

UNITED STATES DEPARTMENT OF AGRICULTURE  
Rural Utilities Service

RUS BULLETIN 1724E-206

**SUBJECT:** Guide Specification for Spun, Prestressed Concrete  
Poles and Concrete Pole Structures

**TO:** All Electric Borrowers

**EFFECTIVE DATE:** Date of Approval

**Office of Primary Interest:** Transmission Branch, Electric Staff  
Division

**PREVIOUS INSTRUCTIONS:** None

**FILING INSTRUCTIONS:** File with 7 CFR Part 1724. This bulletin  
can be accessed via Internet at:

<http://www.usda.gov/rus/regs/>

**PURPOSE:** This bulletin provides a basis for procuring spun,  
prestressed concrete poles and concrete pole structures.

Blaine D. Stockton Jr. /s/  
Assistant Administrator  
Electric Program

12/22/97  
Date

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**INSTRUCTIONS WHEN USING RUS GUIDE SPECIFICATIONS FOR SPUN,  
PRESTRESSED CONCRETE POLES AND CONCRETE POLE STRUCTURES**

**A. Purpose:** This guide specification provides a basis for procuring spun, prestressed concrete poles or concrete pole structures. If poles are competitively bid, use of this specification will eliminate ambiguities which might arise in the evaluation process.

Terminology used in this specification has been simplified in order to provide consistency. Referring to the owner can also mean the owner's representative or Engineer.

The owner is responsible for completing this specification and adding other information, drawings and supplemental requirements as appropriate. It may be necessary for the owner to modify this specification in order to consider special applications or preferences.

**B. Scope:** This purchase specification covers the technical aspects of design, materials, manufacturing, inspection, testing, and delivery of spun, prestressed concrete poles and concrete pole structures. It does not include front-end documents or specifications for construction. The owner has to add front-end documents including instructions to the bidders and general conditions. This specification may be expanded to include H-frame structures.

**C. Initial Design Considerations:** There are several engineering decisions required of the user of this specification when ordering concrete poles or concrete pole structures that this technical specification does not cover in detail. Some examples include, but are not limited to:

- Amount of foundation rotation to consider for incorporating P-delta moments;
- Location of point of fixity;
- Embedment depths;
- Guy wire modulus of elasticity;
- Load cases to be considered in addition to those required by the National Electrical Safety Code (NESC); and
- Deflection limitations.

The user should perform the engineering required for these types of issues or employ an engineering consultant to do so.

**D. Information to be Completed by the Owner** - When using these specifications the owner should detach sheets 1a to 14a and the Commentary, and add or complete the following:

**D.1 Documents and general information to be added to the technical specification:** A number of front-end documents and general information needs to be added to this technical specification.

- a. **RUS Form 198 (Recommended for competitive bidding)**
- b. **Supplemental Instructions to Bidders**
- c. **General Conditions**

It is recommended that RUS Form 198 be used for competitive bidding. This form covers Notice and Instructions to Bidders, Proposal, and Equipment Contract. Other supplemental information which the owner may want to add includes Bid Submission, Bid Price, and Schedule, Bid Acceptance Period, Bid Requirements, Bid Data, and Bidder's Qualifications. A section on General Conditions could include such items as Definition of Terms, Inspection and Acceptance, Interpretation of Bid Documents, Addenda to the Bid Documents, Insurance, Method of Payment (if Form 198 is not used), Quantities, and Tabulation of Unit Prices.

**D.2 Specifications and technical information to be completed by the Owner:**

a. **Configuration requirements and other information (Attachment A of the specification or equivalent):**

- (1) Structure dimensions;
- (2) Conductor support locations (orientation and height);
- (3) Shield wire support location(s) (orientation and height);
- (4) General load information;
- (5) Underbuild support locations (orientation and height); and
- (6) Guy attachment locations (orientation and height).

b. **Structural requirements (Attachment B or equivalent)**

- (1) **Design loads**, with and without overload factors for deflection and cracking requirements.

Minimum loads have to meet the NESC requirements appropriate for the loading district, and any local codes, the NESC extreme wind load provisions, and any necessary extreme ice and wind conditions with the appropriate overload factors. The ASCE Guidelines for Transmission Line Structural Loading can be used for developing loads produced by climate, accidents, construction and maintenance. If crossarms are required, they should be able to sustain a minimum working load of 500 pounds for possible loads from line crews, conductors, and insulators. Calculations need to include the vertical, transverse, and longitudinal loads with wind on the structure and the dead weight of the structure for any given loading condition applied simultaneously.

(2) **Pole deflection limitations, if any.** If deflection limitations are required, specify the loading condition(s) without overload factors.

(3) **Embedment depth(s).** The owner should specify the embedment depth and the point of fixity, if different from the groundline. The owner should specify the maximum anticipated foundation rotation or deflection. If different for individual loading cases, the owner must indicate these requirements in the loading tables (Attachment B). The manufacturer should consider them in the design of the poles when specified.

(4) **Guys, crossarms, and bracing.** The owner should specify the location, orientation, slope, type, size and strength of guys, arms, etc., if any are required (Attachment A or B).

**c. Application Requirements (Attachment C to be completed by the Owner).**

(1) The supplier of the steel arms, guy attachments, and hardware.

(2) Diameter and taper limitations.

(3) Desired method of surface protection, if required. Any special corrosion problems should be identified in order for the manufacturer to recommend a solution.

(4) Location of climbing and/or working devices and the quantity of each to be supplied with the poles.

(5) Pole tests and number of load cases for each test.

(6) Component weight and/or length restrictions.

(7) Delivery schedule, F.O.B. location, and owner's contact.

(8) Special handling requirements.

(9) Additional requirements. Additional items such as special pole color (stain, paint, or dye additive), attachment requirements, arms, attachment hardware, bolts, grounding requirements, guy modulus of elasticity, hot line maintenance requirements, rigging requirements, cant holes, pole splices, switch operating mechanisms, etc.

**E. Information to be Completed by the Manufacturer**

**E.1 The owner should have the following information completed and submitted by each bidder (Attachment E or equivalent).**

- a. Calculated weight of each concrete pole and concrete pole structure;

- b. *For the controlling load case and any other load cases as required by owner for evaluating bids, design calculations including the maximum reactions (moments, shears, and axial loads, including overload factors) in poles at the groundline or point of fixity, and guy wire loads;*
- c. *Pole diameter at top, bottom, and groundline;*
- d. *Tip and butt wall thickness;*
- e. *Prestress strand - quantity, size, and dropout location;*
- f. *28-day compressive strength of concrete; and*
- g. *Diameter taper (in/ft).*

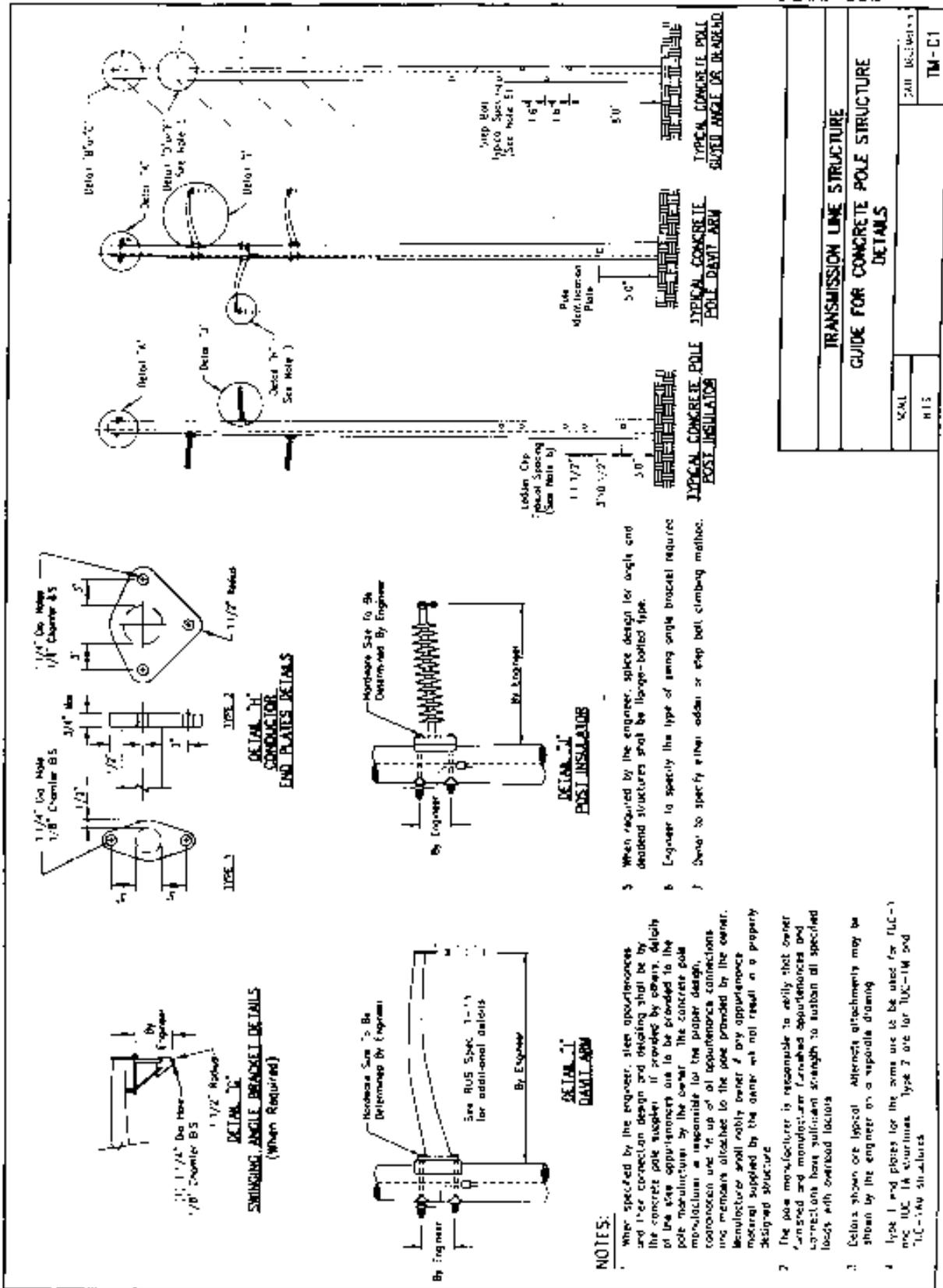
**E.2 The owner should have the following information completed by the successful bidder prior to pole manufacture:**

