NEW DEVELOPMENTS IN REMEDIAL WOOD TREATMENTS

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Introduction

Virtually all materials on our planet degrade at some rate and this rate often dictates our material choices, the steps we take to prepare these materials, and the level of maintenance we apply. For utilities, the choice for materials to support overhead electric transmission and distribution lines is particularly important because a single pole failure is immediately evident to customers, reducing the ability to sell the product (electricity), and can result in costly emergency repairs to restore service. As a result utilities place enormous emphasis on selecting appropriate materials and the various electric safety codes incur added responsibility on the utility to maintain structures at an acceptable residual strength (ANSI, 1995).

Wood poles have generally been the preferred material for distribution or lower voltage transmission lines. While wood poles remain the most commonly used material for supporting overhead lines, a number of alternative materials have emerged including light-duty steel, fiberglass, and spun concrete. Each of these materials has been touted as superior to wood, notably in terms of resistance to biological deterioration. While these materials have some unique properties that make them useful in some applications, none are panaceas. Each requires the same careful specification, installation, and maintenance required for wood if utilities expect to achieve the promised long service life. In addition, utilities need to consider that the methods for treating wood poles with preservatives and the procedures available for maintenance have improved to the point where expected service lives for wood poles should approach one hundred years, particularly in Canada (Lindgren, 1989). This far exceeds the 30 to 40 years that most utilities have long expected. So, how can a utility use wood and achieve these longer service lives?

In this report, we will briefly outline some methods for improving initial pole treatment, then describe several new developments in supplemental treatments for extending pole service life.

Initial Pole Treatments

It is not the purpose of this paper to describe detailed methods for improving initial pole treatment, but there are several pretreatment steps that can have dramatic effects on the advancement of deterioration in service (AWPA, 1996; Brown et al., 1961; Graham et al., 1966; Graham et al., 1969; Graham, 1983; Lindgren, 1989; Merz, 1959; Morrell et al., 1994). Pole treatment is basically the development of an envelope of preservative protection around an untreated heartwood core (AWPA, 1996). The thickness of this layer usually depends on the amount of permeable sapwood on the pole. Thick sapwood species such as southern and red pine, have deep bands of preservation treatment. Even if this band is compromised internally, the thickness of the treated shell makes it highly unlikely that the loss of strength in the core will affect overall pole strength. Thin sapwood species, however lack this margin of safety and maintenance of the protective preservative envelope becomes increasingly critical. As a result, a number of pretreatment steps or processes have been identified to protect the envelope or to enhance the treatment at a specific locations along the pole when the risk of decay is greater.

The simplest method for maintaining the integrity of the treated shell is to make all bore holes and cuts prior to treatment and to ensure that the pole moisture content is as close to the in service moisture content as possible prior to or immediately after treatment (Graham, 1983). This is not always possible, particularly in larger poles. As a result poles continue to dry in service and this drying induces stresses that lead to the development of deep checks that compromise the treated shell.

Several methods have been developed to maintain the integrity of the preservative-treated shell. Kerfing involves making a sawcut along the length of the pole to the pith prior to treatment. This treated kerf then acts to relieve the stresses that normally develop as the pole seasons after treatment (Graham, 1966). This results in fewer deep checks that might compromise the treated shell. Kerfing is used by a limited number of utilities in North America and virtually eliminates internal decay in poles. The alternative to controlling checking is to improve treatment. Through-boring or radial drilling uses this approach to enhance performance (Graham et al., 1969; Merz, 1959). Both processes involve drilling holes into the pole at critical high decay hazard areas (groundline zone and at crossarm attachment points) to increase the amount of wood cross-section exposed to preservative. Radial drilling involves drilling holes at selected spacings around the circumference of the pole to a depth of 75 to 150 mm. Through-boring involves drilling holes on one face of the pole through to the opposite face. Both processes produce deep preservative treatment and virtually eliminate the risk of decay in the drilled zone.

Predrilling, kerfing, radial drilling, and through-boring can all improve pole performance but the final critical step to ensure the protection of a quality pole is strict adherence to well-written specifications. Critical to this process is the institution of in house or third party post-treatment inspection to confirm that all poles meet minimum quality standards. This final but key step, helps to minimize the potential for poorly treated materials entering the system. It is often this very material that necessitates costly emergency repairs and consume a disproportionate amount of limited maintenance dollars.

The rigid adherence to a well-written specification can markedly reduce future problems with all pole materials, but equally important is the development of regular inspection and maintenance procedures. Inspection of wood poles has been addressed in a number of other papers, instead, this paper will focus on the chemicals that can be used to arrest the development of decay on in-service poles.

Remedial Treatment

Once in service, wood poles provide excellent performance, but damage to the treated shell can permit entry by decay fungi (Zabel et al., 1992). Most fungal attack occurs at the groundline, but decay can extend far up the pole in wetter climates (Morrell et al., 1995). Remedial treatments are used to arrest decay on the surface or inside of the pole. In general, surface treatments do not control internal decay, nor do internal treatments have a significant affect on decay near the surface. There have been a number of new developments to improve performance or enhance safety of remedial treatments and these will be outlined below. Surface treatments are normally used to supplement the preservative shell in wood species such as southern pine or western redcedar. They are also used when poles are set in concrete or when poles are moved to new locations. Internal treatments are used on nearly all pole species, but they are most often applied to thin sapwood species such as Douglas-fir, lodgepole pine, or western redcedar.

