ABOVE GROUND PERFORMANCE OF PRESERVATIVE-TREATED WESTERN WOOD SPECIES

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Abstact: Incised and non-incised Douglas-fir, western hemlock, and ponderosa pine L-joints were treated with ammoniacal-based pentachlorophenol, chromated zinc chloride, thiocyanomethylthiobenzothiazole (TCMBT) or TCMTB plus methylenebisthiocyanate or 3 iodo-2-propynyl carbamate with or without chlorpyrifos to retentions between 0.8 and 6.4 kg/m^3 and exposed, uncoated, above ground on a test fence located in Corvallis, Oregon. Additional joints dipped in solutions of zinc naphthenate were similarly exposed. Wood condition was assessed annually over a 12 year period. As expected, untreated ponderosa pine decayed most rapidly, while untreated Douglas-fir only began to exhibit substantial decay after 6 to 8 years of exposure. Preservative treatment markedly improved the appearance of the L-joints regardless of wood species. Incised L-joints performed similarly to treated, but non-incised samples. The results illustrate the marked improvement in performance produced by preservative treatment of western wood species.

INTRODUCTION

Wood that is exposed in non-soil contact applications such as decking or window frames experiences a far lower. risk of biodeterioration than similar material in soil contact. These performance differences reflect nutrient and microflora inputs from soil as well as the ability of the soil to encourage higher wood moisture contents that promote microbial development. Even though wood exposed out of ground normally performs better, it will eventually succumb to decay and should be preservative-treated for maximum performance. One problem with developing preservative retention recommendations for above ground exposures is the lack of adequate field test data in this environment. This is particularly true for wood species in the western United States. Many species found in this region exhibit Some natural durability, but their wood is also moderately to extremely resistant to preservative treatment. As a result, treated lumber from these particular species is characterized by a thin shell of treatment surrounding a largely untreated heartwood core of varying durability. The resulting perfomance of this material will depend on the ability of the treated shell to remain intact as well as the durability of the heartwood. Thus, any test of new preservatives or treatment technologies for these species must employ material that adequately assesses the influence of both parameters. The performance of wood out of soil contact has been the subject of extensive study (Carey and Bravery, 1985, 1986; Carey et al., 1981a, b; Highley, 1984; Purslow and Williams, 1978; Morgan, 1971; Scheffer et al., 1971; Shields and Krzyzewski, 1975; Verrall, 1959; DeGroot, 1992; Fougerousse, 1976; Savory and Carey, 1979). While there are an array of above-ground test methods, the L-joint appears to be the most widely used system for this purpose. The L-joint, as used elsewhere, however, is 25 mm square, a dimension that virtually ensures complete or nearly complete preservative treatment, and that is less likely to develop checks or splits typical of dimension lumber (AWPA, 1996a). As a result, this small dimension may not accurately represent the real decay hazard posed in treated wood of western wood species. These shortcomings led us to evaluate an alternate dimension L-joint on western wood species in the following test.

MATERIALS AND METHODS

Ponderosa pine (*Pinus ponderosa* Laws) sapwood, western hemlock (*Tsugu heterophylla* (Raf.) Sarg) and Douglas-fir heartwood (*Pseudotsuga menziesii* (Mirb.) Franco) lumber (50x100 mm x various lengths) was obtained in a green condition from local sawmills. No anti-stain treatments were applied. Instead, the material was stickered and exposed to continuous air-flow until the moisture content varied between 6 and 15%. Any stained or visibly discolored wood was discarded. A portion of the Douglas-fir and western hemlock boards were transported to a commercial crossarm manufacturer where they were incised on all four sides to a density of approximately 600 incisions per square meter to a depth of approximately 5 mm. The boards were then cut into 250 and 300 mm lengths and these sections were machined into mortise or tenon joints. The resulting pairs were labeled and then conditioned to a stable weight at 21°C and 60% relative humidity.

