Chapter E 126

STRENGTH REQUIREMENTS

E 126.01 Preliminary assumptions
E 126.02 Grades B and C construction
E 126.03 Grade D construction
E 126.04 Grade N construction

E 126.01 Preliminary assumptions. It is recognized that deformation, deflection, or displacement of parts of the structure will, in some cases, change the effects of the loads assumed. In the calculation of stresses, however, no allowance shall be made for such deformation, deflection, or displacement of supporting structures (including poles, towers, conductor fastenings, and suspension insulators) unless the methods used to evaluate them have been approved by the administrative authority.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 126.02 Grades B and C construction. (1) POLES AND TOWERS. The strength requirements for poles and towers may be met by the structures alone or with the aid of guys or braces.

(a) *Average strength of 3 poles.* A pole (single-base structure) not individually meeting the transverse strength requirements will be permitted when reinforced by a stronger pole on each side, if the average strength of the 3 poles meets the transverse strength requirements, and the weak pole has not less than 75% of the required strength. An extra pole inserted in a normal span for the purpose of supporting a service loop may be ignored, if desired, in the calculation of the strength of the line.

1. Exception: In the case of crossings over railroads or communication lines the actual strengths of the crossing poles shall be used.

(b) *Reinforced-concrete poles.* Reinforced-concrete poles shall be of such material and dimensions as to withstand for vertical and transverse strength, the loads assumed in sections E 125.03(1) and (2) and for longitudinal strength the loads in section E 125.03(3) without exceeding the following percentages of their ultimate strength at the ground line for unguyed poles, or at the point of guy attachment for guyed poles. (Where guys are used, see subsection E 126.02 (3).)

	Percentages of Ultimate Strength for Different Grades	
	Grade B	Grade C
For transverse strength (when installed)	25	37.5
For longitudinal strength (at all times)		
In general	100	No requirement
At dead-ends	50	75

(c) *Metal supporting structures.* In the design of metal structures, the term "overload capacity factor" referred to in table 16 is to be interpreted in such a manner that the completed structure, if tested, shall support without permanent deflection the maximum loading to which it will be subjected as specified in chapter E 125, multiplied by the factors given in table 16. The absence of permanent set on the structure indicates that no part has been stressed beyond the strength point. Allowance should be made for bolt slip. Steel supports, steel towers, and metal poles shall be designed and constructed so as to meet the following requirements:

1. Vertical and transverse strength. The completed structure shall be so designed and of sufficient strength as to provide overload capacity factors specified in table 16 under the vertical and transverse loading specified in sections E 125.03(1) and (2).

2. Longitudinal strength. Grade B. The completed structure shall be so designed and of sufficient strength as to provide overload capacity factors specified in table 16 under the longitudinal loading specified in section E 125.03(3).

Grade C. No longitudinal strength requirements except at dead-ends.

3. Minimum strength. Metal structures shall have strength sufficient to withstand, with an overload capacity factor of 1.1, a transverse load on the structures without conductors, equal to 6 times the specified wind pressure.

4. At an angle in a line having supports of metal poles or towers, the strength of the support shall be sufficient to withstand the total transverse loadings specified in section E 125.03(2) (d) Before combining the 2 loads, the transverse wind load shall be multiplied by the appropriate overload capacity factor for transverse strength given in table 16, and the load arising from the change in direction of conductors shall be multiplied by the appropriate overload capacity factor at dead-ends given in table 16.

TABLE 16

MINIMUM OVERLOAD CAPACITY FACTORS OF COMPLETED STRUCTURES

(Based on Strength of Metal)

	Overload Capacity Factors	
	Grade B	Grade C
Vertical Strength	1.27	1.10
Transverse Strength	2.54	2.20
Longitudinal Strength:		
At Crossings		
In general	1.10	No requirement
At dead-ends	1.65	1.10
Elsewhere		
In general	1.00	No requirement
At dead-ends	1.65	1.10

5. Thickness of metal. The thickness of metal in members of steel poles or towers shall be not less than the following:

TABLE 17

THICKNESS OF STRUCTURAL SHAPES

Kind of Member	Thickness of Main Members of Crossarms and Legs	Thickness of Other Members
	Inches	Inches
Galvanized:		
For localities where experience has shown deterioration of galvanized material is rapid	1/4	5/16
For other localities	5/16	1/8
Painted	1/4	1/4 a

a. Painted bracing members having L/R not exceeding 125 may be 5/16 inches in thickness.

6. Unsupported length of compression members. The ratio of L, the unsupported length of a compression member, to R, the least radius of gyration of the member, shall not exceed the following: (These figures do not apply to the complete structure.)

TABLE 18

L/R FOR COMPRESSION MEMBERS

Kind of Compression Member	L/R
Leg members	150
Other members having figured stresses	200
Secondary members without figured stresses	250

7. General construction features. Metal poles or towers, including parts of footings above ground, shall be constructed so that all parts are accessible for inspection, cleaning, and painting, and so that pockets are not formed in which water can collect.

Note: Recommendation: Unless sample structures, or similar ones, have been tested to assure the compliance of structures in any line with these requirements, it is recommended that structures be designed to have a computed strength at least 10 percent greater than that required by these rules.

8. Protective covering or treatment. All metal towers, or supporting structures shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

(d) *Wood poles.* Wood poles shall be of such material and dimensions as to meet the following requirements. Where guys are used, see section E 126.02(3).

1. Transverse strength. Wood poles shall withstand the transverse and vertical loads assumed in sections E 125.03(1) and (2) without exceeding at the ground line for unguyed poles, or at the point of guy attachment for guyed poles, the appropriate allowable percentages of their ultimate stress given in table 20.

2. Longitudinal and dead-end strength. The longitudinal and dead-end strength of wood poles shall be such that they will withstand the appropriate longitudinal loading specified in section E 125.03(3) without exceeding, at the ground line for unguyed poles or at the point of guy attachment for guyed poles, the following percentages of the applicable ultimate fiber stress.