Surface Treatments

Surface treatments are typically used to supplement the initial preservative treatment and protect a relatively shallow zone ranging from 12 to 50 mm from the surface. For many years, these treatments contained a potent array of oil and water soluble chemicals including copper, chromium, arsenic, fluoride, creosote, pentachlorophenol, and dinitrophenol (Chudnoff et al., 1977; DeGroot, 1981; Harkom et al., 1948; Henningsson et al., 1988; Leutriz et al., 1962; Panek et al., 1961; Smith et al., 1967; Ziobro et al., 1987). These systems were highly effective, but increasingly stringent environmental regulations have resulted in substitution of formulations containing combinations of copper naphthenate, sodium fluoride, or boron (Morrell et al., 1994; Morrell et al., 1996; West et al., 1992). A number of field trials have shown that formulations containing these components move through Douglas-fir, ponderosa pine, and western redcedar at rates sufficient to kill fungi near the surface (Figure 1) (Morrell et al., 1996). In general, there appears to be relatively little consistent difference in chemical movement between formulations containing similar biocides. As a result, the extensive biocide substitutions driven by changes in pesticide regulation did not appear to have affected treatment efficacy. Evaluations indicate copper in the copper naphthenate-based material migrates into the wood to only a limited extent, even when a water-soluble amine based copper naphthenate was used. Both boron and fluoride moved more deeply into the wood than copper. Boron has tended to either leach from the pole or diffuse further inward to the point when overall boron levels were below the detection limit of the assay method. These results suggest that boron has relatively little value as a biocidal component in a groundline preservative. Fluoride has tended to remain in the wood to a greater extent than boron, regardless of species.

There is at least one other external preservative formulation that incorporates boron and fluoride as pellets in a plastic wrap. This system is employed in Australia, but is not registered in the U.S. Field tests of this formulation have been established on Douglas-fir pole sections, but have not yet been sampled. One potential drawback of such a system is the susceptibility of either water soluble component to leaching loss as water flows down the pole.

While supplemental external preservatives are widely used, there have been relatively few changes in formulation over the last 5 years. Barring regulatory changes regarding the use of copper compounds, it is likely that there is little incentive to substitute alternative materials.

One aspect of external preservative formulations that remains unknown is the potential for future regulation of copper based biocides. While there are data suggesting that migration of components from external preservatives into the ground surrounding a pole is minima, public sentiment may overwhelm such data. In addition to a sodium fluoride based formulations, several organic based biocides are available in other countries. Formulations containing propiconazole or thiocyanomethylthiobenzothiazole have been evaluated elsewhere but there are no field tests of these formulations in North America.

Internal Treatments

Internal treatments for wood poles can be divided into 3 groups, volatile fumigants, water diffusible chemicals, and oil-based materials.

Void Treatments. Oil-based materials are typically used to treat voids in the wood that may have been caused by decay fungi or insects. These systems have typically contained a fungicide such as sodium fluoride or copper naphthenate and may contain an insecticide such as chloropyrifos. There is relatively little information on the efficacy of these systems. In principle, these systems coat the void surface, limiting expansion of the cavity. In practice, much of the chemical treats rotten wood which has little or no residual strength. In addition, voids often connect to checks, creating the potential for environmental contamination around a pole.

Fumigants. The other two internal remedial treatments have received much greater attention. Fumigants have a long history of successful use for arresting internal decay in wood poles in North America (Giron et al., 1989; Graham, 1983; Helsing et al., 1984; Morrell et al., 1986; Morrell et al., 1996). Throughout this period, however, continuing concerns about the volatility, causticity, and aquatic toxicity of these chemicals have encouraged a search for safer formulations. In the past decade, two new fumigant formulations have been identified and one modification of an existing fumigant has been developed. Methylisothiocyanate in glass or aluminum tubes (MITC-Fume, Osmose Wood Preserving Inc., Buffalo, NY) was developed 8 years ago (Morrell et al., 1992; Zahora et al., 1985). Long term tests of this formulation in Douglas-fir and southern pine poles indicate that MITC-Fume performs better than metham sodium (Table 2). The advantage of MITC-Fume is that the active ingredient is a solid below 37°C and the tube protects the applicator from chemical contamination prior to and during the installation. The disadvantages of this system are higher cost and a tendency for MITC to stay in the tubes for long periods after application, particularly in cooler climates.

Basamid is a solid, crystalline material that decomposes in the presence of water to produce MITC along with a variety of other sulfur compounds (Eslyn et al., 1985; Forsyth et al., 1993; Forsyth et al., 1995; Highley, 1991; Morrell et al., 1988). Field trials initially suggested that this chemical decomposed too slowly to be effective, but more recent trials suggest that Basamid has the potential for longer term release of MITC than metham sodium (Figure 1). This provides the potential for a longer protective period thereby reducing maintenance cost. Basamid decomposition can also be accelerated by addition of copper compounds including copper sulfate or copper naphthenate. The enhanced MITC release appears to be temporary, but may be useful where active fungal attack is present. Basamid is already registered for application to non-food crops and is in the process of registration for wood pole applications. Once approved, Basamid should provide a viable alternative to metham sodium.

The third new fumigant formulation is polymer encapsulated chloropicrin. Chloropicrin is one of the best wood fumigants but its high volatility and toxicity have generally limited its use to poles in rural areas. Recently, a formulation of polymer encapsulated chloropicrin has been labeled by the U.S. Environmental Protection Agency for use in wood poles. The purpose of this formulation was to safely control release of chloropicrin prior to application and by doing so, extend the period between retreatments. Field trials of this formulation have shown that chloropicrin has moved steadily from the ampules to protect the groundline of western redcedar, Douglas-fir, and southern pine pole sections. A series of 10 field test sites have been established in utilities across the United States to evaluate the effectiveness of this chemical under varying climatic conditions. Preliminary data suggest that the rate of chloropicrin movement varies markedly with climate. Unfortunately, registration of this formulation is not being pursued in Canada.

