Attachment B

Final Version of Revisions to GO 95

Table of Contents

Rule 12.1-C

12.1 Construction and Reconstruction of Lines

C Subordinate Element

An element (such as a crossarm or a conductor) added to a pole, tower or structure shall meet all requirements of these rules but does not require any change in like elements already existing except where the added element is related in buck arm construction to an existing arm in which case all construction on the related arms shall meet the requirements of these rules. A crossarm, pole, tower or other structure to which any subordinate element is added shall meet the requirements specified in Rule 44.3.

Rule 12.2

12.2 Maintenance of Lines

All lines and portions of lines shall be maintained in such condition as to meet the requirements specified in Rule 44.1, Rule 44.3, and Rule 48. Lines and portions of lines constructed or reconstructed on or after the effective date of this Order shall be kept in conformity with the requirements of this Order.

The restoration of clearance originally established prior to the effective date of this Order, where the original clearance has been reduced by additional sagging or other causes, is not considered to be reconstruction and the reestablished clearance shall conform to the requirements of the rules in effect at the time the original clearance was established. The changing of clearance for any other purpose is reconstruction and clearances so changed shall comply with the rules of this Order applicable to reconstruction.

Rule 12.3

12.3 Lines Constructed Prior to This Order

The requirements of this Order, other than the requirements specified in Rule 12.2, do not apply to lines or portions of lines constructed or reconstructed prior to the effective date of this Order. In all other particulars, such lines or portions of lines shall conform to the requirements of the rules in effect at the time of their construction or reconstruction.

Lines or portions of lines constructed or reconstructed before July 1, 1942, may conform to and be maintained in accordance with the requirements of this Order, instead of the requirements in effect at the time of such construction or reconstruction.

Rule 34-G

34 Foreign Attachments

G. Guying

Where the effects of the mechanical loads imposed on poles or structures exceed the requirements as specified in Rule 44, or at the request of the granting authority, additional strength shall be provided by the use of guys or other suitable construction. When guying is required, refer to Rules 56 and 86 for applicable requirements.

Rule 43.1-C

C. Temperature

Conductor or messenger temperature shall be assumed to be 0°F at the time of maximum loading. A conductor or messenger temperature of at least 130°F shall also be assumed for computing sag and its effect on structural loads due to weight span.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

Rule 43.2-C

C. Temperature

Conductor or messenger temperature shall be assumed to be 25°F at the time of maximum loading. A conductor or messenger temperature of at least 130°F shall also be assumed for computing sag and its effect on structural loads due to weight span.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

Rule 44

44 Load and Strength Factors

The effects of the loads in Rule 43, multiplied by the load factors in Table 4-1, shall be less than or equal to the strengths of materials and/or line elements multiplied by the applicable strength factors in Table 4-2.

Note 1: Deformation, deflection, or displacement of the structure or parts of the structure may change the effects of the assumed loads. When calculating load effects that account for deformation, deflection, or displacement of supporting structures and other line elements, calculations should be made using Rule 43 loads prior to application of the load factors. Factored loads may be used to calculate load effects that account for deformation, deflection, or displacement of the structure or parts of the structure, when calculations using factored loads result in load effects larger than load effects calculated using Rule 43 loads prior to application of the load factors.

Note 2: The ratios of the load factors in Table 4-1 to the strength factors in Table 4-2 are analogous to factors of safety (i.e., safety factors). These factors are applied to account for variabilities (e.g., deterioration, material properties, environmental loads, additional attachments, construction details and workmanship). See Table F-1 in Appendix F for a summary of comparable factors of safety for various line components.

Note: Revised March 30, 1968 by Decision No. 73813, February 13, 1974 by Decision No. 82466 and February 5, 2014 by Decision No. 14-02-015.

Rule 44.1

44.1 Installation and Reconstruction

The load and strength factors in Table 4-1 and Table 4-2 shall be used when designing lines and elements of lines for installation or reconstruction.

The design shall consider the structural loading and mechanical strength requirements of all supply and communication facilities planned to occupy the structure. For purposes of this rule, the term "planned" applies to the facilities intended to occupy the structure that are actually known to the constructing company at the time of design.

The entity responsible for performing the loading calculation(s) for an installation or reconstruction shall maintain records of these calculations for the service life of the pole or other structure for which the loading calculation was made and shall provide such information to authorized joint use occupants and the Commission upon request.

Note: Revised January 12, 2012 by Decision No. 1201032 and February 5, 2014 by Decision No. 14-02-015.

Table 4-1: Minimum Load Factors

Load Condition	Load Factors		
	"Grade A"	"Grade B"	"Grade C"
Vertical Loads	1.500	1.250	1.250
Wind Loads	1.500	1.250	1.250
Wire Tension Loads	1.500	1.250	1.250

Table 4-2: Maximum Strength Factors

Line Element	Strength Factors		
	"Grade A"	"Grade B"	"Grade C"
Conductors, splices and conductor fastenings (other than tie wires)	0.750	0.625	0.625
Pins	0.750	0.625	0.625
Pole line hardware	0.750	0.625	0.625
Line Insulators (mechanical)	0.500	0.625	0.625
Guy insulators (mechanical)			
Interlocking	0.750	0.625	0.625
Noninterlocking glass fiber	0.500	0.625(a)	0.625(b)
Guys	0.750	0.625	0.625
Messengers and span wires	0.750	0.625	0.625
Foundations against uplift	1.000	0.833	0.833
Foundations against depression	0.500	0.625	0.625
Poles, Towers and Structures			
Wood	0.375	0.415	0.625
Metal (including elements of foundations)	1.000(c)	1.000(c)	1.000(c)
Reinforced concrete	0.375	0.415	0.415
Prestressed or post-tensioned concrete	0.830	0.830	0.830
Other engineered materials	1.000	1.000	1.000
Crossarms			
Wood	0.750	0.625	0.625
Metal	1.000(c)	1.000(c)	1.000(c)
Prestressed Concrete	0.830	0.830	0.830
Other engineered materials	1.000	1.000	1.000

(a) Insulators are to be replaced before their mechanical strengths have been reduced (due to deterioration or changes in construction, arrangement, or other conditions subsequent to installation) to less than 95 percent of the strength required at installation.

(b) Insulators are to be replaced before their mechanical strengths have been reduced (due to deterioration or changes in construction, arrangement, or other conditions subsequent to installation) to less than 75 percent of the strength required at installation.

(c) For aluminum members subject to tension caused by one or more estimated loads and where the critical load combination for the tension member would not endanger adjacent compression members, the strength factor on ultimate tension shall be .75 for Grades "A", "B" and "C" construction.

Rule 44.2

44.2 Additional Construction

Any entity planning the addition of facilities shall ensure that, following the addition, supporting structures, including their members and connections, will meet the strength requirements specified by Rule 44.3.

If performed, the entity responsible for performing loading calculations for additional construction shall maintain these loading calculations for the service life of the pole or other structure for which a loading calculation was made and shall provide such information to authorized joint use occupants and the Commission upon request.

Any loading calculations performed for wood structures more than 15 years old shall incorporate the results of intrusive inspections performed within the previous five years.

Note: Added August 20, 2009 by Decision No. 09-08-029. Revised January 12, 2012 by Decision No. 1201032, and February 5, 014 by Decision No. 14-02-015.

Rule 44.3

44.3 Replacement

Lines or parts thereof shall be replaced or reinforced before their ability to withstand the loads specified in Rule 43 is reduced (due to changes such as the addition of facilities and/or deterioration) to less than two-thirds of that required at installation by Rule 44 for Grades "A" and "B" construction, and to less than one-half of that required for Grade "C" construction.

Poles in Grade "C" construction that only support communication lines shall also conform to the requirements of Rule 81.3-A.

In no case shall the application of this rule be held to permit the use of lines or parts thereof with strengths less than the effects of the loads specified in Rule 43.

Note: Allowed reductions specified in this rule are modified by Table 4-2 Footnotes.

Note: Revised January 13, 2005 by Decision No. 0501030, January 12, 2012 by Decision No. 1201032, and February 5, 2014 by Decision No. 14-02-015.

Rule 45

45 Transverse Strength Requirements

In computing the transverse strength requirements of Lines (See Rule 22.1) under the conditions specified in Rule 43, load and strength factors meeting the requirements of Rule 44 shall be used. In heavy loading areas, for supporting structures carrying more than 10 wires (not including cables and supporting messengers) where the pin spacing does not exceed 15 inches, the transverse wind load shall be calculated on two–thirds of the total number of such wires with a minimum of ten. Where there is a change in direction of conductors and messengers, an additional transverse load shall be the resultant of all tensions under the assumed loading conditions.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

45.1 Special Provisions

Where it is impossible to obtain the required transverse strength except by the use of side guys or special structures and it is physically impossible to install them at the location of the transversely weak support, the strength may be supplied by side guying the support at each side of, and as near as practicable to, such weak support with a distance not in excess of 800 feet between the supports so guyed; provided that the section of line between the transversely strong structures is weak in regard to transverse loads only, that is in a straight line and that the strength of the side guyed supports is calculated on the transverse loading of the entire section of line between them.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

Rule 46

46 Vertical Strength Requirements

In computing vertical strength requirements, the loads upon Lines (See Rule 22.1) shall be their own weight plus the vertical loads which they support under the conditions of Rule 43, together with the effect of any difference in elevation of supports.

On structures with crossarms or guard arms, the vertical loads on the structure shall include a load of 300 lbs. at one end of one of the arms.

Load and strength factors shall apply as specified in Rule 44.

Rule 47

47 Longitudinal Strength Requirements

In computing the longitudinal strength requirements of Lines (See Rule 22.1), the longitudinal load shall be considered as that due to the maximum working tension under the conditions specified in Rule 43.

Load and strength factors shall apply as specified in Rule 44.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

47.1 Use of Guys and Braces

The longitudinal strength requirements for poles, towers and other supporting structures shall be met either by the structure alone or with the aid of guys and/or braces. Deflection shall be limited by guys and/or braces where such structures alone, although providing the load and strength factors required would deflect sufficiently under the prescribed loadings to reduce clearances below the required values.

47.2 Change in Grade of Construction

Where sections of higher grade construction are located in lines of lower grade construction the longitudinal load on each end support of such sections at the level involved shall be taken as an unbalanced load in the direction of the higher grade section equal to the total pull of all conductors in that direction. For spans not exceeding 500 feet in length, where the pull in the direction of the higher grade section exceeds 30,000 lbs., the loading requirements may be modified to consider 30,000 lbs. plus one–fourth the excess above 30,000 lbs., to a maximum of 50,000 lbs. In no case shall the application of this rule be held to permit the design of the end supports (including poles, structures, towers, crossarms, pins, insulators, conductor fastenings and guys) with strengths less than the effects of the loads.

In lieu of meeting the requirements of this rule on single poles or structures at ends of higher grade sections, the longitudinal load may be distributed over two poles or structures provided that the two poles or structures are suitably side guyed or are in a straight line with the direction of the longitudinal load of the higher grade section and that the two poles or structures comply with the requirements for the higher grade as to transverse strength and conductors between the two poles comply with the requirements for the higher grade.

47.3 End Supports in Grades "A" or "B" Construction

In Grades "A" or "B" construction the longitudinal load on each end support of crossings, conflicts or joint use, where located in lines of the same grade of construction, shall be taken as the unbalanced load equal to the tension of one–third of the total number of conductors (not including overhead ground wires), such one–third of the conductors being so selected as to produce the maximum stress in the supports. If the application of the above results in the fractional part of a conductor, the nearest whole number of conductors shall be used. In no case shall the application of this rule be held to permit the design of the end supports (including poles, structures, towers, crossarms, pins, insulators, conductor fastenings and guys) with strengths less than the effects of the loads.

