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STRENGTH REQUIREMENTS FOR ALL CLASSES OF LINES

40. GENERAL

The following rules cover mechanical strength requirements for each class of line (see Rule 20.5), either alone or involved in crossings, conflicts or joint use of poles. The rules of this section are supplemented in many instances by provisions in other sections.

41. CLASSIFICATION OF CIRCUITS AND GRADES OF CONSTRUCTION

For the purpose of recognizing relative hazards, lines are segregated into classes which are defined in Rule 20.5. These classes of lines and the relation of lines to each other and to objects over which they are constructed determine the grade of construction.

42. GRADES OF CONSTRUCTION

For all classes of lines, the relative order of grades is "A," "B," "C" and "F," grade "A" being the highest.

Supply and communication lines, where not involved in crossings, conflicts or on poles jointly used, shall be constructed and maintained so as to conform with grades of construction not less than as follows:

Class H supply	Grade C
Class L supply	Grade C
Class C communication	Grade F

Supply and communication lines, where involved in crossings, conflicts or on poles jointly used, shall be constructed and maintained so as to conform with grades of construction not less than as specified in Table 3.

TABLE 3

GRADES OF CONSTRUCTION

Class of circuit involved at upper level	Other facilities involved at lower level at crossings, conflicts or on poles jointly used	Grade of construction to be used at upper level
H	Major Class C circuits	"A"*
H or L	Major railways (steam, electric or other motive power, at crossings only)	"A"
H or L	Minor railways (at crossings only)	"B"
H	Under all conditions not required to be Grade "A" (except supply cables treated as specified in Rule 57.8)	"B"
L	Under all conditions not required to be Grade "A" or "B"	"C"
Supply cables treated as specified in Rule 57.8-	Under all conditions	"C"
Major Class C	Class H circuits	"A"
Minor Class C	Class H circuits	"B"
C	Major railways (at crossings only)	"B"
C	Class L circuits of more than 750 volts	"C"
C	Supply cables treated as specified in Rule 57.8--	"F"
C	Under all conditions not required to be Grade "A," "B," or "C"	"F"

NOTE: Rule 57.8 specifies bonding and grounding of sheath and messenger of supply cables.

* The requirements of Grade "C" construction only will be sufficient if the supply circuits are in the voltage classification 5,000-20,000 volts.

42.1 Two or More Conditions

Where two or more conditions affecting the grade of construction exist, the grade of construction used shall be the highest required under any of the conditions.

42.2 Line Crossing Two or More Lines

Where a line crosses in one span over two or more other lines the grade of construction shall be not less than would be required if either of the lower lines crossed the other.

42.3 Line Crossing Involved Lines

Where one line crosses over another line which in turn is involved in a second crossing in the same span, the grade of construction for the highest line shall be not less than that required for the next lower line.

43. TEMPERATURE AND LOADING

The following conditions of temperature and loading shall be used for the purposes of these rules in determining the strength required of poles, towers, structures, and all parts thereof and in determining the strength and clearances of conductors. More stringent conditions may be used, if desired, in the design of lines. The use of modified conditions or modified loading district limits may be authorized by this Commission upon application and presentation of data from United States weather records or other adequate and authenticated meteorological data which in the Commission's opinion justifies such change.

43.1 Heavy Loading

Heavy loading shall apply in all parts of the State of Hawaii where the elevation exceeds 6,250 feet above sea level. (See Appendix A for map indicating the approximate location of the heavy loading district.) This loading shall be taken as the resultant stress due to wind, ice and dead weight under the following conditions:

A. Wind

A horizontal wind pressure of 6 pounds per square foot of projected area on cylindrical surfaces, and 10 pounds per square foot on flat surfaces shall be assumed. Where latticed structures are used, the actual exposed area of one lateral face shall be increased by 50% to allow for pressure on the opposite face, provided this computation does not indicate a greater pressure

than would occur on a solid structure of the same outside dimensions, under which conditions the latter shall be taken.

B. Ice

A radial thickness of one-half inch of ice, weighing 57 pounds per cubic foot, on all conductors shall be assumed in computing vertical and wind loadings.