- a. *For each load case, design calculations including the maximum reactions (moments, shears, and axial loads, including overload factors) in poles at the groundline or point of fixity, and in guy wires;*
- b. *Deflections and analyzed stress reactions every 10 feet;*
- c. *Type of material of major components (ASTM number and grade);*
- d. *Quantity, size, and grade of prestressing strands or other reinforcement;*
- e. *Description of pole including thickness, length, diameter, and tape.*
- f. *Method of attaching arms, braces, hardware, and miscellaneous equipment to the pole if supplied by the bidder; and*
- g. *Design exceptions.*

**E.3 Test reports as requested by the owner.**



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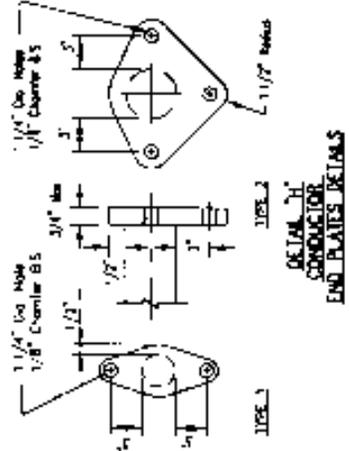
TRANSMISSION LINE STRUCTURE  
GUIDE FOR CONCRETE POLE STRUCTURE  
DETAILS

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REVISION		
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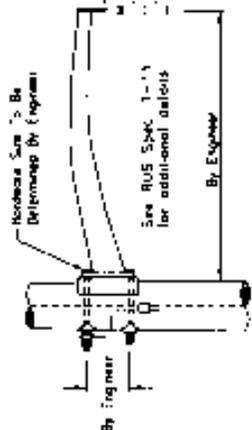
NOTES:

- When specified by the engineer, stem attachments and wire connection design and detailing shall be by the concrete pole supplier. If provided by others, details of the stem attachments are to be provided to the pole manufacturer by the owner. The concrete pole manufacturer is responsible for the proper design, construction and use of all attachments, connections and members attached to the pole provided by the owner. Manufacturer shall notify owner of any attachments material supplied by the owner that not result in a properly designed structure.
- The pole manufacturer is responsible to verify that owner furnished and manufacturer furnished attachments and connections have sufficient strength to sustain all specified loads with overhead factors.
- Details shown are typical. Alternate attachments may be shown by the engineer on a separate drawing.
- Type 1 end plates for the arms are to be used for TUC-1 and TUC-1A structures. Type 2 are for TUC-114 and TUC-149 structures.

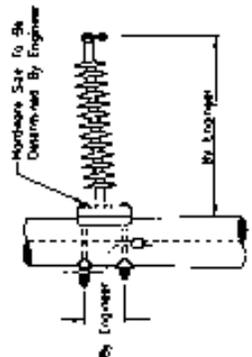
- When required by the engineer, splice design for length end deadend structures shall be lap-joint type.
- Engineer to specify the type of jacking single bracket required.
- Owner to specify either saddle or step bolt climbing method.



SWINGING ANGLE BRACKET DETAILS  
(When Required)

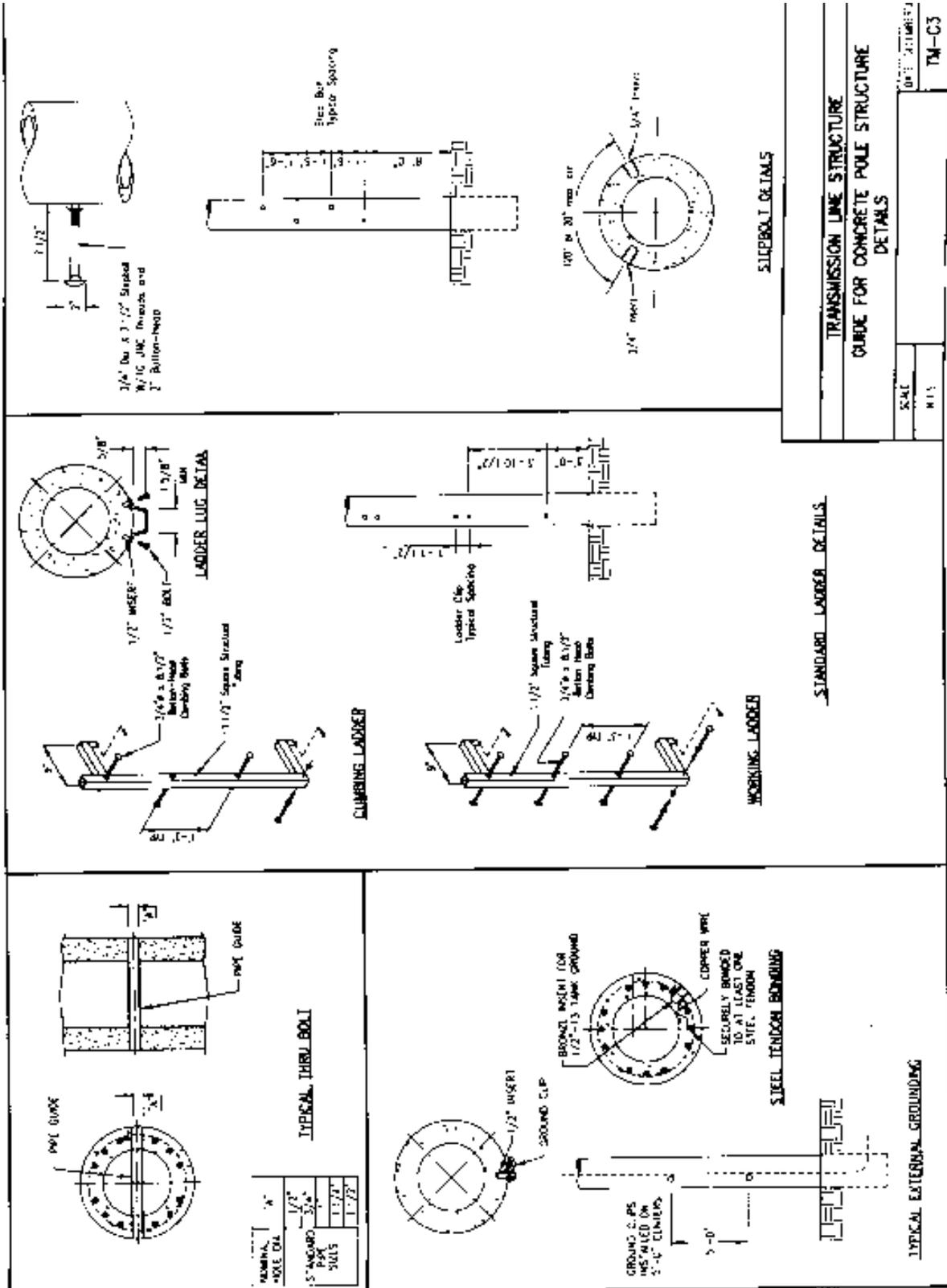


DETAIL 1  
DAVIT ARM



DETAIL 2  
POST INSULATOR

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TRANSMISSION LINE STRUCTURE	
GUIDE FOR CONCRETE POLE STRUCTURE	
DETAILS	
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**TECHNICAL SPECIFICATIONS FOR SPUN, PRESTRESSED  
CONCRETE POLES AND CONCRETE POLE STRUCTURES**

1. **Scope:** This specification covers the design, materials, manufacture, inspection, testing, drawings, shipping, and delivery of spun, prestressed, concrete poles or concrete pole structures.

2. **Definitions**

**Admixture** - Any material other than water, aggregate, or cement that is used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties.

**Appurtenance** - Any hardware or structural members that are attached to the concrete pole to make a complete structure.

**Bonding, electrical** - The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.

**Cant hole** - A through hole in the pole which is used in rotating the pole about its axis during setting. The hole is typically 1-1/2" in diameter and located approximately 4 feet above the *groundline*.

**Circumferential cracks** - Cracks that parallel a cross-section of a concrete pole.

**Cracking moment** - The moment which is developed in the pole at the time the *cracking strength* of the pole is experienced.

**Cracking strength** - The point at which the concrete just begins to separate due to exceeding the tensile strength of the concrete on the tension face of the pole.

**Deadend structure** - A type of guyed or unguyed structure on which the conductors are connected by strain insulators, with the usual purpose of terminating the conductor tension.

**Deleterious substance** - Any substance that is not desirable in a mixture, usually causing harm in sufficient quantities.

