PRACTICAL ASPECTS OF REMEDIAL TREATMENTS FOR POLES

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Decay is one of the most serious problems encountered in long term service of transmission and communication poles. It is more economical to utilize well-treated poles initially, than to correct in-line problems. Even well preserved poles, deeply and uniformly penetrated with "fixed" and highly toxic preservatives, will eventually show depletion of the toxic chemicals, generally commencing in the groundline regions after the poles are set for service (Hawthorne, 1980). This depletion results from physical forces such as sublimation, diffusion, and leaching into the surrounding soil, and occasionally movement of free moisture in the sapwood regions (Zycha, 1963).

When this depletion continues until the threshold retention is exceeded, decay fungi become established in the wood (Fahlstrom, 1964). In some cases "fungal precursors" also set in and degrade the preservatives and thus improve the conditions for rapid deterioration of the wood (Roff and Krzyzewski, 1972). Before this stage is reached remedial treatments should be applied in the form usually referred to as "groundline" treatments.

In general, groundline treatments consist of excavating around the pole butt, and applying a preservative in the form of a thick paste, gel, mastic, or prepared wrapper (Blew, 1973), in close contact with the area of pole to be reinforced with preservatives. Other forms of application are also being used, such as the recently developed "Hydro Spade Process" (Inkis, 1975). These applications usually extend from 45 cm below to 15 cm (18 in. below to 6 in.) above ground.

The fungi-toxic chemicals gradually diffuse into the wood and as long as the concentration of the remedial composition is sufficiently high the diffusion will continue until the concentration of toxicants is more or less uniform throughout the sapwood region under the applied preservative chemicals.

However, after the remedial treatments are applied the same physical forces which reduce the concentration and toxicity of the originally impregnated preservatives now interact with the remedial preservatives and once again reduce the preservative effectiveness. After this period, usually about 7 to 15 years, it becomes necessary to re-apply the groundline treatments.

GENERAL PROBLEM AREAS

The chief problems common to most utilities are:

i) Need of criterion on which to base time of application of remedial treatments, and
ii) Supplies of poles for future requirements.

Reliable inspection procedures can identify candidate poles for re-treatment, and certain criteria are indicated which should "zero-in" on the poles which are ready for treatment so that the time of application will be optimal.

The utilities do not have a reliable source of poles to meet future demands. The predicted shortages of pole material spoken of at the Canadian Electrical Association (Quebec, 1978) were soon upon us (Hawthorne, 1980; Kelso, 1975), and little is being done to replace our forest resources. Kelso (1975) indicated that southern yellow pine poles are no longer readily available.

The timber shortages are being felt in other industries as well. One of our major railways is now making use of concrete railway crossties. Replacement poles are getting more difficult to obtain, and prices continue to escalate.

Substitute materials like plastics, concrete, and metals, are in general more expensive than the pole material they are replacing. Consequently, we must guard our poles as a precious commodity, and adopt principles which will guarantee their life in perpetuity if such were possible.

In future the utilities must make greater use of auxiliary treatments, both "internal" and also the external (frequently called bandage type). They must also develop new methods of protecting the aerial sections of poles so that these will remain serviceable as long as the replenished groundline regions will bear the physical loading on the poles.

A high priority should be given to upgrading poles which are already in lines through intensified inspection programs. Maximum life of new poles can be realized through improved initial inspections, improved routines of inspection in the field, and intensified maintenance programs.

INSPECTION AND UPGRADING

All utilities face these problems and the solution is not an easy one. Some utilities use statistical sampling of poles, and project the results for the entire lines. In this method, usually 10 sample areas per line are designated. Specimens for chemical and/or bio-assay are taken, each from 30 poles in each area. The residual levels of preservative are determined, and in the case of bio-assay the resistance to decay fungi is also determined. These results represent, with a certain degree of uncertainty, the situation in that particular line. The REA recommends that every pole be assayed chemically after about 15 years of service and early decay failure can be practically eliminated.

The pole inspector can be neither too lax, nor too stringent during inspections, since either of these would impose a financial burden on the utility. Poles for remedial treatments show signs that the wood is no longer sound but has sufficient residual strength to warrant further treatment and continued maintenance.

For inspection, the ground is removed around the pole to expose the region below ground level. This is often the location of deep decay pockets which will not be visible so long as the ground is undisturbed especially in dry and arid regions (Graham and Helsing, 1979; Opsal, 1975).