Excluded from the requirements of this rule, where Grade "B" construction is required, are Class L lines crossing minor railways and conductor fastenings of Class C circuits crossing major railways.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

Rule 48

48 Strength of Materials

Structures, including their members and connections, shall be designed and constructed so that the structures and parts thereof will not fail or be seriously distorted under the requirements of Rule 44.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

Rule 48.1

48.1 Wood

A. Natural Wood (Non Laminate)

(1) Poles

The strength for natural wood poles of various species meeting the requirements of ANSI O5.1 2008 shall be the designated fiber strength specified in ANSI O5.1 2008. Table 5 lists some of the values of designated fiber strength specified in ANSI O5.1 2008.

(2) Sawn Wood Structural Members

The strength for sawn wood structural members, such as crossarms and braces, meeting the requirements of ANSI O5.3 2008 shall be the designated fiber strength specified in ANSI O5.3 2008.

Multiply the given designated fiber strength values by an additional factor of 0.55 for sawn wood where the loading being considered is a long-time loading (i.e., continuous load for one year or more).

B. Laminated Wood

The strength for laminated wood poles and other structural members, such as crossarms, meeting the requirements of ANSI O5.2 2006 shall be the designated fiber strength specified in ANSI O5.2 2006.

Table 5: Sample Wood Strengths
Specified in ANSI O5.1-2008

Species	Designated Fiber Strength
Cedar, western red	6,000 lbs per square inch
Douglas fir	8,000 lbs per square inch
Fir, white or red, local	6,600 lbs per square inch
Pine, southern	8,000 lbs per square inch

Note: Revised April 26, 1965 by Decision No. 68835; March 9, 1988 by Resolution E–3076, October 9, 1996 by Resolution SU–40 and February 5, 2014 by Decision No. 14-02-015.

Rule 48.2

48.2 Steel

As applicable, steel members and their connections shall be designed in accordance with the following standards:

Latticed Steel Structures: ASCE 10-97, and

Tubular Steel Pole Structures: ASCE 48-11

Allowable stresses for steel members and their connections shall be derived by multiplying the values specified in the applicable standard by the appropriate strength factors specified in Table 4-2.

Steel members not covered by either of these standards shall be designed using allowable stresses as defined below, consistent with Rule 48:

Tension: The maximum allowable tensile stress shall be calculated using the following formula:

$$F_t = SF\left(F_y\right)$$

Compression: The maximum allowable compressive stress shall be calculated using the following formula:

$$F_a = SF\left[F_y - \left(\frac{F_y - 12{,}000}{200}\right)\frac{l}{r}\right]$$

Shear: The maximum allowable shear stress shall be calculated using the following formula:

$$F_v = SF\ 0.66\ (F_u)$$

Bending: The maximum allowable bending stress for a compact section shall be calculated using the following equation:

$$F_b = SF\ (F_y)$$

The maximum allowable bending stress for a non-compact section shall be determined according to the provisions of Chapter E of the AISC Manual of Steel Construction, Allowable Stress Design, 9th Edition.

Combined Stresses: The strength of members subjected to combined stresses shall be determined according to the provisions of Chapter H of the AISC Manual of Steel Construction, Allowable Stress Design, 9th Edition.

Where,
Fa = maximum allowable axial stress, psi

Fb = maximum allowable bending stress, psi

Ft = maximum allowable tensile stress, psi

Fu = specified minimum tensile stress, psi

Fv = maximum allowable shear stress, psi

Fy = specified minimum yield stress, psi

SF = strength factor specified in Rule 44

l = unsupported length of member, inches

r = radius of gyration of member, inches

The values used for yield stress, Fy, and tensile stress, Fu, shall be the specified minimum values as listed in the appropriate ASTM specification. If the material specification for the steel is unknown and cannot be determined, the values for its yield stress and tensile stress shall be assumed to be 33,000 psi and 60,000 psi, respectively. The modulus of elasticity, E, is defined to be 29,000 ksi.

Note: Revised March 30, 1968 by Decision No. 73813, January 13, 2005 by Decision No. 0501030, and February 5, 2014 by Decision No. 14-02-015.

Rule 48.3

48.3 Concrete

A. Reinforced Concrete

Values used for ultimate strengths of reinforced concrete shall not exceed the following:

Reinforcing steel, tensile or compressive strength, pounds per square inch: 55,000

Concrete, 1:2:4 mixture		Age	Compressive Strength
		7 days	900 lbs per sq. in.
		30 days	2,400 lbs per sq. in.
		90 days	3,100 lbs per sq. in.
		6 months	4,400 lbs per sq. in.

If reinforced concrete is designed for higher strength values which are proven by test, such values may be used in lieu of the figures given.

B. Prestressed Concrete

The minimum strength of the materials used in prestressed concrete structures shall be as follows:

Reinforcing Steel - yield strength (F_y) 40,000 psi
Prestressing Steel - yield strength (F_y) 188,000 psi
Concrete - compressive strength (F'_c)at 28 days 4,000 psi

Other strength values may be used provided the strength values used for design are proven by tests.

Note: Rule 48.3–B added on February 13, 1974 by Decision No. 82466.

Rule 48.4

48.4 Fiber-Reinforced Polymer

The strength of overhead line structures and subcomponents made with fiber-reinforced polymer shall be the lower 5th percentile strength determined in accordance with ASCE 111-2006. This requirement applies to tension and bending, compression and bending, and shear.

The compressive strength shall be determined by a suitable formula for the material or structure, considering the strength of the material, modulus of elasticity, geometry, slenderness ratio and eccentricity of connection.

Note: Added February 5, 2014 by Decision No. 14-02-015.

Rule 48.5

48.5 Other Engineered Materials

The strength of overhead line structures and subcomponents made with other engineered materials shall be the lower 5th percentile strength determined in accordance with ASCE 111-2006. This requirement applies to tension, compression and shear.

Tension: If the material has a published yield strength value, that value shall be used in lieu of the tensile strength value.

Compression: The compressive strength shall be determined by suitable formula for the material used and member geometry, considering yield and /or tensile strength of the material, modulus of elasticity, slenderness ratio and eccentricity of connection. In no case shall the compressive stress be greater than the yield strength of the material.

Note: Added February 5, 2014 by Decision No. 14-02-015.

Rule 48.6

48.6 Conductors, Span Wires, Guys and Messengers

Values used for ultimate strengths of wires and cable shall not exceed those given in Appendix B. The ultimate strengths given in Table 17 to 24 of Appendix B, except for medium–hard drawn copper, are based on the minimum ultimate strengths given in the standard specifications of ASTM International.

The ultimate strengths given in Appendix B for medium–hard drawn copper are based on the referenced ASTM standard specifications and provide an allowance above the minimum values of one–quarter of the difference between minimum and maximum values.

For use of types of wires and cables of other material not included in Appendix B, values for ultimate strengths similarly derived from ASTM standard specifications shall be used except that, if such specifications are nonexistent, manufacturer’s specifications may be used provided that tests have been made which shall justify the manufacturer’s specifications rating for ultimate strength.

Rule 48.7

48.7 Tower or Pole Foundations and Footings

The resistance of soil to foundation or footing bearing and uplift shall be calculated from the best available data or determined by test(s).

Foundations and footings shall be designed consistent with Rule 48.

Rule 49.2-C

C. Strength

Crossarms shall be securely supported by bracing, where necessary, to withstand unbalanced vertical loads and to prevent tipping of any arm sufficiently to decrease clearances below the values specified in Section III. Such bracing shall be securely attached to poles and crossarms. Supports in lieu of crossarms shall have means of resisting rotation in a vertical plane about their attachment to poles or shall be supported by braces as required for crossarms. Metal braces or attachments shall meet the requirements of Rules 48.2 and 49.8.

In addition to the above, a vertical load of 300 lbs. at the outer pin position shall be included in computing the vertical loads on all crossarms.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

(1) Longitudinal Loads Normally Balanced:

(a) Supply Lines: Where longitudinal loads are normally balanced, crossarms supporting supply conductors shall be designed to withstand a load, applied in the direction of the conductors at the outer pin position, of 700 pounds. In no case shall the application of this rule be held to permit the design crossarms with strengths less than the effects of the loads.

(b) Communication Lines, Class C: Where longitudinal loads are normally balanced, crossarms supporting Class C conductors shall have sufficient strength to withstand a load, applied in the direction of the conductors at the outer pin position, of 400 pounds. In no case shall the application of this rule be held to permit the design of crossarms with strengths less than the effects of the loads.

(2) Longitudinal Loads Normally Unbalanced: Crossarms subjected to unbalanced longitudinal loads shall meet the load and strength factors requirements specified in Rule 44.

At unbalanced corners and dead ends in Grades "A", "B" or "C" construction, where conductor tension is held by cantilever strength of pin–type insulators and pins, double crossarms shall be used to permit conductor fastenings at two insulators to prevent slipping. In lieu of double crossarms and double insulators, single crossarms may be used with single insulators and steel pins and prefabricated conductor ties.

For conductor tensions up to 2,000 pounds per conductor, double wood crossarms fitted with spacing devices at each end will be considered as meeting the strength requirements of Rules 47.2 and 47.3.

Note: Revised March 9, 1988 by Resolution E–3076, and February 5, 2014 by Decision No. 14-02-015

Rule 49.3-C

C. Strength

Insulator pins and conductor fastenings shall be able to withstand the loads to which they may be subjected with the load and strength factors specified in Rule 44 applied.

Note: A 1–1/2 inch by 9 inch locust pin will usually provide cantilever strength up to 1,000 pounds tension in the conductor with the conductor 3–1/2 inches above the crossarm and a load factor of unity.

(1) Longitudinal Loads Normally Balanced:

(a) Insulator Pins: Where longitudinal loads are normally balanced, insulator pins which support conductors shall have sufficient strength to withstand a load at the conductor position as follows:

Pins supporting supply conductors 700 pounds
Pins supporting Class C conductors 400 pounds

In no case shall the application of this rule be held to permit the design of insulator pins and conductor fastenings with strengths less than the effects of the loads.

(b) Conductor Fastenings: Where longitudinal loads are normally balanced, tie wires or other conductor fastenings shall be installed in such a manner that they will securely hold the line conductor to the supporting insulators and will withstand without slipping of the conductor unbalanced pulls as follows:

Supply conductor fastening	40% of the maximum working tensions but not more than 500 pounds.
Class C conductor fastenings	15% of the maximum working tensions but not more than 300 pounds.

(2) Longitudinal Loads Normally Unbalanced: At unbalanced corners and dead ends in Grades "A", "B" or "C" construction, where conductor tension is held by cantilever strength of pin–type insulators and pins, double insulators and wood pins or single insulators and steel pins shall be used. Each line conductor shall be tied or fastened to both insulators, or the single insulator, to prevent slipping of the conductor under maximum working tension with a load factor of 2 for the temperature and loading conditions specified in Rule 43.

At changes in grade of construction and at end supports in Grades "A" or "B" construction where the conductors are not dead–ended and are supported on pin–type insulators, double insulators and pins with tie wires, or equivalent fastenings, will be considered as meeting the strength requirements of Rules 47.2 and 47.3 for conductor tensions up to 2,000 pounds per conductor.

Note: Revised March 9, 1988 by Resolution E–3076, and February 5, 2014 by Decision No. 14-02-015.

Rule 49.4-B

B. Size

The minimum sizes of conductors which shall be used in spans of 150 feet or less under the several classes of construction and loadings in both urban and rural districts are specified in Table 8. Larger conductors than those specified in the table will often be necessary to maintain reasonable sag and at the same time to meet the load and strength factor requirements of Rule 44, ground clearances of Table 1, and wire clearances of Table 2.

