A Review of Wood Pole Testing Equipment Compared to Visual and Excavation Techniques Used in Test and Treat Programs

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Abstract

Wooden utility poles provide safe, economic, easily obtainable means of delivering power, communications, and cable television to the masses of industrial and residential locations throughout the world. Wood, however, is a biological commodity that can undergo deterioration by insects, decay fungi, termites, and mechanical destruction. In many ways wood poles can outlast materials constructed of synthetic materials, such as concrete, fiberglass, steel, and aluminum if well maintained and cared for in a consistent and timely manner. With over 165 million wood utility poles in service in North America, this paper presents past, current, and timely views on wood pole life extension and inspection.

This paper reviews current products available to the utility, telephone, and cable company to fortify the preservative in areas where decay can occur, in both aboveground and at ground contact in wood utility poles. Reviewed are common inspection and remediation techniques and devices common to the industry and current technology to supplement the pole plant owner's grasp of what products are now in service and which assets can be further utilized and gain effective life extension. Included in this paper are forward-looking statements about future products that may be in research mode at the moment, and possible products, which may be offered to the industry in the near future to effectively extend wood pole life.

Introduction and Background

The poles, wires, transformers, and insulators of a utility system represent a sizable economic investment. To help protect that investment and the personnel who maintain it, special attention should be directed to a vulnerable spot—the groundline.

A periodic pole inspection program, coupled with maintenance using a good, quality source of years of historical-tested remedial treatment products, reduce outages, eliminate some emergency replacements, improve customer relations, and provide a safer system. This is why remedial treatment programs are becoming so common—pole inspection and maintenance using remedial treatment save money for the utility supplier and prevent problems. Many electric utilities have found that it more than pays for itself.

Throughout the world, hundreds of millions (greater than 165 million at last count in the U.S. alone) of wood poles carry electric power from power stations to substations and on to eventual power users. A pressure process has treated most of these wood poles with one of several preservatives, although non-pressure processes including thermal treatment and butt treatment have effectively treated some species. Pressure treatment, butt treatment, and thermal treatment have been extremely effective in adding many years to the useful life of wood poles.

However, when a pole has been in service for a substantial numbers of years, its failure becomes more likely. In a recent study conducted by the authors, out of 122 poles inspected in East Texas 12 poles were replaced before the inspection because of failure after 45 years of service. Other information gained from the inspection was that 16 newer poles were in the old line that were 25 years old and were in need of remedial treatment, which agrees with historical data. 73 poles were over 45 years old and were in need of shaving, groundline treatment, interior treatment, or reinforcement; this also agrees with historical. Twenty-one poles in the system were priority rejects found after full excavation inspection meaning that the poles were in intimate danger of failing in the system and needed to be replaced. This is an example of what occurs on a normal grid without inspection after 45 years: 73 poles nearing failure, 33 poles that had already failed, and 16 poles that had been replaced 25 years prior to our inspection. Inspection and remedial treatments can add to the service life of the utility grid. The principal cause of pole failure is decay, and this can be arrested by remedial treatments. The most common area for decay to occur is that portion of the pole from approximately 2 inches above groundline to approximately 18 inches below. In this 20-inch section four necessary ingredients are needed for decay to occur—oxygen, moisture, temperature, and nutrients in the form of the wood—are readily available for decay organisms to thrive. By eliminating one of these requirements for decay you can eliminate decay; a utility's pole system will experience a longer average pole life, a decrease in pole failures, less line outage and money savings.

A regular program of inspection and treatment with a quality, tested, and proven pole preservative from a quality producer can maximize the service life of wood pole investment. Without preventative maintenance, the average pressure-treated wood pole will provide service of 25 to 35 years as seen in the earlier study mentioned.

By utilizing an effective pole line inspection program and a groundline pole preservative as needed, utilities have found they can extend the life of a pole 15 years or more. These results, when multiplied across a whole system, can raise the average expected life of the system and save tremendously on replacement costs.

A Simple and Effective Cost Model to Illustrate Why You Should Inspect and Treat Poles

The cost-reduction possible with a groundline treatment program is so great it may seem unbelievable. Even using very conservative estimates, the example below indicates a huge benefit.

The commonly accepted average life of a pole under typical conditions is 30 years. Presently, the cost to purchase, install and wire a replacement pole is approximately \$1200. Therefore, over the life of a pole, its average cost is \$1200/30 years or \$40.00.

