The Realistic Expectation of an In-Place Wood Pole Inspection Program

Gerald L. Daugherty

Abstract

Historically, contracting of in-place wood pole inspection programs was often the responsibility of operations personnel who were familiar with the variables of this art and who understood the expectation of such programs. Today, however, as a result of consolidation of the electric utility industry and the introduction of professional contracting and purchasing agents, contracting is more often than not the responsibility of persons who are not familiar with or less familiar with the variables and expectation of an in-place wood pole inspection program. These observations are made based on my personal experience of having negotiated hundreds of in-place wood pole inspection program contracts.

Considerations associated with wood pole procurement are briefly described, highlighting treatment plant variables, pole inspection before and after treatment, and specifications normally associated with this process. Factors associated with an in-place wood pole inspection program are discussed in detail, including variables inherent in a non-destructive inspection procedure, current methods of inspection, and inspection cycles.

The realistic expectation of an in-place wood pole inspection program is not perfection. I define the realistic expectation of such a program as a tool to allow a pole owner to statistically upgrade the quality of its wood pole plant through a cyclical inspection program and by acting upon the inspection data, thereby minimizing liability as a result of pole failures, recognizing that perfection may be approached, but never completely achieved.

Introduction

Although wood is one of the most variable materials used for structural purposes, wood poles have a long history of satisfactory performance in the electrical and communications industries. Hayes (1986) reported in 1986 that estimates of the number of wood poles in active use on utility systems in the United States ranged from 110 million to 132 million.

With the enormous value of this wood pole plant, and the high cost of replacement, there is little argument concerning the importance of wood pole inspection and maintenance programs. Much as been written about the need for wood pole inspection (Birtz 1977a, 1981; Bodig 1986; Chase 1988; Crosno 1986; Gillies 1978; Goodman 1985; Hayes 1986; Stewart et al. 1988; Taylor 1978; Forest Products Laboratory 1987; REA 1974). A comprehensive wood pole management program, however, includes more than in-place wood pole inspection. At a minimum, a maintenance program encompasses procurement of treated poles, selection of the proper size poles for installation based on anticipated loadings, monitoring of new attachments and loadings to be certain poles are sufficient to carry the new loadings, cyclical in-place inspection and replacement programs based on new loadings and the results of wood pole inspection, and emergency services. Crosno (1986), for example, described Southern California Edison's wood pole quality control program as one which incorporates realistic specifications for new poles and pole treatments, inspection of new poles, proper pole installation, periodic in-place inspection, and in line maintenance.

The purpose of this paper is to demonstrate that what a utility needs to understand is the *realistic* expectation of an in-place wood pole inspection program. Wood pole owners must understand that in-place wood pole inspection is only one aspect of a wood pole management program. In-place inspection of wood poles, by itself, is not wood pole maintenance. Although this caution may be old information to those familiar with the operations of managing a wood pole plant, in recent years more and more aspects of wood pole management have become the responsibility of professional contracting or purchasing agents who normally are not familiar with or less familiar with the variables and expectation of an in-place wood pole inspection program. It is my impression that many of these individuals expect wood pole inspection to be foolproof, and that all poles not classified as "danger" or "reject" should stand until the next inspection, regardless of how far into the future it is scheduled. This is often the case even where a minimal inspection procedure is specified, such as sound and bore without supplemental treatment. Many of the changes involving pole management and maintenance are a result of consolidation in the electric utility industry. I can personally testify to these changes as a result of having negotiated hundreds of in-place wood pole inspection program contracts.

I define the realistic expectation of an in-place wood pole inspection program as a tool to allow a pole owner to statistically upgrade the quality of its wood pole plant through a cyclical inspection program and by acting upon the inspection data, thereby minimizing liability as a result of pole failures, recognizing that perfection may be approached, but never completely achieved.

Variables Affecting the Quality of New Wood Poles

There are many variables that either directly or indirectly affect the efficacy of in-place wood pole inspection. Included among these are factors that affect the quality of new wood poles.

Wood is a highly variable biological substance whose natural characteristics affect its strength. Wood density or specific gravity, for example, is an important determinant of strength: high-density wood is stronger than low-density wood. The specific gravity of Douglas-fir can range from 0.25 to 0.62, while the range for shortleaf pine can be from 0.26 to 0.68 (Brown et al. 1952). Therefore, a wide range in the strength of wood poles made from these two species should be expected.

