STANDARD SPECIFICATIONS FOR WOOD POLES

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Abstract

This paper describes the standards for wood poles prepared by the American National Standards Institute (ANSI) Committee 05 and the Committee's activities in maintaining the standards. The three standards form the basis for purchasing and designing most wood utility structures in the United States. The round pole standard, ANSI 05.1, includes specifications, dimensions, and fiber stress values for design. The other two standards, ANSI 05.2 and 05.3, also address important issues for specifying material properties and deriving fiber stress. The ANSI 05 Committee meets once a year to provide an open forum for discussing concerns related to these standards.

Introduction

Round timbers have been used as structural members for centuries. At the turn of the present century, the development of electric power distribution systems and telegraph and telephone communications prompted a great demand for poles. As more people became involved in converting trees to utility structures, a need arose for a common basis of understanding related to form and quality requirements of utility poles. Pole producers and users met to discuss concerns related to harvesting, processing, and designing pole structures and to reach some agreement on acceptable limits related to form and processing of utility poles. This discussion led to the formation of the American Standards Association Committee 05, which later became the American National Standards Institute (ANSI) Committee 05 as efforts were made to establish national standards. The product of this continuing effort is a nationally recognized standard that provides the basis for material specifications, classification, and engineering properties for wood utility poles. The ANSI 05 Committee provides a forum for pole producers and users that enables them to address changing market issues and maintain a needed supply of utility poles. This committee meets on an annual basis to review and update its standards.

The objective of this paper is to describe the standards for wood poles and other wood products used in utility structures as well as the ongoing activities of ANSI Committee 05 in maintaining the three standards for wood products used in utility structures. The paper reviews other pole-related standards, but it places special emphasis on the role of the ANSI 05.1 wood pole standard specifications. Discussion of topics covered by this standard provides insight to variables considered in the production and design of utility poles as well as some perspective on the influence of the standard.

Development of Wood Pole Standards

Standards written specifically for the structural applications of poles include those currently maintained by ANSI (2-5), the American Society for Testing and Materials (ASTM) (7-10), the American Society of Agricultural Engineers (ASAE) (6), and the Rural Electrification Administration (REA) (15). The ASAE and REA standards reference ANSI and / or ASTM as the basis for selecting and assigning allowable stresses to wood poles. The ASTM standard provides a method for deriving allowable stresses for round timbers used as construction poles, piles, and marine structures. The ANSI standard for wood poles applies to transmission and distribution-line applications.

History

Among the first nationally recognized standards for round timbers were ASTM standard 1915 Specifications for Round Timber Piles) and the American Standards Association (ASA) standard 05, 1924 (Wood Pole Specifications and Dimensions). These standards documented the characteristics that best defined "minimally acceptable" as it relates to pile and/or pole applications and laid the foundation for most current standards related to structural use of roundtimbers.

Engineering properties of wood poles (ANSI 05.1) and piles (ASTM D2899) are set as a function of species and are considered applicable to all poles that meet the minimum quality specifications. In 1941, the American Association of State Highway Officials assigned allowable bearing stresses for three primary species of timber piles: Southern Pine, Douglas-fir, and oak. Thirty years later, ASTM adopted standard procedures for deriving engineering properties for U.S. pole species (ASTM D2899). These procedures are similar to those used for stress-graded lumber, but they recognize no within-species quality gradations. Rated poles simply meet or exceed minimum quality specifications. At about the same time, the ASA also adopted engineering property values for poles on the basis of information from extensive tests (19,20), while recognizing established precedents. Additional data developed within the past 20 years have expanded the knowledge of pole strength and are being considered by the ANSI 05 Committee as a basis for developing a reliability-based load-resistance-factor design approach to the design of utility-pole structural systems (14,15).

Future Trends

The primary use of wood poles in the future will be in maintenance of existing transmission and distribution systems. The use of poles to support telephone and local utility distribution lines is slowly diminishing. In addition to expanding the practice of burying local distribution lines, telephone companies are expanding the use of high-frequency, electromagnetic wave technologies to transmit signals over long distances.

