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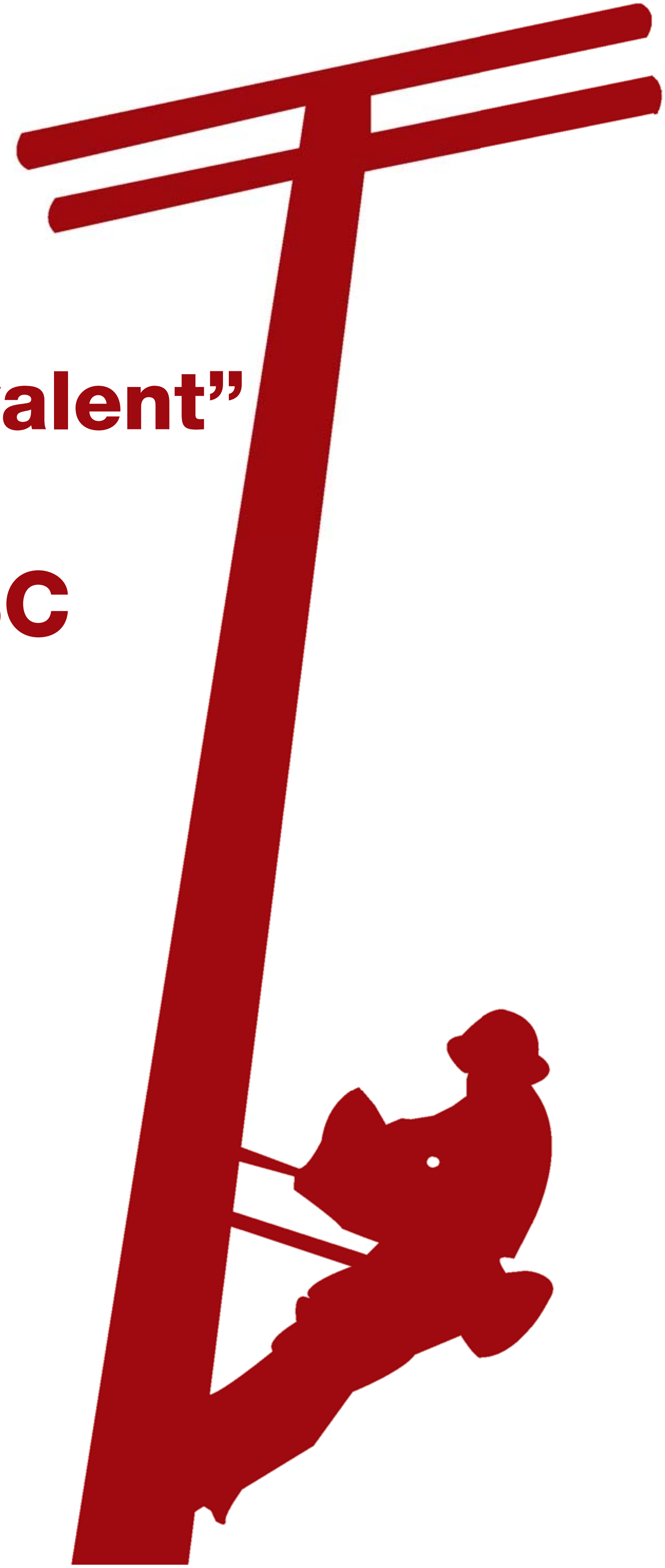

“Wood Equivalent” Utility Poles and the NESC

Prepared by:

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About NAWPC

The North American Wood Pole Council (NAWPC) is a federation of three organizations representing the wood preserving industry in the U.S. and Canada. These organizations provide a variety of services to support the use of preservative-treated wood poles to carry power and communications to consumers.

The three organization are:

Western Wood Preservers Institute
With headquarters in Vancouver, Wash., WWPI is a non-profit trade association founded in 1947. WWPI serves the interests of the preserved wood industry in the 16 western states, Alberta, British Columbia and Mexico so that renewable resources exposed to the elements can maintain favorable use in aquatic, building, commercial and utility applications. WWPI works with federal, state and local agencies, as well as designers, contractors, utilities and other users over the entire preserved wood life cycle, ensuring that these products are used in a safe, responsible and environmentally friendly manner.

