

Objective IV

PERFORMANCE OF EXTERNAL GROUNDLINE PRESERVATIVE SYSTEMS

While preservative treatment provides excellent long term protection against fungal attack in a variety of environments, there are a number of service applications where the treatment eventually loses its effectiveness. Soft rot fungi can then decay the wood surface, gradually reducing the effective circumference of the pole until replacement is necessary (Figure IV-1). In these instances, pole service life can be markedly extended by periodic below ground application of external preservative pastes that eliminate fungi in the wood near the surface and provide a protective barrier against reinvasion by fungi in the surrounding soil (Figure IV-2).

For many years, the pastes used for this purpose incorporated a diverse mixture of chemicals including pentachlorophenol, potassium dichromate, creosote, fluoride and an array of insecticides. The re-examination of pesticide registrations by the U.S. Environmental Protection Agency in the 1980's resulted in several of these components being listed as restricted use pesticides. This action, in turn, encouraged utilities and chemical suppliers to examine alternative preservatives for this application. While these chemicals had prior applications as wood preservatives, there was little data on their efficacy as preservative pastes and this lack of data led to the establishment of this objective. The primary goals of this objective are to assess the laboratory and field performance of external preservative systems for protecting the below ground portions of wood poles.



Figure IV-1. Examples of soft rot at or below the groundline.



Figure IV-2. Example of an external paste being brushed onto the below ground surface of an in-service utility pole.

A. Performance of External Preservative Systems on Douglas-fir, Western redcedar, and Ponderosa Pine Poles in California

The field test in California is now complete. The final results were provided in the 2002 annual report.

B. Performance of Selected Supplemental Groundline Preservatives in Douglas-fir- Poles Exposed Near Corvallis Oregon

The pole sections in the field test of copper/boron and copper/boron/fluoride pastes have declined to the point where they can no longer be sampled and this test was terminated in 2003.

C. Performance of External Treatments for Limiting Groundline Decay in Southern Pine Poles near Beacon, New York

Date Established:	November 2004
Location:	Douglas, Georgia
Pole Species, Treatment, Size	Southern pine, creosote
Circumference @ GL (avg., max., min.)	101, 119, 83 cm

Eighty southern pine transmission poles in the Central Hudson Electric and Gas system were selected for study. The poles were randomly allocated to groups of 10 and received one of the following treatments:

Osmose Cop-R-Plastic
Osmose PoleWrap RTU
BASF Wrap with Cu/F/B
BASF Wrap with Cu/B
Genics Cobra Wrap
Genics Cobra Slim (an experimental wrap)
Triangle Laboratories Biological Treatment

The treatments were applied 0 to 450 mm below the groundline, according to the manufacturer's instructions, and then the soil was backfilled. The total amount of chemical applied to each pole was determined by weighing the containers and applicator brushes before and after chemical application, or by measuring the total amount of prepared wrap applied. An additional set of ten poles served as untreated controls.

The poles were sampled 2, 3 and 5 years after treatment by removing increment cores from selected locations below groundline. The data from the 5 year sampling were reported last year. After 5 years copper levels have started to decline in all four wraps containing copper, and boron levels in both wraps containing boron are low. Fluoride levels remain above threshold in two of the three wraps containing fluoride. The test is next scheduled to be inspected in 2008.

D. Performance of External Treatments for Limiting Groundline Decay on Southern Pine Poles in Southern Georgia

Over the past decades, the UPRC has established a series of tests to evaluate the performance of external supplemental preservative systems on utility poles. Initially, tests were established on non-treated Douglas-fir pole sections. The tests were established on non-treated wood because the absence of prior treatment limited the potential for interference from existing preservatives, and the use of non-decayed wood eliminated the variation in degree of decay that might be found in existing utility poles. Later, we established tests on western redcedar, western pine and Douglas-fir poles in the Pacific Gas and Electric system near Merced, CA. The poles in this test had existing surface decay and were sorted into treatment groups on the basis of residual preservative retentions. Within several years, we also established similar trials in western redcedar and southern pine poles in Binghamton, New York and southern pine poles near Beacon, New York. In the second test, we altered our sampling strategies in consultation with our cooperators and attempted to better control application rates. The chemical systems evaluated in these trials have varied over the years as a result of corporate changes in formulation and cooperator interest. One other drawback of these tests is that none have been performed under truly high decay hazards. In this section, we describe procedures used to establish a test of currently registered formulations in the Georgia Power system.

Southern pine poles that were in service for at least 10 years were selected for the test. The poles were located in easily accessible right-of-ways to minimize the time required to travel between structures, were treated with oil-based treatments (CCA would interfere with analysis of copper containing systems) and would not have been subjected to prior supplemental surface treatment. Unfortunately, we could not locate poles in the Southern Company system that had not been previously treated. All of the poles in this test had previously been treated with OsmoPlastic in 1980 and/or 1994. While the oilborne components in this formulation will not interfere with future analysis, this system also contains fluoride. This necessitated some prior sampling of poles to assess residual fluoride levels for the poles that were to be treated with the two fluoride containing Osmose formulations. We recognize that it would have been better to have poles that had not received prior treatment; however, this was not possible within the system. Prior

treatment can have a number of potential effects. Obviously, residual fluoride can increase the amounts of fluoride found in the test poles; however, we hope to be able to factor this chemical loading out using our pre-treatment sampling. The presence of residual chemical may have other effects on diffusion of newly applied chemicals (potentially both positive and negative); however, this subject has received little attention.

