ANSI Pole Standards: Development and Maintenance

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Abstract

This paper provides an overview of the standards activity of the American National Standards Institute 05 Committee on Wood Poles. Its primary focus is the ANSI 05.1 standard for round poles. The factors addressed by this standard are summarized, and the standard is compared to other standards related to the production and structural use of round timbers.

Introduction

Pole production statistics, obtained through personal communication with a number of pole producers and treaters as well as from a recent American Wood-Preservers' Association (AWPA) publication (12), show that 73.5 million feet (3) of wood were treated in the form of round timber poles in 1990. This production is roughly equivalent to 3.7 million poles. To minimize the communication problems inherent in a market this large, the industry needs to maintain a product standard that addresses issues of importance to consumers as well as producers.

The American National Standards Institute (ANSI) publishes such a standard: ANSI 05.1, Wood Poles, Specifications, and Dimensions (2). Members of ANSI Committee 05 periodically review and update this standard. ANSI requires that committee membership represent a balance of pole users, producers, and interested consumers to assure that controversial issues are addressed and problems are resolved to the mutual satisfaction of all voting interests.

The objective of this paper is to discuss the role that standards play in the production and use of round timber poles. While the paper provides a review of other pole-related standards, it places special emphasis on the role of the ANSI 05.1 wood pole standard specifications. Discussion of topics covered by the ANSI 05.1 standard provides insight to variables considered in the design, production, and use of utility poles and gives the reader some perspective on the influence of this standard. Finally, other pole-related ANSI standards are briefly summarized to show the scope of the ANSI 05 Committee (3,4).

Wood pole standards

Standards written specifically for the structural applications of poles include those currently maintained by ANSI (1-4), ASTM (6-9), the American Society of Agricultural Engineers (ASAE) (5), and the Rural Electrification Administration (REA) (11). The ASAE and REA standards reference ANSI and/or ASTM as the basis for selection and assignment of allowable stresses to wood poles. The ASTM standard provides a method for deriving allowable stresses for construction poles on the basis of clear wood strength. The ASTM standard also provides specifications for poles to be used in structural applications such as round timber piles, piers, and building construction. The ANSI standard for wood poles applies to transmission and distribution line applications.

ASTM Standards

ASTM has three standards related to wood poles. The main standard for poles, designated D 3200 (6), refers to two other standards: D25, Specifications for Round Timber Piles (9), and D2899, Establishing Design Stresses for Round Timber Piles (7). Specifications for round timber piles also apply to poles with the exception that poles are selected on the basis of butt circumference, whereas the table in D25 is set up to specify a minimum tip circumference for piles. Standard D3200 provides a table of minimum butt circumferences for a specified tip.

Standard D2899 provides equations for deriving design stresses for poles or piles on the basis of clear wood strength and material variability.

REA Standards

The REA Specifications for Wood Poles, Stubs, and Anchor Logs (11) describes the minimum acceptable quality of poles purchased by REA borrowers. Material requirements designated by this standard are extracted from the ANSI 05.1 standard. The primary differences between this standard and the ANSI standard are the pole framing details and the designation of treating time and temperatures.

ASAE Standards

The ASAE standard, EP388 (5), references both ANSI 05.1 and ASTM. Material manufacturing and pole dimension requirements reference the ANSI standard, and the derivation of design stresses follows recommendations of ASTM. The ASAE standard provides a basis for specifying and using poles in agricultural pole-frame buildings.

ANSI 05.1 Standards

The Wood Pole Committee 05 of ANSI, originally organized in 1924, is now sponsored by the Exchange Carriers Standards Association (ECSA). This committee consists of about 30 voting members, representing users, producers, and general interest groups. It currently maintains three standards of interest to the utility pole industry:

- 05.1 Wood Poles, Specifications and Dimensions
- 05.2 Structural Glued Laminated Timber for Utility Structures
- 05.3 Solid Sawn Wood Crossarms and Braces

The Wood Pole Committee meets annually, generally in April, to resolve questions of interpretation and to address any new issues. Discussion items are generally referred to one of five subcommittees (material requirements, fiber stress, classification, crossarms, and glulam).