C. Temperature

Temperature shall be considered to be 0° F at the time of maximum loading. The normal temperature for computing erection conditions is 60° F. Maximum temperature shall be assumed as 130° F in computing sag under this condition.

43.2 Light Loading

Light loading shall apply in all parts of the State of Hawaii where the elevation above sea level is 6250 feet or less. (See Appendix A for map.) This loading shall be taken as the resultant of wind pressure and dead weight under the following conditions:

A. Wind

A horizontal wind pressure of 8 pounds per square foot of projected area on cylindrical surfaces, and 13 pounds per square foot on flat surfaces shall be assumed. Where latticed structures are used, the actual exposed area of one lateral face shall be increased by 50% to allow for pressure on the opposite face, provided this computation does not indicate a greater pressure than would occur on a solid structure of the same outside dimensions, under which conditions the latter shall be taken.

B. Ice

No ice loading is to be considered.

C. Temperature

For all locations in the State of Hawaii which are less than 2,000 feet above sea level, the temperature shall be considered to be 50° F at the time of maximum loading. The normal temperature for computing erection conditions shall be 75° F. Maximum temperature shall be assumed as 120° F in computing sag under this condition.

44. SAFETY FACTORS

The safety factors specified in these rules are the minimum allowable ratios of ultimate strengths of materials to the maximum working stresses, except that:

The safety factors for structural steel (towers, poles and crossarms) shall be applied as specified in Rule 48.2, and

The safety factors for wood members in bending shall be applied to longitudinal tension and compression as ratios of the moduli of rupture to the maximum working stresses.

The maximum working stresses used with these safety factors shall be the maximum stresses which would be developed in the materials under the construction arrangement with temperature and loadings as specified in Rule 43.

44.1 Installation and Reconstruction

Lines and elements of lines, upon installation or reconstruction, shall provide as a minimum the safety factors specified in Table 4 for vertical loads and loads transverse to lines and for loads longitudinal to lines except where longitudinal loads are balanced or where there are changes in grade of construction (see Rules 47.3, 47.4 and 47.5).

TABLE 4

MINIMUM SAFETY FACTORS

Element of Line	Grades of Construction			
	Grade "A"	Grade "B"	Grade "C"	Grade "F"
Conductors, splices and conductor fastenings (other than tie wires)	2	2	2	1
Pins	2	2	2	1
Pole line hardware	2	2	2	2
Line insulators (mechanical)	3	2	2	2
Guy insulators (mechanical):				
Interlocking	2	2	2	2
Noninterlocking	3	3	3	---
Guys, except in light loading rural districts	2	2	2	1-1/4
Guys, in light loading rural districts	2	1-1/2	1-1/2	1-1/4
Messengers and span wires	2	2	2	2
Wood poles	4	3	2	1
Structural or tubular steel poles, towers, crossarms and steel members of foundations	1-1/2	1-1/4	1-1/4	---
Foundations against uplift	1-1/2	1-1/2	1-1/2	---
Foundations against depression	3	2	2	---
Reinforced concrete poles	4	3	3	---
Crossarms (wood)	2	2	2	1

44.2 Replacement

Lines or parts thereof shall be replaced or reinforced before safety factors have been reduced (due to deterioration or changes in construction arrangement or other conditions subsequent to installation) in Grades "A" and "B" construction to less than two-thirds of the construction safety factors specified in Rule 44.1 and in Grades "C" and "F" construction to less than one-half of the construction safety factors specified in Rule 44.1. Poles in Grade "F" construction shall also conform to the requirements of Rule 81.3-A.

In no case shall the application of this rule to Grades "A," "B" or "C" construction or to guys in Grade "F" construction be held to permit the use of structures or any member of any structure with a safety factor less than unity.

45. TRANSVERSE STRENGTH REQUIREMENTS

In computing the transverse strength requirements of all parts of structures and in calculating allowable stresses and allowable minimum sags for conductors under the temperature and loading conditions specified in Rule 43, safety factors at least equal to those of Table 4 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. In cases where, due to change of direction in conductors, an unbalanced side stress is imposed on the supporting structure, a transverse load shall be assumed equal to the resultant of all conductor tensions under the assumed loading conditions.