It is likely that there will be ever increasing interest in safer, more easily handled formulations. Although fumigants are not currently widely used in Canada, the development of more controllable fumigant formulations could encourage their use. This is particularly important since fumigants can move rapidly through virtually all wood species to arrest decay and prevent further decay.

Water Diffusible Chemicals. Water diffusible treatments offer an alternative to fumigants for controlling internal decay (Becker, 1976). These systems are based primarily on boron or fluoride but may also contain water soluble copper naphthenate. These materials are applied to the poles in a manner similar to that used for the fumigants, but differ in the rate at which they move through the wood to affect fungal control. Diffusible formulations currently used in North American include fused borate rods (Impel Rods, CSI, Charlotte, NC) sodium fluoride rods (Patox Rods, Osmose Wood Preserving Inc., Buffalo, NY) or sodium fluoride/sodium tetraborateoctahydrate rods (Pole Saver Rods, Preschem Ltd., Cheltham, Queensland, Australia).

Field trials with borate rods have shown that the boron diffuses more slowly through wood than do fumigants and is very sensitive to moisture variations (Highley, 1984; Lebow et al., 1989). Moisture contents in wood poles vary with distance from the groundline, from the outer surface inward and seasonally. All of these factors can result in uneven boron distribution sharply diminishing the value of treatment with boron rods (Table 3). Boron levels in Douglas-fir poles did not reach fungitoxic levels until 3 years after treatment. While this does not preclude use of boron rods for internal decay control, it is clear that the expectations of this chemical must be realistic and must recognize the risk that a pole containing an actively growing decay fungus will continue to experience decay. Off-setting this risk is the relatively low toxicity of boron to nontarget organisms including humans.

Field trials with fluoride/boron rods in Douglas-fir poles have also shown that both boron and fluoride move more slowly through the wood than do fumigants. Unlike the boron rods, however, the levels of these chemicals never exceeded those required for fungal control (Figure 3). These results differ from those found in Australia and may reflect the use of higher dosages on the Australian poles. The levels evaluated on Douglas-fir were based on the potential volume of chemical that could be applied to the treatment hole. It is unlikely that higher chemical loadings would be used since the two rods per hole dosage nearly filled the treatment hole. Higher dosages would require more or larger holes and this would have a negative impact on pole properties.

Sodium fluoride rods have a long history of usage in the railroad industry, but have only recently been registered for application to wood poles. As with both boron and boron/fluoride rods, moisture present in the wood helps to release the fluoride form the rod. Field trials of sodium fluoride rods, which have only been in place for 1 year, show that fluoride levels have not yet reached protective levels, but the chemical does appear to be moving steadily into the wood (Figure 4). Once again, however, this treatment requires more time to arrest decay than a comparable fumigant treatment. This disadvantage is counter balanced by the lack of volatility and safer handling attributes of the rods.

The decision to use diffusible or volatile internal treatments is a function of the risk of decay as well as the perceptions of the user. When used properly, fumigants provide rapid reliable decay control and result in residual protection for 5 to 10 years, depending on the climatic conditions and wood species. Some utilities are hesitant to use volatile chemicals and instead prefer the ease of handling associated with water-diffusible rods. Both systems are effective and should provide control of existing fungal decay, albeit at different rates.

CONCLUSIONS

Remedial treatments have long been used to arrest or prevent decay of wood poles and their effectiveness is demonstrated by the increasing ages of many pole plants. The treatments that produced these improved service lives have some objectionable properties that have encouraged the development of alternative materials with improved handling properties. A variety of field trials indicate that these newer systems have slightly different performance characteristics, but with the exception of the boron/fluoride rods, these materials appear to be capable of arresting internal decay and limiting renewed damage. These newer treatments should continue to provide utilities with a potent array of materials for limiting biological attack on poles and extend the service life well beyond the minimum 30 to 40 year figures that are often quoted. This approach makes wood an ideal choice for supporting future overhead electrical systems.