	Percentages of Ultimate Fiber Stress for Wood Poles	
	Grade B	Grade C
Longitudinal:		
When installed	(a) 75	No requirement
At replacement	100	No requirement
Dead-Ends:		
When installed	(a) 50	(a) 75
At replacement	75	100

(a) Where lines are built for a fixed period of temporary service not exceeding 5 years, the prescribed percentage of fiber stress at installation may be increased, provided the percentage of ultimate fiber stress required at replacement is not exceeded during the life of the line.

a. Exception 1: At a Grade B crossing in a straight section of line, wood poles of approximately round cross-section complying with the transverse strength requirements of section E 126.02(1) (d)1. without the use of transverse guys, shall be considered as having the required longitudinal strength. This exception does not modify the requirements of this rule for dead-ends.

b. Exception 2: At a Grade B crossing of a supply line over a communication line, where there is an angle in the supply line, wood poles of approximately round cross-section shall be considered as having the required longitudinal strength if all of the following conditions obtain:

i The angle is not over 20 degrees.

ii The corner pole is guyed in the plane of the resultant of the conductor tensions on both sides of the corner pole; the tension in this guy not to exceed 50% of its ultimate strength under the loading of section E 125.03(2) (d).

iii The corner pole has sufficient strength to withstand without guys, the transverse loading of section E 125.03(2) (a) which would exist if there were no angle at that pole without exceeding 25% of its ultimate stress when installed, or 37½% at replacement.

3. Ultimate fiber stress. Various species of wood poles are considered as having the ultimate fiber stresses approved as standard by the American Standards Association under conditions specified in Section 4 of ASA 05.1—1963.

Note: It is recognized that fiber glass, plastics and other developments may become available and that the United States of America Standards Institute's approved values will be determined for such materials or combinations of them. It is further recognized that while these materials are in the process of development, they are subject to such test evaluation and trial installations as may be approved by the administrative authority.

4. Allowable percentages of ultimate stress. The allowable percentages of ultimate stress of treated and untreated poles to withstand vertical and transverse loads are given in table 20, except as modified in the following paragraph.

a. At crossings where Grade B construction is required, if the supply line is not maintained throughout (or between and including the nearest guyed points on each side of the crossing) so that the poles will not be stressed at any time in excess of 50% of their ultimate stress under the transverse loading assumed in section E 125.03 (2) the crossing poles, if unguyed, shall be of such strength that they will withstand the transverse loading assumptions of section E 125.03

(2) (a) without exceeding 16 2/3% of their ultimate stress at installation or 25% at replacement. If the crossing poles are side guyed, such guys shall meet the requirements of section E 126.02 (3) (e).

TABLE 20

ALLOWABLE PERCENTAGES OF ULTIMATE STRESS FOR TREATED OR UNTREATED WOOD POLES UNDER VERTICAL AND TRANSVERSE LOADING

	When Installed	At Replacement
Grade B	25.0	37.5
Grade C		
At crossings	37.5	75.0
Elsewhere	50.0	75.0

5. Freedom from defects. Wood poles shall be of suitable and selected timber free from observable defects that would decrease their strength or durability.

6. Minimum pole sizes. Wood poles shall have a nominal top circumference of not less than 15 inches.

7. Spliced and stub-reinforced poles. Spliced poles shall not be used at crossings, conflicts, or joint-use sections requiring Grades B or C construction.

a. The use of stub reinforcements that develop the required strength of the pole is permitted, provided the pole above the ground is in good condition and is of sufficient size to develop its required strength.

(e) *Transverse strength requirements for structures. Where side guying is required, but can only be installed at a distance. Grade B.* In the case of structures where, because of very heavy or numerous conductors or relatively long spans, the transverse-strength requirements of this section cannot be met except by the use of side guys or special structures, and it is physically impracticable to employ side guys, the transverse-strength requirements may be met by side-guying the line at each side of and as near as practicable to, the crossing or other transversely weak structure, and with a distance between such side-guyed structures of not over 800 feet provided that:

1. The side-guyed structures for each such section of 800 feet or less shall be constructed to withstand the calculated transverse load due to wind on the supports and ice-covered conductors, on the entire section between the side-guyed structures.

2. The line between such side-guyed structures shall be substantially in a straight line and the average length of span between the side-guyed structures shall not be in excess of 150 feet.

3. The entire section between the transversely strong structures shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

Grade C. The above provision is not applicable to grade C.

(f) *Longitudinal-strength requirements for sections of higher grade in lines of a lower grade of construction.*

1. Methods of providing longitudinal strength. Grade B. The longitudinal-strength requirements for sections of line of higher grade in lines of a lower grade (see for assumed longitudinal loading section E 125.03(3)(a)) are usually met by placing supporting structures of the required longitudinal strength at either end of the higher-grade section of the line.

a. Where this is impracticable, the supporting structures of the required longitudinal strength may be located one or more span lengths away from the section of higher grade, within 500 feet on either side and with not more than 800 feet between the longitudinally strong structures, provided such structures, and the line between them meet the requirements, as to transverse strength and stringing of conductors, of the highest grade occurring in the section, and provided that the line between the longitudinally strong structures is approximately straight or suitably guyed.

b. The requirements may also be met by distributing the head guys over 2 or more structures on either side of the crossing, such structures and the line between them complying with the requirements for the crossing as to transverse strength and as to conductors and their fastenings.

c. Where it is impracticable to provide the longitudinal strength, the longitudinal loads shall be reduced by increasing the conductor sags. This may require greater conductor separations. See section E 123.06(1)(b)1.

Grade C. The above provision is not applicable to grade C.

2. Flexible supports. Grade B. When supports of the section of higher grade are capable of considerable deflection in the direction of the line, as with wood or concrete poles, or some types of metal poles and towers, it may be necessary to increase the normal clearances specified in chapter E 123 or to provide head guys or special reinforcement to prevent such deflection.

a. So-called flexible steel towers or frames, if used at such locations, shall be adequately reinforced to meet the requirements of section E 126.02(1)(c)2.

b. When the situation is one involving an isolated crossing of higher grade in a line of lower-grade construction, then the structure shall, when practicable, be head-guyed or otherwise reinforced to prevent reduction in the clearances required in chapter E 123. Grade C. The above provision is not applicable to grade C.