Over the past decade, pole production has remained steady at 3 million poles per year. It has been estimated that about 100 million poles are in use today. As new U.S. markets decline, future pole production will focus primarily on maintaining existing lines unless foreign markets are developed. Growing concern for more efficient use of the Nation's timber resources as well as the reliability of utility transmission and distribution systems is leading to a number of innovations that will affect the wood pole industry. Competing materials (steel, aluminum, concrete, and fiberglass) are being used in place of wood. There is also increased interest in extending the life of existing poles through careful inspection, in-place treatment, or repair. Techniques that can accurately determine the residual capacity of existing structures will be in high demand, and these same methods can be used to determine more accurately the properties of new poles, thus providing a basis for more efficient design and use through alternative methods of assigning engineering properties (13).

ANSI Wood Pole Specifications

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-treated wood utility poles are to be given by the purchaser on the basis of requirements detailed in other standards (i.e., AWPA C4 (12) or ASTM D4064 (9)).

The ANSI 05.1 standard includes requirements related to species, acceptance criteria, manufacturing requirements, length and class, and code marking. This standard lists 25 species native to the United States that are considered to exhibit the physical and mechanical properties appropriate for use as poles. Fiber stress values and pole size and shape values are given for each of these species. However, four species have been dropped from the AWPA C4 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. Six of the remaining 15 species account for 90% 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 (Fig. 1).

Surveys taken over the past 10 years have indicated that Southern Pine is by far the most widely used pole species in the United States (17). Of an estimated 3.7 million poles produced in the United States in 1990, 75% were Southern Pine, 9% 'Douglas-fir, and 6% western redcedar (Fig. 1). 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. In the larger transmission (class H) poles, Douglas-fir and western redcedar would make up a larger percentage of the total.

An important consideration in the use of different species for poles is availability. Availability means more than just the number of trees that are currently growing. To be used for poles, 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. Another factor that plays an important role in the acceptability of a species for structural pole applications is its ability to accept and retain chemical preservatives.

There are currently no provisions in the ANSI standards for specifying foreign species in pole classes. A task committee on foreign species within the ANSI 05 Committee developed a proposed set of requirements and procedures that were verbally approved at the Committee's 1997 meeting. This procedure is presently in the balloting process and, if approved, could become a mandatory appendix to ANSI 05.1. Proposed requirements include an evaluation of pole strength using the ASTM D1036 Static Test of Wood Poles (11) or an equivalent method. As the data are reviewed and species are approved, other species may be added to the ANSI 05.1 standard.

Grading

The ANSI specification provides criteria for pole acceptance in four basic categories: pole shape, growth characteristics, naturally occurring defects, and processing defects. Unlike the standards for many other wood products, only one stress-graded standard is provided 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). Sweep in one plane and one direction is limited to 1 inch from a straight line for every 10 A of length surveyed (see Table 1 for SI conversion factors). For short poles (²50 ft), 10% in a given lot may have a sweep deviation from a straight line of 1 inch in 6 ft; for long poles (≥55 ft), 25% in a given lot may have this sweep deviation. 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 groundline with the center of the top is not allowed to pass through the outer surface of the pole at any intermediate point.

Growth characteristics include knots, slope of grain, rate of growth, and compression wood. To set knot size limitations, poles are separated into length categories of ≤ 45 ft and ≥50 ft. Individual knot size limits also vary within a single pole. As one might expect, larger poles are permitted to have larger knots. What might not be quite so intuitive is the fact that a larger single knot is permitted in the upper half of the pole. Average wood strength and cross-section decrease with height in a tree. In the cantilever applications characteristic of most pole structures, the stress in the pole drops off more rapidly than the combined effects of wood strength and section property. With no change in section property, the stress at midheight would be expected to be half that at the groundline. Pole taper, however, is normally so small that at midheight the stress rarely exceeds 60% of that at the butt. If we assume a linear reduction in ultimate fiber stress to the point that tip fibers are half as strong as groundline fibers, midheight wood strength would be 75% of that at groundline. This suggests that at midheight, the pole strength / stress ratio is 25% greater than that at groundline.