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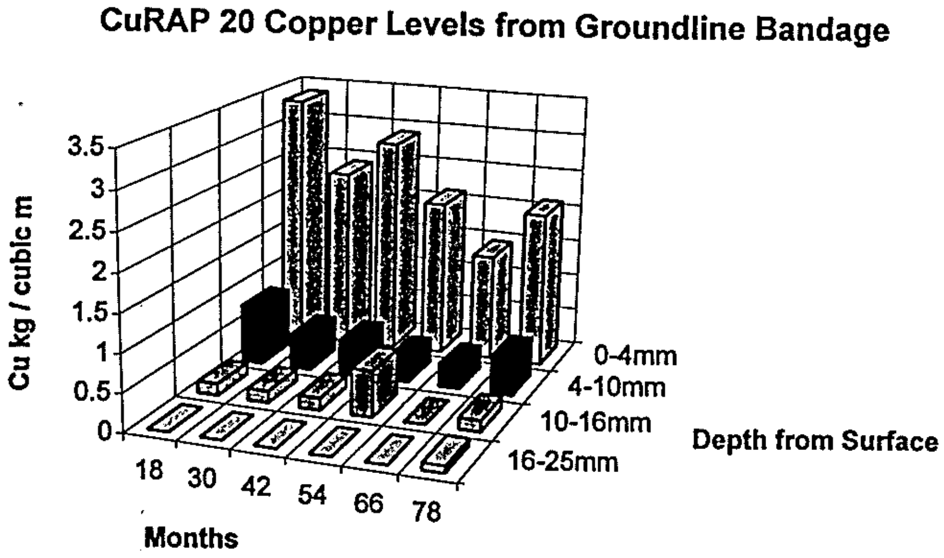
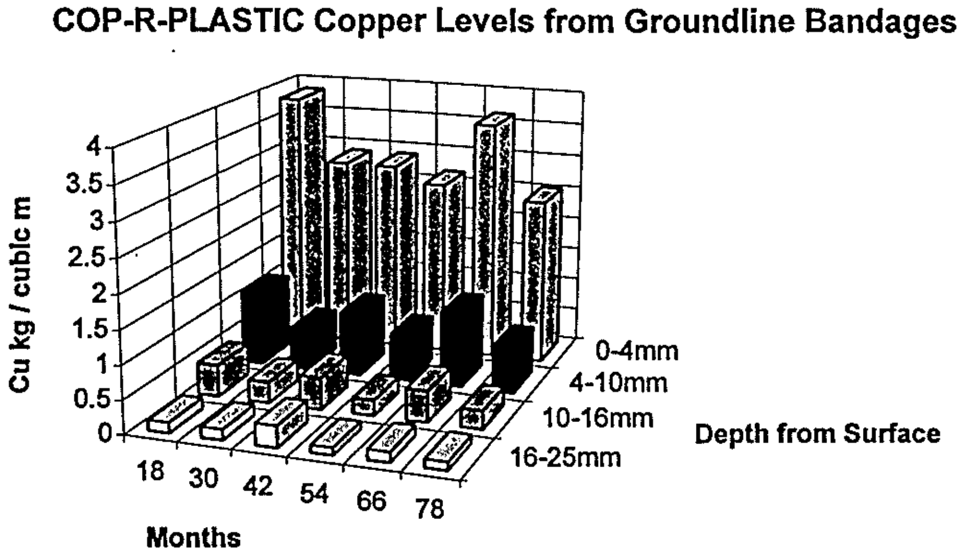
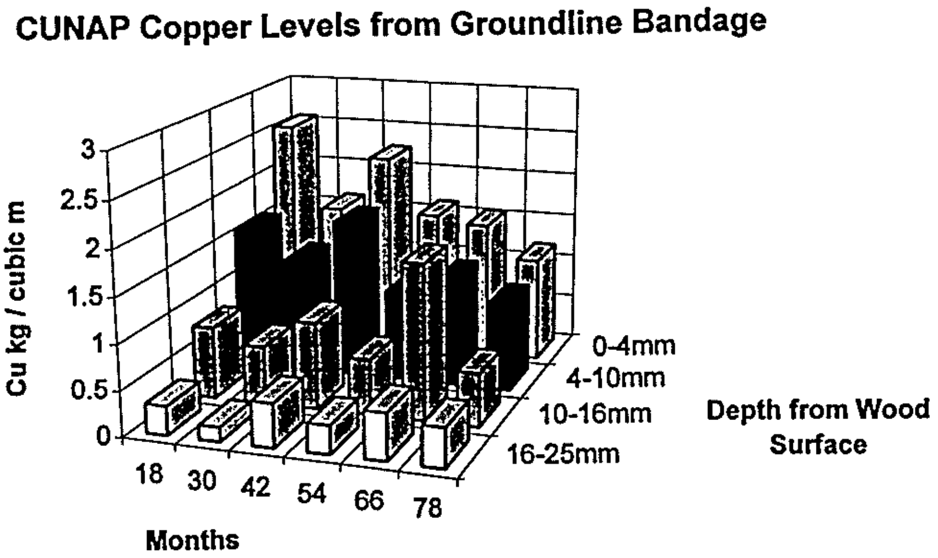


CuRAP 20 Copper Levels from Groundline Bandage

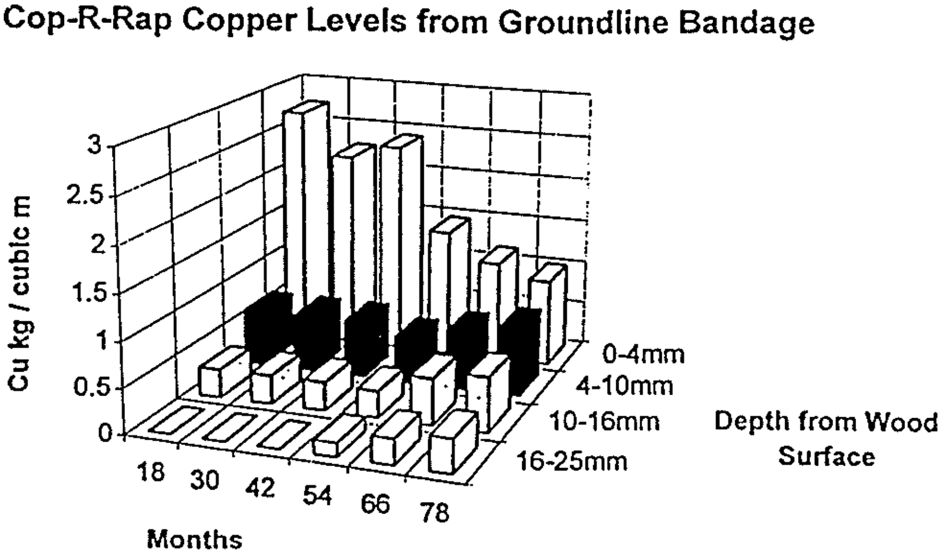


COP-R-PLASTIC Copper Levels from Groundline Bandages

Figure 1. Residual levels of copper naphthenate (as Cu) in Douglas-fir poles treated with (a) CuRap20 or (b) Cop-R-Plastic ground line bandage systems.