Poles "sounded" with a hammer have a characteristic ring and, in the hands of an experienced inspector, the hammer is a very useful tool. A "thud" ranging from a dull dead tone to a muffled resounding tone will indicate stages of internal degradation, or "water-logged" condition. The tone of the hammer impact is related to a mental image of the internal condition of the pole (Graham and Helsing, 1979). To become proficient in this art, poles freshly removed from service should be examined (before they dry out) and then sawn into sections to observe their internal condition. Inspectors are also checking results of Sonic Impulse Equipment in this manner, as there is some controversy as to the interpretation of test results (Shortle et al., 1978; Taylor, 1978).

Poles which are not solid must be inspected for type of degradation, i.e., superficial (within the sapwood), or internal, within the heartwood. Decay in the sapwood region can account for greater strength reduction than decay confined only to the heartwood. If the ring of solid wood is sufficient around the internal decay, a recommendation may include internal treatment.

Another useful tool in the hands of an experienced inspector is the Pressler increment borer (or brace and bit). This can be used to determine the extent of internal decay pockets. If the borer (or bit) advances with a degree of resistance and suddenly fails to advance, or else can be pushed into the wood by hand pressure, this is a positive indication of a decay pocket. The extent of the decay pocket can be evaluated by boring just into the decay pocket, and inserting a long needle-like probe and pressing it to note how far it advances before meeting resistance of solid wood again.

The increment cores taken from poles in the field are inspected for quality of the wood. This could be as follows: sound and normal, solid but "brash", partially "friable" (crumbles from finger pressure), and obviously decayed. These conditions would indicate, no decay, incipient decay, early stage of decay, and positive decay respectively.

If decay is present action must be taken to prevent further degradation of the wood. For confined internal decay a decision can be made in the field that groundline treatment should follow immediately.

Some of the other gradations shown in the increment cores cannot be classified so easily. For example, incipient decay cannot be identified during field inspections since this can only be verified under the microscope. Some species of fungi reduce the strength of wood in the early stages, while others are less destructive until they are well established. In case of doubt, increment cores for microscopic examinations should be taken. The estimation of residual pole strength would be facilitated if inspectors relied more on microscopic examinations, and then related these to the field inspections. Many poles could be saved from early failure if this procedure were adopted.

The removal of obviously rotted sapwood will not get rid of the fungus, since it develops beyond the areas weakened by the attack and will continue to grow as long as the wood is moist and untreated. When decay is evident the safety factor of the pole has been reduced and application of the groundline treatment will not alter this fact. The remedial treatment will reinforce the outer shell of sapwood but will not destroy the deeply advanced fungal hyphae.

The most suitable location for boring poles for internal inspection is about 2.5 to 4 cm (1 to 1.5 inches) away from a principle check especially if it terminates near the groundline. Moisture will be retained in these checks for extended periods and conditions for decay will be very satisfactory. Cores taken from these locations will, in most cases, give a true indication of the internal condition of the pole (Lindgren, 1975).

Poles with incipient decay, or any signs of early decay, will have to be examined further. The depth of sound wood in the outer ring must be determined before any action can be recommended. Some utilities (Inkis, 1975) require a minimum of five centimeters (two inches) of sound shell, but for demanding service such as in transmission lines eight to ten centimeters (three to four inches) is generally specified (Hawthorne, 1980; Inklis, 1975).

Interior heart rot may account for from 10 to 30 percent of the strength of the pole whereas decay in the outer shell may account for up to 60 percent strength reduction. A timber engineer could advise on the adequacy for continued service. Poles having about 13 mm (half an inch) or more of peripheral decay in the sapwood should be reported since strength reduction may be severe.

"Off-center" internal decay is extremely difficult to access since the wood around the decay pocket is also eccentric (Roff and Krzyzewski, 1972). The weakening in such cases can extend to the extreme outer fibres, and experience is required to detect the difference of this defect from "sound" wood.

RECOMMENDATION FOR IMPROVED DESIGNATION

I believe that the difficulties in estimating depth of treated sapwood, especially if inner rot is present, could be reduced. Since poles must be inspected for conformance to treating specifications and physical limitations of defects, before they are delivered to the utility, this would be an opportune time to make use of some form of designation on each pole (tag or brand) which would indicate the depth of preservative penetration. This designation would be of future assistance to the inspectors and the utility as well. About four grades of depth could be standardized for this purpose.