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 line 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 it 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.

46. VERTICAL STRENGTH REQUIREMENTS

In computing vertical strength requirements the loads upon poles, towers, foundations, crossarms, pins, insulators and conductor fastenings shall be their own weight plus the superimposed weight which they support, including that of wires and cables under the loading conditions of Rule 43 plus that which may be added by difference in elevation of supports. The resultant of vertical and transverse loadings on conductors shall be used in determining the allowable and working tensions or sags in accordance with Rule 43.

In addition to the above a vertical load of 200 pounds at the outer pin position shall be included in computing the vertical loads on all crossarms.

All members of structures shall be constructed to withstand vertical loads as specified above with safety factors at least equal to those specified in Rule 44.

47. LONGITUDINAL STRENGTH REQUIREMENTS

In computing the longitudinal strength requirements of structures, or any parts thereof, the pull of the conductors shall be considered as that due to the maximum working tension in them under the loading conditions specified in Rule 43.

47.1 Reduction in Stress

Stresses in supporting structures due to longitudinal load may be reduced by increasing the conductor sags, provided that the prescribed conductor clearances of Section III are maintained.

47.2 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 or braces. Deflection shall be limited by guys or braces where such structures alone, although providing the strength and safety factors required, would deflect sufficiently under the prescribed loadings to reduce clearances below the required values.

47.3 Unbalanced Loads

Poles, towers or structures with longitudinal loads not normally balanced (as at dead ends or angles greater than can be treated as in Rule 45) shall be of sufficient strength, or shall be guyed or braced, to withstand the total unbalanced load with safety factors at least equal to those specified in Rule 44.

47.4 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. The construction of the end supports (including poles, structures, towers, crossarms, pins, insulators, conductor fastenings and guys) of such sections shall be such as to withstand at all times the load specified with a safety factor at least equal to unity.

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.

47.5 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. The construction of the supports (including poles, structures, towers, crossarms, pins, insulators, conductor fastenings and guys) shall be such as to withstand at all times the load specified with a safety factor at least equal to unity. 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.

48. ULTIMATE STRENGTH OF MATERIALS

Values used for the ultimate strength of materials, in connection with the safety factors specified in Rule 44 shall be not more than as follows:

48.1 Wood

Values used for moduli of rupture for wood in bending, in conjunction with the safety factors given in Rule 44, shall not exceed those shown in Table 5.

TABLE 5

WOOD STRENGTHS

Species	Modulus of rupture in bending	
	Sawed rectangular poles, crossarms, etc. (a)	Round poles
Cedar, western red	4,700 lbs. per sq. in.	6,000 lbs. per sq. in.
Douglas fir, dense	6,300 lbs. per sq. in.	6,800 (b) lbs. per sq. in.
Douglas fir, not dense	5,800 lbs. per sq. in.	6,800 (b) lbs. per sq. in.
Fir, white or red, local	4,700 lbs. per sq. in.	5,600 lbs. per sq. in.
Pine, southern yellow, dense	6,300 lbs. per sq. in.	6,800 (b) lbs. per sq. in.
Pine, southern yellow, not dense	5,800 lbs. per sq. in.	6,800 (b) lbs. per sq. in.
Redwood, virgin	5,300 lbs. per sq. in.	6,200 lbs. per sq. in.
Redwood, second growth	3,900 lbs. per sq. in.	4,600 lbs. per sq. in.

(a) Figures given are for select structural grade of material under short time loading with the neutral plane parallel to a side. Multiply the values shown by 1.4 where the neutral plane is on the diagonal of a square. Multiply the given values by 0.55 where the loading being considered is a long time loading (continuous load for one year or more).

(b) Where poles meet specifications of American Standards Association, 05.1-1963 for Douglas Fir Poles and Southern Pine Poles, this value may be increased to not more than 8,000 lbs. per square inch. Such poles shall be given suitable preservative treatment.