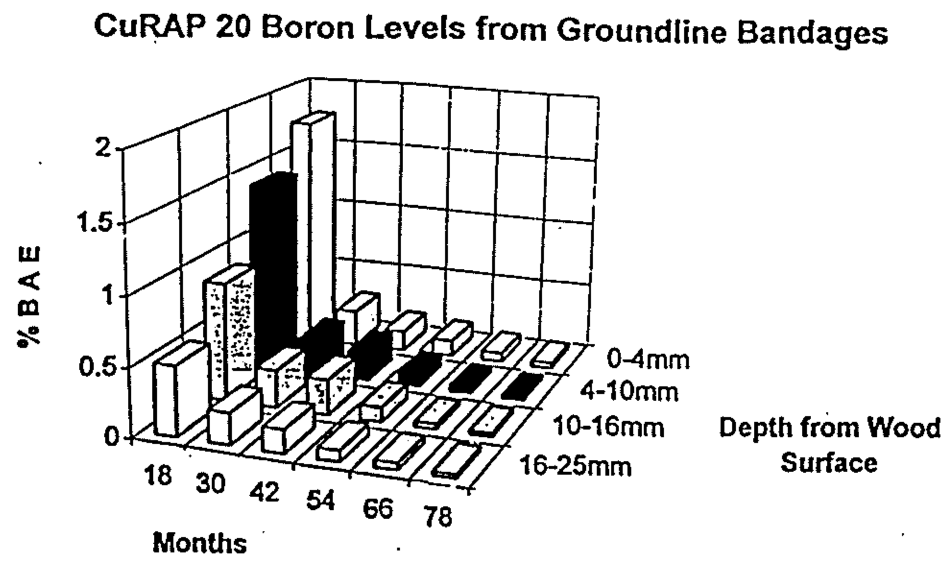


CUNAP Copper Levels from Groundline Bandage



Cop-R-Rap Copper Levels from Groundline Bandage

Figure 1. Residual levels of copper naphthenate (as Cu) in Douglas-fir poles treated with (c) CUNAP WRAP®, (d) COP-R-Rap ground line bandage systems.



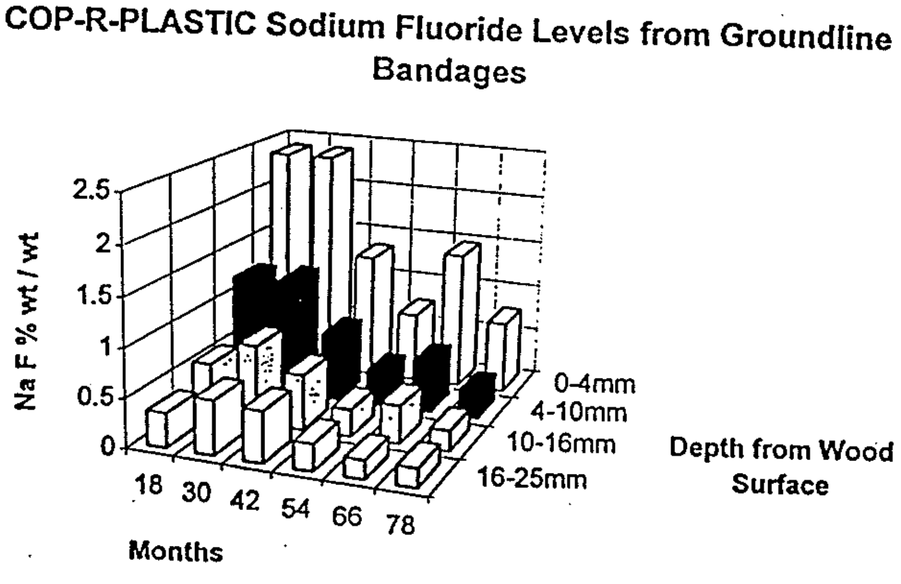
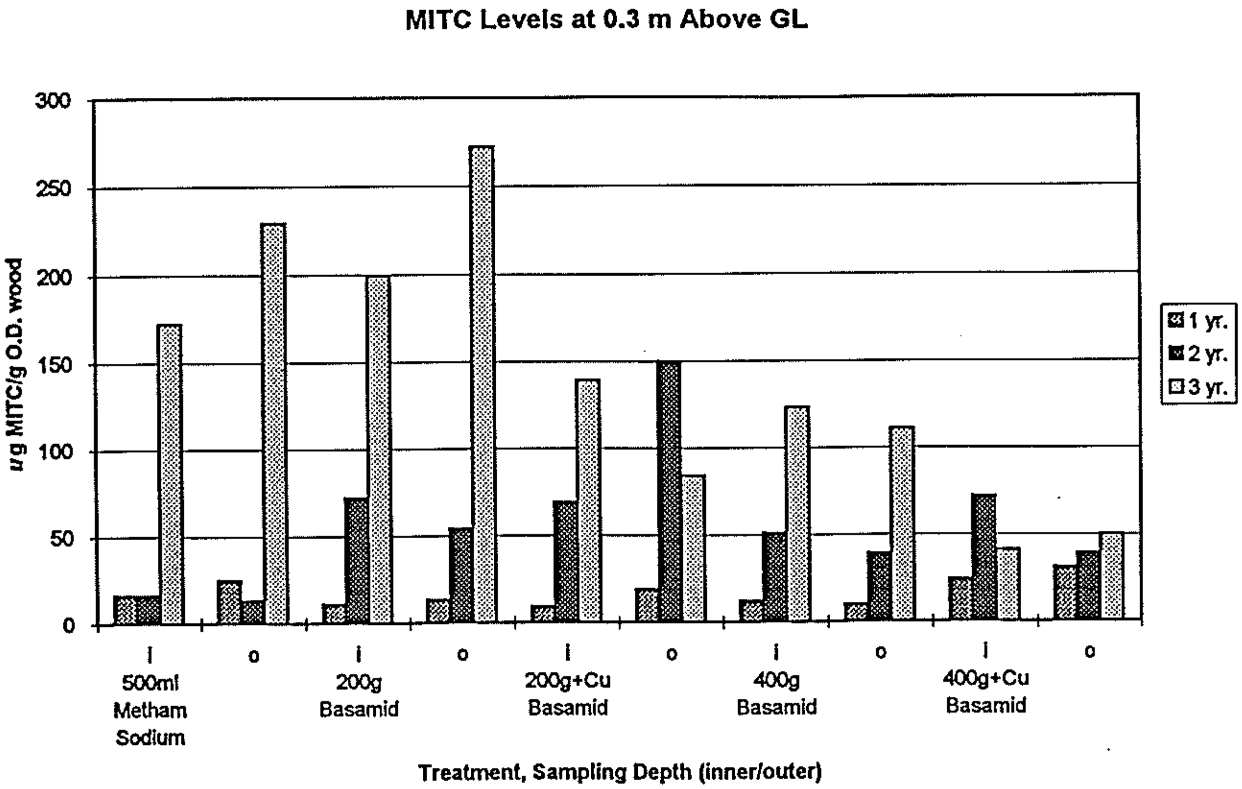


