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UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Development Utilities Programs

BULLETIN 1724E-206
RD-GD-2016-83

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

TO: All Electric Borrowers

EFFECTIVE DATE: Date of Approval

OFFICE OF PRIMARY INTEREST: Engineering Standards Branch; Office of Policy, Outreach, and Standards

FILING INSTRUCTIONS: This bulletin updates RUS Bulletin 1724E-206, "**Guide Specification for Spun, Prestressed Concrete Poles and Concrete Pole Structures**" issued July, 2008.

AVAILABILITY: This bulletin can be accessed via the Internet at:

http://www.rd.usda.gov/publications/regulations-guidelines/bulletins/electric

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

CONTRIBUTORS: Current and former members of the Transmission Subcommittee of the Transmission and Distribution (T&D) Engineering Committee of the National Rural Electric Cooperative Association (NRECA).

Current members:
Ballard, Dominic, **East Kentucky Power Coop.**, Winchester, KY
Beadle, Bob, **North Carolina EMC**, Raleigh, NC
Beckett, Thomas, **Enercon**, Kennesaw, GA
Fan, Quan He, **Georgia Transmission Corporation**, Tucker, GA
Johnson, Wilson, USDA, **Rural Development Utilities Program**, Washington, DC
Lukkarila, Charles, **Great River Energy**, Maple Grove, MN
McAndrew, Jeremy, **South Mississippi Electric Power Assoc.**, Hattiesburg, MS
Metro, Patti, **National Rural Electric Cooperative Association**, Arlington, VA
Nicholson, Norris, USDA, **Rural Development Utilities Program**, Washington, DC
Nordin, Bryan, **Tri-State Generation & Transmission Association, Inc.**, Denver, CO
Ruggeri, Erik, **Power Engineers**, Hailey, ID
Shambrock, Aaron, **South Central Power Company**, Lancaster, OH
Twitty, John, **PowerSouth Energy Cooperative**, Andalusia, AL

8/9/2016
Date

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ABBREVIATIONS

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
EPRI	Electric Power Research Institute
IFI	Industrial Fasteners Institute
kip	1,000 pounds
ksi	kips (1000 lb.) per square inch
LF	Load Factor
mph	miles per hour
NESC	National Electrical Safety Code
OHGW	Overhead ground wire
PCI	Prestressed Concrete Institute
psi	pounds per square inch
PVC	Polyvinyl chloride

DEFINITIONS

Borrower - An entity which borrows or seeks to borrow money from, or arranges financing with the assistance of the Agency through guarantees, lien accommodations or lien subordinations.

Rural Development Utilities Programs Forms – All forms and bulletins referred to in this bulletin are Rural Development Utilities Programs forms and bulletins, unless otherwise noted.

RUS Form 198 - Equipment Contract

Rural Development Electric Program – A program within Rural Development, under the Rural Utilities Service (RUS).

INSTRUCTIONS WHEN USING GUIDE SPECIFICATION FOR PRESTRESSED CONCRETE POLES AND CONCRETE POLE STRUCTURES

1 PURPOSE

The intent of this guide specification is to provide Rural Development Electric Program borrowers with a basis for procuring prestressed concrete poles or concrete pole structures. Use of this specification should help eliminate ambiguities that might arise in the evaluation process of competitively bid concrete pole procurements.

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.

Borrowers or their engineering representatives will need to complete and add to this specification other information, drawings and supplemental requirements as appropriate. Modifications of this specification may be necessary to consider special applications or preferences of the owner.

2 SCOPE

This suggested purchase specification covers the technical aspects of design, materials, manufacturing, inspection, testing, and delivery of prestressed concrete poles and concrete pole structures. This specification does not include contract (front-end) documents or specifications for construction. The user of this specification should add these documents, including general conditions and any supplemental instructions to the bidders. This specification may be expanded to include H-frame structures.

3 INITIAL DESIGN CONSIDERATIONS

There are engineering decisions that should be made before completing the specifications. Some examples include:

- 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.

4 INFORMATION TO BE COMPLETED BY THE OWNER

When using these specifications the owner should detach the instructions and the appendices and complete the following:

a <u>Documents and general information to be added to the technical specification:</u> A number of front-end documents and general information need to be added to this technical specification.

(1) Form 198 (Recommended for competitive bidding)
(2) Supplemental Instructions to Bidders
(3) General Conditions

When there is competitive bidding, it is recommended that RUS Form 198 be used. This form covers Notice and Instructions to Bidders, Proposal, and Equipment Contract. For item (2) above, Supplemental Instructions to Bidders, the user may want to add such items as Bid Submission, Bid Price, and Schedule, Bid Acceptance Period, Bid Requirements, and Bid Data. A section on General Conditions could include such items as Definition of Terms, Interpretation of Bid Documents, Addenda to the Bid Documents, Insurance, Method of Payment (if RUS Form 198 is not used), Quantities, and Tabulation of Unit Prices.

b <u>Requirements to the technical specifications to be added or completed by the owner or owner's representative:</u>

(1) Configuration requirements and other information (Attachment A of the Specification or equivalent):

- Structure dimensions;
- Conductor support locations (orientation and height);
- Overhead ground wire support location(s) (orientation and height);
- Underbuild support locations (orientation and height);
- Guy attachment locations (orientation and height); and
- General load information.

(2) Structural requirements:

(a) Design loads, with and without load factors for deflection and cracking requirements (Attachment B of the Specification to be added).

Minimum loads should meet appropriate NESC District Loads, NESC extreme wind loads, NESC extreme ice with concurrent winds, any extreme ice conditions and local code loads with the appropriate load factors. In addition, all structures should have sufficient strength before conductor stringing to withstand the extreme wind load applied in any direction on the structure. The ASCE Guidelines for Electrical Transmission Line Structural Loading can be used for developing loads produced by climate, accidents, construction, and maintenance. 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. If crossarms or near-horizontal members are required, consideration should be made for including appropriate vertical loads from workers.

(b) Pole deflection limitations, if any, Attachment C of the Specification, to be added**.** If deflection limitations are required, specify the loading condition(s) without load factors.

(c) Embedment depth(s), Attachment C of the Specification, to be completed**.** 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 in Attachment C. 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.

(d) Location, orientation, slope, type, size, strength of guys, (Attachment A of the Specification, and modulus of elasticity of guys, Attachment C of the Specification should be completed.

(3) Application Requirements (Attachment C of the Specification to be completed).

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

(b) Diameter and taper limitations.

(c) Guy wire modulus of elasticity

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

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

(f) Component weight and/or length restrictions.

(g) Delivery schedule, free on board (FOB) location, and owner's contact.

(h) Special handling requirements.

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

(4) Structure drawing details (Attachment D of the Specification, to be added by owner).

Drawings TUC series, TM-C1, and TM-C2 on pages ix, x, xi, xii and xiiii of these instructions are provided as guidance drawings for development of Attachment D of the Specification.

5 INFORMATION TO BE COMPLETED BY THE MANUFACTURER

a The owner should have the following information completed and submitted by each bidder. Attachment E of the specification is a sample bid summary which includes this information.

(1) Calculated weight of each concrete pole and concrete pole structure;

(2) 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 load factors) in poles at the groundline or point of fixity, and guy wire loads;

(3) Pole diameter or width at top, bottom, and groundline;

(4) Tip and butt wall thickness;

(5) Prestress strand details concerning quantity, size, and dropout location;

(6) 28-day compressive strength of concrete; and

(7) Diameter taper (in/ft).

b The owner should have the following information completed by the successful bidder prior to pole manufacture:

(1) For each load case, design calculations including the maximum reactions (moments, shears, and axial loads, including load factors) in poles at the groundline or point of fixity, and in guy wires;

(2) Deflections and analyzed stress reactions every 5 feet;

(3) Type of material of major components (ASTM number and grade);

(4) Quantity, size, and grade of prestressing strands or other reinforcement;

(5) Description of pole including thickness, length, diameter, and taper.

(6) Method of attaching arms, braces, hardware, and miscellaneous equipment to the pole if supplied by the bidder;

(7) Design exceptions; and

(8) Assembly and handling instructions

c Final documentation (as built) after construction.

d Test reports as requested by the owner.