48.2 Structural Steel

Steel structures, steel structural members and their connections, shall be designed and constructed so that the structures and parts thereof will not fail or be seriously distorted at any load less than the maximum working loads (developed under the construction arrangement with loadings as specified in Rule 43) multiplied by the safety factors specified in Rule 44.

The safety factors specified in Rule 44 shall be applied as follows to structural steel:

Tension and Bending: The yield point, 33,000 pounds per square inch, shall be divided by the safety factor to determine the maximum allowable working stress.

Compression: The maximum allowable working stress shall be calculated by the following formula:

$$S_{max} = \frac{1}{f_s}\left[YP - \left(\frac{YP - 12{,}000}{200}\right)\frac{l}{r}\right]$$

where S_{max} = maximum allowable working stress, lbs per sq. in.
f_s = safety factor specified in Rule 44
YP = yield point of the steel, 33,000 lbs per sq. in.
l = unsupported length of member, inches
r = radius of gyration of member, inches

Shear: The ultimate tensile strength, 60,000 pounds per square inch, shall be multiplied by 2/3 and divided by the safety factor specified in Rule 44 to determine the maximum allowable working stress.

Where the figures given are used, structural steel shall conform to Standard Specifications A7-39 of American Society for Testing Materials for carbon steel of structural quality. Other values may be used for steel of other strength provided the yield point and ultimate tensile strength are determined by test.

48.3 Reinforced Concrete

Values used for ultimate strengths of reinforced concrete, in conjunction with safety factors given in Rule 44, 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 mos.----	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.

48.4 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 Tables 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 the American Society for Testing Materials. The ultimate strengths given in Appendix B for medium-hard-drawn copper are based on the standard specifications of the ASTM and provide an allowance above the minimum values of one-quarter of the range between minimum and maximum values. For use of types of wires and cables of other materials not included in Appendix B, values for ultimate strengths similarly derived from specifications of the ASTM shall be used except that, if such specifications are nonexistent, maker's specifications may be used provided that tests have been made which shall justify the maker's rating for ultimate strength.

48.5 Tower or Pole Foundations and Footings

In calculating the resistance of foundations or footings of towers, poles and pole line structures to uplifts, the weight of concrete shall be taken as not more than 145 pounds per cubic foot and the weight of earth (calculated 30 degrees from the vertical) shall be taken as not more than 90 pounds per cubic foot. The resistance of soil to the depression of foundations or footings shall be calculated from the best available data on the soil in question. In lieu of calculation, the strength of foundations or footings against uplift or depression may be determined by tests under the soil conditions obtaining.

49. DETAILED STRENGTH REQUIREMENTS

49.1 Poles, Towers and Other Structures

A. Strength

Wood poles shall be of sound timber, free from defects which would materially reduce their strength or d rability and they shall have sufficient strength to withstand, with safety factors not less than those specified in Rule 44, the maximum stresses to which they are subjected under the loading conditions specified in Rule 43. The modulus of rupture used in calculation of safety factors shall be not greater than the value given in Rule 48.1.

Steel and reinforced concrete poles, together with their foundations, shall be of such material and dimensions as to withstand, with safety factors not less than those specified in Rule 44, the maximum stresses to which they are subjected under the loading conditions specified in Rule 43. The fiber stress values used in calculation of safety factors shall be as specified in Rules 48.2 and 48.3. Certain poles are subject to special stresses due to angles in the line, dead-ending of conductors or other attachments, which stresses must be included in computing the loading and safety factor. Poles subject to these special stresses sometimes require the use of guys, in which case the pole below the point of guy attachment shall be considered merely as a strut, the guy taking all lateral stresses. In such cases the pole strength requirement shall apply at the point of guy attachment rather than at the ground line.

Spliced or stub reinforced poles or pole top extensions, including the attachment (joint) of the different members involved, shall meet all of the vertical, transverse and longitudinal strength requirements of these rules as if a whole pole were used. Spliced or stub reinforced poles or pole top extensions shall not be used where Grade "A" construction is required in supports of crossings or conflicts, or where Grade "B" construction is required for Class C lines crossing the main lines of major railways.

