TRANSMISSION LINE ENGINEERING



APPENDIX B

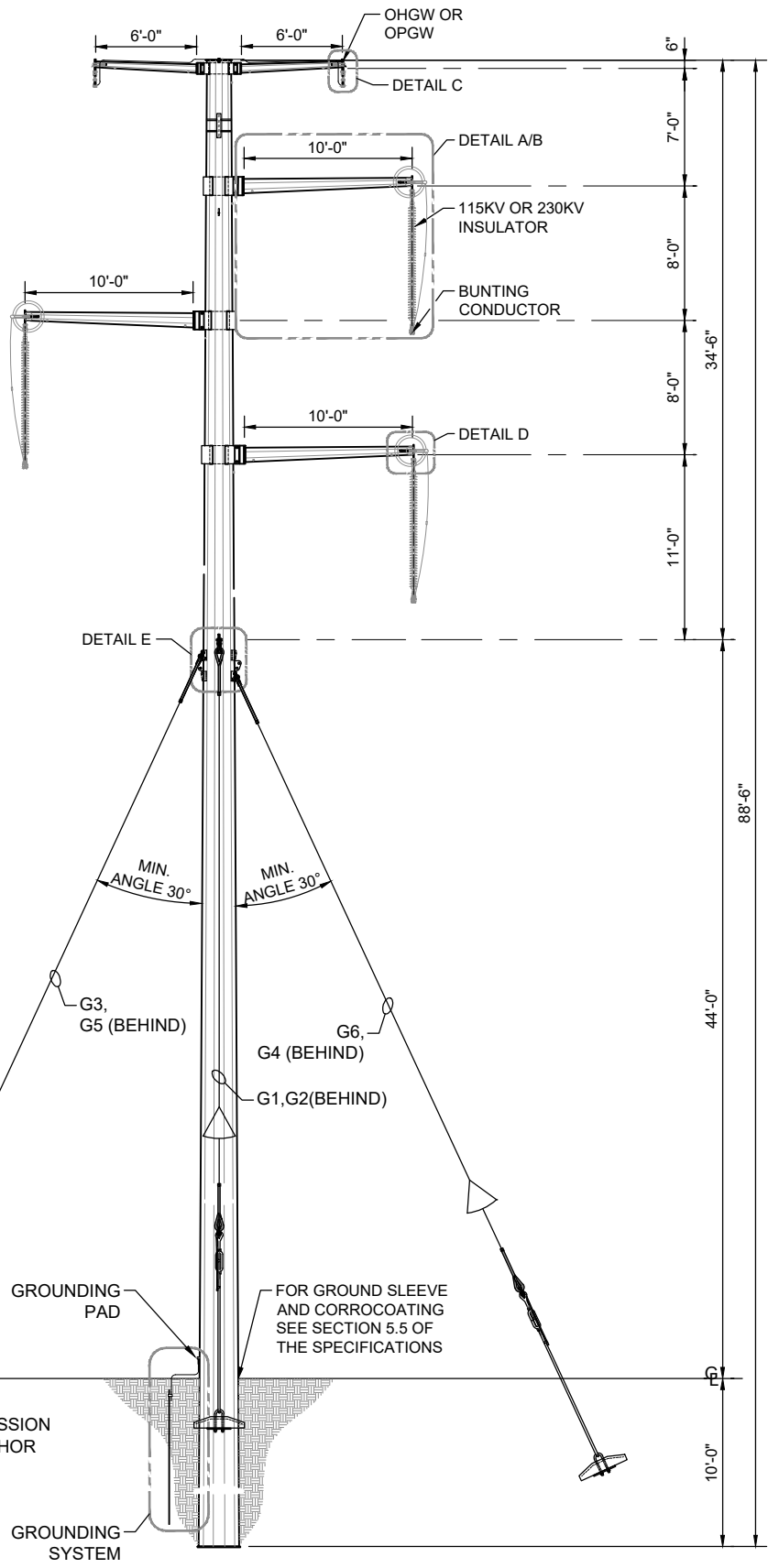
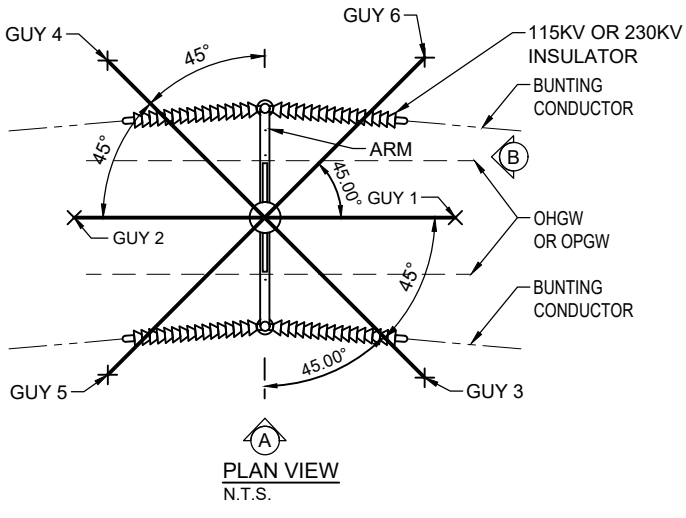


RECOMMENDED DESIGN CONDITIONS:
 HORIZONTAL SPAN = 800'
 VERTICAL SPAN = 800'
 GUYS MINIMUM ANGLE = 30°
 MAXIMUM ALIGNMENT LINE ANGLE = 0° - 10°

| | | | | |
|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-B R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 1 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
 TYPE B-SC-GS-88.5
 ELEVATIONS-SPECIFICATIONS
 TRANSMISSION ENGINEERING



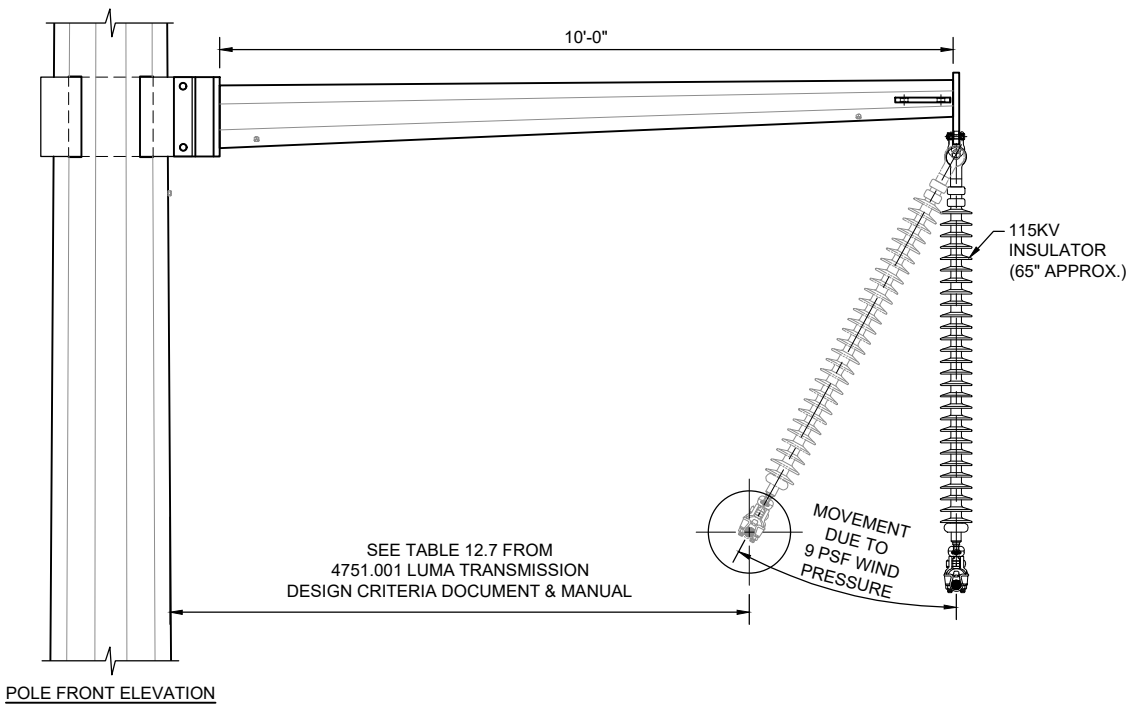


RECOMMENDED DESIGN CONDITIONS:
 HORIZONTAL SPAN = 800'
 VERTICAL SPAN = 800'
 GUYS MINIMUM ANGLE = 30°
 MAXIMUM ALIGNMENT LINE ANGLE = 0° - 10°

