UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1724E-150
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SUBJECT: **Unguyed Distribution Poles—Strength Requirements**

TO: RUS Electric Borrowers and RUS Electric Staff

EFFECTIVE DATE: Date of Approval

OFFICE OF PRIMARY INTEREST: Distribution Branch, Electric Staff Division

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PURPOSE: This guide bulletin presents equations, data, and other information needed to determine: (1) the loads applied to unguyed wood distribution poles; (2) a pole's strength requirements to sustain applied loads; and (3) maximum horizontal spans based on pole strengths. Sample solved problems are included in this bulletin to help the reader understand and apply the presented equations. At the end of this bulletin are tables of calculated ground line moments caused by wind on various species of wood poles and tables of permitted moments at the ground line of various species of wood poles commonly used for distribution construction.

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8/14/14
Date

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POLES, DISTRIBUTION: Strength Requirements, Maximum Spans

ABBREVIATIONS

ACSR	Aluminum Conductor, Steel Reinforced
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DTHL	Design Tension Heavy Loading
EQ	Equation
IEEE	Institute of Electrical and Electronics Engineers
MOR	Modulus of Rupture
NESC	National Electrical Safety Code
RUS	Rural Utilities Service
SYP	Southern Yellow Pine (a type of wood pole)

UNITS OF MEASURE

in	inch or inches (1 inch = 2.54 centimeters = 0.0254 meters)
in-lb	inch-pounds (inch × pounds) (1 inch-pound = 0.370685 newtons)
ft	foot or feet (1 foot = 0.3048 meters)
ft-lb	foot-pounds (feet × pounds) (1 foot-pound = 4.448222 newtons)
kcmil	1,000 circular mils (1 kcmil= 5.067075×10^{-6} square meters)
kV	kilovolts (1 kilovolt = 1,000 volts)

1 INTRODUCTION

a Purpose of Bulletin. This guide bulletin presents equations, data, and other information needed to determine:

- The loads applied to unguyed wood distribution poles 55 ft or less in total length,
- A pole's strength requirements to sustain applied loads, and
- Maximum horizontal spans based on pole strengths.

Sample solved problems are included in this bulletin to help the reader understand and apply the presented equations. Tables of calculated ground line moments caused by wind on wood poles are included in Exhibit A at the end of this bulletin. Tables of calculated permitted moments at the ground line of commonly used wood poles are included in Exhibit B at the end of this bulletin.

b Scope of Bulletin. The presentation in this bulletin is limited to the horizontal loading of unguyed wood distribution poles, 55 ft or less in total length, acting as simple cantilever beams or slender columns. Unguyed poles, according to RUS distribution construction standards, have a maximum line angle of 5 degrees. (The determination of the strength requirements of guyed poles is presented in Section 15 of RUS Bulletin 1724E-153, "Electric Distribution Line Guys and Anchors.")[1] The loading effect of transformers and other heavy equipment on poles is not included in this bulletin.

c National Electrical Safety Code (NESC). Throughout this bulletin are references to rules and selected data contained specifically in the 2012 edition of the NESC. At the time this bulletin was written, the 2012 edition was the latest edition of the NESC. Users of this bulletin should use the rules and data—as may be periodically updated, revised, and renumbered—from the most recent edition of the NESC. The NESC is published by the Institute of Electrical and Electronics Engineers, Inc. (IEEE).[2]

d American National Standards Institute (ANSI). This bulletin also references ANSI 05.1-2008, "Specifications and Dimensions for Wood Poles."[3] This standard provides specifications for quality and dimensions of wood poles that are to be used in single-pole utility structures.

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[1] Copies available from: RUS-USDA, Publications Office, PDRA STOP 1522, Washington, DC 20250-1522; Telephone 202-720-8674.
[2] Copies may be purchased from: IEEE Customer Service, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331; Telephone 1-800-678-4333.
[3] Copies may be purchased from: American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018; Telephone 212-354-3300.

2 CLASSIFICATION AND STRENGTH OF WOOD POLES

a Classification of Wood Poles. ANSI 05.1-2008 designates the fiber stress and dimensions of natural wood poles and also classifies poles by wood species, length, and class. Usually a pole's height and classification are abbreviated. For example, a pole identified as "35-6" indicates a 35-foot, (ANSI) Class 6 pole.

b Strength of Wood Poles by Class. Annex B of ANSI 05.1-2008 defines pole classes so that poles of various species and lengths will have approximately equal load-carrying capability. The minimum circumferences specified at 6 feet from the butt, (shown in Tables 3 through 10) have been calculated such that each species in a given class will not exceed the ground line stresses tabulated in Annex B, when a given horizontal load is applied 2 feet from the top of the pole. For example, all Class 6 poles are capable of holding a 1,500 pound load applied transversely 2 feet from the top of the pole. The ground line circumferences of different species of poles in the same class will deviate because of the differences in allowable fiber stress.

3 EXPLANATION OF APPLIED LOADS AND MOMENTS

a NESC Loading Requirements. Section 25 of the NESC requires that wind and ice loads on conductors and poles be determined according to the location (Heavy, Medium, or Light loading district) of construction. Assumed ice and wind loads have to be increased if they are expected to be greater than the minimum requirements of the NESC. If any part of a pole or the conductors attached to it is 60 feet or more above the ground, then extreme wind loading or extreme ice with concurrent wind loading has to be considered. Extreme wind loading (Rule 250C) or extreme ice with concurrent wind (Rule 250D) has to be applied, using the formulas and data of the NESC, if it is greater than the otherwise calculated wind and ice loading based on loading districts. Loads applied to wood poles have to be multiplied by the appropriate load factors of NESC Table 253-1. Conductor tension data for the appropriate loading case can then be determined as outlined in RUS Bulletin 1724E-152, "The Mechanics of Overhead Distribution Line Conductors."

b Combined Loading Equation. All of the loads that can be expected to be applied to a pole have to be considered in order to determine the pole's strength requirements to sustain the loads. Loads are simultaneously applied to poles in both the horizontal and vertical directions. Poles need to have sufficient strength such that the following relationship is satisfied:

$$\frac{M_{applied}}{S} + \frac{P_{applied}}{A} \leq MOR \qquad EQ\ 3.1$$

Where,

$M_{applied}$ = Moments induced in the pole (in-lb)

$P_{applied}$	=	Vertical loads on the pole (lb)
S	=	Section of modulus (in^3)
A	=	Cross section area of pole (in^2)
MOR	=	Modulus of rupture ($1b/in^2$)

Usually the P/A portion of Equation 3.1 is negligible in comparison with the M/S portion of the equation and, thus, is ignored in the distribution pole strength calculations of this bulletin.

c Direction of Critical Loading**.** By using vector algebra, all horizontal loads applied to a pole can be calculated in 2 component directions: *longitudinal* (parallel to the direction of the line) and *transverse* (perpendicular to the line). Usually there is only one direction of loading that dictates the minimum class of pole required to sustain all of the loads expected to be applied. This direction is called the *direction of critical loading*. Computations for pole strength requirements only need be made for the direction of critical loading when that direction is known. The direction of critical loading for unguyed poles is in the transverse direction.