Suppose that pole is on a system with a groundline treatment program. Laboratory analysis has shown that the preservative in a remedial pole treatment remains effective for 15 years or more. On the basis of field studies, utilities and contractors have stated that a quality treatment product will extend the life of the pole by 15 years with one proper application. For this example, however, let us suppose that the pole is treated twice, once 15 years after installation and again at 25 years—and that the average pole so treated last only 5 years longer than its neglected counterpart. The number of applications used and added service life is well within reported results of actual experience.

The installation cost, as was the case with the earlier pole remains \$1200. Current cost for groundline treatment, depending on various factors, is \$15 to \$25 per pole for materials and labor. Thus the lifetime cost of this pole, including two remedial treatments at the estimate of \$20, is 1240. If this results in a pole that lasts 35 years, only 5 years longer than a pole that is not maintained, its average cost is \$1240/35 or \$35.43.

The average annual cost of the second pole is \$4.57 less than the first, even using conservative numbers. Multiplying the figure by the number of poles in your system will show you the tremendous cost reduction possible with a groundline treatment program. If your system comprises 500,000 poles, 2,285,000 would reduce your average operating cost annually. **Table 1** summarizes this incredible reduction.

Added Benefits to Inspection

The first step in a good maintenance program is inspection of the poles. The attention given to details in this step will determine, to a great extent, how effective, an overall program will be. An inspection can entail only groundline sounding and boring to detect decay, although a more thorough inspection ensures early detection of potential problems and is recommended. A complete program includes above ground visual check, sounding, boring, and trenching around the pole to a depth of 18 inches below groundline. It is only through such a complete program that the maximum possible savings of a maintenance program may be realized.

Although it is not necessary to groundline-treat all poles as they are inspected, most utilities find the incremental cost of this treatment to be minimal, and look upon it as good insurance. After inspection and treatment are completed, a report recording findings and work done should be filed. In addition to the economic advantages of a sound pole maintenance program previously mentioned, there are other indirect advantages. These include:

- Reduction and prevention of property damage
- Improved customer relations and quality perceptions through continuous service
- Expanded knowledge of the pole system
- Increased relative safety for those who work on poles

Table 1. ~ *Example of cost reduction possible by use of a remedial treatment program.*

Pole maintenance	Installed cost per pole	Remedial cost per pole	Lifetime cost per pole	Estimated pole life (Years)	Annual cost per pole	Number of poles in service	Annual cost of system
NO remedial treatment	$1200	$0.00	$1200	30	$40.00	500,000	$20,000,000
Remedial treatment	$1200	$40.00	$1240	35	$35.43	500,000	$17,710,000
Annual savings to utility using remedial treatment: $2,290,000							

- Reduced liability to the utility pole owner/pole sharer from wood pole worker deaths or injuries

A Historical Look at Remedial Treatment Chemicals and Chemical Systems

The use of supplemental wood preservatives applied to the groundline help to fortify the area of a wood pole that needs protection the most—the groundline. This is the area of the pole where we most often see the effects of soil and water leaching of preservatives, preservative breakdown by biotic and non-biotic mechanisms, and incidence of decay and early failure of wood structures. Historical tests have shown that the simple placement of a water repellent barrier at the groundline after a pole has been in service will only serve to raise the effective groundline area raising the decay zone to the top of the barrier where aerobic decay begin to feverishly attack the pole. If however, the new impervious barrier is supplemented with a new dose of wood preservative (that allows for migration), the new groundline, the former groundline, and a good section of the pole above the groundline is also protected. The section below reviews the many uses of biocides over the years and reflects on the gradual replacement of historically proven and used Pentachlorophenol with the newer historically proven, copper naphthenate.

Typical application of external remedial treatment chemicals could be described as one of the following if the preservative is not sold as a pre-manufactured roll or preservative pre-manufactured package. This would include paste and applied at a rate (1/16" to 3/8", but typically at a rate of 1/4" in thickness) sufficient to provide protection at groundline—material may be applied with brush, paddle, sprayer, or with a bandage-maker as supplied by manufacturer. Paste will be applied to an area 3 inches above groundline to 19 inches below groundline. Wrap with impervious barrier and staple covering in place, when livestock or children may be present use padlock tape (or a water resistant, childproof adhesive tape) of a minimum 3 inches tape width. Always read and follow label recommendations. Environmental conditions, exposure to the elements, age of pole, time since last inspection and treatment, and biological stress factors as well as initial preservative treatment depletion should dictate application rate.

