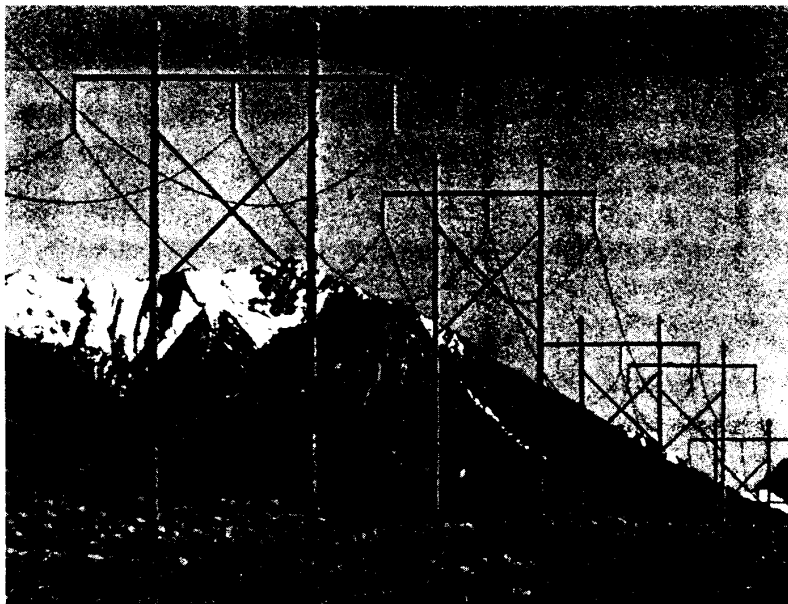


Bonneville Power Administration's Wood Pole Management Program



by

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ABSTRACT

Bonneville Power Administration (BPA) has been engaged in an active wood pole maintenance program for over 30 years. During this time, the Agency faced many challenges pertaining to wood pole problems, particularly the Western Red Cedar and Douglas-fir pole species. As a result of programs developed and implemented over the years for correcting internal and external decay (rot) situations, BPA has been able to increase the service life for wood poles while decreasing the cost of maintaining the system.

BPA wood pole management program breaks down into five major areas. They include:

- 1.) New wood pole specification and third party inspection;
- 2.) Ground-line inspection and remedial treatment programs;
- 3.) Above-ground or climbing inspections and treatments;
- 4.) Pole repair;
- 5.) Record-keeping and reporting.

This paper covers the complete life cycle of a BPA transmission pole.

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INTRODUCTION

BPA's Transmission Line Maintenance Division has practiced a system-wide inspection and remedial field treatment program for over 30 years. This program is organized and implemented in-house by Transmission Line Maintenance crews, which makes it unique. The crews are responsible for maintaining approximately 80,000 transmission poles located throughout Oregon, Washington, Idaho, and Montana.

The primary wood species used by BPA are Douglas-fir and Western Red Cedar. The original preservative treatments range from butt and thermal full-length treatments for cedars, to empty cell pressure treatments for fir. The preservatives of choice have been creosote and pentachlorophenol. However, environmental concerns over these products has lead to specifying copper naphthenate for new poles.

Utilities using Southern Yellow Pine (SYP) may also select a inorganic waterborne CCA treatment for new poles. In addition, decay patterns are different for SYP and inspection and maintenance recommendations will also vary.

As with other Northwest utilities, BPA has been faced with the challenge of maintaining wood poles against deterioration under adverse environmental conditions. The focus of this paper will be to examine BPA's current wood pole management program.

NEW WOOD POLES

The technical specification for new wood poles follows the guidelines set by the American National Standards Institute (ANSI), and the American Wood Preservers' Association (AWPA) Standards. In some instances, however, the Agency's specifications are more stringent than those required by ANSI or AWPA. For example, the Agency is more stringent on spiral grain and knot clusters requirements. These natural defects have been shown by past studies to lower strength properties in poles.

When pressure treating, a minimum 24 hour boulton cycle is required to ensure sterilization. BPA is currently specifying wood species of coastal Douglas-fir or Western Red Cedar to be pressure-treated with copper naphthenate or creosote for Douglas-fir, and copper naphthenate only for cedar.