4 HORIZONTAL MOMENTS ON A POLE

a Equations for Applied Moments. In this bulletin, an applied moment is the multiplication product of an applied load or force times the distance from its centroid to the ground line of the pole. The unit of measure used in this bulletin for moments is foot-pounds (ft-lb). The sum of all of the applied moments, multiplied by the appropriate NESC load factors, has to be determined before a pole of sufficient strength (i.e., class) can be selected. The total of all the ground line moments induced in a pole (M_g) is expressed as follows:

$$M_g = S_h M_{wc} + M_{wp} + M_{we} + M_{tc} + M_{vo} + M_{p-\delta} \qquad \text{EQ 4.1}$$

Where:

S_h = Horizontal wind span (= the sum of 1/2 the lengths of the adjacent spans) (ft)

M_{wc} = Summation of moment loads due to wind on each conductor expressed as moment per unit length of conductor (ft-lb/ft)

$$= F_{ow} \{\Sigma(W_c H_c)\} \cos \theta/2 \qquad \text{EQ 4.2}$$

M_{wp} = The moment due to wind on the pole (ft-lb)

$$= F_{ow} W_p \left[\frac{2C_t + C_g}{K_c}\right] H_p^2 \qquad \text{EQ 4.3}$$

Note: M_{wp} is calculated for several commonly used poles and tabulated in Exhibit

A at the end of this bulletin.

M_{we} = The moment due to wind on the material and equipment attached to the pole (ft-lb)
M_{tc} = Summation of moments due to the tension of the conductors (ft-lb)

$$= 2F_{ot}\{\Sigma(T_c H_c)\}\sin(\theta/2) \qquad \text{EQ 4.4}$$

M_{vo} = The moment due to unbalanced vertical loads (ft-lb)
$M_{p\text{-}\delta}$ = The moment due to pole deflection (ft-lb)

And where:

F_{ow} = NESC (Table 253-1) load factor for wind loads
F_{ot} = NESC (Table 253-1) load factor for longitudinal (tension) loads
H_p = Height of pole above ground (ft)
H_c = Height of each conductor attachment above ground line (ft)
W_c = Wind load per unit length of each conductor (1b/ft)
W_p = Wind load per unit area surface of pole (lb/ft^2)
T_c = Tension in each conductor (lb)
θ = Line angle at pole (degrees)
C_t = Pole circumference at top (in)
C_g = Pole circumference at ground line (in)
K_c = Calculation constant = 72π

b Simplification of Applied Moment Equation. The following force moment terms of Equation 4.1 can usually be omitted for the following reasons:

(1) **M_{we} can usually be ignored** because the transverse moment due to wind on pins, insulators, and the ends of crossarms is typically less than 500 ft-lb. However, M_{we} should be considered for attached transformers or other equipment. Throughout this bulletin it is assumed that no equipment is attached to the pole. If equipment is attached to the pole, the designer *must* take the equipment into account in these calculations.

(2) **M_{tc} is zero on tangent poles where the line angle $\theta = 0$** because the sine of (θ/2) = 0 and thus $M_{tc} = 2F_{ot}\{\Sigma(T_c H_c)\}\sin(\theta/2) = 0$. The nearly equal and opposite longitudinal conductor tensions essentially cancel each other.

(3) **M_{vo} is usually small and can be ignored.** RUS standard crossarm assemblies are symmetrical (looking in the longitudinal direction). Thus, the moments induced in the pole by conductor weights supported by crossarms cancel one another. The remaining conductors are attached directly to the pole. Therefore, the moment induced in the pole due to offset conductor weights is negligible. (Vertical conductor weights alone seldom dictate the required pole class.) Nonbalanced pole loads—such as

narrow profile assemblies—will affect the pole class and must be taken into account in these calculations.

(4) **$M_{p\text{-}\delta}$ are small ground line moments.** Transverse loads cause an unguyed pole to deflect a small distance. Vertical loads on the pole times this deflection distance cause additional moments to be induced in the pole. These additional moments are small compared to the other moments of Equation 4.1 and compensated for in Equation 5.2.

c Simplified Equation for Applied Moments. After applying the assumptions and omissions of Section 4b of this bulletin, Equation 4.1 can be simplified to:

$$M_g = S_h M_{wc} + M_{wp} + M_{tc} \qquad \text{EQ 4.5}$$

d Example Problem 1: Total Horizontal Moment. Given the following information and data, calculate the moment (M_g) at the ground line of a 35-foot unguyed pole adjacent to a highway crossing span that supports a 3-phase, crossarm assembly. The horizontal wind span (S_h) is 300 feet. The line angle (θ) is 2 degrees.

(1) Given pole data:
Pole: Southern Yellow Pine (SYP); 35-foot (set 6 foot deep); Class 5
$C_t = 19$ in $C_g = 29$ in $H_p = 29$ ft

(2) Given conductor data:
NESC Heavy Loading District (0ºF, ½" ice, 4 lb/ft^2 wind)

3 Primary Conductors: 266.8 18/1 kcmil ACSR (“Waxwing”)
$W_c = 0.5363$ lb/ft

1 Neutral Conductor: #1/0 6/1 ACSR (“Raven”)
$W_c = 0.4660$ lb/ft

Conductor attachment heights above ground line:

	A phase	B phase	C phase	Neutral
H_c (ft) =	28.25	29.87	28.25	25.50

Phase conductor design tension: $T_c = 2{,}408$ lb DTHL
Neutral conductor design tension: $T_c = 1{,}731$ lb DTHL

(3) Given NESC data:
NESC Heavy Loading District; NESC Grade C construction (crossing span)
$F_{ow} = 2.20$ $F_{ot} = 1.30$ $W_p = 4$ lb/ft^2

(4) The summation of moments per unit length of conductor (M_{wc}) due to

wind on each conductor can be tabulated as follows:

Phase	$W_c\ H_c$		
A	(0.5363)(28.25)	=	15.15
B	(0.5363)(29.87)	=	16.02
C	(0.5363)(28.25)	=	15.15
N	(0.4660)(25.50)	=	11.88
Total	$\Sigma(W_cH_c)$	=	58.20

$M_{wc} = F_{ow}\{\Sigma(W_cH_c)\}cos(\theta/2)$ = (2.20)(58.20)(cos 1°) = 128.02 ft-lb/ft

(5) The moment due to wind on the pole is calculated using Equation 4.3 as shown below or, alternatively, determined from Table 1 in Exhibit A at the end of this bulletin.

$$M_{wp} = F_{ow}W_p\left[\frac{(2C_t + C_g)}{K_c}\right]H_p^2$$

$$M_{wp} = (2.20)(4)\left[\frac{((2)(19) + 29)}{72\pi}\right](29^2) = 2{,}192\ ft - lb$$

(6) The summation of moments due to the tension of each conductor (M_{tc}) can be calculated as follows:

Phase	T_cH_c		
A	(2,408)(28.25)	=	68,026
B	(2,408)(29.87)	=	71,927
C	(2,408)(28.25)	=	68,026
N	(1,731)(25.50)	=	44,141
Total	$\Sigma(T_cH_c)$	=	252,120

$M_{tc} = 2F_{ot}\{\Sigma(T_cH_c)\}sin(\theta/2)$ = (2)(1.30)(252,120)(sin 1°) = 11,440 ft-lb

(7) The total moment on the pole is calculated using Equation 4.5 as follows:

$M_g = S_hM_{wc} + M_{wp} + M_{tc}$
M_g = 300 (ft) x 128.02 (ft-lb/ft) + 2,192 (ft-lb) + 11,440 ft-lb = 52,038 ft-lb