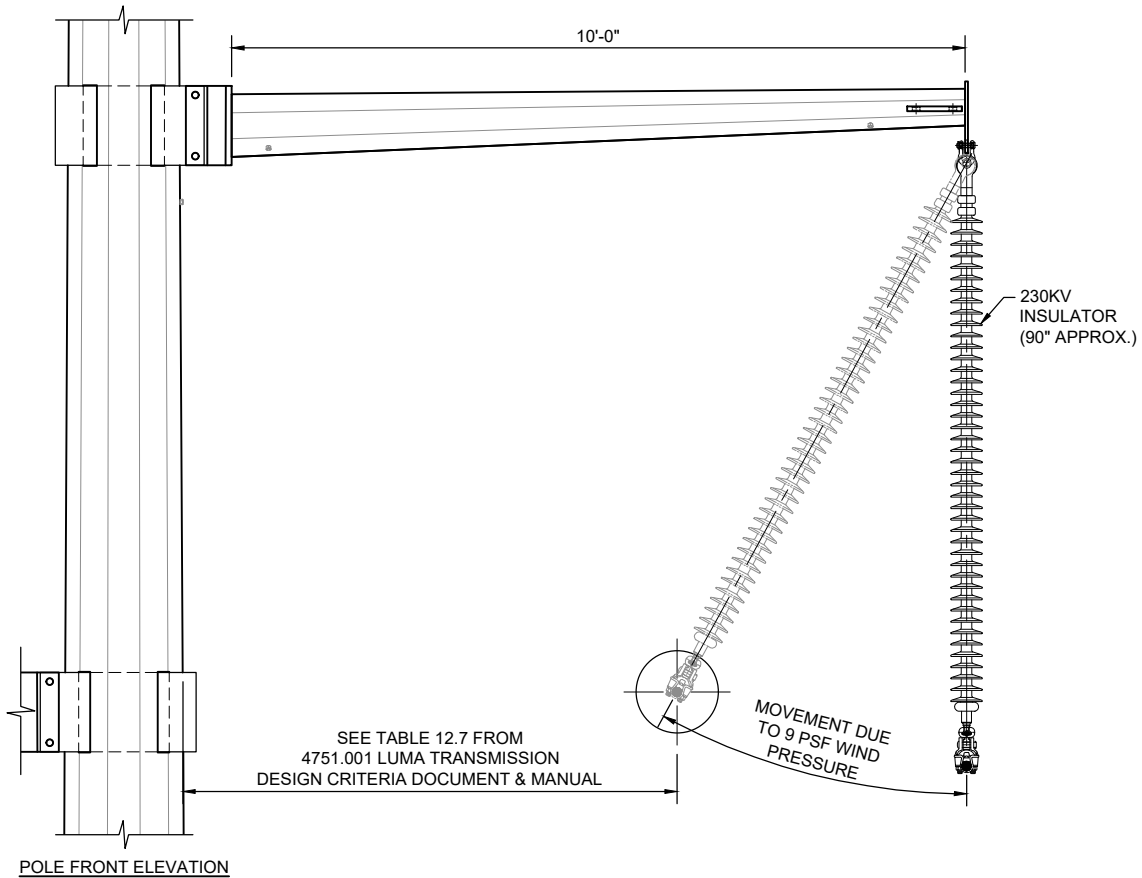
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| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-B R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 2 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
 TYPE B-SC-GS-88.5
 ELEVATIONS-SPECIFICATIONS
 TRANSMISSION ENGINEERING





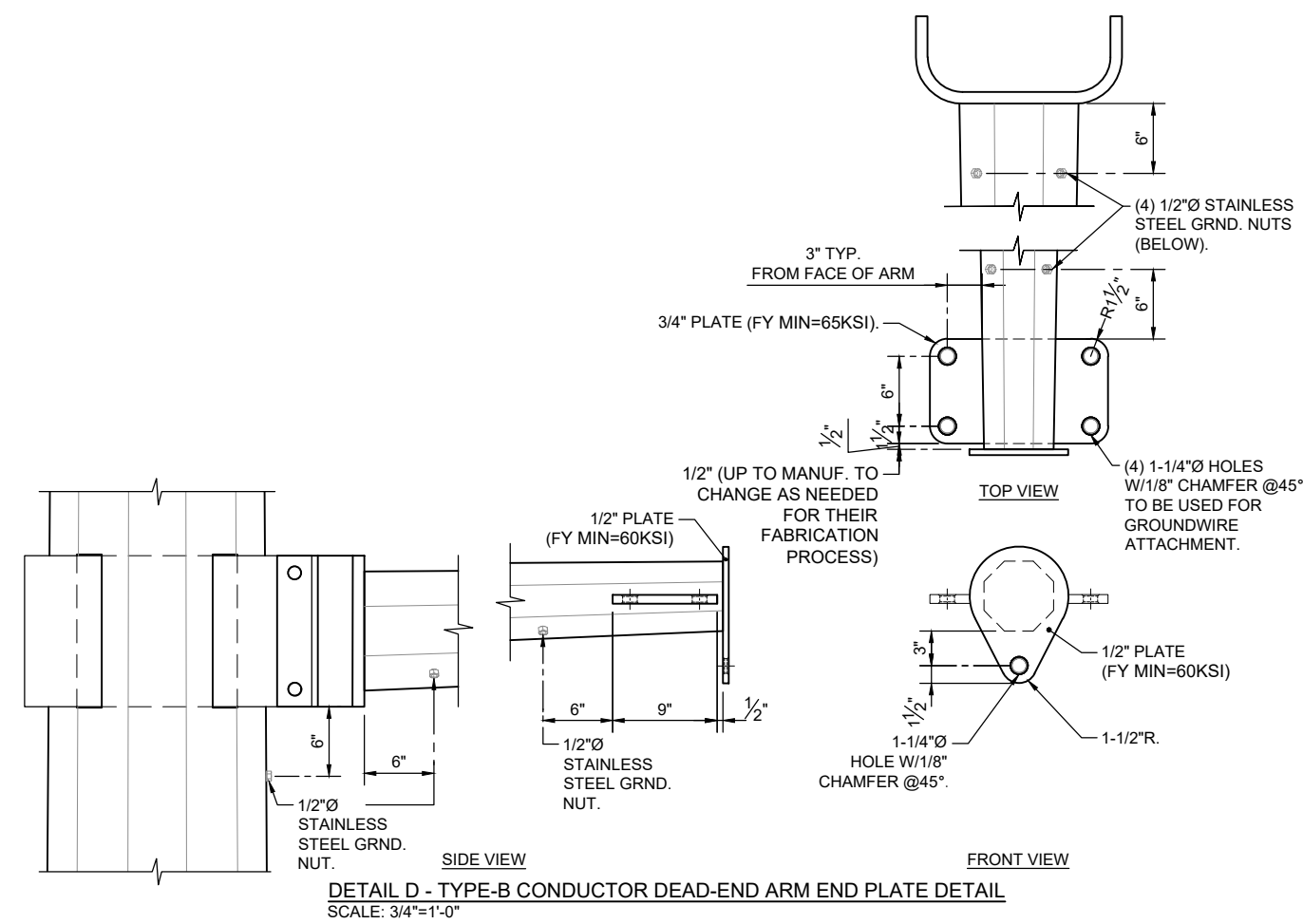
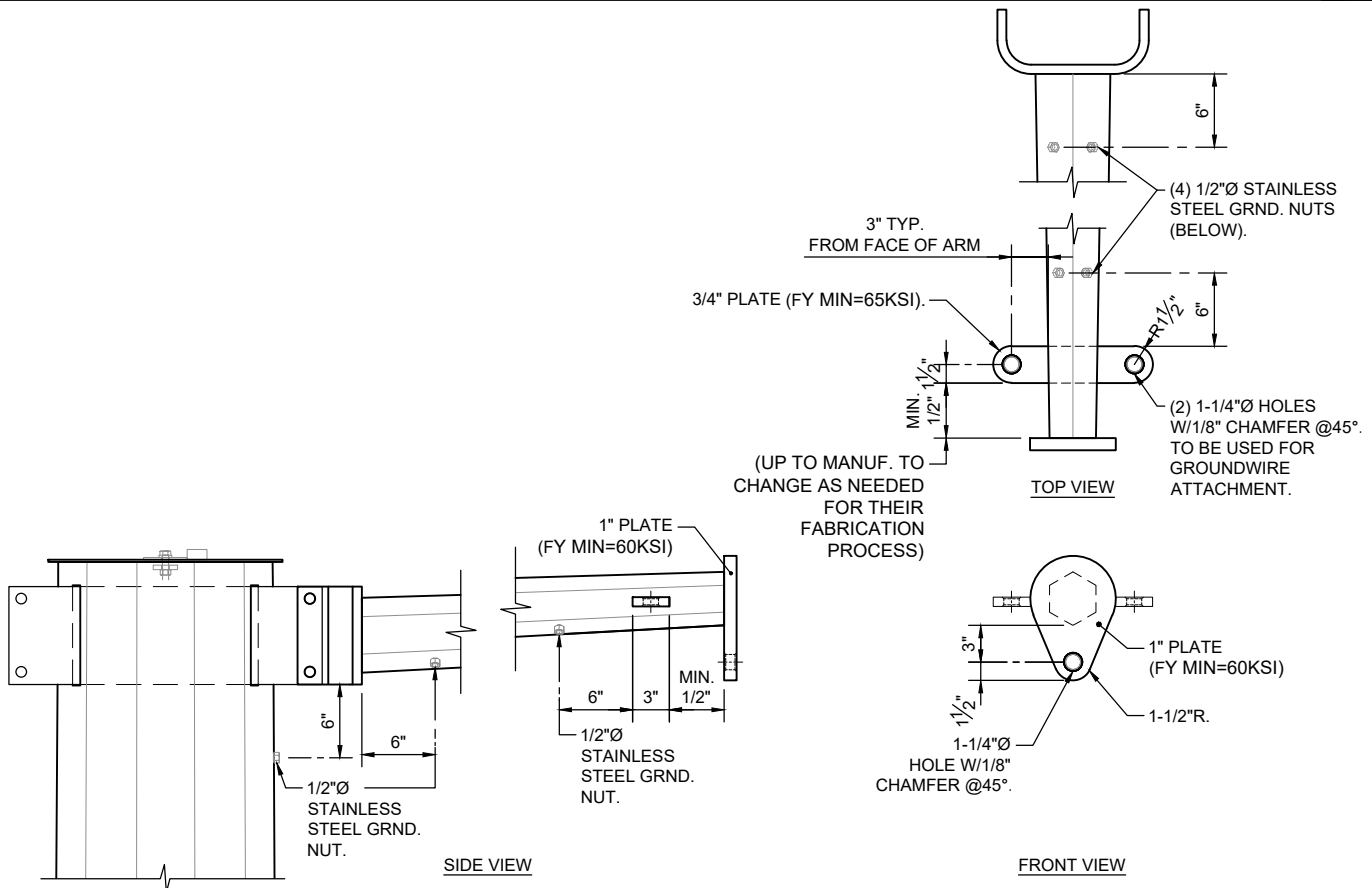
DETAIL A - 115KV JUMPER INSULATOR - ARM CLEARANCE CHECK
SCALE: 3/8"=1'-0"