The ANSI 05.1 standard covers the specifications and dimensions for untreated poles loaded as simple cantilevers subject to transverse load only. Specifications for preservative treatment of wood utility poles are to be given by the purchaser on the basis of requirements detailed in other standards (AWPA C4 (10) or ASTM D4064 (9)). The ANSI 05.1 standard includes requirements related to species, acceptance criteria, manufacturing requirements, length and class, and code marking.

Pole species

The ANSI 05.1 standard lists 25 species considered to have the physical and mechanical properties appropriate for use as poles. For each of these species, fiber stresses and pole size and shape values are given. Of the species listed, however, four have been dropped from the AWPA C4 (10) standard for preservative treatment of poles because they are seldom used; six other species are noted by the ANSI 05.1 standard as not commonly used. As shown in Figure 1, six of the remaining 15 species account for roughly 90 percent of poles produced and used in the United States. These six species include the four species of southern pine that are grouped and marketed together, Douglas-fir, and western redcedar. Surveys taken over the past 10 years show that southern pine is by far the most widely used pole species in the United States. Of an estimated 3.7 million poles produced in the United States in 1990, ap-

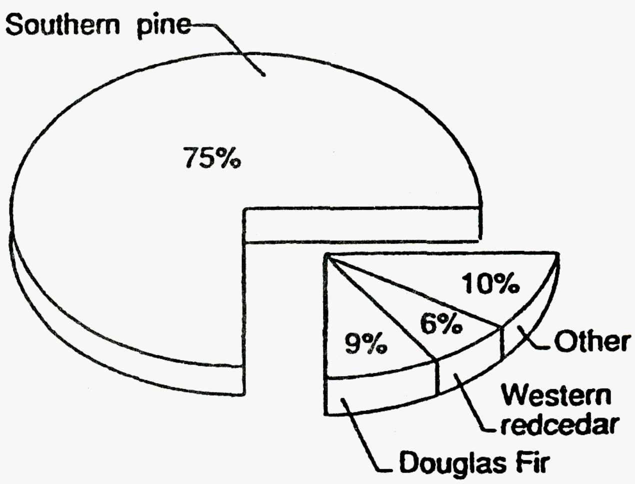

Figure 1. – *U.S. pole production by species. Figure based on AWPA treating plant survey by Mickle-Wright (11).*

proximately 75 percent were southern pine, 9 percent were Douglas fir, and 6 percent were western redcedar. The species designated “other” in Figure 1 include a mix of pines, spruce, larch, and hemlock. The large number of southern pine poles is due in part to extensive use of smaller southern pine poles in distribution classes. Considering only the transmission (class H) poles, Douglas-fir and western redcedar would make up a much larger percentage of the total.

The most important consideration in species use for poles is availability. Availability means more than just the number of trees that are currently growing. To be used as a pole, the trees must have certain growth characteristics such as appropriate size, straightness, few large branches, and generally straight grain. Many of these properties are determined by the environment in which the tree grows rather than by genetics. Trees grown in tight stands normally grow straight and tall with few large branches as a result of the competition for sunlight. Softwoods do much better at growing in tight single-species stands than do hardwoods, and thus are likely to yield a higher percentage of “pole trees” in a given stand. In addition, few hardwood poles are used because many of the better hardwoods, which have large-diameter straight trunks, command a higher price for veneer or lumber than they do for poles.

Acceptance criteria

The ANSI specification provides criteria for pole acceptance in four basic categories: pole shape, growth characteristics, naturally occurring defects, and processing defects. Unlike many other wood products, ANSI gives only one stress grade for poles. To qualify for the ANSI 05 designated stress classification, all poles must meet the minimum set of acceptance criteria.

Pole shape considerations include pole sweep and crook (Fig. 2). For sweep in one plane and one direction, sweep is limited to 1 inch from a straight line for every 10 feet of length surveyed. For short poles ($\leq$ 50 ft.), 10 percent of poles in a given lot may have a sweep deviation from a straight line of 1 inch in 6 feet. For long poles (>55 ft.), 25 percent of the poles in a given lot may have the straight 1 inch in 6 feet of sweep. For sweep in two directions and one plane (reverse sweep) or two planes (double sweep), a straight line joining the center of the pole at the groundline with the center of the top shall not pass through the outer surface of the pole at any intermediate point.