5 POLE STRENGTH AND REQUIREMENTS

a NESC Strength Requirements of Poles. The NESC requires that a support structure be able to withstand a load equivalent to all of the expected applied loads (multiplied by the appropriate NESC load factors) without exceeding the *permitted load* of the support structure. The *permitted load* is the designated strength of the support structure multiplied by the appropriate NESC strength factor of NESC Table 261-1. In this bulletin, "support structure" means a single wood distribution pole. For purposes of this bulletin, the NESC strength requirement for a support structure means the permitted moment (M_r) for a pole at the ground line has to be equal to or exceed the total ground line moment (M_g) induced in the pole. This relationship is expressed in the following equation:

$$M_g \leq M_r \qquad \text{EQ 5.1}$$

b Pole Circumference at the Ground Line. The permitted moment (M_r) for a pole at the ground line can be calculated if the pole's circumference at the ground line is known. However, pole tables tabulate pole circumferences at a fixed distance (usually 6 feet as per ANSI 05.1-2008) from the bottom of each pole which may not be at the ground line. A pole's circumference at its ground line, based on its circumference 6 feet from its bottom, can be calculated by using the following Equation 5.2:

$$C_g = \left[\frac{(L_p - L_g)(C_b - C_t)}{(L_p - L_b)}\right] + C_t \qquad \text{EQ 5.2}$$

Where:

C_g	=	Pole circumference at ground line (in)
L_p	=	Length of pole (ft)
L_g	=	Distance from pole bottom to ground line (ft)
L_b	=	Distance from pole bottom to classification point per ANSI 05.1-2008 (6 feet)
C_b	=	Pole circumference at distance L_b from bottom per ANSI 05.1-2008 (in)
C_t	=	Pole circumference at top (in)

The calculated ground line circumferences (C_g) for several commonly used distribution poles are tabulated in Exhibit A at the end of this bulletin.

c Permitted Moment of Pole at the Ground Line. The permitted moment of a pole at its ground line can he calculated using the following equation:

$$M_r = S_f K_r F_b C_g^3 \qquad \text{EQ 5.3}$$

Where:

M_r	=	Permitted moment at ground line (ft-lb)

S_f = NESC strength factor (NESC Table 261-1)
K_r = Calculation constant = 2.64×10^{-4} (ft/in)
F_b = Designated fiber stress (lb/in^2)

The calculated permitted ground line moments (M_r) for several commonly used distribution poles are tabulated in Exhibit B at the end of this bulletin.

d <u>Example Problem 2: Determine Pole Resisting Moment</u>. Given the following pole data, determine if a 35-foot, Class 5, Southern Yellow Pine pole (35-5 SYP) is adequate to sustain the total moment of 52,038 ft-lb calculated in Example Problem 1 in Section 4d of this bulletin.

(1) <u>Given pole and NESC data</u>:

C_b = 29 in	L_p = 35 ft	F_b = 8,000 1b/in^2
C_t = 19 in	L_g = 6 ft	S_f = 0.85
	L_b = 6 ft	

(2) <u>The pole circumference at the ground line</u> (C_g) does not need to be calculated for this particular pole height because $L_g = L_b$ = 6 feet and, therefore, $C_g = C_b$ = 29 in. Normally, for other pole heights and classes, C_g needs to be calculated using Equation 5.2 or determined using Exhibit A at the end of this bulletin.

(3) <u>The permitted moment at the ground line</u> of a 35-5 SYP pole can be calculated using Equation 5.4 as follows or determined using Exhibit B at the end of this bulletin.

$$M_r = S_f K_r F_b C_g^{3}$$
$$= (0.85)(0.000264 \text{ ft/in})(8{,}000 \text{ lb/in}^2)(29^3 \text{ in}^3)$$
$$M_r = 43{,}783 \text{ ft-lb}$$

Since the induced moment of 52,038 ft-lb is greater than the resisting moment of a SYP 35-5 pole, a pole of greater strength (higher class) needs to be selected to sustain the given loads and conditions of Example Problem 1 in Section 4d of this bulletin.

e <u>Repeat Comparison Procedure</u>. If calculations show that a selected pole does not have adequate strength to sustain the calculated loads, then another, stronger pole needs to be selected. The permitted moment (M_r) of any (new) selected pole needs to be determined and ascertained that the M_r of the new selected pole is greater than the total moment expected to be induced in the pole. Use the equations and procedure included in Sections 5a through 5c of this bulletin.

f <u>Moments Above Guy Attachments</u>. Where horizontal loads are applied at some distance above a guy attachment, it is advisable to check for the pole strength at the guy attachment location. The portion of a pole below a guy attachment is considered to be a strut with only vertical loads applied. The loads above the top guy attachment and the strength of the pole at the guy attachment location are calculated in the same manner as an unguyed pole with the following two modifications.

(1) The moments above a guy attachment can be calculated and summed using the same equations and procedure presented in Section 4 of this bulletin. However, the distances from the applied loads to the pole's ground line (H_c in Equation 4.2) has to be replaced with the distances from the applied loads to the top guy attachment location on the pole.

(2) The circumference of the pole at the top guy attachment location can be calculated by replacing the distance L_g in Equation 5.2 with the distance from the bottom of the pole to the guy attachment location. Thus, M_r in Equation 5.3 becomes the permitted moment at the guy attachment location and can be calculated and compared to the calculated moment at the guy attachment location.

6 DETERMINATION OF MAXIMUM HORIZONTAL SPANS

a Maximum Horizontal Span. The maximum permitted horizontal span for an unguyed pole based on a pole's species, height, and class can be calculated by essentially reversing the procedure presented in Sections 4 and 5 of this bulletin. Usually the pole height and class are known or given. When unknown, the pole's species should be assumed to be the type with the lowest fiber stress for calculation purposes.

b Equation for the Maximum Horizontal Span. The (simplified) equation for the total ground line moment induced in an unguyed pole with no large or heavy equipment attached was presented in Section 4a in this bulletin as:

$$M_g = S_h M_{wc} + M_{wp} + M_{tc} \qquad \text{EQ 4.5}$$

(1) Equation 4.5 can be rearranged as follows to determine the horizontal span (S_h) as a function of the induced moments in the pole:

$$S_h = \frac{(M_g - M_{wp} - M_{tc})}{M_{wc}} \ ft \qquad \text{EQ 6.1}$$

(2) By replacing M_g in Equation 6.1 with M_r, the permitted moment of the pole at its ground line, the equation becomes an expression for the maximum horizontal span, $S_{h\text{-}max}$ as follows:

$$S_{h-max} = \frac{(M_r - M_{wp} - M_{tc})}{M_{wc}} \; ft \qquad EQ\ 6.2$$

The definitions of the moment terms in Equation 6.2 are provided in Section 4a and Section 5b of this bulletin. M_{tc} is zero where the line angle $\theta = 0$, because the sine of $(\theta/2) = 0$ and, thus, $M_{tc} = 2F_{ot}\{\Sigma(T_c H_c)\}sin(\theta/2) = 0$.

c Example Problem 3: Determination of Maximum Span. Determine the maximum horizontal span ($S_{h\text{-}max}$) for a 35-5 SYP pole using the moments calculated in Example Problem 1 in Section 4d of this bulletin.