Initial fluoride levels in poles receiving either Cop-R-Plastic or Pole Wrap averaged 1.18 and 0.96 kg/m³, respectively, in the outer 25 mm prior to treatment (Table IV-1). These levels are well above the internal threshold for fluoride (0.67 kg/m³) but still below the level we have traditionally used for performance of fluoride based materials in soil contact (2.24 kg/m³). Fluoride levels further inward ranged from 0.46 to 0.62 kg/m³. These levels are at or just below the internal threshold. It is clear that we will have to use caution in interpreting the results from these tests. On the positive side, however, the results suggest that some re-examination of the retreatment cycle might be advisable to determine if the period between treatments might be extended.

Table IV-1. Fluoride levels at selected distances from the surface of southern pine poles 10 years after application of a fluoride-containing external preservative system.

Proposed Treatment	Distance from Surface (mm)	Fluoride Level (kg/m ³)
Cop-R-Plastic	0-25	1.18 (1.77)
	25-50	0.46 (0.35)
	50-75	0.53 (0.36)
Pole Wrap	0-25	0.96 (0.89)
	25-50	0.54 (0.25)
	50-75	0.62 (0.28)

Poles in the test were allocated to a given treatment and each treatment was replicated on a minimum of 10 poles. An additional 10 poles were included as non-treated controls.

The treatments in this test were:

- CuBor (paste and bandage)
- CuRap 20 (paste and bandage)
- Cobra Wrap
- Cop-R-Plastic
- Pole Wrap (Bandage)

Each pole was excavated to a depth of 600mm (24 inches) and any weakened wood was scraped away. Although each pesticide label recommends scraping or shaving the pole surface prior to application, not all of the poles in the test were scraped. The poles in this test had been previously treated and most had little or no advanced decay when this test was installed. It is unknown what effect, if any, the lack of shaving had on chemical movement from the pastes and bandages into the wood. The residual circumference of the pole was measured at groundline then the chemical was applied according to the manufacturer's recommendations. In cases where the label allows for a range, it was agreed in the field to use the same thickness for all paste systems (see discussion below). The amount of chemical applied to each pole was determined by weighing the container and brush applicator before and after treatment. The difference was used, along with the surface area to which chemical was applied, to calculate a rate per unit area of pole surface. The treated areas were covered with whatever material was recommended by the manufacturers of that formulation, then the soil was replaced around the pole. In the case of the CuBor, which allows a range of thicknesses to be used, the thinnest paste thickness was used. The remaining systems allow for one paste thickness.

Chemical movement from the pastes into the wood was assessed in five poles per treatment one year after treatment by removing increment cores from approximately 150 mm below the groundline. A small patch of the exterior bandage and any adhering paste was scraped away, then increment cores were removed from the exposed wood on one side of the pole.

The cores were cut into two different patterns. Chemicals containing copper-based biocides were segmented into zones corresponding to 0-6, 6-13 and 13-25 mm from the wood surface. Wood from a given zone from each pole were combined and then ground to pass a 20 mesh screen. Copper was assayed by x-ray fluorescence spectroscopy (XRF). Cores removed from poles treated with boron and fluoride containing systems were cut into zones corresponding to 0-13, 13-25, 25-50 and 50-75 from the wood surface. These segments were processed in the same manner as described for the copper containing cores. Boron was analyzed by extracting the ground wood in hot water, then analyzing the extract using the azomethine-H method, while fluoride was analyzed by neutron activation analysis.

Several months after this test was installed, a number of questions were raised by various cooperators about aspects of the treatment including the application of a pasture wrap to the tops of some poles but not others, the possible interference of prior fluoride presence on the new treatment, and most importantly, the decision to use a single thickness for all of the paste systems. The pasture wrap was apparently offered to all cooperators and is required in the Georgia Power Specification for poles in livestock fields, but was not used on all poles. The potential fluoride interference was a known when the test was established. While we recognize that fluoride levels vary by location in the poles, we believe that, as a composite of the poles in the test, we can develop a correction factor to apply to those poles treated with the fluoride containing systems.

There was considerable discussion about this test at the 2005 Fall Advisory committee meeting. After much discussion, it was agreed that we would proceed with the test with the understanding that we would note that the CuBor was applied at the lowest label recommendation, that there were objections to the presence of the original fluoride and that we would continue to assess the effects of variables such as the presence of the pasture wrap on wrap performance. Finally, at the time, the producers of CuRap 20 asked that we not sample their poles in this test. Although they later changed their mind, this decision was made after the one year sample. As a result, there were no 1 year CuRap 20 data.