Conductors of the sizes specified in Table 8 may be used in spans longer than 150 feet, except when specifically prevented by Rule 49.4–C, provided the sags and conductor positions are so adjusted that the allowable working tensions and clearances of this Order are not violated.

The common neutral conductor in common neutral systems shall conform to the requirements of Rule 59.3–B in addition to the above requirements.

Note: Revised February 5, 2014 by Decision No. 1402015.

Rule 49.4-Table 8 (Minimum Conductor Sizes)

Table 8: Minimum Conductor Sizes (150–Foot Spans or Less)						
Loading Conditions and Grade of Construction	Material or Type of Conductor					
	Soft or Annealed Copper	Hard–Drawn or Medium Hard–Drawn Copper	Stranded Aluminum	Aluminum Conductor Steel Reinforced	Copper Covered Steel, Bronze or Composites	Galvanized Iron or Galvanized Steel
	AWG	AWG	AWG	AWG	AWG	
Heavy Loading						
Grade "A"	4	6	1	4	6	.25 Dia. in.
Grade "B" (a) (h)	4	6	1	6	8	.148 Dia. in.
Grade "C" (h)	4	6	1	6	8	.148 Dia. in.
Light Loading						
Grade "A"	4	6	1	4	8	.25 Dia. in. (b)
Grade "B" (a) (c) (h)	6	6	1	6	8	.148 Dia. in.
Grade "C" (c) (h)	6	8	1	6	10	.148 Dia. in.
Heavy and Light Loading						
Supply Service Drops Crossing Trolley Wires	8	10	-	-	12	-
Other Supply Service Drops	10	10	-	-	12	-
Grade "C", Single Conductors (d)	-	(e)	-	-	(e)	.083 Dia. in.
Grade "C", Paired Conductors (d)	-	14(f)			17 (g)	-

(a) Communication conductors crossing over major railroads may be smaller but shall be not less than as specified in Rule 113.4.
(b) Three–sixteenth–inch strand may be used upon special permission of this Commission.
(c) May be smaller but shall provide tensile strength not less than #8 AWG soft copper, if less than 750

Volts, as per Rule 49.4–C2.

(d) Communication service drops over supply lines shall conform to Rules 32.2–F and 32.2–G.
(e) #12 AWG or #14 NBS.
(f) Paired wire may be smaller per Rule 49.4–C7b.
(g) High strength paired wire may be smaller per Rules 49.4–C7b and 49.4–C8.
(h) May be reduced per Rule 49.4–C3.

Rule 49.5

49.5 Insulators

A. Line

Insulators, supports, clamps and other miscellaneous attachments shall be designed to withstand the mechanical load to which they are subjected by conductors, wires or structures, under the loading conditions as specified in Rule 43, with the load and strength factors of Rule 44 applied.

Pin insulators shall effectively engage the thread of the pin for at least two and one–half turns.

B. Guy

Guy insulators, including insulators in messengers, shall have mechanical strength at least equal to that required of the guys or messengers in which they are installed.

C. Replacements (See Rule 44.3)

D. Post

Post insulator units including insulator supports, clamps, and other miscellaneous attachments shall have a cantilever strength determined in accordance with paragraph 5.1.3 of the American Standard Insulator Tests, Publication No. C29.1–1961, or the latest revision thereof, equal to or greater than the mechanical load to which they are subjected by conductors, wires, or structures under the loading conditions as specified in Rule 43 with the load and strength factors of Rule 44 applied.

Note: Added January 6, 1968 by Decision No. 73455

Rule 49.6-B

B. Size

The size and ultimate strength of guys crossing in spans over Class H, L, T or C circuits shall be not less than as specified in Table 9 and shall also meet the load and strength factor requirements specified in Rule 44 for the loads imposed by the construction involved under the loading conditions specified in Rule 43.

Rule 49.7

49.7 Messengers and Span Wires

A. Material

Messengers and span wires shall be stranded and of galvanized steel, copper–covered steel or other corrosion–resisting material not subject to rapid deterioration.

B. Strength

Messengers and span wires with the load and strength factor requirements specified in Rule 44 applied shall be capable of withstanding the tension developed because of the load they support combined with the loading conditions specified in Rule 43. An allowance of 300 lbs. of vertical load for a worker and cable chair shall be made in computing tensions in messengers and span wires which support cables except in the case of short spans which are not required to support workers or where the ice loading specified in Rule 43.1–B would exceed the allowance for the worker and cable chair.

Guys supporting messenger loads shall comply with the load and strength factor requirements specified in Rule 44.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

C. Supports

Messengers supporting cables shall be attached to poles or crossarms with hardware that complies with the load and strength factor requirements specified in Rule 44, based on the weight of the messenger wire, cable, line-mounted equipment plus an allowance of 300 lbs. for a worker and cable chair. If in heavy loading areas the specified ice load exceeds in weight the 300 lbs. allowance, such ice load shall be used in making the calculations in preference to the weight of the worker and cable chair.

Note: Revised February 5, 2014 by Decision No. 14-02-015.

D. Replacements (See Rule 44.3)

Rule 54.5

54.5 Sags

Minimum conductor sags shall be such that, under the loading conditions specified in Rule 43, the requirements specified in Rule 44 shall be met. See Charts in Appendix C for suggested sags at normal temperatures.

Rule 56.2

56 Overhead Guys, Anchor Guys and Span Wires

56.2 Use

Where the effects of the mechanical loads imposed on poles, towers, or structures are greater than can be supported with the requirements specified in Rule 44, additional strength shall be provided by the use of guys or other suitable construction.

Where guys are used with poles or similar structures capable of considerable deflection before failure, the guys shall be able to support the entire load, the pole below the point of guy attachment acting merely as a strut.

Guys shall be attached to structures, as nearly as practicable, at the center of load. They shall be maintained taut and of such strength as to meet the requirements of Rule 44.

Rule 57.2

57.2 Use of Messenger

Where a cable is of such weight that it would not meet the requirements of Rule 44 when self–supported, attachment to stranded messenger shall be made for supporting said weight.

Rule 66.2

66 Guys

66.2 Use

Where the effects of the_mechanical loads imposed on towers or structures are greater than can be supported per the requirements specified in Rule 44 or the design of such towers and structures requires it, additional strength shall be provided by the use of guys or other suitable construction.

Where guys are used with structures capable of considerable deflection before failure, the guys shall be able to support the entire load, the structure below the point of guy attachment acting merely as a strut.

Guys shall be attached to structures, as nearly as practicable, at the center of load. They shall be maintained taut and of such strength as to meet the requirements of Rule 44.

Rule 77.3

77.3 Material and Strength

B. Strength

The strength of span wires, backbones, messengers, etc., shall be such that the requirements of Rule 44 are met.

Rule 81.3

81.3 Material and Strength

Communication poles shall meet the material and strength requirements specified in Section IV.

A. Replacement of Wood Poles in Grade C Construction

Wood poles in Grade C construction shall be replaced or reinforced in accordance with the requirements of Rule 44.3, except that the circumference of sound solid wood within 18 inches above and below the ground line on such poles before replacement or reinforcement shall not be less than as follows:

Poles supporting 10 or less open wire Conductors	9 inches
Poles supporting cable, or more than 10 open wires conductors	12 inches

Note: Revised November 21, 1990 by Resolution SU–6, January 13, 2005 by Decision No. 0501030, and February 5, 2014 by Decision No. 1402015.

Rule 84.5

84.5 Sags

The minimum conductor sags shall be such that under the specified loading conditions, the requirements specified in Rule 44 shall be met.

Rule 86.2

86.2 Use

Where the effects of the mechanical loads imposed on poles, towers or structures are greater than can be supported per the requirements specified in Rule 44, additional strength shall be provided by the use of guys or other suitable construction.

Where guys are used with poles or similar structures capable of considerable deflection before failure, the guys shall be able to support the entire stress, the pole below the point of guy attachment acting merely as a strut.

Guys shall be attached to structures as nearly as practicable at the center of load. They shall be maintained taut and of such strength as to meet the requirements of Rule 44.

Rule 87.2

87.2 Use of Messenger

Where a cable is of such weight that it would not meet the requirements of Rule 44_when self–supported, said weight shall be supported by attachment to a stranded messenger.

Rule 87.5

87.5 Fastenings

Messenger fastenings shall meet the requirements of Rule 44. The fastenings or attachments by which messengers are deadended shall have a strength at least equal to that of the strand to which they are attached.

Rule 94.3

94.3 General Requirements

On joint use poles supporting Class T, C, L or H Circuits (up to 50 kV), the following shall apply:

A. Antennas shall meet the requirements of Class C equipment, unless otherwise specified in this rule.

B. All associated elements of the antenna (e.g. associated cables, messengers) shall meet the requirements of Class C circuits.

C. Support elements (e.g. arms, braces, brackets, hardware) and pole-top extensions shall conform to the requirements of Section IV.

Note: Support elements (e.g. arms, braces, brackets, hardware) and pole-top extensions installed above supply lines shall meet Grade "A" requirements specified in Rule 44.

Appendix B

Appendix B Mechanical and Loading Data for Conductors

The tables included in Appendix B contain mechanical data for conductors commonly used in supply and communication lines. The ultimate strengths and other data for copper, steel and iron wires are those contained in specifications of ASTM International (formerly - the American Society for Testing Materials) are ultimate strengths based upon such specifications. For other types and kinds of conductors the ultimate strengths and other data used have been taken from manufacturers' specifications.

The requirements of Rule 43 were used to calculate the loaded conductor conditions.

Table No.

17	Copper Wire–Bare–Solid–Characteristics and Loading
18	Copper Wire–Bare–Stranded and Solid–Characteristics and Loading
19	Copper Wire–Stranded and Solid–Double Braid Weather–proof–Characteristics and Loading
20	Copper Wire–Stranded and Solid–Triple Braid Weather–proof–Characteristics and Loading
21	Galvanized Steel and Iron Wire–Bare–Solid - Characteristics and Loading
22	Copper Covered Steel–Strand, Solid and Composite - Characteristics and Loading
23	Aluminum Cable Steel Reinforced–Bare–Characteristics and Loading
24	Mechanical Characteristics of Galvanized Steel Strand

<u>Proposed Final Appendix B Table Footnotes</u>

Tables 17-20

- **ASTM B1-13(2018)** Standard Specification for Hard-Drawn Copper Wire

Tables 17-10

- **ASTM B2 - 13(2018)** Standard Specification for Medium-Hard-Drawn Copper Wire

Table 21

- **ASTM A111– 99a(2014)** Standard Specification for Zinc-Coated (Galvanized) "Iron" Telephone and Telegraph Line Wire

Table 24

- **ASTM A123 /A123M-17** Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

Appendix C

Appendix C (a), Conductor Sags

(a) Basis of Sag Curves for Supply Conductors

Data are presented in Appendix C in the form of curves in Charts numbers 1 to 9 inclusive, showing conductor sags which produce tensions that do not exceed either 35% of ultimate strength of the conductor at 60° F. and no wind, or 50% of ultimate strength of the conductor under the maximum loading conditions specified for Light or Heavy Loadings in Rule 43. These sags are considered particularly applicable to the stringing of new wire (i.e., they should be considered initial sags for conductors which have not been prestressed) and are not recommended in the case of used or so–called prestressed wire.

(b) Communication Conductor Sags

The requirements of Rule 44 and the conductor sizes of Rule 49.4 are the minimum requirements applicable to communication conductors. Conductors will meet the minimum requirements of these rules for Grade "C" construction.

Appendix F

Appendix F
Typical Problems

The application of line construction requirements specified in this Order is exemplified in the following:

Part 1. Crossing Problem–A Class H and a Class C circuit Crossing over a major railroad, major Class C circuits and a highway.

Part 2. Deadend Problem–H and Class L circuits at a dead end.

Part 3. Angle Pole Problem–Guying a pole supporting Class H and Class L circuits at angles in lines.