(1) Given (previously calculated) moments:

M_{wp}	=	2,192 ft-lb	See Section 4d(5) of this bulletin
M_{tc}	=	11,440 ft-lb	See Section 4d(6) of this bulletin
M_{wc}	=	128.02 ft-lb/ft	See Section 4d(4) of this bulletin
M_r	=	43,783 ft-lb	See Section 5d(3) of this bulletin and Section 6c(2) immediately below.

(2) Maximum horizontal span:

$$S_{h-max} = \frac{(M_r - M_{wp} - M_{tc})}{M_{wc}} \qquad (EQ\ 6.2)$$

$$S_{h-max} = \frac{(43{,}783\ (ft - lb) - 2{,}192(ft - lb) - 11{,}440\ (ft - lb))}{128.02\ (ft - lb\ /\ ft)}$$

$$S_{h-max} = 235\ ft$$

7 CONTRIBUTORS

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

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EXHIBIT A
GROUND LINE MOMENTS CAUSED BY WIND ON WOOD POLES

TABLE 1
NESC Heavy Loading District/Grade C Construction

Loading: Heavy
Grade: C

			Southern Yellow Pine & Douglas Fir		Lodgepole Pine & Red Pine		Western Larch		Western Red Cedar	
Length (ft)	**G_L** (ft)	**C_T** (in)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)
Class 1		27.0								
35	6.0		39.0	2,430	41.5	2,490	38.0	2,400	42.5	2,520
40	6.0		41.0	3,400	44.0	3,510	40.0	3,370	45.0	3,550
45	6.5		42.8	4,450	45.8	4,580	41.8	4,400	47.2	4,650
50	7.0		44.6	5,650	47.5	5,810	43.6	5,590	49.0	5,900
55	7.5		45.9	6,980	48.8	7,180	44.9	6,910	50.8	7,320
Class 2		25.0								
35	6.0		36.5	2,260	38.5	2,310	35.5	2,230	40.0	2,350
40	6.0		38.5	3,170	41.0	3,260	37.5	3,140	42.5	3,310
45	6.5		40.3	4,150	42.8	4,260	39.3	4,100	44.3	4,330
50	7.0		41.6	5,250	44.5	5,410	40.6	5,190	46.0	5,500
55	7.5		42.9	6,490	45.8	6,700	42.0	6,430	47.8	6,830
Class 3		23.0								
35	6.0		34.0	2,090	36.0	2,140	33.0	2,060	37.5	2,180
40	6.0		36.0	2,940	38.0	3,010	35.0	2,900	39.5	3,060
45	6.5		37.3	3,830	39.8	3,940	36.8	3,800	41.3	4,010
50	7.0		38.6	4,850	41.6	5,020	38.1	4,820	43.0	5,100
55	7.5		40.0	6,010	42.9	6,210	39.5	5,970	44.3	6,310
Class 4		21.0								
35	6.0		31.5	1,920	33.5	1,970	31.0	1,900	34.5	2,000
40	6.0		33.5	2,710	35.5	2,780	32.5	2,670	36.5	2,810
45	6.5		34.8	3,530	36.8	3,620	33.8	3,480	38.3	3,690
50	7.0		36.1	4,480	38.6	4,620	35.2	4,420	39.6	4,670
55	7.5		37.5	5,550	39.9	5,720	36.5	5,490	41.4	5,830
Class 5		19.0								
35	6.0		29.0	1,750	31.0	1,800	28.5	1,740	32.0	1,830
40	6.0		31.0	2,470	33.0	2,540	30.0	2,440	34.0	2,580
45	6.5		32.3	3,230	34.3	3,320	31.3	3,190	35.8	3,390
50	7.0		33.7	4,110	35.6	4,220	32.7	4,050	37.1	4,300
Class 6		17.0								
35	6.0		27.0	1,590	28.5	1,630	26.5	1,580	30.0	1,670
40	6.0		28.5	2,240	30.5	2,310	28.0	2,220	31.5	2,350
45	6.5		29.8	2,930	31.8	3,020	28.8	2,890	32.8	3,070

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 2
NESC Heavy Loading District/Grade C Construction—Crossing Spans

Loading: Heavy
Grade: CX

			Southern Yellow Pine & Douglas Fir		Lodgepole Pine & Red Pine		Western Larch		Western Red Cedar	
Length (ft)	**G_L** (ft)	**C_T** (in)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)
Class 1		27.0								
35	6.0		39.0	3,050	41.5	3,130	38.0	3,020	42.5	3,160
40	6.0		41.0	4,280	44.0	4,410	40.0	4,230	45.0	4,460
45	6.5		42.8	5,590	45.8	5,760	41.8	5,530	47.2	5,840
50	7.0		44.6	7,100	47.5	7,310	43.6	7,030	49.0	7,410
55	7.5		45.9	8,770	48.8	9,030	44.9	8,690	50.8	9,200
Class 2		25.0								
35	6.0		36.5	2,840	38.5	2,900	35.5	2,800	40.0	2,950
40	6.0		38.5	3,990	41.0	4,100	37.5	3,940	42.5	4,170
45	6.5		40.3	5,210	42.8	5,350	39.3	5,160	44.3	5,440
50	7.0		41.6	6,600	44.5	6,810	40.6	6,520	46.0	6,910
55	7.5		42.9	8,160	45.8	8,420	42.0	8,080	47.8	8,590
Class 3		23.0								
35	6.0		34.0	2,620	36.0	2,690	33.0	2,590	37.5	2,740
40	6.0		36.0	3,690	38.0	3,780	35.0	3,650	39.5	3,850
45	6.5		37.3	4,810	39.8	4,950	36.8	4,780	41.3	5,040
50	7.0		38.6	6,090	41.6	6,300	38.1	6,060	43.0	6,410
55	7.5		40.0	7,550	42.9	7,810	39.5	7,510	44.3	7,930
Class 4		21.0								
35	6.0		31.5	2,410	33.5	2,480	31.0	2,390	34.5	2,510
40	6.0		33.5	3,400	35.5	3,490	32.5	3,360	36.5	3,540
45	6.5		34.8	4,430	36.8	4,550	33.8	4,380	38.3	4,630
50	7.0		36.1	5,630	38.6	5,800	35.2	5,560	39.6	5,870
55	7.5		37.5	6,980	39.9	7,190	36.5	6,900	41.4	7,320
Class 5		19.0								
35	6.0		29.0	2,200	31.0	2,260	28.5	2,180	32.0	2,300
40	6.0		31.0	3,110	33.0	3,200	30.0	3,060	34.0	3,240
45	6.5		32.3	4,060	34.3	4,170	31.3	4,000	35.8	4,260
50	7.0		33.7	5,160	35.6	5,300	32.7	5,090	37.1	5,410
Class 6		17.0								
35	6.0		27.0	2,000	28.5	2,050	26.5	1,980	30.0	2,100
40	6.0		28.5	2,820	30.5	2,910	28.0	2,790	31.5	2,950
45	6.5		29.8	3,690	31.8	3,800	28.8	3,630	32.8	3,860

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 3
NESC Heavy Loading District/Grade B Construction