(g) *Strength at angles in a line.* At an angle in the line, the strength of a pole at the ground line, if not guyed or at the point of guy attachment if guyed, shall be sufficient to withstand the total transverse loadings specified in section E 125.03 (2) (d). The transverse wind load shall be multiplied by the appropriate factor as shown below before combining with the load arising from change in direction

Grade of Construction	When Installed	At Replacement
B	2.0	2.0
C at crossings	2.0	1.33
C elsewhere	1.5	1.33

of conductors. The allowable percentage of ultimate stress at dead-ends given in section E 126.02(1) (d) shall not be exceeded for the total load thus computed.

(2) FOUNDATIONS. (a) *Use of foundations.* 1. Wood and reinforced-concrete poles. No special foundation construction is generally required.

2. Metal poles or towers. Metal poles or towers set in earth shall be suitably protected against injurious corrosion at and below the ground line.

(b) *Strength of foundations.* 1. Metal supports. The foundations and footings shall be so designed and constructed as to withstand the stresses due to the loads assumed in section E 125.03. Metal parts shall withstand these loads with the overload capacity factors specified in table 16. Since in many localities the soil and climatic conditions are such as to alter the strength of foundations considerably from time to time, there should usually be provided a considerable margin of strength in foundations above that which (by calculation) will just withstand the loads under the assumption of average conditions of climate and soil.

2. Wood and concrete poles. Foundations and settings for unguyed poles shall be such as to withstand the loads assumed in sections E 125.03 (1), (2), and (3).

MINIMUM DEPTH OF SETTING POLES

Length of Pole	Setting in Firm Soil	Setting in Rock
Feet	Feet	Feet
20	3.5	2.0
25	4.0	2.5
30	4.5	3.0
35	5.0	3.5
40	5.5	4.0
45	6.0	4.5
50	6.5	4.5
55	6.5	4.5
60	7.0	5.0
65	7.0	5.0
70	7.5	5.5
75	8.0	5.5
80	8.5	6.0

(3) GUYS. (a) *General.* The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (see chapter E 128).

(b) *For poles in insecure earth.* Where crossing poles are set in insecure earth the transverse strength requirements should, where practicable be met by the use of side guys or braces.

(c) *On metal structures.* The use of guys to obtain compliance with these requirements is regarded as generally undesirable. When guys are necessarily used, the steel supports or towers, unless capable of considerable deflection, shall be regarded as taking all of the load up to their allowable working load, and the guys shall have sufficient strength to take the remainder of the assumed maximum load. (See section E 126.02(1) (f)2. for flexible supports).

(d) *On wood or concrete poles.* When guys are used to meet the strength requirements for wood or concrete poles, they shall be considered as taking the entire load in the direction in which they act, the poles acting as struts only. Frequently the use of shorter spans or larger poles will permit the omission of guys at crossings.

(e) *Strength of guys.* 1. Guys when required, shall be of such material and dimensions as will withstand the transverse loads assumed in section E 125.03(2) and the longitudinal load assumed in section E 125.03(3) without exceeding the following percentages of their ultimate strength:

	Percentages of Ultimate Strength	
	Grade B	Grade C
For transverse strength (when installed)	37.50	50.00
For longitudinal strength (at all times)		
In general	100	No requirement
At dead-ends	(a) 66.70	(a) 87.50

(a) If deflection of supporting structures is taken into account in the computations, 66⅔% shall be reduced to 60% and 87½% shall be reduced to 75%.

2. At an angle in the line, the strength of a transverse guy or guys shall be sufficient to withstand the total transverse loadings specified in section E 125.03(2) (d). The transverse wind load shall be multiplied by 1.78 for both grades B and C before combining with the load arising from the change in direction of conductors. The allowable percentage of ultimate strength at dead-ends given in 1. above shall not be exceeded for the total load thus computed.

(4) CROSSARMS. (a) *Vertical strength.* Crossarms shall, when installed, withstand the vertical loads specified in section E 125.03(1) without the stress under these loads exceeding 50% of the assumed ultimate stress of the material.

1. Exception: For built-up metal crossarms on metal structures, see table 16 for minimum overload capacity factors.

(b) *Bracing.* Crossarms shall be securely supported by bracing, if necessary, so as to support safely all other loads to which they may be subjected in use, including linemen working on them. Any crossarm or buck arm except the top one shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

(c) *Longitudinal strength.* 1. General. Crossarms shall withstand any unbalanced longitudinal loads to which they are exposed, with a limit of unbalanced tension where conductor pulls are normally balanced, of 700 pounds at the outer pin.

2. At dead-ends and at ends of higher-grade-construction in line of lower grade. Grade B. Wood crossarms shall be of sufficient strength to withstand at all times, without exceeding their ultimate stresses, an unbalanced pull equal to the tension in all supported conductors under assumed maximum loading as given in section E 125.02. Metal arms shall withstand this load with the overload capacity factor for longitudinal loads given in table 16.

Grade C. The above provisions do not apply to grade C.

3. At ends of transversely weak sections. Grade B. The crossarms connected to the structure at each end of the transversely weak section, such as described in section E 126.02(1) (e), shall be such as to withstand at all times without exceeding their ultimate stresses, under the conditions of loading prescribed in chapter E 125, an unbalanced load equivalent to the combined pull in the direction of the transversely weak section of all the conductors supported.

Grade C. The above provisions do not apply to grade C.

4. Methods of meeting section E 126.02(4). Grade B. Where conductor tensions are limited to a maximum of 2,000 pounds per conductor, double wood crossarms fitted with spacing bolts equipped with spacing nuts and washers, pipe spacers, or similar construction, or with spacing blocks or plates, or metallic support of equivalent strength will be considered as meeting the strength requirements in 2. and 3. preceding.