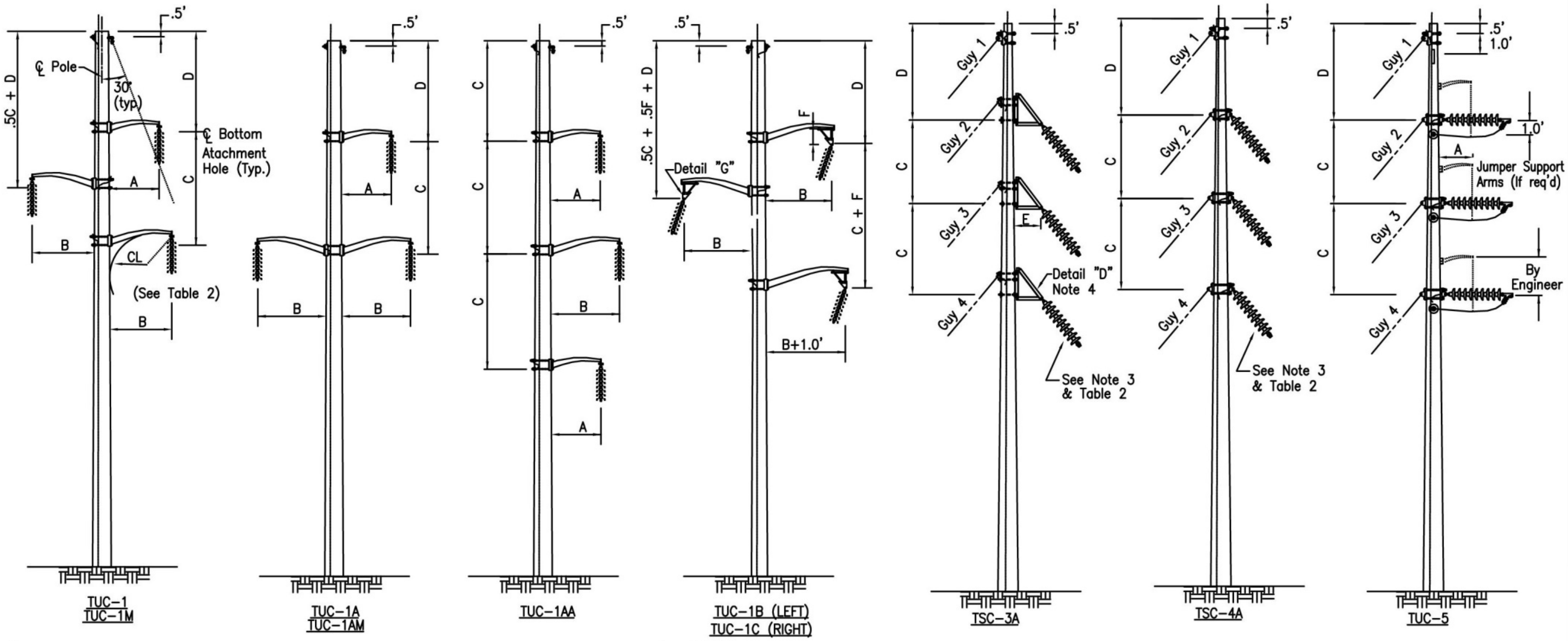


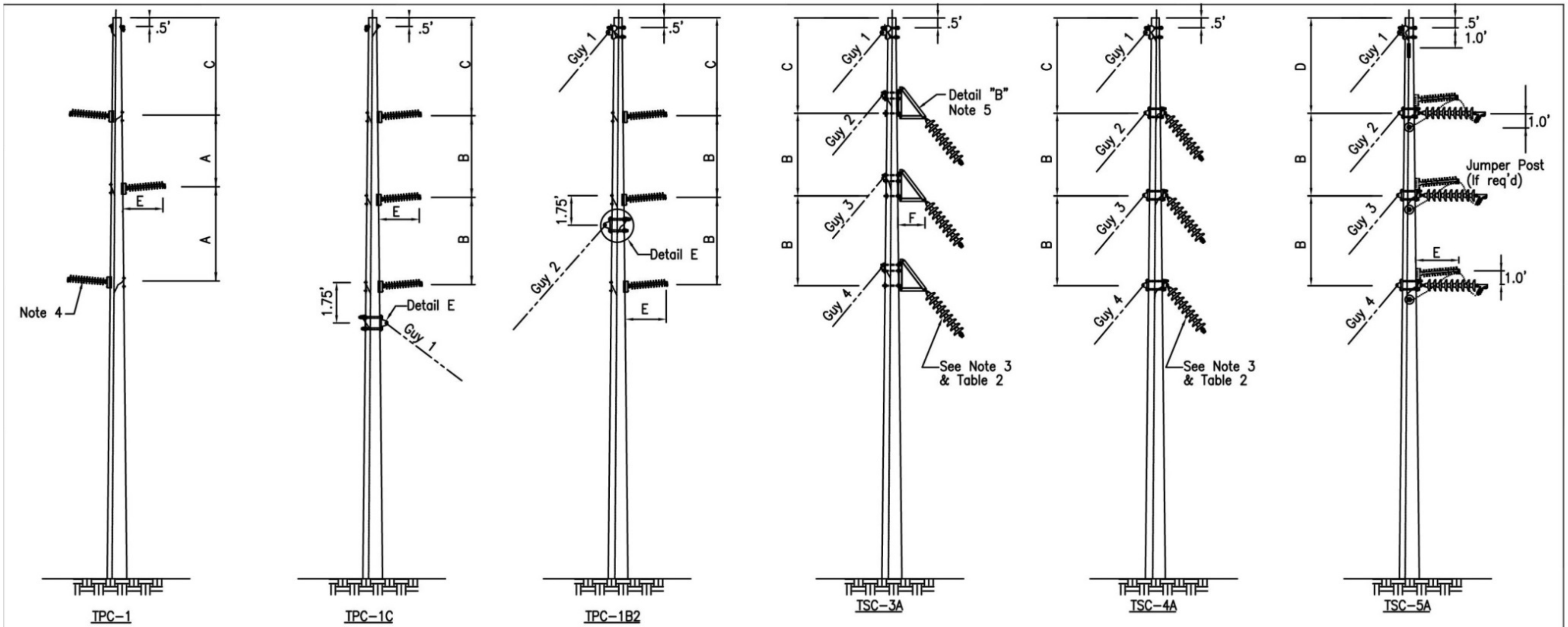
TABLE 1 – MINIMUM DIMENSIONS (FEET)								
VOLTAGE	115 KV		138 KV		161 KV		230 KV	
NUMBER OF INSULATORS	7	8	8	9	10	11	12	13
A	6.0	7.0	7.0	7.5	8.5	9.0	9.75	10.5
B	7.0	8.0	8.0	8.5	9.5	10.0	11.0	11.5
C	8.0	9.0	9.0	10.0	11.0	12.0	13.0	14.0
D	5.5	6.5	6.5	7.5	8.0	9.0	10.0	11.0
E	AS REQUIRED (BY ENGINEER)							
F	AS REQUIRED (BY ENGINEER)							

TABLE 2 – MINIMUM CLEARANCES (INCHES)								
VOLTAGE	115 KV		138 KV		161 KV		230 KV	
NUMBER OF INSULATORS	7	8	8	9	10	11	12	13
NO WIND	42	48	48	54	60	65	71	77
6 PSF WIND	26	26	30	30	35	35	52	52
EXTREME WIND	10	10	12	12	14	14	20	20

NOTES:

1. Dimensions and clearances in tables are minimums and based on the use of porcelain bell insulators. Greater dimensions may be required to improve insulator swing, galloping performance, or separation requirements. A 30 degree shielding angle is assumed. For structures of heights greater than 80 ft., the shield angle should be decreased. For high isokeraunic levels, high ground resistance, or high contamination areas use the larger number of insulators (second column for each voltage).
2. A maximum altitude of 3300 feet above M.S.L. is assumed. For higher altitudes, clearances in Table 2 should be increased.
3. The number of insulators in Table 2 are for tangent and small angle structures. For angle structures (TSC–3A and 4A), one additional insulator bell should be used. For the deadend structures (TUC–5, TUC–1M, and TUC–1AM), two additional bells should be used.
4. Engineer to specify swing angle bracket type.
5. Arm length is from face of arm bracket to end of arm shaft. Vertical dimensions between arms are from centerline to centerline of bottom attachment holes.
6. Type 1 end plates for crossarms to be with TUC–1 and TUC–1A. Type 2 plates are to be used with TUC–1M, TUC–1AM. See drawing TM–C1, Detail "H".
7. For strucutres TUC–1B and TUC–1C, the length of the crossarms to the inside of the line angle may be less than the indicated minimum dimensions in Table 1.