B. Dimensions

The minimum top circumference of wood poles shall be not less than the following:

	Inches
Grade "A" heavy loading district	22
Grade "A" light loading district	19
Grade "B"* heavy and light loading districts..	19
Grade "C" heavy and light loading, urban districts	19
Grade "C" circuits of 750-7500 volts, heavy loading, rural districts	19
Grade "C" supply circuits of 0-750 volts and communication circuits, heavy loading rural districts	16
Grade "C", light loading, rural districts	16
Grade "F", cable or more than 4 single wires or 8 conductors duplexed or paired, heavy loading districts	15
Grade "F". cable or more than 6 single wires or 12 conductors duplexed or paired, light loading districts	15
Grade "F" not more than 4 single wires or 8 conductors duplexed or paired, heavy loading districts	12
Grade "F" not more than 6 single wires or 12 conductors duplexed or paired, light loading districts	12

NOTE: Poles having a ground line circumference of less than 12 inches are not safe to climb unless supported by guys, pike poles, etc.

*Supply Poles in Grade "B" construction in rural, light loading districts may have a top circumference less than 19 inches but not less than 16 inches.

*Communication Poles in Grade "B" construction at crossings over major railroads may have top circumferences less than 19 inches but not less than the following, provided such poles meet the specifications of the American Standards Association, 05.2-1941, 05.4-1941 or 05.6-1941, and are butt treated if of western red cedar or are full-length pressure treated if of Douglas fir or southern yellow pine:

Number of Conductors Supported	Minimum Pole Top Circumference (inches)	
	Heavy Loading	Light Loading
10 or less	15	15
11 - 20	17	17
21 - 40	19	17
More than 40	19	19

C. Setting of Wood Poles

The depths of pole setting given in Table 6 are applicable to wood poles set in firm soil or in solid rock. Where the soil is not firm, deeper settings or special methods of pole setting should be resorted to. Where unguyed poles are set subject to heavy strain, or at corners or curves, a greater depth should be used. Guyed poles may be set not more than one foot less than the depths specified in Table 6 provided the guys do not assume any normal working load under conditions of no wind and the resulting depths of setting are not less than 3 feet.

For communication lines, sawed poles of a cross section of 36 square inches or less may be set to a depth of 6 inches less than the specifications shown in the following table.

TABLE 6
Pole Setting Depths

Total Length of Pole (feet)	Depth in Soil (feet)	Depth in Rock (feet)
20	4	3
25	4½	3
30	5	3
35	5	3½
40	5½	3½
45	6	4
50	6½	4
55	7	4½
60	7	4½
65	7½	5
70	7½	5
75	8	5½
80	8	6

D. Gains

Gains or equivalent means shall be provided for increasing surface contact of crossarms with round wood poles. Where gains are cut, the depth shall be not less than one-half inch or more than one inch. "Slab" gains, metal gains, pole bands, or assemblies of wood or metal supports that provide suitable surface contact and adequate strength are permitted.

E. Replacements (see Rule 44.2)

49.2 Crossarms

A. Material

(1) Wood: Wood crossarms shall be of suitable grades of Douglas fir, southern yellow pine or other accepted species.

(2) Metal: Metal crossarms shall be of structural steel, cast steel, or malleable cast iron, properly galvanized or otherwise protected to resist corrosion, or may be of any corrosion-resisting metal or alloy.

B. Minimum Size

(1) Wood: Crossarms used to support or guard supply conductors shall have cross-sectional dimensions not less than the following:

One piece (homogeneous): 3-1/4 X 4-1/4 inches,
Fabricated: any single member, 1-3/4 X 4-1/4 inches,
Laminated: 3 X 4 inches.

Crossarms supporting or guarding communications conductors shall provide the strength of douglas fir having a cross section not less than 2-3/4 by 3-3/4 inches, provided that supply conductors are occupying the top position. In locations when communications conductors occupy the upper position, such crossarms shall provide the strength of douglas fir having a cross section not less than 3 by 4-1/4 inches.

(2) Metal: The physical properties as a result of dimensions, shape and cross-sectional area of metal crossarms shall be such as to result in sufficient strength to meet the requirements of Rules 46, 47 and 48.2, provided the thickness of any element shall be not less than 3/32 inch.