Areas of Greatest Importance

Wood Pole Inspection and Treatment Techniques

Seventeen Essential and Easy Steps

1. Visually inspect the pole from top to bottom
2. Hammer sound the pole
3. Bore the pole above ground
4. Excavate the pole
5. Measure the pole circumference at or near groundline
6. Bore the pole below groundline
7. Scrape away any decayed wood from voids and checks using a check scraper
8. Chip away any decayed wood from groundline to below ground
9. Brush away any loose or remaining soft wood following chipping
10. Measure the remaining sound wood pole circumference
11. Calculate remaining pole strength
12. Apply remedial treatment paste or gel
13. Cover recently treated area with impervious barrier
14. Secure barrier sheet in place
15. Backfill excavated pole area
16. Tamp loose dirt/earth into place
17. Secure tag(s) on pole to indicate inspection date and chemicals used

Details of the 17 Essential and Easy Steps

It should be noted that steps one, two, and three should always be performed whether or not remedially treating the pole or not, which would include typical prior to climbing lineman inspection and work on, near, or around a treated wood utility pole.

Step One: Visually inspect the pole from top to bottom. This procedure is mandatory for both inspection personnel and lineman. You should use both the naked eye and preferably a set of binoculars to inspect the pole from top to bottom. At the bottom of the pole, you should look for insect tracks, checking, cracking, mud filled checks, and discolored or disfigured wood,

Table 2. ~ *Inspection efficiencies (from G. Daugherty).*

Pole inspection method	Efficacy	Inspection cycle
Visual	10–20%	1 year
Visual, sound and bore	20–40%	2–3 years
Visual, partial excavation, sound, and bore	60–80%	5–8 years
Visual, full excavation, sound, and bore	99%	8–12 years

including any obvious disfigurement to the wood, such as reduced surface area or discoloration. From the top of the pole, make sure the top is intact and not missing wood, look for loosened hardware, loosened conductor lines, insect attack, as well as woodpecker holes, which may indicate attack in a decayed area. The use of a visual inspection cannot be overlooked, as it is one of the most valuable tools in the inspection of a wood utility pole and the safety of personnel.

Step Two: Hammer sound the pole. Typically sounding the pole should be conducted with a reticulated face hammer. This type of hammer is often called a framing hammer and is used to differentiate it from other hammer marks found on the pole from consumers and other people using a typical clout hammer hammering on signs and appearances. Hammer sound the pole from as close to the groundline as possible to as high as the inspector can physically reach. This is typically an area in of eight to nine feet tall depending upon how tall the inspector is. You should hammer sound the pole on all four quadrants (north, south, east, and west) with minimal hollow sounds of the pole every few inches, at least in 120° degree increments in thirds around the pole, from the base of the pole until the highest point that you can reach from standing on the ground. Once the ear is adequately trained to detect hollow sounds, cracks, and splits in the pole, hammer sounding will be a very useful technique and you can usually gain confidence in this method with less than 24 hours training.

Step Three: Bore the pole above the ground. This procedure is accomplished by using an increment borer, or preferably a power drill. Drill the pole above the ground, starting at the ground line and going in a spiral pattern around the pole, usually in 120° increments, up until almost breast height. Inspection of the sawdust coming from the bore hole will tell you if decay is present or if there is soft, spongy, or punky wood present in the pole. If the bit goes in very quick and rapidly without resistance it will tell you if there is a decay pocket in the hole or a void. Be sure to record all the information from steps one, two, and three which are required any time you inspect or work on a pole whether or not you are going to be remedially treating it or doing further inspection below ground or on adequate computer-based software, PDA's, or handwritten inspection and record sheets. Be sure to use a shell thickness indicator if any voids are detected in the drilling and boring process.

Step Four: Excavate the pole. Typically what is done is to remove earth from around the pole, usually going down at least 18 to 24 inches and excavating the earth around the pole at least six inches away from the pole at groundline.

Step Five: Measure the pole circumference at or near groundline. Using a round tape, measure the pole circumference at or near the ground line. Typically there will not be any eroded away or soft, rotted wood away from the area just immediately above the groundline. You can measure the original groundline circumference which will be used later on to calculate remaining pole strength and remaining pole circumference to see if the pole needs to be remedially treated, stubbed, or braced, and used to calculate remaining pole strength.

Step Six: Bore the pole below groundline. Using a power drill and typically a 3/4" or 7/8" auger bit, bore the pole below groundline in several sections around the pole, usually in 120° increments, usually about six to eight inches below ground line. Inspect the frass and the wood shavings to look for decay as well as damp or moist wood. In addition to this be aware that when you are drilling into the pole you may hit a void or a soft spot, so when leaning against the drill and pressing against it, make sure you are wearing head protection such as a hard hat.