For the purposes of protective levels required for the performance of each system, we took the following approach. We recognize that remedial treatments are applied to in-service poles that still contain some initial treatment; however, there is no way that an inspector could realistically quantify that level for an individual pole. As a result, chemical loadings could vary from virtually none to far more than was originally specified. We took a conservative approach in this case and assumed that the initial treatment did not contribute to the efficacy of a barrier system, although we recognize that, in most cases, it does.

In addition, there are no good data for the thresholds of multi-component systems currently on the market though Fahlstrom (1964) produced some excellent data on a number of the earlier systems. Although we recognize the potential for synergy among the biocides in multi-component systems, we are just now beginning to produce data on how effective these systems are at preventing surface decay. Again, as a result of the lack of definitive information, we do not consider multi-component systems. Instead, we use the previously reported threshold for protection of wood against decay in soil contact. In the case of copper-based biocides, we have used a single threshold for copper naphthenate, while we use upper and lower thresholds for the boron and fluoride. We have taken this approach because of the differential movement of the oil and water based systems. In virtually all previous tests, the copper based biocides

have moved only a short distance into the wood from the surface. Thus, the primary function of the copper compound is surface protection against soil inhabiting organisms.

Conversely, the boron and fluoride are both capable of diffusing inward for considerable distances from the surface. As a result, they have the potential to provide protection against both internal decay fungi and insects. The dual thresholds reflect that potential. Thus, for these chemicals, the lower threshold is presented to provide some guide to the potential performance of these systems away from the surface, while the upper threshold is the more direct measure of surface protection.

We are currently attempting to develop more definitive data on the thresholds for multi-component systems that takes into account the role of the initial treatment and the benefits of multi-component systems, but for the present, we will continue to take a very conservative approach to interpreting our external barrier data.

Copper levels in the four copper containing systems ranged from 0.35 to well over 1.5 kg/m³ in the outer 6 mm one year after treatment and did not change appreciably in the second year (Figure IV-3). Copper levels in the CRP system increased between 1 and 2 years in the outer 6 mm, while those for the two CuBor systems declined slightly in this zone. Copper levels in the 6 to 12 mm zone increased slightly in the two CuBor treatments and were the only treatments above the threshold in this zone at 2 years. At this point, there is little difference in copper levels between the three systems. Copper levels in the CuRap 20 paste and bandage systems were similar to those found for the CRP and CuBor systems 2 years after treatment. These results are consistent with previous tests of this system on other wood species. Copper levels in the Cobra system were below the threshold for copper naphthenate in soil contact at both time points.

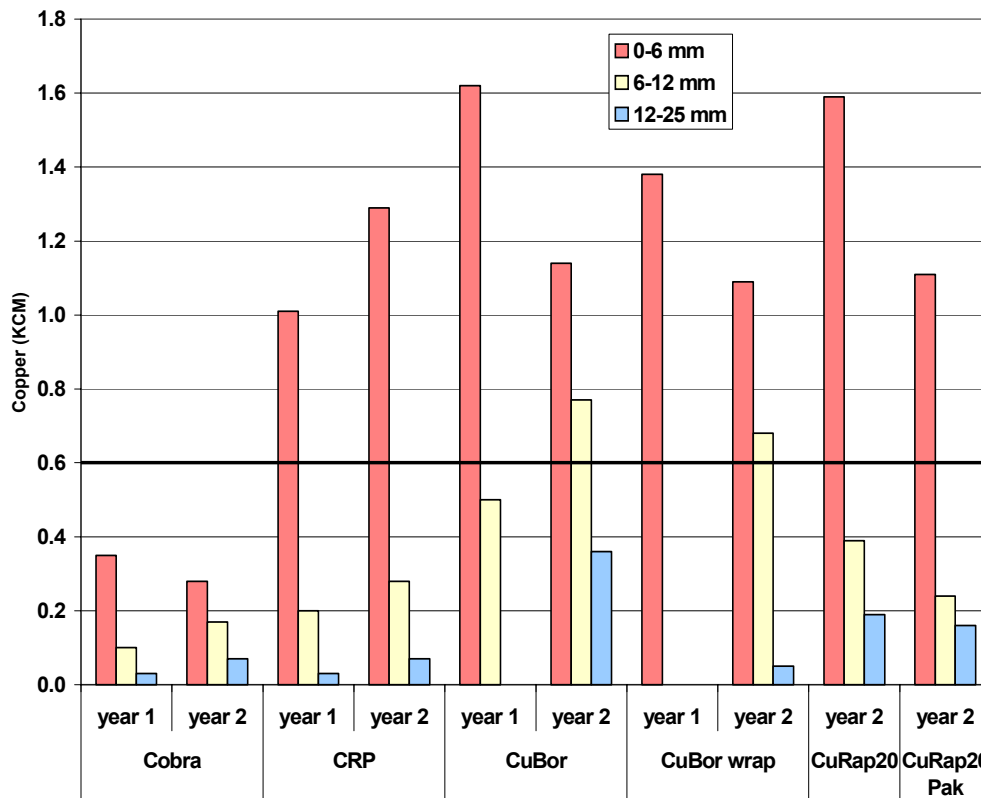


Figure IV-3. Residual copper levels at selected distances from the wood surface 150 mm below groundline on southern pine poles 1 and 2 years after treatment with Cobra Wrap, Cop-R-Plastic (CRP) or CuBor in paste or bandage form.