DETAIL B - 230KV JUMPER INSULATOR - ARM CLEARANCE CHECK
SCALE: 3/8"=1'-0"

| | | | | | |
|------------------------------|----------------------|--------------------|---|-------------------|--|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN | SINGLE CIRCUIT GUYED STEEL POLE TYPE B-SC-GS-88.5 ARM CLEARANCES CHECK-SPECS. TRANSMISSION LINE ENGINEERING |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-B R00 | | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 3 OF 5 | | |

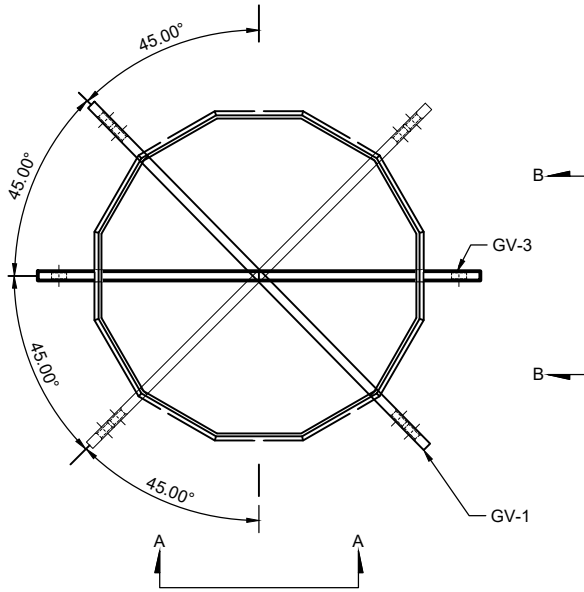




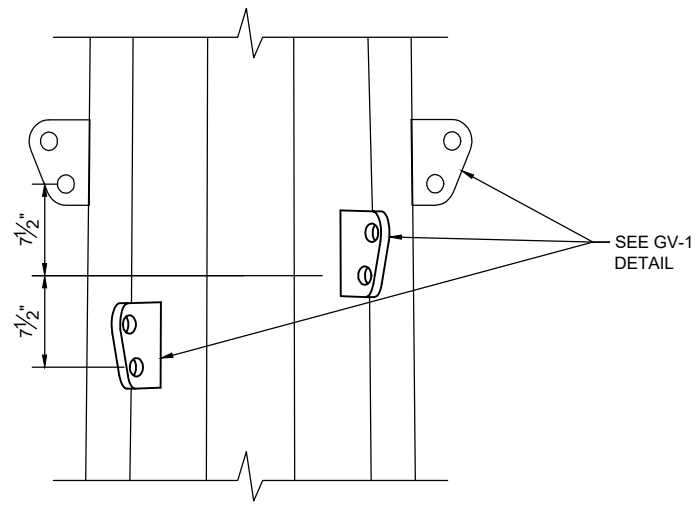
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|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-B R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 4 OF 5 | |

SINGLE CIRCUIT GUYED STEEL POLE
TYPE B-SC-GS-88.5
ARMS END PLATE DETAILS-SPECS.
TRANSMISSION LINE ENGINEERING

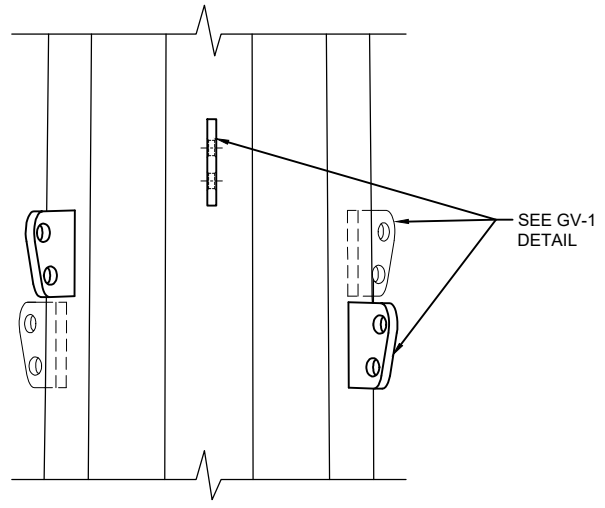




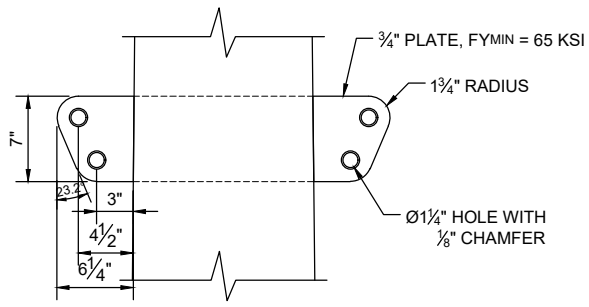
TOP VIEW
SCALE: 3/4" = 1'-0"