Step Seven: Scrape away any decayed wood from voids and checks using a check scraper. Scraping away any decayed wood prevents re-infestation to the area of the pole that has not been previously attacked and removes all the existing decayed wood, which is a growing zone not only for soft rock fungi (ascyomyetes) as well as decay organisms. There also might be attack to the outer surfaces by boring insects such as termites. The use of a check scraper here is essential.

Step Eight: Chip away any decayed wood from the groundline to below groundline. Using a chipper which is essentially a sharp-edged, flat-edged, sharp-shooter shovel, or similar, chip away any decayed wood from the groundline to below ground and make sure all the decayed wood is removed until you hit solid wood. This can usually be accomplished both by the tension which is required to chip away the wood as well as visually inspecting the wood to make sure it is sound. This also serves the purpose of removing any decayed wood from the groundline to below ground before applying any materials to it for future remediation.

Step Nine: Brush away any loose or remaining soft wood following chipping. This is usually done with a stiff metallic brush or a very stiff nylon brush. Basically what this does is remove any material from the pole that will impede penetration or possibly interfere with the remedial treatment chemicals which will be applied later.

Step Ten: Measure the remaining sound wood whole circumference. Again, using a round tape, measure the sound wood after you have removed all of the decayed wood from below groundline. Measure the circumference as this value will be used to calculate the remaining pole strength and help you to determine whether the pole needs re-enforcing, stubbing, or other methodologies to re-enforce the strength of the pole at groundline and bring it back to original strength or possibly stronger than the original strength.

Step Eleven: Calculate the remaining pole strength. Using the chart from the original 1957 Edison Electric Institute Paper, calculate the remaining pole strength by using the value of reduced circumference compared to the original circumference. Alternatively, you can use a standard slide, which is manufactured by many remedial pole manufacturers to calculate remaining pole strength. Some pole remedial companies actually have programs built into their PDAs or into their laptops that will calculate pole strength depending on species and original circumference vs. reduced circumference after decayed wood has been chipped away. All methods are equally important and serve the same purpose, although some are quite easier.

Step Twelve: After plugging the holes that you made in the pole at groundline and below groundline with treated wood plugs or with solid plastic plugs, apply the remedial treatment paste or gel. Again, follow EPA directions—the EPA label is the law. Many remedial treatment products such as pastes or gels require a minimum of 1/16"-thick coating to be used as a groundline. Whereas, depending upon your decay zone and the condition of the pole, you may wish to apply as much as 1/4" to 3/8" of the gel or paste remedial treatment-chemical based on your economic model years before you re-treat the next pole and the EPA label recommendations. Applying the paste or gel is usually done with a reasonably soft brush, usually an oval or round headed brush that may be easily being dipped or submerged into the remedial treatment paste or gel buck, and then coming out with a few ounces to a few pounds of remedial treatment paste or gel on the brush head that can then be applied in vertical, up and down, brush strokes on the pole at least 16 inches below ground and at least 4 inches above ground.

Step Thirteen: Cover recently treated area with impervious barrier. The purpose of covering the recently treated area which you have coated with a paste or gel with an impervious barrier is to force the wood preservatives deep within the surface of the wood pole and, if it contains a diffusible chemical, to aid in preventing the diffusible chemical loss to the adjoining wet soil. Also, this will keep the remedial treatment chemical in intimate contact with the wood until adequate penetration occurs following the backfilling with earth. If in an environmentally sensitive area, the impervious barrier will also keep chemicals from migrating from the remedial treatment-paste and from the wood utility pole into the surrounding environment and into the surrounding soil.

Step Fourteen: Secure barrier sheet in place. Securing the impervious barrier sheet in place, which can be anything from craft paper, with one side lined with an impervious plastic to roof sheeting material, to impervious plastic barriers serves multiple purposes, which includes keeping the barrier in place to keep cribbing animals from attacking the material and also from keeping the material from sliding up and down the pole, especially during backfilling operations. Remember when livestock or children may be present use padlock tape (or a water resistant, childproof adhesive tape) of a minimum 3 inches in tape width.

Step Fifteen: Backfill the excavated pole area. The purpose of backfilling the excavated pole area is to fill in the pole area that you have excavated so there will not be any future injuries by people falling in or stumbling on the open area in the ground. In addition, the backfilled earth will help keep the preservative both onto the surface of the wood pole as well as move deep within the wood pole itself.