Copper levels fell off sharply from the 0 to 6 mm segments to the 6 to 12 mm segments for all treatments, particularly with the prepared CuBor bandage 1 year after treatment. Copper levels in the 6-12 mm zone increased markedly in year 2 with the CuBor wrap. Copper levels in the Cobra and CRP treatments were generally lower in the 6 to 12 mm zone than those in the CuBor treatments as were the copper levels in the inner zones for the 2 year CuRap 20 treatment. Copper levels were low in the zone 12 to 25 mm from the surface for all four systems. The sharp drop-off in chemical loading with distance from the surface is typical of copper based systems, which will tend to migrate for only short distances from the wood surface. Since the primary function of the copper component is surface protection, the immobilization of copper in the outer zone is a useful attribute for these systems.

Boron was a component of both the CuBor and CuRap 20 systems. Boron levels in poles receiving these treatments were nearly all well over the threshold for surface fungal attack in the outer 13 mm of the pole (Figure IV-4). Boron levels dropped steadily with distance from the pole surface, but were still above the lower threshold 13 to 25 mm from the pole surface with both systems. Interestingly, boron levels were higher for the bandage than the paste for CuRap 20 but the levels in the CuBor were similar for wrap and paste systems 2 years after treatment. We typically consider pastes to provide more intimate wood contact than bandages, but this does not always appear to affect the resulting chemical levels. Boron levels 25 to 50 mm and 50 to 75 mm below the surface were above the thresholds for both systems, indicating that this chemical has moved well into the wood over the 2 years after application.

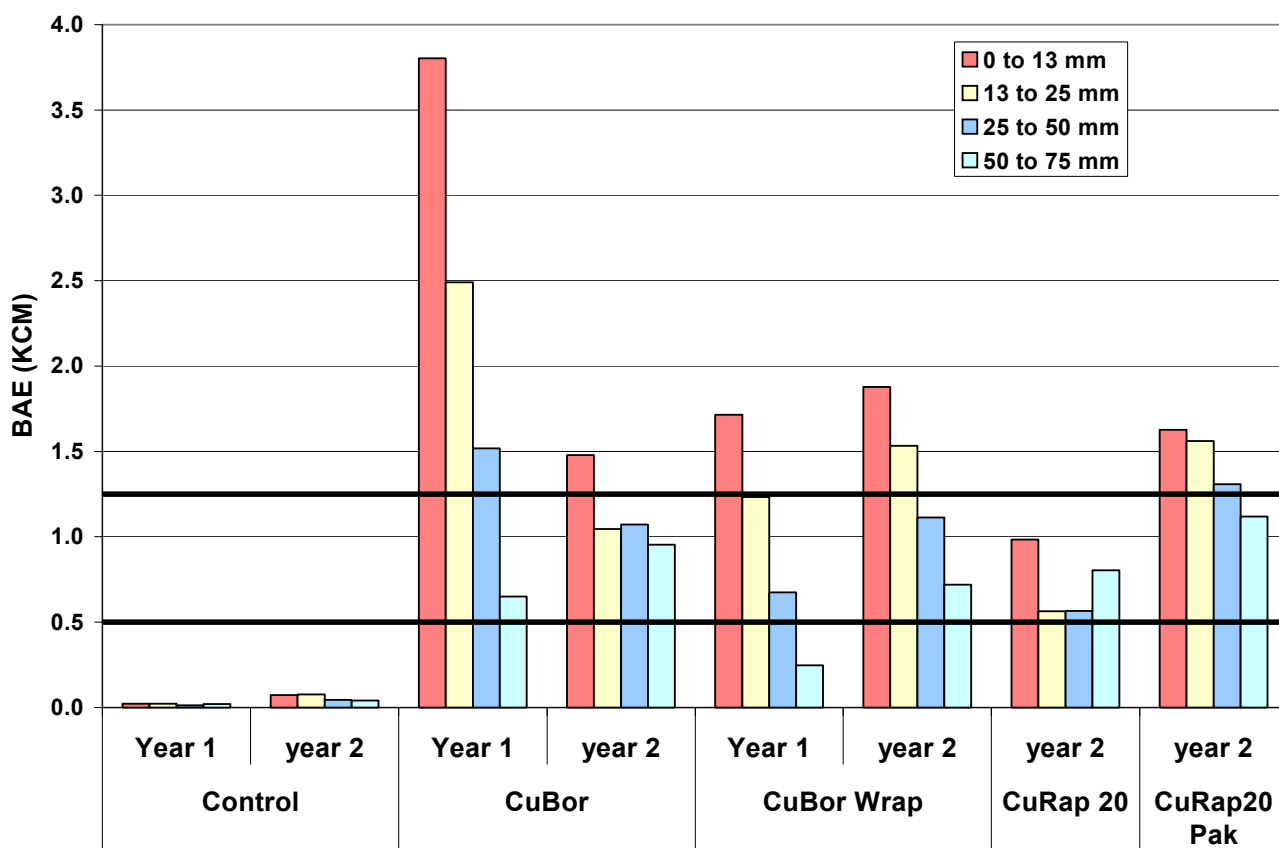


Figure IV-4. Residual boron levels at selected distances from the wood surface 150 mm below groundline on southern pine poles 1 and 2 years after treatment with CuBor and CuRap 20 in paste and bandage form.