Grade C. The above provisions do not apply to grade C.

(d) *Dimensions of crossarms of selected yellow pine or fir.* The cross-sectional dimensions of selected yellow pine or fir crossarms shall not be less than values of table 21.

TABLE 21

CROSSARM CROSS SECTIONS

Number of Pins	Grade B	Grade C	
		Supply	Communication
	Inches	Inches	Inches
2 or 4	3 by 4	2¾ by 3¾	
6 or 8	3¼ by 4¼	3 by 4	
6			2¾ by 3¾
10			3 by 4

(e) *Double crossarms or brackets.* Grade B. Where pin-type construction is used, double crossarms or a metallic support of equivalent strength shall be used at each crossing structure, at ends of joint use or conflict sections, at dead-ends and at corners where the angle of departure from a straight line exceeds 20 degrees. Where a bracket or rack supports a conductor operated at more than 750 volts to ground and there is no crossarm below, double brackets or double racks shall be used.

1. Exception: The above does not apply where communication cables or conductors cross below supply conductors and either 1. are attached to the same pole or 2. where supply conductors are continuous and of uniform tension in a crossing span and each adjacent span. This exception does not apply to railroad crossings.

Grade C. The above provisions do not apply to Grade C.

(f) *Location.* In general, crossarms should be maintained at right angles to the axis of the pole and to the direction of the attached conductors. At crossings, crossarms should be attached to that face of the structure away from the crossing, unless special bracing or double crossarms are used.

(5) PINS AND CONDUCTOR FASTENINGS. (a) *General.* 1. The conductor fastenings and the height, material and cross section of the pin shall be chosen so as to afford the required strength.

2. Tie wires, fastenings, or conductor supports shall have no sharp edges or burrs at contacts with conductors.

3. Where tie wires or similar fastenings are used with pin type construction, conductors shall be placed so that the side pull due to change in direction shall be against the insulator rather than the tie wire.

(b) *Strength.* 1. General. Pins and ties or other conductor fastenings shall have sufficient strength to withstand an unbalanced tension in the conductor, up to a limit of 700 pounds per pin or conductor fastening. (The unbalanced tensions often encountered especially with small conductors will be less than the maximum specified above. For these cases, the conductor fastenings need only develop strength equal to the anticipated unbalance.)

2. At dead-ends and at ends of higher-grade construction in line of lower grade. Grade B. Pins and ties or other conductor fastenings connected to the structure at a dead-end or at each end of the higher-grade section shall be of sufficient strength to withstand at all times without exceeding their ultimate strength, an unbalanced pull due to the conductor loading specified in section E 125.02.

Grade C. The above provisions do not apply to grade C except for dead-ends.

3. At ends of transversely weak sections. Grade B. Pins and ties or other conductor fastenings connected to the structure at each end of the transversely weak section as described in section E 126.02 (1) (e) shall be such as to withstand at all times without exceeding their ultimate strength, the unbalanced pull in the direction of the transversely weak section of the conductor supported, under the loading prescribed in section E 125.02. Grade C. The above provisions do not apply to grade C.

4. Methods of meeting sections E 126.02(5) (b)2. and 3. Grade B. Where conductor tensions are limited to 2,000 pounds and such conductors are supported on pin insulators, double wood pins and ties or their equivalent will be considered to meet the requirements of 2. and 3. preceding. Grade C. The above provision does not apply to Grade C.

(c) *Double pins and conductor fastenings.* Grade B. Where wood pins are used, double pins and conductor fastenings shall be used where double crossarms or brackets are required by section E 126.02 (4) (e).

1. Exception: The above does not apply where communication cables or conductors cross below supply conductors and either 1. are attached to the same pole, or 2. where supply conductors are continuous and of uniform tension in a crossing span and each adjacent span. This exception does not apply in the case of railroad crossings.

Grade C. The above provision does not apply to grade C.

(d) *Single supports used in lieu of double wood pins.* A single conductor support and its conductor fastening when used in lieu of double wood pins, shall develop strength equivalent to double wood pins and their conductor fastenings as specified in section E 126.02(5) (b)1.

(6) OPEN SUPPLY CONDUCTORS. (a) *Material.* Conductors shall be of material or combinations of materials which will not corrode excessively under the prevailing conditions.

Note: Recommendation: It is recommended that hard-drawn or medium-hard-drawn copper wire (conforming to the specifications of the American Society for Testing Materials) be used instead of soft in new construction, especially for sizes smaller than No. 2.

(b) *Minimum sizes of supply conductors.* Supply conductors, both bare and covered, shall have an ultimate strength and an overall diameter of metallic conductor not less than that of medium-hard-drawn copper of the gage size A.W.G. shown in table 22, except that conductors made entirely of bare or galvanized iron or steel shall have an overall diameter not less than Stl. W.G. of the gage sizes shown.

1. Exception 1: At railroad crossings, for stranded conductors, other than those in which a central core wire is entirely covered by the outside wires, any individual wire of such a stranded conductor containing steel shall be not less than 0.100 inch in diameter if copper-covered and not less than 0.115 inch in diameter if otherwise protected or if bare.

2. Exception 2: Supply service leads of 0 to 750 volts may have the sizes set forth in section E 126.04(5).

3. Exception 3: Where the short-span method of construction is employed in accordance with section E 126.02(11) the conductor sizes and sags herein specified are not required.

TABLE 22

MINIMUM OVERALL CONDUCTOR SIZES

Grade of Construction	Gage Size (a)
B	6
C	8

(a) For No. 6 and No. 8 medium-hard-drawn copper wire the nominal diameters are 0.1620 and 0.1285 inch, and the minimum values of breaking load are 1,010 and 643.9 pounds, respectively. For steel wire gage the nominal diameters are 0.192 inch for No. 6 and 0.162 inch for No. 8.

(c) *Lightning protection wires.* The requirements as to size, material, and stringing of wires used as lightning protection wires when placed above and paralleling supply conductors shall be the same as that required for supply conductors.