All poles will be 'through-bored' (a design modification which bores a series of holes completely through the pole) in both the top crossarm and groundline areas (Fig. 1). This is one of several design strategies available for improving the preservative penetration in Douglas-fir poles. Other available methods include deep incising, radial boring, and kerfing. Through-boring, however, is the only method which provides 100% preservative penetration into the otherwise untreatable Douglas-fir heartwood. The performance of this product has been outstanding. BPA adopted this practice in 1966,

to date, there have been virtually no groundline decay problems with these poles. We plan to continue monitoring them to determine future maintenance needs.

The most frequently asked question about through-bored poles concerns possible strength effects, and a look at past research provides a clue to the concern. Through-boring was developed in the late 1950's. At that time, several research attempts were underway to address concerns with strength. The research found strength reductions ranging from 3-15 %. This is not surprising, since researchers used the ANSI 05.1 mean value for Douglas-fir bending strengths as the baseline of comparison (Fig.2).

It is important to understand that in any given population of poles, there will be a normal distribution of strengths values. Accurate assessments of strength effects can not be calculated without prior knowledge of the individual pole strength prior to modification. A more practical study was done in 1969 by Grassel, in which he planted two 75 foot / class 2 poles and broke them by applying a cantilevered bending test. The poles broke at 8.5 and 14 feet above groundline, which is well above the through-bored zone. This result is not surprising, since the maximum bending stress for transmission size poles usually occurs well above groundline.

In regard to the strength effects, the Agency believes that 25 years of through-bored field performance without an incidence of failure speaks for itself.

NEW POLE INSPECTION

Every pole candidate is inspected twice before the pole is incorporated into the BPA system. The first inspection occurs prior to pressure-treatment (white wood). The inspector examines the pole in accordance to ANSI 05.1 for any non conforming natural defects. The following inspection occurs after treatment. It verifies that adequate preservative penetration and retention requirements are met as specified in the American Wood Preservers Association (AWPA) Standards.

GROUNDLINE INSPECTION AND REMEDIAL TREATMENT

Before remedial treatment strategies can be discussed, it is necessary to know about wood technology, about the enemies of wood, and about proper pole inspection procedures. Proper inspection is the key to prescribing proper treatment. Meanwhile, without proper documentation and record-keeping both programs suffer.

Enemies of Wood: The most significant cause of pole deterioration is fungal decay. Internal decay (brown rot) is a serious problem with Douglas-fir. Above-ground surface decay or "shell rot" occurs in the sapwood of butt-treated Western Red Cedar. Soft rot fungi are a well known source of groundline shell rot in Southern Yellow Pine. To a

Fig. 1. The through-boring pattern for groundline and pole top areas.