For many pole species, knots occur in "clusters" or "whirls." For these cases, limits are set on the sum of diameters as measured perpendicular to the axis of the pole. The allowable sum of knots is calculated as one-third the average pole circumference at the cluster location, with the overriding limit that the circumference fall between 8 and 12 inches for poles ≤45 ft long and between 10 and 14 inches for poles ≥50 ft.

Spiral grain is limited to one complete revolution in 10, 16, or 20 ft for poles ≥30 ft, 35 to 45 ft, and ≥ 50 ft long, respectively. for average growth, the growth rate must be at least six rings per inch in the outer 2- or 3-inches of the pole diameter; four rings per inch is acceptable if growth rings have ≥50% latewood. Compression wood is not permitted in the outer 1-inch of the pole diameter as viewed from either end of the pole.

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-inches of the pole diameter could significantly affect 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 < 10% of the butt cross-section) caused by splinter pulling when the tree is felled. Shake is permitted within limits considered to have minimal impact on strength; however, if shake occurs at the top of the pole, the 05.1 standard requires treatment of the full length of the pole. Decay is generally permitted only in very specific instances, such as hollow pith centers in poles to be treated 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 an unavoidable consequence 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 they extend 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 chainsaw may be tolerated provided the reduced section still meets the required circumference for the pole class.

Manufacturing requirements are established to 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 marking, and storage.

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 be measured easily and properly classified. Bark removal/shaving should remove all inner bark but leave sufficient sapwood to obtain the customer's minimum requirement for preservative penetration. Finally, proper trimming of branch stubs and overgrown knots that rise >1 inch from the surface facilitates handling.

Conditioning

Proper conditioning is important for both the strength and handling of wood poles. In many cases, however, conditioning involves exposure of the pole to high temperatures for purposes of drying, sterilization, and preservative treatment. Because of differences in drying characteristics of different species and the fact that high-temperature exposure for extended periods results in wood strength loss, conditioning methods involving high temperatures cannot be applied generically. The ANSI 05.1 standard lists species by treatment group (Table 2) with designated limitations on pre- and post-treatment conditioning to address these differences. The standard includes requirements for air seasoning, Boulton drying, and kiln drying to facilitate handling and improve durability at minimal cost to pole strength. These requirements generally correspond to those given in the American Wood Preservers' Association (AWPA) standard C4.

Air seasoning is required for treatment group A (Table 2) and is permitted for all species except ponderosa pine. Pre or post-steaming is permitted for up to 4 h at 240°F. For ponderosa pine with <25% moisture content 2.5 inches from the surface, steaming may continue for 6 h.

Boulton drying is to be used with coastal Douglas-fir and western larch (treatment group B). This method should not exceed 220°F in any pretreatment process. After treatment, the poles may be steamed at temperatures not to exceed 240°F for 4 h.

Kiln drying of poles is a topic of some controversy. Some kiln operators feel increasing dry-bulb temperatures, wet-bulb depression, and airflow allows poles to tolerate faster drying. At present, dry-bulb temperature is limited to 170°F for ponderosa pine, red pine, and jack pine, and to 160°F for western redcedar. At these temperatures, ANSI recommends that the wet-bulb depression not exceed 50°F.

For Southern Pine, lodgepole pine, Douglas-fir, and larch, ANSI permits dry-bulb temperatures ≤ 230°F. For temperatures > 200°F, wet-bulb depression is required to exceed 50°F. The philosophy behind acceptance of higher temperature with a greater wet-bulb depression is that the total time at the high temperature will be reduced, lessening the chance for high-temperature strength reduction. There is some question, however, as to the effect of faster drying on the quality of the pole and the strength of surface fibers that are subject to these higher temperatures.