The problems are computed on the assumptions of light loading conditions (Rule 43.2), with Grade "A" construction used for the power circuits and Grade "C" construction used for the communication circuits except in the crossing spans where Grade "B" is required. The construction details specified in these Typical Problems are made to conform to current good practice.

This edition of GO 95 replaces the use of "safety factors" with "load factors" (Table 4-1) and "strength factors" (Table 4-2). The ratios of the load factors in Table 4-1 to the strength factors in Table 4-2 correspond to equivalent minimum safety factors as indicated in Rule 44. In some cases, there are slight differences due to rounding the results of the calculations. The equivalent minimum safety factors are provided in Table F-1 (Table 4) which matches the minimum safety factors in Table 4 from previous editions of GO 95. Table F-1 (Table 4), previously referred to as Table 4, is referenced in Appendix F for historical purposes, and so other General Orders which incorporate Table 4 may continue to reference Table 4.

Table F-1 (Table 4) Minimum Safety Factors

Line Element	Grades of Construction		
	Grade "A"	Grade "B"	Grade "C"
Conductors, splices and conductor fastenings (other than tie wires)	2	2	2
Pins	2	2	2
Pole line hardware	2	2	2
Line Insulators (mechanical)	3	2	2
Guy insulators (mechanical)			
Interlocking	2	2	2
Noninterlocking glass fiber	3	2 (a)	2 (b)
Guys	2	2	2
Messengers and span wires	2	2	2
Foundations against uplift	1.5	1.5	1.5
Foundations against depression	3	2	2
Poles, Towers and Structures			
Wood	4	3	2
Metal (including elements of foundations)	1.5 (c)	1.25 (c)	1.25 (c)
Reinforced concrete	4	3	3
Prestressed or post-tensioned concrete	1.8	1.5	1.5
Other engineered materials	1.5	1.25	1.25
Crossarms			
Wood	2	2	2
Metal (c)	1.5 (c)	1.25 (c)	1.25 (c)
Prestressed Concrete	1.8	1.5	1.5
Other engineered materials	1.5	1.25	1.25

(a) Insulators are to be replaced before safety factors have been reduced (due to deterioration or changes in construction, arrangement, or other conditions subsequent to installation) to less than 95 percent of the safety factor specified in Rule 44.1.

(b) Insulators are to be replaced before safety factors have been reduced (due to deterioration or changes in construction, arrangement, or other conditions subsequent to installation) to less than 75 percent of the safety factor specified in Rule 44.1.

(c) For aluminum members subject to tension caused by one or more estimated loads and where the critical load combination for the tension member would not endanger adjacent compression members, the safety factor on ultimate tension shall be 2 for Grade "A" and 1.67 for Grades "B" and "C" construction.

Part I

Crossing Problem

A diagram including dimensions is shown at the end of Part 1. The data chosen for the crossing follow:

Data of Crossing

Circuits

Two 3–phase 60,000 Volt power circuits. One metallic private Class "C" telephone circuit.

Configuration

Power conductors of each circuit are in vertical planes on opposite ends of the crossarm. Private telephone circuit is in a horizontal plane.

Conductors

Power circuits are six No. 00 AWG, bare, stranded, hard–drawn copper. Private telephone circuit is two No. 8 AWG, bare, solid, hard–drawn copper, except in the crossing span where it is two No. 6 AWG, bare, solid, hard-drawn copper.

Insulators

Porcelain, pin type, meeting the requirements of Rule 49.5–A.

Ties

Annealed copper wire to comply with Rules 49.3–B and 49.3–C.

Pins

Power circuits–wrought iron pipe (extra strong), 1–1/2″ x 18–1/2″, to comply with Rules 49.3–B and 49.3C. Assumed bonded in accordance with the requirements of Rule 53.4.

Communication circuit - 1–1/2″ x 9″ locust.

Crossarms

Power circuits–Douglas fir (dense), 4–3/4″ x 5–3/4″ x 12′, 1.9″ pin holes, 11/16″ hole for through bolt.

Communication circuit–Douglas fir (dense), 3–1/4″ x 4–1/4″ x 42″, l–l/2″ pin holes, 11/16″ hole for through bolt.

Crossarm Braces

Meeting the requirements of Rule 49.2–C.

Poles

Western red cedar, round, butt treated.

Span Length

Crossing span, 200 feet.

Adjacent spans, 150 feet.

Construction Requirements

1. Conductor Sags and Tensions

The conductors are assumed to be strung so that at normal conditions of 60°F and no wind the tension will be 35% of the ultimate tension of the conductors. From Chart No. 1, Page C–6, it will be seen that under these conditions the No. 00 AWG conductor, for a 200 foot span, will have a sag of 1.0 foot (0.99 when calculated), and the No. 6 AWG conductor will have a sag of 0.90 foot (0.89 when calculated). These sags may be calculated by means of the following approximation formula:

$$\text{Sag}=\frac{wd^2}{8T}$$

Where w = conductor loading, pounds per lineal foot
d = span length, feet
T = assumed allowable conductor tensions at 60°F and no wind

For No. 00 AWG conductor

$$\text{Sag}=\frac{0.4109 \times 200^2}{8 \times 2074} = 0.99 \text{ Foot}$$

For No 6 AWG conductor

$$\text{Sag}=\frac{0.0795 \times 200^2}{8 \times 448} = 0.89 \text{ Foot}$$

Maximum conductor load to be met with load and strength factors applied as specified in Rule 44.1 will occur at the conditions of 25°F and an 8 pounds per square foot (psf) wind (Rule 43.2). Conductors which have been strung at the normal conditions stated above (60°F, no wind, and 35% ultimate tension) will have sags and tensions at the maximum loading conditions of 25°F and an 8 psf wind as indicated below. Maximum conductor sags will occur at the condition of maximum temperature, 130°F and also are shown in the following tabulation:

	#00 AWG (Power)		#6 AWG (Comm)	
	Sag (Feet)	Tension (Pounds)	Sag (Feet)	Tension (Pounds)
Ultimate Conductor Tension (See Appendix B, Table 18)	-	5,925	-	1,280
35% Ultimate at 60°F, No Wind	0.99	2,074	0.89	448
25°F, 8 psf Wind	0.95	2,605	1.18	570
130°F, No Wind	1.78	1,157	1.55	256

The tension in the supply conductors (2,605 lbs) at maximum loading (25°F, 8 psf wind), multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the conductors (5,925 lbs) multiplied by the strength factor of 0.75 (Table 4-2), or it is required that

2,605 lbs x 1.5 ≤ 5,925 lbs x 0.75

or

2,605 lbs ≤ 5,925 lbs /(1.5/0.75) = 5,925 lbs /2.0 = 2,962 lbs

The tension in the communication conductors (570 lbs) at maximum loading (25°F, 8 psf wind), multiplied by the load factor of 1.25 (Table 4-1), for Grade B construction, must not exceed the strength of the conductors (1,280 lbs) multiplied by the strength factor of 0.625 (Table 4-2), or it is required that

and

$$570 \text{ lbs} \times 1.25 \leq 1{,}280 \text{ lbs} \times 0.625$$

or

$$570 \text{ lbs} \leq 1{,}280 \text{ lbs} /(1.25/0.625) = 1{,}280 \text{ lbs} /2.0 = 640 \text{ lbs}$$

Hence, the tensions at maximum loading for both types of circuits are within the required limits.

Lesser sags than those shown above may be used, provided conductor tension, at maximum loading condition specified in Rule 43does not exceed 50% of the ultimate tension of the conductor. The rules, of course, do not prevent the use of greater sags than are calculated above.

2. Conductor Clearance from Center Line of Pole

Minimum clearances specified in Table 1, Case 8 and Rule 54.4–D2 and the clearances assumed for the purposed of this problem are as follows:

	Minimum	Used
60,000 Volt circuits	21.5″	5′ 6″
Communications circuit	15″	18″

3. Conductor Separation

Table 2, Case 12, Column H modified by Rule 54.4–C1c, permits a vertical separation of not less than 36 inches between the conductors of a 60,000 Volt circuit in vertical configuration. For this problem a separation of 5′6″ is used.

The minimum separation between the level of the lowest supply conductor and the communication circuit is 72 inches (Table 2, Case 8, Column H). For the problem, a separation of 96 inches between crossarm centers is used.

4. Clearances of Conductors Above Crossarms

The minimum clearance of a 60,000–volt conductor from the surface of a crossarm is required (by Table 1, Case 9, Column F) to be at least 1/4 of the pin spacing specified in Table 2, Case 15, Column H, which would be a minimum clearance of 9 inches. For this problem, an 18–1/2 inch pin is used which, with its insulator, places the conductor 14 inches above the crossarm.

5. Conductor Clearances Above Highway, Pole Lines and Railroad Tracks

The poles supporting the crossing span are 55 feet in length, set 7 feet (Rule 49.1C) in the ground. From dimensions of the pole framing diagram the distance of the private telephone circuit above ground is 28′ 4″. For this problem, a common elevation has been assumed for the ground line, the railroad tracks and the highway.

The sag of the communication conductors in the crossing span is approximately 11 inches at 60°F and 19 inches at 130° F. Since the allowable variation of 5% for temperature, applied to the ground clearance of 27′ 5″ (28′ 4″ - 11″), is 1′ 4″, which is greater than the difference between the sags at 60°F (11″) and at 130°F (19″), the clearances may be determined at 60°F for all conditions. In the crossing diagram, at the end of Part 1, the distances from supporting pole C to the various objects crossed over by the conductors are as follows:

Telephone pole line	37′	6″
Highway (center)	60′	0″
Telegraph pole line on RR r/w	97′	6″
Railroad Tracks (center)	138′	9″
Railroad Signal pole line	180′	0″

The total length of crossing span is 200 feet. Therefore, the clearance at 60°F of the private communications circuit above the telephone lead at point of crossing is obtained as follows:

Clearance point distance from Pole C is 37′ 6″.

At 37′ 6″, or 18.8% of the span, the sag is equivalent to 61% of the center sag (see Chart No. 9 on Page C–14), or 0.61 x 11 = 7″ sag.

Therefore, the clearance equals:

28′ 4″ - (7″ + 24′) = 3′ 9″ clearance.

The minimum required clearance as given in Table 2, Case 3, Column C is 2 feet.
In a like manner the clearances, at 60°F, of the private communication circuit conductors at the other points of crossing are as follows:

Points of crossing	Clearances		Minimum by Rule	
Highway (center)	27′	7″	18′	0″
Telegraph pole line	3′	5″	2′	0″
Railroad Tracks (center)	27′	7″	25′	0″
Railroad Signal pole line	6′	0″	2′	0″

6. Insulators

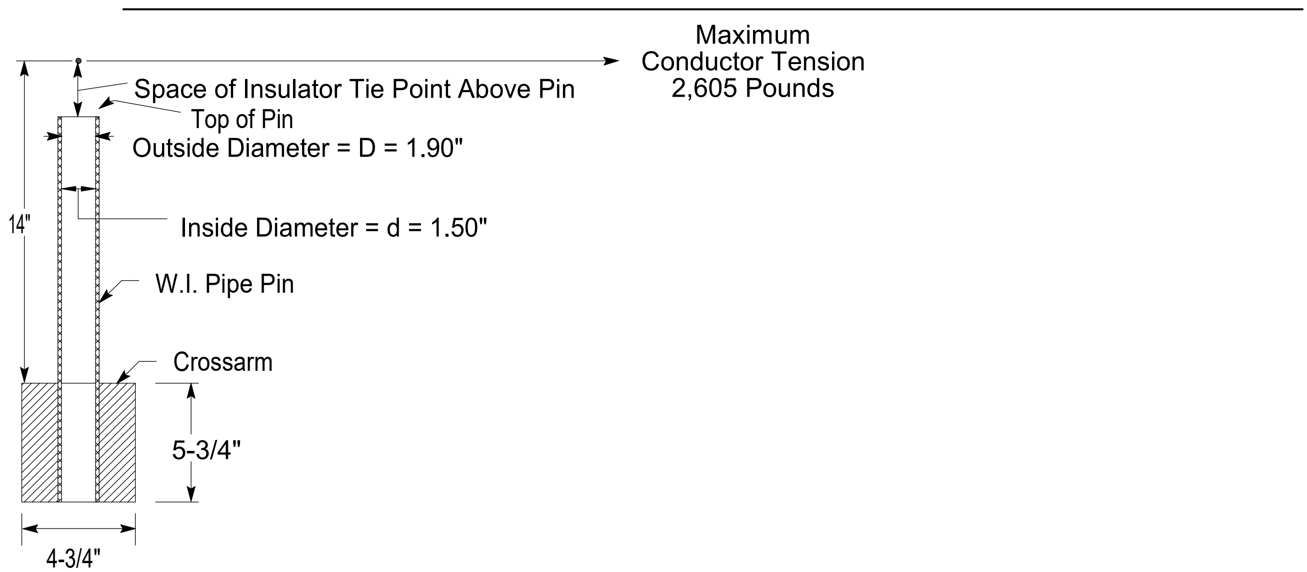
In addition to the electrical requirements set forth in Rules 55 and 104, the insulators supporting the supply and communication conductors shall have safety factors (mechanical) of 3 and 2, respectively.