DETAIL E ELEVATION VIEW A-A
SCALE: 3/4" = 1'-0"



DETAIL E ELEVATION VIEW B-B
SCALE: 3/4" = 1'-0"



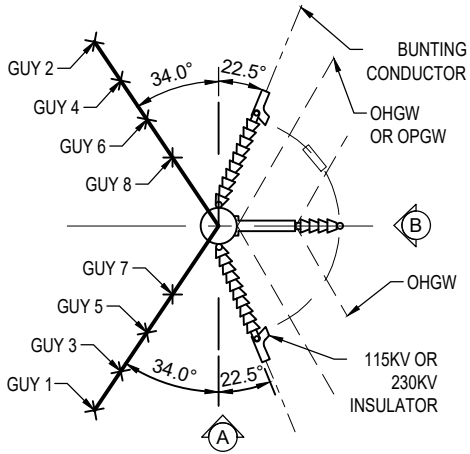
GUY VANG DETAIL 1
SCALE: 3/4" = 1'-0"

| | | | | |
|-------------------------------------|-----------------------------|---------------------------|--|------------------------------|
| PREPARED ELIAM GAUD | LICENSE NO. 3318 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE 3/4" = 1'-0" |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-B | R00 |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 5 OF 5 | |

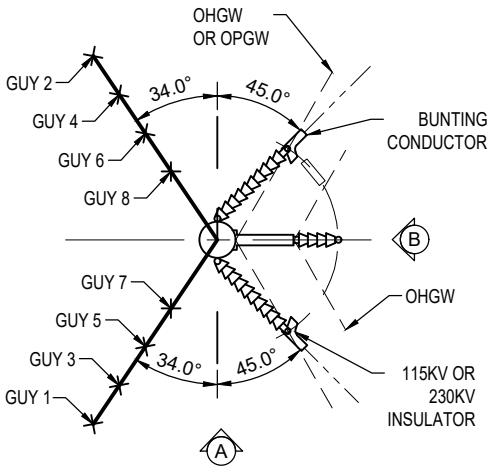
115 - 230KV STEEL POLE TYPE - B
TYPE B-SC-GS-88.5
GUYING CONFIGURATION AND DETAIL
TRANSMISSION LINE ENGINEERING



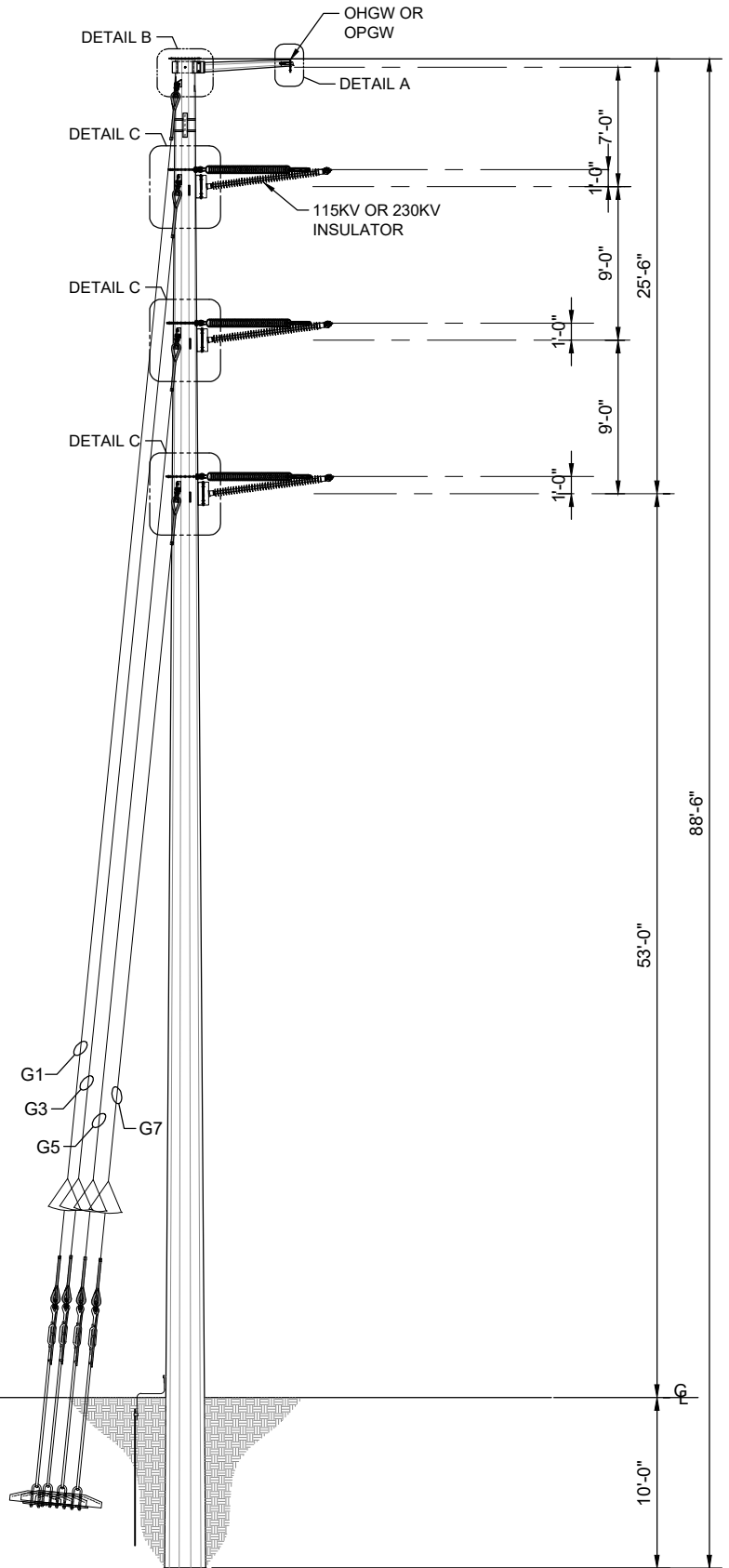
APPENDIX C



PLAN VIEW FOR 45° LINE ANGLE
N.T.S.



PLAN VIEW FOR 90° LINE ANGLE
N.T.S.



ELEVATION-A
SCALE: 3/32"=1'-0"

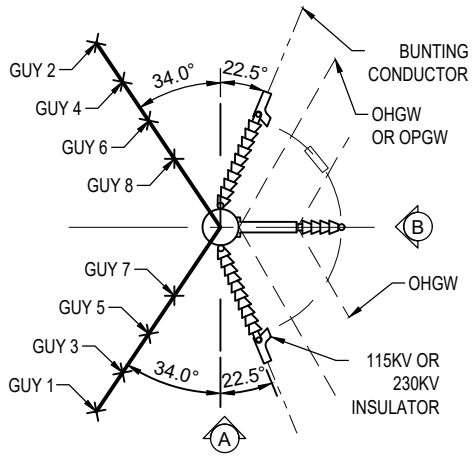
RECOMMENDED DESIGN CONDITIONS:

- HORIZONTAL SPAN = 800'
- VERTICAL SPAN = 800'
- GUYS MINIMUM ANGLE = 30°
- MAXIMUM ALIGNMENT LINE ANGLE = 45° - 90°

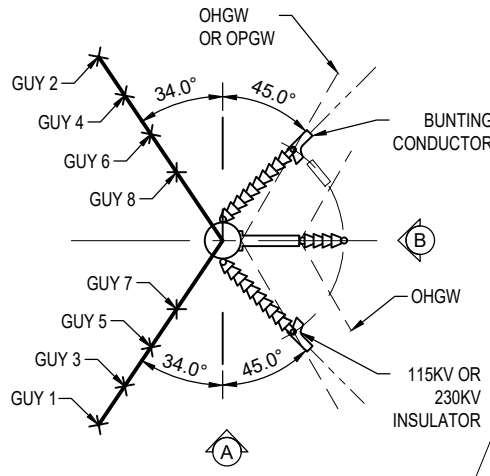
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|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-C R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 1 OF 4 | |

115 - 230KV STEEL POLE TYPE - C
TYPE C-SC-GS-88.5
ELEVATIONS-SPECIFICATIONS
TRANSMISSION ENGINEERING

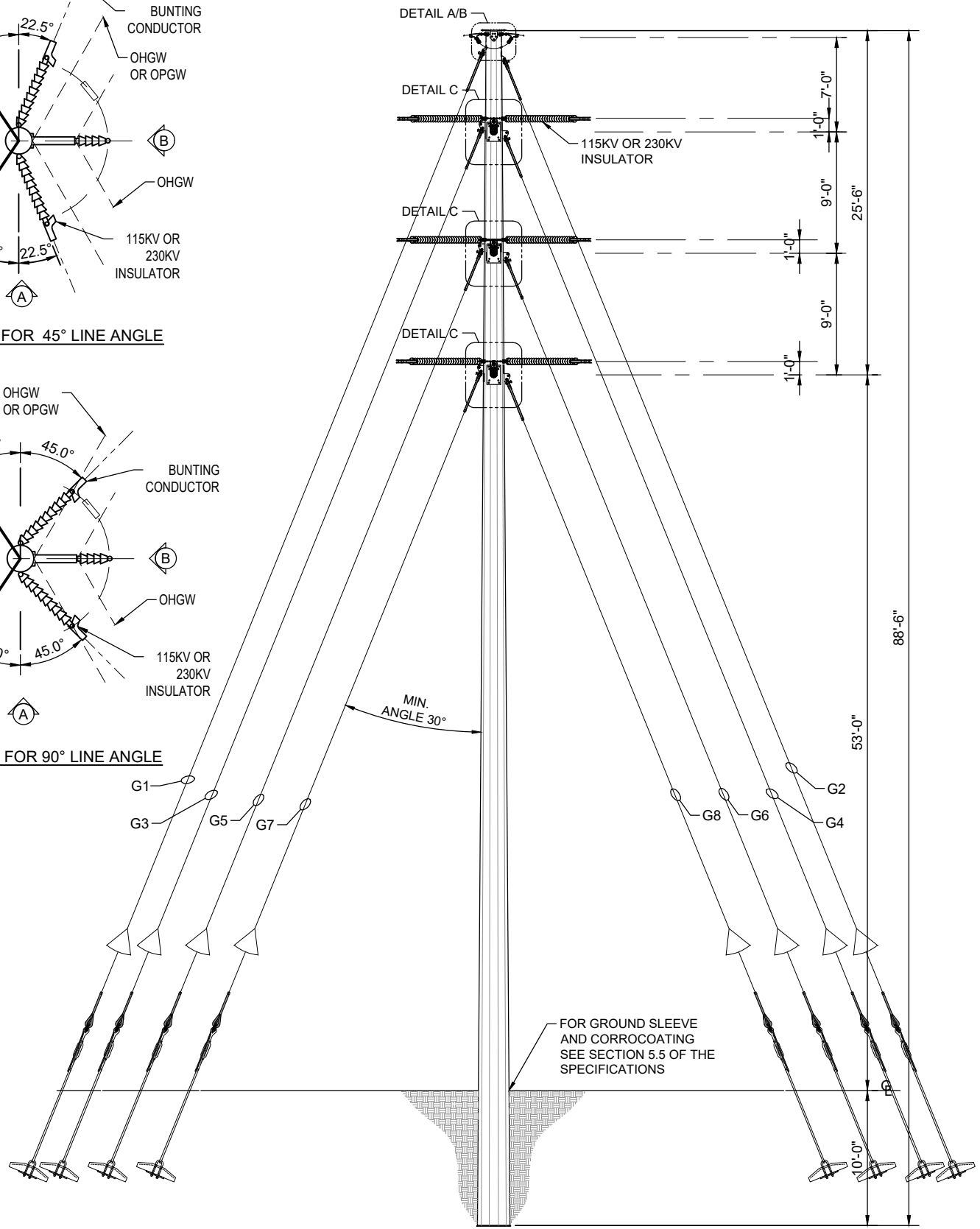




PLAN VIEW FOR 45° LINE ANGLE
N.T.S.



PLAN VIEW FOR 90° LINE ANGLE
N.T.S.



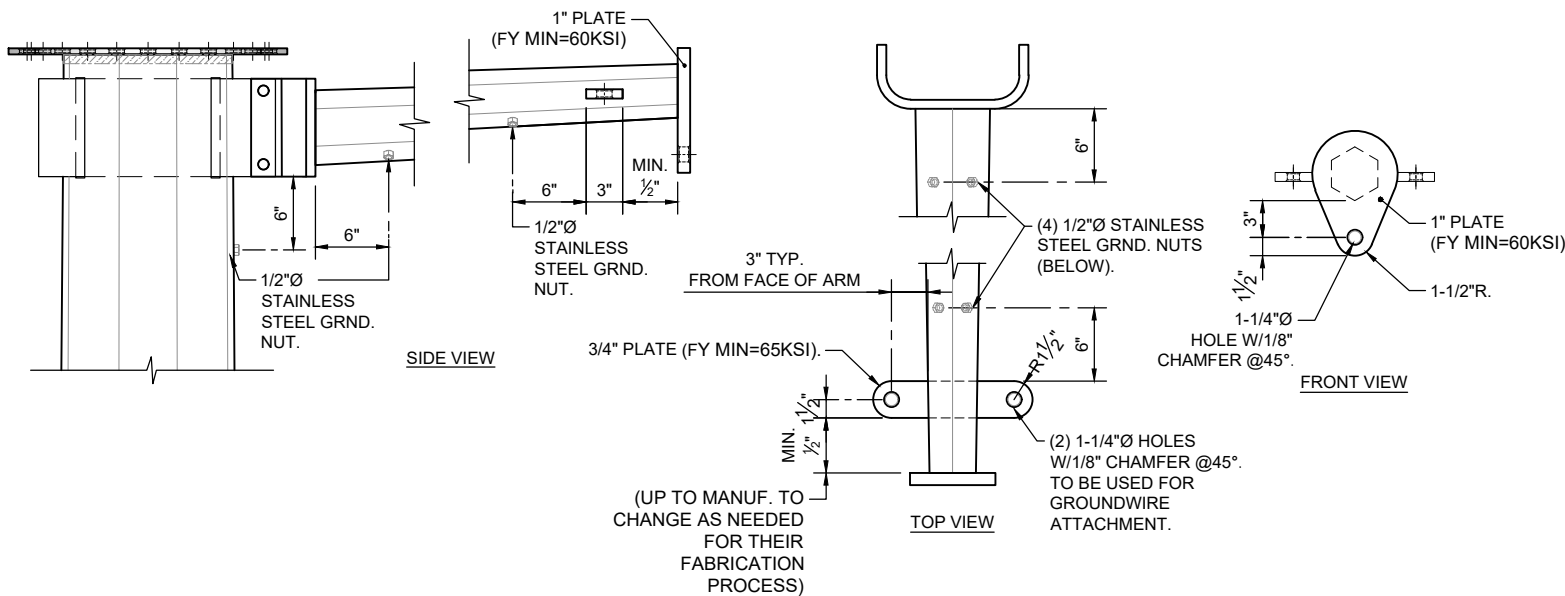
ELEVATION-B
SCALE: 3/32"=1'-0"