Naturally occurring growth characteristics include knots, slope of grain, rate of growth, and compression wood. Knot and slope of grain limits are shown in Figure 3. These limits vary with the pole length. Knots are classified as either single or clusters. The largest single knot allowed depends on pole length and knot location. Knot diameter limits in the lower half of the pole are more restrictive: 3 inches instead of 5 inches for poles up to 45 feet long (2 in. instead of 4 in. if the pole is in classes 4 through 10) and 4 inches instead of 6 inches for poles 50 feet long. When knots occur in a cluster, the sum of individual knots >1/2 inch in diameter, within any 1-foot length, is limited to between 8 and 12 inches for poles <45 feet long, or between 10 and 14 inches for poles >50 feet long. Between these limits, the sum-of-knots limit is determined as one-third the average pole diameter at the cluster location ($d_x/3$), as shown in Figure 3. Spiral grain is limited to one complete revolution in 10, 16, or 20 feet for poles up to 30 feet, between 35 and 45 feet, or >50 feet long, respectively. Growth

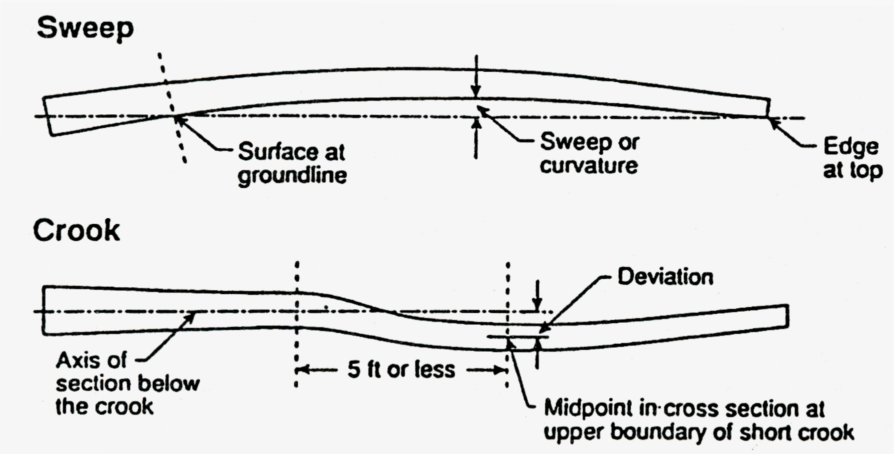

Figure 2. — ***Pole shape limitations.***

Pole length	D_L (in.)	D_u (in.)	Σ knots in 1'	Spiral length (ft)
≤ 30'	3	5	Min(12, Max(dx/3, 8))	10
≤ 45'				16
≥ 50'	4	6	Min(14, Max(dx/3, 10))	20