TRANSMISSION LINE STRUCTURE	
GUIDE FOR CONCRETE POLE STRUCTURE DIMENSIONS (115 KV – 230 KV)	
SCALE: N.T.S.	DATE: DECEMBER'97
	TUC (Series)



NOTES:

1. Dimensions and clearances in tables are recommended. Greater dimensions may be required to improve galloping performance, or separation requirements. A 30 degree shielding angle is assumed. For structures of heights greater than 80 feet, the shield angle should be decreased. For high isokeraunic levels, high ground resistance, or high contamination areas use the larger number of insulators in Table 2.
2. A maximum altitude of 3300 feet above M.S.L. is assumed. For higher altitudes, clearances in Table 2 should be increased.
3. The number of insulators in Table 2 are for angle structures, TSC–3A and TSC–4A. For the deadend structures TSC–5A, one additional bell should be used.
4. Engineer is to specify porcelain horizontal post insulator with load limiters or non–ceramic horizontal post insulators. Engineer shall adjust dimension "C" to obtain an appropriate shield angle. (30° maximum recommended)
5. Engineer to specify swing angle bracket type.
6. Vertical dimensions between post insulators are from centerline to centerline of top attachment holes.
7. For TPC structure types, where applied loading exceeds the strength limitations of the post insulator, a braced post insulator assembly may be considered by the engineer.

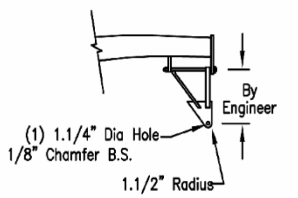
TABLE 1 – RECOMMENDED DIMENSIONS (FEET)

VOLTAGE	115 KV	138 KV	161 KV
A	8.0	9.0	11.0
B	9.0	10.0	12.0
C	9.0	10.0	12.0
D	9.5	10.5	12.5
E	BY ENGINEER		
F	BY ENGINEER		

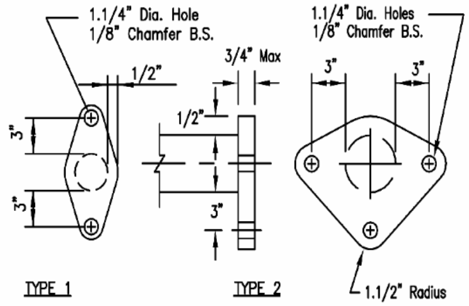
TABLE 2 – MINIMUM CLEARANCES FOR ANGLE STRUCTURES (INCHES)

VOLTAGE	115 KV		138 KV		161 KV	
NUMBER OF INSULATORS	8	9	9	10	11	12
NO WIND	42	48	48	54	60	65
6 PSF WIND	26	26	30	30	35	35
EXTREME WIND	10	10	12	12	14	14

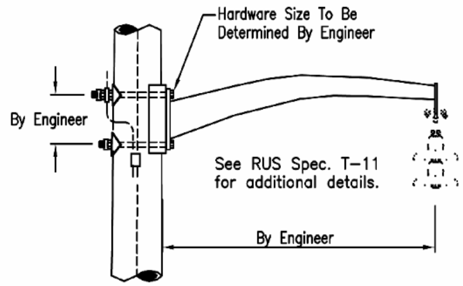
TRANSMISSION LINE STRUCTURE		
GUIDE FOR CONCRETE POLE STRUCTURE DIMENSIONS 115 KV – 161 KV		
SCALE:		DATE: DECEMBER'97
N.T.S.		TPC (Series)



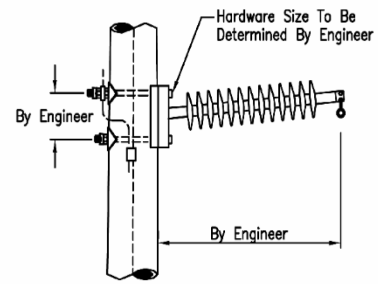
DETAIL "G"
SWINGING ANGLE BRACKET DETAILS
(When Required)



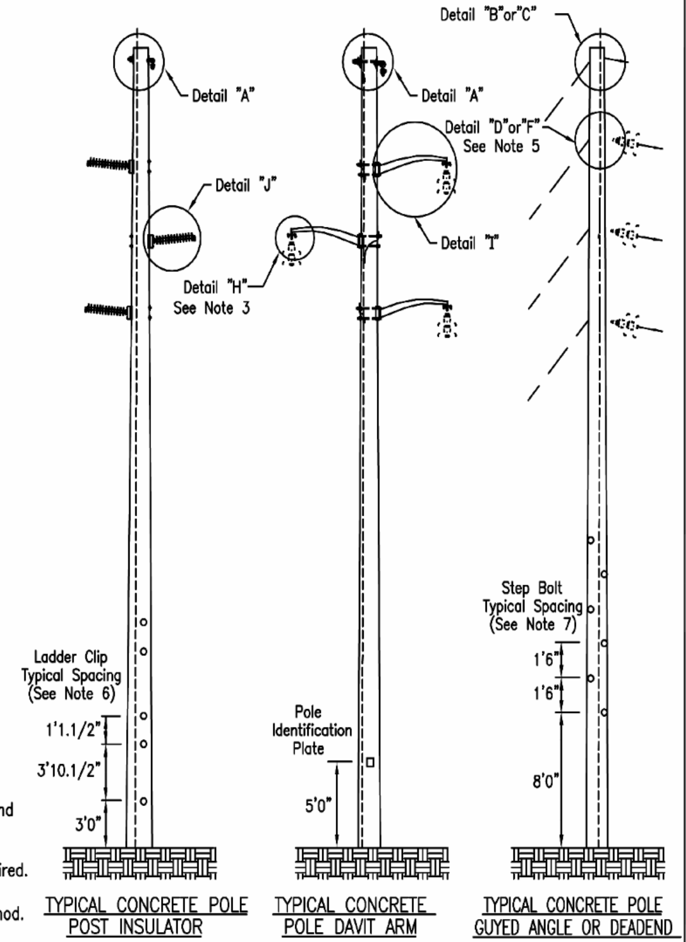
DETAIL "H"
CONDUCTOR
END PLATES DETAILS



DETAIL "I"
DAVIT ARM



DETAIL "J"
POST INSULATOR



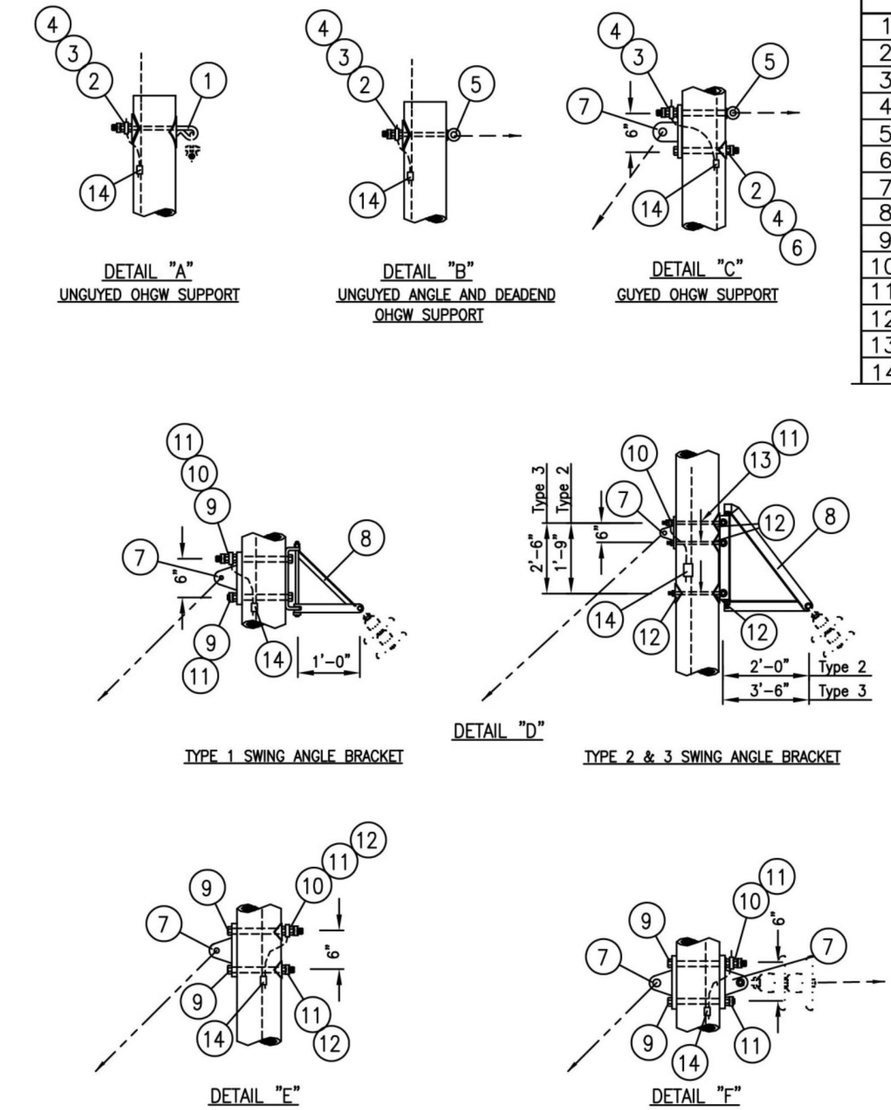
NOTES:

1. When specified by the engineer, steel appurtenances and their connection design and detailing shall be by the concrete pole supplier. If provided by others, details of the steel appurtenances are to be provided to the pole manufacturer by the owner. The concrete pole manufacturer is responsible for the proper design, coordination and fit up of all appurtenance connections and members attached to the pole provided by the owner. Manufacturer shall notify owner if any appurtenance material supplied by the owner will not result in a properly designed structure.
2. The pole manufacturer is responsible to verify that owner furnished and manufacturer furnished appurtenances and connections have sufficient strength to sustain all specified loads with overload factors.
3. Details shown are typical. Alternate attachments may be shown by the engineer on a separate drawing.
4. Type 1 end plates for the arms are to be used for TUC-1 and TUC-1A structures. Type 2 are for TUC-1M and TUC-1AM structures
5. When required by the engineer, splice design for angle and deadend structures shall be flange-bolted type.
6. Engineer to specify the type of swing angle bracket required.
7. Owner to specify either ladder or step bolt climbing method.

TRANSMISSION LINE STRUCTURE

GUIDE FOR CONCRETE POLE STRUCTURE
DETAILS

SCALE:		DATE: JUNE, 2008
N.T.S.		TM-C1



DETAIL "A"
UNGUYED OHGW SUPPORT

DETAIL "B"
UNGUYED ANGLE AND DEADEND OHGW SUPPORT

DETAIL "C"
GUYED OHGW SUPPORT

DETAIL "D"
TYPE 1 SWING ANGLE BRACKET
TYPE 2 & 3 SWING ANGLE BRACKET

DETAIL "E"
MEDIUM DUTY GUYING TEE

DETAIL "F"
TYPICAL ANGLE & DEADEND DETAIL

	Details							LIST OF MATERIALS
	A	B	C	D_1	$D_{2,3}$	E	F	Description
1	1							Support, Single Bolt OHGW, 3/4" dia. x Required Length
2	1	1	1					Washer, Curved, 4" Sq. x 1/4", 13/16" Hole
3	1	1	1					3/4" Clamp, Ground Wire w/ Nut
4	1	1	2					3/4" Locknut, MF Type
5		1	1					3/4" Bolt, Shoulder Eye, by Required Length
6			1					3/4" Bolt, Machine, by Required Length
7			1	1	1	1	2	Tee, Deadend & Guying, Medium Duty
8				1	1			Bracket, Swinging Angle, Medium Duty (Specify Type)
9				2		2	2	7/8" Bolt, Machine, by Required Length
10				1	1	1	1	7/8" Clamp, Ground Wire w/ Nut
11				2	3	2	2	7/8" Locknut, MF Type
12					4	2		Washer, Curved, 4" Sq. x 1/4", 15/16" Hole
13					3			7/8" Mounting Hardware, by Required Length
14	1	1	1	1	1	1	1	Connector, Compression

NOTES:

1. When specified by the engineer, steel appurtenances and their connection design and detailing shall be by the concrete pole supplier. If provided by others, details of steel appurtenances are to be provided by the owner to the pole manufacturer. The concrete pole manufacturer is responsible for the proper design, coordination and fit up of all appurtenance connections and members attached to the pole which are provided by the owner. Manufacturer shall notify the owner if any appurtenance material supplied by the owner will not result in a properly designed structure.

2. Details shown are typical. Alternate attachments may be shown by the engineer on a separate drawing.

3. The pole manufacturer is responsible to verify that owner furnished and manufacturer furnished appurtenances and connections have sufficient strength to sustain all specified loads with overload factors.

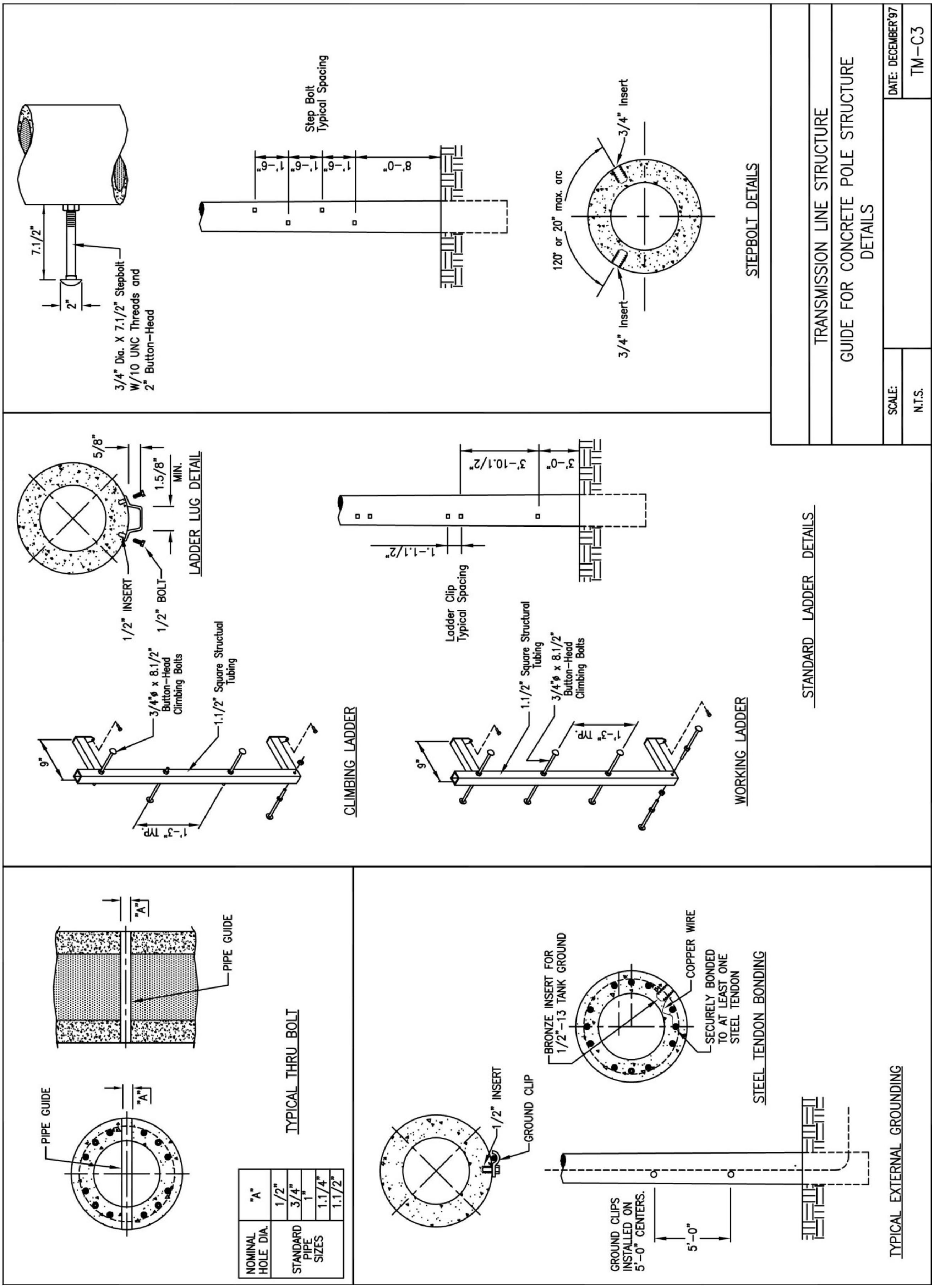
TRANSMISSION LINE STRUCTURE

GUIDE FOR CONCRETE POLE STRUCTURE DETAILS

SCALE: N.T.S.