Southern Pressure Treaters' Association
SPTA was chartered in New Orleans in 1954 and its members supply vital wood components for America's infrastructure. These include pressure treated wood poles and wood crossarms, and pressure treated timber piles, which continue to be the mainstay of foundation systems for manufacturing plants, airports, commercial buildings, processing facilities, homes, piers, wharfs, bulkheads or simple boat docks. The membership of SPTA is composed of producers of industrial treated wood products, suppliers of AWPA-approved industrial preservatives and preservative components, distributors, engineers, manufacturers, academia, inspection agencies and producers of untreated wood products.

Wood Preservation Canada
WPC is the industry association that represents the treated wood industry in Canada. WPC operates under Federal Charter and serves as a forum for those concerned with all phases of the pressure treated wood industry, including research, production, handling, use and the environment. WPC is dedicated to promoting and supporting a stronger Canadian wood treating industry; informing the public on the benefits to be gained from the use of quality wood products; and preserving the integrity of the environment through the promotion of responsible stewardship of our resources.

“Wood Equivalent” Utility Poles and the National Electrical Safety Code (NESC)

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Introduction

This document is an update of the original discussion document prepared in 2003 and reflects relevant changes made in the National Electrical Safety Code (NESC)[3] through the current 2017 edition.

Utility poles constructed of materials other than wood are now being aggressively marketed for use in distribution applications. Although steel and prestressed concrete poles have been used for many years for transmission applications, these products are now being used on a broader basis in distribution pole applications.

Whereas it is common practice to design transmission structures individually, distribution line designs have typically been based on a range of standard pole sizes. This allows for poles to be inventoried and allows repair and new construction to proceed without the delays inherent in a custom design and fabrication scenario.

Historically, virtually all distribution poles were wood and wood poles have been manufactured to distinct class sizes established by the American National Standards Institute (ANSI) specification for wood poles, presently known as ANSI O5.1.[1] Wood pole classes are designated by numerals such as Class 3 or Class 4, with the class numeral being associated with a specified horizontal load capacity. Lower numerals indicate a higher strength and each succeeding class goes up in strength by approximately 25 percent.

The most common distribution pole classes are Class 5, Class 4 and Class 3, which have horizontal load capacities of 1,900 pounds, 2,400 pounds, and 3,000 pounds, respectively.

In order to improve market acceptance, non-wood distribution poles have been marketed as “wood equivalent” pole classes. Because the NESC applies different strength and load factors to poles of different materials under different controlling design conditions, there can be no true “wood equivalent” pole.

A non-wood distribution pole, for instance, designed for equivalence to meet the requirements of NESC Grade B under a transverse wind load condition, will not be equivalent under the requirements of NESC Grade C, which controls the safety of most distribution pole designs.

Most non-wood distribution poles are manufactured for “equivalence” based on NESC Rule 250B Grade B Transverse Wind Load design situations. Yet most distribution lines are subject to the provisions of NESC Grade C, creating confusion in the field concerning how to utilize these poles in Grade C designs based on wood.

Changes in NESC

The “wood equivalent” pole has been the subject of discussion in several earlier documents.[2 4 5] A number of changes have been made in the NESC since these documents were prepared.

One important change was the addition of a new load case, Extreme Ice with Concurrent Wind, as Rule 250D in the 2007 version of the NESC. Starting with the 2002 version of the NESC, poles of all materials have the same load factors for transverse wind loads. However, the load factors for other loading conditions may vary from wood to other materials.

The strength factors for wood change with the grade of construction. For example, a non-wood pole designed to be equivalent under transverse wind load in accordance with Grade B Rule 250B is not a “wood equivalent” pole under Grade C Rule 250B, or under Rule 250C Extreme Wind, or under Rule 250D Extreme Ice with Concurrent Wind load conditions.

There are 14 different load conditions for which the NESC provides load factors and strength factors. In many cases the load and strength factors vary between wood and non-wood materials, and the ratio of the combination of the two values represents the "wood equivalent" design condition for non-wood materials.

Load, Strength Factors

Table 1 presents the load factors and strength factors for the Transverse Load Condition and Table 2 presents the load and strength factors for the Other Load Conditions. An examination of these tables reveals there are five different ratios of required non-wood design strength relative to the wood design strength.

It's important to note in some cases the controlling design is transverse load, while in others, it may be another load condition such as vertical loading.