The depth of preserved sapwood determines the decay "induction period", i.e., the length of time after installation before the first signs of decay appear. Poles with the deepest sapwood will have the longest induction period, while the shallower sapwood poles will have comparatively shorter periods. Consequently, poles with deep sapwood will require groundline treatments from 10 to 20 years later than poles with shallow sapwood. This effect stems from the fact that poles with deep sapwood do not tend to expose untreated heart when seasoning checks occur after installation, whereas, shallow sapwood will frequently check into the heartwood regions.

This designation would also be of benefit to the utilities. For example, poles with the deepest preservative penetrations would be reserved for service where the longest life expectancy will be demanded, and for difficult access terrain. Thus, in order to realize the maximum benefit from the treatment, it is time that the utilities specified minimum sapwood depth requirements for each type of service location.

Adoption of this principle should reduce cost of inspections, increase the probability that the groundline treatments will be applied at optimum periods of service, and will permit allotment of the best poles for the most stringent service locations.

EFFECTIVENESS OF GROUNDLINE TREATMENTS

The service life of poles containing deep sapwood can be extended almost indefinitely, limited only by the physical life of the timber resulting from use of climbing irons, poor handling practices, etc. The level of preservatives in sapwood can be replenished by groundline treatments and we can prevent fungal attack if the treatments are re-applied before the threshold values are reached. The heartwood regions can be protected by use of "internal" treatments, and this is the subject of another technical paper to be presented today.

Performance of several types of penta groundline preservatives, e.g., grease, gel, emulsion, and a three-component system (containing inorganic salts), were evaluated at the Eastern Laboratory of Forintek Canada Corp.

Retentions were determined in three zones of depth (in 30 year old creosoted, red pine poles) at 12, 36, 48, and 60 months following treatments. Borings were taken at the groundline and at mid-point of the treated zone below ground level.

All tests indicated that equilibrium concentrations of the toxic components had not been established in four to five years (Krzyzewski, 1974; Krzyzewski and Spicer, 1974). It was concluded that treatments should remain effective for at least another five years or longer.

NEW GROUNDLINE FORMULATION

A groundline preservative recently developed and patented at the Eastern Laboratory of Forintek Canada Corp. (Canadian Patent No. 1058353) is called the Thickened Ammonia Base (TAB) treatment. TAB penetrates wood deeply, especially under moist conditions, and has a high degree of fixation. Copper arsenate (the active fungicide in TAB) has such a high resistance to leaching that it was estimated that re-treatment would not be required for possibly 20 to 25 years, but this must be borne out by field testing.

Results of the laboratory tests of absorption and penetration are shown in Table 1. During the early tests the retentions were based on the volume of sapwood treated, the weight difference of the applied mastic preservative and the recovered residue, after 30 days of storage either indoors, or five months outdoors during winter months (Table 1).

Examination of penetration showed that the sapwood was penetrated from 12 to 18 inches (30 to 45 cm) beyond the zones of the applied mastic. Consequently, field trials should include much narrower bands of application of the preservative. The rapid rate of diffusion of this preservative may allow the application of treated zones to be applied no more than 10 inches (25 cm) below ground and the treatment could be covered completely to be hidden from view. These aspects should also be tested in field applications.

Now for the composition of TAB preservatives. TAB consists of water insoluble chemicals which are solubilized for application as groundline preservatives, and this accounts for later fixation, and leach resistance. Copper arsenate, copper meta borate, copper carbonate, and zinc oxide, were the chemicals tested and all appeared to perform in the same manner. These chemicals were dissolved in ammonium hydroxide (at levels of 3.2 to 15 percent ammonia). The hydroxide solution was carried as a 50/50 mixture in Petrofibe (industrial vaseline) and Hedman-Cationic Fibre (an asbestos-like by-product of the mining industry). TAB can be worked easily in the usual manner in the field, and is most suitable for application in the spring (while pole butts are wet) and in the fall when the vapor pressure of ammonia is less objectionable to sensitive workers. The average depth of penetration in test sections of white spruce, white pine, and red pine specimens at high moisture content was 22.8 mm (0.9 inches) i.e., complete sapwood penetration in all test specimens (Figures 1 and 2). The average retention of copper arsenate was 29.9 kg/m^3 (1.87 pcf.) and if we allow a high margin for error, these retentions would still be effectively high. Figure 3 shows the effect of moisture content on depth of penetration.