DATE: DECEMBER'97

TM–C2


TRANSMISSION LINE STRUCTURE
GUIDE FOR CONCRETE POLE STRUCTURE DETAILS
SCALE: N.T.S.
DATE: DECEMBER'97
TM-C3
STEPBOLT DETAILS
3/4" Dia. X 7.1/2" Stepbolt W/10 UNC Threads and 2" Button-Head
7.1/2"
2"
Step Bolt Typical Spacing
1'-6"
1'-6"
1'-6"
8'-0"
120° or 20" max. arc
3/4" Insert
3/4" Insert
STANDARD LADDER DETAILS
LADDER LUG DETAIL
5/8"
1.5/8" MIN.
1/2" INSERT
1/2" BOLT
Ladder Clip Typical Spacing
1'-1.1/2"
3'-10.1/2"
3'-0"
CLIMBING LADDER
9"
3/4"ø x 8.1/2" Button-Head Climbing Bolts
1.1/2" Square Structural Tubing
1'-3" TYP.
WORKING LADDER
1.1/2" Square Structural Tubing
3/4"ø x 8.1/2" Button-Head Climbing Bolts
1'-3" TYP.
TYPICAL THRU BOLT
PIPE GUIDE
PIPE GUIDE
"A"
"A"
NOMINAL HOLE DIA.
"A"
STANDARD PIPE SIZES
1/2"
3/4"
1"
1.1/4"
1.1/2"
STEEL TENDON BONDING
BRONZE INSERT FOR 1/2"-13 TANK GROUND
COPPER WIRE
SECURELY BONDED TO AT LEAST ONE STEEL TENDON
TYPICAL EXTERNAL GROUNDING
1/2" INSERT
GROUND CLIP
GROUND CLIPS INSTALLED ON 5'-0" CENTERS.
5'-0"

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TECHNICAL SPECIFICATIONS FOR PRESTRESSED CONCRETE POLES AND CONCRETE POLE STRUCTURES

1 SCOPE

This specification covers the design, materials, manufacture, inspection, testing, drawings, shipping, and delivery of 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*. Additional through holes below the groundline at 4 foot spacing may be specified to facilitate rotating the pole while it is being lowered into the ground.

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. For an assembly that requires only one bolt hole, that one hole constitutes a group.

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.

Load factor - A multiplier which is applied to each of the vertical, transverse, and longitudinal structure loadings to obtain an *ultimate factored load.*

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 supplier responsible for the fabrication of the poles. The *manufacturer* makes the poles based on the design drawings developed by the *structural designer*, who is the engineer responsible for the structural design of the poles and is usually employed by the manufacturer.

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

Owner - The Rural Development Utilities Programs borrower procuring the concrete poles.

P-delta (P-Δ) moment - The additional moment created by vertical loads acting on the structure which deflects from its unloaded position.

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 end squareness – A measure of how perpendicular the finished surface of the pole butt is to the longitudinal axis 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 *load 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 *load 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 through centrifugal force.

Statically cast concrete pole - A pole which is manufactured by placing *prestressed steel strands* and *spiral reinforcement* in a mold, then adding fresh concrete 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 *load 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 a *load factor*.

Unfactored load - A loading in which the *load 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 this specification. 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 prestressed concrete poles:

a American Concrete Institute (ACI):

ACI 318, Building Code Requirements for Structural Concrete

b Prestressed Concrete Institute (PCI):

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

c American Welding Society (AWS):

AWS D1.1, Structural Welding Code – Steel d American Society for Testing Materials (ASTM):

ASTM A416	Standard Specification for Steel Strand, Uncoated Seven-Wire For Prestressed Concrete
ASTM A421	Standard Specification for Uncoated Stress-Relieved Steel Wire For Prestressed Concrete
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars For Concrete Reinforcement
ASTM A641	Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A706	Standard Specification for Deformed and Plain Low-Alloy Steel Bars For Concrete Reinforcement
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C150	Standard Specification for Portland Cement
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C289	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
ASTM C494	Standard Specification for Chemical Admixtures For Concrete
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C935	Standard Specification for General Requirements for Prestressed Concrete Poles Statically Cast
ASTM C1089	Standard Specification For Spun Cast Prestressed Concrete Poles

e Industrial Fasteners Institute (IFI):
Fastener Standards

f Institute of Electrical and Electronics Engineers (IEEE):
National Electrical Safety Code (NESC)

g 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:

a <u>Design</u>

(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.

(2) Poles shall withstand the loading conditions, including specified load 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.

(3) Poles shall be designed by the ultimate strength method as explained in ACI 318 and in accordance with the PCI Guide for the Design of Prestressed Concrete Poles. 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) 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.

(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.

(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 should not exceed 65 percent of the rated breaking strength of the guy for all load cases. The manufacturer shall advise the owner if the specified guy size is inappropriate prior to submitting a bid. The owner may elect to change the guying or allow an increase up to 90 percent of the rated breaking strength of the guy as per the NESC. For design purposes, guy wire modulus of elasticity should be specified by the owner.

(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.

(8) The design of each pole shall be performed using the applicable codes and standards listed in Section 3, Codes and Standards, of this specification.

(9) Pole design and design calculations shall be the responsibility of the manufacturer.

b <u>Materials</u>

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

(2) All load bearing anchors and inserts provided by the manufacturer shall be hot dip galvanized steel, stainless steel, or die-cast zinc alloy. Cadmium-plated and aluminum material shall not be used. All inserts shall be noncorrosive materials designed and manufactured for the intended purpose, shall not stain or react unfavorably with the concrete or fasteners, 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.

(3) The concrete shall have a minimum 28-day compressive strength of 8,000 psi for spun concrete and 5,000 psi for statically cast concrete 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) The cement shall be either Type I, II, III, or V Portland cement conforming to ASTM C150.

(5) Fine aggregate shall be a natural sand, manufactured sand, or a combination thereof, consisting of clean, strong, hard, durable uncoated particles conforming to ASTM C33, 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.

(6) Coarse aggregate shall be clean, tough, crushed stone conforming to ASTM C33, 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 C131. Absorption shall be less than 4 percent or aggregate shall be saturated with water prior to use in concrete.

(7) Aggregate shall be tested in accordance with ASTM C289 to determine an alkali-aggregate reaction. Crushed rock or partially crushed rock shall be the source of the aggregate.

(8) Water shall be clean, free from undesirable amounts of oils, acids, alkalis, salts, organic materials, or other deleterious substances, and shall not contain concentrations of chloride ions in excess of 500 ppm or sulfate ions in excess of 1000 ppm.

(9) Chemical admixtures shall conform to ASTM C494. Air entraining admixtures can be used if approved by the owner and conform to ASTM C260. Fly ash shall conform to ASTM C618. Admixtures shall not contain chloride ions in quantities that would cause the total chloride content of the concrete to exceed 0.06 percent.

(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.

(11) Concrete mix design requirements listed above can be altered with the owner's approval.

c Workmanship

(1) The pole cross sectional shape shall be clearly described by the manufacturer at the time of bidding and shall be round, 12-sided, 8-sided,

6-sided, or square. Allowable shapes should be specified by the owner in the Application Requirements (see Attachment C).

(2) The pole shall have a uniform taper from top to butt.

(3) Deviation of the pole from straightness is allowed in one plane and one direction only. The detensioning operation shall be performed in a manner to keep the prestressing forces symmetrical.

(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.

(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.

(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.

(7) The manufacturer shall provide holes through each pole as specified on the pole framing guide drawing(s), included as Attachment A. Holes shall be installed 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. The owner shall be notified of any hole orientation that may be difficult, impractical, or impossible to place as shown on the pole

framing drawing. The owner shall approve any deviation in orientation prior to manufacture.