Steam conditioning is primarily used for southern pines (Table 3, treatment group C). Temperatures during this process should be kept below 245°F and steaming time held to under 17 h for poles with a circumference 137.5 inches at 6 ft from the butt. For a circumference > 37.5 inches at this distance from the butt, the steaming limit is 20 h. When Douglas-fir and western larch poles are to be treated with waterborne preservative and have not been Boulton dried, ANSI permits steam conditioning at temperatures not to exceed 240°F for 0 h provided that the initial moisture content does not exceed 25% at 2 inches from the surface. This is a slight deviation from the AWPA C4 standard, which limits steaming temperature to 225°F for 15 h.

Marking

Identification markings are used by utilities for maintenance and life-cycle cost records. The ANSI standard requires that these markings include the followinginformation:

- supplier's code or trademark
- plant and year of treatment
- pole species and preservative used
- 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 ensure that the marking can be read easily after the pole is placed in service. Marking on poles ≤50 ft long must be located 10 ft ± 2 inches from the butt end. For poles ≥55 ft, the marking is located 14 ft ± 2 inches from the butt end.

Storage

Pole suppliers will normally maintain an inventory of poles in the more popular sizes, and pole users often keep a supply of poles for emergency use. It is important to store these poles properly to prevent any deterioration priorto use. The ANSI standard specifies adequatestructuralsupportabovegroundandprovides guidelines for handling to minimize mechanical damage.

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 2 lists ANSI values for the more popular pole species. These fiber stress values approximate average pole strength and are much higher than the design values that engineers use for buildings and bridges. These fiber stress values are used to determine pole class sizes for each species, and they 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 3 lists the 15 ANSI pole classes and their respective required load capacity, length range, and minimum tip circumference.

Minimum circumference 6 ft from the butt listed in the ANSI 05.1 standard is derived to assure that each pole has the groundline bending momentcapacity required to carry its pole class load. As groundline distances vary with pole length, required circumferences are translated to a location 6 ft from the butt to facilitate pole classification. The translation from "groundline" to 6 ft assumes a linear circumference taper (Table 2).

The ANSI minimum tip circumference measurement has been a topic of discussion because of some possible confusion in interpreting the standard. The standard allows pole length to vary: poles < 50 ft long can be shorter by 3 inches or longer by 6 inches; poles ≥50 ft long can be 3 inches shorter or 12 inches longer. The top dimension requirement has been interpreted asbeingapplicabletothe "minimum length permitted" which is at a location either 3 or 6 inches less than the nominal length. This means that for a long (≥50 ft) pole that is 12 inches longer than the specified length, the minimum tip circumference for the pole class may be measured as far as 10 inches below the actual top of the pole. As a result of the combined effects of 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, which is equivalent to about 0.4 inch in diameter. This is important in that tip diameter is used as the basis for the design of utility hardware. I-lowever, since such hardware can tolerate a 0.5-inch variation in pole diameter, this interpretation should not cause a design problem.

Other Pole Standards

As mentioned earlier, a number of committees maintain standards that are specifically focused on the structural use of round timbers. These include ASTM, ASAE, and REA standards.

ASTM Standard: Three ASTM standards are related to wood poles. The main standard, designated D3200 (8), refers to two other standards: ASTM D25, Specifications for Round Timber Piles (10) and ASTM 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 ASTM D25 is set up to specify a minimum tip circumference for piles. ASTM D3200 provides a table of specified tip Circumference values for corresponding minimum butt circumference values. ASTM D2899 provides equations for deriving design stresses for poles or piles on the basis of clear wood strength and material variability.

ASAE Standard: The ASAE standard EP388 (6) references ANSI 05.1, AWPA, and ASTM standards. Material manufacturing and pole dimension requirements reference the ANSI standard, and the derivation of design stresses follows ASTM recommendations. The ASAE standard provides a basis for specifying and using poles in agricultural pole-frame buildings. This standard is currently under revision. Once approved, a new standard will be issued as EP560, which will no longer include glued- and mechanically laminated posts, but concentrate only on roundwood construction poles.