H.H. Unligil, Pathologist at the Eastern Laboratory of Forintek Canada Corp. issued a certificate (Appendix I) that field tests conducted on 30 eastern cedar poles treated with TAB formulations (over winter from October to June) showed an average depth of penetration of preservative to 12.9 mm (half an inch) into heartwood regions of poles. Diffusion treatments are not known generally for effective penetration into the heartwood regions of poles.

Table 1

TAB Preservative - Penetration and Retention Tests

Test	Diameter		Moisture Content (%)		Penetration		Retention (3)	
No.	cm	in.	outer (1)	inner (2)	mm	in.	kg/m^3	pcf.
Unseasoned Logs Stored 30 Days Indoors								
1 Red pine:								
1	13.0	5.1	116	78	25.4	1.0	19.2	1.2
2	13.5	5.3	98	33	25.4	1.0	25.6	1.6
2 Jack pine:								
3	21.8	8.6	95	56	20.3	0.80	33.6	2.1
4	22.4	8.8	45	37	7.6	0.30	33.6	2.1
3 White spruce:								
5	24.8	9.8	145	129	25.4	1.0	8.32	0.52
6	26.9	10.6	93	41	15.2	0.6	19.2	1.2
7	24.9	9.8	131	35	25.4	1.0	28.8	1.8
8	24.9	9.8	91	33	20.3	0.8	36.8	2.3
9	23.1	9.1	91	33	20.3	0.8	51.2	3.2
10	25.7	10.1	14	14	2.5	0.1	-	-
11	18.3	7.2	113	188	31.8	1.25	38.4	2.4
12	17.0	6.7	65	38	27.9	1.1	32.0	2.0
Unseasoned Logs Stored Outdoors Five Months (Winter).								
4 White spruce:								
13	24.9	9.8	134	49	25.4	1.0	30.4	1.9
5 Jack pine:								
14	21.8	8.6	76	91	25.4	1.0	32.0	2.0
Creosoted Logs (144 kg/m^3 - 9 pcf.) Stored 30 Days Indoors.								
6 White spruce:								
15	18.5	7.3	22	17	5.1	0.2	-	-
16	17.8	7.0	55	18	10.2	0.4	9.4	0.6
17	16.8	6.6	85	35	15.2	0.6	17.6	1.1

(1) - 25.4 mm, 1-inch depth
(2) - 38 mm, 1.5-inch depth
(3) - Retention was expressed in terms of the active ingredient - copper arsenate.

Note: Specimen No. 10 was not included in calculations of averages (low m.c.).

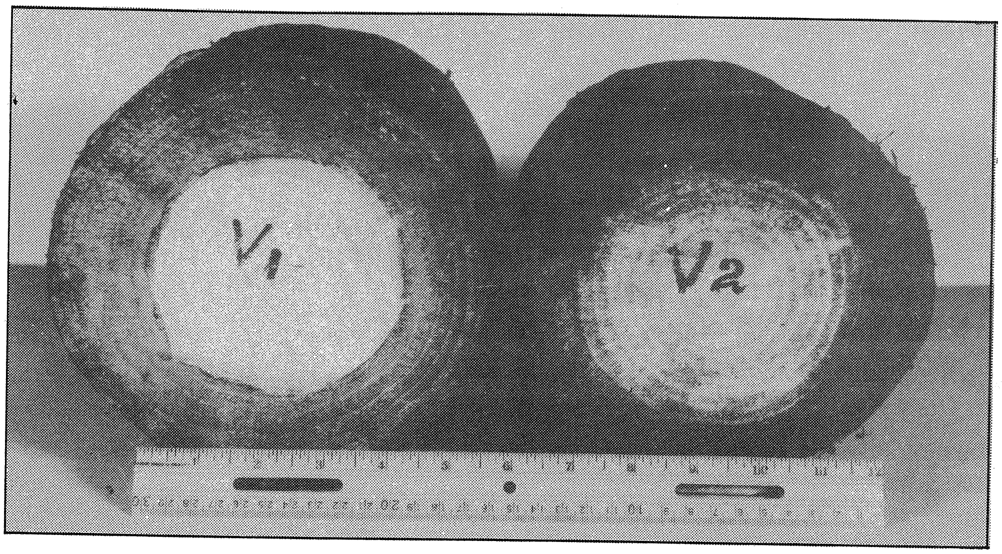

Figure 1. Penetration of TAB Preservative in White Spruce Logs.