A non-wood pole designed to be "wood equivalent" under a transverse load would not be a "wood equivalent" pole if vertical loading was the controlling criteria.

For example, even though the relative strength ratio in Table 1 is 0.65 for the transverse load condition of Grade B Rule 250B, Combined Ice and Wind Load, and it is also 0.65 in Table 2 for Grade B, Vertical Load, the "wood equivalent" pole would not be the same in each case.

In the first case, the non-wood pole would have to be designed to 65 percent of the ANSI wood pole transverse strength. In the second case, the non-wood design would have to be to 65 percent of the column loading strength of the ANSI wood pole. These are not the same design point, and the effect would be different depending upon the non-wood material used for the pole.

In other words, the relative transverse load strength vs. column loading strength of poles varies by material and method of construction. A thin-walled steel pole, a prestressed concrete pole, a fiber-reinforced polymer pole and a wood pole all designed to have the same transverse load capacity may have markedly different column loading capacities.

Transverse Loads

Some pole designers and users feel it is counterintuitive that a "wood equivalent" steel, prestressed concrete or fiber-reinforced polymer pole designed for transverse load equivalence in Grade B, which is the more conservative design condition, cannot be used as a substitute for wood in a Grade C design based on wood. The reason is that wood is penalized in Grade B designs because of its perceived higher variability of strength.

That is why the wood strength factor is only 0.65 in Grade B designs. However, in Grade C, the wood strength factor is 0.85 and under Rule 250C Extreme

Table 1

	Transverse Load Conditions								
	Extreme Ice with Concurrent Wind Rule 250D		*Extreme Wind Rule 250C*		*Grade B Combined Ice & Wind Rule 250B*	*Grade C Combined Ice & Wind At Crossings Rule 250B*	*Grade C Combined Ice & Wind Elsewhere Rule 250B*	*Wire Tension Grade B*	*Wire Tension Grade C*
	Grade B	*Grade C*	*Grade B*	*Grade C*					
Wood Load Factor (Table 253-1)	1.0	1.0	1.0	0.87	2.5	2.2	1.75	1.65	1.3
Wood Strength Factor (Table 261-1)	0.75	0.75	0.75	0.75	0.65	0.85	0.85	0.65	0.85
Steel, Concrete & Fiber-Reinforced Polymer Load Factor (Table 253-1)	1.0	1.0	1.0	0.87	2.5	2.2	1.75	1.65	1.1
Steel, Prestressed Concrete & Fiber-Reinforced Polymer Strength Factor (Table 261-1)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ratio of Required Steel, Prestressed Concrete & Fiber-Reinforced Polymer Strength to ANSI Wood Pole Strength	0.75	0.75	0.75	0.75	0.65	0.85	0.85	0.65	0.72

Table 2

	Other Load Conditions				
	Vertical Load Grade B	*Vertical Load Grade C*	*Longitudinal Load Grade B In General*	*Longitudinal Load Grade B At Dead Ends*	*Longitudinal Load Grade C At Dead Ends*
Wood Load Factor (Table 253-1)	1.5	1.9	1.1	1.65	1.3
Wood Strength Factor (Table 261-1)	0.65	0.85	0.65	0.65	0.85
Steel, Concrete & Fiber-Reinforced Polymer Load Factor (Table 253-1)	1.5	1.5	1.1	1.65	1.1
Steel, Prestressed Concrete & Fiber-Reinforced Polymer Strength Factor (Table 261-1)	1.0	1.0	1.0	1.0	1.0
Ratio of Required Steel, Prestressed Concrete & Fiber-Reinforced Polymer Strength to ANSI Wood Pole Strength	0.65	0.67	0.65	0.65	0.72

Wind and Rule 250D Extreme Ice with Concurrent Wind, the strength factor is 0.75.

Therefore, a "wood equivalent" pole of steel, prestressed concrete or fiber-reinforced composite would have to be designed to 85 percent of the ANSI O5.1 wood pole transverse strength to be suitable for substitution for wood in a transverse load Grade C design and 75 percent of the ANSI strength in a situation controlled by Rule 250C or Rule 250D.

Most non-wood distribution poles are designed to 65 percent of the ANSI transverse strength. Therefore, it should be clear those poles could not be substituted for wood poles of the same numerical class in NESC Grade C or Rule 250C or Rule 250D transverse load situations.