Step Sixteen: Tamp loose dirt into place. The purpose of tamping the loose dirt into place is so you will not have any additional loss of cohesion of the soil to the wood utility pole, and so the wood utility pole will not have any greater flexural capabilities with the soil being tamped firmly in place. Packing the earth in place also helps to force the preservative that is currently under the impervious barrier, deep within the wood pole and securing it to the wood pole surface.

Step Seventeen: Secure tags on the pole to indicate inspection date and chemicals used. In addition to plugging the holes that were moored above ground, the operator and treatment inspector may wish to place in the inspection holes either fumigant, remedial treatment paste or gel, or liquid chemicals such as liquid copper naphthenate solution if there is a void that has been discovered or found. Always remember that every hole drilled in the pole must be plugged with either a suitable plastic replacement plug, such as a re-plug, or a treated wood dowel. Use of removable, screw fit, plastic plugs also allows auditors to go back in later and see what chemicals were used in the inspection holes, if fumigants or void treatments were used, and also lets you go back in with a probe inspector and probe for internal checks.

Securing the tags on the pole also serves to help keep your pole plant in good repair and also lets the people who come and climb the pole or inspect the pole following your treatment and inspection know when the last inspection pole was performed, if the pole was a danger pole, or if it was remedially treated—and if it was remedially treated what chemicals were used.

There are several variations in doing all of these inspection methods. Included below is an example chart taken from an International Pole Conference paper by Gerry Daugherty, which has been verified by several companies to show inspection efficiencies. It is noted that visual inspection is the least efficient inspection, whereas full excavation and treatment is the most thorough inspection with the highest percentage of both efficiency and confidence that you have determined a sound or solid pole.

Products and Chemical Technologies Available to Extend Pole Service Life

Single Biocides

Pol-Nu: This groundline preservative grease was originally registered by Chapman Chemical Company with the U.S. EPA in June of 1951 and contains 9.14% Pentachlorophenol as its sole active ingredient. In historical tests, this product was historically the best supplemental wood-preservative applied to the base of wood pole stubs/posts tested by the U.S. Government USDA-Forest Products Lab in their test site in southern Mississippi until CuRrap 20 testing was completed in 2009. Due to decisions made by the manufacturers of the active ingredient, Pentachlorophenol, the U.S. EPA is no longer allowing the use and the manufacture of this product due to lack of support by the active biocide manufacturer. This product has been effectively removed from the market in 1999 and received its official cancellation by the U.S. EPA in the year 2000. Although more than 30 million poles have been treated by this chemical since 1972, this product is no longer sold into the U.S. and World market.

Pole Wrap (formerly Patox): Pole Wrap is a manufactured preservative bandage, rather than a paste. Osmose, Inc. registered and introduced the product to North America in 1977. Pole Wrap contains 70.6% sodium fluoride as its sole active ingredient. Sodium fluoride has a 65-year successful track record as the most effective, water-diffusible active ingredient for the treatment of in-service wood poles. Laboratory testing and field trials performed by Osmose and Oregon State University confirm that sodium fluoride leaves the bandage and penetrates deeply into the pole. Pole Wrap's unique feature is that it is a dry-to-the-touch bandage, making it easy to use while eliminating exposure to workers or the soil. This product originally contained a second biocide in the form of NaPCP, but has not contained this second active for over a decade and a half.

COBRA WRAP: This pre-packaged wrap was originally registered ion 8 August 27 of 1998 and is a single biocide component wrap composed of Copper Naphthenate at a concentration of 17.8% (2% copper as metal). It has had widespread appeal to small REA's/RUS's/EMC's and municipalities who wish to install their own wraps at a competitive advantage. It should be noted that this formulation is a general use pesticide and does not usually require a certified applicator license to use and purchase this product. Essentially this product is the formerly sold product called Tenino Pole Wrap, but now includes a more effective packaging and delivery system.

Multiple Biocides

OsmosPlastic CF or COP-R-PLASTIC: Cop-R-Plastic combines the proven efficacy of sodium fluoride with highly effective copper naphthenate, in a thixotropic gel. Oregon State University conducted field trials suggesting that the penetration and retention of these active ingredients may be superior to alternative materials of similar composition. Cop-R-Plastic contains 44.4% sodium fluoride and 20% copper naphthenate (2% copper as metal). It should be noted that this formulation is a general-use pesticide and does not usually require a certified applicator license to use and purchase this product. One important thing to note about this system, is that even though it is a relatively new product on the, market, it has been tested and evaluated for over a decade before ever being launched and the biocides in it have a performance record of almost 100 years.