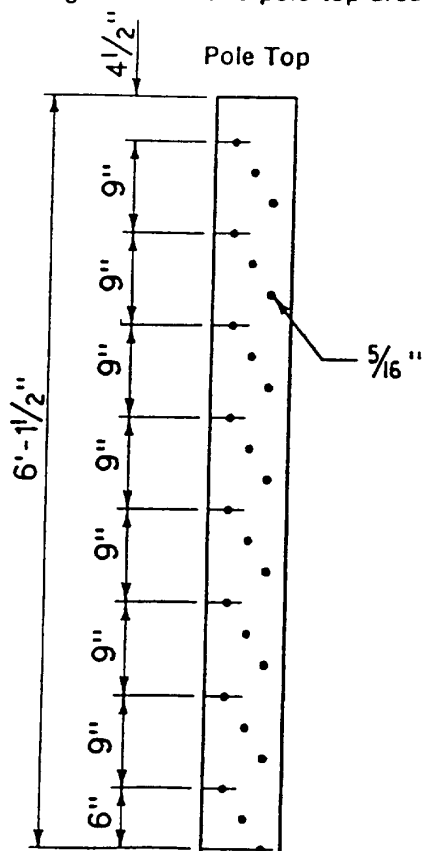
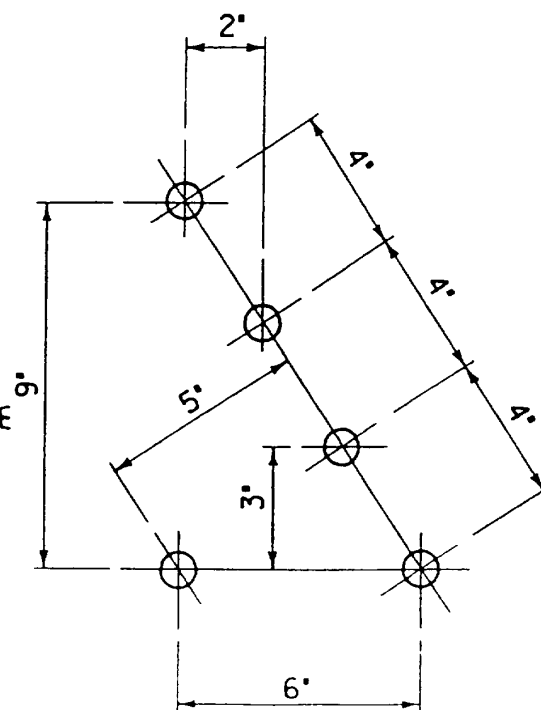
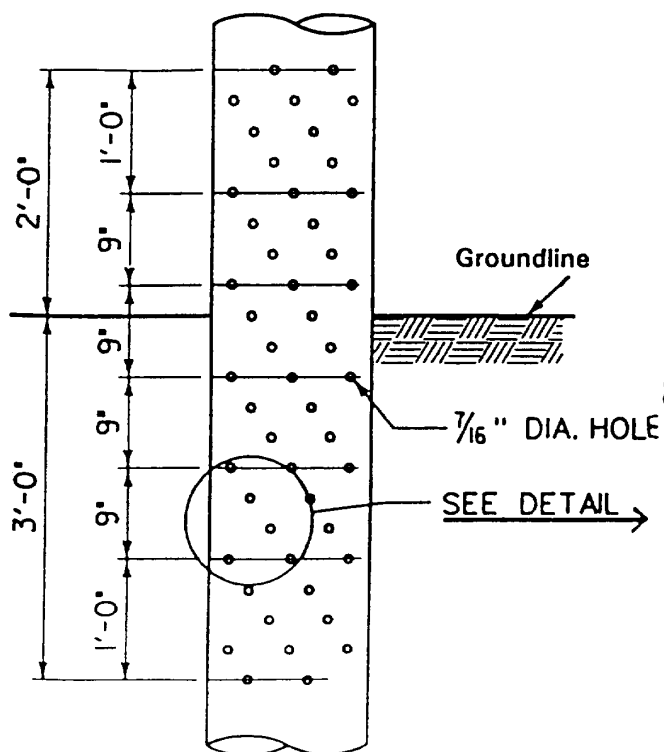
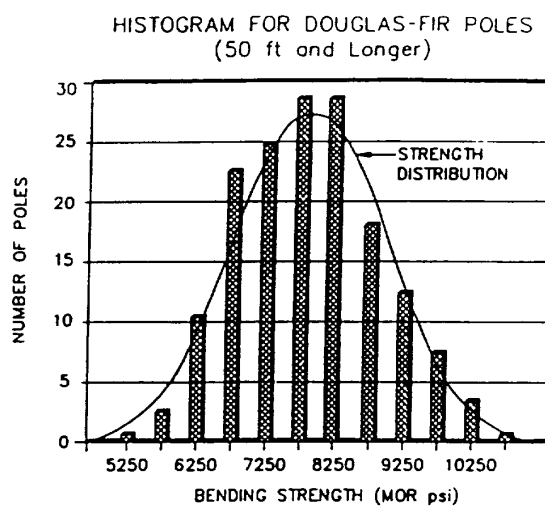


Fig. 2. Bending strength histogram for Douglas-fir poles.



lesser degree, insects also cause wood pole deterioration. The principal wood-destroying insects in the region are buprestid beetles, carpenter ants, and dampwood termites. Woodpecker damage is normally a minor problem. However, when attack occurs in localized areas it is considered a serious problem. Fire damage is often caused by lightning, range fires, or field burning of agricultural land.