Loading: Heavy
Grade: B

Length (ft)	G_L (ft)	C_T (in)	Southern Yellow Pine & Douglas Fir C_{GL} (in)	Southern Yellow Pine & Douglas Fir M_{WP} (ft-lb)	Lodgepole Pine & Red Pine C_{GL} (in)	Lodgepole Pine & Red Pine M_{WP} (ft-lb)	Western Larch C_{GL} (in)	Western Larch M_{WP} (ft-lb)	Western Red Cedar C_{GL} (in)	Western Red Cedar M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	3,460	41.5	3,560	38.0	3,430	42.5	3,590
40	6.0		41.0	4,860	44.0	5,010	40.0	4,810	45.0	5,060
45	6.5		42.8	6,350	45.8	6,540	41.8	6,280	47.2	6,640
50	7.0		44.6	8,060	47.5	8,300	43.6	7,980	49.0	8,420
55	7.5		45.9	9,970	48.8	10,260	44.9	9,870	50.8	10,450
Class 2		25.0								
35	6.0		36.5	3,220	38.5	3,300	35.5	3,180	40.0	3,350
40	6.0		38.5	4,530	41.0	4,660	37.5	4,480	42.5	4,730
45	6.5		40.3	5,920	42.8	6,080	39.3	5,860	44.3	6,180
50	7.0		41.6	7,490	44.5	7,730	40.6	7,410	46.0	7,850
55	7.5		42.9	9,270	45.8	9,570	42.0	9,180	47.8	9,760
Class 3		23.0								
35	6.0		34.0	2,980	36.0	3,050	33.0	2,940	37.5	3,110
40	6.0		36.0	4,200	38.0	4,300	35.0	4,140	39.5	4,370
45	6.5		37.3	5,460	39.8	5,630	36.8	5,430	41.3	5,720
50	7.0		38.6	6,920	41.6	7,160	38.1	6,880	43.0	7,280
55	7.5		40.0	8,580	42.9	8,870	39.5	8,530	44.3	9,010
Class 4		21.0								
35	6.0		31.5	2,740	33.5	2,810	31.0	2,720	34.5	2,850
40	6.0		33.5	3,860	35.5	3,970	32.5	3,810	36.5	4,020
45	6.5		34.8	5,040	36.8	5,170	33.8	4,970	38.3	5,270
50	7.0		36.1	6,390	38.6	6,590	35.2	6,310	39.6	6,670
55	7.5		37.5	7,930	39.9	8,170	36.5	7,840	41.4	8,320
Class 5		19.0								
35	6.0		29.0	2,500	31.0	2,570	28.5	2,480	32.0	2,610
40	6.0		31.0	3,530	33.0	3,630	30.0	3,480	34.0	3,680
45	6.5		32.3	4,610	34.3	4,740	31.3	4,550	35.8	4,840
50	7.0		33.7	5,860	35.6	6,020	32.7	5,780	37.1	6,140
Class 6		17.0								
35	6.0		27.0	2,270	28.5	2,330	26.5	2,250	30.0	2,380
40	6.0		28.5	3,200	30.5	3,300	28.0	3,170	31.5	3,350
45	6.5		29.8	4,190	31.8	4,320	28.8	4,120	32.8	4,380

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 4
NESC Medium Loading District/Grade C Construction

Loading: Medium
Grade: C

Length (ft)	G_L (ft)	C_T (in)	Southern Yellow Pine & Douglas Fir C_{GL} (in)	Southern Yellow Pine & Douglas Fir M_{WP} (ft-lb)	Lodgepole Pine & Red Pine C_{GL} (in)	Lodgepole Pine & Red Pine M_{WP} (ft-lb)	Western Larch C_{GL} (in)	Western Larch M_{WP} (ft-lb)	Western Red Cedar C_{GL} (in)	Western Red Cedar M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	2,430	41.5	2,490	38.0	2,400	42.5	2,520
40	6.0		41.0	3,400	44.0	3,510	40.0	3,370	45.0	3,550
45	6.5		42.8	4,450	45.8	4,580	41.8	4,400	47.2	4,650
50	7.0		44.6	5,650	47.5	5,810	43.6	5,590	49.0	5,900
55	7.5		45.9	6,980	48.8	7,180	44.9	6,910	50.8	7,320
Class 2		25.0								
35	6.0		36.5	2,260	38.5	2,310	35.5	2,230	40.0	2,350
40	6.0		38.5	3,170	41.0	3,260	37.5	3,140	42.5	3,310
45	6.5		40.3	4,150	42.8	4,260	39.3	4,100	44.3	4,330
50	7.0		41.6	5,250	44.5	5,410	40.6	5,190	46.0	5,500
55	7.5		42.9	6,490	45.8	6,700	42.0	6,430	47.8	6,830
Class 3		23.0								
35	6.0		34.0	2,090	36.0	2,140	33.0	2,060	37.5	2,180
40	6.0		36.0	2,940	38.0	3,010	35.0	2,900	39.5	3,060
45	6.5		37.3	3,830	39.8	3,940	36.8	3,800	41.3	4,010
50	7.0		38.6	4,850	41.6	5,020	38.1	4,820	43.0	5,100
55	7.5		40.0	6,010	42.9	6,210	39.5	5,970	44.3	6,310
Class 4		21.0								
35	6.0		31.5	1,920	33.5	1,970	31.0	1,900	34.5	2,000
40	6.0		33.5	2,710	35.5	2,780	32.5	2,670	36.5	2,810
45	6.5		34.8	3,530	36.8	3,620	33.8	3,480	38.3	3,690
50	7.0		36.1	4,480	38.6	4,620	35.2	4,420	39.6	4,670
55	7.5		37.5	5,550	39.9	5,720	36.5	5,490	41.4	5,830
Class 5		19.0								
35	6.0		29.0	1,750	31.0	1,800	28.5	1,740	32.0	1,830
40	6.0		31.0	2,470	33.0	2,540	30.0	2,440	34.0	2,580
45	6.5		32.3	3,230	34.3	3,320	31.3	3,190	35.8	3,390
50	7.0		33.7	4,110	35.6	4,220	32.7	4,050	37.1	4,300
Class 6		17.0								
35	6.0		27.0	1,590	28.5	1,630	26.5	1,580	30.0	1,670
40	6.0		28.5	2,240	30.5	2,310	28.0	2,220	31.5	2,350
45	6.5		29.8	2,930	31.8	3,020	28.8	2,890	32.8	3,070

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 5
NESC Medium Loading District/Grade C Construction—Crossing Spans