Flawed Concept

Under each of the potentially controlling design conditions shown in Tables 1 and 2, a different "wood equivalent" pole may be required. For these reasons, the concept of a "wood equivalent" pole is fundamentally flawed.

It is imperative that users of non-wood poles employ them in accordance with the requirements of the NESC. Failure to meet the requirements of the NESC could have serious consequences.

However, many non-wood distribution pole manufacturers only produce "wood equivalent" poles that are manufactured to be equivalent in an NESC Grade B Rule 250B Transverse Wind Load design. This creates potential problems in misapplication of the product, because NESC Grade C Rule 250B, or Rule 250C, or Rule 250D are the criteria applicable to most utility structures.

In order to employ a non-wood "wood equivalent" distribution pole designed for equivalency under Rule 250B Grade B transverse load conditions in a Rule 250B Grade C wood pole line, the engineer must determine which "wood equivalent" pole class is required.

Design Example

As an example, consider a simple tangent structure wood distribution line designed to utilize an ANSI O5.1 Class 4 pole 40 feet in length. The transverse load capacity of the wood Class 4 pole is 2,400 pounds applied at a location 2 feet from the tip.

Using the typical 6-foot setting depth, the transverse load moment capacity at the ground line is 76,800 foot-pounds. Applying the NESC Grade C strength factor of 0.85 results in a moment capacity of 65,280 foot-pounds.

The non-wood pole is typically designed to 65 percent of the ANSI transverse load capacity (Grade B), so the moment capacity of a Grade B "wood equivalent" Class 4 pole is only 49,920 foot-pounds. That is based on a transverse load capacity of 65 percent of 2,400 pounds times the non-wood strength factor of 1.0 times the same 32-foot moment arm.

A Class 3 wood pole has a horizontal load capacity of 3,000 pounds, while a Class 2 has a capacity of 3,700 pounds. Using the methodology explained previously, the non-wood "wood equivalent" Class 3 has a moment capacity of 62,400 foot-pounds, still less than the required 65,280 foot-pounds.

The Class 2 "wood equivalent" non-wood pole would have a moment capacity of 76,960 foot-pounds, comfortably above the required 65,280 foot pounds.

Therefore, a "wood equivalent" non-wood pole two classes higher in strength – a "wood equivalent" Class 2 – would be required as a substitute for a wood Class 4 pole in a Rule 250B Grade C line design.

From this example it should be clear that a non-wood distribution pole manufactured to be a "wood equivalent" pole under an NESC Grade B Transverse Wind Load cannot be used as a direct substitute for wood in a Grade C Transverse Wind Load situation, which governs most distribution pole installations.

Use of the Grade B "wood equivalent" pole in anything other than an installation governed by transverse wind loads under Grade B Rule 250B may result in conditions not in compliance with the NESC.

Summary

It is clear there can be no universally applicable "wood equivalent" pole made from steel, prestressed concrete, fiber-reinforced polymer, or other non-wood material.

Such "equivalence" is not possible due to: the differences in relative strengths inherent in poles manufactured of different materials by different methods; the many different permutations of possible controlling load configurations in the NESC; and the different load and strength factors assigned to different materials under different load conditions in the NESC.

The corollary to this statement is equally true: a wood pole cannot be used as a replacement for a steel or prestressed concrete pole without a thorough evaluation of all of the design loads and the proper application of the appropriate load and strength factors for wood.

The line design engineer or utility company must have a complete understanding of the basis for the "wood equivalent" pole design. Failure to understand this can lead to misapplication of the product in situations for which it was not designed, resulting in construction not meeting the NESC minimum requirements.

Since there may be statutory or regulatory provisions requiring utility construction to meet the minimum standards, there could be substantial risk associated with any failure to fully comply with the code requirements.

The line designer does not need to use the "wood equivalent" pole concept in order to effectively utilize non-wood poles. Using the actual design strength and the appropriate load and strength factors for the material of construction, under the controlling load condition and grade of construction specified in the NESC, will ensure the design will meet the code requirements.

To use the "wood equivalent" pole concept in a line designed for wood under Grade C Rule 250B transverse load conditions, with the non-wood poles designed for equivalency in Grade B, Rule 250B, the designer may be required to use non-wood poles two "wood equivalent" pole classes stronger in order to meet the requirements of the NESC.

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