Figure 1. Residual levels of boron or fluoride in Douglas-fir poles treated with (e) CuRap20® or (f) COP-R-PLASTIC®, respectively.



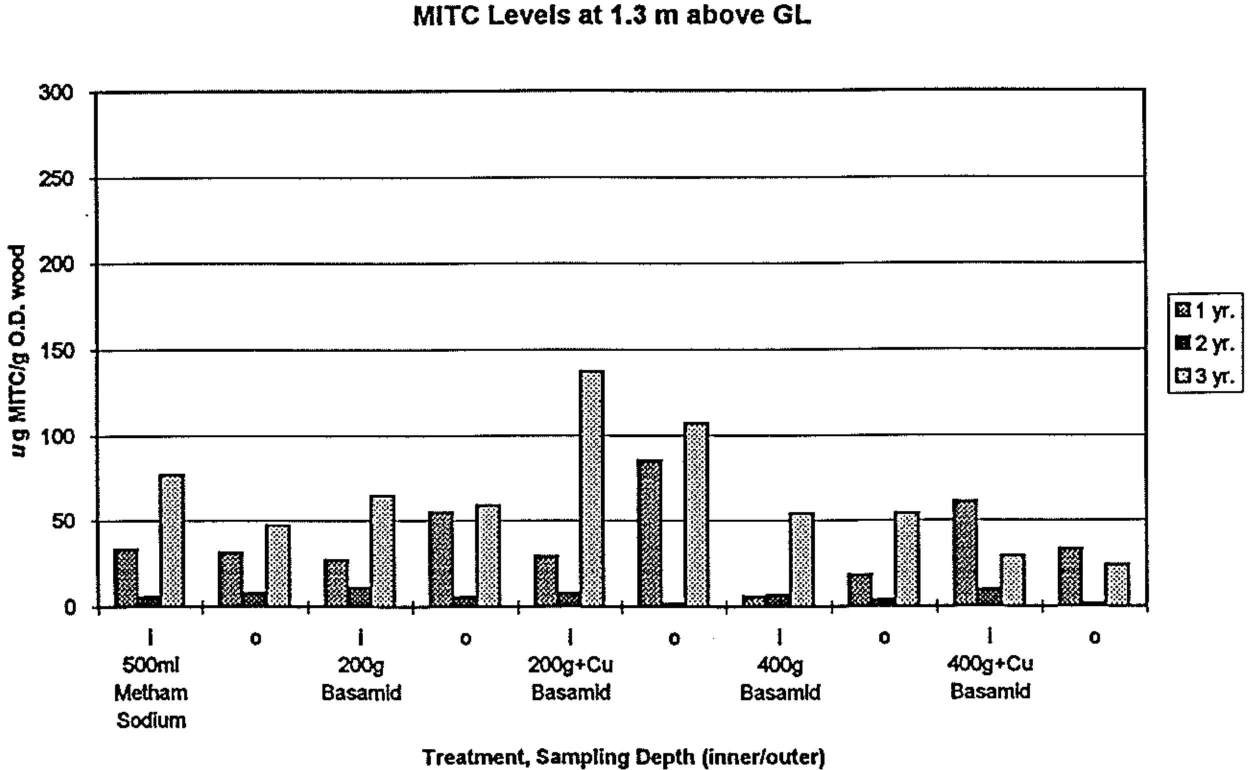


Figure 2. MITC levels in Douglas-fir poles 1 to 3 years after treatment with 500 ml of metham sodium or 200 or 400 g of Basamid with or without copper sulfate.