Fluoride levels in poles treated with Cop-R-Plastic and Pole Wrap were all well above the threshold from the surface to 75 mm inward (Figure IV-5). As noted earlier, all of the poles in the test had received a fluoride containing groundline treatment (OsmoPlastic) 10 and/or 24 years earlier. Initial sampling indicated that fluoride remained in these poles, albeit at low levels. Fluoride levels in the outer zones of the same poles 1 year after treatment were 4 to 6 times higher than the background levels. Fluoride levels in poles 2 years after treatment were generally similar to those found after one year. There was slight concentration gradient inward from the surface, but the trends were not always consistent. Fluoride levels at all depths sampled remain above the threshold.

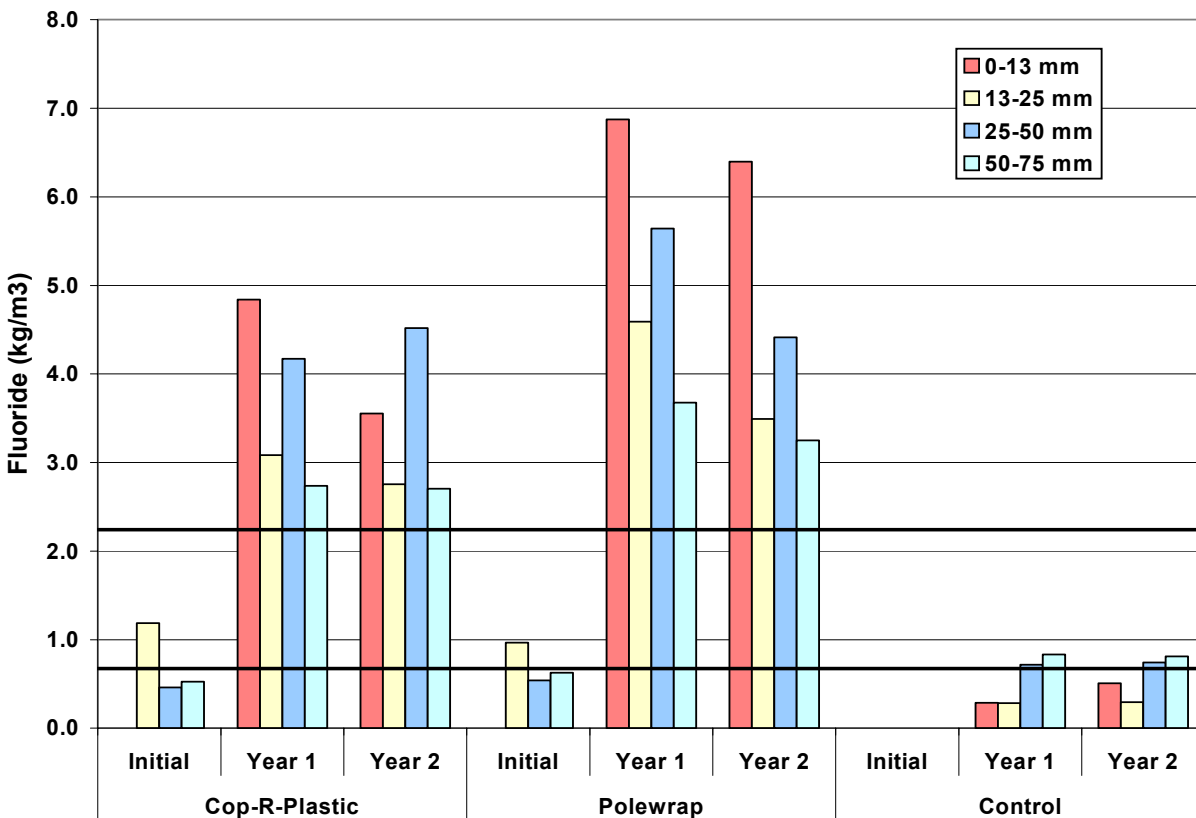


Figure IV-5. Residual fluoride levels at selected distances from the wood surface 150 mm below groundline on southern pine poles 1 or 2 years after treatment with Cop-R-Plastic or Pole Wrap.

The 2 year results with all five systems inspected indicate that components of all of the systems have moved into the wood, although there are clearly differences in degree of movement among the systems and with the use of pastes vs. bandages.

E. Effect of Moisture Content on Movement of Copper and Boron from CuBor and CuRap 20 Treated Douglas-fir Sapwood

Over the years, we have established both laboratory and field trials to assess the ability of various external preservative paste components to move into the sapwood of various wood species. The field trials provide excellent long term performance data and, because many of these tests take place on in-service utility poles, the data generated is directly applicable to the utility system. At the same time, the discussion in Section D highlights the problems associated with field tests. To partially address these issues, we have often established laboratory trials of external preservative systems to better understand the rates of chemical movement under more controlled conditions.