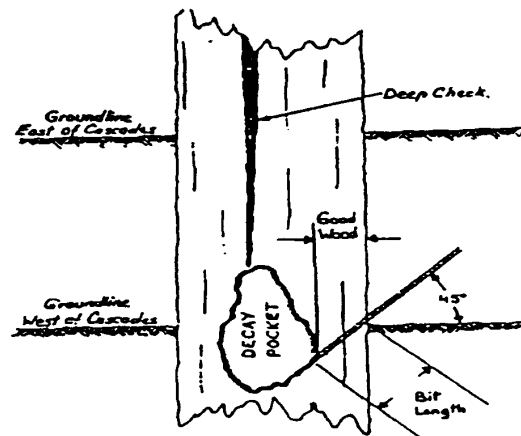
Groundline Inspection: West of the Cascades, drill a hole at a downward sloping 45° angle at groundline. To look for internal decay (Fig. 3), drill the hole into one of four different pole quarters with a 9/16-inch diameter X 18-inch long ship auger type bit.

East of the Cascades, dig down 18-inches and drill the test hole. If the wood is sound, reinspect or redrill a different quarter every 10 years. However, if decay is found, drill the other three pole quarters at groundline. Next, move up the pole to 2-3 feet and drill two additional holes to assess the extent of decay. Measure this decay using a shell depth indicator.

In the case of the decayed pole, schedule reinspection every 5 years. In all cases, apply Vapam (Sodium N-methyldithiocarbamate) into the inspection holes. Vapam is a liquid fumigant that diffuses through the wood as a gas to arrest and prevent decay fungi.

Through-bored poles are the only exception to this rule. These poles should be drilled with one 3/8" bit in a parallel orientation to the through-bored hole. The hole should be drilled near groundline to check for 100 % preservative penetration and for decay. Flood these treating holes with a liquid preservative (copper naphthenate; 2 % copper as metal solution). Plug every hole with a tight-fitting preservative treated dowel.

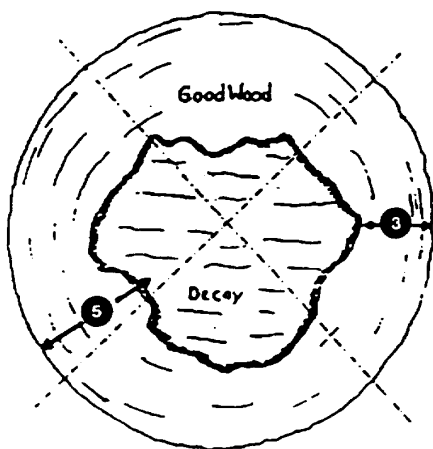
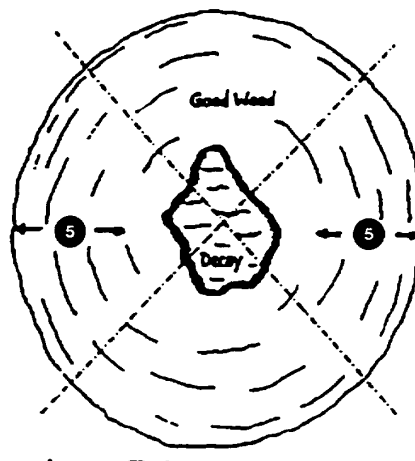
Fig. 3. Location of groundline butt-inspection for west and eastside locations.



The criteria for rejecting decayed poles is as follows:

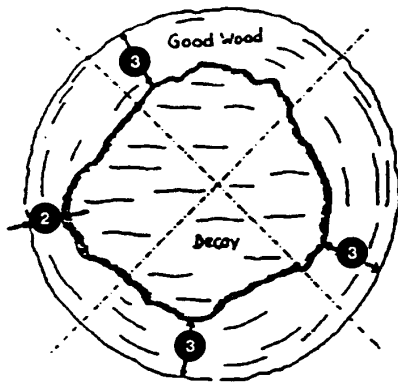
Program for Reinspection

- If the decay is limited to a small area, or all 4 quarters have more than 5 inches of sound wood as shown, then fumigate and reinspect the pole every 5 years.