Other factors affecting the strength of wood includes spiral and diagonal grain, knots and knot clusters, ring shake, reaction wood (especially compression wood), and damage done by sap stains, insects, and decay fungi (Brown et al. 1952; Panshin and deZeeuw 1980; Forest Products Laboratory 1987). The American National Standards Institute (ANSI) takes into account these and other variables when establishing load-carrying capacity for various classes and sizes of wood poles (ANSI 1992).

Stoddard (1986) describes how wood's natural characteristics and other factors affect wood pole production. Whether or not a given wood pole, prior to preservative treatment, is selected for further processing is often based solely on human judgment, namely that of a trained inspector. This phase of inspection is called the white wood pole inspection. Since human judgment is not perfect, some below-standard poles will enter the stream of commerce. There are, however, devices available to estimate the strength of poles in service that may be useful in culling low strength white wood poles. Devices used in the nondestructive evaluation (NDE) of installed wood poles include the Sonic Wave Processor™ (Goodman 1985), the PoleTest™ (Bodig 1986; Stewart et al. 1988), and Vibrante (vibration analysis testing) (Murphy and Taylor-Wilson 1988).

Stoddard (1986) also discusses variables associated with the preservative treatment of wood poles. One concern relative to the future performance of a wood pole is whether or not it has been sterilized either before treatment by kiln drying or during treatment in those processes where heat is used. Taylor (1978) discusses the concern of biological infection of wood poles during air seasoning prior to treatment as a precursor to heart rot.

Wood poles are inspected after treatment to ensure proper preservative penetration and retention. As noted by Stoddard (1986), white wood inspection and treated wood inspection standards are normally established by the pole purchaser. The protocols can be industry standards such as *ANSI 05.1-1992 American National Standard for Wood Poles – Specifications and Dimensions* (ANSI 1992) and *Standard C4-95 Poles-Preservative Treatment By Pressure Processes* (AWPA 1997), or in-house standards created by the pole producer.

The American-Wood Preservers' Association's (AWPA) *C4-95* describes the penetration and retention requirements and verification procedures for the approved preservative treatments. The penetration verification requirement for Group B poles (poles whose circumference 6 feet from the butt is 37.5 inches or more) is that all poles must be tested by boring. Penetration testing of Group A poles (circumference at 6 feet from the butt less than 37.5 inches) requires only a statistical sampling of 20 poles from each charge. If 18 of the borings meet the penetration requirement, the charge is accepted; the nonconforming poles, however must be re-treated. This means that for Group A poles, there will be some poles in the charge that do not meet the penetration requirement. In a charge of 60 poles, for example, 20 are analyzed and two rejected for not meeting the penetration requirements. Statistically speaking, it can be assumed that of the 40 poles not sampled, at least four do not meet the penetration requirement. The actual number, of course, can be more or less. This adds an additional variable to the quality of treated poles introduced into the wood pole plant. Many utilities, to their credit, require that all poles, regardless of group designation, be subject to penetration sampling.

For treatment with creosote and oil-borne preservatives, AWPA *C4-95* allows, with certain restrictions, steaming, heating in the preservative, Boulton drying, or a combination thereof. Specific variables of the treatment process such as temperature, pressure, vacuum, and time must be kept within the restrictions or limitations placed on them in order to avoid thermal degradation and weakening of the wood poles (REA 1957). Although treatment processes which employ heat sterilize the wood pole and improve its treatment with preservative, they can also be detrimental to the strength of the pole. Thus, it is important for the treating plant to keep accurate charts of the treatment process. This allows an inspector to determine whether or not any of the restrictions or limitations have been exceeded, as it is normally not

Figure 1.—Decay severity zones for wood poles (REA 1974; RUS 1996).

obvious by visual inspection that a wood pole has been damaged by the treatment process.

Many pole purchasers utilize the services of a third-party inspector or inspection agency. Powell (1986) describes the role of an independent inspection agency in ensuring the quality of preservative treatment. It is important that someone in the purchasing utility monitor the inspection agency to ensure that the agency is following its contractual obligations. If a third-party agency is not used, it is important that utility personnel monitor the treating plant to ensure that it complies with its contractual obligations.