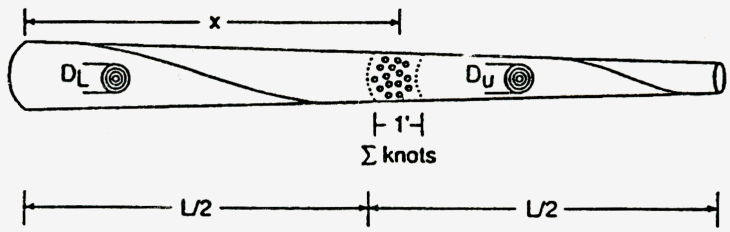

Figure 3. – ***Pole knot and spiral grain limitations.***

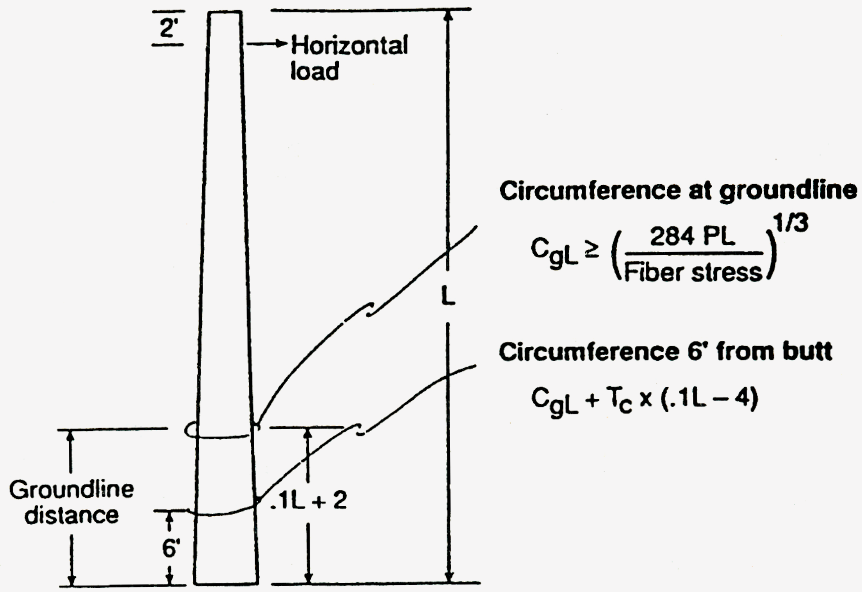

Figure 4. – *ANSI pole design analog. Load (P) applied 2 feet from top is used to estimate required pole circumference at the groundline (0.1L + 2 ft.). This value plus circumference taper (T_c) multiplied by distance from the groundline to 6 feet from butt gives tabulated circumference values.*

rate must be at least six rings per inch in the outer 2- or 3-inch of the pole diameter for average growth and four rings per inch if the growth rings are 50 percent latewood. Compression wood is not permitted in the outer 1-inch of the pole diameter as viewed from either end.

Naturally occurring defects include bark inclusions, insect and decay damage, and shake. Any defects that significantly reduce the effective section properties in the outer 2- to 3-inch of the pole diameter could significantly affect pole bending strength and are therefore limited. Defects permitted by the ANSI standard include bark inclusions <2 inches deep, insect damage consisting of holes ≤1/16 inch in diameter, surface scoring or channeling, firm red heart not accompanied by decay, and hollowing in the butt (if less than 10% of the butt cross section) caused by splinter pulling when felling the tree. Shake is permitted within limits considered to have minimal impact on strength; however, if the shake occurs at the top of the pole, the 05.1 standard requires that the full length of the pole be treated to be acceptable. Decay is generally permitted only in very specific instances, such as hollow pith centers in poles to be treated as full length. Any holes, hollow portions, or dead streaks indicative of incipient decay are prohibited.

Processing defects include splits, checks, and mechanical damage caused by mishandling. Splits and checks are unavoidable consequences of drying round timbers. These defects rarely have a significant effect on the strength of the pole, but they do provide openings for decay and insect access to poorly treated heartwood. Splits can also cause problems for hardware connections. Generally, the ANSI 05.1 standard limits the length of splits to 12 inches when extended from the pole top and 24 inches when extended upward from the butt. Visible damage, such as 1/4-inch-deep indentations resulting from handling slings or forklift tines, indicates that the damage may be more than superficial surface scarring and is also limited by the ANSI 05.1 acceptance criteria. Surface cuts caused by a chain saw may be tolerated provided the section still meets the required circumference for the pole class.

Manufacturing requirements

Manufacturing requirements are established to prevent or minimize any strength loss during the tree-to-pole conversion process and to maximize effectiveness of subsequent preservative treatment to extend the expected service life. Aspects of the manufacturing process covered by ANSI include whole tree processing, conditioning, brand markings, and storage.

The whole-tree processing involves a number of steps that affect the grading and service life of the pole. Poles must be cut to length so that they can easily be measured and properly classified. Bark removal/shaving should remove all inner bark but leave sufficient sapwood to obtain the customers' minimum preservative penetration requirement. Finally, proper trimming of overgrown knots rising more than 1 inch from the surface and branch stubs facilitates handling.