Routine Replacement or Reinforce

- If all 4 quarters have less than 5" but more than 3" of sound wood as shown, fumigate above the decay pocket and replace or reinforce with a steel stub within 3 years.



Immediate Replacement

- If any two quarters have 2" or less of sound wood, or if at least three quarters have 3" or less of sound wood as shown, replace the pole within 6 months.

Table 1. Program for initial and follow-up groundline inspections

Pole Kinds	Initial Inspection (Years)	Follow-up Sound poles (Years)	Inspection Minor decay (Years)
C - Butt-Treated Cedar	15	10	5
P - Full-length Treated Cedar	15	10	5
F - Nonthrough-bored D-fir	10	5	5
D - through-bored D-fir	15	10	5
N - Through-bored Copper Naphthenate D-fir	15	10	5

ABOVE-GROUND INSPECTION & REMEDIAL TREATMENT

When conducting a climbing inspection, the linemen will often use a combination of 'sounding,' increment boring, or drilling to examine suspicious areas in poles, cross arms and cross bracing. Holes made during the inspection are flooded with copper naphthenate (2 % copper as metal) solution and plugged with a preservative treated dowel.

BPA field-drills all of its poles for above ground attachments (i.e. bolt-holes). This penetrates the preservative-treated shell and exposes untreated wood in non-through-bored areas. BPA has adopted the practice of flooding these holes with copper naphthenate immediately after drilling. It has been shown by Newbill and Morrell that these field treatments provide a protective barrier around the bolts.

From 1956-1988, BPA hired commercial contractors to apply a 10% Pentachlorophenol solution by washing or flooding the surface (sapwood) of its butt-treated Western Red Cedar poles. Research conducted by Enos found this method effective in preventing shell rot of cedar poles, as well as extending their service life considerably.

Treatment should be applied 15 years after installation for butt-treated cedars, and 30 years for full-length treated cedars. The treatment should be reapplied approximately every 10 years west of the Cascade mountain range (Oregon, Washington), and 15 years east of the Cascades (Oregon, Washington, Idaho, and Montana). Today, due to environmental concerns, the Agency has substituted copper naphthenate for pentachlorophenol. BPA will be working with Oregon State University's Forest Research Laboratory to develop appropriate retreating schedules.

POLE REPAIR

Woodpecker Damage: Woodpeckers often drum on poles as a means of: a.) finding food; b.) sexually exciting females during courtship, and; c.) building nests.

This activity may breach the poles preservative-treated shell, exposing the otherwise untreated core to a host of wood destroying organisms. The amount of this damage in the Pacific Northwest is considered low as compared to other areas of the United States.

Patching small woodpecker holes with a two-part epoxy foam filler is the best prevention against the development of large internal voids. When such extensive damage is found, the Agency schedules the pole for replacement.

Crossarms: BPA has used solid sawn or round spar arms on 69, 115, and 230 kV structures. A disadvantage of spar arms is that, on drying, seasoning checks reopen and collect unwanted moisture. The result can be premature failure. Solid sawn arms have performed better. However, the availability of large dimension, long length, defect-free material is uncertain, and the cost prohibitive. For these reasons, the Agency has initiated the conversion from wood to weathering steel crossarms for all routine maintenance work. Steel crossarms are specified for new construction projects as well.

Groundline Reinforcement: Following inspection, examination of the record-keeping reports (see below, RECORD-KEEPING) will undoubtedly uncover a population of poles with moderate to high levels of bio-deterioration. Even though remedial fumigant treatments have proved effective in minimizing this damage, reliability concerns may warrant extra insurance be given to keep the pole in service. Reinforcement of the pole at groundline is a viable alternative to pole replacement, and can be economically

attractive. Several different products are available for this use, including wood stubs, fiberglass systems, encasements and galvanized metal C-trusses. The Agency currently uses the C-truss.