(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.

(9) Holes may be drilled through the pole wall as long as the longitudinal reinforcement is not damaged in any way and is properly sealed. Hole drilling techniques shall be utilized which introduce little to no spalling on the inside face of the pole wall.

(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. If a PVC liner is to be installed in the drilled hole where steel has been exposed, epoxy is to be applied prior to installation.

(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.

d Manufacturing Tolerances

Manufacturing tolerances shall be limited to the following:

Pole Length	±2 inches, or ±1 inch +1/8 inch per 10 feet of length, whichever is greater (eg., a 120 foot pole shall have a length of 120 feet ± 2 1/2 inches)
	-6 inches or +12 inches for assembled spliced structure
Pole Diameter or Width	±1/4 inch as measured at any location on the pole
Wall Thickness	-1/4 inch or -12 percent of wall thickness. (Note: This requirement may be waived for small areas if the structural adequacy and durability of the pole are not impaired.)
Pole End Squareness	±1/2 inch per foot of pole diameter
Pole Sweep	1/4 inch per 10 feet of pole length
Pole Weight	+10 percent and -5 percent of calculated value
Location of longitudinal reinforcement	± 1/4 inch for individual elements and ±1/8 inch for the centroid of a group
Location of spiral reinforcement	Spacing may vary ± 25 percent, but the total required quantity per 5 feet of pole length shall be maintained.
Location of a group of bolt holes from top of the pole	±2.0 inches
Location of bolt holes within a group of bolt holes	±1/8 inch
Location of centerline between groups of bolt holes	±1.0 inch
Bolt hole diameter	±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, blockout, and handhole	±2 inches

e Grounding

(1) An external pole ground wire shall be used in order to verify continuity of the pole ground while in service. The pole ground wire shall extend one foot above the top of the pole. Threaded inserts for attaching ground wire clips that hold the external ground wire shall be sized and positioned per the attached drawings.

(2) Except for bonding of the steel tendons, there shall be no internal pole grounds. To provide good electrical continuity, the spiral reinforcement shall be securely and electrically tied to each longitudinal reinforcing steel member it contacts within 1 foot of the top and butt of the pole. A minimum of one longitudinal steel strand shall be bonded electrically to threaded bronze inserts located within 2 feet of the pole top and butt, and at one foot below groundline (See Attachment A for location of groundline). 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.

(3) If required by the owner, manufacturer shall provide ground wire clamps for all ground wire attachments.

f Climbing Devices

(1) Design Loads:

(a) Step Bolts and removable steps: The step bolts, removable steps and attachment to the pole shall be designed to support a minimum of a 300 pound worker and equipment multiplied by a load factor as defined in paragraph 4.f.2. The load shall be at the outer edge of the step or bolt.

(b) Removable Ladders: The ladder and each attachment to the pole shall be designed to support a minimum of a 300 pound worker and equipment multiplied by a load factor as defined in paragraph 4.f.2. The load shall be at the outer edge of the step or bolt.

(2) Load Factor: A load factor of 2.0 shall be applied to the design loads in 4.f.1. These loads shall be supported without permanent deformation.

(3) Location: Climbing devices shall start 8 feet above groundline and extend to the pole top unless specified by the owner. The climbing device shall be spaced such that each step is 1 foot 6 inches apart and orientated to

provide maximum ease of climbing. They shall be located to avoid interference with other attachments.

(4) Finish: Step bolts, removable steps, and removable ladders shall be hot dipped galvanized.

(5) Intent of steps/ladder: This system is intended for climbing the pole and working on the structure. It is not intended to replace the worker's fall arrest system.

g <u>Inserts</u>

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

h <u>Cover</u>

(1) The minimum clear concrete cover over all longitudinal reinforcement and all spiral reinforcement shall be 3/4 inch for spun poles and 1 inch for statically cast poles. Poles not meeting this requirement shall be rejected except as allowed by Section 4.h.2.

(2) The minimum specified wall thickness at all points along the pole for spun concrete poles shall be 2.5 inches and for statically cast poles shall be 3.0 inches.

(a) For spun poles, 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.h.1 are met in the spinning process and provided the pole can meet all other requirements of the specifications.

(b) The owner shall, as soon as possible, be notified of any poles with an inside clear cover less than 3/4 inch of spun concrete or less than 1 inch of statically cast concrete 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.

i Splices

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

(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.

(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.

j Appurtenances

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

(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.

(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) 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.

(5) For appurtenance material manufacturer supplies, manufacturer shall provide torque requirements for all load carrying bolts including step bolts.

k Finishing

(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.

(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.

(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) 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.

(5) The center void at the top end of the pole shall be sealed with a minimum 6 inch thick 1000 psi strength concrete plug and the pole tip capped with a suitable epoxy-aggregate mortar securely bonded to the pole, or the top end of the pole shall be fitted with a galvanized steel or polymer cap securely held in place with mechanical fasteners or epoxy. Sharp edges shall be tooled to form smooth, chamfered corners. The manufacturer shall assure that the capping method will prevent weather intrusion into the pole and prevent pole tip deterioration.

(6) The center void at the bottom end of the pole shall be sealed with a minimum 12 inch thick 1000 psi strength concrete plug. The plug shall be securely bonded to the pole and shall be tooled to form a smooth, uniform bearing surface. A 2 inch diameter formed hole shall be provided in the center of the plug to allow for drainage.

(7) 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.

l <u>Marking</u>

(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

(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 on the back of the plate to permit bonding to the pole.

(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) Unless otherwise directed by the owner, 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.

(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 INSPECTION AND TESTING

a General

(1) Manufacturing and testing procedures shall be in compliance with applicable codes and standards listed in Section 3.0 in this specification.

(2) Upon request, the manufacturer shall furnish the owner with certified test reports for the steel and concrete used.

b Inspection

(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.

(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.

(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.

(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) Tests shall be in accordance with all applicable standard specifications and codes.

(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.

c Concrete and Aggregate Testing

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

(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 strength test for determining release strength;

(b) Minimum of one strength test at 7 days;

(c) Minimum of one strength test at 14 days; and

(d) Minimum of one strength test at 28 days.

A strength test shall be the average of the strengths of two or more cylinders, depending on cylinder size, made from the same sample of concrete.

(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.

(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) 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.

d Structure Testing

(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.

(2) Material procurement for test poles shall be identical to material procurement procedures for regular production run poles.

(3) The design load testing of any specific pole shall be on a full-scale basis at the manufacturer’s facility or at a location as specified by the owner. 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.

(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) 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.

(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.

(7) Use of any factory tested poles to meet order requirements shall be determined by the owner.

6 SHIPPING AND DELIVERY

a <u>Shipping</u>

(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.

(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.

(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.

(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.

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

(6) Handling instructions shall be included with the pole shipment.

b <u>Delivery</u>

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 DRAWINGS AND INFORMATION TO BE SUPPLIED BY THE MANUFACTURER

a <u>Information to be supplied with the proposal (Attachment E of this Specification)</u>:

(1) Calculated weight of each concrete pole and concrete pole structure.

(2) For the controlling load case and any other load case required by owner, the maximum reactions (moments, shears, and axial loads, including load factors) in poles at the groundline or point of fixity and guy wire loads.

(3) Pole cross-sectional shape and diameter or width at top, bottom, and groundline.

(4) Tip and butt wall thickness.

(5) Prestress strand information concerning quantity, size, and dropout location.

(6) Design strength of concrete (28 day compressive strength).

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

b <u>Documentation to be supplied for the owner's approval prior to fabrication</u>

(1) For each load case, design calculations including the maximum reactions (moments, shears, and axial loads, including load factors) in poles at the groundline or point of fixity, guy wire loads, deflections, and analyzed stress reactions every 5 feet.

(2) After the manufacturer's proposal has been accepted, the manufacturer shall submit to the owner two prints (or electronic PDF if acceptable to the owner) 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.

(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.

(4) All design and detail drawings shall be reviewed and approved by the owner before pole manufacture.

(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.

(6) 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 APPROVAL, ACCEPTANCE, AND OWNERSHIP

a 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.

b 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.

c 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.

d 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 the pole is shipped. Any pole whose delivered weight is outside the tolerances specified in Section 4.4 may be rejected by the owner.