Douglas-fir sapwood blocks (37.5 by 87.5 by 100 mm long) were cut from kiln dried lumber. A round well, 25 mm in diameter and 10 mm deep was cut into one narrow face of each block. The blocks were then oven dried and weighed before being pressure soaked with water. The blocks were conditioned to either 30 or 60 % moisture content, a piece of duct tape was placed over the 25 mm diameter hole, and the block was then dipped twice in molten wax to retard further moisture loss. The blocks were then stored for 2 to 4 weeks to allow moisture to further equilibrate.

The blocks were then treated with either CuRap 20 or CuBor applied to a thickness of 1.6 mm or 6.0 mm in the well (Table IV-2). The paste was covered with duct tape, then the blocks were incubated at room temperature with the holes on the sides of the blocks for 4 to 24 weeks. The ability of copper and boron to move from the paste into the wood beneath was assessed 8, 16, and 24 weeks after treatment by destructively sampling five blocks per paste thickness per chemical system. A set of blocks remains for a 48 week sampling.

Paste Thickness (mm)	CuBor			CuRap 20		
	Total (g)	Boron (g)	Copper (g)	Total (g)	Boron (g)	Copper (g)
1.6	1.17	0.06	0.03	1.50	0.07	0.03
6.0	4.68	0.23	0.13	6.00	0.27	0.12

At each sampling, the tape was removed from the 25 mm well and any residual chemical was scraped away. The treated zone was cut from the rest of the wood with a band saw and the remaining core directly below the treatment well was then divided into zones corresponding to 0 to 6, 6-13, 13-25, 25-38 and 38-64 mm from the original point of paste application. The wood from a given zone was combined for a given treatment, then this material was ground to pass a 20 mesh screen. The samples were first analyzed for copper by x-ray fluorescence spectroscopy, then the samples were hot water extracted and analyzed for boron by the azomethine-H method.

As expected, copper levels were only meaningful in the outer 6 mm of the test blocks over the 24 week test period (Table IV-3). Copper levels increased slightly between 8 and 16 weeks for the thicker CuBor treatment, but then declined in the 24 week sample in blocks at 30% moisture content (Figure IV-6). Copper levels were elevated 8 weeks after treatment with the same treatment in blocks at 60 % moisture content, reflecting the availability of moisture aid in chemical movement. Copper levels were more variable in blocks treated with the thinner CuBor paste.

Copper levels in CuRap 20 treated blocks tended to be higher in blocks at 60% than in those at 30% for the thicker paste rate, but the results were much more variable in blocks receiving the thinner dosage. The results suggest that paste thickness may not necessary translate into proportionally larger amounts of chemical in the wood, but they may help insure more uniform movement.

Boron levels in blocks treated with CuBor or CuRap 20 tended to be largely confined to the outer 6 mm over the 24 week period, although some movement was noted into the 6 to 13 mm assay zone (Table IV-4). Boron levels tended to be higher in the outer zones of blocks conditioned to 60% moisture content, reflecting the need for moisture for diffusion to occur; however, the lack of substantial boron movement remains perplexing (Figure IV-7). Boron levels also appeared to be less affected by paste thickness, again suggesting that paste thickness may not necessarily affect initial loadings, but may play a longer term role in terms of treatment uniformity.

Table IV-3. Copper levels at selected distances from the surface in Douglas-fir sapwood blocks conditioned to 30 or 60% moisture content and then treated with a 1.5 or 6 mm thick layer of CuRap 20 or CuBor and incubated for 8 to 24 weeks.

Chemical	Distance from treatment (mm)	Copper (KCM)											
		1/4"						1/16"					
		30% MC			60% MC			30% MC			60% MC		
		8 week	16 wk	24 wk	8 week	16 wk	24 wk	8 week	16 wk	24 wk	8 week	16 wk	24 wk
CuBor	0-6	0.31	1.65	0.95	2.57	1.48	2.16	1.13	2.72	0.65	1.60	3.24	1.61
	6-13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	25-38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	38-64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CuRap 20	0-6	1.36	1.13	1.02	2.18	1.26	2.78	1.01	2.42	0.32	1.03	3.26	0.01
	6-13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	25-38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	38-64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control	0-6	0.01	0.00	0.00	0.00	0.00							
	6-13	0.00	0.00	0.00	0.00	0.00							
	13-25	0.00	0.00	0.00	0.00	0.00							
	25-38	0.00	0.00	0.00	0.00	0.00							
	38-64	0.00	0.00	0.00	0.00	0.00							