Rough handling at the treatment plant, dropping of poles during unloading at the utility yard or at an inventory site maintained by the supplier, and subsequent mishandling before and during installation can damage wood poles. While splits and gouges are easily seen, damage such as compression failures is not always readily apparent (Stoddard 1986; REA 1957).

All of the above variables directly influence the quality of new wood poles going into service. Many of these factors, however, also influence the efficacy of in-place wood pole inspection. The inherent characteristics of wood, the limitations of visually inspecting white wood, quality control exercised over the treatment process, and damage done to poles during handling prior to installation cannot be remedied by in-place inspection.

In-Place Wood Pole Inspection

I defined in-place wood pole inspection as a nondestructive inspection or nondestructive evaluation to determine strength loss in service of a highly variable material, wood, which has been processed, prior to installation, by treatment with wood preservatives designed to resist attack by wood-destroying organisms such as fungal decay and insects.

Table 1. – Recommended pole inspection schedules (REA 1974; RUS 1996)

Decay zone	Initial inspection	Subsequent reinspection	Percent of total poles inspected each year
	- - - - - - (yrs.)	- - - - - -	(%)
1	12 to 15	12	8.3
2 and 3	10 to 12	10	10.0
4 and 5	8 to 10	8	12.5

Numerous reports describe the various methods of inspecting wood poles in-place (Birtz 1977a; Bodig 1986; Chase 1988; Goodman 1985; Hayes 1986; Osmose 1985-1988, 1997a; Stewart et at. 1988; Stoddard 1986; REA 1957, 1974; RUS 1996; Wright and Smith 1995). REA *Bulletin 161-4* (REA 1957) details a wood pole inspection program including scheduling of inspections, and groundline inspection methods and remedial treatments allowed, as well as other types of pole maintenance such as treatment of the upper portion of standing poles. In this article, I deal mainly with what is referred to as groundline inspection of standing or in-place wood poles. However, most groundline inspection programs include a visual assessment of the above-ground portion of the pole. Revisions to *Bulletin 161-4* were made in 1974 (REA) and in 1996 (RUS), after REA became the Rural Utilities Service. These later bulletins contain a decay severity zone map (Fig.1) and proposed initial pole inspection and subsequent reinspection schedules based on the decay zone (Table 1). The decay zones are somewhat imprecise, and thus add another variable that a pole owner must account for when scheduling both the initial inspection and subsequent reinspections. Interestingly, Houston Light & Power Co., located in decay severity zone 5, inspects poles at as early as age 6 (Grimes 1998).

Birtz (1977a, 1981) describes conventional methods for inspecting standing wood poles, provides remarks on the efficacy of each method, and gives his opinion as to how often reinspection should be done (Table 2). Hayes (1986) discusses conventional groundline inspection methods and includes a description of the plusses and minuses of NDE inspection tools such as the Shigometer®, x-ray equipment, tomographic devices, and various sonic testers. He also talks about using the Pilodyn pin penetration device, which is designed to detect surface decay in wood, to determine whether the soundness/hardness of a pole's shell is sufficient for safe climbing by linemen. Bodig (1986) and Stewart et al. (1988) describe the development and usefulness of the PoleTest™ device to assist in the groundline inspection of standing wood poles. Wright and Smith (1995) compared the conventional decay area method of determining strength loss with PoleTest™ results. They concluded that while neither technique provided a highly reliable correlation between predicted and actual bending strength of in-place poles, the decay area method provided a better correlation. As noted earlier, it appears that some devices, such as the PoleTest™, for example, give better results when used on poles without advanced decay.

The decay area method is associated with the historical conventional inspection method in which the groundline portion of the pole is first excavated. Then, the decayed areas of the pole are mapped either by taking borings or by estimating the thickness of its shell with a probing rod. Electronic devices are not used with this method. Using prepared tables, the inspector assesses the acceptability of the pole, in accordance with the specifications of the pole owner, and determines whether or not the pole is a "danger", a "reject", or merely partially decayed, but serviceable. Estimates of pole residual strength are not made.