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

9 LIST OF ATTACHMENTS TO THIS SPECIFICATION

- Attachment A, Structure Dimensions and Other Information (to be completed by the engineer)
- Attachment B, Design Loads (to be completed by the engineer)
- Attachment C, Application Requirements (to be completed by the engineer)
- Attachment D, Drawings (to be completed by the engineer)
- Attachment E, Bid Summary-Design Information, Weights, and Costs (to be completed by the manufacturer and submitted with proposal)

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Attachment A, Structure Dimensions and Other Information (to be completed by the engineer)

ATTACHMENT "A": STRUCTURE DIMENSIONS AND OTHER INFORMATION

A. CLEARANCE REQUIREMENTS

INSULATOR STRING LENGTH______IN.

LOADING CONDITION	SWING ANGLE	CLEARANCE (INCHES)
NORMAL,C1 Φ1		
6 LB.,C2 Φ2		
HIGH WIND,C3 Φ3		

B. SHIELD ANGLE IS______

C. GUY INFORMATION

GUY TYPE AND SIZE:

R.B.S: LEAD:

D. ARM DIMENSIONS

ARM	LENGTH	ARM	LENGTH

E. POLE DIMENSIONS

dim	TOTAL POLE LENGTH									
L1										
L2										
L3										
L4										
L5										
L6										

F. LOAD INFORMATION

DESIGN SPANS: V.S. H.S. RULING SPAN:

LINE ANGLE: MAX: MIN.

CONDUCTOR:	UNIT LOADS				LONGITUDINAL		WIRE TENSION	
DESCRIPTION OF LOAD, TEM	VERT	LF	TRANS	LF	KIPS	LF	KIPS	LF
OHGW								

TRANSMISSION LINE STRUCTURE

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Attachment B, Design Loads (To Be Completed By The Engineer)

ATTACHMENT "B" DESIGN LOADS

CONDUCTOR______________ OHGW_____________ V.S. _________ H.S._________

A. LOADS WITH LOAD FACTOR (LF)

DESCRIPTION OF LOAD	TEMP	LOAD IN KIPS (INCLUDES L.F)												w		
	F	V1	T1	L1	V2	T2	L2	V3	T3	L3	VG	TG	LG	PSF	Δg	θg

B. LOADS WITHOUT LOAD FACTOR (LF)

DESCRIPTION OF LOAD	TEMP	LOAD IN KIPS (DOES NOT INCLUDE L.F)												w		
	F	V1	T1	L1	V2	T2	L2	V3	T3	L3	VG	TG	LG	PSF	Δg	θg

COMMENTS:

V1=VERTICAL LOAD, KIPS
T1=TRANSVERSE LOAD, KIPS
L1=LONGITUDINAL LOAD, KIPS
w=WIND LOAD ON THE POLE,PSF
Δ = DEFLECTION AT GROUNDLINE
θg=ROTATION AT THE GROUND.

TRANSMISSION LINE STRUCTURE

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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. Pole cross-sectional shape (check all allowed)
   □ Round □ 12-Sided □ 8-Sided □ 6-Sided □ Square □ Other _________________

5. Maximum diameter at groundline (in)
   a. Tangent: __________
   b. Angle: __________
   c. Deadend: __________

6. Maximum taper (inches/foot) based on total difference between top and bottom diameters .... ___________

7. Guy wire modulus of elasticity .... ___________

8. Climbing device desired by owner .... ___________

9. Unguyed angle poles to be raked or plumb. .... ___________

10. Unguyed tangent deadends to be raked or plumb .... ___________

11. Special handling requirements ....

12. Component weight restrictions .... ___________

13. Pole length restrictions .... ___________

Attachment C (Cont'd)
Application Requirements

14. Delivery schedule.. ___________

15. Free on board destination (F.O.B.) .... ___________

16. Structures to be tested:

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

17. Additional Requirements

Attachment D

(Drawings to be added by owner)

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Attachment E, Bid Summary-Design Information, Weights, and Costs (to be completed by the manufacturer and submitted with proposal)

DESIGN INFORMATION										
STRUCTURE DESIGNATION										
STRUCTURE HEIGHT										
BOTTOM DIAMETER										
GROUNDLINE DIAMETER										
TOP DIAMETER										
WALL THICKNESS -BUTT										
WALL THICKNESS - TIP										
TOP PRESTRESSING STEEL										
NUMBER OF STRANDS										
SIZE OF STRANDS										
BOTTOM PRESTRESSING STEEL										
NUMBER OF STRANDS										
SIZE OF STRAND										
DROPOUT LOC. OF STRANDS (FROM BUTT)										
POLE TOP DEFLECTION CONTROL. CASE										
28 DAY COMPRESSIVE STRENGTH										
DESIGN LOADS										
MAX REACTIONS AT GROUNDLINE										
MOMENT (INCLUDES L.F.)										
CONTROLLING LOAD CASE										
SHEAR (INCLUDES L.F.)										
AXIAL (INCLUDES L.F.)										
MAX REACTIONS AT POINT OF FIXITY (INCLUDES L.F.) IF DIFFERENT THAN GROUNDLINE										
MOMENT (INCLUDES L.F.)										
CONTROLLING LOAD CASE										
SHEAR (INCLUDES L.F.)										
AXIAL (INCLUDES L.F.)										
MAX LOAD IN GUYS (INCLUDES L.F.)										
CONTROLLING LOAD CASE										
GUY 1										
GUY 2										
GUY 3										
GUY 4										
SUMMARY OF WEIGHTS AND PRICES										
WEIGHT OF ARMS PER STRUCTURE										
WEIGHT OF POLE										
TOTAL WEIGHT PER STRUCTURE										
TOTAL COST PER STRUCTURE										
NUMBER OF STRUCTURES										
TOTAL WEIGHTS										
TOTAL COSTS										

COMMENTS

TRANSMISSION LINE STRUCTURE

ATTACHMENT E

BID SUMMARY - DESIGN INFORMATION, WEIGHTS, AND PRICE INFORMATION

(INFORMATION TO BE SUPPLIED WITH THE PROPOSAL)

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APPENDIX A

COMMENTARY TO THE GUIDE SPECIFICATIONS FOR PRESTRESSED CONCRETE POLES AND CONCRETE POLE STRUCTURES

1 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.

There are several items in the specification which need further explanation. The section references in the commentary refer to the section in the Specifications.

2 Section 4. Design

Loads (Section 4.a.(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. Load 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. Load 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 load 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.a.(3))
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.a.(4))
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 load 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 load 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 load 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.a.(5))
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 (P- Δ) Effect (Section 4.a.)
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 load factors) indicated in the loading agenda.

Foundation Rotation and Deflection (Section 4.a.(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 load factors.

Longitudinal Loads (Section 4.a.(6))
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.a.(6))
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. The loading in the guy should be no greater than 65 percent of its ASTM rated breaking strength unless an increase is allowed by the owner. 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 or quantity. This action should be avoided unless the owner approves a change. The owner may elect to change the guying or allow an increase in the percent of the rated breaking strength of the guy but not to exceed the limit allowed by the National Electrical Safety Code.

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

The guy modulus of elasticity can vary. 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 Concrete Poles (Section 4.a.)
The general effects of air entrainment are to increase workability, decrease density (unit weight), decrease strength, reduce bleeding and segregation, and increase durability.

An air content of 5 percent plus or minus 1 percent is required by ASTM C935 for statically cast poles "unless otherwise specified". The owner should refer to ACI 318, Section 4.4 for concrete exposed to freezing and thawing. The required air content by ACI 318 will be a function of the exposure, the maximum aggregate size, and the specified compressive strength.

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. 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.

Cross-Sectional Shape (Section 4.c.(1))
Concrete poles can be manufactured in many different shapes, depending upon each manufacturer's equipment and capabilities. Some shapes are more conducive than others when it comes to bolt hole orientation and hardware fit.

For example, if the owner allows a square pole shape, it would be difficult to install through holes in a direction other than on the pole flats which are 90° apart. Even with holes installed out of the flat plane, the hardware fit would be cumbersome at best. Depending on the manufacturer and situation, some poles can be made with blockouts that create a type of flat over a short distance to allow the hardware to be properly attached. For 12-sided poles, the flats are 30° apart which lends itself to better hole orientation. Even with round cross-sections, there can be some deviation in the specified hole orientation due to longitudinal reinforcement placement.