RECOMMENDED DESIGN CONDITIONS:
 HORIZONTAL SPAN = 800'
 VERTICAL SPAN = 800'
 GUYS MINIMUM ANGLE = 30°
 MAXIMUM ALIGNMENT LINE ANGLE = 45° - 90°

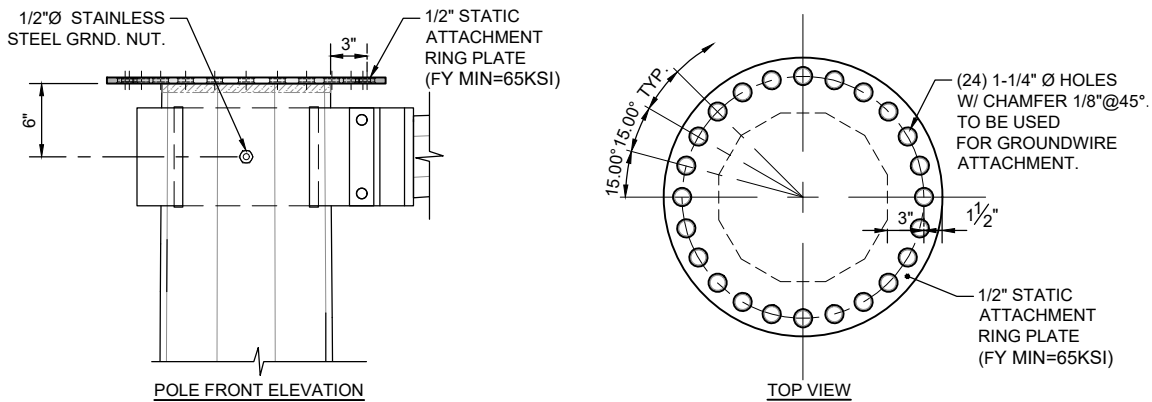
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| PREPARED EMILIO CADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-C R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 2 OF 4 | |

115 - 230KV STEEL POLE TYPE - C
 TYPE C-SC-GS-88.5
 ELEVATIONS-SPECIFICATIONS
 TRANSMISSION ENGINEERING

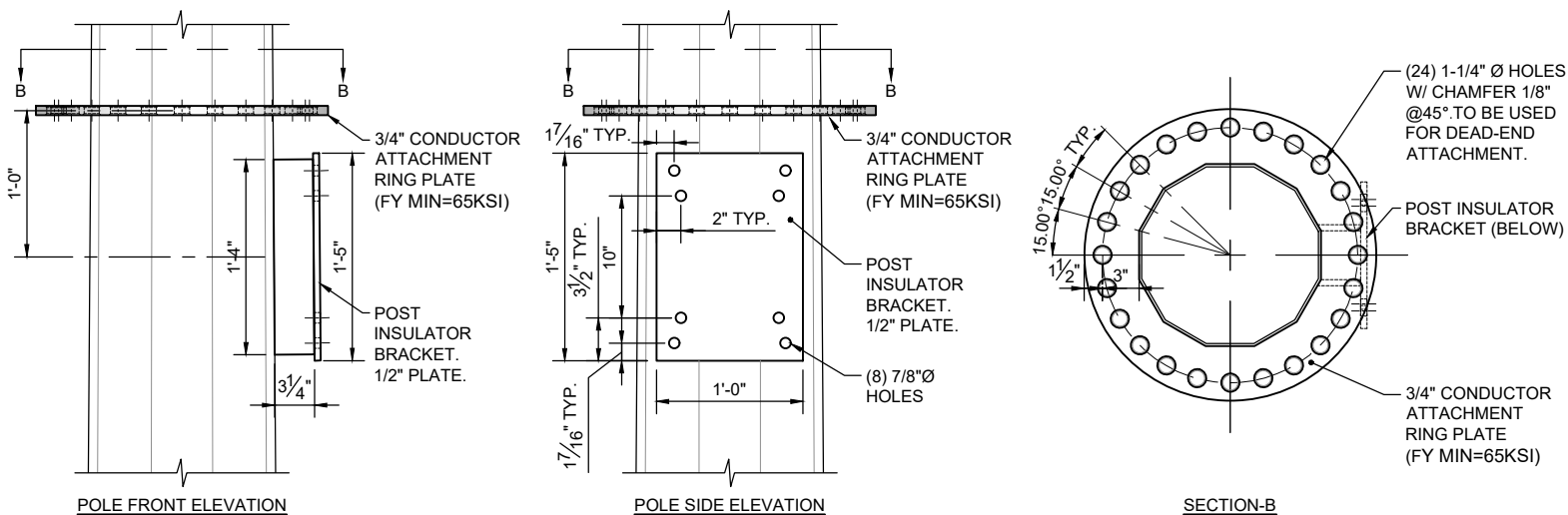




DETAIL A - TYPE-C STATIC SUSPENSION ARM END PLATE DETAIL
SCALE: 3/4"=1'-0"



DETAIL B - TYPE-C POLE CAP PLATE AND POLE VANG DETAIL
SCALE: 3/4"=1'-0"

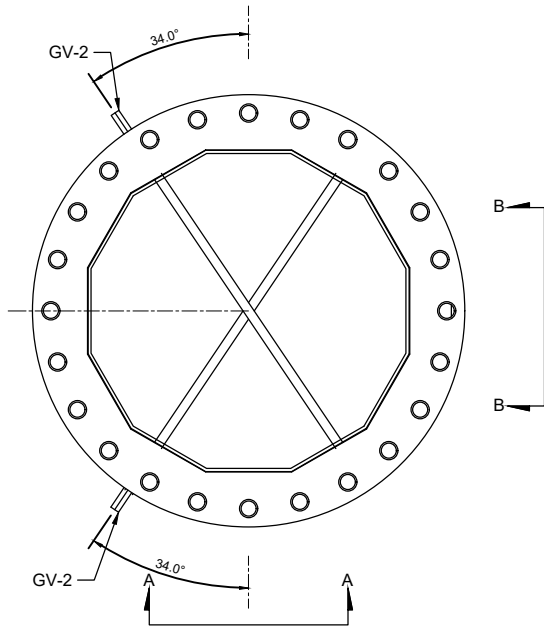


DETAIL C - TYPE-C CONDUCTOR ATTACHMENT PLATES DETAIL
SCALE: 3/4"=1'-0"

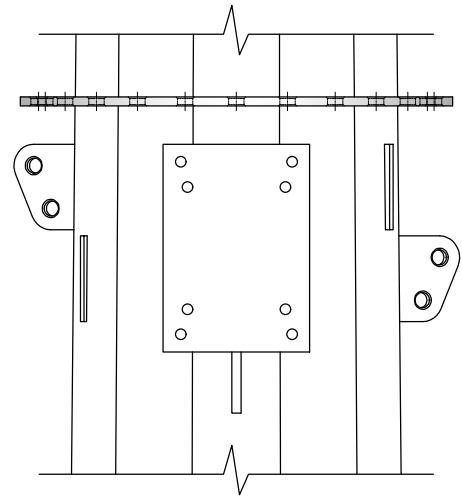
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|------------------------------|----------------------|--------------------|---|-------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE AS SHOWN |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-C R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 3 OF 4 | |

115 - 230KV STEEL POLE TYPE - C
TYPE C-SC-GS-88.5
POLE CAP & CONDUCTOR PLATE DETAILS-SPECS.
TRANSMISSION LINE ENGINEERING