(d) *Sags and tensions.* Conductor sags shall be such that, under the assumed loading of section E 125.02 the tension of the conductor shall be not more than 60% of its ultimate strength. Also the tension at 60°F., without external load, shall not exceed the following percentages of the conductor ultimate strength:

Initial unloaded tension	35%
Final unloaded tension	25%

1. Exception: In the case of conductors having a cross-section of a generally triangular shape, such as cables composed of three wires,

the final unloaded tension at 60°F. shall not exceed 30 percent of the ultimate strength of the conductor.

Note: The above limitations are based on the use of recognized methods for avoiding fatigue failures by minimizing chafing and stress concentration. If such practices are not followed, lower tensions should be employed.

(e) *Splices and taps.* Grade B. Splices shall as far as practicable be avoided in the crossing and adjacent spans. If it is impracticable to avoid such splices, they shall be of such a type and so made as to have a strength substantially equal to that of the conductor in which they are placed. Taps shall be avoided in the crossing span where practicable, but if required shall be of a type which will not impair the strength of the conductors to which they are attached.

Grade C. The above does not apply to grade C.

(f) *Trolley contact conductors.* In order to provide for wear, no trolley contact conductor shall be installed of less size than No. 0, if of copper; of No. 4, if of silicon bronze.

(7) SUPPLY CABLES. (a) *Specially installed supply cables.* Cable having effectively grounded continuous metal sheath or armor, or insulated conductors supported on and lashed together with an effectively grounded messenger, where located on jointly used poles, or where located on other poles, and having a grade of construction less than that required for open wire supply lines of the same voltage, shall meet the requirements of section E 126.02(7)(a) 1., 2., 3. and 4. below.

1. Messengers. Messengers shall be stranded and of corrosion-resistant material, and shall not be stressed beyond 60% of their ultimate strength under the loadings specified in section E 125.02.

2. Grounding of cable sheath and messenger. Each section of metal sheath or armored cable between splices shall be suitably and effectively bonded to the messenger wire at not less than 2 places. The messenger wire shall be grounded at the ends of the line and at intermediate points not exceeding 800 feet apart. (See Wis. Adm. Code chapter E 103 for method).

3. Cable splices. Splices in the cable shall be made so that their insulation is not materially weaker than the remainder of the cable. The sheath or armor wire, when present, shall be made electrically continuous at the splice.

4. Cable insulation. The conductors of the cable shall be insulated so as to withstand a factory potential test of at least twice the operating voltage at operating frequency applied continuously for 5 minutes between conductors and between any conductor and the sheath or armor.

(b) *Other supply cables.* The following requirements apply to all supply cables not included in section E 126.02(7)(a) above.

1. Messenger. The messenger shall be of corrosion-resistant material, and shall not be stressed beyond 60% of its ultimate strength under the loadings specified in section E 125.02.

2. Cable. There are no strength requirements for cables supported by messengers.

(8) OPEN-WIRE COMMUNICATION CONDUCTORS. Open-wire communication conductors in grade B or C construction shall have the sizes and sags given in section E 126.02(6)(b) and (d) for supply conductors of the same grade.

(a) *Exception:* Where open-wire communication conductors in spans of 150 feet or less are above supply circuits of 5,000 volts or less, grade C sizes and sags may be replaced by grade D sizes and sags, except that where the supply conductors are trolley-contact conductors of 0 to 750 volts. No. 12 hard-drawn copper wire may be used for spans 0 to 100 feet, and No. 10 steel or No. 12 high strength steel wire may be used for spans of 125 to 150 feet.

(9) COMMUNICATION CABLES. (a) *Metal-sheathed communication cables.* There are no strength requirements for such cables supported by messengers.

(b) *Messenger.* The messenger shall be of corrosion-resistant material, and shall not be stressed beyond 60% of its ultimate strength under the loadings specified in section E 125.02.

(10) PAIRED COMMUNICATION CONDUCTORS. (a) *Paired conductors supported on messenger.*

1. Use of messenger. A messenger of corrosion-resistant material may be used for supporting paired conductors in any location, but is only required for paired conductors crossing over trolley-contact conductors of more than 750 volts.

2. Sag of messenger. Messenger used for supporting paired conductors required to meet grade B construction because of crossing over trolley-contact conductors shall meet the sag requirements for grade D messengers.

3. Size and sag of conductors. There are no requirements for paired conductors when supported on messenger.

(b) *Paired conductors not supported on messenger.*

1. Above supply lines. Grade B. Sizes and sags shall be not less than those required by sections E 126.02(6)(b) and (d) for supply conductors of similar grade.

Grade C. Sizes and sags shall be not less than the following:

Spans 0 to 100 feet. No sag requirements. Each conductor shall be of corrosion-resistant material, and shall have an ultimate strength of not less than 170 pounds.

Spans 100 to 150 feet. Sizes and sags shall be not less than required for grade D communication conductors.

Spans exceeding 150 feet. Sizes and sags shall be not less than required for grade C supply conductors (section E 126.02(6)(d)).

2. Above trolley-contact conductors.

Grade B. Sizes and sags shall be not less than the following:

Spans 0 to 100 feet. No size requirements. Sags shall be not less than for No. 8 A.W.G. hard-drawn copper. (See section E 126.02 (6)(d).)

Spans exceeding 100 feet. Each conductor shall be of corrosion-resistant material, and shall have an ultimate strength of not less than 170 pounds. Sags shall be not less than for No. 8 A.W.G. hard-drawn copper. (See section E 126.02(6)(d).)

Grade C. Sizes and sags shall be as follows:

Spans 0 to 100 feet. No requirements.

Spans exceeding 100 feet. No sag requirements. Each conductor shall be of corrosion-resistant material, and shall have an ultimate strength of not less than 170 pounds.