7. Pins, Ties and Conductor Fastenings

Ties used in connection with pin–type insulators shall conform to Rule 49.3. In this problem a No. 4 and No. 8 annealed copper wire are used for the No. 00 and No. 8 circuits involved.

Pins used in connection with pin–type insulators shall have sufficient strength to withstand the tension in the conductor. In the case under discussion wrought iron pipe–pins of the dimensions and construction indicated below are to be employed for the power conductors.

Appendix F, Part 1



Bending moment (at crossarm) M = 2,605 x 14 = 36,470 pound–inches

$$\text{Section Modulus } E = \frac{\pi(D^4 - d^4)}{32D} =$$

$$0.0982 \times \frac{(1.90^4 - 1.50^4)}{1.90} = 0.412 \text{ in}^3$$

$$\text{Stress } S = \frac{M}{E} = \frac{36470}{0.412} = 88500 \text{ psi}$$

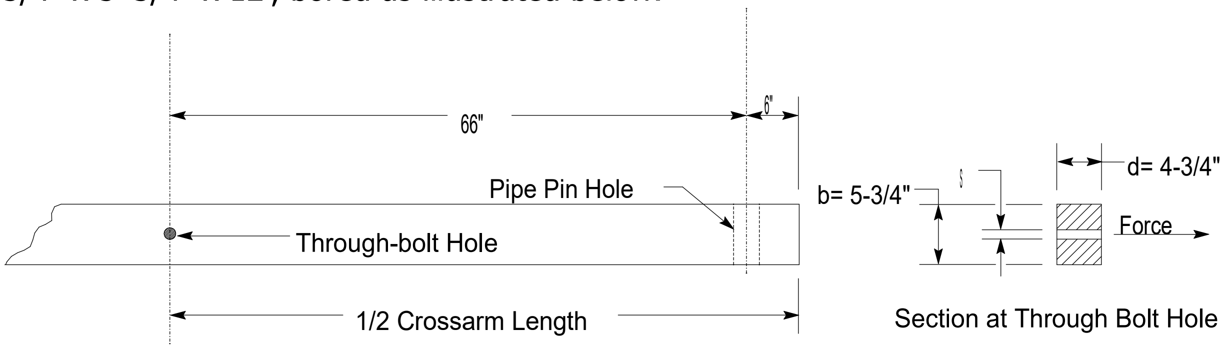
Since the stress in the pin (88,500 psi) at maximum loading must not exceed the strength of the pin (48,000 psi), is required by Rule 47.3, two pins are necessary and therefore double crossarms, pins and insulators are used on the poles supporting the crossing span.

Locust pins are to be used in this case for the private telephone conductors. Although a 1–1/2 inch locust pin would be sufficient to withstand the conductor tension of 570 pounds, as required by Rule 47.2, care would be necessary to provide sufficient strength in the conductor fastenings. In this problem, the private telephone conductors are considered to be dead–ended at the ends of the crossing span.

8. Crossarms–Horizontal Loads

Power Circuits

The point of maximum bending moment will be at the crossarm through bolt attaching the arm to the pole, at which point the cross section of the arm is reduced by the amount of the bolt hole. Crossarms supporting the 60 kV wires are to be Douglas fir, dense, dimensions 4–3/4″ x 5–3/4″ x 12′, bored as illustrated below.



The section through the arm and the method of computing the fiber stress is shown below. Note: for simplicity this example only assesses weak axis bending stress on the crossarm, there may be other load effects that should be assessed.

Long–time loading: Since longitudinal conductor loads are normally balanced, long–time horizontal loading of the power circuit crossarms need not be considered.

Single arm, Maximum loading, 25°F and an 8 psf wind

Bending moment = 2,605 x 66 = 171,930 pound–inches

Section modulus = $\frac{bd^2}{6}$ where

b = 5.75″ – 0.69 = 5.06″
d = 4.75″
s = 11/16″ = 0.69″

Section modulus = $\frac{5.06 \times 4.75^2}{6}$ = 19.0 in^3

Fiber Stress = Bending moment divided by

Section modulus = $\frac{171930}{19.0}$ = 9050 psi

As the value for designated fiber strength in bending under maximum loading conditions is 7,800 psi (see ANSI O5.3 2008), a single crossarm of the size chosen provides a strength of only 0.86 of the assumed load effects at maximum loading conditions, whereas the provisions of Rule 47.3 do not allow a strength less than the effects of the load . Double arms will, therefore, be used in this problem to meet the strength requirements applicable to crossarms at end supports of crossings. Double crossarm construction of this type with separation maintained by space bolts is assumed to have a horizontal strength equivalent to 130% of the sum of the strengths of two single crossarms acting independently.

Maximum loading, 25°F and an 8 psf wind

Bending moment = 2,605 x 66 = 171,930 pound–inches

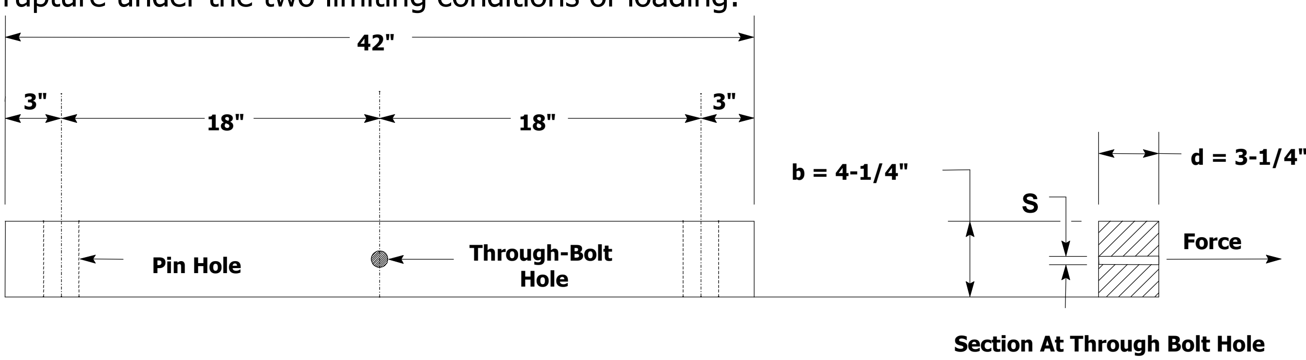
Single arm section modulus (same as previously calculated) = 19.0 in^3
Double arm section modulus = 19.0 x 2 x 1.3 = 49.4 in^3

$$\text{Fiber stress} = \frac{171930}{49.4} = 3840 \text{ psi}$$

Hence the fiber stress in the double crossarm (3,840 psi) at maximum loading (25°F, 8 psf wind) does not exceed the designated fiber strength of the crossarm (7,800 psi), as required by Rule 47.3.

Private Communication Circuit

At the crossing span, double crossarms are used on account of dead–end construction due to change of conductor size. Current practice provides for this method of construction although a single arm has sufficient strength as is found from the following calculations of modulus of rupture under the two limiting conditions of loading:



Long–time loading, 60°F and no wind

Bending moment = 448 x 18 = 8,064 pound–inches

$$\text{Section modulus} = \frac{bd^2}{6} = \frac{3.56 \text{ x } 3.25^2}{6} = 6.26 \text{ in}^3$$

where d = 3.25”
s = 0.69”

$$b = 4.25'' - 0.69'' = 3.56''$$

Fiber stress=$\frac{8064}{6.26}$=1290 pounds per square inch (psi)

The value for designated fiber strength for long-time loading in bending (Rule 48.1: ANSI O5.3 2008) is 0.55 x 7,800 = 4,290 psi. '

Hence, the fiber stress in the single crossarm (1,290 psi) at maximum loading (25°F, 8 psf wind) does not exceed the long-time strength of the crossarm (4,290 psi), as required by Rule 47.3.

Maximum Loading

Bending moment = 570 x 18 = 10,260 pound–inches
Section modulus = 6.26 inches^3 (as per calculations above)
Fiber stress=$\frac{10260}{6.26}$=1640 psi

The value for designated fiber strength in bending, under maximum loading conditions, is 7,800 psi (ANSI O5.3 2008).

Hence, the fiber stress in the single crossarm (1,640 psi) at maximum loading (25°F, 8 psf wind) does not exceed the designated fiber strength of the crossarm (7,800 psi), as required by Rule 47.3.

9. Crossarms - Vertical Loads

Power Circuits

The vertical load on crossarms, where supports are approximately at the same elevation, is due to the vertical load of conductors in each adjacent span plus 300 pounds at the outer pin position. In the problem under consideration, the conductor supports on the crossing poles (C and D) are at the same elevation, and the supports at the adjacent poles (B and E) are 4.5 feet lower in elevation, which difference in elevation is greater than the normal sag. Then the conductor loading on a crossing span support would be one–half the weight of the conductor of the crossing span plus one–half the conductor weight of a hypothetical span, the curve of which passes through the points of support.

Half the length of the hypothetical span may be calculated as follows:

$$X = \frac{D}{2} + \frac{hT}{Dw}$$

Where

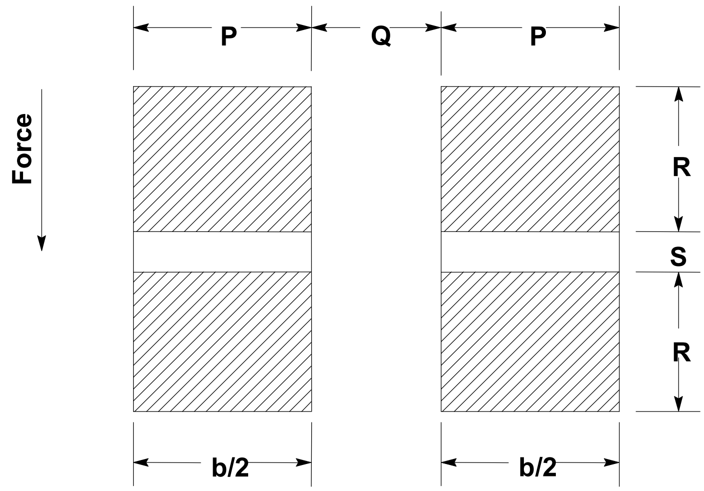
X = 1/2 the hypothetical span in feet.
D = horizontal distance between supports in feet.
h = difference in elevation of supports in feet.
T = conductor tension in pounds.
w = weight of conductor in pounds per foot.