Proper conditioning is important for both strength and handling. A properly dried pole is easier to handle, less expensive to ship, and less prone to decay problems. Wood exposed to high temperatures for extended periods, however, will lose strength. The ANSI 05.1 standard includes requirements of air seasoning, Boulton drying, and kiln-drying to maximize the benefits at minimal cost to pole strength. Conditioning methods involving high temperatures cannot be generically applied because of differences in the drying characteristics of different species. Species are therefore placed in treatment groups (Table 1) to accommodate these differences. Methods used to condition poles prior to treatment include air seasoning, Boulton drying, kiln-drying, and steam conditioning. The ANSI 05.1 limitations on the use of these methods are as follows:

Air seasoning is required for treatment group A and is permitted for all species except ponderosa pine. Presteaming or poststeaming is permitted for up to 4 hours at 240°F. For ponderosa pine with moisture content of <25 percent 2.5 inches from the surface, steaming may continue for 6 hours.

Boulton drying is to be used with treatment group B. This method should not exceed 220°F in any pretreatment process. After treatment, the poles may be steamed at temperatures $\leq$240°F for 4 hours.

Kiln-drying of poles is a topic of some controversy. Some kiln operators feel that poles should be able to tolerate faster drying by increasing dry-bulb temperatures, wet-bulb depression, and air flow. At present, dry-bulb temperatures are limited to 170°F for southern pine, ponderosa pine, red pine, jack pine, lodgepole pine, Douglas-fir, and western larch, and to 160°F for western redcedar.

At these temperatures, ANSI recommends that the wet-bulb depression not exceed 50°F. As an exception to this requirement, ANSI does permit higher temperatures (170°F < dry bulb $\leq$ 230°F) for southern pine, lodgepole pine, Douglas-fir, and western larches. For temperatures >200°F, however, wet-bulb depression is required to be $\leq$50°F. By using a higher temperature with a greater wet-bulb depression, the total time at the high temperature will be reduced, lessening the chance for high-temperature strength reduction.

Steam conditioning is used for treatment group C. This process should be kept below 245°F and

Table 1. – *ANSI species listed by treatment group along with their corresponding fiber stress value.*

Treatment group	Fiber stress	Circular taper
	(lb./in^2)	(in./ft.)
Group A		
Western redcedar	6000	0.38
Yellow cedar	7400	0.20
Jack pine	6600	0.30
Lodgepole pine	6600	0.30
Red pine	6600	0.30
Douglas-fir	8000	0.21
Group B		
Coastal Douglas-fir	8000	0.21
Western larch	8400	0.21
Group C (southern, loblolly, bayleaf, shortleaf, and slash pines)	8000	0.25

steaming time held to <17 hours for poles with a circumference of ≤37.5 inches at 6 feet from the butt. For a circumference of >37.5 inches at 6 feet from the butt, the steaming limit is 20 hours. When Douglas-fir and western larch poles are steam conditioned, ANSI limits temperatures to 240°F for ≤8 hours, provided initial moisture content does not exceed 25 percent.

Identification markings are used by utilities for maintenance and life-cycle cost records. The ANSI standard requires that these markings include suppliers code or trademark, plant and year of treatment, pole species and preservative used, and circumference class and length. In addition to this information, the standard requires that the poles be marked at a set distance from the butt to assure that the markings can be read easily after the pole is placed in service. Markings on poles ≤50 feet long must be located 10 feet ± 1 inch from the butt end. For poles >50 feet, the markings are located 14 feet ± 2 inches from the butt end.

Finally, to minimize turnaround time, pole suppliers will normally maintain an inventory of poles in the more popular sizes. Improperly stored poles may be subject to decay, insect damage, or mechanical damage. The ANSI standard specifies adequate structural support above ground and places limits on stack height to avoid these kinds of problems.

Pole classification

The ANSI 05.1 classification system is based on pole load capacity. This system treats all poles that meet the acceptance criteria as a single grade in which strength varies only with species. Poles are classified only by the size needed to meet preset load capacity requirements for the target pole class.