**Dropout, steel cable** - The terminating point of any longitudinal steel that is not continuous for the length of the pole.

**Efflorescence** - The formation of a white film on the surface of the pole, typically caused by the emergence of chlorides during curing.

**Embedment** - That portion of the pole which is designed to be located in the ground or other supporting medium.

**Factored load** - See *Ultimate Load*.

**Foundation deflection** - The magnitude and direction of displacement of the embedded portion of the pole or supporting foundation which is expected to occur with the response of the soil or supporting medium to the applied loading conditions. It is usually expressed in inches from the plumb position at the groundline or point below the groundline where supporting soil begins.

**Foundation rotation** - The degree and direction of rotation of the embedded portion of the pole or supporting foundation about the *groundline* or *point of fixity*, if specified, which is expected to occur with the response of the soil or supporting medium to the applied loading conditions.

**Groundline** - The point at which the *embedment* begins. Groundline is used for transmission line design such as determining ground clearances. Resistance from the supporting soils or other medium begins at or below *groundline*.

**Group of bolt holes** - All of the holes in which a single hardware assembly will be attached.

**Guyed structure** - A structure in which cable supports are used to increase its lateral load resistance.

**In-line face** - The face of the pole which "faces" an adjacent structure in the line.

**Load cycle** - The point at which a structure has undergone the range of loadings that are expected to occur over the life of the structure.

**Load case** - A group of loadings, restraints, (*foundation deflections* and *foundation rotations*) which are simultaneously applied to the structure at a particular point in time. Additional structural performance requirements may also be included.

**Longitudinal cracks** - Cracks in concrete that parallel to the long axis of the pole.

**Longitudinal reinforcement** - The *reinforcing steel* which is installed along the long axis of the pole.

**Manufacturer** - The company responsible for the fabrication of the poles. The *manufacturer* makes the poles based on the design drawings developed by the *structural designer*.

**Modulus of elasticity** - The slope of the stress-strain diagram within the proportional range of an elastic material.

**Overload factor** - A multiplier which is applied to each of the vertical, transverse, and longitudinal structure loadings to obtain an *ultimate factored load*. The multiplier takes into account the variability of climatic events as well as the importance of the structure.

**Owner** - The Rural Utilities Service borrower procuring the concrete poles.

**P-delta moment** - The secondary moment created by vertical loads acting on the structure which deflects from its unloaded position.

**Pole end symmetry** - Pole ends having the same size, shape, and relative position of parts on opposite sides about the pole axis.

**Point of fixity** - The point on the pole at or below groundline where the maximum moment occurs. Location of this point is dependent on the characteristics of soils around the embedded portion of the pole.

**Pole failure** - The point at which the maximum strength of the pole is realized. Failure usually occurs with crushing of the concrete or permanent deformation.

**Pole sweep** - The measure of deviation from straightness along the length of the pole.

**Post-tensioned steel strand** - The longitudinal reinforcement that has been tensioned after the concrete has hardened.

**Prestressed concrete** - Reinforced concrete in which internal stresses have been introduced to reduce potential tensile stress in concrete resulting from loads.

**Pretensioned steel strand** - The longitudinal reinforcement that has been tensioned before concrete is placed. Also referred to as prestressed steel strand.

**Pyrite staining** - A pale brass-yellow colored stain in the concrete caused from the concrete mixture containing an excess amount of iron disulfides.

**Reinforcing steel** - Any steel for the purpose of reinforcement of the concrete, including *longitudinal reinforcement*, *spiral reinforcement*, and deformed reinforcing bars.

**Release strength** - The minimum concrete strength that is necessary before the *pretensioned strands* can be released.

**Secondary stresses** - The additional stresses created by continued application of the loads as the structure displaces or deflects from its unloaded position.

**Service load** - The loading which is usually synonymous to the NESC district loadings without *overload factors* applied, and sometimes referred to as *unfactored district load* or *working load*. The *service load* may also be a greater ice and/or wind load when compared to the NESC district loads. Any *service load*, multiplied by the appropriate *overload factor* will give the *ultimate load*.

**Spiral reinforcement** - Steel reinforcement, continuously wound in the form of a cylindrical helix, that encloses the longitudinal steel.

**Spun concrete pole** - A pole which is manufactured by placing *prestressed steel strands* and *spiral reinforcement* in a mold, adding fresh concrete and spinning the mold to form the pole.

**Structural designer** - The engineer(s) responsible for structural design of the poles, usually employed by or is a hired consultant of a company which fabricates concrete pole structures.

**Ultimate load** - The maximum design load which includes the appropriate *overload factor* specified.

**Ultimate moment capacity** - The moment which is developed in the pole at the time the *ultimate strength* of the structure is realized.

**Unbalanced lateral load** - Any loading of a significant duration and magnitude which is not restrained or offset by guys or cables which generates bending moments along a section of the pole.

**Ultimate strength** - The maximum strength in the stress-strain diagram. For the pole, this is considered to be the point at which the pole fails, usually with crushing of the concrete.

**Unfactored district load** - See *Service Load*.

**Unfactored extreme load** - The extreme wind, ice, or other extreme loading without considering an *overload factor*.

**Unfactored load** - A loading in which the *overload factor* has not been applied.

**Working load** - See *Service Load*.

**Yield strength** - The minimum stress at which a material will start to physically deform without further increase in load or which produces a permanent strain. This is known as the elastic limit of the material.

**Zero tension strength** - The moment at which a crack that was previously created by exceeding the cracking moment strength will open again. Under this condition, an applied moment will not cause any tensile stress in the concrete. It will always be less than the cracking moment strength.

### 3. Codes and Standards

Codes, standards, or other documents referred to in this specification are to be considered as part of it. In the event of a conflict between this specification and the National Electrical Safety Code (NESC), the

NESC shall be followed. In the event of a conflict between this specification and all other referenced documents, this specification shall be followed. If a conflict between several referenced documents occurs, the more stringent requirement shall be followed. If clarification is necessary, contact the owner.

The most recent editions of the following codes and standards shall be followed in the design, manufacture, inspection, testing, and shipment of spun, prestressed concrete poles:

**3.1 American Concrete Institute (ACI):**

ACI 318, Building Code Requirements for Reinforced Concrete

**3.2 Prestressed Concrete Institute (PCI):**

MNL 116, Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products

**3.3 American Welding Society (AWS):**

AWS D1.1, Recommended Procedures for Welding, Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction

**3.4 American Society for Testing Materials (ASTM):**

ASTM A82	Steel Wire Plain, For Concrete Reinforcement
ASTM A416	Steel Strand, Uncoated 7-wire For Prestressed Concrete
ASTM A421	Uncoated Stressed Relieved Steel For Prestressed Concrete
ASTM A496	Steel Wire, Deformed For Concrete Reinforcement
ASTM A615/A615M,	Deformed and Plain Billet-Steel Bars For Concrete Reinforcement
ASTM A617/A617M,	Axle-Steel Deformed and Plain Bars For Concrete Reinforcement
ASTM A641M	Zinc Coated (Galvanized) Carbon Steel Wire (Metric)
ASTM A706A/A706M,	Low Alloy Steel Deformed Bars For Concrete Reinforcement
ASTM C31 and 39,	Specifications for Sampling Concrete and Testing Concrete Cylinders
ASTM C33	Concrete Aggregates
ASTM C150	Portland Cement
ASTM C172	Sampling Freshly Mixed Concrete

ASTM C289	Testing Potential Alkali-Silica Reactivity of Aggregates
ASTM C494	Chemical Admixtures For Concrete
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C1089	Standard Specification For Spun Cast Prestressed Concrete Poles

**3.5 Industrial Fasteners Institute (IFI):**

Fastener Standards

**3.6 American National Standards Institute (ANSI) C2, National Electrical Safety Code**

**3.7 American Society of Civil Engineers/Prestressed Concrete Institute (ASCE/PCI) Joint Committee on Concrete Poles:**

Guide for the Design of Prestressed Concrete Poles, latest edition

**4. General Requirements** The design, fabrication, processes, tolerances, and inspection of poles shall conform to the following:

**4.1 Design Requirements**

**4.1.1** Pole designs shall be prepared from the attached configuration drawings and design loads. The pole shall be capable of withstanding all specified loading cases including wind on pole and secondary stresses from foundation deflection and rotation, and from vertical loads acting on lateral pole deflection (P-delta effect). Design of poles for these secondary stresses shall not consider the possible restraining effect of conductors or shield wires. The pole shall withstand the loads without failure and without exceeding any specified deflection limitations.

**4.1.2** Poles shall withstand the loading conditions, including specified overload factors. The pole design shall include allowances for loads from handling, transportation, and erection without failure, permanent deformation, or damage to the pole when handled according to the manufacturer's instructions. (See Section 6.1)

**4.1.3** Poles shall be designed by the ultimate strength method as explained in ACI 318. Poles shall be designed so that the ultimate strength of the pole exceeds the required strength calculated from the factored loads applied to the pole including wind on the pole, as specified by the owner. The point of fixity on the pole shall be considered at groundline or other location as specified with the embedment depths shown on the attached drawings.

**4.1.4** Poles shall be designed so that the cracking strength of the pole exceeds the required strength calculated from the service loads applied to the pole, as specified by the owner.

**4.1.5** Poles that are subjected to a permanent unbalanced lateral load (such as unguyed angle or unguyed deadend structures), or any other structures specified by the owner, shall be designed so that the zero tension strength of the pole exceeds the required strength calculated from the service loads applied to the pole, as specified by the owner.