The total crossing support–load is calculated as follows:

$$0.411 \text{ x } \frac{200}{2} + 0.411\left(\frac{150}{2}+\frac{4.5 \text{ x } 2074}{150 \text{ x } 0.411}\right) + 300 = 434 \text{ pounds}$$

The bending moment is: 434 x 66 = 28,640 pound–inches

Appendix F, Part 1



The method of calculating the unit fiber stress of the double crossarms acting as a simple beam is as follows:

$$\text{Section modulus} = \frac{b}{6} \times \frac{d^3 - d_1^3}{d} \quad \text{where}$$

$b = P + P = 9.50''$

$d = R + S + R = 5.75''$

$d_1 = S = 0.69''$

$$\text{Section modulus} = \frac{9.50}{6}\left(\frac{5.75^3 - 0.69^3}{5.75}\right) = \frac{9.50}{6} \times \frac{189.8}{5.75} = 52.3 \text{ in}^3$$

$$\text{Fiber stress} = \frac{\text{Bending moment}}{\text{Section modulus}} = \frac{28640}{52.3} = 550 \text{ psi}$$

Long–Time Loading

The designated fiber strength for long-time loading in bending (Rule 48.1: ANSI O5.3 2008) is 0.55 x 7,800 psi or 4,290 psi. The effects of the load (550 psi) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the long-time strength of the crossarm (4,290 psi) multiplied by the strength factor of 0.75 (Table 4-2), or it is required that

$$550 \text{ psi} \times 1.5 \leq 4{,}290 \text{ psi} \times 0.75$$

or

$$550 \text{ psi} \leq 4{,}290 \text{ psi}/(1.5/0.75) = 4{,}290 \text{ psi}/2.0 = 2{,}145 \text{ psi}$$

Hence, the crossarms are more than adequate.

The fiber stress in the double crossarms of the private telephone circuit, similarly calculated, is found to be less than the required strength.

Shear, compression and torsion stresses are not considered in this problem as they are negligible and likewise the effect of reduction of cross section due to bolt holes is not considered except for the through bolt holes.

10. Poles

The crossing poles are western red cedar and their dimensions are as follows:

Length	55 feet
Height above ground	48 feet
Circumference at top	28 inches
Diameter at top	8.9 inches
Circumference at ground line	49.0 inches
Diameter at ground line	15.6 inches

Distance from ground line to conductors supported is given as follows:

Top supply conductors	48′ 9″
Middle supply conductors	43′ 3″
Lower supply conductors	37′ 9″
Private telephone conductors	28′ 4″

Ground level at base of pole is considered to be at the same elevation as top of rail.

Dimensions of adjacent poles B and E are:

Length	50 feet
Height above ground	43.5 feet
Circumference of top	28 .0 inches
Diameter of top	8.9 inches
Circumference at ground line	47.0 inches
Diameter at ground line	15.0 inches

11. Transverse Load on Crossing Poles C and D

The moment at the ground due to an 8 psf wind pressure on conductors is:

$$Mc = Ln\ P_h\left(\frac{S_1 + S_2}{2}\right) \text{ pound–feet}$$

Where:

L	=	Height of conductors above ground in feet
n	=	Number of wires
S_1 and S_2	=	Length of crossing and adjacent spans, respectively
P_h	=	Horizontal load per lineal foot due to an 8 psf wind pressure on projected area of wire
P_h	=	0.276 pounds per lineal foot for 00 AWG bare, stranded copper
	=	0.108 pounds per lineal foot for 6 AWG bare, solid copper
	=	0.085 pounds per lineal foot for 8 AWG bare, solid copper
M_{c0}	=	Moment due to pressure on top supply conductors
M_{c1}	=	Moment due to pressure on middle supply conductors
M_{c2}	=	Moment due to pressure on lower supply conductors
M_{c3}	=	Moment due to pressure on telephone conductors

$$M_{c0}=48.75 \text{ x } 2 \text{ x } 0.276 \text{ x } \left(\frac{150+200}{2}\right)=4710 \text{ lb-feet}$$

$$M_{c1}=43.25 \text{ x } 2 \text{ x } 0.276 \text{ x } \left(\frac{150+200}{2}\right)=4180 \text{ lb-feet}$$

$$M_{c2}=37.75 \text{ x } 2 \text{ x } 0.276 \text{ x } \left(\frac{150+200}{2}\right)=3650 \text{ lb-feet}$$

$$AM_{c3}=28.33 \text{ x } 2 \text{ x } 0.108 \text{ x } \left(\frac{200}{E2}\right)=610 \text{ lb-feeEt}$$

$$M_{c3}=28.33 \text{ x } 2 \text{ x } 0.085 \text{ x } \left(\frac{150}{2}\right)=360 \text{ lb-feet}$$

Total Moment due to Wind pressure on conductors = 13,510 lb-feet

The moment at the ground due to an 8 psf wind pressure on the pole is:

$$M_P=PH^2\left(\frac{D_1+2D_2}{72}\right) \text{ pound-feet}$$

Where:

M_p	=	Moment due to wind pressure on pole
P	=	Pressure in psf. on projected area of pole (8 psf)
H	=	Height of pole above ground in feet (48′)
D_1	=	Diameter of pole at ground in inches (15.6″)
D_2	=	Diameter of pole at top in inches (8.9″)

$$M_P=\frac{8 \text{ x } 48^2 \text{ x } (15.6 + 2 \text{ x } 8.9)}{72} = 8550 \text{ lb-ft.}$$

Total moment = 13,510 + 8,550 = 22,060 lb–ft.

Moment of resistance of pole = $M=\frac{FI}{c}$

Where:

F = Fiber stress in psi

I = Moment of inertia of section $= \frac{\pi D_1^4}{64x12}$

c = Distance from neutral axis to outer fiber = $\frac{D_1}{2}$

$$M = \frac{\pi F D_1^3}{384} = \frac{F D_1^3}{122}$$

$$F = \frac{122M}{D_1^3} = \frac{122 \text{ x } 22060}{15.6^3} = 710 \text{ psi}$$

The effects of the load (710 psi) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the pole (6000 psi, Table 5) multiplied by the strength factor of 0.375 (Table 4-2), or it is required that

710 psi x 1.5 ≤ 6,000 psi x 0.375

or

710 psi ≤ 6,000 psi /(1.5/0.375) = 6,000 psi/4.0 = 1,500 psi

Hence the crossing poles are not required to be side guyed.

12. Side Guying

If side guying were required for the crossing poles C and D the method of computing the same would be as follows:

Side guys are designed to take the entire transverse load of the pole, the pole acting merely as a strut.

The transverse force acting on the poles will be due to wind pressure on poles C and D and the transverse wind pressure on the conductors supported. The length of conductor used in computing this transverse force will be equal to one–half the distance between the guyed poles C and D, plus one–half the length of the span adjacent to these poles.

The total wind pressure is computed as follows:

On Conductors

$$3 \text{ x } 2 \text{ x } 0.276 \text{ x } \frac{150 + 200}{2} = 289.8 \text{ pounds}$$

$$2 \text{ x } 0.108 \text{ x } \frac{200}{2} = 21.6 \text{ pounds}$$

$$2 \text{ x } 0.085 \text{ x } \frac{150}{2} = 12.8 \text{ pounds}$$

On Pole

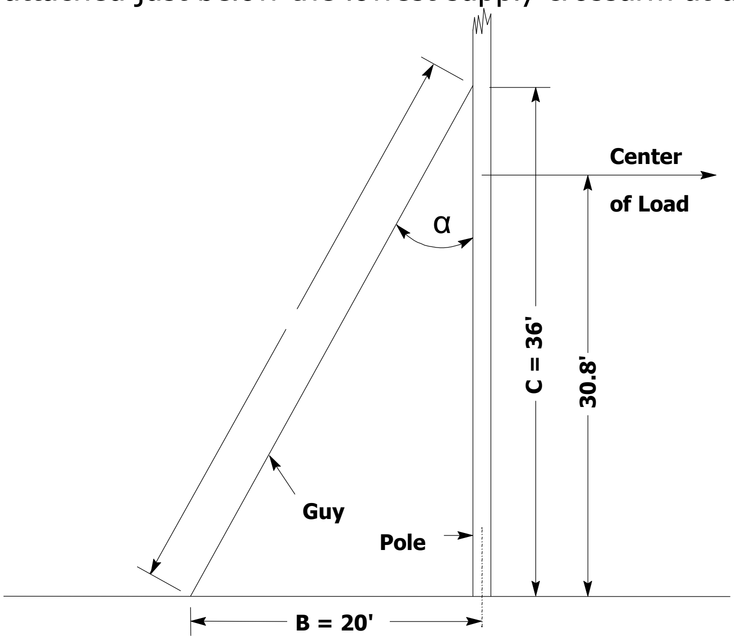
$$\frac{(D_1 + D_2)\ H \times P}{24} = \frac{(15.6 + 8.91)\ 48 \times 8}{24} = 392.2 \text{ pounds}$$

Total Wind Pressure = 716.4 pounds

The total moment on the poles is the same as developed for "Transverse load on poles" which was 22,060 pound–feet.

$$\frac{22060}{716.4} = 30.8 \text{ feet above ground}$$

A side guy could not be attached at this center of load and provide the required clearances from the communication line; therefore, for construction purposes the guy is assumed attached just below the lowest supply crossarm at a distance of 36 feet above ground.



Let	M_t	=	Total moment on pole = 22,060 pound–feet
	C	=	Height of guy attachment above ground = 36 feet (assumed)
	B	=	Distance of guy anchor from base of pole = 20 feet
	T	=	Tension in guy wire in pounds
	A	=	Length of guy = $\sqrt{\left(20^2 + 36^2\right)} = 41.2\,feet$

$\sqrt{20^2 + 36^2}$ = 41.2 feet

$$T = \frac{M_2}{C \sin \alpha}$$

$$Sin\alpha = \frac{B}{A}\, where$$

1. $A = \sqrt{B^2 + C^2}$

$$Sin\alpha = \frac{20}{\sqrt{20^2 + 36^2}} = 0.485$$

$$T=\frac{22060}{36 \times 0.485}=1260 \text{ pounds}$$

The effects of the load (1,260 lbs) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the guy multiplied by the strength factor of 0.75 (Table 4-2). For example, for a 5/16 common galvanized steel strand for which Table 24 indicates the strength is 3,200 lbs, it is required that

1,260 lbs x 1.5 ≤ 3,200 lbs x 0.75

or

1,260 lbs ≤ 3,200 lbs /(1.5/0.75) = 3,200 lbs /2.0 = 1,600 lbs

Hence, one 5/16 inch common galvanized–steel strand would meet the requirements for transverse load. One 1/4 inch Siemens–Martin (3,150 lbs, Table 24) would also meet the requirements.

13. Longitudinal Load on Crossing Poles C and D

Rule 47.3 provides that the strength of the crossing structures shall withstand at all times the unbalanced stress due to the combined pull toward the crossing of one–third of the total number of conductors supported, the pull in each such conductor being taken as the tension due to the specified loading.