Loading: Medium
Grade: CX

			Southern Yellow Pine & Douglas Fir		Lodgepole Pine & Red Pine		Western Larch		Western Red Cedar	
Length (ft)	**G_L** (ft)	**C_T** (in)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)	**C_{GL}** (in)	**M_{WP}** (ft-lb)
Class 1		27.0								
35	6.0		39.0	3,050	41.5	3,130	38.0	3,020	42.5	3,160
40	6.0		41.0	4,280	44.0	4,410	40.0	4,230	45.0	4,460
45	6.5		42.8	5,590	45.8	5,760	41.8	5,530	47.2	5,840
50	7.0		44.6	7,100	47.5	7,310	43.6	7,030	49.0	7,410
55	7.5		45.9	8,770	48.8	9,030	44.9	8,690	50.8	9,200
Class 2		25.0								
35	6.0		36.5	2,840	38.5	2,900	35.5	2,800	40.0	2,950
40	6.0		38.5	3,990	41.0	4,100	37.5	3,940	42.5	4,170
45	6.5		40.3	5,210	42.8	5,350	39.3	5,160	44.3	5,440
50	7.0		41.6	6,600	44.5	6,810	40.6	6,520	46.0	6,910
55	7.5		42.9	8,160	45.8	8,420	42.0	8,080	47.8	8,590
Class 3		23.0								
35	6.0		34.0	2,620	36.0	2,690	33.0	2,590	37.5	2,740
40	6.0		36.0	3,690	38.0	3,780	35.0	3,650	39.5	3,850
45	6.5		37.3	4,810	39.8	4,950	36.8	4,780	41.3	5,040
50	7.0		38.6	6,090	41.6	6,300	38.1	6,060	43.0	6,410
55	7.5		40.0	7,550	42.9	7,810	39.5	7,510	44.3	7,930
Class 4		21.0								
35	6.0		31.5	2,410	33.5	2,480	31.0	2,390	34.5	2,510
40	6.0		33.5	3,400	35.5	3,490	32.5	3,360	36.5	3,540
45	6.5		34.8	4,430	36.8	4,550	33.8	4,380	38.3	4,630
50	7.0		36.1	5,630	38.6	5,800	35.2	5,560	39.6	5,870
55	7.5		37.5	6,980	39.9	7,190	36.5	6,900	41.4	7,320
Class 5		19.0								
35	6.0		29.0	2,200	31.0	2,260	28.5	2,180	32.0	2,300
40	6.0		31.0	3,110	33.0	3,200	30.0	3,060	34.0	3,240
45	6.5		32.3	4,060	34.3	4,170	31.3	4,000	35.8	4,260
50	7.0		33.7	5,160	35.6	5,300	32.7	5,090	37.1	5,410
Class 6		17.0								
35	6.0		27.0	2,000	28.5	2,050	26.5	1,980	30.0	2,100
40	6.0		28.5	2,820	30.5	2,910	28.0	2,790	31.5	2,950
45	6.5		29.8	3,690	31.8	3,800	28.8	3,630	32.8	3,860

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 6
NESC Medium Loading District/Grade B Construction

Loading: Medium
Grade: B

Length (ft)	G_L (ft)	C_T (in)	Southern Yellow Pine & Douglas Fir C_{GL} (in)	Southern Yellow Pine & Douglas Fir M_{WP} (ft-lb)	Lodgepole Pine & Red Pine C_{GL} (in)	Lodgepole Pine & Red Pine M_{WP} (ft-lb)	Western Larch C_{GL} (in)	Western Larch M_{WP} (ft-lb)	Western Red Cedar C_{GL} (in)	Western Red Cedar M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	3,460	41.5	3,560	38.0	3,430	42.5	3,590
40	6.0		41.0	4,860	44.0	5,010	40.0	4,810	45.0	5,060
45	6.5		42.8	6,350	45.8	6,540	41.8	6,280	47.2	6,640
50	7.0		44.6	8,060	47.5	8,300	43.6	7,980	49.0	8,420
55	7.5		45.9	9,970	48.8	10,260	44.9	9,870	50.8	10,450
Class 2		25.0								
35	6.0		36.5	3,220	38.5	3,300	35.5	3,180	40.0	3,350
40	6.0		38.5	4,530	41.0	4,660	37.5	4,480	42.5	4,730
45	6.5		40.3	5,920	42.8	6,080	39.3	5,860	44.3	6,180
50	7.0		41.6	7,490	44.5	7,730	40.6	7,410	46.0	7,850
55	7.5		42.9	9,270	45.8	9,570	42.0	9,180	47.8	9,760
Class 3		23.0								
35	6.0		34.0	2,980	36.0	3,050	33.0	2,940	37.5	3,110
40	6.0		36.0	4,200	38.0	4,300	35.0	4,140	39.5	4,370
45	6.5		37.3	5,460	39.8	5,630	36.8	5,430	41.3	5,720
50	7.0		38.6	6,920	41.6	7,160	38.1	6,880	43.0	7,280
55	7.5		40.0	8,580	42.9	8,870	39.5	8,530	44.3	9,010
Class 4		21.0								
35	6.0		31.5	2,740	33.5	2,810	31.0	2,720	34.5	2,850
40	6.0		33.5	3,860	35.5	3,970	32.5	3,810	36.5	4,020
45	6.5		34.8	5,040	36.8	5,170	33.8	4,970	38.3	5,270
50	7.0		36.1	6,390	38.6	6,590	35.2	6,310	39.6	6,670
55	7.5		37.5	7,930	39.9	8,170	36.5	7,840	41.4	8,320
Class 5		19.0								
35	6.0		29.0	2,500	31.0	2,570	28.5	2,480	32.0	2,610
40	6.0		31.0	3,530	33.0	3,630	30.0	3,480	34.0	3,680
45	6.5		32.3	4,610	34.3	4,740	31.3	4,550	35.8	4,840
50	7.0		33.7	5,860	35.6	6,020	32.7	5,780	37.1	6,140
Class 6		17.0								
35	6.0		27.0	2,270	28.5	2,330	26.5	2,250	30.0	2,380
40	6.0		28.5	3,200	30.5	3,300	28.0	3,170	31.5	3,350
45	6.5		29.8	4,190	31.8	4,320	28.8	4,120	32.8	4,380

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 7
NESC Light Loading District/Grade C Construction

Loading: Light
Grade: C

			Southern Yellow Pine & Douglas Fir		Lodgepole Pine & Red Pine		Western Larch		Western Red Cedar	
Length (ft)	G_L (ft)	C_T (in)	C_{GL} (in)	M_{WP} (ft-lb)	C_{GL} (in)	M_{WP} (ft-lb)	C_{GL} (in)	M_{WP} (ft-lb)	C_{GL} (in)	M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	5,450	41.5	5,600	38.0	5,390	42.5	5,660
40	6.0		41.0	7,650	44.0	7,890	40.0	7,570	45.0	7,970
45	6.5		42.8	10,000	45.8	10,300	41.8	9,890	47.2	10,450
50	7.0		44.6	12,700	47.5	13,080	43.6	12,570	49.0	13,260
55	7.5		45.9	15,700	48.8	16,160	44.9	15,550	50.8	16,460
Class 2		25.0								
35	6.0		36.5	5,070	38.5	5,190	35.5	5,010	40.0	5,280
40	6.0		38.5	7,130	41.0	7,330	37.5	7,050	42.5	7,450
45	6.5		40.3	9,320	42.8	9,580	39.3	9,220	44.3	9,730
50	7.0		41.6	11,800	44.5	12,180	40.6	11,670	46.0	12,370
55	7.5		42.9	14,610	45.8	15,060	42.0	14,450	47.8	15,370
Class 3		23.0								
35	6.0		34.0	4,690	36.0	4,810	33.0	4,630	37.5	4,890
40	6.0		36.0	6,610	38.0	6,770	35.0	6,520	39.5	6,890
45	6.5		37.3	8,600	39.8	8,860	36.8	8,550	41.3	9,010
50	7.0		38.6	10,900	41.6	11,280	38.1	10,840	43.0	11,470
55	7.5		40.0	13,510	42.9	13,970	39.5	13,430	44.3	14,200
Class 4		21.0								
35	6.0		31.5	4,310	33.5	4,430	31.0	4,280	34.5	4,480
40	6.0		33.5	6,080	35.5	6,240	32.5	6,000	36.5	6,320
45	6.5		34.8	7,930	36.8	8,140	33.8	7,830	38.3	8,290
50	7.0		36.1	10,070	38.6	10,380	35.2	9,940	39.6	10,510
55	7.5		37.5	12,490	39.9	12,870	36.5	12,340	41.4	13,100
Class 5		19.0								
35	6.0		29.0	3,930	31.0	4,050	28.5	3,900	32.0	4,100
40	6.0		31.0	5,560	33.0	5,720	30.0	5,480	34.0	5,800
45	6.5		32.3	7,260	34.3	7,470	31.3	7,160	35.8	7,620
50	7.0		33.7	9,230	35.6	9,480	32.7	9,110	37.1	9,670
Class 6		17.0								
35	6.0		27.0	3,580	28.5	3,660	26.5	3,550	30.0	3,750
40	6.0		28.5	5,040	30.5	5,200	28.0	5,000	31.5	5,280
45	6.5		29.8	6,590	31.8	6,800	28.8	6,490	32.8	6,900