**4.1.6** Poles shall be designed in combination with the appropriate column load applied along the pole axis as a result of the guys, braces, etc. When guys are specified, the ultimate load in the guy shall not exceed 65 percent of the rated breaking strength of the guy for all load cases. For design purposes, guy wire modulus of elasticity shall be specified by the owner. The manufacturer shall advise the owner if the specified guy size is inappropriate prior to submitting a bid.

**4.1.7** Poles shall be designed to withstand a one-point (tilting) pickup during erection. The manufacturer shall include the weight of the pole with all insulators and hardware attached. The poles shall be designed for two-point pickup for horizontal handling. All pickup points shall be clearly shown on the fabrication drawings. All poles shall be designed for the loads generated from handling and erecting without exceeding the cracking moment capacity of the poles.

**4.1.8** The design of each pole shall be performed using the applicable codes and standards listed in Section 3.0 of this specification.

**4.1.9** Pole design and design calculations shall be the responsibility of the manufacturer.

## **4.2 Materials**

**4.2.1** The chemical properties of materials used in the manufacture of the poles shall meet the requirements of the applicable ASTM specification and be such that noticeable pyrite staining or efflorescence due to sulfates and/or chlorides does not occur.

**4.2.2** All anchors and inserts provided by the manufacturer shall be hot dip galvanized or noncorrosive material. Cadmium-plated and aluminum material shall not be used. All inserts shall be noncorrosive materials designed and manufactured for the intended purpose and used according to manufacturer's recommendations. If the manufacturer considers lifting devices necessary or desirable, suitable flush inserts may be cast into the pole with removable lifting attachments.

**4.2.3** The concrete shall have a minimum 28-day compressive strength of 5,000 psi with a maximum water-cement ratio of 0.40. Higher strengths and lower water-cement ratios are encouraged and may be necessary to offset steel cover requirements.

**4.2.4** The cement shall be either Type I, II, III, or V portland cement conforming to ASTM C 150. Flyash can be used in the cement. Use of flyash cement requires owner approval.

**4.2.5** Fine aggregate shall be a natural sand, consisting of clean, strong, hard, durable uncoated particles conforming to ASTM C 33, and all specifications included therein. The aggregate shall be well graded from No. 4 to No. 200 sieve. Deleterious substances shall not comprise more than 5 percent of the sample.

**4.2.6** Coarse aggregate shall be clean, tough, crushed stone conforming to ASTM C 33, and all specifications included therein. The aggregate shall be well graded from a 3/4 inch to a No. 8 sieve with no more than 5 percent of the sample passing a No. 8 sieve. Deleterious substance content shall not exceed 5 percent of the sample. Resistance to abrasion shall not exceed 40 percent as tested in conformance with ASTM C 131. Absorption shall be less than 4 percent or aggregate shall be saturated with water prior to use in concrete.

**4.2.7** Aggregate shall be tested in accordance with ASTM C 289 to determine an alkali-aggregate reaction. Crushed rock or partially crushed rock shall be the source of the aggregate.

**4.2.8** Water shall be clean, free from undesirable amounts of oils, acids, alkalis, salts, organic materials, or other deleterious substances.

**4.2.9** Admixtures shall conform to ASTM C 494. Air entraining admixtures can be used if approved by the owner. Admixtures shall not contain chloride ions in quantities that would cause the total chloride content of the concrete to exceed 0.4 pound per cubic yard.

**4.2.10** Prestressing steel mechanical properties, reinforcing steel and spiral reinforcement shall be in accordance with the applicable ASTM specifications listed in Section 3.0 of this specification.

**4.2.11** Concrete mix design requirements listed above can be altered with the owner's approval.

### **4.3 Workmanship**

**4.3.1** The pole shall be circular in cross section and the diameter, as measured at any location on the pole, shall not vary by more than 1/4 inch from any other measurement taken on that cross section.

**4.3.2** The pole shall have a uniform taper from top to butt.

**4.3.3** Deviation of the pole from straightness is allowed in one plane and one direction only. A straight line joining the edge of the pole at the butt and the edge of the pole at the top shall not be further from the surface of the pole at any point by more than the accumulated value of 0.25 inches for each 10 feet of length between the two ends. The detensioning operation shall be performed in a manner to keep the prestressing forces symmetrical.

**4.3.4** Prestressing steel stress limits shall not exceed:

- a. 80 percent of the ultimate strength or 94 percent of the yield strength or the maximum value recommended by the manufacturer of prestressing steels or anchorages for jacking force;
- b. 74 percent of the ultimate strength or 82 percent of the yield strength immediately after prestress transfer; and
- c. 70 percent of the ultimate strength for post-tensioned steel at anchorages and couplers immediately after anchorage.

**4.3.5** Spiral reinforcement shall cover the entire pole length. The minimum clear spacing of spiral reinforcement in the top 2 feet and bottom 2 feet of the pole shall be  $4/3$  of the maximum coarse aggregate or three times the strand diameter, whichever is larger, but not less than one inch. The maximum clear spacing for the remainder of the pole shall not exceed 4 inches.

**4.3.6** Clear distance between prestressing steel strands shall be either  $4/3$  times the maximum aggregate size or 3 times the strand diameter, whichever is larger. In the event that this condition is not met at the pole tip, closer spacing would be permitted provided that the placement of concrete can be accomplished satisfactorily, adequate stress transfer can take place, and appropriate provisions are used for maintaining spacing between the prestressing steel strands.

**4.3.7** The manufacturer shall provide holes through each pole as specified on the pole framing guide drawing(s). Preformed holes shall be cast using rigid PVC inserts (or other suitable material) held firmly in place. Plugs may be used with the owner's approval. Preformed inserts shall be sized for the specified hole diameter and shall be full length of pole diameter for all through holes. Unless otherwise noted on the drawings, holes shall be perpendicular to and pass through the centerline of the pole.

**4.3.8** The pole manufacturer shall provide preformed inserts at two locations to allow air circulation within the pole. Inserts shall be 1 inch minimum diameter and shall have a louvered opening. The inserts shall be located within 10 feet of the tip and within 10 feet above the groundline.

**4.3.9** Holes may not be drilled through the pole wall, except as specifically necessary to correct errors or omissions and only if approved by the owner.

**4.3.10** The longitudinal steel shall not be cut for any reason unless approved by the owner. The owner may reject any pole in which the longitudinal steel is cut. All exposed steel resulting from drilled holes shall be covered with an epoxy paste per ASTM C881 Type III. Areas with moderate or severe spalling shall be cleaned and reformed with an epoxy paste or epoxy concrete per ASTM C881 Type II.

**4.3.11** The owner shall have the right to reject any pole in which the performance of a bolted connection may be reduced due to the lack of a clearly preformed or drilled hole.

**4.4 Manufacturing Tolerances**

Manufacturing tolerances shall be limited to the following:

Pole Length	$\pm 2$ inches, or $\pm 1$ inch $\pm 1/8$ inch per 10 feet of length, whichever is greater (i.e. - 120 foot pole shall have a length of 120 feet $\pm 2 1/2$ inches)
	-6 inches or +12 inches for assembled spliced structure
Pole Diameter	$\pm 1/4$ inch
Wall Thickness	1/4 inch or 12 percent of wall thickness. (Note: This requirement may be waived provided that structural adequacy and durability are not impaired.)
Pole End Symmetry	$\pm 1/2$ inch per foot of pole diameter
Pole Sweep	1/4 inch per 10 feet of pole length
Pole Weight	$\pm 10$ percent calculated value
Location of longitudinal	+ 1/4 inch and $\pm 1/8$ inch reinforcement placement for the centroid of a group
Location of spiral	$\pm 25$ percent of clear spacing required with total reinforcement placement required quantity per 3 feet of pole length maintained.
Location of a group of bolt holes from top of the pole	$\pm 2.0$ inches
Location of bolt holes within a group of bolt holes	$\pm 1/8$ inch
Location of centerline between groups of bolt holes	$\pm 1.0$ inch
Bolt hole diameter	$\pm 1/16$ inch of specified diameter (Note: The specified diameter is up to 1/4 inch greater than bolt diameter.)
Bolt hole alignment	Not to vary from the longitudinal pole centerline of that group of holes by more than 1/8 inch
Location of identification plate	$\pm 2.0$ inch

#### 4.5 Grounding

**4.5.1** An external pole ground wire shall be used. Threaded inserts for attaching ground wire clips that hold the external ground wire shall be sized and positioned per the attached drawings.

**4.5.2** Except for bonding of the steel tendons, there shall be no internal pole grounds. A minimum of one longitudinal steel strand shall be bonded electrically to a threaded bronze insert at the top and bottom of the pole. Each bond shall be located within the top 2 feet of the pole and at one foot below groundline (See attached drawings). For spliced poles an additional bond shall be provided above and below the splice to a threaded bronze insert within 24 inches of the splice. Steel splice sections shall have the appropriate number of grounding attachments. This bonding system shall be noncorrosive and shall be approved by the owner.

**4.5.3** If required by the owner, manufacturer shall provide ground wire clamps for all ground wire attachments.

#### **4.6 Climbing Devices**

**4.6.1** Clips for removable ladders shall begin not closer than 3 feet above the base plate or 3 feet above ground for a direct embedded pole and extend to the top of the pole. Each ladder clip shall be designed to support a minimum 1,000 lb. shear working load. Ladder clips shall be located to avoid interference between ladders and other attachments.