REA Standard: The REA specifications for wood poles, stubs, and anchor logs (18) describe the minimum acceptable quality of poles purchased by REA borrowers. Material requirements designated by this standard are extracted from ANSI 05. The primary differences between this standard and the ANSI standard are the pole framing details and the designation of treating time and temperatures.

ANSI 05 Wood Pole Committee

The American National Standards Institute's Wood Pole Committee (ANSI 05) was originally organized in 1924. The committee is currently under the sponsorship of the Alliance for Telecommunications Industry Solutions (ATIS), and it consists of about 30 voting members, representing a balance of pole users, producers, and general interests to provide some assurance that all interests are considered. Members meet annually to review and update the following three standards of interest to the utility pole industry: ANSI 05.1–Wood Poles, Specifications and Dimensions (2), ANSI 05.2–Structural Glued Laminated Timber for Utility Structures (5), ANSI 05.3–Solid Sawn Wood Crossarms and Braces (4).

The ANSI 05 Committee meetings are open to anyone who wishes to express a concern related to the content or application of the standards. Discussion items are generally referred to one of six subcommittees (Table 4). The subcommittees on material requirements, fiber stress, and classification relate to the 05.1 standard. The structural composite lumber subcommittee is developing a new standard. Non-voting members may express concerns at meetings or by contacting the appropriate subcommittee chairman (Table 4).

Related Activities

In addition to the standard specification on wood poles, the ANSI 05 committee is responsible for standards in glulam timber and wood crossarms. The ANSI standard on glued-laminated (glulam) utility structures (05.2) covers requirements for manufacturing and quality control of structural glulam timber of Douglas-fir and Southern Pine for electric power and communication structures. The latest edition of this standard includes a procedure for obtaining fiber stress values for glulam members based on design values published by the glulam industry

The ANSI standard for solid-sawn wood crossarms and braces (05.3) includes material specifications for

Douglas-fir and Southern Pine. This specification includes crossarm manufacturing, seasoning, quality limitations, treatment, marking, and storage. The latest edition includes a fiber stress value for Douglas-fir crossarms (Table 5). Efforts are underway to obtain data on Southern Pine crossarms as well.

Both ANSI 05.2 and 05.3 include procedures for determining fiber stress values for crossarms based on testing of the product. This permits the use of crossarms of various species of either solid-sawn or glulam timber. An ANSI 05 subcommittee has also been considering the technical feasibility of incorporating nondestructive evaluation (NDE) methods in the pole stress grading process. The major challenge in applying this concept is determining how it would be compatible with established utility pole markets.

Metric Units Policy

The ANSI policy on metric units is that "units of the International Systems of Units (SI) are the preferred units of measurement in American National Standards." Other standards-writing organizations such as ASTM are making concerted efforts to produce future standards in metric units and to produce dual metric/English units for existing standards. Kressbach et al. (16) have proposed several significant changes leading to metric conversion of ANSI 05.1. These changes include reducing the number of ANSI classes from 15 to 10 as well as a number of simplifications for the derivation of pole sizes. The ANSI 05 committee considered this proposal but voted not to make any changes at this time. The preferred method expressed by the Committee is to include metric equivalents in the text of the standards and include separate tables with metric units to accompany the present tables.

Technology Transfer

The ANSI 05 committee is trying to make it easier for people to communicate their concerns about the production and use of wood poles. The material requirements subcommittee is compiling a manual that depicts permitted as well as restricted wood pole characteristics. This manual will provide color photographs that should be helpful in explaining characteristics described with jargon such as bark inclusions, cat face, juvenile wood, firm red heart, and dead streaks. The Committee sponsor, ATIS, has also developed a World Wide Web page that includes meeting schedules and minutes of the annual meetings. The Web address is

http://www.atis.org/atis/05/05hom.htm

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Table 1. SI conversion factors.