Penetration - V1 - 1.25 inches (31.8 mm)
V2 - 1.10 inches (28.0 mm)

Retention - V1 - 2.35 pcf. (37.7 kg/m^3)
- V2 - 2.04 pcf. (32.7 kg/m^3).

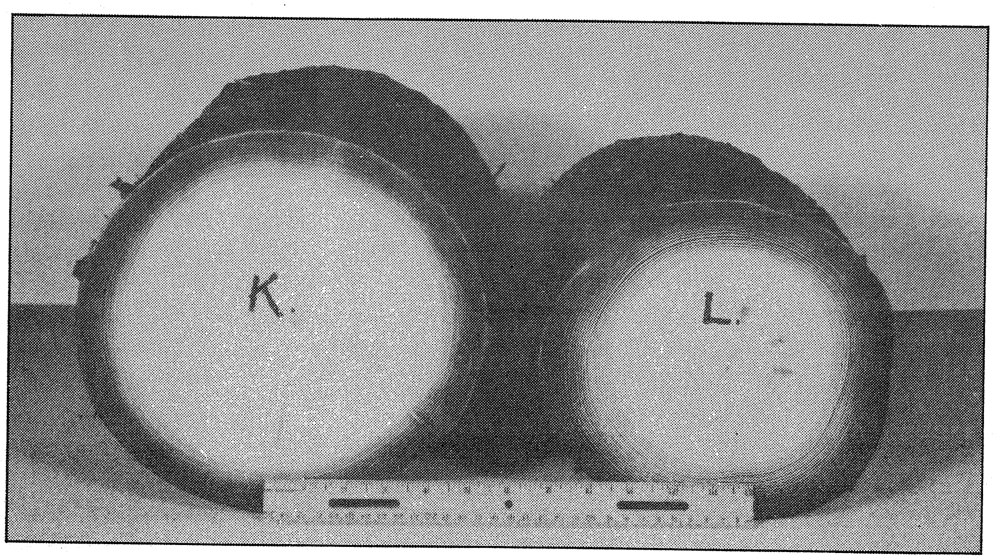

Figure 2. Penetration of TAB Preservative During Five Months of Winter Storage.

K - White spruce
L - Jack pine

Penetration - K - 1.0 inches (25.4 mm)
L - 1.0 inches (25.4 mm)

Retention - K - 1.9 pcf. (30.4 kg/m^3)
- L - 2.0 pcf. (32.0 kg/m^3).