**4.6.2** Removable step bolts shall be provided with spacing as indicated beginning 8 feet above groundline and extending to the structure top. Each step lug and step bolts shall be capable of withstanding a minimum of 500 lb. working load. Step bolt mounting nuts shall be spaced at 1 foot 6 inch intervals and oriented to provide maximum ease of climbing.

#### **4.7 Inserts**

**4.7.1** Inserts shall be made of materials which will not deteriorate in the environment in which they are placed. The insert shall be made of materials that will not react unfavorably with the concrete or fasteners. The insert shall not be made of materials that will corrode and stain the concrete.

**4.7.2** Inserts shall not fail before the pole reaches ultimate strength, unless permitted by the owner.

#### 4.8 Cover

4.8.1 There shall be a minimum of 3/4 inch of clear concrete cover over all longitudinal reinforcement and all spiral reinforcement as a result of the concrete spinning process. Poles not meeting this requirement shall be rejected except as allowed by Section 4.8.2.

4.8.2 There shall be a minimum specified wall thickness of 2.5 inches of spun concrete at all points along the pole.

4.8.2.1 An actual wall thickness of less than 2.5 inches of spun concrete may be allowed from the pole tip to 3 feet below the pole tip provided the cover requirements of Section 4.8.1 are met in the spinning process and provided the pole can meet all other requirements of the specifications.

4.8.2.2 The owner shall, as soon as possible, be notified of any poles with less than 3/4 inch of spun concrete inside cover within 3 feet of the pole tip. At the owner's sole discretion, the owner may reject the pole or may allow the pole to be repaired by swabbing the interior with an epoxy liner (per ASTM C881 - Type V, Class B or C) and plugging with 3,000 psi. concrete to the owner's satisfaction to a distance of 42 inches from the tip. No pole shall be plugged or considered for acceptance by the owner unless assurance is made by the manufacturer that the repaired pole can meet all requirements of this specification.

#### 4.9 Splices

4.9.1 Flange-bolted or slip-joint type of splices are permitted. When required, flange-bolted type splice shall be used at guyed structures.

4.9.2 The reinforcing steel and connection apparatus comprising the splice shall be properly anchored as part of the pole. The pole shall be designed to fail before the splice fails by yielding of the splice steel.

4.9.3 The axis of the pole shall not be distorted after the pole is mated. Shims will not be allowed to straighten the pole unless approved by the owner. The owner reserves the right to reject a pole based on the improper mating of a pole splice.

#### 4.10 Appurtenances

4.10.1 See Attachment C for list of appurtenances and associated supplier(s).

4.10.2 For appurtenance material that owner supplies, owner shall provide manufacturer connector and/or member locations, orientations, sizes, types, and strength capacities in Attachment C.

4.10.3 All steel appurtenance connections and members designed and supplied by the manufacturer shall be in accordance with the latest

editions of the ASCE Design of Steel Transmission Pole Structures and the AISC Manual of Steel Construction.

**4.10.4** Regardless of the supplier, the concrete pole manufacturer is responsible for the proper design coordination and fit up of all appurtenance connections and members to the pole(s). Manufacturer shall notify owner if any appurtenance material supplied by owner will not result in properly designed structure.

**4.10.5** For appurtenance material manufacturer supplies, manufacturer shall provide torque requirements for all load carrying bolts including step bolts.

#### **4.11 Finishing**

**4.11.1** The surface of the pole shall have a smooth finish with no unsealed cracks. Cracks shall be sealed either by use of an epoxy injection system following the epoxy manufacturer's specifications, or by V-notching the crack on a 1:1 slope to a minimum depth of 1/4 inch, then filling the V-notch with an epoxy seal per ASTM C881 Type IV. Covering the crack with an epoxy coating will not be allowed.

**4.11.2** Small cavities caused by air bubbles, honeycomb spots, or other small voids, shall be cleaned thoroughly, saturated with water and then carefully pointed with a cement mortar. A small cavity is defined as one not larger than 1/2 inch in diameter or deeper than 1/4 inch.

**4.11.3** If any cavities or voids absorb water which indicate the void extends into wall of the pole, then the pole shall be rejected.

**4.11.4** The manufacturer shall seal both ends of the pole and protect the steel stands from corrosion. The system used shall be approved by the owner.

**4.11.5** The center void at the top and bottom ends of the pole shall be sealed with a minimum 6 inch and 12 inch thick 1000 psi strength concrete plug respectively. This plug shall be securely bonded to the pole. Sharp edges shall be tooled to form smooth, chamfered corners. The top of the pole shall be rounded to avoid ponding of rain water.

**4.11.6** Where application of epoxy-aggregate mortar is specified, the surface of the pole where the mortar is to be applied shall first be coated with the epoxy coating. This coating shall be allowed to cure to a tacky, but not hardened state, before the mortar is applied. After the mortar has been applied and allowed to cure for 24 hours, a top coat of epoxy coating, 5 mil thick, shall be applied over the mortar and the surrounding area of the pole.

#### **4.12 Marking**

**4.12.1** Each pole shall be identified with the manufacturer's identification plate. The following information shall be stamped into the plate with letters not less than 1/4 inch in height:

Manufacturer's name  
Day, month, and year of manufacture  
Structure number  
Length of pole  
Ultimate moment capacity at groundline or point of fixity  
Pole framing designation (per framing guide) or pole type  
Owner's name

**4.12.2** The manufacturer's identification plate shall be fabricated from a noncorrosive, nonstaining metal such as bronze, brass, Series 300 stainless steel, or an aluminum alloy that will not react unfavorably with concrete. The plate shall have suitable anchor or anchors welded to the back of the plate to permit bonding to the pole.

**4.12.3** The identification information listed above may be cast into the surface of each pole. These marks shall be at least 3/4 inch in height and 1/8 inch deep.

**4.12.4** The identification plate or cast in-place markings shall be located on an in-line face of the pole in the direction of the transmission line. The bottom of the identification plate or last line of the cast in-place markings shall be located five feet above the groundline.

**4.12.5** Each pole shall be marked with the information listed below. A permanent marker shall be used and the writing shall be kept small but legible. For spliced poles, each section shall be marked as below:

- a. Support points;
- b. Two-point pickup location for handling the pole in the horizontal position;
- c. One-point pickup location for use in raising the pole to a vertical position and handling during the setting operation;
- d. Pole length, fabrication number, structure number, and pole framing guide number on the butt of the pole; and
- e. Cant hole locations, if required by owner.

## **5.0 Inspection And Testing**

### **5.1 General**

**5.1.1** Manufacturing and testing procedures shall be in compliance with applicable codes and standards listed in Section 3.0 in this specification.

**5.1.2** Upon request, the manufacturer shall furnish the owner with certified test reports for the steel and concrete used.

## **5.2 Inspection**

**5.2.1** The manufacturer shall make adequate tests and inspections to determine that each of the poles furnished is in strict accordance with this specification. At the request of the owner, the manufacturer shall submit a quality assurance report to the owner prior to the shipment of each pole and shall include the following minimum information:

- Fabrication number and owner's structure number;
- Minimum and maximum tip wall thicknesses and steel coverages (to inside and outside) measurements shall be made at 3 inches from the tip;
- Minimum and maximum butt wall thicknesses and steel coverages (to inside and outside) measurements shall be made at 3 inches from butt;
- Condition of pole interior and evidence of exposed rings or reinforcement steel;
- Proper hole and insert locations and sizes;
- Evidence of cracking during or after two-point handling.
- Actual manufactured pole weight;
- Report of any repairs made to the pole;
- Date of manufacture and inspection(s); and
- Inspector's seal.

**5.2.2** All material and workmanship shall be subject to inspection, examination, and test for conformance to the requirements of this specification by the owner. The inspection, examination, or testing could be done at any time during material procurement, manufacturing, storage periods, transit, or at the pole destination. Inspection, examinations, and tests may be waived by the owner, but in no case shall this be interpreted as releasing the manufacturer from the manufacturer's responsibilities for delivering poles that meet the requirements of this specification.

**5.2.3** The owner shall have free entry, at all times, while work is being carried on, to all parts of the manufacturer's plant where manufacture of the owner's poles is being performed. The manufacturer shall afford the owner reasonable facilities, without charge, to satisfy the owner that the poles are being manufactured in strict accordance with this specification.

**5.2.4** The manufacturer shall furnish certified test reports to the owner, upon request, showing the results of all of the tests required by this specification and applicable reference specifications.

**5.2.5** Tests shall be in accordance with all applicable standard specifications and codes.

**5.2.6** Failure of the manufacturer to comply with these specifications will be sufficient reason for rejection of any or all poles which do not comply with these specifications.

### **5.3 Concrete and Aggregate Testing**

**5.3.1** Concrete used on owners' poles shall have the quality to meet the design strength and other requirements included in this specification.

**5.3.2** For manufacturers that batch their own concrete, the manufacturer shall take a minimum of 8 concrete test cylinders per representative sample. Samples shall be taken at minimum intervals of one per day, one per 25 cubic yards of concrete batched, and with each change in raw material supplier for batches used to make the owners' poles. The test cylinders for each day's concrete that is batched shall be tested for compressive strength as follows:

- a. Minimum of one for determining release strength;
- b. Minimum of one at 7 days;
- c. Minimum of one at 14 days; and
- d. Minimum of one at 28 days.

**5.3.3** For manufacturers that acquire concrete from outside sources, test cylinders shall be taken from each truck load of concrete and tested in accordance with this specification.