Variables Affecting the Efficacy of In-Place Wood Pole Inspection

Many variables affect the efficacy of in-place wood pole inspection. The most obvious is the inspection method or combination of methods used to inspect a given pole, since different methods are not equally effective. It is the responsibility of the pole owner to specify the method(s) of inspection to be utilized by its employees or by an outside contractor. In some cases, this responsibility is delegated to a third-party consultant hired by the pole owner. Sometimes the third-party consultant also is given the responsibility of contracting directly with the pole inspector.

When inspection methods that do not utilize NDE devices are employed, determination of the suitability of a given wood pole, or lack thereof, is a subjective decision made by a human being. Since all inspectors are not alike – some are more skilled and conscientious than others – another variable affecting the efficacy of in-place wood pole inspection is introduced.

At least one inspection contractor I know of informs the pole owner, prior to contracting, of some of the variables associated with in-place wood pole inspection (Osmose 1997b):

> "Pole Owners should be aware that the present art of inspecting poles and the equipment and the site where these items are typically located is not perfect, and there is no test equipment or methods to make it so. When evaluating wood poles, there are variables affecting wood quality for which the Contractor has no control. These would include the species of timber involved, the effectiveness or lack of original treatment, soil and climate conditions, brash or brittle wood, including brash wood caused by soft rot which lacks required strength, but is not always able to be detected by any known field methods, as well as insect activity, bird damage or lightning damage occurring or resuming after the time of inspection. For these and similar reasons, perfection is not always possible, even with highly trained professional inspectors and electronic instrumentation."

If the inspection contract calls for reporting of additional field information beyond the condition of the pole the following is also pertinent (Osmose 1997b):

> "When attempting to identify defective equipment and field conditions, there are also additional variables over which a Contractor has little or no

Table 2. – Efficacy of conventional wood pole inspection programs (adapted from Birtz 1997a, 1981).

	Type of inspection	Reinspection cycle	Remarks
1.	Visual and sounding.	Yearly	Almost worthless. Even misses danger poles. Does nothing to maintain pole plant.
2.	Visual, sonic and bore.	2 to 3 years	Finds 40 to 50% of the bad poles. Caution must be exercised or good poles with shake are thrown out. Should find most danger poles. Does nothing to maintain pole plant.
3.	Visual, sound and bore.	2 to 3 years	Finds about 50 to 60% of the bad poles and most danger poles. Does nothing to maintain pole plant.
4.	Visual, partial excavate, sound and bore.	3 to 5 years	80 to 90% of rejects can be located. Fair inspection but does not prolong the life of pole plant.
5.	Excavate 6 to 8 in. around entire circumference, inspect and treat to 18 in. all poles with decay or defects.	5 to 6 years	90 to 95% of rejects can be located. Good inspection and most of the poles that would fail early are treated. Usually treat about 20% of the older poles.
6.	Visual, excavate, sound, bore and groundline treat.	8 to 10 years	99% of all rejects are located. Most economical in long run as the life of the pole plant is extended.

Table 3. – Efficacy of conventional and newer sonic wood pole inspection programs (Osmose 1997a).

	Type of inspection	Reinspection cycle	Remarks
1.	Visual.	Several times a year	Provides little information to help improve pole plant. Misses most reject and priority poles.
2.	Sonic.	Yearly	Used with visual inspection, 40 to 50% of reject and priority poles will be found.
3.	Sound and bore.	Yearly	Used with visual inspection, 50 to 60% of reject and priority poles will be found.
4.	Partial excavation plus sound and bore.	3 to 5 years depending on decay hazard zone [a]	Used with visual inspection, 80 to 90% of reject and priority poles will be found.
5.	18 to 24 in. excavation plus sound and bore.[b]	6 to 10 years depending on decay hazard zone [a]	Used with visual inspection, 98% of reject and priority poles will be found. [c]

[a] Assumes supplemental treatment applied at time of inspection.

[b] Deep decay will not be found unless the specifications call for excavation below 18 to 24 in.

[c] Full effectiveness will not be achieved on poles which cannot be fully excavated due to obstructions beyond the control of the inspector such as rock, adjacent buildings, sidewalks, keys, roots, risers and underground cable.

influence. Trees and other vegetation on utility right-of-ways continue to grow after the inspection date. New attachments and lines are added to poles, and old equipment is removed by power, telephone and cable television personnel and line construction contractors. Utility subscribers and others can build, alter or demolish various structures, and roads and driveways are added or re-routed, which violates clearance requirements and cable burial depth without Pole Owners or inspectors being notified. The longer time passes after an inspection is performed, the less reliable the data on attachments, defective equipment and clearance becomes."