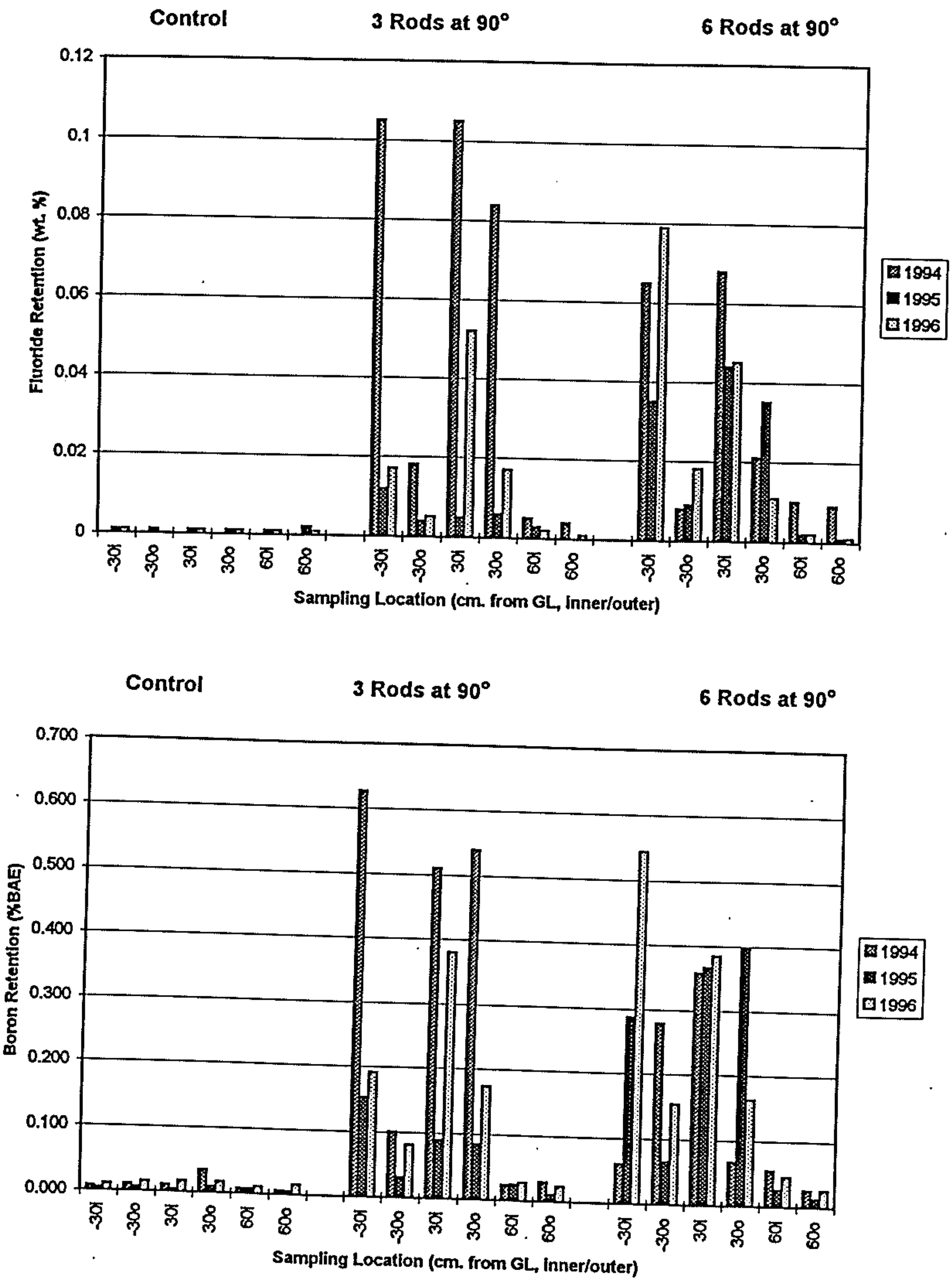
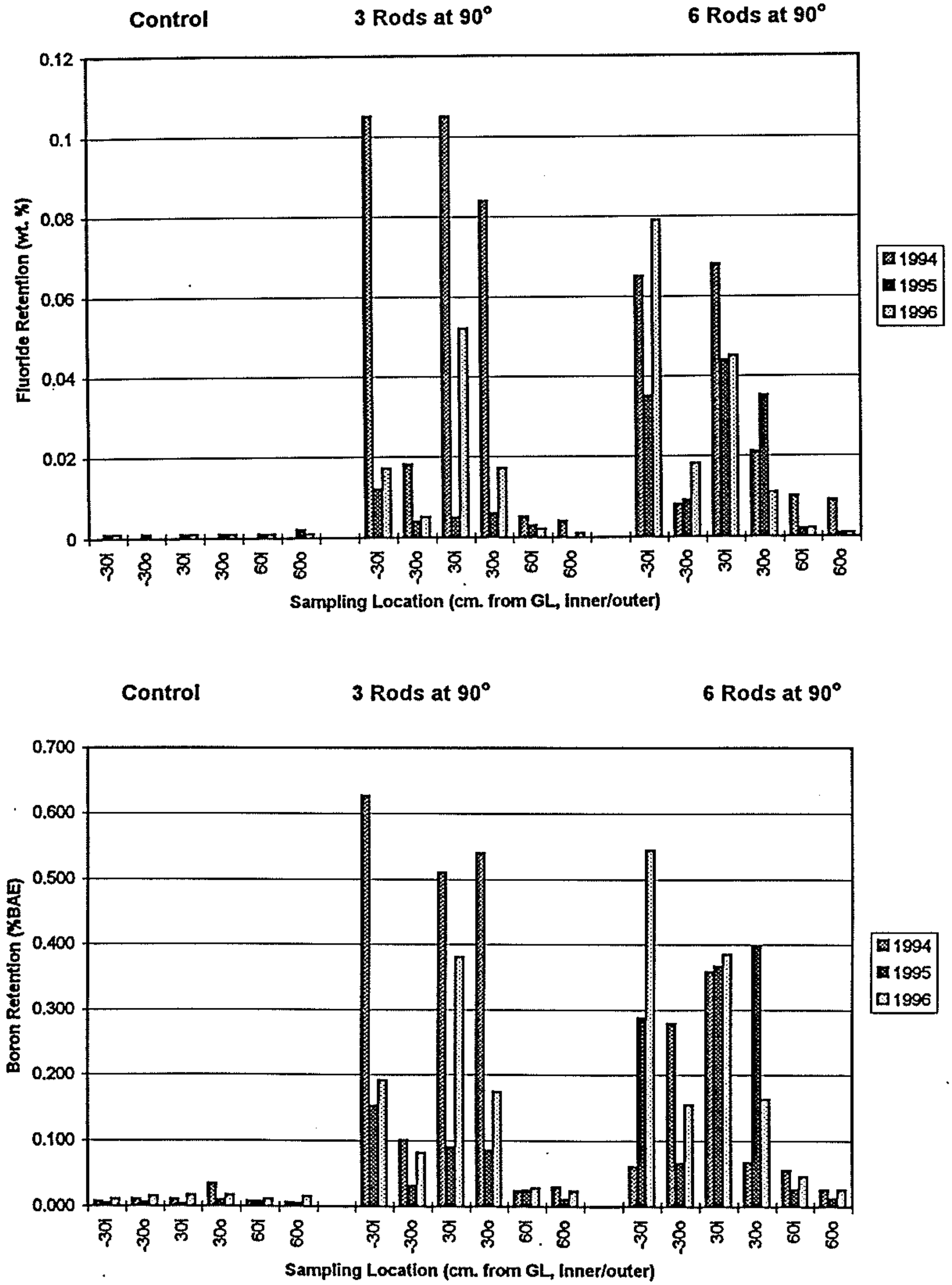