RECORD-KEEPING

Proper record-keeping is a powerful tool that provides information for long term management of the wood pole system, including the functions of evaluation, assessment, problem-solving, predicting, purchasing and planning. The cost savings associated with record-keeping are a direct result of managers using the best available information as the basis for making wise business decisions. BPA estimates that record-keeping accounts for \$2 million in annual savings in the wood pole management program.

In 1960, BPA initiated a system-wide field inspection program for detecting decay in Western Red Cedar and Douglas-fir poles. These inspections showed a serious decay problem, and thus formed the foundation for our current wood pole inspection program. This program is organized and conducted at each Transmission Line Maintenance's district headquarters. Linemen conduct the wood pole inspections and record data on an annual basis. Inspectors examine poles on rotating cycles based on individual pole age, pole kind, and condition from prior inspections (Table 1). Conversely, many utilities use contractors to inspect their wood poles. They will inspect and remedially treat every pole in line with products designed to prevent or arrest decay for 10 years. In this way, every pole in the line can be reinspected on a 10 year cycle.

Each of BPA's 16 district headquarters submit reports to the System Maintenance Information System (SMIS) - a central database system. With the SMIS system, the Agency has developed an extensive wood pole history that tracks the performance of each pole over its entire service life. In addition, SMIS allows the pole manager to examine the number and age distribution of each pole kind (Table 2). This information can be very valuable in predicting maintenance needs.

New Pole Installation

During construction of new wood pole lines, or when replacing retired poles from service, the pole information on the 'brand' or metal identification tag is recorded. This information includes vendor name, year treated, wood species, preservative treatment and retention, and pole height and class. This data provides the foundation by which pole service life is measured. Once installed, additional information collected includes the year installed, 'ADNO' number (4 digit code for the location and line name), mile and structure in the line, structure type, and relative position. With this basic information, the Agency tracks pole service performance.

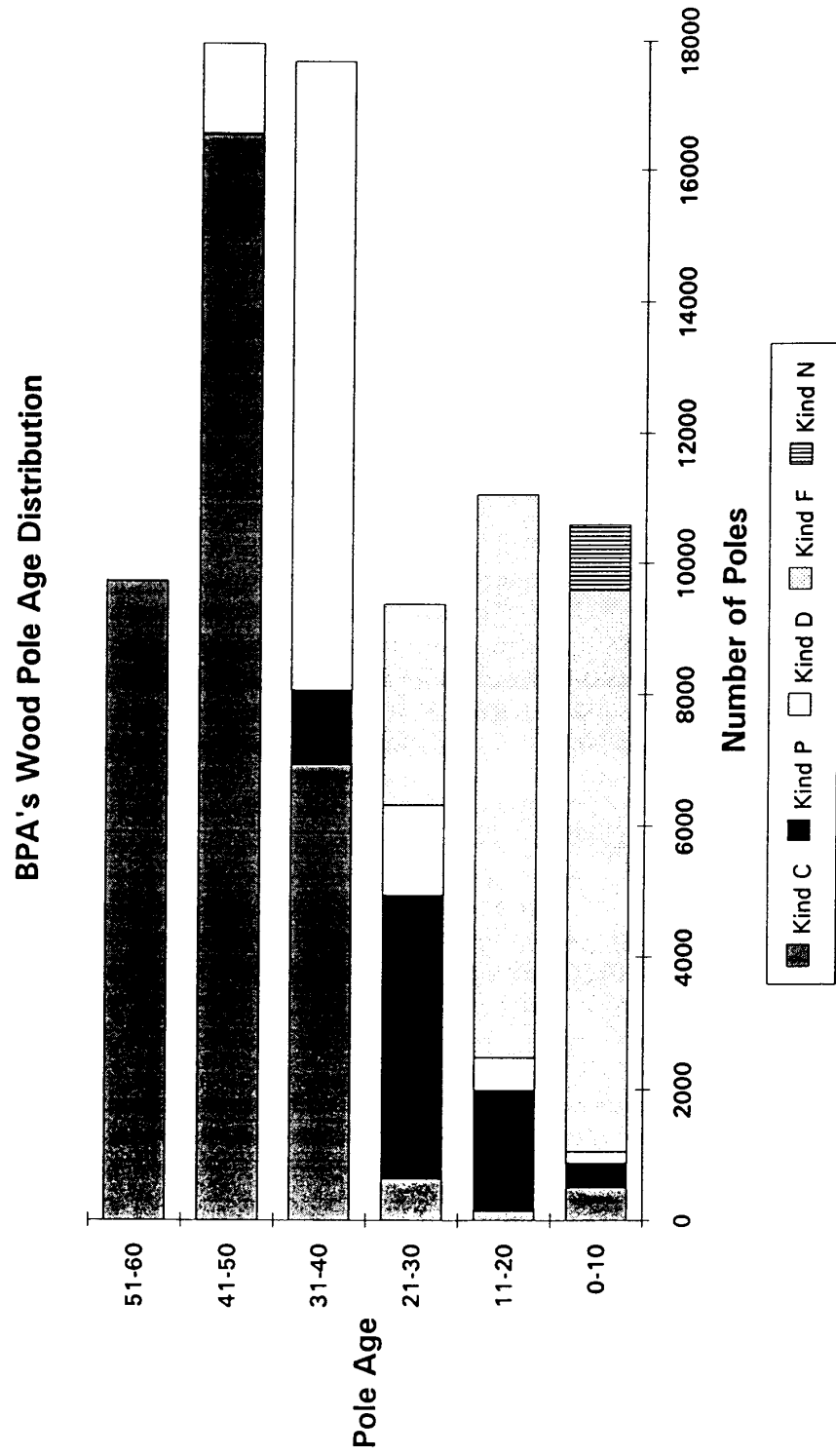
In addition, poles are periodically inspected and the historical data is gathered and verified. This completes the first step, which helps the utility identify specific type of wood pole system.