Because of these issues, the owner should specify in the Application Requirements which pole shapes are acceptable for each structure. The owner should also specify the allowable angular tolerance on the hole orientation as this can significantly impact the manufacturing process and cost. For example, if a deadend structure is to be installed at a centerline survey line angle of 50°, is a hole orientation of 60° acceptable if that is at the center of a flat or between longitudinal stranding?

Grounding (Section 4.e.)
The advantages of an external ground wire include the following: (1) it is visible and can be inspected, (2) hardware can be easily bonded and inspected, (3) it can be easily repaired or replaced, and (4) potentially offers the benefit of suffering less damage from lightning strike (particularly in areas with high isokeraunic levels). For these reasons, external ground wires are preferred in this specification.

If these specifications are altered to allow internal ground wires, then the following should be addressed adequately: (1) requiring grounding lugs at hardware attachments, (2) requiring grounding lugs at pole top and groundline (for external ground electrode), (3) considering the possibility of damage from lightning strike, and (4) considering grounding requirements for maintenance workers.

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.

3 Section 5.d 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.

4 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 "A": STRUCTURE DIMENSIONS AND OTHER INFORMATION

A. ARM DESIGN - CLEARANCE REQUIREMENTS

INSULATOR STRING LENGTH : 70

LOADING CONDITION	SWING ANGLE DEGREES	CLEARANCE C1,C2,C3 (INCHES)
NORMAL,C1, Φ1	22°	66
6 LB. C2 Φ2	60°	35
HIGH WIND,C3 Φ3	78°	14

B. SHIELD ANGLE IS 30±

C. GUY INFORMATION

GUY TYPE AND SIZE : N.A.

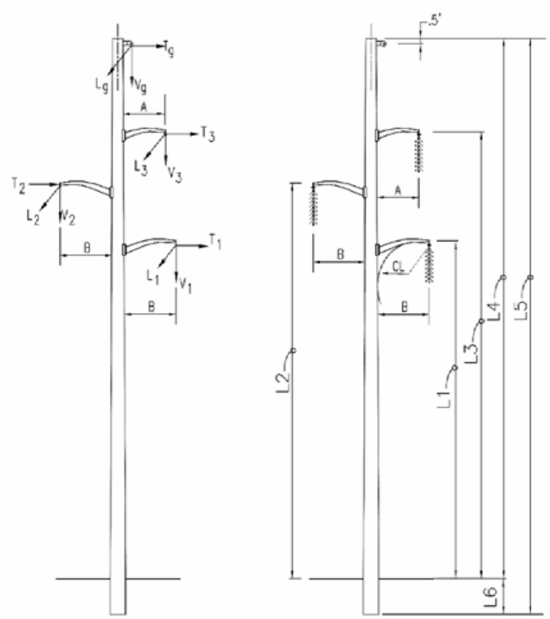
R.B.S. : N.A. Lead : N.A.

D. ARM DIMENSIONS

ARM	LENGTH	ARM	LENGTH
A	9.0		
B	10.0		

E. POLE DIMENSIONS

DIM	TOTAL POLE LENGTH 80	90	100	110
L1	47	56	65	74
L2	53	62	71	80
L3	59	68	77	86
L4	68	77	86	95
L5	80	90	100	110
L6	12	13	14	15



F. LOAD INFORMATION

DESIGN SPANS : V.S. 1200' H.S. 900' RULING SPAN 800'

LINE ANGLE : MAX. 0° MIN. : 0° WT. OF INSUL(LBS) 600

DESCRIPTION OF LOAD, TEMP	UNIT LOADS VERT	LF	TRANS	LF	LONGITUDINAL KIPS	LF	WIRE TENSION KIPS	LF
CONDUCTOR :								
NESC Heavy (4) , 0°	2.094	1.5	0.703	2.5	1.4	1.1	13.0	1.65
High Wind (21 psf) , 60°	1.094	1.1	1.939	1.1	---	---	10.8	1.1
Ext. Ice & Wind (1",4psf) , 32°	3.715	1.1	1.036	1.1	---	---	14.8	1.1
Unbal. Ice (1"/0") , 32°	2.405	1.1	---	---	---	---	2.1	1.1
No Load , 60°	1.094	---	---	---	---	---	7.7	1.0
No Load , 32°	1.094	---	---	---	---	---	8.6	1.0
OHGW								
NESC Heavy (4) , 0°	0.980	1.5	0.478	2.5	0	---	8.3	1.65
High Wind (21 psf) , 60°	0.399	1.1	0.761	1.1	---	---	6.7	1.1
Ext. Ice & Wind (1",4psf) , 32°	2.184	1.1	0.812	1.1	---	---	9.6	1.1
Unbal. Ice (1"/0") , 32°	1.291	1.1	---	---	---	---	2.6	1.1
No Load , 60°	0.339	---	---	---	---	---	5.9	1.0
No Load , 32°	0.339	---	---	---	---	---	6.3	1.0

V.S.=Vertical span
H.S.=Horizontal span
LF=Overload factor
L6 = Embedment depth

GREENE TAP

TRANSMISSION LINE STRUCTURE

TANGENT SUSPENSION
161 kV

Scale	Rural Cooperative	6/13/2008
None		TUC-1

ATTACHMENT "B" DESIGN LOADS (CONDUCTOR 795, 26/7 ACSR OHGW 7/16 E.H.S. V.S. 1200' H.S. 900')

a. LOADS WITH L.F.

DESCRIPTION OF LOAD	TEMP	LOADS IN KIPS (INCLUDES L.F.)												*w*		
	° F	V1	T1	L1	V2	T2	L2	V3	T3	L3	VG	TG	LG	psf	Δg	θui
1. NESC Heavy	0	5.27	1.58	1.54	5.27	1.58	1.54	5.27	1.58	1.54	1.76	1.08	0.00	10.0	0	0
2. High Wind (21 psf)	60	2.10	1.92	---	2.10	1.92	---	2.10	1.92	---	0.53	0.75	---	39.0	0	0
3. Ext. Ice & Wind (1", 4psf))	32	5.56	1.03	---	5.56	1.03	---	5.56	1.03	---	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	---	2.86	---	0	0
6. High Wind (no cond)	60				---	---	---	---	---	---	---	---	---	39.0	0	0

b. LOADS WITHOUT L.F.

DESCRIPTION OF LOAD	TEMP	LOADS IN KIPS (DOES NOT INCLUDE L.F.)												*w*		
	° F	V1	T1	L1	V2	T2	L2	V3	T3	L3	VG	TG	LG	psf	Δg	θg
1. NESC Load	0	3.61	0.63	1.40	3.61	0.63	1.40	3.61	0.63	1.40	1.18	0.43	0.00	4.0	0	0
2. High Wind (21 psf)	60	2.35	1.75	---	2.35	1.75	---	2.35	1.75	---	0.48	0.68	---	35.5	0	0
3. Ext. Ice & Wind (1", 4psf))	32	5.56	0.93	---	5.56	0.93	---	5.56	0.93	---	2.62	---	---		0	0
															0	0
															0	0
															0	0
7. No Load	60	1.31	0.00	---	1.31	0.00	---	1.31	0.00	---		---	---	---	0	0

COMMENTS:

1. "w"is 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 Drwg. on Att. A for load location.

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

GREENE TAP

TRANSMISSION LINE STRUCTURE

TANGENT SUSPENSION
161 kV

Scale	Rural Cooperative	9/1/2007
None		TUC-1

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APPENDIX C

SELECTED SI-METRIC CONVERSIONS

Selected SI-Metric Conversions

AREA

To Convert From	To	Multiply By
circular mil (cmil)	square meter (m^2)	5.067075 E-10
square centimeter (cm^2)	square meter (m^2)	*1.000 E-04
square foot (ft^2)	square meter (m^2)	*9.290304 E-02
square inch (in^2)	square meter (m^2)	*6.451600 E-04
square kilometer (km^2)	square meter (m^2)	*1.000 E+06
square mile (mi^2)	square meter (m^2)	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^3)	kilogram per cubic meter (kg/m^3)	2.767990 E+04
pound per cubic foot (lb/ft^3)	kilogram per cubic	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

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

PRESSURE

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

BENDING MOMENT

To Convert From	To	Multiply By
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

To Convert From	To	Multiply By
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)	4.437030 E-01
meter per hour(m/h)	meter per second (m/s)	2.777778 E-04

*Exact Conversion.