Many persons involved in wood pole inspection automatically assume that brash failure of a wood pole is associated with decay. Decay, however, is not always the cause of brash failure in wood. Lyon and Thompson (1982) performed cable pull tests on class 5, 35-foot guyed utility poles. All of the poles were "good" poles that met the purchasing specifications of the utilities that supplied them for testing, Mississippi Power and Light Company and Mississippi Power Company. Of the 22 poles tested to failure, four exhibited brash failure. On the basis of this test alone, persons should be cautioned about making a rash decision as to the cause of brash failure in a wood pole. Brash failure is also associated with damage caused to wood poles as a result of exposure to abnormally high temperatures and high pressures during processing, or when time at allowable temperatures is exceeded during kiln drying and treating (REA 1957). Additionally, brash failure is associated with reaction wood, sap stain-infected wood, and wood that sustains hidden compression failures as a result of, for instance, being dropped. Brash failure in wood sometimes occurs as a result of an impact loading. This is especially true in fast-grown and low-density poles, which still meet product specifications. In my personal experience with toughness testing (impact bending) of both untreated and treated wood, a surprising number of specimens exhibited brash failures (Daugherty 1968-1979). The toughness of blue-stained softwoods can be reduced by up to 25 percent (Panshin and deZeeuw 1980). Although blue stain affects the toughness of wood, the bending strength of blue-stained softwoods is not significantly reduced. The only way to conclusively determine whether or not decay is present in wood that has failed brashly, but appears to be sound by visual inspection, is to perform a microscopic examination of the wood adjacent to the break for the presence of decay fungi.

Birtz (1977a, 1981) gives his opinion as to the efficacy or reliability of six types of conventional wood pole inspection methods (Table 2). Osmose (1997a) also provides estimates of the efficacy of various conventional inspection methods and sonic testing devices (Table 3). Osmose's estimates are similar to those reported by Birtz even though several new sonic inspection devices have been commercialized since publication of his articles.

Taylor (1998) testified that the accuracy of detecting internal decay in wood poles by sounding with a hammer was from 51 to 99 percent. This range of accuracy is quite wide, and does not correspond with the comments of Birtz (Table 2) and Osmose (Table 3). I believe that the higher rate of accuracy espoused by Taylor refers only to poles with a high percentage of hollow heart decay that resound like a drum when hit with a hammer, or to poles with such advanced shell rot that the hammer embeds in the pole. The data shown in Tables 4 and 5 tends to refute Taylor's overly optimistic view of the accuracy of the hammer sounding inspection method.

Commenting on the efficacy of in-place wood pole inspection methods, REA (1974) cautions "no method is completely fail-safe where human judgments or sophisticated instrumentation is involved. Thorough training and experience of inspectors are essential requisites to good inspection practices and a random recheck of any work it advisable." Interestingly, RUS has removed this language from the 1996 version (RUS 1996), even though there have been no breakthroughs in pole inspection methods or technology. In any event, no method of in-place wood pole inspection is completely fail-safe. I advocate, as does RUS, that all wood pole inspection contracts include a quality control recheck of randomly selected work, not only to determine the quality of the inspection, but also to assess the quality of the application of remedial treatments, if this is part of the contract.

The reliability of an inspection program can be judged by what actually occurs in a population of poles after the inspection results are reported to the pole owner. As part of a comprehensive wood pole management program, the inspection results need to be analyzed and appropriate action taken. As advised by RUS (1996), "inspection results should be used to update pole plant records, evaluate pole conditions, plan future inspection and maintenance action, and provide information for system map revisions."

Gillies (1978) reported on the efficacy of the wood pole reliability operations of the Bonneville Power Administration (BPA). These operations include inspection and remedial preservative treatment programs. It is important to note that while BPA had pole failures despite its wood pole reliability operation, that BPA was satisfied with the existing operation: "I still feel that the study has shown that BPA line design criteria and maintenance programs have been very successful in limiting structure failures." The program was successful, but not perfect.