Number of conductors involved $=\frac{8}{3}=$ 2-2/3 ;use 3

Location of conductors resulting in maximum load - two on top arm and one on next arm below

Bending moment:

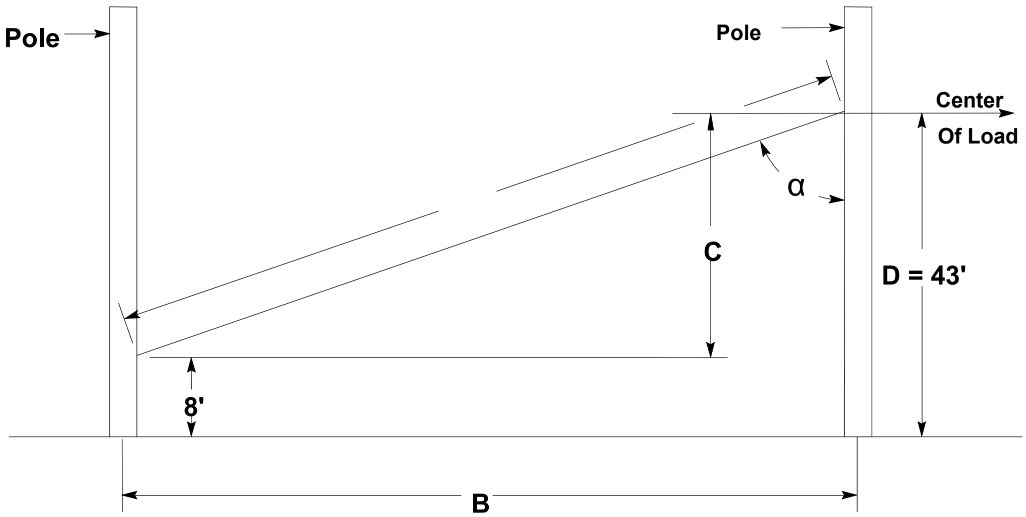
2 x 2,605 x 48.75 = 254,000 pound–feet

1 x 2,605 x 43.25 = 112,600 pound–feet

Total Moment = 366,600 pound–feet

Fiber stress $= \frac{122M}{{D_1}^3} = 122 \times \frac{366600}{15.6^3} = 11780$ psi

The fiber stress is greater than the designated fiber strength of 6,000 psi, hence, poles C and D must be head guyed for longitudinal load.



The head guy should be attached approximately at the normal center of load, therefore:

The bending moment under full longitudinal load would be:

48.75 x 2 x 2,605	=	254,000 pound–feet
43.25 x 2 x 2,605	=	225,300 pound–feet
37.75 x 2 x 2,605	=	196,700 pound–feet
28.33 x 2 x 570	=	32,300 pound–feet
Total moment	=	708,300 pound–feet

The total longitudinal load would be:

3(2 x 2,605)	=	15,630 pounds
2 x 570	=	1,140 pounds
Total wire tensions	=	16,770 pounds

Therefore, the center of longitudinal load is:

$$D=\frac{\text{Longitudinal Bending Moment}}{\text{Longitudinal Load}}$$

$$=\frac{708300}{16770}=42.2 \text{ feet load center above ground}$$

Use 43 feet (to avoid contact with arm)

B = 150 feet

C = 43 - 8 = 35 feet *

$$A=\sqrt{B^2 + C^2}=\sqrt{(43)^2 + (150)^2}=156.0$$

$$Sin\alpha = \frac{B}{A} = \frac{150}{156.0} = 0.962$$

* Lower end of guy assumed 8 feet above ground on Poles A and E.

A guy attached at a point 43 feet above ground on pole C or D and at a point 8 feet above ground on pole B or E, respectively, would be required to withstand a load of:

$$\frac{366000}{43 \text{ x } 0.962}=8860 \text{ pounds}$$

In this case, a 9/16 inch common, 7/16 inch Siemens–Martin, or 3/8 inch high–strength guy strand would meet the requirements of Rule 47.3. The horizontal load transmitted to pole B or E by such a head guy would be:

8,860 x sin α = 8,860 x 0.962 = 8,520 pounds

The longitudinal moment on pole B and E would be:

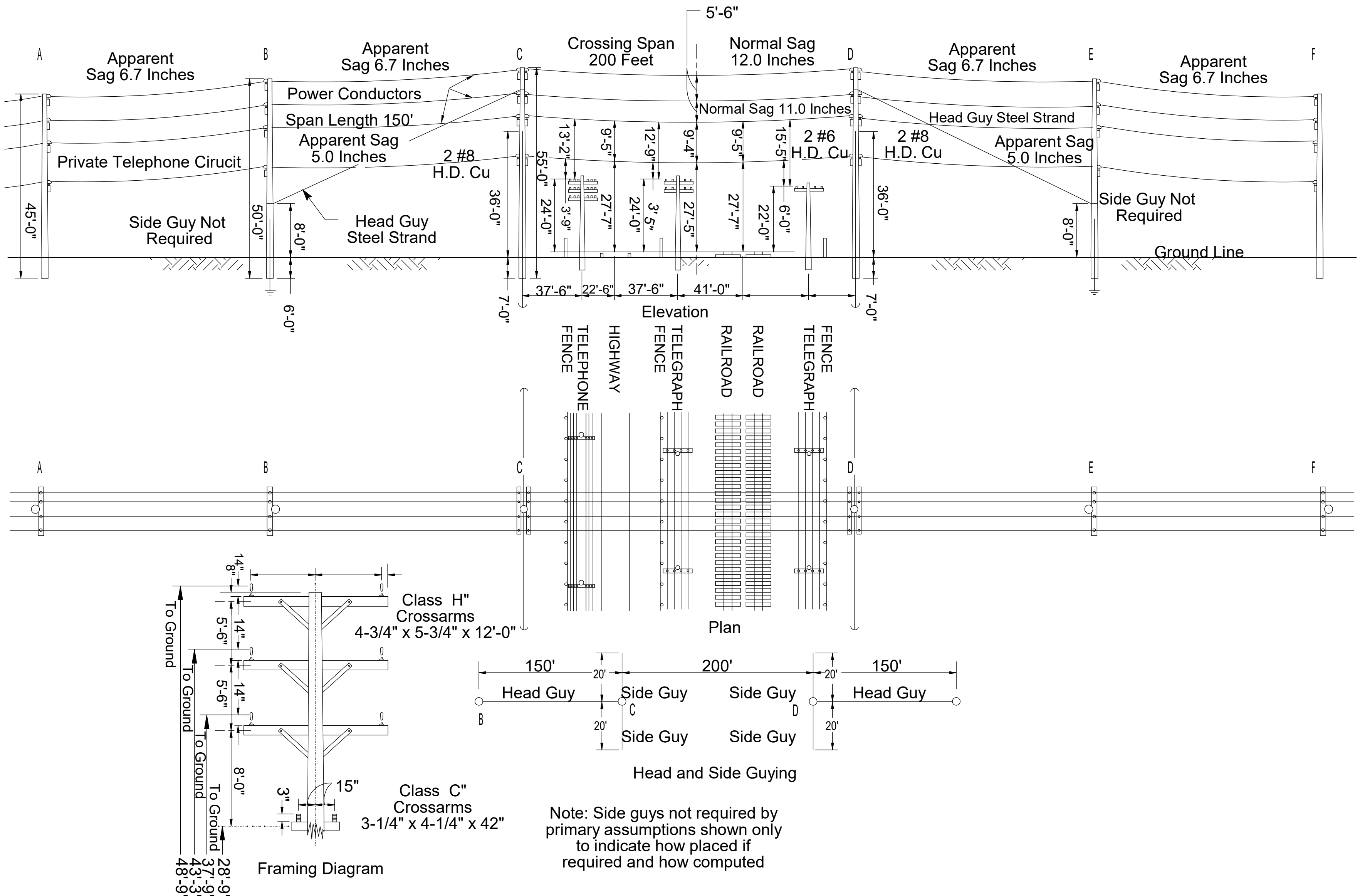
8,520 x 8 = 68,160 pound–feet

and the fiber stress developed in pole B or E by the tension of 8,520 pounds in the head guy would be:

$$F=\frac{122M}{D_1^3}=\frac{122 \times 68160}{15.0^3}=2460 \text{ psi}$$

Poles B and E would, therefore, be adequate to hold the contemplated guy tension since the effects of the loads do not exceed the strength as required by Rule 47.3.

Crossing of Class H" Supply Line Over Major Railroad and Major Communication Lines



Part 2

Deadend Problem

It is the object of this problem to indicate the construction requirements for a typical deadend structure, since the longitudinal stresses imposed upon such a structure differ substantially from those on a pole on which the conductors supported are normally balanced. The deadend structure considered herein is assumed to support an 11,000 volt circuit, a 4,000 volt circuit and two secondary circuits. It is also assumed that the deadend pole takes Grade A construction by virtue of its location.

The deadend structure diagram and dimensions are shown at the end of Part 2. The primary data chosen for this structure are as follows:

Data For Deadend Structure

Supply Conductors

11 kV circuit	3 #0 AWG Stranded, hard–drawn copper
4 kV circuit	4 #2 AWG Stranded, hard–drawn copper
120/240 volt circuit	3 #4 AWG Solid, hard–drawn copper
120/240 volt circuit	3 #2 AWG Stranded, hard–drawn copper

Insulators - Strain Type (to conform to Rule 49.5).
Conductor fastenings (to meet the safety factor of Table 4, Rule 44.1)

Crossarms:

11 kV circuit	Douglas fir 4–3/4″ x 5–3/4″ x 8′–0″
4 kV circuit	Douglas fir 4–3/4″ x 4–3/4″ x 7′–8″
Secondary circuits	Douglas fir 4–3/4″ x 4–3/4″ x 7′–0″

Crossarm braces (to conform to Rule 48.2 and 49.8)
Pole - western red cedar.
Pole dimensions: 55′ in length; 25″ top circumference; 50″ ground line circumference (ground line diameter 15.9″).

Construction Requirements

1. Conductor Tensions

It is assumed that the conductors are strung with the minimum sags specified in sag curves of Appendix C, hence the tension values at 60ºF and no wind (normal tensions) are 35% of the ultimate tensions shown in Table 18. These tensions for each of the conductor sizes and corresponding tensions at maximum loading (25ºF and wind of 8 psf) are as follows, where span length is 250 feet:

	Tension–Pounds	
	35% of Ultimate	At Maximum Loading
#O AWG Stranded, hard–drawn copper	1,664	2,125
#2 AWG Stranded, hard–drawn copper	1,065	1,360
#4 AWG Solid, hard–drawn copper	690	890

2. Crossarms

Spacings assumed are shown on the pole framing diagram at the end of Part 2. Double crossarms of Douglas fir, dense, are employed for each of the four different circuits.

Computations of the fiber stresses imposed upon the various crossarms by the unbalanced wire loads of conductors in the physical configuration shown on the diagram are made in accordance with the method outlined in Part 1 to show these stresses under the conditions of long–time loading and maximum loading. Furthermore, double crossarm construction of this type with separation maintained by space bolts is assumed to have a horizontal strength equivalent to 130% of the sum of the strengths of two single crossarms acting independently. The stresses computed in this manner are:

	Fiber Stress (psi)	
	Long–Time Loading	Maximum Loading
Top crossarms	1,412	1,804
Second crossarms	1,598	2,040
Third crossarms	932	1,202
Fourth crossarms	1,438	1,811

The second crossarm is subject to the greatest loading, for which effects of the load (1,598 psi long-time and 2,040 psi maximum) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the crossarm (Rule 48.1: ANSI O5.3 2008: 7,800 psi maximum or 0.55 x 7,800 psi = 4,290 psi long-time) multiplied by the strength factor of 0.75 (Table 4-2); or it is required that

$$1{,}598 \text{ psi} \times 1.5 \leq 4{,}290 \text{ psi} \times 0.75$$

or

$$1{,}598 \text{ psi} \leq 4{,}290 \text{ psi} /(1.5/0.75) = 4{,}290 \text{ psi}/2.0 = 2{,}145 \text{ psi}$$

and

$$2{,}040 \text{ psi} \times 1.5 \leq 7{,}800 \text{ psi} \times 0.75$$

or

$$2{,}040 \text{ psi} \leq 7{,}800 \text{ psi} /(1.5/0.75) = 7{,}800 \text{ psi}/2.0 = 3{,}900 \text{ psi}$$

Hence, all the crossarms chosen are satisfactory.