(11) SHORT-SPAN CROSSING CONSTRUCTION. Where supply lines cross over railways or communication lines by the short-span method, the requirements for grade B or C conductor sags and sizes are waived, in so far as such grades are required by the crossing, provided that an effectively grounded guard arm is installed at each cross-over support in such a manner as to prevent conductors which break in either adjoining span from swinging back into the conductors crossed over, or in the case of a railroad crossing into the space between the crossing supports.

Note: The short-span method of crossing requires the cross-over span to be of such height that a conductor breaking in that span can not come within 15 feet of the ground or rails at a railroad crossing or make contact with any wires crossed over at a wire crossing.

This character of construction is facilitated where the cross-over supports can be placed quite near together and in the case of wire crossings where the span crossed over is at a minimum elevation above ground.

(12) CRADLES AT SUPPLY LINE CROSSINGS. Cradles should not be used.

Note: It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

(13) PROTECTIVE COVERING OR TREATMENT FOR METAL WORK. All hardware, including bolts, washers, guys, anchor rods and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 126.03 Grade D construction. (1) POLES. (a) *Strength of unguyed poles.* Unguyed poles, except as provided in section E 126.03 (1) (h) shall withstand the vertical and transverse loads specified in sections E 125.03(1) and (2), and the longitudinal loads specified in section E 125.03(3)(d) without exceeding the following percentages of their ultimate stress.

	Percentages of Ultimate Stress
For transverse loads:	
When installed	25.0
At replacement	37.5
For longitudinal loads:	
When installed	75.0
At replacement	100.0

(b) *Strength of guyed poles.* Where poles are guyed, the poles shall be considered as acting as struts, resisting the vertical component of the tension in the guy calculated as in section E 126.03(3) combined with the vertical load.

(c) *Strength requirements for poles where guying is required, but can only be installed at a distance.* Where on account of physical conditions it is impracticable to guy or brace the crossing poles as specified in section E 126.03(3), the requirements there given may be met by head-guying and side-guying the line as near as practicable to the crossing, but at a distance not exceeding 500 feet from the nearest crossing pole, provided that the line is approximately straight

and that a stranded steel wire or other standard strand of strength equivalent to that of the head guy is run between the 2 guyed poles, being attached to the guyed poles at the point at which the head guys are attached, this wire being securely attached to every pole between the guyed poles.

(d) *Pole locations at crossings.* Where communication lines cross over railroads, the poles shall be located as follows:

1. The poles supporting the crossing span and the adjacent spans should be located in a straight line, if practicable. Where the poles supporting the crossing span and the adjacent spans are not in line, additional guying shall be placed to take care of the unbalanced load.

2. The crossing span shall, where practicable, not exceed 100 feet.

(e) *Freedom from defects.* Wood poles shall be of suitable and selected timber free from observable defects that would decrease their strength or durability.

(f) *Minimum pole sizes.* Wood poles shall have a nominal top circumference of not less than 15 inches.

(g) *Spliced and stub-reinforced poles.* Spliced poles shall not be used at grade D crossings. The use of stub reinforcements that develop the required strength of the pole is permitted, provided the pole above the ground is in good condition and is of sufficient size to develop its required strength.

(h) *Poles located at crossings over spur tracks.* Where a communication line paralleling a railroad track on the right of way of the railroad crosses a spur or stub track without any change in the general direction of line, the transverse strength requirements for grade D construction may be met without the use of side guys, providing the pole is not stressed beyond one-third its ultimate stress. No requirements for longitudinal strength are made if the conductor tensions are balanced. Where conductor tensions are not balanced, due to a small angle in the line at one or both poles, or to dead-ending any of the wires, either guys or braces shall be installed capable of withstanding such unbalanced tensions.

(2) POLE SETTINGS. Foundations and settings for unguyed poles shall be such as to withstand the loads assumed in sections E 125.03 (1), (2) and (3). (See section E 126.02(2)(b)2.)

(3) GUYS. (a) *General.* The general requirements for guys are covered under "Miscellaneous requirements for overhead construction" (See chapter E 128).

(b) *Where used.* Side guys or braces shall be used on poles supporting the crossing span to withstand the loads put upon them in accordance with the conditions specified in section E 125.03(2). Head guys shall be installed in accordance with table 23.

1. Exception 1: Side guys are not required where the crossing poles have the transverse strength specified in section E 126.03(1)(a) without the reduction for conductor shielding specified in sections E 125.03 (2)(a) and (b).

2. Exception 2: Head guys are not required where the crossing poles have the longitudinal strength specified in section E 126.03(1)(a), or for lines carrying only aerial cable. For lines carrying both open wire and aerial cable, head guying is required only for the number

of wires in excess of 10 if the cable is supported by a 6,000 pound messenger, or for the number of wires in excess of 20 if the cable is supported by a 10,000 pound messenger.

3. Exception 3: Where a line crossing a railroad changes direction more than 10 degrees at either crossing support, the side guy within the angle may be omitted and the head guy, if required, shall be placed in the direction of the adjacent span unless the angle of turn is greater than 60 degrees.

4. Exception 4: Guying may be omitted where communication lines cross over spur or stub tracks as provided in section E 126.03(1)(b).

5. Exception 5: This rule does not apply to crossing poles under the special conditions set forth in section E 126.03(1)(c).

TABLE 23

STRENGTH (IN POUNDS) OF HEAD GUYS REQUIRED

(Combinations of standard-size guys may be used)

Number of Wires	Ratio of Guy Lead to Height Not Less Than				
	1¼	1	¾	⅔	½
2	4,000	4,000	4,000	4,000	4,000
6	4,000	4,000	4,000	4,000	6,000
10	6,000	6,000	6,000	10,000	10,000
20	10,000	10,000	12,000	16,000	16,000
30	16,000	16,000	20,000	20,000	26,000
40	20,000	20,000	26,000	26,000	32,000
50	20,000	20,000	30,000	32,000	42,000
60	26,000	30,000	36,000	36,000	48,000
70	30,000	30,000	40,000	48,000	60,000
80	36,000	40,000	48,000	60,000	70,000

Note to Table 23. This table is based on ultimate or breaking strength of guys equal to seven-sixths of the nominal strengths shown in the table and a wire load of 50% No. 8 B.W.G. iron and 50% No. 9 A.W.G. copper with an average pull of 408.75 pounds per wire. No guy will be required for a cable, since the suspension strands serve as a head guy.