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 8
NESC Light Loading District/Grade C Construction—Crossing Spans

Loading: Light
Grade: CX

Length (ft)	G_L (ft)	C_T (in)	Southern Yellow Pine & Douglas Fir C_{GL} (in)	Southern Yellow Pine & Douglas Fir M_{WP} (ft-lb)	Lodgepole Pine & Red Pine C_{GL} (in)	Lodgepole Pine & Red Pine M_{WP} (ft-lb)	Western Larch C_{GL} (in)	Western Larch M_{WP} (ft-lb)	Western Red Cedar C_{GL} (in)	Western Red Cedar M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	6,850	41.5	7,040	38.0	6,780	42.5	7,110
40	6.0		41.0	9,620	44.0	9,920	40.0	9,520	45.0	10,020
45	6.5		42.8	12,560	45.8	12,950	41.8	12,440	47.2	13,140
50	7.0		44.6	15,960	47.5	16,440	43.6	15,800	49.0	16,670
55	7.5		45.9	19,740	48.8	20,310	44.9	19,540	50.8	20,690
Class 2		25.0								
35	6.0		36.5	6,370	38.5	6,520	35.5	6,300	40.0	6,630
40	6.0		38.5	8,960	41.0	9,210	37.5	8,860	42.5	9,370
45	6.5		40.3	11,720	42.8	12,040	39.3	11,590	44.3	12,230
50	7.0		41.6	14,830	44.5	15,310	40.6	14,670	46.0	15,540
55	7.5		42.9	18,360	45.8	18,930	42.0	18,170	47.8	19,320
Class 3		23.0								
35	6.0		34.0	5,890	36.0	6,040	33.0	5,820	37.5	6,150
40	6.0		36.0	8,300	38.0	8,510	35.0	8,200	39.5	8,660
45	6.5		37.3	10,810	39.8	11,140	36.8	10,750	41.3	11,330
50	7.0		38.6	13,700	41.6	14,180	38.1	13,620	43.0	14,420
55	7.5		40.0	16,980	42.9	17,560	39.5	16,890	44.3	17,840
Class 4		21.0								
35	6.0		31.5	5,420	33.5	5,560	31.0	5,380	34.5	5,640
40	6.0		33.5	7,640	35.5	7,850	32.5	7,540	36.5	7,950
45	6.5		34.8	9,970	36.8	10,230	33.8	9,840	38.3	10,420
50	7.0		36.1	12,650	38.6	13,050	35.2	12,500	39.6	13,210
55	7.5		37.5	15,700	39.9	16,180	36.5	15,510	41.4	16,470
Class 5		19.0								
35	6.0		29.0	4,940	31.0	5,080	28.5	4,900	32.0	5,160
40	6.0		31.0	6,990	33.0	7,190	30.0	6,890	34.0	7,290
45	6.5		32.3	9,130	34.3	9,390	31.3	9,000	35.8	9,580
50	7.0		33.7	11,600	35.6	11,920	32.7	11,450	37.1	12,160
Class 6		17.0								
35	6.0		27.0	4,500	28.5	4,610	26.5	4,460	30.0	4,720
40	6.0		28.5	6,330	30.5	6,530	28.0	6,280	31.5	6,630
45	6.5		29.8	8,290	31.8	8,540	28.8	8,160	32.8	8,670

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

TABLE 9
NESC Light Loading District/Grade B Construction

Loading: Light
Grade: B

Length (ft)	G_L (ft)	C_T (in)	Southern Yellow Pine & Douglas Fir C_{GL} (in)	Southern Yellow Pine & Douglas Fir M_{WP} (ft-lb)	Lodgepole Pine & Red Pine C_{GL} (in)	Lodgepole Pine & Red Pine M_{WP} (ft-lb)	Western Larch C_{GL} (in)	Western Larch M_{WP} (ft-lb)	Western Red Cedar C_{GL} (in)	Western Red Cedar M_{WP} (ft-lb)
Class 1		27.0								
35	6.0		39.0	7,780	41.5	7,990	38.0	7,700	42.5	8,080
40	6.0		41.0	10,930	44.0	11,270	40.0	10,810	45.0	11,390
45	6.5		42.8	14,280	45.8	14,710	41.8	14,130	47.2	14,930
50	7.0		44.6	18,140	47.5	18,680	43.6	17,960	49.0	18,950
55	7.5		45.9	22,430	48.8	23,080	44.9	22,210	50.8	23,510
Class 2		25.0								
35	6.0		36.5	7,240	38.5	7,410	35.5	7,160	40.0	7,530
40	6.0		38.5	10,180	41.0	10,470	37.5	10,070	42.5	10,640
45	6.5		40.3	13,320	42.8	13,680	39.3	13,170	44.3	13,900
50	7.0		41.6	16,850	44.5	17,390	40.6	16,680	46.0	17,660
55	7.5		42.9	20,860	45.8	21,520	42.0	20,640	47.8	21,950
Class 3		23.0								
35	6.0		34.0	6,700	36.0	6,860	33.0	6,610	37.5	6,990
40	6.0		36.0	9,430	38.0	9,660	35.0	9,320	39.5	9,840
45	6.5		37.3	12,290	39.8	12,650	36.8	12,220	41.3	12,870
50	7.0		38.6	15,570	41.6	16,110	38.1	15,480	43.0	16,380
55	7.5		40.0	19,300	42.9	19,950	39.5	19,190	44.3	20,280
Class 4		21.0								
35	6.0		31.5	6,150	33.5	6,320	31.0	6,110	34.5	6,400
40	6.0		33.5	8,690	35.5	8,920	32.5	8,570	36.5	9,030
45	6.5		34.8	11,330	36.8	11,620	33.8	11,190	38.3	11,840
50	7.0		36.1	14,380	38.6	14,830	35.2	14,200	39.6	15,010
55	7.5		37.5	17,840	39.9	18,390	36.5	17,630	41.4	18,710
Class 5		19.0								
35	6.0		29.0	5,610	31.0	5,780	28.5	5,570	32.0	5,860
40	6.0		31.0	7,940	33.0	8,170	30.0	7,820	34.0	8,280
45	6.5		32.3	10,370	34.3	10,670	31.3	10,230	35.8	10,880
50	7.0		33.7	13,180	35.6	13,540	32.7	13,010	37.1	13,810
Class 6		17.0								
35	6.0		27.0	5,110	28.5	5,230	26.5	5,070	30.0	5,360
40	6.0		28.5	7,190	30.5	7,420	28.0	7,130	31.5	7,540
45	6.5		29.8	9,420	31.8	9,710	28.8	9,270	32.8	9,850