The samples were weighed (nearest 0.1 g), placed into a tank containing the desired chemical concentration and pressure treated. The treatment cycle consisted of a 30 minute vacuum (80 kPa), followed by a 4 to 5 hour pressure period (800 kPa). The specimens were then blotted dry and weighed. Gross solution absorption served as the measure of chemical uptake. A sufficient quantity of specimens of each species were treated to produce a minimum of IO replicates within +/- 10% of the target retention. Target retentions for the chemicals selected were 0.8, 2.4, 4.0, and 6.4 kg/m^3. Chemicals evaluated were chromated zinc chloride, an ammoniacal pentachlorophenol system (Reichhold Chemicals, Tacoma, WA), thiocypanomethylthiobenzothiazole (TCMTB, Buckman Chemicals, Memphis, TN), TCMTB plus methylenebisthiocyanate (Buckman Chemicals) and 3-ido-2-propynylbutylcarbamate (IPBC), Troy Chemical Corp., Newark, NJ) with or without 1% chlorpyrifos (Lentrek, DowElanco, Indianapolis, Indiana). In addition, sets of 10 L-joints of western hemlock and pondersoa pine were dipped for 3 minutes in 0.5, 1.0, 2.0, or 3.0% (as Zn) solutions of three water based zinc naphthenate formulations (OMG Inc., Cleveland, Ohio).

Following treatment, the samples were stickered and air dried. A single 10 mm diameter by 25 mm deep plug was cut from the back of each mortise. The holes were filled with silicone. This plug was cut into zones corresponding to 0 to 5, 5 to 10, 10 to 15, and 15 to 25 mm, then wood from a given zone was combined from each species/retention/combination. The resulting samples were ground to pass a 20 mesh screen and retained for analyses.

The conditioned mortise and tenon joints were then assembled and placed on a south-facing test fence at a 5 degree angle to encourage water trapping in the joint area. The test site was partially shaded by several oak trees that also provided occasional leaf litter that served as a supplemental inoculum source. The site receives approximately 1125 mm of rainfall per year, primarily between November and May. Temperatures are moderate with winter lows rarely below freezing and summer highs rarely above 30°C The site has a Sheffer Climate Index of 60 (Scheffer, 1971).

The samples were rated anually on a visual basis according to the following scale:

10	Sound, no decay or stain
9.5	Stain or algal discoloration
9.0	Stain visible
7.0	Very early stages of decay
4.0	Advanced decay
0	Failure

The samples were also probed with a sharpened screwdriver, particularly near the joint for evidence of internal decay.

RESULTS AND DISCUSSION

As expected, the rate of decay development in untreated wood of all three species was relatively slow in comparison with similar samples in soil contact at a nearby site (Miller, 1986) and far slower than that found at more aggressive test sites (Archer et ai., 1989; Jin et al., 1992) {Table 1). The rate of decay varied markedly among the three species. Ponderosa pine was least resistant to decay, while Douglas-fir heartwood samples were still largely sound after 12 years of exposure. Douglas-fir heartwood is moderately durable and is often used without supplemental treatment in above ground exposure (Scheffer and Cowling, 1966). Nearly all of the decay was present in the mortise/tenon joint, reflecting the moisture trapping capabilities in this zone. The damage was not visible directly on the surface, but was generally several mm beneath the surface. This internal decay was partially a function of the larger size of the test specimens, which was likely to have left untreated heartwood in the center of each specimen. In general, untreated ponderosa pine decayed at a more rapid rate than did western hemlock, although both are reported to have little natural durability. The pine joints however, tended to absorb water more rapidly, and thus, conditions may have been more conducive to microbial activity in these samples. The rates of decay for ponderosa pine appeared to be intermediate between those found in previous tests in Ottawa, Canada (Shields an Krzyzewski, 1975) and Madison, Wisconsin (Eslyn et al., 1985); The dry summers at our test site may account for the slower rate of attack.

L-joints of Douglas-fir or western hemlock treated with ammoniacal penta or chromated zinc chloride were generally free of visible decay 9 years after treatment. The exceptions were the lower retentions of both chemicals on ponderosa pine which experienced some decay at the 9 year point. Some decay was evident in treated western hemlock joints after an additional 2 years of exposure. The test site had experienced several years of below average rainfall that might have slowed the rate of decay, but the last 2 years have brought well above average precipitation. The improved climate for microbial growth might have produced the increased rate of decay. Treated ponderosa pine tended to be more susceptible to decay, especially at the two lower retentions. Samples treated to the recommended above ground retention (4.0 kg/m^3) remained sound as did those treated to the ground contact retention. The excellent performance of samples treated to the proper retentions demonstrates the benefits of a preservative barrier, even out of soil contact.