The database can be used to develop a wood pole age distribution for each different pole kind. For instance, BPA has 43% butt-treated (creosote or pentachlorophenol) Western Red Cedar with an average age of 45 years. Ten percent are full-length treated (penta) Western Red Cedar with an average age of 30 years. Fifteen percent are pressure-treated (creosote or penta) Douglas-fir with an average age of 35 years. Thirty percent are through-bored, pressure-treated (creosote or penta) Douglas-fir with an average age of 15 years. The remaining 2% of the system is through-bored, pressure-treated (copper naphthenate) Douglas-fir with an average age of two years. This information allows the manager to evaluate and predict the needs of the system. For example, BPA has 10,000 cedar poles between the ages of 50 - 60 years old. These two different pole kinds are of concern because of the potential for large-scale replacement in the upcoming years.

Wood pole managers must be able to evaluate performance data, examine historical data, have an understanding of wood technology, of bio-deterioration processes, and of preservative systems. The managers must be able to weigh the impacts of various environmental conditions. Vital background information describes the symptoms for which the wood pole manager can prescribe the best available treatment strategy. It allows for prediction and planning decisions. For example, BPA will attempt to extend pole service life by using internal fumigant treatments or reinforcement systems to avoid sharp increases in pole replacements. This maintenance program has a moderate annual expense, but avoids the extreme annual expense that would otherwise be certain. This philosophy diffuses those replacement costs over a longer period. Another indirect benefit which results from long-run management philosophy is an increased system reliability (less down time), customer satisfaction, and increased safety in the workplace.

Data showing wood pole history performance may provide insight into premature failures of a certain type of preservative system. Comparisons can be made between preservative systems subjected to similar environmental conditions. For example, utility co. XYZ uses performance data to compare two different pole kinds. One has an average service life of 30 years, while the other has a 40 year service life. However, the 30 year pole costs 10% less initially. Which pole kind is the better deal? Analysis shows that capital costs amortized out over the entire life of the product. Any short-run saving gained by selecting the 30 year pole will be surpassed by the savings through long-run management of the 40 year pole.

Wood pole managers may now work closely with purchasing agents to save money by avoiding short-term fixes that are ultimately more costly.