G_L = Distance from bottom of pole to ground line (ft)
C_T = Circumference of pole at top (inches)
C_{GL} = Circumference of pole at ground line (inches)
M_{WP} = Ground line moment induced by wind on pole (ft-lbs)

EXHIBIT B
PERMITTED[4] MOMENTS AT GROUND LINE OF WOOD POLES

TABLE 10
NESC Grade C Construction

Grade: C

		Southern Yellow Pine & Douglas Fir	Lodgepole Pine & Red Pine	Western Larch	Western Red Cedar
DFS =		**8,000**	**6,600**	**8,400**	**6,000**
Length (ft)	**G_L** (ft)	**$M_{R\text{-}GL}$** (ft-lb)	**$M_{R\text{-}GL}$** (ft-lb)	**$M_{R\text{-}GL}$** (ft-lb)	**$M_{R\text{-}GL}$** (ft-lb)
Class 1					
35	6.0	106,500	105,900	103,500	103,400
40	6.0	123,800	126,200	120,700	122,700
45	6.5	140,700	141,900	137,800	142,000
50	7.0	159,200	159,000	156,400	158,300
55	7.5	173,700	172,300	171,100	176,000
Class 2					
35	6.0	87,300	84,600	84,400	86,200
40	6.0	102,500	102,100	99,500	103,400
45	6.5	117,600	115,900	114,600	116,700
50	7.0	129,400	131,000	126,500	131,200
55	7.5	142,100	142,700	139,300	146,900
Class 3					
35	6.0	70,600	69,100	67,800	71,100
40	6.0	83,800	81,300	80,900	83,000
45	6.5	93,300	93,300	94,100	94,600
50	7.0	103,600	106,400	104,700	107,400
55	7.5	114,600	116,800	116,000	117,300
Class 4					
35	6.0	56,200	55,700	56,200	55,300
40	6.0	67,500	66,300	64,800	65,500
45	6.5	75,800	73,800	73,100	75,500
50	7.0	84,800	85,200	82,100	83,500
55	7.5	94,600	94,100	91,800	95,300
Class 5					
35	6.0	43,800	44,200	43,700	44,200
40	6.0	53,500	53,300	50,900	53,000
45	6.5	60,700	59,800	58,100	61,700
50	7.0	68,500	66,900	65,800	68,700
Class 6					
35	6.0	35,400	34,300	35,100	36,400
40	6.0	41,600	42,100	41,400	42,100
45	6.5	47,700	47,700	45,300	47,500

G_L = Distance from bottom of pole to ground line (ft)
$M_{R\text{-}GL}$ = Resistive moment of pole at ground line (ft-lb)
DFS = Designated fiber stress of poles (lb/in^2)

[4] "Permitted" means strength factor of NESC Table 261-1 has been factored in values of **$M_{R\text{-}GL}$**

TABLE 11
NESC Grade C Construction—Crossing Spans

Grade: CX

Length (ft)	G_L (ft)	Southern Yellow Pine & Douglas Fir, DFS = 8,000: $M_{R\text{-}GL}$ (ft-lb)	Lodgepole Pine & Red Pine, DFS = 6,600: $M_{R\text{-}GL}$ (ft-lb)	Western Larch, DFS = 8,400: $M_{R\text{-}GL}$ (ft-lb)	Western Red Cedar, DFS = 6,000: $M_{R\text{-}GL}$ (ft-lb)
Class 1					
35	6.0	106,500	105,900	103,500	103,400
40	6.0	123,800	126,200	120,700	122,700
45	6.5	140,700	141,900	137,800	142,000
50	7.0	159,200	159,000	156,400	158,300
55	7.5	173,700	172,300	171,100	176,000
Class 2					
35	6.0	87,300	84,600	84,400	86,200
40	6.0	102,500	102,100	99,500	103,400
45	6.5	117,600	115,900	114,600	116,700
50	7.0	129,400	131,000	126,500	131,200
55	7.5	142,100	142,700	139,300	146,900
Class 3					
35	6.0	70,600	69,100	67,800	71,100
40	6.0	83,800	81,300	80,900	83,000
45	6.5	93,300	93,300	94,100	94,600
50	7.0	103,600	106,400	104,700	107,400
55	7.5	114,600	116,800	116,000	117,300
Class 4					
35	6.0	56,200	55,700	56,200	55,300
40	6.0	67,500	66,300	64,800	65,500
45	6.5	75,800	73,800	73,100	75,500
50	7.0	84,800	85,200	82,100	83,500
55	7.5	94,600	94,100	91,800	95,300
Class 5					
35	6.0	43,800	44,200	43,700	44,200
40	6.0	53,500	53,300	50,900	53,000
45	6.5	60,700	59,800	58,100	61,700
50	7.0	68,500	66,900	65,800	68,700
Class 6					
35	6.0	35,400	34,300	35,100	36,400
40	6.0	41,600	42,100	41,400	42,100
45	6.5	47,700	47,700	45,300	47,500

G_L = Distance from bottom of pole to ground line (ft)
$M_{R\text{-}GL}$ = Resistive moment of pole at ground line (ft-lb)
DFS = Designated fiber stress of poles (lb/in^2)

TABLE 12
NESC Grade B Construction

Grade: B

Length (ft)	G_L (ft)	Southern Yellow Pine & Douglas Fir	Lodgepole Pine & Red Pine	Western Larch	Western Red Cedar
	DFS =	8,000	6,600	8,400	6,000
		M_{R-GL} (ft-lb)	M_{R-GL} (ft-lb)	M_{R-GL} (ft-lb)	M_{R-GL} (ft-lb)
Class 1					
35	6.0	81,500	81,000	79,100	79,100
40	6.0	94,700	96,500	92,300	93,900
45	6.5	107,600	108,500	105,400	108,600
50	7.0	121,800	121,600	119,600	121,100
55	7.5	132,800	131,800	130,800	134,600
Class 2					
35	6.0	66,800	64,700	64,500	65,900
40	6.0	78,400	78,100	76,100	79,100
45	6.5	89,900	88,700	87,600	89,300
50	7.0	99,000	100,200	96,800	100,300
55	7.5	108,700	109,200	106,600	112,400
Class 3					
35	6.0	54,000	52,900	51,900	54,300
40	6.0	64,100	62,200	61,900	63,500
45	6.5	71,400	71,400	72,000	72,400
50	7.0	79,200	81,400	80,100	82,100
55	7.5	87,700	89,300	88,700	89,700
Class 4					
35	6.0	43,000	42,600	43,000	42,300
40	6.0	51,700	50,700	49,500	50,100
45	6.5	58,000	56,500	55,900	57,800
50	7.0	64,900	65,100	62,800	63,800
55	7.5	72,300	72,000	70,200	72,900
Class 5					
35	6.0	33,500	33,800	33,400	33,800
40	6.0	40,900	40,800	39,000	40,500
45	6.5	46,400	45,800	44,400	47,200
50	7.0	52,400	51,200	50,400	52,500
Class 6					
35	6.0	27,100	26,300	26,900	27,800
40	6.0	31,800	32,200	31,700	32,200
45	6.5	36,500	36,500	34,600	36,400

G_L = Distance from bottom of pole to ground line (ft)
M_{R-GL} = Resistive moment of pole at ground line (ft-lb)
DFS = Designated fiber stress of poles (lb/in^2)