English unit	Conversion factor	SI unit
inch	25.4	millimeters (mm)
foot (ft)	0.3048	meter (m)
pound (lb)	0.454	kilogram (kg)
pound per square inch (lb/in^2)	6.894	Pascal (Pa)
temperature **(°F)**	**(**T_F **-** 32)/1.8	°C

Table 2. ANSI pole species by treatment group and corresponding fiber stress and taper values.

Treatment group	Fiber stress (lb/in²)	Circumference taper (inch/ft)
Group A (air seasoning)		
Cedar, western red	6,000	0.38
Cedar, yellow	7,400	0.20
Pine, ponderosa	6,000	0.29
Pine, jack	6,600	0.30
Pine, lodgepole	6,600	0.30
Pine, red	6,600	0.30
Douglas-fir (interior north)	8,000	0.21
Group B (Boulton drying)		
Douglas-fir, coast	8,000	0.21
larch, western	8,400	0.21
Group C (steam conditioning)		
Southern Pine[a]	8,000	0.25

[a]loblolly, longleaf, shortleaf, and slash pines.

Table 3. ANSI classification of wood poles

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

Table 4. ANSI 05 Committee on wood poles.

Committee	Officer	Affiliation
Main committee	Russ Moody, Chair	USDA Forest Service, Forest Products Laboratory
	Alvin Lai, Secretary	Alliance for Telecommunications Industry Solutions
Subcommittee		
Material requirements	Colin McGowan, Chair	Thomasson Lumber Company
Fiber stress	Robert Kluge, Chair	Wisconsin Power and Light
Classification	Richard Leinfelder, Chair	McFarland Cascade
Crossarms	Robert Lash, Chair	Rural Utilities Services
Glulam	Steve Smith, Chair	Hughes Bros. Inc.
Structural composite lumber.	Bruce Craig, Chair	Trus-Joist McMillan

Table 5. Fiber stress for glulam and Douglas-fir solid-sawn crossarms

Product	Fiber stress (lb/in^2)
Glulam	
2.5/8 to 6-3/4 inches wide, 3 to 15 inches deep	K = 2.9[a]
Larger	K = 2.7[a]
Douglas-fir, solid sawn	
ANSI 05.3 limitations, table 1	7,800
ANSI 05.3 limitations, table 2	7,400

“Fiber stress values obtained by multiplying design values in bending from AITC 117 (1) by this K factor.