Fiber stresses listed by ANSI for domestic species vary from 4,000 to 8,400 lb./in.^{2} Table 1 lists the ANSI values for the more popular pole species. These fiber stress values approximate average pole strength, not a design value. In addition to being used to determine pole class sizes for each species, these values are intended to be used with recommendations included in the ANSI C2 standard (National Electric Safety Code (NESC)) for the design of utility pole structures. Table 2 lists the 15 ANSI pole classes along with their respective required load capacity, length range, and minimum tip circumference.

Minimum circumferences 6 feet from the butt listed in the ANSI 05.1 Standard are derived so that a given class pole will have the required groundline bending moment capacity, regardless of species. Designated loads for each pole class (Table 2), when applied perpendicular to the pole length, 2 feet from the top will give a groundline bending moment of approximately .9L. Dividing the bending moment by the ANSI fiber stress (Table 1) gives the required section modulus. Solving for circumference gives:

$$C_{.9L} = \frac{284\ FL}{\text{Fiber Stress}}$$

The ANSI minimum tip circumference measurement has been a topic of discussion because of some apparent ambiguity in the wording of the standards. The standard allows pole length to vary from 3 to 6 inches for poles with a nominal length <50 feet and 6 to 12 inches for nominal lengths >50 feet. The top dimension requirement applies at the "minimum length permitted." This means the minimum tip circumference for the pole class may be measured as far as 18 inches below the actual top of the pole. Between in-service drying and pole taper, the reduction in size from required minimum (measured in green condition) to actual tip circumference could be as much as 1.25 inches. Tip circumference is used as the basis for the design of utility hardware, which can easily tolerate an 0.5-inch variation in pole diameter, so this wording does not cause a design problem.

Table 2. – *ANSI classification of wood poles.*

Pole class	Horizontal load	Length range	Minimum tip circumference
	(lb.)	(ft.)	(in.)
H6	11,400	45 to 125	39
H5	10,000	45 to 125	37
H4	8,700	40 to 125	35
H3	7,500	40 to 125	33
H2	6,400	35 to 125	31
H1	5,400	35 to 125	29
1	4,500	35 to 125	27
2	3,700	20 to 125	25
3	3,000	20 to 90	23
4	2,400	20 to 70	21
5	1,900	20 to 50	19
6	1,500	20 to 45	17
7	1,200	20 to 35	15
9	740	20 to 30	15
10	370	20 to 25	12

Other ANSI wood pole standards

In addition to the standard specification on wood poles, the ANSI 05 committee is responsible for standards on glulam timber (05.2) and wood crossarms (05.3). The 05.2 standard covers requirements for manufacturing and quality control of structural glulam timber of Douglas-fir and southern pine for electric power and communication structures. The 05.3 standard comprises specifications for solid-sawn wood crossarms and braces made using either Douglas-fir or southern pine. This specification includes crossarm manufacturing, seasoning, quality limitations, treatment, marking, and storage. The ANSI committees are developing fiber stress values for both glulam timber and crossarms that will be added to both standards.

An ANSI 05 subcommittee has also been formed to study the possibilities for incorporating new nondestructive evaluation methods in the pole stress-grading process. The major difficulty for this subcommittee is to develop a standard nondestructive grading methodology that is compatible with established utility pole markets.

Concluding remarks

The ANSI 05.1 standard for wood pole specifications and dimensions is strictly voluntary. The intent of this document is to serve as a basis for communication between producers and users of utility poles. By addressing the concerns of both groups, this ANSI specification helps them optimize the production and use of utility poles. It does not, however, preclude anyone from producing, marketing, or using poles that do not conform to its recommendations.

This standard provides for classification of poles according to size and species. Each species is assigned a fiber stress on the basis of pole tests and analysis. The standard translates that strength into pole dimensions required to meet the load requirements of the 15 pole classes. Sections dealing with manufacturing and acceptance requirements are provided as a basis for communication between producers and buyers of utility poles.

The ANSI 05 committee welcomes any and all input pertinent to the activities of the 05.1 standard as well as their other standards on wood poles.

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