CuRap 20: This groundline preservative grease was originally registered by Chapman Chemical Company, now d/b/a ISK Biocides with the U.S. EPA in February of 1989 and contains 18.16% copper naphthenate (2% copper as metal) and 40.0% sodium tetraborate decahydrate (Borax) as its dual active ingredients. In historical tests, this product has proven to be the best supplemental wood preservative applied to the base of wood pole stubs/posts tested by the Mississippi State University Forest Products Lab in their test site in southern Mississippi and has outperformed Pol-Nu, a 10% penta-based wood preservative in recently published 15.5 year-old efficacy studies. This outstanding performance is most probably due to 1) the use of a dual biocide system, one to be the organic fraction to protect the shell and immediately underlying area from soft-rot attack, and 2) a diffusible component, borax, to effectively treat the inner zones of the wood, including the previously non-pressure treatable heartwood, and allows the diffusible component to move vertically up and down the pole as much as three feet from the site of application. It should be noted that this formulation is a general use pesticide and does not usually require a certified applicator license to use and purchase this product.

Pol-Nu 15-15: This special combination of 15% creosote and 15% pentachlorophenol was originally registered by the U.S. EPA in September of 1967 by Chapman Chemicals Company now d/b/a/ ISK Biocides. This special combination of two biocides was reviewed and specially formulated at the request of the AEP utilities as it was determined to be the most effective groundline treatment for poles in their particular system utilizing the combination of penta and creosote which Lumsden found to be synergistic. Although more than 25 million poles have been treated by this chemical since 1968, this product is no longer sold into the U.S. and World market.

TimPreg: This formulation of three biocides, penta, creosote, and sodium fluoride was a mainstay in the groundline wood preservation market for years. Originally registered by the U.S. EPA by Chapman Chemicals Company, it combines the synergistic wood preservation combination of penta, and creosote for shell and soft-rot protection and a diffusible component, sodium fluoride to deeply penetrate the untreated and treated area of the sapwood and heartwood to further protect the wood pole and the original pressure-treatment chemicals were depleted by leaching and environmental conditions. Although more than 15 million poles have been treated by this chemical since 1975, this product is no longer sold into the U.S. and World market.

TimPreg B Special: This is the same formulation as Timpreg, with the exception that Borax, a more effective biocide than sodium fluoride (Fahlstrom) was substituted for the diffusible component of this mixture. It was originally registered by the U.S. EPA by Chapman Chemicals Company. Although more than 30 million poles have been treated by this chemical since 1970, especially in Canada, this product is no longer sold into the Canadian and World market.

TriTox: This formulation was originally registered by Koppers Company with the U.S. EPA in the 1960s and is essentially the same as Timpreg and very similar to one of the earlier generation Osmosplastic F formulations.

Osmosplastic (Timber Life): OsmoPlastic was the world's most widely used paste preservative for in-service poles, with more than 1.5 million poles treated annually. OsmoPlastic combines both oil- and water-borne biocides in a thixotropic gel. OsmoPlastic was originally a mixture of a FCAP type of wood preservative with creosote combining the fungitoxic properties of Pentachlorophenol; di-nitrophenol, potassium dichromate, sodium fluoride, and creosote in a gel like paste. OsmoPlastic now contains 44.42% sodium fluoride, 45.62% creosote, and 3.2% sodium dichromate. Field trials confirm that sodium fluoride in OsmoPlastic penetrates as deep and stays in place at fungitoxic levels, than any other active ingredient used in paste systems. Creosote has proven to be a very effective co-biocide to protect the pole surface area. Sales of this product, although minor are now as compared to previous years, and still has some market share in Greece, Turkey, and some other Mediterranean areas.

Fumigants

Fumigants are basically chemicals that when reacted with a woody substrate, air, or other chemical ingredient, such as Cu or an acidic media, release a dose of gaseous compounds that are lethal to both decay organisms and insects. The most widely used fumigants in the marketplace today are based on decades of use in the agricultural chemical markets. These include Metham Sodium (i.e., vapam), Chloropicrin, Basimid (Ultra Fume, Super Fume, etc.), and very minor uses of sulfuryl fluoride and methyl bromide, but these last two enjoy most of their dwindling market share ex U.S. and Canada.

Internal Treatments

Although most of the above listed chemicals may be used for internal treatment of standing utility poles, the two major products used for this purpose in the marketplace today, include Oil-Borne Copper Naphthenate (OB CuNap 2%) and Hollow-Heart CF, a mixture of CuNap and NaF. Other earlier versions of Hollow-Heart contained other biocide mixtures, including such items as arsenic acid, sodium arsenate, sodium dichromate, potassium dichromate, dinitrophenol, and other insecticidal compounds, these formulations are no longer marketed today, since the very effective formulations of either CuNap or CuNap + NaF have proven themselves to be so effective over the last decade or two.