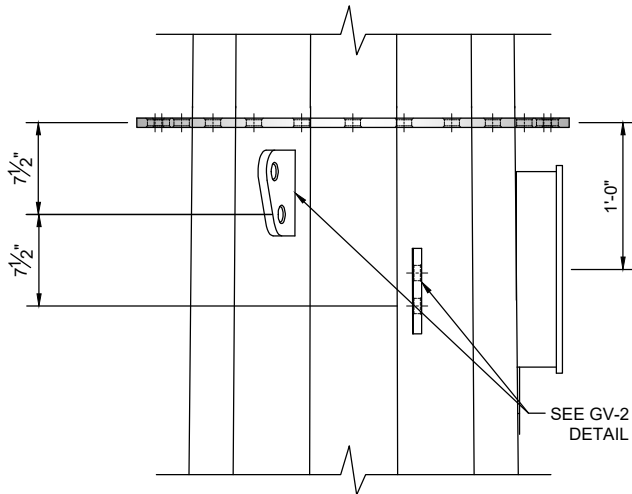




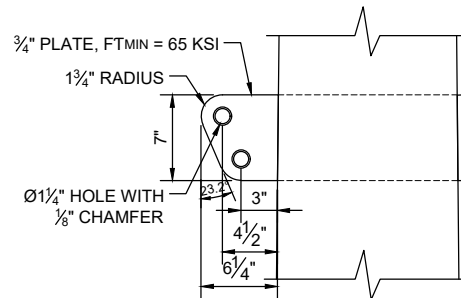
TOP VIEW
SCALE: 3/4" = 1'-0"



DETAIL C ELEVATION VIEW B-B
SCALE: 3/4" = 1'-0"



DETAIL C ELEVATION VIEW A-A
SCALE: 3/4" = 1'-0"



GUY VANG DETAIL 2
SCALE: 3/4" = 1'-0"

| | | | | |
|------------------------------|----------------------|--------------------|---|-----------------------|
| PREPARED EMILIO CUADRADO | LICENSE NO. 3000 | DATE 03/18/2025 | WAREHOUSE CODE N/A | SCALE 3/4" = 1'-0" |
| REVIEWED OSCAR VENEGAS | LICENSE NO. 23125 | DATE 03/18/2025 | DOCUMENT NO. 4751.008 APPENDIX-C R00 | |
| APPROVED REINALDO BARETTY | LICENSE NO. 16712 | DATE 03/18/2025 | SHEET 4 OF 4 | |

115 - 230KV STEEL POLE TYPE - C
TYPE C-SC-GS-88.5
GUYING CONFIGURATION AND DETAIL
TRANSMISSION LINE ENGINEERING



APPENDIX D

| LOADING TABLE 1: TANGENT TYPE A STRUCTURE- 800 FT - 0-3 deg | | | | | | | | | | |
|---|--|---|--------------------------|------|-----|--|------|-----|------------|--|
| LOAD CASE | LOADING CASE DESCRIPTION | OVERLOAD CAPACITY FACTORS | OPGW-DNO-12494 (KIPS) | | | 1192.5 KCMIL ACSR "BUNTING" (KIPS) | | | W (PSF) | |
| | | | Ts | Ls | Vs | Tc | Lc | Vc | | |
| 1 | NESC Warm Island Rule 250B (9 psf Wind, 50° F., K=0.30) | VERTICAL: 1.50 TENSION: 1.65 WIND: 2.50 | 1.6 | - | 0.5 | 2.7 | - | 1.9 | 22.5 | |
| 2 | NESC EXTREME WIND Rule 250C (54 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 2.7 | - | 0.3 | 5.6 | - | 1.3 | 54 | |
| 3 | LUMA HURRICANE WIND (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.10 TENSION: 1.10 WIND: 1.10 | 3.6 | - | 0.4 | 7.4 | - | 1.4 | 72 | |
| 4 | LUMA BROKEN WIRE (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.10 TENSION: 1.10 WIND: 1.10 | 1.8 | 12.2 | 0.2 | 3.7 | 21.4 | 0.8 | 72 | |
| 5 | EVERYDAY (0 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 0.4 | - | 0.3 | 0.3 | - | 1.3 | 0 | |
| 6 | LUMA CLEARANCE CHECK (9 psf Wind, 80° F., K=0.30) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 0.8 | - | 0.3 | 1.2 | - | 1.3 | 9 | |

NOTES:
(1) 19500 LBS CONDUCTOR TENSION, UNDER HURRICANE 160MPH
(2) 11120 LBS GROUND WIRE TENSION, UNDER HURRICANE 160MPH
(3) W=WIND ON PROJECTED AREA OF POLE, WITH OVERLOAD FACTORS.
(4) CONDUCTOR AND SHIELD WIRE LOADS ARE PER PHASE AND WITH OVERLOAD FACTORS.

| LOADING TABLE 2: STRAIN TYPE B STRUCTURE - 800 FT - 0-10 deg | | | | | | | | | | |
|--|--|---|--------------------------|------|-----|--|------|-----|------------|--|
| LOAD CASE | LOADING CASE DESCRIPTION | OVERLOAD CAPACITY FACTORS | OPGW-DNO-12494 (KIPS) | | | 1192.5 KCMIL ACSR "BUNTING" (KIPS) | | | W (PSF) | |
| | | | Ts | Ls | Vs | Tc | Lc | Vc | | |
| 1 | NESC Warm Island Rule 250B (Intact) 10° (9 psf Wind, 50° F., K=0.30) | VERTICAL: 1.50 TENSION: 1.65 WIND: 2.50 | 3.2 | - | 0.5 | 4.2 | - | 1.9 | 22.5 | |
| 2 | NESC EXTREME WIND Rule 250C (Intact) (54 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 4 | - | 0.3 | 7.8 | - | 1.3 | 54 | |
| 3 | LUMA HURRICANE WIND (Intact) 10° (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.10 TENSION: 1.10 WIND: 1.10 | 5.1 | - | 0.4 | 10.0 | - | 1.4 | 72 | |
| 4 | LUMA HURRICANE WIND (Broken Wire) 0° (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.10 TENSION: 1.10 WIND: 1.10 | 2.5 | 12.2 | 0.2 | 5 | 21.4 | 0.8 | 72 | |
| 5 | EVERYDAY (0 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 1.3 | - | 0.3 | 1 | - | 1.3 | 0 | |
| 6 | LUMA CLEARANCE CHECK (9 psf Wind, 80° F., K=0.30) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 1.7 | - | 0.3 | 2 | - | 1.3 | 9 | |
| 7 | LUMA STRINGING (3 psf Wind, 80° F., K=0.00) | VERTICAL: 1.50 TENSION: 1.50 WIND: 1.50 | 1.1 | 11.1 | 3.5 | 0.8 | 9.1 | 4.4 | 4.5 | |

NOTES:
(1) 19500 LBS CONDUCTOR TENSION, UNDER HURRICANE 160MPH
(2) 11120 LBS GROUND WIRE TENSION, UNDER HURRICANE 160MPH
(3) W=WIND ON PROJECTED AREA OF POLE, WITH OVERLOAD FACTORS.
(4) CONDUCTOR AND SHIELD WIRE LOADS ARE PER PHASE AND WITH OVERLOAD FACTORS.
(5) STRINGING LOADS SHOULD BE APPLIED TO ALL ATTACHMENTS POINTS SIMULTANEOUSLY.