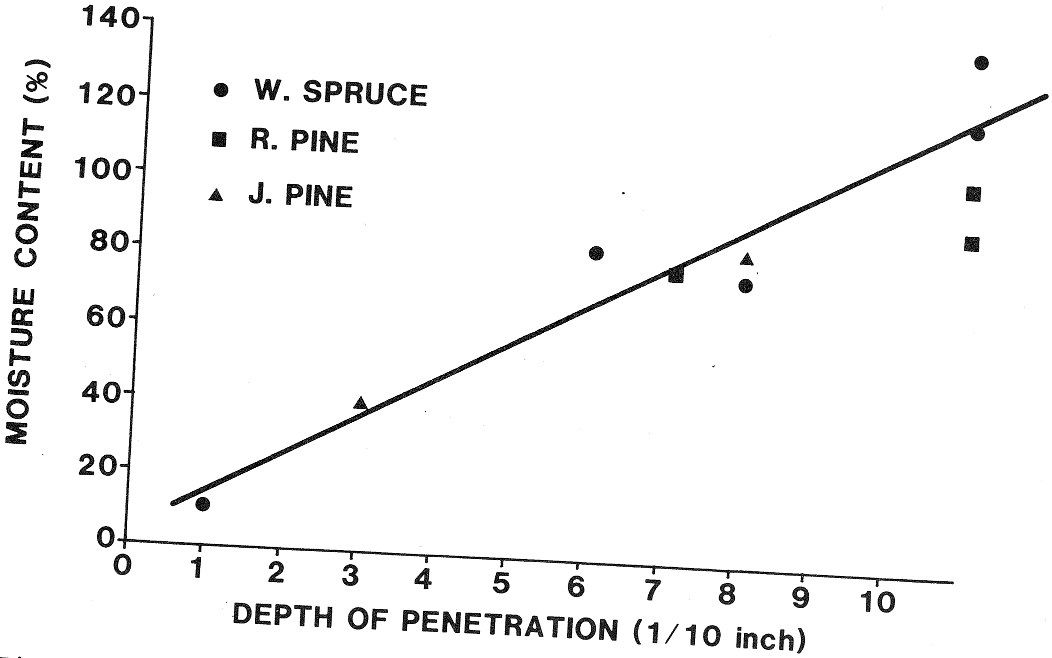

Figure 3. Influence of Moisture Content on Depth of Penetration.

Bioassay tests also conducted at the Eastern Laboratory of Forintek Canada Corp., on four red pine (*Pinus resinosa* Ait.) bolts treated with a CAA-TAB formulation at high moisture content, showed that they were effectively preserved against degradation by two arsenic tolerant fungi (Krzyzewski and Unligil, 1981). The bolts were stored for 30 days, and were penetrated to a depth of 24.2 mm (0.95 inches). The fungicidal effectiveness extended to this full depth.

EXPERIENCE GAINED FROM PAST PERFORMANCE

The pole utilities continue their research on pole maintenance and methods of extension of service life. A few interesting items have been listed in the following paragraphs.

If poles are stored for future use in horizontal piles, and the bottom tiers remain for long periods, gravity attraction will cause oil-borne toxicants to flow to the bottom regions, while check formations develop on the tops. As these increase in width and trap moisture, infection of the interior wood commences and continues at a rapid rate. Pressure treated poles had serious internal decay identified after three to seven years of such storage (Kelso, 1975; Opsal, 1975).

Poles should not remain in storage yards beyond 12 months (Kelso, 1975) and those taken from yards should be re-examined, and groundline treatments applied if any trace of white wood can be detected. Many utilities apply groundline treatments to all poles taken from storage yards.

Well preserved sound poles which required re-location after 10 years of line service decayed in new locations within four years (Opsal, 1975). Serious degradation was found well below ground in cold regions where decay was not considered to be a problem (Lindgren, 1975).

No matter how well a pole is preserved or upgraded in subsequent maintenance, gradual degradation will take place, and though the rate is reduced eventually the wood will be degraded sufficiently to require replacement (Taylor, 1978).

When re-treating decayed poles, even three millimeters (an eighth of an inch) of decay cannot be covered with a groundline preservative without aggravating the situation further (Lindgren, 1975). All decayed matter must be scraped off before remedial preservatives are applied.

Deep sapwood species preserved to 128 kg/m^3 (8 pcf.) of five percent penta can be expected to have a service life exceeding 50 years, and indications are that by intensified initial inspections a 90 year life can be expected.

Large poles require more than two years to air-season properly, and the seasoning affects the service life after the poles are installed (Lindgren, 1975). Narrow seasoning checks frequently expose the untreated heart and only deep penetration can offset this injurious effect. Retort conditioning is being recommended to replace air-seasoning as poles treated in this manner are superior in resisting decay attack in line service (Kelso, 1975). Poles conditioned by long Boulton cycle were shown to have the least amount of white wood showing after poles were set in line service (Lindgren, 1975). Artificial seasoning by steaming and vacuum method does not extract as much moisture as the extended Boulton process (Maclean, 1935).

In my visits to various treating plants, I have seen routine practice of Boultonizing carried out to remove moisture barely to the Fibre Saturation Point, and then the preservative was injected. These poles retained free moisture and on removal from the retort the poles had the same superficial appearance as unseasoned poles. No fine checking patterns were observed as would be expected had the poles been seasoned to, let us say, 30 percent m.c.

Consequently, your utility inspectors (when conducting plant inspections) should insist that conditioning be carried out until the check formation on the pole surfaces incidates that all free moisture has been removed and the cell walls are being dehydrated.

Superficial treatment (by brush and dip method) was shown by the Eastern Laboratory of Forintek Canada Corp. (Sedziak et al., 1970) to be very effective for above ground treatment. More use should be made of superficial treatments of checks in aerial sections of poles, as this too will prolong the life of the poles substantially.