Additionally, some use of diffusible rods is also being used in the internal treatment industry. These include Flour Rods based on a solidified form of NaF in rod form; Cobra Rods, a mixture of Cupric Hydroxide and Boron, in solid rod form; and TimBor rods, a solid form of DOT (disodium octaborate tetrahydrate) solidified into rod form. It should be noted that this author has found rods to be very effective in arresting decay and preventing decay in wood, but only when average pole moisture contact immediately surrounding the rod exceeds +22% MC.

Historical Tests

There are many historical test sites throughout the country and the world. Many of these test sites are located at universities with active wood science programs, or near highly bioactive areas where decay and insect attack readily occur. This topic is too broad to be covered in this paper, however one should rely on independent test data when choosing and specifying an external groundline preservative paste. The suggested reading list and bibliography to this paper include many such references.

Manual, Mechanical, and Ultrasonic Inspection Devices

There are many technology-based inspection devices that have been created to try and reduce or replace manual inspection. This is because manual inspection takes skilled labor. As of yet no inspection technique can replace that of manual inspection described. That does not mean that these tools cannot be useful but that these tool are quite useful to a skillful inspector and you will probably find a few of these tools in a good inspector's tool bag. Below are inspection device descriptions, advantages, and disadvantages that are currently on the market.

Manual

Visual Inspection: Visually inspect the pole from top to bottom as seen earlier in Step One. This is one of the most basic and important steps for safety and identifying problem areas.

Hammer Sounding: Hammer sound the pole from as close to the groundline as possible to as high as the inspector can physically reach just as described earlier in Step Two of inspection. A low-pitched thud will help you locate decay or voids and tell you where to bore and probe into the utility pole.

Probe and Bore: A probe is used by inspectors and lineman to determine the extent of any soft spots on the surface of the utility pole located by the hammer. This is a fast way to determine the soundness of the utility pole. Routinely pressing around the pole with the probe at groundline will quickly show any badly decayed areas. Boring is describe in Step Three and can be used on any area of the utility pole in a series of borings or in areas identified by sounding to determine the quality of the wood into the center of the utility pole. Hammer Sounding, Probing and Boring in past studies completed by the authors proved to be accurate and faster than the ultra sonic test methods when compared for accuracy to full excavation.

Increment Borer: This device is very basic and can be twisted into the wooden utility pole or it can be attached to an apparatus that allows it to be chucked into a power drill. The tool consists of a handle, a carbide steel auger bit that is hollow, and a small, half circular, metal tray (core extractor) that fits into the auger bit. Cores are removed from poles and have a number of uses for inspection methods. The core can be taken from the outside of the pole to the pith showing the radius of the pole. Subjective measurements can be observed, such as the condition of the wood across the radius, the penetration of the preservative, and the later status of decay if present. Analytical measurements can be made, such as penetration, retention, percent active, the early detection of decay fungi, and fungi species. Strength properties can also be extrapolated from the core using various lab methods and by field devices. This is a valuable test in many instances in the inspection practice.

Mechanical

Pilodyn: This is a non-destructive test device. An integral striking pin is spring-fired into the wood using a predetermined load and the depth of penetration is contingent upon the density. The scale readings provide an accurate indication of the presence of "soft rot." The Pilodyn is also useful for wood density comparisons. This device is used in multiple disciplines and is a widely accepted test for comparison of surface density.

Resistograph: This is a non-destructive test device that captures the resistance of the constant force of a special micro-drill bit as it travels through the wood of the utility pole. This allows the user to identify soft spots and voids inside the wood. A corresponding graph is produced that shows the depth (inches and cm) and changes in density according to resistance providing a profile of the pole. Data from this device is used in various computer models to determine strength; it can stand alone as an inspection device, if used with a number of test points and is well received by engineers outside of wood science. Remember that observations are made across small sites and must be coupled with other inspection techniques to determine the overall condition of wood poles. This device cannot determine early stages of decay.

Fractometer: This device measures the mechanical bending fracture strength of increment cores removed from wooden poles. Assessments of decayed wood may be made by measuring the stiffness and fracture strength. This device is affected by the decay species infesting the wood. In early stages of wood decay by soft rot, species affect the bending fracture by showing normal fracture and large bending angles because of the degradation of lignin. Brown rot fungi will show just the opposite, resulting in smaller bending angles and quick breaks, this is a result of erratic cellulose decomposition. These data are used in models or a component of the model for determining strength of the wood. It is important to care for the increment borer used for extracting the core. The borer must be kept sharp and clean. Care must be taken of the core because a damaged core may affect the readings taken or at least make them suspect. Wood is variable so be sure to use the strength data provided with the instrument, if the species vary it may be necessary to develop strength data for that species. It is important to add a diffusible biocide to the increment core hole and fill with the appropriate treated dowel rod.