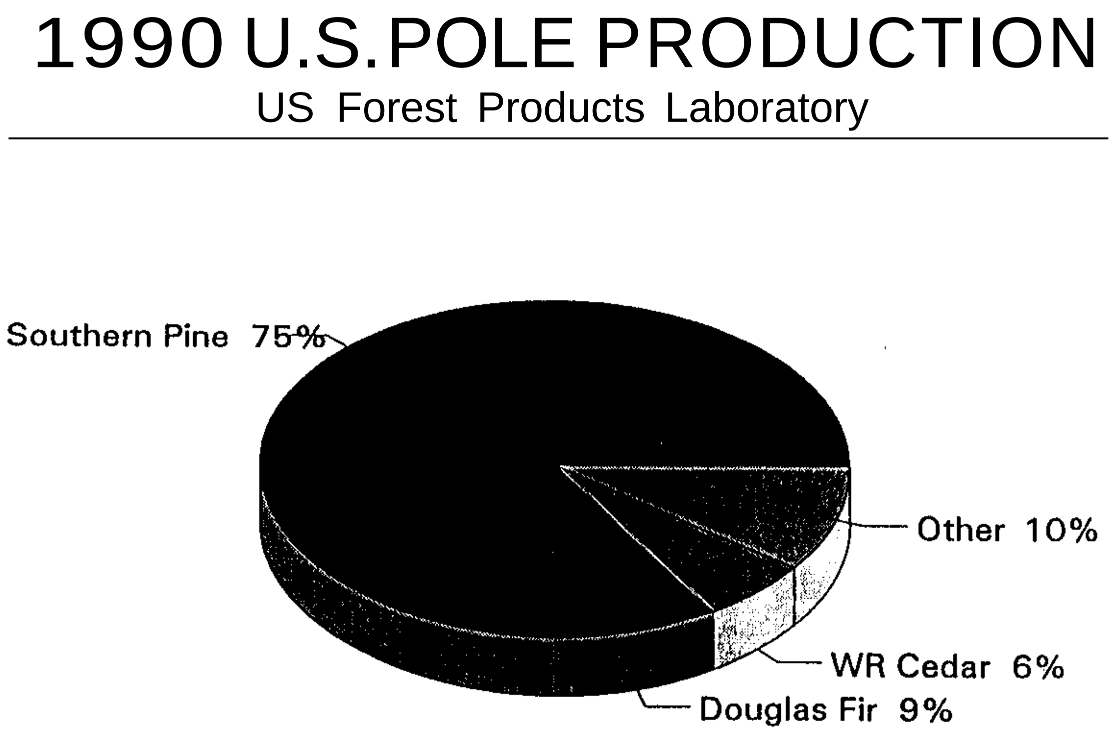

Figure 1. U.S. pole production by species. Figure based on number of poles in AWPA treating plant survey by Micklewright (1 7). WR is western redcedar.

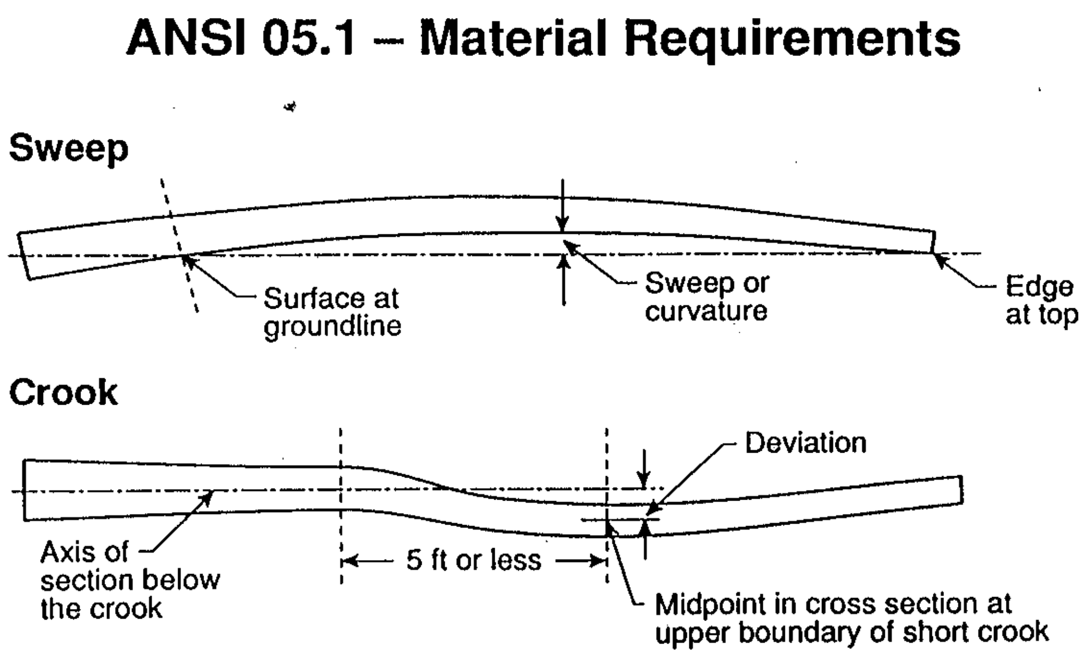

Figure 2. Pole shape limitations (1 ft - 0.3048 m).