| LOADING TABLE 3: DEAD-END TYPE C STRUCTURE - 800 FT - 45-90 deg | | | | | | | | | | |
|---|--|---|--------------------------|------|-----|--|------|-----|------------|--|
| LOAD CASE | LOADING CASE DESCRIPTION | OVERLOAD CAPACITY FACTORS | OPGW-DNO-12494 (KIPS) | | | 1192.5 KCMIL ACSR "BUNTING" (KIPS) | | | W (PSF) | |
| | | | Ts | Ls | Vs | Tc | Lc | Vc | | |
| 1 | NESC Warm Island Rule 250B (Intact) 90° (9 psf Wind, 50° F., K=0.30) | VERTICAL: 1.50 TENSION: 1.65 WIND: 2.50 | 19.3 | - | 0.5 | 19.2 | - | 1.9 | 22.5 | |
| 1A | NESC Warm Island Rule 250B (Dead End) 90° (9 psf Wind, 50° F., K=0.30) | VERTICAL: 1.50 TENSION: 1.65 WIND: 2.50 | 9.6 | 9.3 | 0.3 | 9.6 | 8.9 | 1.1 | 22.5 | |
| 2 | NESC EXTREME WIND Rule 250C (Intact) (54 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 16.4 | - | 0.3 | 28.3 | - | 1.3 | 54 | |
| 2A | NESC EXTREME WIND Rule 250C (Dead-End) (54 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 8.2 | 7.4 | 0.2 | 14.2 | 12.5 | 0.7 | 54 | |
| 3 | LUMA HURRICANE WIND (Intact) 90° (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.10 TENSION: 1.10 WIND: 1.10 | 19.4 | - | 0.4 | 34.8 | - | 1.4 | 72 | |
| 4 | LUMA HURRICANE WIND (Dead- End) 45° (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.20 TENSION: 1.20 WIND: 1.20 | 7.4 | 14.2 | 0.2 | 13.4 | 24.8 | 0.8 | 78.6 | |
| 4A | LUMA HURRICANE WIND LA (Dead-End) 90° (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.20 TENSION: 1.20 WIND: 1.20 | 10.6 | 9.4 | 0.2 | 19.0 | 16.5 | 0.8 | 78.6 | |
| 5 | LUMA HURRICANE WIND LA 45° (Dead-End) (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 6.1 | 11.8 | 0.2 | 11.2 | 20.7 | 0.7 | 66 | |
| 6 | LUMA HURRICANE WIND LA 90° (Dead-End) (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 8.8 | 7.9 | 0.2 | 15.8 | 13.8 | 0.7 | 66 | |
| 6A | LUMA HURRICANE WIND LA 90° (Intact) (66 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 17.6 | - | 0.3 | 31.6 | - | 1.2 | 66 | |
| 7 | EVERYDAY (0 psf Wind, 80° F., K=0.00) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 10.2 | - | 0.3 | 8.4 | - | 1.2 | 0 | |
| 8 | LUMA CLEARANCE CHECK (9 psf Wind, 80° F., K=0.30) | VERTICAL: 1.00 TENSION: 1.00 WIND: 1.00 | 10.9 | - | 0.3 | 10.5 | - | 1.3 | 9 | |

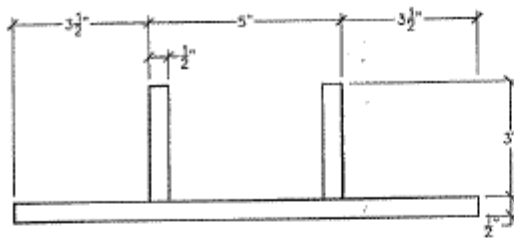
NOTES:
(1) 19500 LBS CONDUCTOR TENSION, UNDER HURRICANE 160MPH
(2) 11120 LBS GROUND WIRE TENSION, UNDER HURRICANE 160MPH
(3) W=WIND ON PROJECTED AREA OF POLE, WITH OVERLOAD FACTORS.
(4) CONDUCTOR AND SHIELD WIRE LOADS ARE PER PHASE AND WITH OVERLOAD FACTORS.

LOADING NOTES:

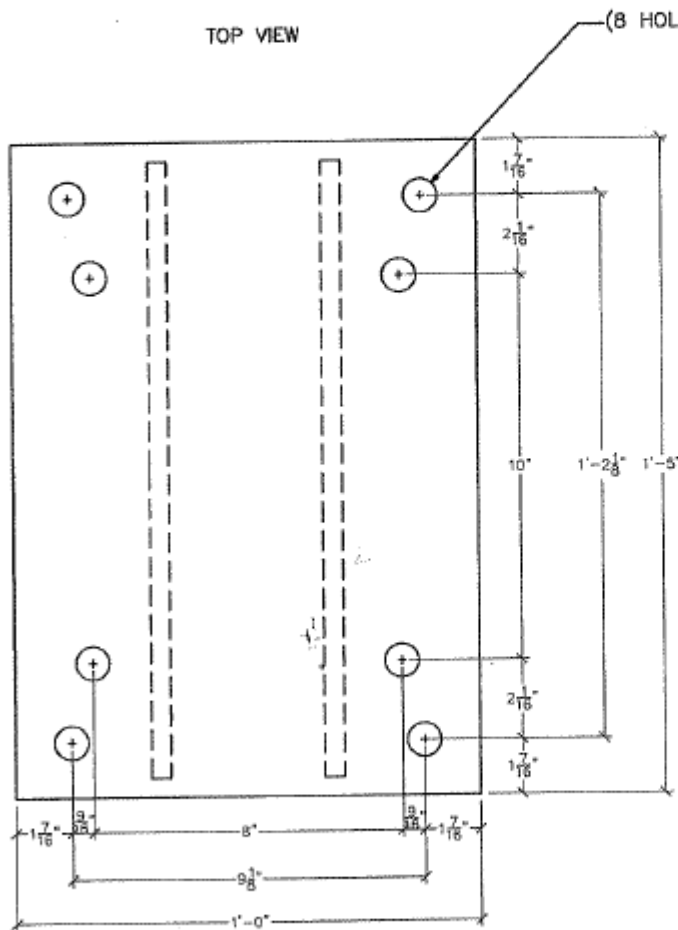
- ALL LOADS IN THE TABLE INCLUDE OVERLOAD FACTORS INCLUDING STRUCTURE WIND PRESSURE.
- WIND PRESSURE SHALL BE APPLIED IN THE DIRECTION THAT PRODUCES MAXIMUM STRESSES.
- FOR CONSTRUCTION LOAD CASES, THE DEFLECTION OF THE STRUCTURE SHALL BE RESTRICTED TO 2% OF THE POLE HEIGHT.
- MAXIMUM DEFLECTION OF THE POLE SHALL BE RESTRICTED TO 8% OF THE POLE HEIGHT UNDER ALL INTACT CASES
- BROKEN WIRE LOAD CASE SHALL BE APPLIED FOR ONE WIRE POSITION AT A TIME. FOR THE INTACT WIRE POSITIONS USE HURRICANE INTACT LOADING.
- THE CONSTRUCTION LOAD CASE CONSIDERS A DE CONDITION UNDER 3PSF WIND AND 60F WEATHER CONDITIONS, WERE ALL AHEAD OR ALL BACK WIRES ARE INSTALLED.

APPENDIX E

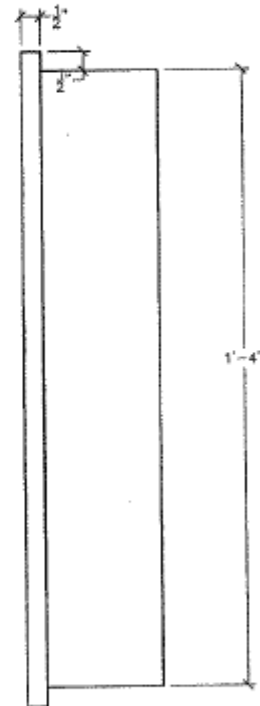
115 / 230 kV Post Insulator Brackett Assembly



TOP VIEW



FRONT VIEW



LATERAL VIEW











4751.008 V05 115kV-230kV Transmission Guyed Steel Poles (Type A, Type B, Type C)

Final Audit Report

2025-03-27

| | |
|-----------------|--|
| Created: | 2025-03-27 |
| By: | Oscar E Venegas (oscar.venegas@lumapr.com) |
| Status: | Signed |
| Transaction ID: | CBJCHBCAABAAo2aUMuF3idzgEOdWVnxU7dwztlA8S2rS |

"4751.008 V05 115kV-230kV Transmission Guyed Steel Poles (Type A, Type B, Type C)" History

-  Document created by Oscar E Venegas (oscar.venegas@lumapr.com)
2025-03-27 - 2:40:11 PM GMT
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2025-03-27 - 2:40:28 PM GMT
-  Document emailed to Reinaldo Baretty (reinaldo.baretty@lumapr.com) for signature
2025-03-27 - 2:40:29 PM GMT
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-  Email viewed by Oscar E Venegas (oscar.venegas@lumapr.com)
2025-03-27 - 2:43:09 PM GMT
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Signature Date: 2025-03-27 - 2:43:25 PM GMT - Time Source: server
-  Email viewed by Ricardo Castro (ricardo.castro@lumapr.com)
2025-03-27 - 3:12:18 PM GMT
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