(c) *Guys used for transverse strength.* Side guys used in straight sections of line shall be considered as taking the entire load in the direction in which they act, without exceeding 37.5% of their ultimate strength.

(d) *Guys used for longitudinal strength.* 1. Direction of head guys. Where head guys are required, they shall be installed in the direction away from the crossing.

2. Size and number of head guys. Guys, if required for various open-wire loads, shall be in accordance with table 23.

(e) *Maintenance.* Guys and anchors shall be maintained so that the guys carry the load.

(4) CROSSARMS. (a) *Material.* Wood crossarms supporting the crossing span shall be of yellow pine, fir, or other suitable timber. Metal crossarms protected against corrosion and of strength equal to wood crossarms may be used.

(b) *Minimum size.* 1. Wood crossarms. Wood crossarms shall have a cross-section not less than the following:

Maximum Number of Wires to be Carried	Nominal Length		Nominal Cross-section (Inches)
	Feet	Inches	
2	1	4½	2⅝ by 3⅝
4	3	4½	2⅝ by 3⅝
6	6	0	2¾ by 3¾
10	8	6	2¾ by 3¾
10	10	0	3 by 4
12 (a) (b)	10	0	3¼ by 4¼

(a) Where crossarms are bored for ½ inch steel pins, 3-inch by 4¼-inch crossarms may be used.
(b) Maximum number allowed.

2. Steel or iron crossarms. Galvanized or painted iron or steel crossarms of strength equal to wood crossarms may be used.

(c) *Double crossarms.* Crossarms and insulators shall be double on the crossing poles. The crossarms shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins. Spacing blocks or spacing bolts are not required for two-pin crossarms.

1. Exception: Single dead-end type crossarms may be used where it is necessary to dead-end conductors of the crossing span, provided such crossarms and associated dead-end fastenings are of sufficient size and strength to withstand the maximum tension of the conductors under the loading specified in section E 125.02 and provided further that the conductors are dead-ended on insulators so designed and installed that the conductor will not fall in the event of insulator breakage.

(5) BRACKETS AND RACKS. Wood brackets may be used only if used in duplicate or otherwise designed so as to afford two points of support for each conductor. Single metal brackets, racks, drive hooks or other fixtures may be used if designed and attached in such a manner as to withstand the full dead-end pull of the wires supported.

(6) PINS. (a) *Material.* Insulator pins shall be of steel, or other appropriate metal or locust or equivalent wood.

(b) *Strength.* Insulator pins shall have sufficient strength to withstand the loads to which they may be subjected.

(c) *Size.* 1. Wood pins. Wood pins shall be sound and straight-grained with a diameter of shank not less than 1¼ inches.

2. Metal pins. Steel or iron pins shall have diameter of shank not less than one-half inch.

(7) INSULATORS. Each insulator shall be of such pattern, design and material that when mounted it will withstand without injury and without being pulled off the pin, the ultimate strength of the conductor attached to the insulator.

(8) ATTACHMENT OF CONDUCTOR TO INSULATOR. The conductors shall be securely tied to each supporting insulator.

(9) CONDUCTORS. (a) *Material.* Conductors shall be of material or combinations of materials which will not corrode excessively under the prevailing conditions.

(b) *Size.* Conductors of the crossing span, if of hard-drawn copper or galvanized steel, shall have sizes not less than specified in sections

E 126.03(9)(b)1. and 2. Conductors of material other than the above shall be of such size and so strung as to have a mechanical strength not less than that of the sizes of copper conductors given in sections E 126.03(9)(b)1. and 2. below.

1. Spans not exceeding 150 feet. The sizes in table 24 apply.

TABLE 24

GRADE D MINIMUM WIRE SIZES

(A.W.G. for Copper; Stl. W.G. for Steel)

Conductor	Spans of 125 Feet or Less	Spans of 125 Feet to 150 Feet
Copper, hard-drawn	10	9
Steel, galvanized:		
In General	10	8

2. Spans exceeding 150 feet. If spans in excess of 150 feet are necessary, the size of conductors specified above or the sags of the conductors shall be correspondingly increased.

(c) *Paired conductors without messengers.* Paired wires without a supporting messenger shall be eliminated as far as practicable and where used shall meet the following requirements:

1. Material and strength. Each conductor shall be of material or combinations of materials which will not corrode excessively under the prevailing conditions and shall have an ultimate strength of not less than 170 pounds.

2. Limiting span lengths. Paired wires shall in no case be used without a supporting messenger in spans longer than 100 feet.

(d) *Sags.* Table 25 specifies the recommended sags for wires shown in table 24.

TABLE 25

STRINGING SAGS

Length of Span	100°F.	80°F.	60°F.	40°F.	20°F.	0°F.
Feet	In.	In.	In.	In.	In.	In.
70	5.7	4.4	3.4	2.7	2.2	1.8
75	6.4	5.1	4.0	3.1	2.5	2.1
80	7.4	5.8	4.5	3.5	2.9	2.4
85	8.4	6.6	5.1	4.0	3.2	2.7
90	9.4	7.3	5.7	4.5	3.6	3.0
95	10.0	8.2	6.3	5.0	4.0	3.4
100	11.6	9.0	7.0	5.5	4.5	3.7
110	14.0	11.0	8.5	6.7	5.4	4.5
120	16.6	13.0	10.1	7.9	6.4	5.4
130	19.5	15.3	11.8	9.3	7.6	6.3
140	22.6	17.7	13.7	10.8	8.8	7.3
150	26.0	20.3	15.8	12.4	10.1	8.4

1. For conductors other than copper, conductor sags shall be such that, under the assumed loading of section E 125.02, and assuming rigid structures for the purpose of calculations, the tension of the conductor shall be not more than 60% of its ultimate strength. Also the tension at 60 degrees F., without external load, shall not exceed 20% of the conductor ultimate strength.