Field Reports

Canned Reports: BPA's field inspection procedures require examination of poles on rotating cycles, based on individual age, pole 'kind' (species/treatment specific), and condition from the previous inspections. Capturing field data completes the cycle and allows the wood pole manager to generate reports on a pole-specific basis. Canned reports are generated annually and sent out to the field Foreman several months prior to scheduling a work activity. Two commonly used workload reports are: 1.) candidate list of the poles requiring inspection for the next season; and 2.) candidate list for priority replacements. The reports are beneficial because they provide the line crews with a 'workload schedule.' The Foreman can plan other needed maintenance activities or incorporate them at this time. This provides line crews with the flexibility to complete their jobs as efficiently as possible. Cost savings from proper planning is realized, although it is difficult to assign a dollar figure due to a variety of circumstances.

Queried Reports: Queried reports allow the wood pole manager an opportunity to examine specific types of data in poles, such as damage caused by insects, decay fungi, or woodpeckers. Queried reports also allow measurement as to the extent of this damage. The ability to evaluate details is an extremely important feature. For example, BPA has identified approximately 3,000 poles that have moderate level of woodpecker damage. If left unrepaired, the replacement costs would be approximately \$9 million dollars. As another example, Douglas-fir poles treated by the Cellon method are known to fail prematurely. Inspection information helps pick out weak sisters and steps can be taken to implement a remedial groundline treatment program if one does not already exist. As yet another example, queried reports can also be used to evaluate the effectiveness of a contractor: Utility co. XYZ decides to start a wood pole inspection and treatment program. In the first inspection cycle, the contractor finds 15% of the poles as rejects and field-treats everything else. The second inspection cycle (10 years later), the reject rate may be down to as low as 2%. The manager is now in a position to evaluate the success of the program. He or she can also extract specific data comparing before and after conditions. This information would confirm the efficacy of treatments. Either way the manager now has information that: a.) supports the program, or; b.) requires changes be made. In the case of successful inspection and treatment programs, permanent record-keeping data supports the economic benefits associated with long-run management.

Pole Replacement and Disposal

BPA's modern wood pole managers cannot, as they once did, simply buy more poles. Rather, they must look at a host of extenuating circumstances surrounding the procurement of new wood poles. Utility poles of today must meet the following criteria:

- Long-term Performance
- Economical
- User Friendly
- Environmentally Acceptable
- Disposable

As wood poles are retired from the system, the utility finds itself encumbered with disposing of a relative large mass of treated wood. BPA's current wood pole disposal policy was developed from a scientific understanding of wood preservation principles and State and Federal laws. The Environmental Protection Agency (EPA) regulates solid and hazardous wastes under the Resource Conservation and Recovery Act (RCRA). In March 1990, EPA introduced the Toxicity Characteristic Leaching Procedure (TCLP) as a standard test method for quantifying the amount of chemical leaching from a group of 40 pesticides. The Electric Power Research Institute (EPRI) conducted a series of tests on pentachlorophenol and creosote and concluded that the treated wood easily passed the minimum threshold levels. These findings encouraged EPRI to support a solid (non-hazardous) waste classification. State regulations usually follow the leadership of Federal law.

BPA practices landowner giveaway, solid waste landfilling, and internal reuse projects for our line maintenance needs.

Co-generation and bio-remediation are future technologies that may offer a permanent, yet environmentally acceptable disposal option for wood poles.

CONCLUSIONS

This paper describes BPA's philosophy and programs regarding wood pole management. It offers some ideas and methods that BPA has successfully used in solving some of our wood pole problems. The most beneficial programs include:

- Above-ground treatment of Western Red Cedar. The treatment has prevented shell rot, and thus extended pole service life while reducing potential climbing hazards for linemen.
- Internal groundline fumigant treatment of both Western Red Cedar and Douglas-fir. This practice has greatly reduced the invasion of wood rotting fungi and insect attack. It is primarily responsible for extending the life of approximately 10,000 non-through-bored Douglas-fir poles (Kind F).
- Improved new wood pole design by through-boring tops and butts has virtually eliminated decay. At this point (25 years into the program), predicting the average service life of a through-bored pole will be difficult, since the Agency has not removed many from service.
- The wood pole history reports have supplied BPA's wood pole managers with insight into potential problems in the system. The wood pole manager can use this information as a tool for predicting and planning maintenance activities.

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