**5.3.4** Test cylinders shall be prepared, then cured in the same curing environment as the pole itself or cured per the applicable ASTM specification.

**5.3.5** Upon request from the owner, the manufacturer shall provide owner statistical data on concrete strength quality in accordance to applicable ACI and ASTM specifications. A correlation factor between rodded cylinders and the spun concrete, substantiated by test data, shall be provided.

### **5.4 Structure Testing**

**5.4.1** Details of all test procedures contained herein and methods of measuring and recording test loads and deflections shall be specified by the manufacturer and approved by the owner prior to manufacture.

**5.4.2** Material procurement for test poles shall be identical to material procurement procedures for regular production run poles.

**5.4.3** The design load testing of any specific pole shall be on a full-scale basis. Costs for such testing shall be the responsibility of the owner, shall be separated from the manufacturer's bid, and shall be negotiated in advance of any test preparation.

**5.4.4** The number, location, direction, holding time, sequence, and increments of the test loads along with the number, location, and

direction of deflection readings for an individual pole test shall be approved by the owner prior to pole testing.

**5.4.5** The method of attaching the test loads to the pole, applying the test loads, measuring and recording the test loads, and measuring and recording the deflections shall be approved by the owner prior to pole testing.

**5.4.6** A full report listing results shall be submitted to the owner after completion of all testing. Copies of mill test reports shall be included in the load test report. The report shall also include a complete description of the load tests with diagrams and photographs. If required, the manufacturer shall provide the owner with the following testing data:

- a. Location of testing;
- b. Method of full scale testing: upright or horizontal; and
- c. The pole tester shall issue the owner three (3) copies of the Pole Test Report. This report shall include descriptions, tools, and drawings describing the above test.

**5.4.7** Use of any factory tested poles to meet order requirements shall be determined by the owner.

## **6.0 Shipping And Delivery**

### **6.1 Shipping**

**6.1.1** If appurtenances are to be supplied by the manufacturer of the concrete poles, each shipment shall be accompanied by a list of all parts, identifiable by structure type and number. Arms, bolts, and miscellaneous hardware shall be identified by the list for match up with the respective pole shaft. All parts required for any one structure shall be in one shipment, if possible.

**6.1.2** The owner and owner's representative shall be notified prior to shipment that such shipment is to take place, and the owner reserves the right to postpone a shipment. The owner has the right to inspect the components prior to shipment. The notification of a shipment shall give quantities, weight, name of common carrier used, and expected time of arrival.

**6.1.3** Poles shall be lifted and supported during manufacturing, stockpiling, and transporting only at the lifting or support points, or both, as designed by the manufacturer.

**6.1.4** Transportation and site handling shall be performed with acceptable equipment and methods by qualified personnel. The manufacturer shall exercise precaution to protect poles against damage in transit.

6.1.5 Poles shall be sufficiently cured before shipment to resist forces from handling, transportation, and construction.

6.1.6 Handling instructions shall be included with the pole shipment.

**6.2 Delivery**

The owner (or the owner's construction contractor) may take delivery at a designated location or with the delivering carrier's cooperation and consent, have the poles transported to the installation locations with the carrier's equipment. The manufacturer shall coordinate and cooperate with the owner to ensure smooth and efficient delivery of poles. The owner will provide all labor, equipment, and materials for the unloading of poles at the project site. A pole is considered delivered when the pole is lifted from the trailer or semitrailer of the delivery carrier by the owner.

**7.0 Drawings And Information To Be Supplied By The Manufacturer**

**7.1 Information To Be Supplied With The Proposal:**

- a. Calculated weight of each concrete pole and concrete pole structure.
- b. For the controlling load case and any other load case required by owner, the maximum reactions (moments, shears, and axial loads, including overload factors) in poles at the groundline or point of fixity and guy wire loads.
- c. Pole diameter at top, bottom, and groundline.
- d. Tip and butt wall thickness.
- e. Prestress strand - quantity, size, and dropout location.
- f. Design strength of concrete (28 day compressive strength).
- g. Diameter taper in/ft.

For all other load cases specified by owner the above information shall be provided by the manufacturer following award of bid.

**7.2 Information And Drawings To Be Supplied For Owner's Approval Prior To Fabrication:**

**7.2.1** For each load case, design calculations including the maximum reactions (moments, shears, and axial loads, including overload factors) in poles at the groundline or point of fixity, guy wire loads, deflections, and analyzed stress reactions every 10 feet.

**7.2.2** After the manufacturer's proposal has been accepted, the manufacturer shall submit to the owner two prints of each fabrication drawing. One set of these drawings will be returned to the manufacturer with indication of review corrections. Where a correction is required, two sets of revised prints shall be resubmitted to the owner. These prints shall be marked "Revised" and dated.

**7.2.3** Final fabrication drawings for each different framing pattern and pole calculations for each load case shall be submitted to and approved by the owner before release of order for manufacture.

**7.2.4** All design and detail drawings shall be reviewed and approved by the owner before pole manufacture.

**7.2.5 Information To Be Provided On Drawings:** The manufacturer shall be responsible for the correctness of dimensions and details on the drawings. The review of such drawings by the owner shall not relieve the manufacturer of this responsibility.

Drawing titles shall clearly indicate the owner's name and pole-type identification. Each detail drawing shall include the following minimum information:

- a. Complete dimensional information;
- b. Description and location of all steel reinforcements, and, if dropout system is used, the location of each steel cable dropout;
- c. Twenty-eight day strength of concrete and strength of concrete at time of release of pretensioning strands;
- d. Steel strand prestress loads;
- e. Size, description, quantity, and location of all holes and hardware that is a part of the pole;
- f. Weight and location of the center of gravity of the pole;
- g. Location of pickup points and storage points. Both pickup locations and recommended storage locations shall be shown;
- h. Location of climbing devices and grounding inserts;
- i. Pole identification plate location and details;
- j. Location of groundline;
- k. The ultimate moment and cracking moment capacities at the groundline or point of fixity; and
- l. Any other special information deemed necessary by the manufacturer and owner.

## **8.0 Approvals, Acceptance, And Ownership**

**8.1** Final designs must be approved by the owner before material ordering. Material ordering and fabrication prior to approval of the owner will be at the manufacturer's risk. Award of the contract to the manufacturer does not constitute acceptance of design calculations submitted with the bid. If corrections are required in the final pole designs due to manufacturer's errors, omissions, or misinterpretations of the specifications, the quoted price shall not change. Approval of the drawings and calculations by the owner does not relieve the manufacturer of responsibility for the adequacy of the design, correctness of dimensions, details on the drawings, or the proper fit of parts.

**8.2** Upon delivery, poles shall be free of defects and blemishes which would have a detrimental effect on the structure capacity and/or longevity of the pole. They also shall be smooth, attractive, unscarred and in new condition. Poles not meeting these requirements

shall be repaired or replaced by the manufacturer at no additional cost to the owner.

**8.3** Poles failing to meet strength requirements, poles with circumferential or longitudinal cracks, poles failing to meet manufacturing tolerances or cover requirements, poles with exposed steel, poles with cavities that absorb water, and spliced poles that do not fit together properly or are distorted after mating shall be rejected by the owner and replaced by the manufacturer at no cost to the owner.

**8.4** If the delivered weight of a pole will exceed the calculated weight by 5 percent, the manufacturer shall notify the owner of the actual weight before pole delivery. Any pole whose delivered weight exceeds or is below 10 percent of its calculated weight may be rejected by the owner.

**8.5** All final drawings shall become the property of the owner, who shall have full rights to reproduce and use them, but shall not share them with other concrete pole suppliers.

### **9. List of Attachments**

(Attachments A,B,C, and D to be completed by the engineer.  
Attachment E to be completed by the manufacturer.)

- Attachment A, Structure Dimensions and Other Information
- Attachment B, Design Loads
- Attachment C, Application Requirements
- Attachment D, Drawings
- Attachment E, Bid Summary-Design Information, Weights, and Costs (Information to be Submitted with Proposal)

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## Attachment C Application Requirements

1. Appurtenance Material
  - a. Arms and mounting hardware to be supplied by..\_\_\_\_\_
  - b. Guy attachment and mounting hardware to be supplied by .....\_\_\_\_\_
  - c. Hardware other than items 1 and 2 above to be supplied by .....\_\_\_\_\_

For appurtenance material that owner supplies, owner shall provide manufacturer connector and/or member locations, orientations, sizes, types, and strength capacities with this Attachment.

2. Pole deflection limitations
  - a. Structure Type.....\_\_\_\_\_
  - b. Amount of deflection limits .....\_\_\_\_\_
  - c. Loading conditions for deflection limits.....\_\_\_\_\_
3. Maximum anticipated foundation rotation measured from the vertical axis(degrees) and maximum anticipated deflection at the groundline (inches).....\_\_\_\_\_
4. Maximum diameter at groundline (in)
  - a. Tangent: \_\_\_\_\_
  - b. Angle: \_\_\_\_\_
  - c. Deadend: \_\_\_\_\_
5. Maximum taper (inches/foot) based on total difference between top and bottom diameters.....\_\_\_\_\_
6. Guy wire modulus of elasticity.....\_\_\_\_\_
7. Climbing device desired by owner.....\_\_\_\_\_
8. Unguyed angle poles to be raked or plumb.....\_\_\_\_\_
9. Unguyed tangent deadends to be raked or plumb.....\_\_\_\_\_

**Attachment C (Cont'd)**  
**Application Requirements**

- 10. Special handling requirements.....
- 11. Component weight restrictions.....\_\_\_\_\_
- 12. Pole length restrictions.....\_\_\_\_\_
- 13. Delivery schedule.....\_\_\_\_\_
- 14. Free on board destination (F.O.B.).....\_\_\_\_\_
- 15. Structures to be tested:

Structure Type	Load Cases to be Tested
a.	
b.	
c.	