(e) *Splices and taps.* Splices shall as far as practicable be avoided in the crossing and adjacent spans. If it is impracticable to avoid such splices, they shall be of such a type and so made as to have a strength substantially equal to that of the conductor in which they are placed. Taps shall be avoided in the crossing span where practicable, but if required shall be of a type which will not impair the strength of the conductors to which they are attached.

(10) MESSENGERS. (a) *Minimum size.* 1. Spans not exceeding 150 feet. Table 26 gives the minimum sizes of galvanized steel-strand messenger to be used for supporting different sizes of cables:

TABLE 26

MINIMUM SIZES OF MESSENGER

Size of Cable in Weight per Foot	Messenger (Nominal Breaking Load) Pounds
Less than 2.25 pounds	6,000
2.25 to 5 pounds	10,000
Exceeding 5 and less than 8.5 pounds	16,000

2. Spans exceeding 150 feet. For spans exceeding 150 feet or for heavier cables a proportionately larger messenger or other proportionately stronger means of support shall be used.

(b) *Sags and tensions.* Multiple-wire cables and their messengers shall be so suspended that when they are subjected to the loading prescribed in section E 125.02, the tension in the messenger will not exceed 60% of its ultimate strength.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 126.04 Grade N construction. (1) POLES AND TOWERS. Poles used for lines for which neither grade B, C, or D is required shall be of such initial size and so guyed or braced, where necessary, as to withstand the wind and ice loading specified in chapter E 125 plus the weight of lineman and pole mounted equipment without exceeding the allowable stress.

(2) GUYS. The general requirements for guys are covered under "Miscellaneous Requirements" (chapter E 128).

(3) CROSSARM STRENGTH. Crossarms shall be securely supported, by bracing if necessary, so as to support safely loads to which they may be subjected in use, including linemen working on them. Any crossarm, or buckarm, except the top one, shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

(4) SUPPLY-LINE CONDUCTORS. (a) *Material.* All supply-line conductors shall be of material or combinations of materials which will not corrode excessively under the prevailing conditions.

(b) *Sizes.* Supply-line conductors shall be not smaller than the following:

TABLE 27

GRADE N MINIMUM GAUGE SIZES FOR SUPPLY-LINE CONDUCTORS

(A.W.G. for Copper and Aluminum; Stl. W.G. for Steel)

	Urban	Rural
Soft copper	6	8
Medium or hard-drawn copper	8	8
Steel	9	9
	Urban and Rural	
	Spans 150 ft. or Less	Spans Exceeding 150 ft.
Stranded aluminum		
Not reinforced	1	0
Steel-reinforced	6	4

Recommendation: It is recommended that, except as modified in subsection E 126.02(6)(b), these minimum sizes for copper and steel not be used in spans longer than 150 feet.

(5) SUPPLY SERVICES. (a) *Material.* All supply service conductors shall be of material or combinations of materials which will not corrode excessively under the prevailing conditions and the ungrounded service conductors extending from the service entrance to the first pole shall have rubber or approved equivalent insulation if in a raceway; and rubber, weatherproof, or approved equivalent insulation where exposed.

(b) *Size of open-wire services.* 1. Not over 750 volts. Supply-service leads of not over 750 volts shall be not smaller than required by a. or b. below.

a. Spans not exceeding 150 feet. Sizes shall be not smaller than specified in table 28.

TABLE 28

MINIMUM SIZES OF SERVICE LEADS CARRYING 750 VOLTS OR LESS

(A.W.G. for Copper; Stl. W.G. for Steel)

Situation	Copper Wire		Steel Wire
	Soft-drawn	Medium or Hard-drawn	
Alone	10	12	12
Concerned with communication conductors	10	12	12
Over supply conductors of 0–750 volts	10	12	12
750 to 8,700 volts (a)	8	10	12
Exceeding 8,700 volts (a)	6	8	9
Over trolley contact conductors			
0 to 750 volts a.c. or d.c.	8	10	12
Exceeding 750 volts d.c.	6	8	9

(a) Installation of service leads of not more than 750 volts over supply lines of more than 750 volts should be avoided where practicable.

b. Spans exceeding 150 feet. Sizes shall be not smaller than required for grade C (section E 126.02(6)(b)).

2. Exceeding 750 volts. Sizes of supply-service leads of more than 750 volts between conductors shall be not less than required for supply line conductors of the same voltage.

(c) *Sag, open-wire services.* 1. Not over 750 volts. Supply service leads of not over 750 volts shall have sags not less than shown in table 29.

TABLE 29

SAGS FOR OPEN-WIRE SERVICES

Span Lengths (in feet)	Sag
	Inches
100 or less	12
100 to 125	18
125 to 150	27
Exceeding 150	Grade C sags

2. Exceeding 750 volts. Supply service leads of more than 750 volts shall comply as to sags with the requirements for supply line conductors of the same voltage.

(d) *Cabled services.* Supply service leads may be grouped together in a cable, provided the following requirements are met:

1. Conductivity. The conductivity of each conductor shall not be less than the conductivity of No. 12 copper.

2. Stress. The messenger member of an assembly designed to have the insulated conductors supported by the messenger shall not be stressed beyond 60% of its ultimate strength with the loading specified in section E 125.02.

3. Insulation. The insulation should be sufficient to withstand twice the normal operating voltage.

(6) LIGHTNING PROTECTION WIRES. The requirements as to size and materials for wires used as lightning protection wires when placed above and paralleling supply conductors shall be the same as that required for supply conductors.

(7) TROLLEY CONTACT CONDUCTORS. In order to provide for wear, no trolley contact conductors shall be installed of less size than No. 0, if of copper, or No. 4, if of silicon bronze.

(8) CRADLES AT SUPPLY-LINE CROSSINGS. Cradles should not be used.

Note: It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

(9) COMMUNICATION CONDUCTORS. There are no specific requirements for grade N communication line conductors or service drops.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.