Removal of poles is recommended only as a last resort if remedial treatment is not justified. Poles can frequently be saved by "stubbing" using either treated wood stubs, or steel channels which are driven into the ground alongside the poles, usually to a deeper depth than practical for wooden stubs. These are strapped to the body of the poles to strengthen the groundline support regions.

When poles are set in damp soil a reliable indicator of the internal condition, or of cellulose breakdown, is the moisture content readings taken on the pole butts, below ground level. Readings of only 50 percent or less, under such conditions, are a positive indication that the pole butts must be examined further (Taylor, 1975).

Our main purpose is to realize the maximum possible life from the poles in service whether it be by groundline treatments, internal treatments, by superficial treatments of the aerial sections, or by stubbing salvageable poles, since we must provide the safest poles for service, and conserve our forest resources as much as possible.

REFERENCES

Blew, J.O. 1973. Pole Groundline Preservative Treatments Evaluated. US FPL, Madison, WI.

Fahlstrom, G. 1964. Threshold values for wood preservatives. For. Prod. J. 14(11):529-530.

Graham, R. and G. Helsing. 1979. Wood pole maintenance manual. Res. Bull. No. 24, For. Res. Lab. Oregon State Univ. Corvallis, OR.

Hawthorne, S.H. 1980. Wood Preservation Research at Ontario Hydro. Ont. Hydro. Res. Rev. No. 1, Ontario Hydro, Toronto, Ont. p. 9-12.

Inkis, W. 1975. Labor saving system for pole groundline treatment. Proc. Sixth Wd. Pole Inst., Col. St. Univ., Ft. Collins, CO. p. 197-204.

Kelso, W.C. 1975. Uniform pole specifications. Proc. Sixth Wd. Pole Inst., Col. St. Univ., Fort Collins, CO. p. 33-34.

Krzyzewski, J. 1972. Five Year Performance of Slow Release Type Groundline Preservatives in Creosoted Pine Poles. Dept. Env. Can. For. Ser. EFPL Rep. OPX 44, Ottawa, Ont.

Krzyzewski, J. 1978. Thickened Ammonia-Base Preservatives. Canadian Pat. No. 1058353, Can. Pat. & Dev. Ltd., Ottawa, Ont.

Krzyzewski, J. and B. Spicer. 1974. Four Year Performance of Three Component Groundline Preservative. Dept. Env. Can. For. Ser. EFPL Rep. OPX 80, Ottawa, Ont.

Krzyzewski, J. and H.H. Unligil. 1981. Laboratory Evaluation of a Wood Preservative Bandage Containing Copper and Arsenic. Tech. Rep. No. 510E, Eastern Laboratory, Forintek Canada Corp., Ottawa, Ont.

Lindgren, P. 1975. Inspection of experimental Douglas-fir poles, Dorena tap line - Cottage Grove, Oregon. Proc. Sixth Wd. Pole Inst., Col. St. Univ., Fort Collins, CO. p. 41-46.

Maclean, J.D. 1935. Manual on Preservative Treatment of Wood by Pressure. USDA Misc. Pub. 224, Washington, D.C.

Opsal, P. 1975. Regional analysis of the service life of poles. Problems and solutions. Proc. Sixth Wd. Pole Inst., Col. St. Univ., Fort Collins, CO p. 33-34.

Roff, J. and J. Krzyzewski. 1972. In-Service Assessment of Load Capacity, Decay, and Re-Treatment of Utility Poles. Dept. Env. Can. For. Ser. EFPL Rep. No. OPX 45, Ottawa, Ont.

Sedziak, H., J.K. Shields and J. Krzyzewski. 1970. Effectiveness of brush and dip preservative treatments for above-ground exterior exposure of wood. J. Int. Biodeter. Bull. 6(4):149-155.

Shortle, W.C., J. Ochrymowych and A. Shigo. 1978. Patterns of resistance to a pulsed electric current in sound and decayed utility poles. For. Prod. J. 28(1):48-51.

Taylor, J. 1975. Panel discussion. Proc. Sixth Wd. Pole Inst., Col. St. Univ., Fort Collins, CO. p. 146.

Taylor, J.A. 1978. Pole maintenance - Its need and its effectiveness. Amer. Wood Pres. Assoc. Proc. 74:129-141.

Zycha, H. 1963. Observations on the migration of preservatives in bandaged poles. Holz Roh- Werkst. 21(9):380-385.