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 computing the strength requirements to meet vertical loads the effect of such bracing may be considered.

(1) Longitudinal Loads Normally Balanced:

a) Supply Lines: Where longitudinal loads are normally balanced, crossarms supporting supply conductors shall have sufficient strength to withstand a load, applied in the direction of the conductors at the outer pin position, of 700 pounds with a safety factor of not less than unity.

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 with a safety factor of not less than unity.

(2) Longitudinal Loads Normally Unbalanced: Where crossarms are subjected to unbalanced longitudinal loads they shall have sufficient strength to meet the strength requirements with safety factors at least equal to those specified in Rule 44.

At unbalanced corners and dead ends in Grades "A", "B", or "C" construction, where conductors are supported on pins and insulators, single crossarm construction with the conductor fastening made to a single insulator will be permitted provided the strength requirements of Rules 44, 47.4 and 47.5 are met and the conductor is fastened to the insulator in a manner so as to prevent slipping of the conductor.

For conductor tensions up to 2000 pounds per conductor, double pins with double wood crossarms fitted with spacing devices at each end will be considered as meeting the strength requirements of Rule 47.4 and 47.5.

D. Replacements (see Rule 44.2)

49.3 Pins and Conductor Fastenings

A. Material

(1) Pins: Insulator pins shall be of galvanized steel, galvanized iron or other corrosion-resisting metal or of locust or other suitable wood.

(2) Fastenings: Conductor fastenings shall be of galvanized steel, galvanized iron or other corrosion-resisting metal.

B. Size

(1) Wood Pins: The minimum diameter of the shank shall not be less than 1-1/4 inches.

(2) Metal Pins: The minimum diameter of the shank shall not be less than 1/2 inch.

(3) Fastenings and Tie Wires: Fastenings and tie wires shall have no sharp edges at points of contact with conductors, and shall be applied in such a manner as not to damage the conductor. The materials and minimum sizes of tie wires for the various sizes and types of conductors shall be as shown in Table 7. Flat tie wire having a cross-sectional area not less than that of round wire of the gage specified for tie wires may be used.

TABLE 7

Size and Material of Tie Wires

LINE CONDUCTOR		TIE WIRE	
MATERIAL	SIZE	SIZE	MATERIAL
Copper, bronze, copper-covered steel, or composites of any of them	6 AWG and smaller	Same as line conductor	Soft copper or annealed copper-covered steel
	4 AWG	6 AWG	
	2 AWG and larger	4 AWG	
Galvanized iron or galvanized steel	10 BWG and smaller	Same as line conductor	Soft galvanized iron or galvanized steel
	9 BWG	10 BWG	
	8 BWG	9 BWG	
	4 and 6 BWG	8 BWG	
Aluminum or ACSR	4 AWG and smaller	Same as line conductor	Soft Aluminum
	2 AWG and larger	4 AWG	

C. Strength

Insulator pins and conductor fastenings shall be able to withstand the loads to which they may be subjected with safety factors at least equal to those specified in Rule 44.

NOTE: a 1-1/2 by 9 inch locust pin will usually provide cantilever strength up to 1000 pounds tension in the conductor with the conductor 3-1/2 inches above the crossarm and a safety 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, with a safety factor of not less than unity, a load at the conductor position as follows:

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

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 fastenings -- 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

Tie wires are not required on Class C conductors at point-type transpositions in Grade F construction.

(2) Longitudinal Loads Normally Unbalanced: At unbalanced corners and dead ends in Grades "A", "B", or "C"

construction, where the conductor tensions are held by cantilever strength in pin-type insulators and pins a single insulator and pin may be used provided the insulator strength is adequate and the conductor is fastened to the insulator so as to prevent slipping of the conductor under the maximum working tension with a safety factor of 2 under the temperature 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 47.4 and 47.5 for conductor tensions up to 2000 pounds per conductor.