Figure 3. Residual fluoride and boron levels at selected distances from the ground line of Douglas-fir poles 1 to 3 years after treatment with 3 or 6 boron/fluoride rods in 3 holes spaced 90 or 120 degrees around the pole.



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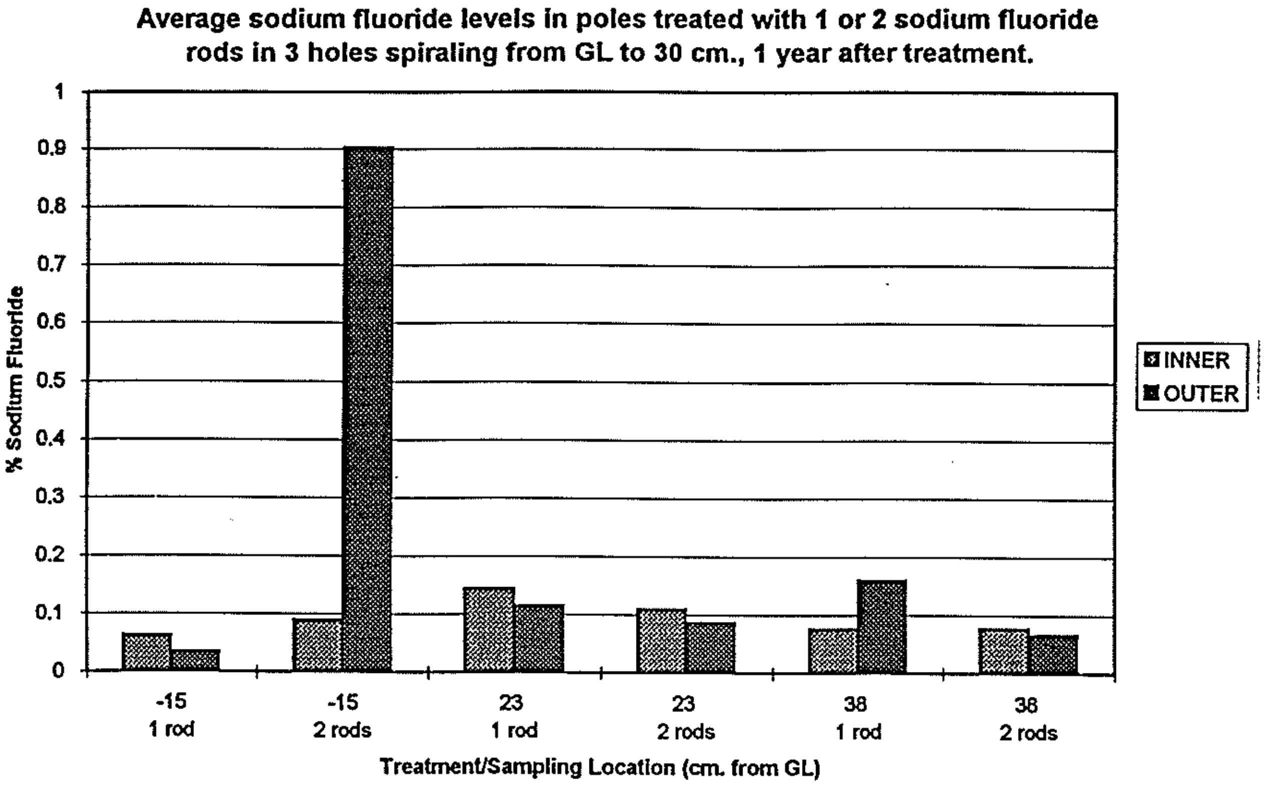

Figure 4. Residual fluoride levels in the inner or outer 25 mm of increment cores removed from above or below the ground line of Douglas-fir poles 1 year after treatment with sodium fluoride rods.