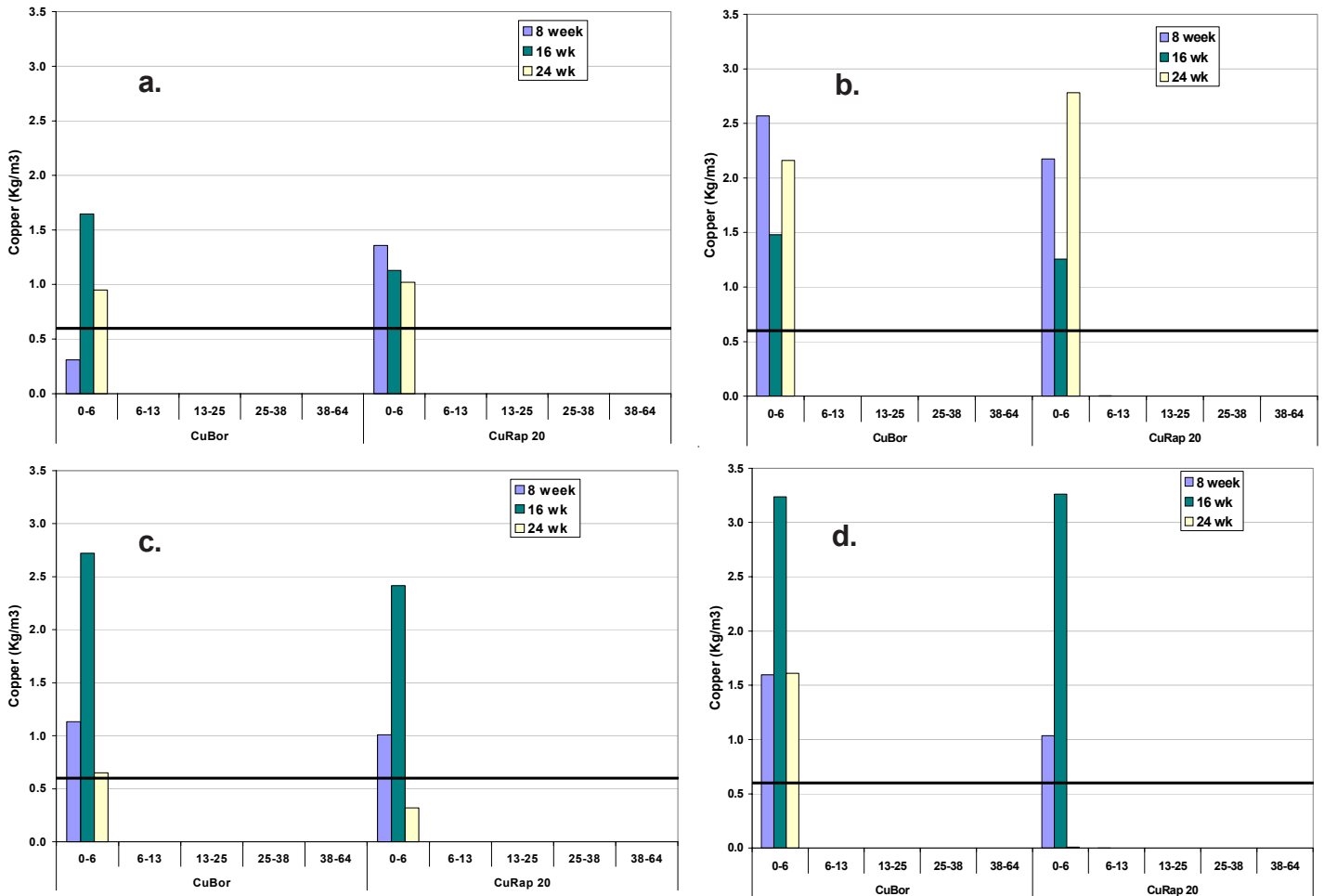


Figure IV-6. Residual copper levels at selected distances from the surface of Douglas-fir sapwood blocks at 30% (a,c) or 60% (b,d) moisture content 4 to 24 weeks after application of 1.6 mm (c,d) or 6.0 mm (a,b) of two copper/boron pastes. The threshold level for copper is 0.6 kg/m³.

Table IV-4. Boron levels at selected distances from the surface in Douglas-fir sapwood blocks conditioned to 30 or 60% moisture content and then treated with a 1.5 or 6 mm thick layer of CuRap 20 or CuBor and incubated for 8 to 24 weeks.

Chemical	Distance from treatment (mm)	Boron (KCM BAE)											
		1/4"						1/16"					
		30% MC			60% MC			30% MC			60% MC		
		8 wk	16 wk	24 wk	8 wk	16 wk	24 wk	8 wk	16 wk	24 wk	8 wk	16 wk	24 wk
CuBor	0-6	1.11	3.05	0.33	4.64	4.57	0.81	2.30	2.98	0.20	4.88	4.33	0.67
	6-13	0.01	0.00	0.01	0.21	0.46	0.13	0.08	0.01	0.01	0.32	0.68	0.08
	13-25	0.03	0.00	0.01	0.04	0.01	0.02	0.02	0.01	0.01	0.04	0.14	0.01
	25-38	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.00
	38-64	0.01	0.00	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.03	0.00	0.00
CuRap 20	0-6	2.76	3.59	0.11	3.39	3.98	0.97	2.72	2.32	0.39	2.24	3.15	0.44
	6-13	0.02	0.00	0.01	0.14	0.38	0.29	0.17	0.00	0.01	0.10	0.51	0.10
	13-25	0.01	0.00	0.00	0.00	0.00	0.09	0.01	0.00	0.01	0.01	0.08	0.02
	25-38	0.01	0.00	0.00	0.01	0.00	0.01	0.02	0.00	0.01	0.03	0.00	0.01
	38-64	0.01	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.01	0.02	0.00	0.00
Control	0-6	0.00	0.00	0.01	0.00	0.00							
	6-13	0.02	0.00	0.00	0.02	0.00							
	13-25	0.00	0.00	0.00	0.00	0.00							
	25-38	0.00	0.00	0.00	0.00	0.00							
	38-64	0.00	0.00	0.00	0.00	0.00							