Treatment with TCMTB or TCMTB/MBT also appeared to provide nearly complete protection against fungal attack over the 9 year test period, although samples were generally weathered and eroded (Table 2). Ratings declined markedly at the lower retention between 9 and 12 years in ponderosa pine and western hemlock. Once again, increased rainfall may have contributed to the increased decay.

Treatment of samples with IPBC amended with 1% chlorpyrifos has produced protection similar to that found with the other chemicals (Table 2). Chlorpyrifos was originally added to provide supplemental insect protection to IPBC. Unfortunately, the proponent did not choose to test IPBC alone to determine if the chlorpyrifos enhanced IPBC activity (Woods et al., 1994). Chlorpyrifos alone has had little or no activity against decay fungi and L-joints treated with this chemical have experienced decay at a rate similar to that of the untreated control.

Dip treatment with zinc naphthenate initially provided some protection to western hemlock and ponderosa pine, but these joints were later attacked by stain fungi and then decay fungi. They are now experiencing substantial attack as evidenced by decay at the joints and fruiting bodies along the end grain. Western hemlock appeared to outperform ponderosa pine at all treatment levels. Clearly, dipping enhanced, but did not completely protect decay susceptible woods such as ponderosa pine or western hemlock. The use of a more robust biocide might improve performance, but this biocide was originally included because many greenhouses use zinc naphthenate as a brush-on treatment to protect wood in their soil beds.

Incising is generally presumed to improve the treatment of both Douglas-fir and western hemlock lumber, and is required for treatment of many thin sapwood species (AWPA 1996b). While we also noted improved treatment in our tests, the time frame of this study was apparently not long enough for performance differences between incised and non-incised wood to become apparent. One difference noted between incised and non-incised samples was a tendency for algae to be concentrated around incisions. Water collection in the incision may have accounted for the enhanced algal growth.

CONCLUSIONS

Preservative treatment of Dougias-fir or western hemlock lumber using pressure processes provided excellent protection against fungal attack Similar treatments using ponderosa pine provide slightly less protection when retentions lower than the currently specified 4.0 kg/m are employed. The resuIts illustrate the benefits of preservative treatment for extending service life and improving the reliability of products fabricated with these species. Dip treatments initially protected L-joints, but this protection declined with time.

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SESSION CHAIRMAN BAXTER : Thank you Jeff.

Our next paper today is brought to us by Dr. Poo Chow. Poo Chow is a member of AWPA, as well as RTA, IRG, and the AREA. He comes to us from the University of Illinois. He is in teaching and research and he's bringing us a paper today entitled, "Effects of Weathering on the Decay Resistance of Creosote- Treated Oak."

Table 1. Effect of incising and treatment with an ammoniacal-based pentachlorophenol or chromated zinc chloride on above ground performance of western hemlock, Douglas-fir, and ponderosa pine L-joints.

			Wood Condition[a]													
			Incised							Non-Incised						
Treatment	Wood Species	Retention kg/m³	1yr	3yr	5yr	6yr	8yr	9yr	12yr	1yr	3yr	5yr	6yr	8yr	9yr	12yr
Ammon. Penta	P. pine	0.8	-	-	-	-	-	-	-	9.9	9.5	9.7	8.8	7.4	7.0	6.0
		2.4	-	-	-	-	-	-	-	10.0	9.5	9.7	8.8	7.4	7.0	6.8
		4.0	-	-	-	-	-	-	-	10.0	9.8	10.0	6.1	9.5	9.5	9.0
		6.4	-	-	-	-	-	-	-	10.0	9.8	10.0	9.5	9.5	9.5	9.5
	Douglas-fir	0.8	10.0	10.0	9.5	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		2.4	10.0	10.0	9.5	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		4.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		6.4	10.0	10.0	10.0	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
	W. hemlock	0.8	10.0	10.0	9.5	9.5	9.5	9.5	9.5	10.0	10.0	9.5	9.5	9.5	9.5	9.5
		2.4	10.0	10.0	9.5	9.0	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		4.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		6.4	10.0	10.0	9.5	9.5	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
CZC	P. pine	0.8	-	-	-	-	-	-	-	9.3	9.3	9.2	8.0	8.0	8.0	8.0
		2.4	-	-	-	-	-	-	-	9.5	9.3	9.2	9.0	8.9	7.2	7.0
		4.0	-	-	-	-	-	-	-	9.4	9.5	9.5	9.5	9.5	9.5	9.5
		6.4	-	-	-	-	-	-	-	9.8	9.6	10.0	10.0	9.5	9.5	9.5
	Doug.-fir	0.8	10.0	10.0	10.0	10.0	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5
		2.4	10.0	10.0	10.0	10.0	9.5	9.5	9.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5