D. Replacements (see Rule 44.2)

49.4 Conductors

A. Material

Conductors shall be of copper, copper-covered steel, bronze, stranded cable composites of any of the foregoing, aluminum, aluminum cable steel reinforced, galvanized iron, galvanized steel or of other corrosion-resisting metal not subject to rapid deterioration, except that in common neutral systems the provisions of Rule 59.3-A shall also apply.

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 provide the required safety factors 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.

TABLE 8

Minimum Conductor Sizes (150-foot spans or less)

Loading condition and grade of construction	MATERIAL OR TYPE OF CONDUCTOR					
	Soft or annealed copper	Hard-drawn or medium-hard-drawn copper	Stranded aluminum	Aluminum cable, steel reinforced	Copper-covered steel, bronze or composites	Galvanized iron or galvanized steel
HEAVY LOADING	AWG	AWG	AWG	AWG	AWG	
Grade "A"	4	6	1	4	6	1/4-in. diam. strand
Grade "B" (a) (h)	4	6	1	6	8	9 BWG
Grade "C" (h)	4	6	1	6	8	9 BWG
LIGHT LOADING						
Grade "A"	4	6	1	4	8	1/4-in. diam. strand (b)
Grade "B" (a) (c) (h)	6	6	1	6	8	9 BWG
Grade "C" (c) (h)	6	8	1	6	10	9 BWG
HEAVY AND LIGHT LOADING						
Supply service drops crossing trolley wires	8	10	-----	-----	12	-----
Other supply service drops	10	10	-----	-----	12	-----
Grade "F" single conductors (d)	-----	(e)	-----	-----	(e)	14 BWG
Grade "F" 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 No. 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) No. 12 AWG or No. 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.

C. Strength

(1) Heavy Loading Districts: Conductors in Grade "A" construction and in spans exceeding 150 feet shall have a tensile strength not less than that of No. 4 AWG medium-hard-drawn copper and said conductors shall preferably be stranded.

(2) Light Loading Districts: The following requirements apply for various grades of construction and span lengths.

Conductors in Grade "A" construction in spans exceeding 150 feet and not exceeding 300 feet in length shall have a tensile strength not less than that of No. 6 AWG medium-hard-drawn copper.

Supply conductors of less than 750 volts in Grade "B" or "C" construction in spans not exceeding 150 feet in length shall have a tensile strength not less than that of No. 8 AWG soft-drawn copper.

(3) Heavy or Light Loading Districts: Where signal or communication lines take Grade "B" or "C" classification other than at railroad crossings, a minimum size of No. 8 AWG medium-hard-drawn copper or its equivalent in tensile strength may be used.

(4) Conductors of Voltages Exceeding 17,000 Volts: Conductors of voltages exceeding 17,000 volts crossing conductors of less than 17,000 volts or crossing a public highway shall have a strength at least equal to No. 4 AWG stranded medium-hard-drawn copper. In lieu of this, the conductors carrying more than 17,000 volts shall, at the point of crossing, be supported on poles of such height and so placed that under no circumstances can the conductor of over 17,000 volts, in case of breakage of same or otherwise come in contact with any conductor carrying less than 17,000 volts, or fall within a distance of ten feet from the surface of any public highway.

(5) Sags and Tensions: Conductor sags shall be such that under the loading conditions specified in Rule 43 the tension in the conductors shall not be more than one-half the breaking strength of

the conductor, other than communication circuits. The use of sags greater than the allowable minimum may be desirable in order to reduce working tensions.

Where the minimum size pins are used, the conductor tensions shall be limited to 2000 pounds when applying the double arm, pin and conductor fastening provisions of Rules 49.2 and 49.3.

(6) Splices: Splices in line conductors shall be in accordance with the requirements of Table 4 except as provided in Rules 103.1-A and 113.1-A.

(7) Service Drops:

a) Supply: The minimum sizes shall apply only where the span does not exceed 150 feet. The minimum for supply lines of like voltage and grade shall apply when the service drop is in excess of 150 feet.