The results of an initial inspection of three different pole populations and subsequent re-inspection from 9 to 12 years later are summarized in Tables 4 and 5 (Osmose 1985-1988, 1997a). In all three cases the pole owners utilized the initial inspection data to upgrade the quality of their pole plant by removing danger and reject poles as part of their maintenance operations. The subsequent reinspections show a reduction in the number of danger and reject poles. Clearly, the quality of the pole populations has improved, but still, they are not perfect.

These results also show that the percentage of reject poles found by sound and bore inspection only was much lower than the percentage of reject and danger poles found when an 18-inch-deep groundline excavation inspection was utilized. These results support the opinion of others (Birtz 1977a, 1981; Chase 1988; Osmose 1997b) that excavation is necessary to improve the reliability of in-place pole inspection. Although these results show that no danger poles were found by sound and bore inspection, this method of inspection can find danger poles. However, the reliability of the sound and bore method is such that danger poles will not always be found (Birtz 1977a, 1981; Chase 1988; Osmose 1997b).

It should be noted that none of these studies is perfect because the population of standing poles assessed during the initial inspection was not identical to the population examined during the subsequent reinspection. This is because danger and reject poles, once found, are normally replaced with new poles. Also, the criteria for the initial inspection of a new pole often are such that it is not inspected during an initial inspection of a pole population, but only during a subsequent reinspection. For example, a pole owner may specify that only poles over 15 years of age are to be inspected as part of the initial inspection. Finally, the criteria for which poles are to be sounded and bored only may change over time.

Table 4. – Wood pole inspection summary of the Midwest

Date	Poles excavated	Reject	Percent	Decayed	Percent	Danger	Percent	Poles sound and bore	Reject	Percent
Initial inspection										
1986 to 1988	18,404	1,297	7.1	3,815	20.7	80	4.3	3,578	101	2.8
Second inspection										
1997	11,871	266	2.2	1,482	12.5	12	1.0	3,442	38	1.1

Table 5. – Wood pole inspection summary of the Southeast.

Date	Poles Excavated	Reject	Percent	Decayed	Percent	Danger	Percent	Poles sound and bore	Reject	Percent
Population I										
Initial Inspection										
1986	1,201	204	17.0	294	24.5	32	2.7	203	8	3.9
1988	2,063	141	6.8	313	15.2	42	2.0	313	6	1.9
Total	3,264	342	10.5	607	18.6	74	2.3	516	14	2.7
Second Inspection										
1997	2,942	17	0.6	239	8.1	0	0.0	408	7	1.7
Population II										
Initial inspection										
1985	2,044	155	7.6	149	7.3	9	0.4	141	1	0.7
1987	2,024	182	9.0	159	7.9	10	0.5	100	1	1.0
Total	4,068	337	8.3	308	7.6	19	0.5	241	2	0.8
Second Inspection										
1997	4,063	20	0.5	108	2.7	0	0.0	140	0	0.0

Clearly, the variables associated with in-place wood pole inspection affect the results. However, as seen in the results reported here, an in-place wood pole inspection program, especially a cyclical program, will statistically improve the quality of the wood pole plant. Shortening the reinspection cycles will likely speed attempts to attain perfection, though perfection will never be achieved. Thus, a pole owner needs to consider the cost of shortening the reinspection cycle. Although some may believe that perfection in the quality of a wood pole plant can or should be achieved, the variables associated with wood, with the production of new poles, and with in-place pole inspection make it clear that perfection may be approached but never achieved.

Extending the Service Life of Wood Poles

Hand in hand with a wood pole inspection program, a pole owner should consider the use of supplemental preservative treatments to extend the service life of poles not classified as reject or danger. Most pole owners include this aspect of their wood pole management program in the wood pole inspection contract. The need for and benefits of a remedial treatment program are well known and accepted (Birtz 1977b, 1981; Chase 1988; Crosno 1986; Gillies 1978; Hayes 1986; Osmose 1997b; REA 1957, 1974; RUS 1996). Likewise, certain reject poles that meet the criteria of the pole owner can be treated and then reinforced or restored with any one of a number of commercial reinforcement or restoration systems. Chase (1988), Crosno (1986), Hayes (1986), and REA (1957) discuss the wood stub, steel, truss, and other reinforcement methods. Since the publication of these papers, newer techniques such as fiberglass wrap systems have been commercialized.