Table 1. Effect of incising and treatment with an ammoniacal-based pentachlorophenol or chromated zinc chloride on above ground performance of western hemlock, Douglas-fir, and ponderosa pine L-joints.

Treatment	Wood Species	Retention kg/m³	Wood Condition[a]													
			Incised							Non-Incised						
			1yr	3yr	5yr	6yr	8yr	9yr	12yr	1yr	3yr	5yr	6yr	8yr	9yr	12yr
		4.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	10.0	10.0	10.0	10.0	9.5	9.5	9.5
		6.4	10.0	10.0	10.0	10.0	9.5	9.5	9.5	10.0	10.0	10.0	10.0	9.5	9.5	9.5
	W. hemlock	0.8	10.0	10.0	9.5	9.5	9.5	9.5	9.0	9.8	10.0	9.8	9.0	9.3	9.5	9.4
		2.4	10.0	10.0	9.5	9.0	9.5	9.5	7.6	10.0	10.0	9.6	9.5	9.5	9.0	7.7
		4.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	10.0	10.0	9.6	9.5	9.5	9.5	8.4
		6.4	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.9	10.0	10.0	9.5	9.5	9.5	9.0
None	P. pine	--	--	--	--	--	--	--	---	9.1	9.0	8.6	5.2	4.3	4.5	4.5
	Douglas-fir	--	10.0	9.5		9.0	8.0	8.2	3.0	10.0	10.0	10.0	8.6	9.5	9.5	9.0
	W. hemlock	--	10.0	9.9		5.3	4.2	1.8	0.4	10.0	8.6	10.0	7.1	4.0	5.6	1.3

[a] Values represent means of 10 L-joints per treatment where 10 represents no visible damage and 0 represents complete failure.

Table 3. Condition of ponderosa pine and western hemlock L-joints dip-treated with selected zinc naphthenate formulations and exposed on a test fence for 11 years in Corvallis, Oregon.

Treatment	Conc. [b] (%)	Average Wood Condition [a]					
		Ponderosa pine			Western hemlock		
		5 yr	8 yr	11 yr	5 yr	8 yr	11 yr
W553	0.5	8.0	7.4	3.0	10.0	9.0	7.3
	1.0	8.0	8.0	0.7	10.0	10.0	8.0
	2.0	9.5	8.2	7.3	10.0	9.5	9.0
	3.0	9.5	9.0	7.4	9.5	9.5	9.0
W550	0.5	5.5	6.4	1.9	9.5	9.5	9.5
	1.0	9.0	7.7	2.9	9.0	9.5	9.5
	2.0	9.0	7.9	5.5	9.5	9.5	9.0
	3.0	9.0	9.3	8.8	9.5	9.5	9.0
W552	0.5	5.8	7.3	3.2	8.6	8.4	7.9
	1.0	9.0	9.0	6.8	9.0	9.0	9.0
	2.0	9.0	9.0	7.0	10.0	9.5	9.5
	3.0	9.0	9.0	5.7	9.5	9.5	9.5
None	--	5.4	7.4	4.3	8.5	8.5	6.3

[a] Values represent means of 10 L-joints per treatment where 10 represents no visible damage and 0 represents complete failure.
[b] As Zn metal

PROCEEDINGS

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