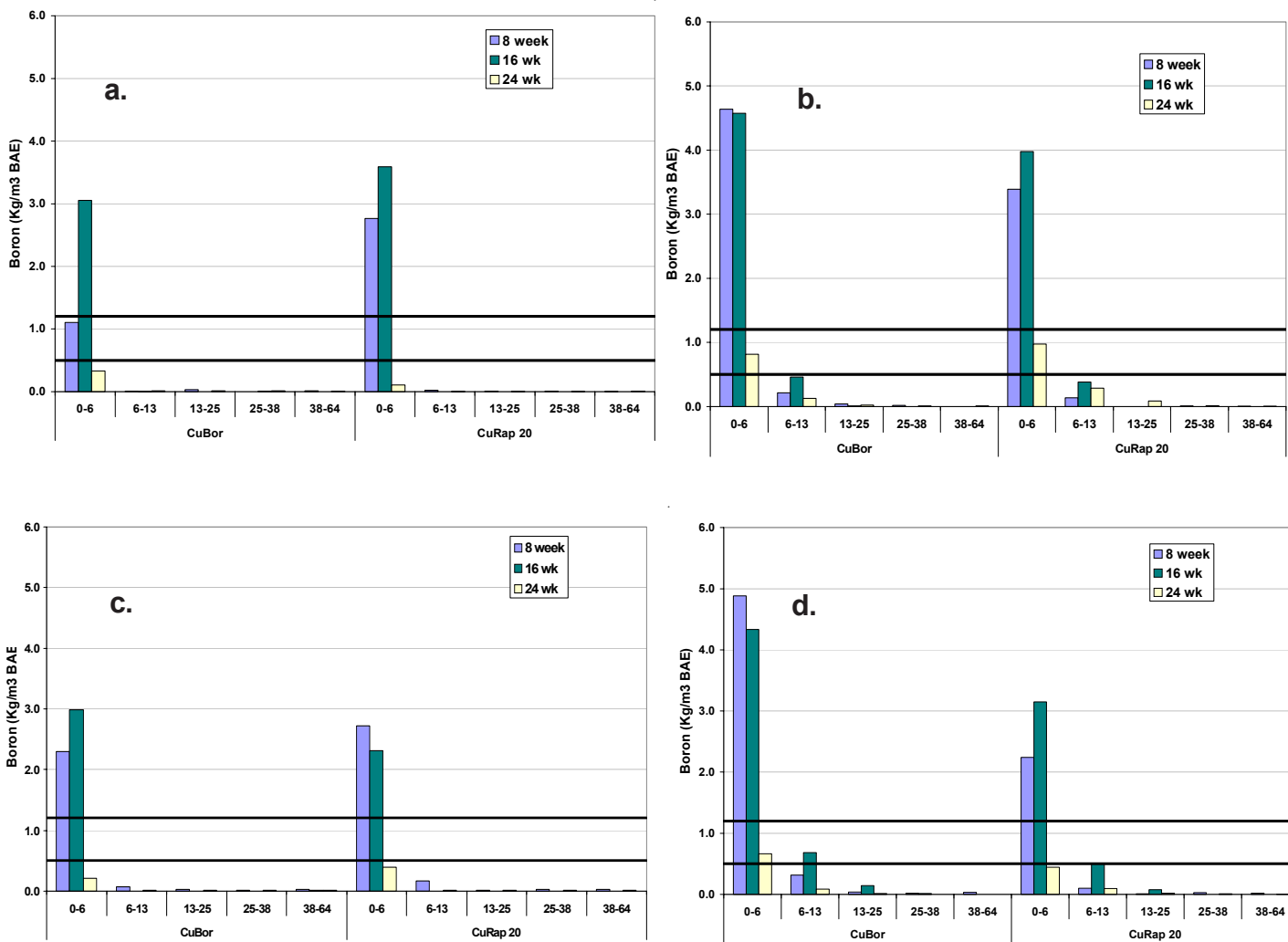


Figure IV-7. Residual boron levels at selected distances from the surface of Douglas-fir sapwood blocks at 30 % (a,c) or 60 % (b,d) moisture content 4 to 24 weeks after application of 1.6 mm (c,d) or 6.0 (a,b) of two copper/boron pastes. The upper and lower threshold levels for boron are 0.5 and 1.2kg/m³, respectively.