- 16. Additional Requirements

**Attachment D**  
**Drawings**

(Drawings to be added by owner)

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## APPENDIX A

## COMMENTARY

**A. General**

The necessity of a clear bid specification for the purchase of concrete poles is very important to the bid evaluation process and the acquisition of structurally adequate poles. The specification should contain sufficient requirements and information so that all bids can be evaluated equally and so that the manufacturer clearly understands what is expected of the manufacturer.

**B. Section 4. Design****Loads (Section 4.1)**

The primary loads for concrete poles are weather and erection loads. Common handling loads are determined by the manufacturer and included in the manufacturer's design. Weather, construction, and maintenance loads need to be clearly specified by the owner. The location and direction of loads should be indicated in a loading agenda or loading trees, and should have units of Newtons, pounds, or kips (or for uniform wind loads on the structure, pascals, lb. per square feet, or kips per square feet). The specifying of loads in the form of general environmental criteria such as wind velocity or radial thickness of ice, is insufficient. Not only is there difficulty in evaluating bids, but there also is a greater possibility of error in calculated design loads. Overload factors for NESC light, medium, and heavy loading districts should be at least equal to those given in the applicable edition of NESC for Grade B construction. Overload factors for extreme ice and extreme wind shall be at least 1.1. The manufacturer's analysis should include secondary moments due to the vertical moving from its original position (see p-delta effect).

Reliability based design has shown that the NESC district loading alone may not be a desirable service loading in some locations. For service loads, some owners may wish to consider a more stringent ice and/or wind loading than the NESC district loads. For example, in some locations, it may be desirable to consider an 80 mph wind loading (or other wind speed as appropriate for the location) as a service load. This wind loading would be more stringent than the 60 mph NESC Light loading. The owner may consider this 80 mph loading as occurring with the same frequency as the NESC district loading occurs in other locations, hence the need to designate the 80 mph wind as a service load.

An extreme loading condition occurs infrequently. Statistically, the extreme load will occur once every 50 to 100 years. The overload factor of at least 1.1 is applied to this type of loading. In the example above, the owner which considers the service load to be an 80 mph wind, will consider a much higher wind loading as the extreme wind load.

In addition to using the NESC district loading requirements, the ASCE publication, "Guidelines for Transmission Line Structure Loading" can be used to provide owners with procedures for the selection of design loads and load factors related to climate, accidents, construction, and maintenance.

**Point of Fixity** (Section 4.1)

Point of fixity for this specification is defined as the location on the pole where maximum moment occurs. Maximum moment is calculated by the pole designer using the loadings provided by the owner and multiplying those loadings by the appropriate moment arms. The existing soil and backfill has to be able to support the pole with these bending moments applied. The location of this point of fixity could be at or below the groundline. The exact location is theoretical and depends on the soil condition and backfill used to support the pole. The owner should determine where the location of the point of fixity is and convey it to the structural designer.

The point of fixity should be determined by someone familiar with soils engineering. This point could be located at groundline if very good structural supporting soil is present all the way to the ground surface. However, this point is usually assumed to occur below the groundline depending on the resistance of the soil and any soil disturbance that has or could occur at the ground surface. Soils investigation and a proper analysis should be done by the owner to locate this point if the resistance of the soil is in doubt.

**Cracking Strength** (Section 4.1)

While it is desirable to avoid pole cracking under the service load conditions, such as unfactored NESC district loading and any other service loads specified by the owner, care should be taken when considering cracking strength requirements under extreme conditions with small overload factors. Initial cracking occurs at about 40-55 percent of ultimate strength of the pole. If an extreme wind is applied to a pole with a 1.1 overload factor, this load would be the same as the ultimate (factored) load. If the pole were designed with the cracking strength equal to or greater than the extreme wind load with a 1.1 overload factor, the resulting ultimate strength of the pole would be about double the strength necessary based only on the ultimate strength loading requirement.

**Zero Tension Strength** (Section 4.1)

The zero tension strength will always be less than the cracking strength. It is about 70-85 percent of the first cracking strength. The avoidance of open cracks may be necessary to protect the steel reinforcing. The conditions which may be important in order to avoid open cracks will be in situations of significant unbalanced lateral loading and in extremely corrosive environments.

Typical structures with permanent unbalanced lateral loads are unguyed angle and unguyed deadend structures. Without the owner specifying that the pole should be designed for a zero tension strength, the manufacturer may not consider this aspect in the pole design. For example, some structures may be unguyed at the static wire location, but guyed at other load points. It may be desirable for this structure to meet the strength requirements for the zero tension strength due to the cantilevered static loading.

The owner should specify which structures are to be designed for the zero tension strength requirement. In the absence of this, the pole designer should consider the unfactored loading conditions to determine if there are significant lateral loadings to warrant adherence to this strength requirement.

#### **P-Delta Effect** (Section 4.1)

Whenever there is a transverse or longitudinal load, the pole will deflect in the direction of the load. As a result, the vertical load is no longer in its original position. The vertical load moves over as the pole deflects, causing additional moments in the pole. Also, the pole weight can place significant secondary moment loads in the pole. This specification requires this moment to be included in the analysis. The additional stress caused by this secondary moment is dependent on the magnitude of the vertical load and deflected shape of the pole. Many pole designs, particularly tall poles, have to be calculated for the position of equilibrium of forces in the fully displaced position. The solution typically takes many iterations. A full nonlinear analysis will consider the change in orientation of the loads relative to the displaced positions of the structural members. The design of the pole should have this analysis performed to take into account secondary moments. Pole deflection and resulting secondary moments should be calculated for the loads (including overload factors) indicated in the loading agenda.

#### **Foundation Rotation and Deflection** (Section 4.1)

This specification allows the owner the option of specifying a foundation rotation (and point of fixity), either as a maximum for all load cases or as a certain amount for each load case. For purposes of bidding and design, the owner also has the option to specify a fixed base with no foundation rotation or deflection.

When specifying the maximum value for the foundation rotation and deflection for all load cases, the owner establishes performance requirements for the concrete pole and foundation. In determining this value, the owner may perform an engineering analysis of soils in the area where the poles are to be installed, and may consider aesthetics, phase-to-structure clearances, phase-to-ground clearances, or even the ability to replumb a structure.

The specifying of a rotation and deflection for each load case is a refinement in analysis and design which allows the owner to match types and probability of loads with foundation response. For

instance, under a 50-year extreme wind load, one may allow more foundation rotation and deflection than under NESC heavy loading district loads.

If foundation rotation and/or deflection is specified, the manufacturer should include such effects in the calculations of final deflected pole stresses. The rotation and deflections when specified should be for the respective loads with overload factors.

**Longitudinal Loads** (Section 4.1)

Because concrete poles are flexible structures, there may be a reduction in induced moments in a pole under some types of longitudinal loads due to the restraining effect of the overhead ground wires. Traditionally, static longitudinal loads are specified due to the complexity of calculating the influence of structure flexibility. The results of the EPRI project, Longitudinal Loads on Transmission Line Structures, published in August 1978, suggest design procedures for longitudinal load analysis, taking into account deflections of wires, insulators, and structures. Design curves have been developed and can be used to approximate the longitudinal loading on the structure for given line systems. Although the EPRI project is extremely worthwhile, utilization of these results by some of the bidders does present certain difficulties in bid evaluation. In order to be certain that concrete pole bids can be evaluated on an equal basis, this specification requires that all longitudinal loads specified in the loading agenda are not to be reduced due to flexibility of the structure. If the owner wishes to take advantage of structure flexibility, then the owner's engineer should estimate structure and line parameters. Using the design approach suggested in the EPRI project, the longitudinal design loads should then be specified on the loading trees. It is felt that this approach is better than having the concrete pole manufacturer account for structure flexibility for several reasons: 1) not all manufacturers have the capability to perform such an analysis, 2) the owner will have to evaluate the manufacturer's design anyway, 3) and plan and profile drawings would have to be included in the contract documents in order to properly evaluate the effect of longitudinal loads between deadends.

**Guy Wires** (Section 4.1)

Any time a concrete pole structure is guyed, the guy type, size, modulus of elasticity, and guy slope or angle has to be specified by the owner. The manufacturer needs this information to properly analyze the structure. This specification limits the load in the guy to 65 percent of its ASTM rated breaking strength. The manufacturer should design the pole and guy wire(s) as a system. The manufacturer may wish to reduce pole capacity by using a larger than specified guy wire size. This action should be avoided unless the owner approves the use of a larger guy size, and subsequent anchor changes.

In design, the loads with the respective overload factors are applied at appropriate locations on the guyed structure.

The guy modulus of elasticity can increase from a minimum value at the time of manufacture, to a maximum value which results from periodic stretching and relaxing during the load cycles. Ranges from 19,000 ksi to 28,000 ksi have been stated. The ASCE steel pole specification (ASCE Manual 72) has suggested a guy wire modulus of elasticity of 23,000 ksi be used by the pole designer whenever it is not specified.