A pole owner should understand that remedial treatments will not always eliminate future decay or insect problems. After all, the new pole that was treated with an approved preservative in a highly controlled environment is now the old pole that needs remedial treatment in the field. Taylor (1978) reports that decay is sometimes found during the second inspection cycle, and that the majority of it is internal. The data of Tables 4 and 5 confirm that decay and even reject and danger poles are found during the second inspection cycle. Taylor's findings speak to the need for supplemental surface treatments and highlight the necessity for internal treatment when hidden decay is found during the initial inspection. However, incipient decay is not always detected during the initial inspection. As a consequence, internal decay appears to be the predominant form of decay found during the subsequent inspection. Incipient decay in the shell of poles not excavated and surface-treated during the initial inspection will continue to degrade the wood and will be identified during a subsequent inspection as a reject or danger pole. As Taylor (1978) advises, "some may think that supplemental treatment should cure all ills. Supplement treatment does not replace the original treatment. It is intended to only restore the toxicity level in the critical groundline sector. Some decay is to be expected on the second inspection."

Summary

Many natural and processing variables affect the strength of new wood poles used in the electric and communications industries. Included among them are the natural characteristics of wood, and the variables associated with wood pole processing, such as white wood inspection, preservative treatment, post-treatment inspection for preservative penetration and retention, and damage incurred during processing, handling, and installation. Because the effects of these variables are often hidden, in-place wood pole inspection cannot find all those poles which do not meet a pole owner's new pole specifications.

In light of the many variables that affect the efficacy of the various in-place wood pole inspection methods, and given that these methods are non-destructive, not all reject, danger, or decayed poles will be found. As Goodman (1985) explains, "The only way to exactly determine the existing strength of every pole in a service area is to test them all to destruction, an obviously impractical solution." A pole owner should know and realize from the start, that it will not have perfect knowledge of the quality of a given population of poles based on the results of existing nondestructive evaluation methods for the inspection of in-place poles. However, analysis of the results of wood pole inspection programs clearly chows that cyclical inspection programs afford a pole owner the opportunity to statistically improve the quality of its wood pole plant.

With this in mind, linemen who climb poles need to be informed that an inspection tag is not a guarantee or warranty that a pole is safe to climb. While, statistically speaking, most poles not tagged "reject" or "danger" are safe to climb, there is, in every population of in-place inspected poles, a few reject and danger poles that may not be safe to climb. When a population of poles is inspected using one of the more reliable methods – sound and bore plus 18 inches of excavation, for instance – the number of unsafe poles will be lower than if that same population was inspected using a less reliable procedure such as sound and bore, or sound and selectively bore. In any event, individuals who climb poles must decide for themselves whether or not a pole is safe to climb, and what safety precautions to take.

Pole owners have resources available to them to write specifications for the procurement of new wood poles and the subsequent inspection and reinspection of in-place poles. These aspects of a wood pole management program will help determine the performance and reliability of such a program. Pole owners with higher standards in their specifications can expect to achieve better results than those with lower standards. However, even pole owners with lower standards in their specifications can be expected to improve the quality of their wood pole plant by utilizing a cyclical in-place wood pole inspection program.

Literature Cited

American National Standards Institute. 1992. ANSI 05.1-1992 American National Standard for Wood Poles-Specifications and Dimensions. ANSI. New York, New York.

American-Wood Preservers' Association. 1997. Standard C4-95 Poles-Preservative Treatment By Pressure Processes. AWPA. Granbury, Texas.

Birtz, R. 1977a. Conventional Methods for the Inspection of Poles. Wood Pole Maintenance Workshop, North Carolina State University, April 27, 1977.

Birtz, R. 1977b. Extending the Life of Poles In-Place - Current Practices. Wood Pole Maintenance Workshop, North Carolina State University, April27, 1977.

Birtz, R. 1981. Reliability of the Various Groundline Pole Inspection Methods and Proper Application of Fumigants. 7th Wood Pole Institute, Colorado State University.

Bodig, J. 1986. Practical Definition of Wood Pole Strength: Relation to Construction Standards. Wood Pole Conference Proceedings 1986. J.J. Morrell, Editor.