Multiple conductor cable with a bare neutral is permissible provided that the attachment of such a cable at the pole and building ends shall be by means of an insulator. Supply service drops of 0-750 volts shall have a weather resistant covering equivalent to a standard double braid weatherproofing.

b) Communication: Paired wire communication service drops of high strength bronze or high strength copper-covered steel of No. 18 AWG in heavy loading areas and of No. 20 AWG in light loading areas may be used provided the breaking strength of the pair is not less than 340 lbs. in heavy loading areas and 200 lbs. in light loading areas.

Communication service drops of No. 16 AWG paired copper wire may be used in both heavy and light loading areas, provided they do not cross over supply lines, trolley contact or feeder conductors, or railways.

(8) Communication Line Conductors: Paired wire of high strength bronze or high strength copper-covered steel of No. 18 AWG in heavy loading areas and of

No. 20 AWG in light loading areas may be used as communication line conductors provided the breaking strength of the pair is not less than 340 lbs. in heavy loading areas and 200 lbs. in light loading areas.

D. Replacements (see Rule 44.2)

E. Connections

All electrical connections shall be of suitable electrical and mechanical design.

49.5 Insulators

A. Line

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

C. Replacements (see Rule 44.2)

49.6 Guys and Anchors

A. Material

The exposed surface of all guys and guy rods shall be of corrosion-resisting material.

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 be such as to provide safety factors not less than those specified in Rule 44 for the loads imposed by the construction involved under the loading conditions specified in Rule 43.

TABLE 9

Minimum Size and Strength of Guys Crossing over Class H, L, T or C Circuits

MATERIAL OF STRAND	MINIMUM SIZE	
	Anchor Guys	Overhead Guys
Galvanized steel:		
Common or Siemens-Martin	5/16 in. diam.	1/4-in. diam.
High strength or extra-high strength	1/4-in. diam.	3/16 in. diam.
Copper-covered steel	3 No. 9 AWG	3 No. 10 AWG
Bronze	1/4-in. diam.	3 No. 10 AWG
Minimum allowable ultimate strength of guys-	3,200 pounds	1,900 pounds

C. Strength

Where guys are used with poles or similar structures, capable of considerable deflection before failure, they shall be able to support the entire load, the pole below the point of guy attachments acting merely as a strut. Stranded wires shall be used when the ultimate strength of the guy exceeds 1800 pounds. Anchor rods and their appurtenances shall meet the same strength requirements as the guy wire or strand. (See Rule 44.)

D. Replacements (see Rule 44.2).

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 shall be capable of withstanding, with safety factors as specified in Rule 44, the tension developed because of the load they support combined with the loading conditions specified in Rule 43. An allowance of 200 pounds of vertical load for a man 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 workmen or where the ice loading specified in Rule 43.1-B would exceed the allowance for the man and cable chair.

The strength of guys supporting messenger loads shall be such that the safety factor of such guys is not less than the safety factor required of the messenger as specified in Rule 44. It is recommended that overhead guys shall be the same size as the suspension strand and that anchor guys shall be enough larger than the suspension strand to compensate for the angle between the plane of the horizontal load of the suspension strand and the line of the guy.

Messenger cables installed as part of a secondary aerial cable shall be designed according to this rule except the 200 pounds vertical load allowance may be reduced to 50 pounds to allow for the load of workmen on ladders provided a cable chair will not be used to work on these circuits.

C. Supports

Messengers supporting cables shall be attached to poles or crossarms with hardware which provides safety factors at least equal to those specified in Rule 44, based on the weight of the cable plus an allowance of 200 lbs. for the man and cable chair. If in heavy loading areas the specified ice load exceeds in weight the 200 lbs. allowance, such ice load shall be used in making the calculations in preference to the weight of the man and cable chair. All hardware subject to injurious corrosion shall be protected by galvanizing, painting or other suitable treatment.

Messenger cables installed as part of a secondary aerial cable shall be designed according to this rule except the 200 pounds vertical load allowance may be reduced to 50 pounds to allow for the load of workmen on ladders provided a cable chair will not be used to work on these circuits.

D. Replacements (see Rule 44.2)

49.8 Hardware

All pole line hardware shall be galvanized, otherwise protected by a corrosion-resisting treatment, or shall be composed of material which is corrosion resisting.