3. Pole (See Diagram at End of Part 2)

Rule 47 specifies that guys may be used to support unbalanced longitudinal loads with the load and strength factors provided in Rule 44. (Where guys are used they must take the entire load with the load factors (Table 4-1) and strength factors (Table 4-2) applied and the pole being considered merely as a strut).

Using the values given above for tensions at maximum loading, the following moments due to dead ending the conductors are obtained:

3 x 2,125 x 47.3	=	301,500 pound–feet
4 x 1,360 x 38.3	=	208,400 pound–feet
3 x 890 x 30.3	=	80,900 pound–feet
3 x 1,360 x 25.3	=	103,200 pound–feet
Total Moments	=	694,000 pound–feet

The total deadend load, using the tension values for maximum loading given above, will be:

3 x 2,125	=	6,380 pounds
4 x 1,360	=	5,440 pounds
3 x 890	=	2,670 pounds
3 x 1,360	=	4,080 pounds
Total	=	18,570 pounds

Center of load = $\frac{694000}{18570}$=37.4 feet above ground

The tension (T) of a single guy with a lead to height ratio of 1 to 1 (assumed), or a 45º angle, and a safety factor of 2 would be:

$$T = \text{total load}/\cos(45^\circ) = 18{,}570 \text{ lbs}/0.707 = 26{,}265 \text{ lbs}$$

The effects of the load (26,265 lbs) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the guy multiplied by the strength factor of 0.75 (Table 4-2), or it is required that

$$26{,}265 \text{ lbs} \times 1.5 \leq \text{strength} \times 0.75$$

or

$$\text{strength} \geq 26{,}265 \text{ lbs} \times 1.5/0.75 = 26{,}265 \text{ lbs} \times 2.0 = 52{,}530 \text{ lbs}$$

A stranded guy attached at the center of load could be used provided the allowable fiber stress of the pole is not exceeded. The stress due to guying at this point would be as follows:

The center of load (37.4’ above ground) would be

9.9 ft. (118.8”) below the top conductors (11 kV) and
0.9 ft. (10.8”) below the second crossarm (4 kV)

The fiber stress in the pole at the center of load due to the tension in the conductors above the center of load is computed as follows:

Bending moment	3 x 2,125 x 118.8	=	757,400 pound–inches
	1,360 x 10.8	=	8,800 pound–inches
Total moment		=	16,200 pound–inches

The section modulus of a solid circular section is $E = \frac{\pi \ d^3}{32} = 0.0982d^3$

The diameter of the pole at the center of load is d = 9.7 inches

Then, E = 0.0982 x $(9.7)^3$ = 89.6 in^3

$$\text{Fiber stress} = \frac{\text{Bending Moment}}{\text{Section modulus}} = \frac{816200}{89.6} = 9110 \text{ psi}$$

The effects of the load (9,110 psi) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the pole (6,000 psi, Table 5) multiplied by the strength factor of 0.375 (Table 4-2), or it is required that

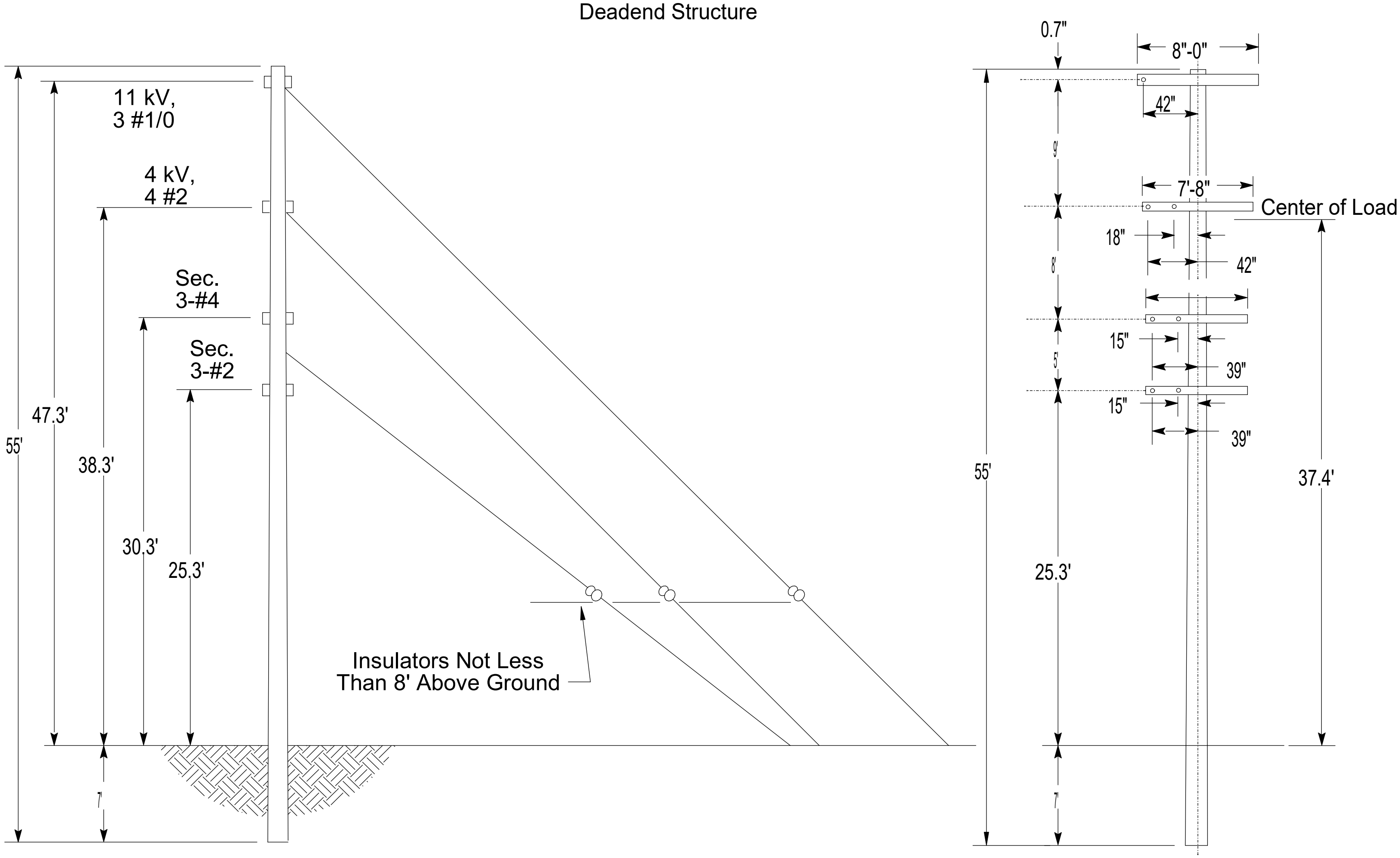
9,110 psi x 1.5 ≤ 6,000 psi x 0.375

or

9,110 psi ≤ 6,000 psi /(1.5/0.375) = 6,000 psi/4.0 = 1,500 psi

which condition is not satisfied. Hence, the pole cannot be guyed by a single guy but can be guyed as illustrated in the diagram of the deadend structure.

Deadend Structure



January 2020

Part 3
Angle Pole Problem – Methods of Providing Proper Strength for Unbalanced Conductor Loads at Angle Poles

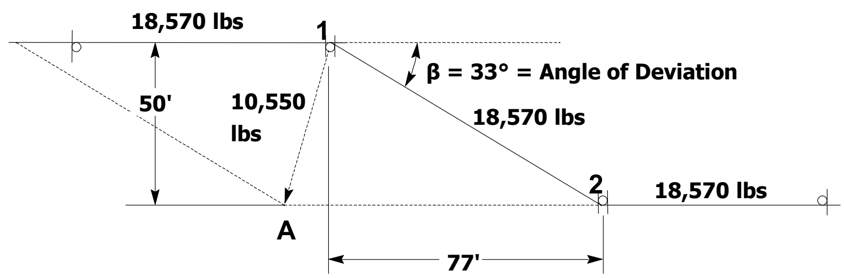
To maintain poles in proper position at angles and corners, it is generally necessary to use guys or some other form of pole bracing. Unless the line is dead–ended, the pull of the conductors is taken as being the same throughout the line.

The degree of unbalanced pull at an angle or corner pole is dependent upon the angle in the line at that point; that is, the greater the angle in the line, the greater is the magnitude of unbalance. Rule 45 specifies that where there is a change in the direction of conductors and messengers, transverse load shall be calculated as the resultant of all tensions under the assumed loading conditions. The members stressed shall be of such strength, using guys if necessary, as to withstand the total unbalanced load with load and strength factors equal to those of Rule 44. It is assumed that the line considered in this problem is Grade "A" construction.

It is assumed that the line discussed in the foregoing deadend problem crosses from one side of a street to the opposite side, that the longitudinal distance along the street between the two poles concerned is 77 feet, and that the angle of deviation is 33° (see sketch). This would result in an unbalanced force being exerted in the direction of A of

$$18570x2Sin\frac{\beta}{2} = 18570x2x0.2840 = 10550 pounds$$

Methods of Guying Angle Poles



Force Diagram

Assuming the pole height and framing as shown in Part 2, the top circumference of pole to be 25", the ground circumference to be 50" and the center of load to be 37.4 feet above ground line (as determined in Part 2), the fiber stress on the pole at the ground line is as follows:

Bending moment, M = 37.4 x 10,550 = 394,400 pound–feet

$$\text{Fiber stress} = \frac{122M}{d^3}$$

where circumference = 50″ and d = 15.9″

$$\text{Fiber stress} = \frac{122 \text{ x } 349400}{15.9^3} = 11970 \text{ psi}$$

The effects of the load (11,970 psi) multiplied by the load factor of 1.5 (Table 4-1), for the assumed Grade A construction, must not exceed the strength of the pole (6,000 psi, Table 5) multiplied by the strength factor of 0.375 (Table 4-2), or it is required that

11,970 psi x 1.5 ≤ 6,000 psi x 0.375

or

11,970 psi ≤ 6,000 psi /(1.5/0.375) = 6,000 psi/4.0 = 1,500 psi

which condition is not satisfied. Hence, even without the additional horizontal load due to wind loading (Rule 43), it is clear the pole must be guyed to support the transverse loading.

A single guy attached at the center of load could be used provided the effects of the load at the point of guying do not exceed the required strength of the pole. The stress due to guying at this point is as follows:

Bending moments

$$Toparm = 3x2125x118.8x2\sin\frac{\beta}{2} = 430200 pound-inches$$

$$Secondarm = 4x1370x10.8x2\sin\frac{\beta}{2} = 33400 pound-inches$$

Total moment=463600 pound-incheEs

Section modulus, E

The section modulus (E) at 37.4 feet above ground is 89.6 in^3, which is the value computed in the example in Part 2.

Fiber stress:

The fiber stress is

$$F = \frac{M}{E} = \frac{463600}{89.6} = 5170 \text{ psi}$$

The effects of the load (11,970 psi) multiplied by the load factor of 1.5 (Table 4-1), for Grade A construction, must not exceed the strength of the pole (6,000 psi, Table 5) multiplied by the strength factor of 0.375 (Table 4-2), or it is required that

$$5{,}170 \text{ psi} \times 1.5 \leq 6{,}000 \text{ psi} \times 0.375$$

or

$$5{,}170 \text{ psi} \leq 6{,}000 \text{ psi} /(1.5/0.375) = 6{,}000 \text{ psi}/4.0 = 1{,}500 \text{ psi}$$

which condition is not satisfied. Hence, it is necessary to place guys at more than one point on the pole, and therefore, they are attached at positions similar to the guys shown in the diagram at the end of Part 2.

(This Page Intentionally Left Blank)