Brown, H., A. Panshin and C. Forsaith. 1952. Textbook of Wood Technology Vol. II. The Physical, Mechanical, and Chemical Properties of the Commercial Woods of the United States. McGraw-Hill Book Company New York, New York.

Chase, B. 1988. Below Groundline Pole Inspections Essential. Transmission & Distribution. January 1988.

Crosno, R. 1986. Product Quality Control-Wood Poles. Wood Pole Conference Proceedings 1986. J. J. Morrell, Editor.

Daugherty, G. 1968-1979. Unpublished results.

Forest Products Laboratory. 1987. Wood Handbook: Wood as an Engineering Material Agricultural Handbook No.72. USDA Forest Service. Madison, Wisconsin.

Grimes, W. 1998. Managing a Groundline Maintenance Program. International Conference on Utility Line Structures, Fort Collins, Colorado, March 23-25, 1998.

Gilles, D. 1978. Wood Pole Reliability Operations. Proceedings of the Fifth Annual Reliability Engineering Conference for the Electric Power Industry. American Society For Quality Control-Portland Section.

Goodman, J. 1985. Comprehensive Wood Pole Management Program. Proceedings of the Eighth Wood Pole Institute, Colorado State University.

Hayes, W. 1986. Extending Wood Pole Life-Solving A $5-Billion/year Program. Electrical World. February 1986.

Lyon, D. and W. Thompson. 1982. Cable Pull Tests of Southern Pine Utility Poles in Line. Proceedings of the American Wood-Preservers' Association. AWPA. Granbury, Texas.

Murphy, M. and J. Taylor-Wilson. 1988. Vibration Analysis: An Alternative to Sonic Testing. Wood Poles for Performance and Profit. Proceedings of the 9th Wood Pole Institute, Colorado State University; Craig E. Shuler; Editor.

Osmose Wood Preserving, Inc. 1985, 1986, 1987, 1988, 1997a. Wood Pole Summaries. Buffalo, New York.

Osmose Wood Preserving, Inc. 1997b. Exhibit B, Document 110.19c Rev 5/97. Buffalo, New York.

Panshin, A. and C. deZeeuw. 1970. Textbook of Wood Technology Vol. I. Structure, Identification, Uses and Properties of the Commercial Woods of the United States and Canada. McGraw-Hill Book Company. New York, New York.

Powell, H. 1986. The Role of an Independent Agency in the Inspection of Wood Products Used by Utilities. Wood Pole Conference Proceedings 1986. J. J. Morrell, Editor.

Rural Electrification Administration. 1957. Pole Maintenance. REA Bulletins 1614 (Electric) and 441-1 (Telephone). USDA. Washington, D. C.

Rural Electrification Administration. 1974. Pole Inspection and Maintenance. REA Bulletin 1614. USDA. Washington, D. C.

Rural Utilities Service. 1996. Pole Inspection and Maintenance. RUS Bulletin 1730B-121. USDA. Washington, D. C.

Stewart, A., J. Goodman and R. Nelson. 1988. Innovative Wood Pole Management. Wood Poles for Performance and Profit. Proceedings of the 9th Wood Pole Institute. Colorado State University. Craig E. Shuler, Editor.

Stoddard, C. 1986. Factors in Wood Pole Production. Wood Pole Conference Proceedings 1986. J. J. Morrell, Editor.

Taylor, J. 1978. Pole Maintenance-Its Need and Effectiveness. Proceedings of the American Wood-Preservers' Association. AWPA. Granbury, Texas.

Taylor, J. 1998. Testimony *in* Yvonne E. Ellis v. Kerr-McGee Chemical Corporation, et al., Twenty-Second Judicial Circuit Court of Missouri, Cause No.952-07910 Division 10.

Wright, M. and W. Smith. 1995. Performance of Utility Pole Strength Prediction Techniques. Proceedings of the American Wood-Preservers' Association. AWPA. Granbury, Texas.

Gerald L. Daugherty, President, Timcon Associates, Inc., Las Vegas, Nevada and Prescott, Arizona.

This article is a revised version of a paper of the same title presented at the International Conference on Utility Line Structures, March 23-25, 1998, Fort Collins, Colorado.