### **Wind Induced Vibrations**

Appurtenances to concrete structures may occasionally be subject to wind induced vibrations. The owner should advise the manufacturer if the structure will be prone to wind induced vibrations. The manufacturer should detail each structure using good design practices considering this possibility. If vibrations are experienced, the owner should add additional damping to the structure. Damping may be particularly important on structures which are to be installed without conductors for an extended period of time.

### **Air Entrainment in Spun Concrete Poles (Section 4.2)**

Air entrainment in spun concrete poles is similar to air entrainment in normal concrete except the fabrication processes of pumping, vibrating, and spinning causes a large percentage of the entrained air to migrate out of the concrete. The general effects of air entrainment are to increase workability, decrease density (unit weight), decrease strength, reduce bleeding and segregation, and increase durability. For a spun concrete pole, the spinning process creates a very dense concrete and counteracts the air entrainment effects. Since pumping occurs prior to the pole being spun, the air entrainment effects are present during the fabrication of spun poles. The percentage of air entrained in a spun concrete pole after it is spun is unknown. However, it is believed poles that have concrete containing an air entrainment agent will have a higher void ratio than those without this agent. The owner has to be aware that as the percentage of air entrainment increases the concrete strength decreases.

### **Grounding (Section 4.5)**

All internal reinforcing should be bonded electrically to the external pole ground wire. This will keep the external ground and internal reinforcing potential voltage differences lower in lightning events. There have been cases reported of step lugs and other materials embedded in the concrete that were near or in contact with the reinforcing being dislodged from lightning. Spliced poles should have reinforcing on each side of the splice bonded electrically to the external pole ground wire. This should lower potential voltage differences of embedded material between each pole section.

### **C. Section 5.4 Structure Testing**

An option is available in the specification for full scale testing of poles. For a manufacturer which has been designing and fabricating concrete poles with the same processes for a good number of years, the need for testing of a concrete pole is questionable. Pole testing may be appropriate in cases where there are unusual requirements, new fabrication techniques or when new suppliers are used to validate their design.

**D. Section 7.0 Drawings and Information to be Supplied by the Manufacturer**

In order to properly evaluate bids, the specification requires certain information to be supplied with the bid. This information may be supplied on the preliminary drawings from the Bidder. If the forms in Attachment B are used, one will be able to quickly review the information on the forms and simultaneously compare the information from the different manufacturers.

**APPENDIX B**  
**EXAMPLES OF**  
**ATTACHMENTS A & B**

ATTACHMENT "B" DESIGN LOADS (CONDUCTOR 705, 207 ACS OHGW 7/16 EHS V5 1200 H.S. 900')															
LOADS WITH OLF		LOADS IN KIPS (INCLUDES O.L.F.)													
DESCRIPTION OF LOAD	TEMP °F	V1	T1	L1	V2	T2	L2	V3	L3	VG	TG	LG	W	WGT	
1. NEG. WIND	0	5.42	1.58	1.54	5.42	1.58	1.54	5.42	1.58	1.54	1.76	1.08	1.00	100	0
2. HIGH WIND (21.1 MPH)	60	2.05	1.92	--	2.05	1.92	--	2.05	1.92	0.53	0.75	--	300	0	0
3. EXTREME WIND (32.1 MPH)	32	6.11	--	--	6.11	--	--	6.11	--	2.88	--	--	--	0	0
4. UNBALANCED ICE (COND)	32	4.38	--	2.31	6.11	--	--	6.11	--	2.88	--	--	--	0	0
5. UNBALANCED ICE (OHGW)	32	6.11	--	--	6.11	--	--	6.11	--	1.70	--	2.88	--	0	0
6. HIGH WIND (NO COND)	60	--	--	--	--	--	--	--	--	--	--	--	190	0	0
LOADS WITHOUT OLF															
DESCRIPTION OF LOAD	TEMP °F	V1	T1	L1	V2	T2	L2	V3	L3	VG	TG	LG	W	WGT	
1. NEG. WIND	0	2.61	0.63	1.40	2.61	0.63	1.40	2.61	0.63	1.40	0.43	0.00	400	0	0
2. HIGH WIND (21.1 MPH)	60	2.35	1.75	--	2.35	1.75	--	2.35	1.75	0.48	0.68	--	150	0	0
3. EXTREME WIND (32.1 MPH)	32	5.06	--	--	5.56	--	--	5.56	--	1.82	--	--	--	0	0
7. NO LOAD	60	31	0.00	--	1.3	0.00	--	1.31	0.00	--	--	--	--	0	0
COMMENTS															
1. WTS FOR A SHAPE FACTOR OF 1.0															
2. LOADS 'T' AND 'L' ARE REVERSIBLE															
3. HIGH WIND FROM LOAD CASE '6' IS FROM ANY DIRECTION															
4. LOAD CASE '4' IS FOR ANY CONDUCTOR POSITION															
5. REFER TO DRAWING ON ATT. A FOR LOAD LOCATION															
GREEN IAP															
TRANSMISSION LINE STRUCTURE															
TANGENT SUSPENSION															
161 kV															
SCALE										RURAL COOPERATIVE					
DATE										10/1/79					

V1 = VERTICAL LOAD, KIPS  
 T1 = TRANSVERSE LOAD, KIPS  
 L1 = LONGITUDINAL LOAD, KIPS  
 W = WIND LOAD ON THE POLE, PSF  
 A = DEFLECTION AT GROUNDLINE

GREEN IAP  
 TRANSMISSION LINE STRUCTURE  
 TANGENT SUSPENSION  
 161 kV

SCALE  
 RURAL COOPERATIVE  
 10/1/79



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**APPENDIX C**  
**SELECTED SI-METRIC CONVERSIONS**

## APPENDIX C

## SELECTED SI-METRIC CONVERSIONS

AREA

To Convert From	To	Multiply by	
circular mil (cmil)	square meter (m <sup>2</sup> )	5.067075	E-10
square centimeter (cm <sup>2</sup> )	square meter (m <sup>2</sup> )	*1.000	E-04
square foot (ft <sup>2</sup> )	square meter (m <sup>2</sup> )	*9.290304	E-02
square inch (in <sup>2</sup> )	square meter (m <sup>2</sup> )	*6.451600	E-04
square kilometer (km <sup>2</sup> )	square meter (m <sup>2</sup> )	*1.000	E+06
square mile (mi <sup>2</sup> )	square meter (m <sup>2</sup> )	2.589988	E+06

FORCE

To Convert From	To	Multiply by	
kilogram force (kgf)	Newton (N)	*9.806650	
kip	Newton (N)	4.448222	E+03
pound force (lbf)	Newton (N)	4.44822	

FORCE PER LENGTH

To Convert From	To	Multiply By	
kilogram force per meter (kgf/m)	Newton per meter (N/m)	*9.806650	
pound per foot (lb/ft)	Newton per meter (N/m)	1.459390	E+01

DENSITY

To Convert From	To	Multiply By	
pound per cubic inch (lb/in <sup>3</sup> )	kilogram per cubic meter (kg/m <sup>3</sup> )	2.767990	E+04
pound per cubic foot (lb/ft <sup>3</sup> )	kilogram per cubic meter (kg/m <sup>3</sup> )	1.601846	E+01

LENGTH

To Convert From	To	Multiply By	
foot (ft)	meter (m)	3.048	E-01
inch (in)	meter (m)	*2.540	E-02
kilometer (km)	meter (m)	*1.000	E+03
mile (mi)	meter (m)	*1.609344	E+03

\*Exact Conversion.

Selected SI-Metric Conversions, Cont.LOAD CONCENTRATION

<u>To Convert From</u>	<u>To</u>	<u>Multiply By</u>	
pound per square inch (lb/in <sup>2</sup> )	kilograms per square meter (kg/m <sup>2</sup> )	7.030696	E+02
pound per square foot (lb/ft <sup>2</sup> )	kilograms per square meter (kg/m <sup>2</sup> )	4.788026	
ton per square foot (ton/ft <sup>2</sup> )	kilograms per square meter (kg/m <sup>2</sup> )	9.071847	E+02

PRESSURE

<u>To Convert From</u>	<u>To</u>	<u>Multiply By</u>	
kip per square inch (kip/in <sup>2</sup> )	Pascal (Pa)	6.894757	E+06
kip per square foot (kip/ft <sup>2</sup> )	Pascal (Pa)	4.788026	E+04
Newton per square meter (N/m <sup>2</sup> )	Pascal (Pa)	*1.000	
pound per square foot (lb/ft <sup>2</sup> )	Pascal (Pa)	4.788026	E+01
pound per square inch (lb/in <sup>2</sup> )	Pascal (Pa)	6.894757	E+03

BENDING MOMENT

<u>To Convert From</u>	<u>To</u>	<u>Multiply By</u>	
kilogram force meter (kgf-m)	Newton meter (N-m)	*9.806650	
kip-foot (kip-ft)	Newton meter (N-m)	1.355818	E+02
pound-foot (lb-ft)	Newton meter (N-m)	1.355818	

VELOCITY

<u>To Convert From</u>	<u>To</u>	<u>Multiply By</u>	
foot per second(ft/s)	meter per second (m/s)	*3.048	E-01
kilometer per hour (km/h)	meter per second (m/s)	2.777778	E-01
mile per hour(mi/h)	meter per second (m/s)	4/370300	E-01
meter per hour(m/h)	meter per second (m/s)	2.777778	E-04

\*Exact Conversion.

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## APPENDIX D

### CONTRIBUTORS

The following members of the Transmission Line Subcommittee of the National Rural Electric Cooperative Association, Transmission and Distribution Engineering Committee provided invaluable assistance in preparing this document.

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