Electrical

Shigometer: This device is a non-destructive test method and measures electrical resistance using a probe with two wires on its tip. Probes are inserted into very small holes drilled into the wood pole (3/32 of an inch) and can detect resistance changes inside the wood pole that are associated with early stages of decay. It is known that metal ions are released by damaged cells causing the decrease in resistance; also decay fungi increase the moisture sorption of the wood cell causing the conductivity of the wood to increase by presence of moisture. It is important to remember that conductivity is moisture and temperature dependent; also this method is an indication of the presence of decay but not location in the pole. Other inspection techniques should be used for total evaluation and this is an important inspection tool for the toolbox. One technique is to use the frass from the drill bit just as in the bore inspection method listed earlier.

Ultrasonic: This device uses a sound wave sent by a transmitter (electronic or manual rasping with a hammer) through the tree to a receiver. Sound waves travel fast through most solid wood any decay causes the speed of the signal to go slower. The time for the signal to reach the receiver is measurement used and this is displayed and compared to the ideal transit time for the wood species. Various devices may use variables like wood species, diameter of the base, etc., to enhance their precision. If cavities are present the sound wave travels through the wood in a non-direct route causing the signal to takes longer. This device has been shown to be time-consuming in the field in its use for utility poles. Multiple readings are required in multiple quadrants to give accurate readings. Excessive pole bleeding, cracks, checks, and vegetation are some of the impediments of the device. It requires less invasive inspection practices and is handy to have in the tool bag for some jobs but it takes training to learn how to overcome its disadvantages.

Ultrasonic Tomography: This device uses multiple ultrasonic sensors to capture tomographic displays. Typically 10 to 14 sensors are used along with computer software to provide onscreen tomographic display. This is great for research and visualizing the cross-section of the utility pole. The Ultra Sonic Tomography device works up to diameters of 36 inches.

Stress Wave Timers: The devices are non-destructive and are similar to the ultrasonic devices in fact, they measure the time it takes for sound to travel through the poles cross-section using a transducer and hammer. The sound produced is a low frequency impulse generated by a special hammer that is used to tap one of the sensors and start a sound wave through the wood pole. These devices require contact with wood and screws that are inserted through a short distance into the wood pole. The lower frequencies used by these devices do not dissipate as quickly as the ultrasonics thus allowing for clearer signals. Some products use multiple sensors. This device has similar uses and disadvantages as ultrasonic but is used on bigger samples as longitudinal pole sections and observations on wood outside the utility pole market.

Polux: This is a nondestructive test device that is applied to the base of the utility pole and produces pole strength data by taking the groundline measurement of fiber strength (2–2.5 inches of the surface face to which it is attached), moisture content of a pole, and six other visual parameters: species, knots, circumference, height, age, and mechanical damage, to calculate the moment of rupture (MOR) at groundline. Resistograph data are used if better readings are needed for the internal condition of the utility pole. This MOR compares directly with the ANSI value to derive a percentage loss of strength from new.

Summary and Conclusions

It makes good sense to have an inspection and remedial treatment program in place to ensure that the investment in a pole plant can continue to provide useful and reliable service, as is its intended use, including protection of property and human life. External remedial treatments play a large and intensive role in that program as most, but not all, decay and insect attack are seen at or near the groundline. Many products are available on the market that will give adequate protection to the end user of these products and provide an excellent opportunity to extend a pole's useful service life. Although the model described in this paper gives an extended service life of only five years to a pole with two remedial treatments, it may be estimated that the average service life of 35 years for a pole may be essentially doubled if a regular and intensive groundline and aboveground inspection and maintenance program is employed. External remedial wood treatment can provide an excellent opportunity for the utility company to save millions of dollars over the long haul, while a nominal annual investment can easily be justified to supplement the service life of wood poles.

The findings of these scientists were that although many devices exist to inspect wood poles, in-service and prior to installation, the most effective system is the combination of a detailed visual inspection, top to excavated bottom, coupled with a sound and bore system. Although all the other inspection devices yield useful information, they cost the user more, plus have the capability of yielding more false positives than visual plus sound and bore inspection, with a fully excavated pole to a minimal excavation depth of at least 22 inches.

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